Assessing the Feasibility of Constructing and Upgrading Trails in the Broad Meadow Brook Wildlife Sanctuary to Allow All Persons Access

An Interactive Qualifying Project Proposal
Submitted to:

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In partial fulfillment of the requirements for the

Interactive Qualifying Project

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Abstract

This report, prepared for the Broad Meadow Brook Wildlife Sanctuary in Worcester, Massachusetts, outlines the research, methods, and data used to assess the feasibility of constructing and upgrading trails in their system to allow All Persons access. A comprehensive analysis of data collected from many sources regarding All Persons trails, as well as our own research, provides recommendations for the placement and implementation of new or improved trails.

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Authorship Page

All sections of this report were written, in full, by Greg Costanzo, Anthony Maietta, Jeff Model, and Linh Nguyen. The Literature Review and Bibliography include detailed information about our resources.

1. INTRODUCTION 11

2. BACKGROUND INFORMATION 12

2.1. INTRODUCTION 12
2.2. ORGANIZATIONS RELATED TO THE PROJECT 12
2.2.1. Blackstone River Valley National Heritage Corridor 13
2.2.2. Massachusetts Audubon Society 14
2.2.3. Broad Meadow Brook Wildlife Sanctuary 15
2.2.4. Beneficial Designs 17
2.2.5. National Center on Accessibility 17
2.3. DEFINING THE TERM —ALL PERSONS" 18
2.3.1. Current Regulations for All Persons Trails 19
2.3.2. Aspects Related to Children Hiking Nature Trails 21
2.3.3. Aspects Related to Persons With Cognitive Impairment Hiking Nature Trails 22
2.3.4. Aspects Related to the Elderly Hiking Nature Trails 23
2.3.5. Aspects Related to Pregnant Women Hiking Nature Trails 24
2.3.6. Aspects Related to People Requiring a Wheelchair When on Nature Trails 25
2.3.7. Aspects Related to Those with Visual Impairments When Hiking Nature Trails 27
2.3.8. Aspects Related to All Persons when hiking nature trails 28
2.4. PREVIOUSLY COMPILED DATA ON THE SUBJECT OF ALL PERSONS WILDERNESS TRAILS 28
2.4.1. Examples of Previously Constructed Accessible Wilderness Trails 29
2.4.2. Previously Conducted Studies on All Persons Wilderness Trail Topics 29
2.4.2.1. People with Disabilities – National Survey of Recreation and the Environment 30
2.4.2.2. Preferred Natural Environments and People with Disabilities 31
2.4.2.3. Visitor Expectations and Perceptions of Program and Physical Accessibility in the National Park Service 32
2.5. FACTORS IN WILDERNESS TRAIL CONSTRUCTION 33
2.5.1. Aspects Related to Erosion When Planning Nature Trails 34
2.5.2. Aspects Related to Vegetation When Planning Nature Trails 35
2.5.3. Aspects Related to Disturbance of Wildlife When Planning Nature Trails 36
2.6. ELECTRONIC DEVICES AND SOFTWARE USED IN TRAIL CONSTRUCTION 36
2.6.1. Global Positioning System Devices 37
2.6.2. Geographical Information Systems 38
2.7. CONVENTIONAL SURVEYING METHODS 38
2.8. UNIVERSAL TRAIL ASSESSMENT PROCESS 39
2.9. EXISTING MAPS OF THE SANCTUARY AND TRAIL NETWORK 40
2.10. MATERIALS INVOLVED IN CONSTRUCTING ALL PERSONS WILDERNESS TRAILS 41
2.10.1. Bridges for Crossing Waterways and Streets 41

2.10.2. Resting Areas and Benches *42*
2.10.2.1. Strategic Placement of Resting Areas Along the Wilderness Trails 43
2.10.2.2. Durability of Different Benches, Maintenance Requirements, and Costs 44
2.10.3. Mechanisms for Guidance Along the Wilderness Trails *45*
2.10.3.1. Marking Trails in a Manner Effective for Everyone 45
2.10.3.2. Ridges and Boards for Guidance Along Wilderness Trails 47
2.10.3.3. Handrails and Ropes to Follow Around the Wilderness Trails 48
2.10.4. Elevated Walkways for use in Wilderness Trail Construction *48*
2.10.4.1. Costs Related to of Elevated Walkway Materials and Installation 49
2.10.4.2. Maintenance Requirements of Elevated Walkways 50
2.10.4.3. Advantages and Disadvantages of Using Elevated Walkways for Wilderness Trails 50
2.10.5. Improved Footpaths for use in Wilderness Trail Construction *50*
2.10.5.1. Costs related to Improved Footpaths Materials and Installation 51
2.10.5.2. Maintenance Issues of Improved Footpaths 52
2.10.5.3. Advantages and Disadvantages of Using Improved Footpaths 53
2.10.6. Paved Walkway for use in Wilderness Trail Construction *53*
2.10.6.1. Costs for Paved Walkway Materials and Installation 53
2.10.6.2. Maintenance Issues Pertaining to Paved Walkways 54
2.10.6.3. Advantages and Disadvantages of Using Paved Walkways 55
2.11. SUMMARY 55

3. METHODOLOGY 57

3.1 QUESTIONNAIRE 57
3.1.1 The Questionnaire's Target Population *58*
3.1.2 Sampling Design *58*
3.1.3 Questionnaire Design *59*
3.1.4 Questionnaire Procedure *60*
3.1.5 Questionnaire Limitations *60*
3.2 INTERVIEWING 61
3.3 PLANNING THE TRAIL 61
3.3.1 Using Global Positioning Systems *62*
3.3.1.1 Using the GPS Unit 62
3.3.1.2 Using Computer Software to Record GPS Data 63
3.3.2 Using GIS to Map the Area *72*
3.3.2.1 Choosing Layers that are Appropriate for Planning a Wilderness Trail 72
3.3.2.2 Trail Layer on a Geographical Information System Map 73
3.3.2.3 Topography Layer on a Geographical Information System Map 73
3.3.2.4 Road Layer on a Geographical Information System Map 73
3.3.2.5 Lakes, Streams, Water Layer on a Geographical Information System 74
3.3.3 Determining Trail Grades and Inclinations *74*

3.3.3.1 Using Clinometer Readings in Wilderness Trail Assessment 75
3.3.3.2 Using Geometry for Grade Assessment 75
3.3.3.3 Using Inclinometer Readings in Wilderness Trail Assessment 76
3.3.3.4 Determining Cross Slopes of Wilderness Trails 76
3.3.3.5 Measuring Trail Length 76
3.4 SYSTEMATICALLY RECORDING OUR DATA 77
3.4.1 Recording Questionnaire Results *77*
3.4.2 Recording Surveying Results *78*
3.5 METHODOLOGY SUMMARY 78
4. DATA ANALYSIS 79
4.1. INTERVIEWS 79
4.1.1. Documented Suggestions Made by the Interviewees *80*
4.1.2. Research the Feasibility of the Suggestions *82*
4.2. CHOOSING A TRAIL SURFACE 83
4.2.1. Material Cost Per Square Foot *83*
4.2.2. Aggregate Costs *84*
4.2.3. Aesthetics *85*
4.2.4. Maintenance *85*
4.2.5. Installed Cost *87*
4.2.6. Total Score *87*
4.3. INFORMATION ABOUT THE CURRENT TRAIL NETWORK 88
4.3.1. Grades of Existing Trail Network *89*
4.3.2. Distances of Existing Trail Network *100*
4.3.3. GPS Mapping *101*
4.4. SURVEY INFORMATION 116
5. CONCLUSIONS AND RECOMMENDATIONS 116
5.1. PLACEMENT OF THE TRAILS 117
5.2. TYPE OF TRAIL 130
5.3. MATERIAL 131
5.4. PLACEMENT OF BENCHES 132
5.5. PROPER SIGNAGE ALONG WILDERNESS TRAILS 133
APPENDIX A 138
APPENDIX B 139
Questionnaire Results *139*
Compile Statistics *139*

Conclusions Drawn From the Questionnaire *143*

APPENDIX C **146**

EXAMPLES OF ACCESSIBLE TRAILS IN MASSACHUSETTS 146

APPENDIX D **147**

GLOSSARY 147

REFERENCES 151

APPENDIX F **154**

TRAILS SURFACES AND MANUFACTURERS 154

Table of Figures

Figure 1 (Wheelchair Dimensions) 26
Figure 2 (Optimal Field of Vision for Sitting and Standing Adults) 47
Figure 3 (New Table Dialog Box) 64
Figure 4 (New Table Structure Box) 65
Figure 5 (Create New Table Dialog Box) 66
Figure 6 (Setup GPS GeoCoding Dialog Box) 67
Figure 7 (Setup GPS Tracking Dialog Box) 68
Figure 8 (The Geographic Tracker Program) 69
Figure 9 (Select a GPS Simulation Log File Dialog Box) 70
Figure 10 (The Geographic Tracker Dialog Box) 71
Figure 11 (Polyline Tool Box Button) 71
Figure 12 (Thumbtack Tool Box Button) 71
Figure 13 (Holdredge Trail Grades Assessment 1) 90
Figure 14 (Holdredge Trail Grade Assessment 2) 90
Figure 15 (Holdredge Trail Grade Assessment 3) 91
Figure 16 (Holdredge Trail Grade Assessment 4) 91
Figure 17 (Sprague Trail Grade Assessment 1) 92
Figure 18 (Sprague Trail Grade Assessment 2) 93
Figure 19 (Sprague Trail Grade Assessment 3) 93
Figure 20 (Sprague Trail Grade Assessment 4) 94
Figure 21 (Sprague Trail Grade Assessment 5) 95
Figure 22 (Sprague Trail Grade Assessment 6) 95
Figure 23 (Holdredge Trail Grade Assessment) 96
Figure 24 (Frog Pond Trail Grade Assessment) 96
Figure 25 (Enchanted Forest Trail Grade Assessment) 97
Figure 26 (Sprague Extension Grade Assessment) 97
Figure 27 (Lady Slipper Trail Grade Assessment) 98
Figure 28 (Cardinal Trail Grade Assessment) 98
Figure 29 (Troaino Brookside Trail Grade Assessment) 99
Figure 30 (North Link Trail Grade Assessment) 99
Figure 31 (Blue Well Trail Grade Assessment) 100
Figure 32 (Nov 4, 2002 GPS Mapping) 102
Figure 33 (November 5, 2002 GPS Mapping) 104

Figure 34 (November 7, 2002 GPS Mapping) 106
Figure 35 (November 11, 2002 GPS Mapping) 108
Figure 36 (November 11, 2000 GPS Mapping 2) 109
Figure 37 (November 15, 2002 GPS Mapping) 111
Figure 38 (November 18, 2002 GPS Mapping) 112
Figure 39 (December 4, 2002 GPS Mapping) 113
Figure 40 (December 5, 2002 GPS Mapping) 114
Figure 41 (December 5, 2002 GPS Mapping) 115
Figure 42 (Visitor Center to Intersection A) 118
Figure 43 (Sprague Spur Trail) 121
Figure 44 (Enchanted Trail Loop) 124
Figure 45 (Connection to the Blackstone River Valley) 127
Figure 46 (Example of Standard Trail Sign) 134
Figure 47 (Questionnaire Data) 140

1. Introduction

The Massachusetts Audubon Society's Broad Meadow Brook Wildlife Sanctuary is currently the largest urban nature preserve is New England. With over 400 acres of protected lands in the heart of Worcester County, the Sanctuary attracts a wide range of nature enthusiasts. Currently, however, there are only limited opportunities for those with physical disabilities (Broad Meadow Brook Wildlife Sanctuary Pamphlet, 2002). Within the Sanctuary, there are currently no trails accessible to people with disabilities and certain physical limitations.

In an effort to create equality for the physically disabled, the Massachusetts Audubon Society seeks to develop a network of trails that are accessible to the 42% of the general population with disabilities (Americans with Disabilities Act, 2002). Because of the City's abnormally large disabled population, the Worcester community has a desire for this All Persons trail (Schaffer, 2002). The steep and varied terrain of the Sanctuary makes trail planning difficult. We were also aware of sensitive ecological areas that impose further impediments to trail planning. This proposal makes recommendations to the Sanctuary concerning the placement of an "All Persons" trail that connects the Sanctuary to the bike path following the Blackstone River and route 146.

2. Background Information

2.1. Introduction

Our team conducted extensive research in the issues related to –All Persons" trails. This section takes a look at work that has been previously done on –All Persons" trails that is usable in our project. Care has been taken to explore existing information about the trails in the Broad Meadow Brook Wildlife Sanctuary, which lies in the Blackstone River Valley National Heritage Corridor. We have also given special consideration to the words that have been used to describe our project. For definitions of some of the words refer to our glossary in Appendix D. For the purposes of this project the term –All Persons" has been defined to suit our needs. We have researched the different mitigating factors that groups of varying ability pose on the trail, and incorporated them into the definition for –All Persons." Lastly we have explored the benefits and disadvantages to using several different materials in wilderness trail applications. This research has contributed greatly to our understanding of the projects details.

2.2. Organizations Related to the Project

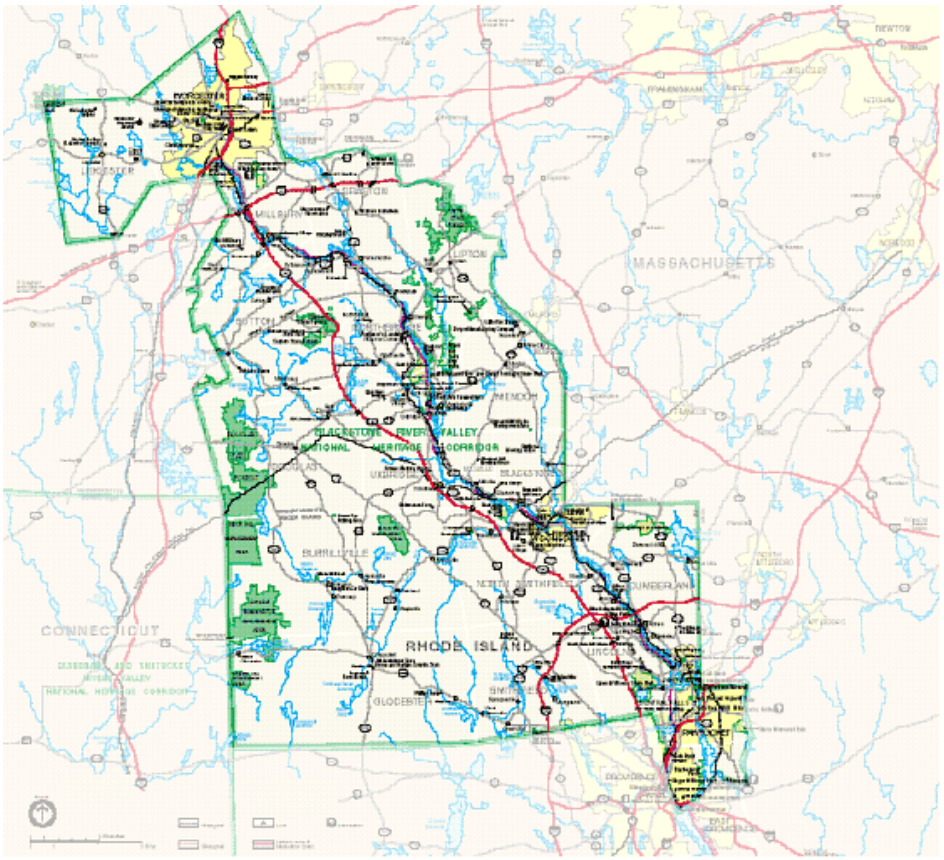
The impact of this project relies on the cooperation of many organizations. The Blackstone River Valley National Heritage Corridor is home to the Broad Meadow Brook Wildlife Sanctuary, and encompasses much of central Massachusetts. The Massachusetts Audubon Society provides financial support for the Sanctuary. Each of these organizations has objectives connected to our project and are discussed in the sections

that follow.

2.2.1. Blackstone River Valley National Heritage Corridor

The Blackstone River Valley National Heritage Corridor is located in Central Massachusetts and Northern Rhode Island. The Corridor is unique because of its diversity, falling within the park boundaries are cities, towns, villages and almost one million people. Unlike other parks, the Federal Government does not own or manage any of the land or resources in the Corridor. Rather, it consists of a partnership between the National Park Service, two state governments, dozens of local municipalities, businesses, nonprofit historical and environmental organizations, educational institutions, many private citizens, and a unifying commission all who work together to protect the Valley's special identity and prepare for its future. The Corridor covers nearly 400,000 acres located within Worcester County in Central Massachusetts and Providence County in Northern Rhode Island (See Map 1). The National Corridor was designated by an Act of Congress on November 10, 1986 to preserve and protect the unique and significant value of the Blackstone Valley (http://www.nps.gov).

Map 1 - Blackstone River Valley National Heritage Corridor



2.2.2. Massachusetts Audubon Society

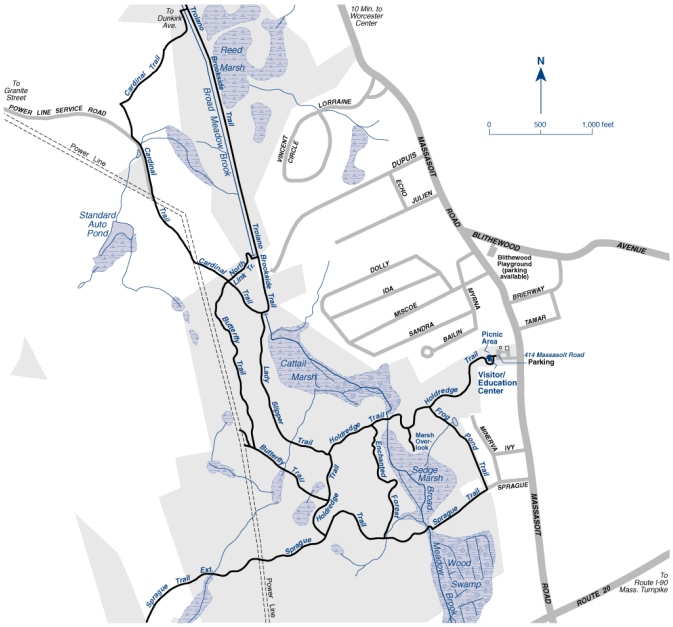
The Massachusetts Audubon Society was established in 1896. It is the largest organization in New England dedicated to conservation of land and natural resources. It serves to encourage conservation, to educate its users, and to protect the land. The Society is supported by 65,000 members and the over 250,000 people of all ages that take advantage of its educational programs each year. Over 29,000 acres of land are protected by the Society in forty-one wildlife sanctuaries that are open to the public (Massachusetts

Audubon Society, 2002). The Massachusetts Audubon Society owns and operates the Broad Meadow Brook Wildlife Sanctuary.

2.2.3. Broad Meadow Brook Wildlife Sanctuary

One of the many staffed Sanctuaries in Massachusetts; the Broad Meadow Brook Wildlife Sanctuary is the largest urban wildlife sanctuary in New England. In June of 1990 the Broad Meadow Brook Wildlife Sanctuary was established because the Worcester community wanted to help the Massachusetts Audubon Society raise funds to protect this ―400-acre urban oasis" from encroaching business developers (Broad Meadow Brook Pamphlet, 2002).

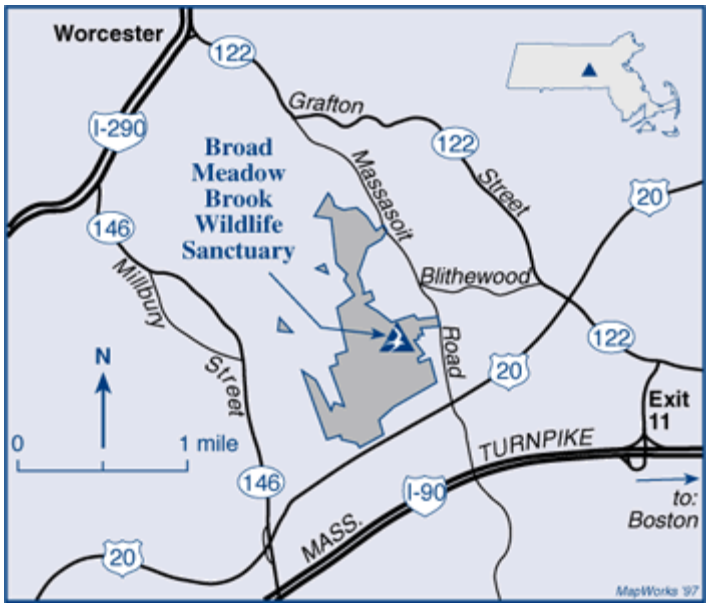
Map 2 - Sanctuary Trail Network



The Society's 15 acres became the vital link between the 137 acres owned by the New England Power Company and the 120 acres owned by the City of Worcester. These

lands collectively were designated as conservation land by the City of Worcester to be managed by the Society as a wildlife sanctuary (See Map 2). Since 1919, neighbors interested in maintaining this wildlife area have donated additional lands to the Sanctuary. The Sanctuary is also exploring the shared use of lands from other sources, including land owned by the Harvey Ball organization. The goal of this effort is to conserve vanishing natural resources and inspire awareness of the Blackstone River watershed. Forest, fields, brooks, and marshlands can all be seen by hiking along one of the numerous trails. Seventy-eight different species of butterflies and 224 species of birds have been identified in the Sanctuary (http://www.nps.gov/blac/index.htm).

Map 3 - Location



Access to the bike trail running parallel to the new extension of Route 146 would increase Sanctuary popularity. A goal of the Massachusetts Audubon Society is to build a trail that connects the bike route with the rest of the Sanctuary. This trail, which we

have planned to be accessible by –All Persons," will help to bring many new visitors to the Sanctuary from other places in the Blackstone River Valley.

2.2.4. Beneficial Designs

Peter Alexson started Beneficial Designs after he sustained a spinal cord injury in 1981. The company he founded has been an industry leader, increasing the accessibility for those with physical limitations. Beneficial Designs researches products that open opportunities to those who otherwise might lead a sheltered life. Through the innovation of products such as hand controls for a manual transmission car, a piano pedal pusher operated by the abdominal muscles and countless improvements to wheelchairs. Beneficial Designs has made great strides in making the lives of the physically limited bearable (http://www.beneficialdesigns.com). Working with the Federal Government, Beneficial Designs has made many advances in attempting to amend the Americans with Disability Act such that it includes regulations for handicapped accessible nature trails. Beneficial Designs also provided much of the research which the proposed amendments to the ADA are based on. They designed the Universal Trail Assessment Process (UTAP) which is discussed in the pages that follow (http://www.beneficialdesigns.com).

2.2.5. National Center on Accessibility

The National Center on Accessibility, located at Indiana University, is a leader in the movement to include people with disabilities in recreation, parks, and tourism. The NCA provides technical assistance to organizations who are designing their leisure areas and

programs for accessibility. The NCA conducts research on issues essential to accessibility (http://www.ncaonline.org). This research shapes instruction for the NCA education programs held throughout the United States.

The NCA assists organizations in all phases of development, encouraging understanding and involvement. They provide the expertise to assist those designing environments and programs to make them accessible. Through project research, NCA serves organizations working to make the arts, beaches, sports, national monuments, resorts, amusement parks and playgrounds more welcoming to all people, this makes the NCA a particularly useful resource in our project (http://www.ncaonline.org).

2.3. Defining the Term "All Persons"

In this modern day of equality, various social groups are able to operate on a level playing field. One group that has made great advances in the last ten years is the disabled. Barriers that once held these people back are beginning to fall. Starting with the Americans with Disabilities Act (ADA) of 1990, the disabled and physically limited have made great strides in attaining social equality through, among other things, federal regulation. A discussion covering the details of the regulations facing nature trails is presented in the section titled "Current Regulations."

A term that includes to the disabled or physically limited is "All Persons." All Persons is a term that is hard to define because it includes so many different people. For this project, All Persons was the target population. By incorporating the needs of all people

with a physical limitation or a disability we satisfied the requirements of our target population. Looking at the limitations that the physically disabled will place on our proposed trail, it is not feasible for us to have planned it around the trail requirements that every group presents. Our team incorporated many different groups of physically disabled people into our discussion of nature trail requirements. Below is a sampling of limitation types that fall under the term All Persons. These requirements were derived from different literatures discussed in their individual sections.

Physical Limitation	**Nature Trail Requirements**
Children	Short, Entertaining natural wonders
Cognitive Limitations	Entertaining natural wonders, Short
Elderly	Benches, Easy slopes, Firm surfaces
Pregnancy	Short distances on difficult terrain, Benches
Visually Impaired	Method for following the trail
Wheelchair Assistance	Firm & wide trail, Excessively easy slopes

Many of the requirements overlap, but the most difficult requirements to accommodate are for those in need of wheelchair assistance. Designing a trail for those who need wheelchair assistance will allow most others with physical limitations to partake in the enjoyment of nature along the trail. This does not mean that the trail is only designed considering wheelchairs; we have incorporated the special requirements of other groups into our plan for the All Persons accessibility aspect of the trail.

2.3.1. Current Regulations for All Persons Trails

At the time of this project, there were no regulations stated in the Americans with Disabilities Act (ADA) that deal with the accessibility of nature trails. In fact, nature trails have a specific exemption (http://www.access-board.gov). There are however, proposed amendments to the ADA that address trails. Under these new provisions,

specifications would be made for two types of environmental concerns: outdoor recreational access routes and trails. Outdoor recreation access routes are defined as "A continuous unobstructed path designated for pedestrian use that connects accessible elements within a picnic area, camping area, or designated trailhead" (http://www.access-board.gov/outdoor/outdoor-rec-rpt.htm). These paths are often paved and very short in length. Trails are defined as "A route that is designed, constructed, or designated for recreational pedestrian use or provided as a pedestrian alternative to vehicular routes within a transportation system (http://www.access-board.gov/outdoor/outdoor-rec-rpt.htm)." The stereotypical nature trail flowing through the woods are encompassed by this definition. The trail that is being proposed connecting the Broad Meadow Brook Sanctuary to the Blackstone River Corridor would fall into the category of "Trail." The proposed regulations that a handicapped accessible trail would require are:

- The clear tread width of the trail shall be 36 inches
- Protruding objects on trails shall comply with ADAAG 4.4.1.and shall have 80 inches minimum clear head room
- Where tread obstacles exist, they shall not exceed 2 inches high maximum
- Where the clear tread width of the trail is less than 60 inches, passing spaces shall be provided at intervals of 1000 feet maximum. Passing spaces shall be either a 60 inches minimum by 60 inches minimum space, or an intersection of two walking surfaces which provide a T-shaped space complying with ADAAG 4.2.3 provided that the arms and stem of the T-shaped space extend at least 48 inches beyond the intersection
- The cross slope shall not exceed 1:20 maximum
- Running slope shall be 1:20 or less for any distance
- Running slope shall be 1:12 maximum for 200 feet maximum. Resting intervals complying with 16.2.8 shall be provided at distances no greater than 200 feet apart
- Running slope shall be 1:10 maximum for 30 feet maximum. Resting intervals complying with 16.2.8 shall be provided at distances no greater than 30 feet apart
- Running slope shall be 1:8 maximum for 10 feet maximum. Resting intervals complying with 16.2.8 shall be provided at distances no greater than 10 feet apart

- Resting intervals shall be 60 inches minimum in length, shall have a width at least as wide as the widest portion of the trail segment leading to the resting interval, and have a slope not exceeding 1:20 in any direction
- Where edge protection is provided along a trail, the edge protection shall have a height of 3 inches minimum. Newly constructed and altered trails and trail segments complying with 16.2 shall be designated with a symbol at the trailhead and all designated access points. Signs identifying accessible trail segments shall include the total distance of the accessible segment and the location of the first point of departure from the technical provisions
- The trail surface shall be firm and stable

(http://www.access-board.gov/outdoor/outdoor-rec-rpt.htm)

2.3.2. Aspects Related to Children Hiking Nature Trails

Every year schools throughout the city go on field trips to the Broad Meadow Brook Wildlife Sanctuary. Many special factors about hiking have to be considered when hiking with children. The naturalists at the Sanctuary try to develop walks that keep children not only stimulated, but interested in the environment they are walking through. Because children have had less experience than adults, they are less mentally and physically developed (Tilton, 1994). Children tend to have the following characteristics when compared to adults:

- One-third less peripheral vision
- Less accuracy in judging speed and distance
- Difficulty localizing the direction of sounds
- Overconfidence
- Inability to read or comprehend warning signs
- More susceptible to heat problems
- Dehydrate faster
- Difficulty sustaining warmth

Nature Trail Requirements for Children

- Length of the trail must be short enough to maintain interest
- Scenery must be entertaining and exciting
- Benches along the trail to take breaks
- Trees should provide shade to keep them cool
- Signs must be at a reading level that can be understood

2.3.3. Aspects Related to Persons With Cognitive Impairment Hiking Nature Trails

Persons with cognitive disabilities often lead normal lives. K. G. Maietta (personal communication, September 24, 2002) mentioned that although they may function in a normal fashion physically, they need special consideration in other aspects of trail construction. Cognition is the ability to perceive, recognize, understand, interpret, and respond to information. It relies on complex processes such as thinking, knowing, memory, learning, and recognition. Cognitive disabilities can hinder the ability to think, learn, respond, and perform coordinated motor skills. In an interview with Professor Ault (Personal communication, December 4, 2002) it was mentioned that the movement skills of people with cognitive disabilities vary tremendously. The motor skills and fitness potential of people with cognitive disorders are often hampered by a lack of opportunity to learn and practice appropriate physical activity movements. As a result, walking speed has been shown to decrease with the presence of cognitive or depressive disabilities. Design approaches for people with cognitive impairments also might benefit children and the more than 20 percent of American adults who do not read English (Hopf Raber, 1994). Signs on the side of the trail need to be on an eighth grade reading level. A sign reading, "The trail that follows is convoluted and very tiring for your cardiovascular system" would generally be too complicated for someone with a cognitive disability. A

sign reading –The trail that follows is for good hikers only" would be more understandable. A person with a cognitive disability may have a lessoned attention span and, like children, they need interesting landmarks along the trail.

Nature Trail Requirements those with Cognitive Disabilities
• Length of the trail must be short enough to maintain interest • Signs must be at a reading level that can be understood • Scenery must be entertaining and exciting • Benches along the trail to take breaks

2.3.4. Aspects Related to the Elderly Hiking Nature Trails

Like children, the elderly are another group more susceptible to illness and injuries than most. Improvements in public health, nutrition, surgical procedures, prescription medication, and medical care since 1900 have added years to life expectancy, resulting in an ever larger –aging" population. According to the National Institute on Aging, the number of Americans over the age of 65 is expected to grow from 26 million to 66.6 million by the year 2040 (Carter, 2001). Although aging itself is not a disability, according to the U.S. Census, in 1990 –most persons aged 75 or older had a disability." Professor Ault mentioned that the ability to see and hear can deteriorate with aging (Personal Communication, December 4, 2002). Many of the characteristics commonly associated with aging might limit mobility. Although not all older adults have disabilities, those who do, benefit from accessible designs. The aging process frequently causes a general deterioration of physical, cognitive, and sensory abilities. These changes intensify over time and are most pronounced for individuals over 75 years of age. Characteristics of many older adults may include the following:

- Vision problems, such as degraded acuity, poor central vision, and reduced ability to scan the environment
- Reduced range of joint motion
- Reduced ability to detect, localize, and differentiate sounds
- Limited attention span, memory, and cognitive abilities
- Reduced endurance
- Reduced tolerance for extreme temperature and environments
- Decreased agility, balance, and stability
- Inability to quickly avoid dangerous situations
- Slower reflexes
- Impaired judgment, confidence, and decision-making abilities

(Carter, 2001).

Nature Trail Requirements for the Elderly
• Length of the trail must be short enough to walk • Benches along the trail to take breaks • Trail must be level and firm enough to provide stability • Grades must not be difficult

2.3.5. Aspects Related to Pregnant Women Hiking Nature Trails

It is important for the development of the fetus for a pregnant mother to maintain a healthy lifestyle. A healthy lifestyle should include a balanced diet and regular exercise. It is also important not to over exercise, become overheated or become dehydrated. Also, pregnancy's effects on the body can make heart rate monitoring an inaccurate measure of fitness levels during this time (Bryant, 1999). There are many cautions that are involved in being pregnant that need to be considered. We should design the trail in a manner that encourages use, but remains cautious of the mother's health. If a trail is too steep or does not have an even path the mother may fall, injuring not only herself but also her unborn child.

Nature Trail Requirements for Pregnant Women
• Length of the trail must be short enough to walk • Benches along the trail to take breaks • Trail must be level and firm enough to provide stability • Grades must not be difficult

2.3.6. Aspects Related to People Requiring a Wheelchair When on Nature Trails

Wheelchairs have become a common sight in the United States of America. In 1990, 1.9 million Americans identified themselves as wheelchair users for the U.S. Census. All public buildings are required by Federal Law to have wheelchair accessible ramps, parking spots, bathrooms, and other facilities (http://www.access-board.gov). Wheelchairs are so commonly used they have become synonymous with the word ~~"h~~handicapped." The standard wheelchair is propelled by either the power of its occupant, or another person pushing from behind. Modern technology has created motorized chairs that give people with more physically demanding limitations the ability to move around on their own. A battery operated motor, controlled by a joystick in the occupant's hand guides the chair; some are even controlled by breathing into a tube. Many times, the wheels on a motorized wheelchair offer a more rugged tread that affords the user the opportunity to explore less developed areas. Even though the users of these chairs are more limited physically, with these motorized chairs, they are able to move around as much as those confined to standard wheelchairs. The cost of a motorized wheelchair can be quite substantial; this precludes many users of conventional wheelchairs from upgrading.

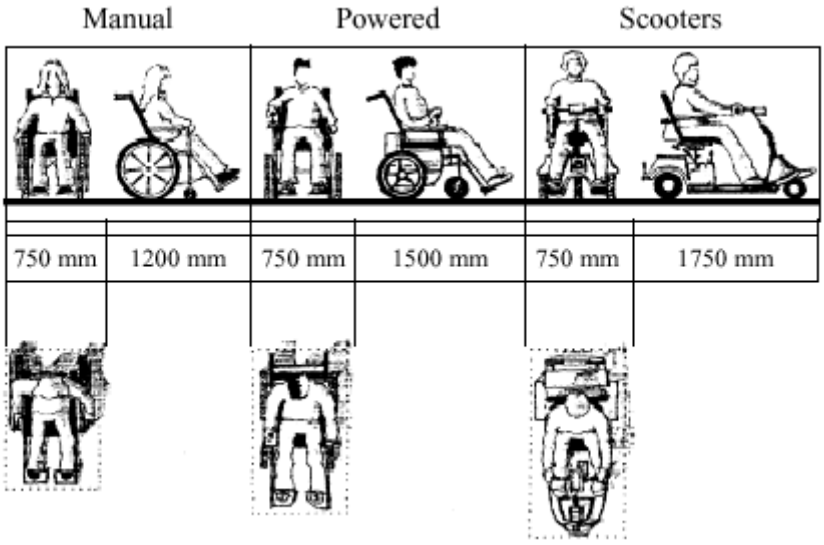


Figure 1 (Wheelchair Dimensions)

Wheelchairs are limited to traveling on very gradual slopes as it becomes more difficult to propel the chair as the slope increases. Generally, asphalt, cement or wooden walkways are preferred for tread surface because they are firm, smooth, and durable. Stability and control can be affected by surfaces with cross-slopes, grades, or rough terrain. Wheelchair users require a wider path of travel than normal trail users. Therefore, sufficient passing space should be provided to allow wheelchair users to pass one another and to turn around. The turning diameter of a wheelchair is dependent upon the length of its wheelbase. We have taken into account the dimensions of a wheelchair to design a trail that meets the chairs needs. In Figure 1, we can see the dimensions vary depending on the type of wheelchair. Powered wheelchairs and scooters are generally longer than manual wheelchairs.

Nature Trail Requirements for those who require a Wheelchair
• Trail must be level and firm enough to provide stability • Trail must be wide enough to pass other wheelers • Grades must not be of difficult slope • Grades must not be of excessive length

2.3.7. Aspects Related to Those with Visual Impairments When Hiking Nature Trails

An estimated 1.1 million people in the United States are classified as legally blind (Van Hasselt, 1988). Based on National Center for Health Statistics estimates, 4.3 million people have severe visual impairments (Van Hasselt, 1988). The five leading causes of impaired vision and blindness in the United States: are age-related maculopathy, cataracts, glaucoma, diabetic retinopathy and atrophy of the optic nerve (Van Hasselt, 1988). People with visual impairments will need something to help guide them down the trail. Possibilities for this mechanism include: distinguishable tread delineation, an elevated edge to the trail that could be followed with a cane or a rope that would run parallel to the trail at hand's height. The tread on the trail must be uniform so to not surprise or mislead the walker into thinking they have left the trail. Visual disabilities can cause the following impediments to mobility:

- Limited perception of the path ahead
- Navigation with limited information about surroundings, providing less protection against obstacles and other dangers
- Reliance on memory and unchanging conditions in familiar terrain
- The need to assimilate information obtained through non-visual sources such as texture and sound
- Because many people with visual disabilities have diminished peripheral vision, they may have difficulty perceiving or reacting quickly to approaching dangers, obstacles, and changing conditions

Nature Trail Requirements for those with Visual Impairments
• Trail texture must differ from surrounding area • A method for following the trail must be provided • Braille must be provided on signs • Roots must not be exposed • Blazes must be different shapes rather than different colors

2.3.8. Aspects Related to All Persons when hiking nature trails

Many factors need to be considered when designing a nature trail for All Persons. These factors are a combination of the requirements discussed in the previous sections, included are:

- Length of the trail must be short enough to maintain interest
- Scenery must be entertaining and exciting
- Benches along the trail to take breaks
- Trees should provide shade to keep them cool
- Signs must be at a reading level that can be understood
- Trail must be level and firm enough to provide stability
- Trail must be wide enough to pass other wheelers
- Grades must not be of difficult slope
- Grades must not be of excessive length
- Trail texture must differ from surrounding area
- A method for following the trail must be provided
- Braille must be provided on signs
- Roots must not be exposed
- Blazes must be different shapes rather than different colors

2.4. Previously Compiled Data on the Subject of All Persons Wilderness Trails

While much of the research presented in this paper is original, it is important not to dismiss the works compiled by others on similar projects. In an effort to include only information helpful to the project only successful accessible wilderness trails and surveys

were considered. This previously compiled work was obtained over the internet and by request from its sources.

2.4.1. Examples of Previously Constructed Accessible Wilderness Trails

Several wilderness trails currently exist that are already accessible, to some extent, by All Persons. A list including some of these trails can be found in Appendix C. The constructors and planners of these wilderness trails faced many similar problems that we did and came up with many solutions that can be reused in our trail.

Located in northern Massachusetts, Dunn State Park has successfully implemented a wilderness trail that is accessible by the handicapped. In their efforts to make the trails easier for everyone they used a standardized signing system where each sign includes information about the trail grade, average slope and maximum slope. These signs allow trail goers to decide right away if they think the trail might be too difficult. Dunn State Park also provides a useful trail map that has information about where stairs are located on the trail and how firm the trail surfaces are. This warns users who may be worried about using stairs or walking on soft, potentially uneven surfaces.

2.4.2. Previously Conducted Studies on All Persons Wilderness Trail Topics

There have been several studies and surveys completed regarding people with disabilities. Because our project pertains largely to aspects related to disabilities much of this

information can be used in our application. The following pages discuss different studies that aided us in our project.

2.4.2.1. People with Disabilities – National Survey of Recreation and the Environment

The National Survey on Recreation and the Environment (NSRE) is the most recent study of outdoor research of the US population. The study was conducted by the US Forest Service from January 1994, through April 1995, and included 17,216 Americans over the age of 15. All respondents were asked if they had a disability and over 1,200 people answering the survey claimed in some form that they did. The report presents summary information on the characteristics, outdoor activity participation, and attitudes of people with disabilities in the NSRE survey.

Key Results

People with Disabilities in the NSRE

- The most frequently reported disability overall was that of physical disability. This category included people who reported mobility problems. The second largest category was ―illnesses." Included in this category were heart conditions, cancer, and diabetes. The ―other" category represents the third largest category of those with disabilities. Examples of the ―other" were arthritis, asthma, back problems.
- As a group, people with disabilities tended to be older than people without disabilities in the survey. People with disabilities, although reporting higher education, were less likely to be employed than people without disabilities at all age levels. People with disabilities as a group reported lower annual income than people without disabilities.

Regarding the use of adaptive devices or assistance when doing outdoor activities the NSRE asked respondents if they required assistance. From the responses they were able to identify up to 10 possible assistive devices or adaptations used for participation in outdoor recreation.

- Overall, 30% of people with disabilities identified that they require some sort of adaptive device, assistance from others or facility modifications to participate in outdoor recreation.
- The use of mobility aids such as wheelchairs, canes or walkers was the most common assistive device used. The next two common ones were companions or support persons, and architectural accessibility.

The NSRE respondents also were asked about their attitudes toward accessibility in primitive and wilderness recreation areas.

- Overall, a large majority of people with disabilities anticipated lower levels of access for people with disabilities in primitive areas, and that in order to maintain the unique qualities of nature in these areas, the level of accessibility for people would be less then in more urbanized settings. Yet, they felt that regardless of how primitive an outdoor recreation setting was, modification should always be made to accommodate people with disabilities.

2.4.2.2. Preferred Natural Environments and People with Disabilities

Providing accessibility to nature is very important. Attention must be paid to the choice of settings that are made accessible. Sponsored by the National Center on Accessibility, the intent of this research was to determine the ideas of people with mobility limitations as well as their family or caretakers with respect to parks and nature places.

Key Results

- Scenes with a predominance of trees (forested scenes) were far preferred to those with few if any trees (open fields)
- Although participants were instructed to assume no accessibility problems in indicating their preferences for the scenes, the visual presence of a path gave a better rating then without

2.4.2.3. Visitor Expectations and Perceptions of Program and Physical Accessibility in the National Park Service

Several studies have been written about the trip characteristics of State and National Park users. However, very little has been done for park visitors with disabilities. During the spring of 2001, the National Center on Accessibility and the National Park Service sponsored a study of National Park visitors with disabilities. They gathered information from the communities surrounding five Parks. The purpose of the study was to "identify the perceptions of people with disabilities relative to program and physical accessibility in the National Park Service."

Key Results

Characteristics of Visitors with Disabilities

- The three most common assistances/devices used by park visitors with disabilities were manual wheelchairs (36%), canes (25%), and power wheelchairs (25%), hearing aids (10%), crutches (8%), scooters (9%), communication devices (4%), and service animals (3%).
- The activities most frequently participated in by Hot Spring National Park visitors with disabilities were visiting a scenic area (50%), visiting a historical site (39%), camping (33%), fishing (28%), and (22%) visiting a museum.

2.4.2.4 Conclusions from Previous Studies and Surveys

After reviewing the previous research and data from the studies and surveys, we discovered significant information that is relevant for our project. Below are the conclusions of this research that were helpful in our project.

In the survey concerning people with disabilities from the NSRE and visitor expectations and perceptions from the NPS, we can learn what is the most common person with disability is. The most common traits among people with disabilities are:

- The highest percentage of people with disabilities is people with physical disabilities
- People with disabilities tended to be older than people without disabilities in the survey
- 30% of people with disabilities identified that they require some sort of adaptive device, assistance from others or facility modifications to participate in outdoor recreation
- Wheelchairs, canes or walkers were the most common assistive device used

In the study concerning preferred natural environments and people with disabilities we can learn what is the best scenery for people with disabilities. From here we can design a trail according what people with disabilities want. The people with disabilities tend to prefer forested scenes over open fields.

2.5. Factors in Wilderness Trail Construction

While the distinction of our wilderness trail is that it is accessible by All Persons, it is important not to neglect mentioning aspects that need to be considered when constructing any trail. People without any special requirements also fall under the category of All Persons. Among the factors critical to any wilderness trail planning are aspects related to erosion, vegetation, and wildlife. Each requiring its own discussion these aspects need to be handled with care, as lack of consideration will yield a troublesome trail.

2.5.1. Aspects Related to Erosion When Planning Nature Trails

"Layout, soils, use, and drainage are the most important factors affecting erosion (Demrow & Salisbury, 1998)." Erosion occurs when water flows down a trail and picks up particles of soil. These particles are then deposited further down the trail, or off of it completely, when the water slows down. Erosion can expose roots and make trees unhealthy and unstable, choke smaller plants, or create bars that contribute to flooding. Because trail erosion can have detrimental effects on other areas of the Sanctuary, it is very important to minimize this. To avoid erosion, care must be taken to avoid steep slopes, extended slopes, and areas where water will either flow along or sit on the trail.

Summary of Soil Indicators for Evaluation of a Proposed Trail Installation

Conditions	Conditions Posing **Slight** Limitations for Trail Installations	Conditions Posing **Moderate** Limitations for Trail Installations	Conditions Posing **Severe** Limitations for Trail Installations
Soil Wetness	Depth to seasonal high water table 4ft or more; well drained to moderately well drained	Depth to seasonal high water table 1 to 4ft; excessively drained	Depth to seasonal high water table less than 1ft; poorly drained
Soil Texture	Particle mixture of sand, clay, silt' 20-50% of content gravel	High sand content; less than 50% but greater than 20% of content gravel	High clay content; no gravel
Soil Structure	None	None	Hardpans less than one foot from soil surface; peaty, muck soils
Soil Depth to Bedrock	Greater than 3ft	1.5-3ft	Less than 1.5ft

Slope	0-5%	5-20%	Greater than 20%

(Demrow & Salisbury, 1998)

Nature Trail Requirements regarding Erosion
• Grade must be appropriate for soil type • Wet soil must be avoided • Attention should be paid to soil texture

2.5.2. Aspects Related to Vegetation When Planning Nature Trails

The Sanctuary is filled with many different types of vegetation. When blazing a new trail, it is often necessary to remove some trees and vegetation. Our proposed trail has a minimal impact on the environment when removing this vegetation.

Aside from aesthetic value, vegetation along a trail has two purposes, when properly used it can prevent erosion and control traffic. The roots of vegetation serve to help hold the ground together. Without these plants anchoring the soil, the trail could simply wash away in the rain (Demrow & Salisbury, 1998). Removal of the vegetation can have a very detrimental effect on the trail surface.

Vegetation can also be used to control the traffic on a trail. Our trail will likely have a large number of switchbacks to minimize the slope. Hikers will often try to cut between switchbacks in an attempt to shorten the hike. Vegetation can be used to make these cuts undesirable, if not impossible. Dense vegetation between switchbacks will encourage hikers to stay on the trail. This will lessen the impact of trail use on the surrounding environment (Demrow & Salisbury, 1998).

Nature Trail Requirements regarding Vegetation
• Removal of ground cover should be minimized • Management function of vegetation should be looked into

2.5.3. Aspects Related to Disturbance of Wildlife When Planning Nature Trails

The Broad Meadow Brook Conservation and Wildlife Sanctuary is home to 78 species of butterflies and 224 species of birds (http://www.massaudubon.org/Nature_Connection/Sanctuaries/Broad_Meadow/index.html). During the construction of the proposed trails, care must be taken not to invade the habitats of the wildlife. Invasion of their habitats may force the animals away from the Sanctuary into unprotected areas. Many birds and butterflies are dormant for part of the year. Attention has been paid to when the wildlife is least active to minimize the disruption (Demrow & Salisbury, 1998). Most animals are dormant in the winter, however constructing during this season can be quite difficult as the ground is often frozen. More seasonal problems arise when constructing improved footpaths as many of the hardeners must be applied during the dry season. (http://www.imba.com/resources/trail_building/itn_11_5_wildlife.html)

2.6. Electronic Devices and Software Used in Trail Construction

Before the construction of a trail can begin, it is important to know where the trail should go. To visualize where the trail will lie and make sure that the actual trail is in the same

place as we recommend, we made use of GPS and GIS data. These mechanisms are also an efficient method of gathering and storing geographical data.

2.6.1. Global Positioning System Devices

The Global Positioning System (GPS) is a satellite-based navigation system made up of a network of 24 satellites placed into geosynchronous orbit by the U.S. Department of Defense (http://www.garmin.com/aboutGPS/index.html). GPS was originally intended for military applications, but in the 1980s the government made the system available for civilian use. There are no subscription fees or setup charges to use GPS. People standing on the ground can use a handheld GPS unit to find their location on a map, while a plane flying through the air can use a GPS unit to guide them to a runway on a foggy night.

GPS is capable of giving positions in three dimensions. While this means that we could have used our GPS unit to calculate slopes and grades, the data is not accurate enough for our purpose. Two dimensional position data (latitude and longitude) are accurate to about +/- 3 meters (Meridian Platinum Manual, 2002). This is sufficiently accurate for plotting a trail because only a close estimate of where the trail should be is required. Elevation data is accurate to +/-24 ft. This means that a large error is within the bounds of the data. Clearly, we needed more precise elevation data than is obtainable from the GPS.

2.6.2. Geographical Information Systems

The Geographic Information System (GIS) is a system of maps that provide more information to the user than a conventional map would. At the heart of GIS maps are layers. A conventional street map contains both geographical features and urban landmarks. A GIS map is divided into separate maps that highlight things such as: only the street, or only commercial stores. Each map is a different layer, and each layer can be shown or hidden individually. The layers in a GIS map can also interact with each other. For example, changes made to a topographic layer would show up in a layer that shows the slopes. For our application, we used the GIS mapping system to show and keep track of existing trails, unblazed trails, high water areas, areas which needed special attention, and many other things.

2.7. Conventional Surveying Methods

For years maps have been made and trails have been successfully blazed without the assistance of GPS or GIS. Even now people who are skeptical of the accuracy and precision of GPS devices use more traditional surveying methods. The accuracy of a GPS device can range from a few centimeters to several hundred feet. In a meeting with Professor Defalco, he mentioned that more conventional surveying methods, like head to tail vector analysis, can be consistently more accurate (Personal Communication, November 4, 2002).

A GPS device recalculates its position for each data point, this is two sided, on one end it is a disadvantage as any given point along a GPS line may be inaccurate, on the other it is a great advantage, as errors will not accumulate. When mapping a long trail with conventional methods a small error in an angle at the beginning of the map will cause large errors in the end result.

One method of verifying head to tail vector data is to close the circuit mathematically and see if it closes physically (Personal Interview, Professor Defalco, November 4, 2002). That is, calculate some vectors from the end point back to the starting point, and see if following those vectors actually does bring you back. If an error has occurred at any point along the line it will show up, unless multiple errors have been made which cancel each other out.

2.8. Universal Trail Assessment Process

The Universal Trail Assessment Process (UTAP) was formed through a cooperative effort between Beneficial Designs and the National Park System in June of 1993 (http://www.beneficialdesigns.com/trails/utap.html#overview%20background). The UTAP objectively documents the actual conditions in the outdoors, natural environments. Every year Beneficial Designs offers week long instructional workshops about their UTAP, they also publish a training manual which can be purchased over the phone or internet. The manual discusses methods for trail assessment and provides sample forms

for recording trail information. The methods explained in the UTAP manual were useful for gathering information about the trails. The fundamental principles of the UTAP are:

- Objective measurements
- Description of the trail tread
- Documentation of features on and around the trail
- Measurements of typical and extreme values
- Collection of all data in one assessment
- Generation of data required land managers
- Dissemination of information to trail users

The Federal Access Board has used many aspects of the UTAP in their proposed regulations for use as amendments to the ADA. The feasibility of accessible trails was assessed in part through use of the UTAP system.

2.9. Existing Maps of the Sanctuary and Trail Network

Prior to our work at the Sanctuary there was a map of the trails. We were informed by Colin Novick that the current trail map was made using a best guess approach (Personal Interview, November 12, 2002). The lines of the trails were drawn in reference to known points found in aerial photographs along with guesses made by people experienced with the layout of the trail network. A copy of the current trail map is shown in Map 2. Topographical maps, parcel information, and information about the position of streams and ponds were obtained from The Greater Worcester Land Trust. These maps were provided in the form of ArcView GIS maps.

2.10. Materials Involved in Constructing All Persons Wilderness Trails

Wilderness trails are separated into two groups: Developed trails, and Undeveloped Trails (www.maxpages.com/enabledrver/Rolling_Down_The_Trail.html). Developed trails are trails that have been planned and prepared intentionally for use. Undeveloped trails may be trails that were created unintentionally by people frequently using a common route. Undeveloped trails are inaccessible to people with mobility limitations (www.maxpages.com/enabledrver/Rolling_Down_The_Trail.html).

Our trail is planned to be constructed in a manner suitable to the requirements of All Persons. This means we planned a developed trail. The three types of developed trails are: Paved Walkway, Elevated Walkway, and Improved Footpath. Each of these types has its own specialized set of materials from which it can be constructed.

Technology has produced many different trail construction materials, each with its own set of benefits and disadvantages. A proper balance of durability, low cost, longevity and aesthetics is desired. To achieve this balance we must take each of these factors into consideration and weigh their values against each other.

2.10.1. Bridges for Crossing Waterways and Streets

Currently trails in the Sanctuary cross the Broad Meadow Brook at several points. To allow passage over the brook, large rocks have been laid down which create a seemingly

natural bridge. While these bridges are perfectly acceptable for the agile hiker they will not be passable by those in wheelchairs or people unable to hop from rock to rock. The connection of the Broad Meadow Brook Wildlife Sanctuary visitor center to the Blackstone River requires crossing Following is a discussion of several different types of overpasses that are used in trail construction.

Footbridges are commonly steel bridges. Prefabricated steel bridges are inexpensive and easily acquired; it often takes 8 to 10 weeks from order to delivery (Steinholtz, 2002). They are also ideal for small crossings such as a brook or street. A metal, CorTen, is commonly used when constructing steel bridges, this metal was chosen because when it rusts the oxidized surface is more weatherproof, resulting in a bridge with lower maintenance requirements. Prefabricated bridges severely lack in aesthetics as unpainted steel will rust, and painted steel needs frequent maintenance. Bridges that are cast in place have a cost range of $65 to $80 per square foot, where prefabricated bridges range from $70 to $80 (http://www.steelbridge.com).

2.10.2. Resting Areas and Benches

Rest areas are level portions of a trail that are wide enough to provide wheelchair users and others a place to rest. Where there are long steep slopes on the trail network the trail users will need relief from prevailing grade and cross-slope demands. As discussed, resting points are mitigating factors placed on the trail by several groups classified under All Persons. Resting areas are particularly important to people in wheelchairs. If a person in a wheel chair is going up a slope and needs to take a break, there should be a

flat area to stop on. Wheelchair handbrakes may not be strong enough to prevent gravity from pulling the chair down a slope. The ADA has specific regulations on distances between and placement of resting points (http://www.access-board.gov). In 1993 the Access to Parks Guidelines was published with the following bench regulations.

I. Concept
   A. Fixed benches, where provided, must be made accessible for users with various types of disabilities.
   B. At least 50% of the fixed benches being provided in a facility or a building shall be accessible and shall be dispersed among the types provided.
   C. Of the number of fixed benches required to be accessible, at least 40% shall be provided along an accessible route of travel.
II. Clear Spaces
   A. The surface around the accessible bench shall be firm and stable.
   B. A minimum area of 30" x 48" shall be provided at one end of the fixed bench so that a wheelchair user may be seated shoulder to shoulder with an individual seated on the bench.
   C. Clear spaces shall have a slope that does not exceed 2% in any direction (if necessary for proper drainage, 3% maximum is allowed).
III. Bench Design
   A. The fixed bench should be free of sharp edges or protruding hardware that may be hazardous.
   B. The height of the front edge of the seating surface shall be between 17" and 19" above the adjacent grade or floor space.
   C. A back support shall be provided along the full length of the accessible bench.
   D. Accessible benches shall have seats that are 20" to 24" in depth and 42" minimum in length. The back support shall extend from a point 2" maximum above the bench to 18" minimum above the bench.
   E. 50% of the accessible fixed benches shall have at least one armrest that can withstand 250 lbs. of force in any direction.
   F. Where installed in wet locations, the surface of accessible benches shall be slip resistant and shall not accumulate water.

2.10.2.1. Strategic Placement of Resting Areas Along the Wilderness Trails

In the regulations proposed by the Access Board, it is required that there are level stopping places at regular intervals along inclines. For an incline with a slope of 1:12, the interval is 200ft; for a slope of 1:10 the interval is 30ft, and for a slope of 1:8 the interval

shrinks to just 10ft (ADA Regulations, 2002). While some stopping points will simply be a small level area in between two inclines, others will be placed in scenic areas so trail users can enjoy nature while they are resting. A bench at every stopping point would not be practical, but a carefully placed bench before and after slopes that are difficult or near scenic areas will be greatly appreciated. At least 50% of a park's benches should be placed along the trails (Access to Parks Guidelines, 1993). Rest areas located to the side of the trail allow users to stop without interfering with trail traffic. Placing these rest areas in scenic locations is preferable as resting users will be able to enjoy the surrounding environment.

2.10.2.2. Durability of Different Benches, Maintenance Requirements, and Costs

The durability of materials from which benches can be constructed has to be considered. Ideally, a long lasting, inexpensive material will be chosen. There is a large selection of prefabricated benches that are available at reasonable prices.

It is important to choose benches which will not require regular maintenance. A bench that needs to be painted every year, or have rust removed quite frequently, will be more troublesome to the sanctuary operators than it is worth. These benches will all be placed outside, it is therefore important to choose benches that will not gather water, as they will require much wiping off after rainstorms or snowstorms.

When choosing benches it is important to consider how much it will cost to purchase, construct, and install each bench. Buying raw materials and constructing a bench from scratch is often more expensive than buying a prefabricated bench.

2.10.3. Mechanisms for Guidance Along the Wilderness Trails

Trail users with normal vision and even those who are partially blind can guide themselves along a properly blazed trail without problems. Trail users who are completely blind require another method of guidance. To guide these users along the trail, there are several other methods. Handrails or ropes can be placed along the side of the trail that visually impaired users could follow around the network. A ridge placed along the edge of the trail can be followed with a cane, although special care should be taken to make sure that it is not a ridge that will trip anyone. In an interview with Professor Ault it was mentioned that unique surface texture is often used by the visually impaired as a method of guidance along the trail. Stepping off the trail will mean stepping onto a surface of a different texture and alert the hiker about the edge of the path (Personal Communication, December 4, 2002).

2.10.3.1. Marking Trails in a Manner Effective for Everyone

Hikers select trails according to several factors, including personal interest, destination, environment and level of difficulty. Accurate and detailed trail information will provide users the ability to choose a suitable route for their skill level and experience. Trail

information can be given in a variety of formats, including trail blazes, signs, and trail maps. Signage that provides objective and detailed information about potential obstacles, surface type, grade, cross-slope, and other trail features further benefits users by allowing them to accurately assess whether or not a trail meets their personal level of safety, comfort, and access.

The standard system of trail blazes and signage is effective for people with normal vision. For people with visual impairment, the system is inadequate. Trail users with visual impairments benefit from signs with large lettering, Braille panels, raised lettering, or audio boxes that play prerecorded trail information at the push of a button. Currently, the signs which denote the trails consist of blue text on a white background. A person from The Worcester Center for the Blind recommends having white text on a black background (Personal Communication, November 2, 2002). These colors are easier for people with poor vision to read, and also have less glare on sunny days. Trail blazes for the visually impaired should follow the same guidelines as signs. It is important to use bold, bright colors that stand out from the surroundings. The shapes of trail blazes should be distinct and easy to differentiate. (Axelson, P.W., Chesney, D.A., Faraone, M., Kirschbaum, J.B., Longmuir, P.E., Richter, W.M., Wong, K.M., 1997) Installing audio boxes in the sanctuary network would be difficult as they would require a power source.

As shown in Figure 2 it is important to place the signs at a level that will not be uncomfortable to sign readers. A sign that is placed too high or low may go unnoticed, or be difficult to read. Visually, ideal placement for a sign is between 4 feet and 5 feet. The

Sanctuary may however decide to place signs at a height unreachable to trail users to prevent damage. In this case audio boxes, or another alternative to Braille, must be used.

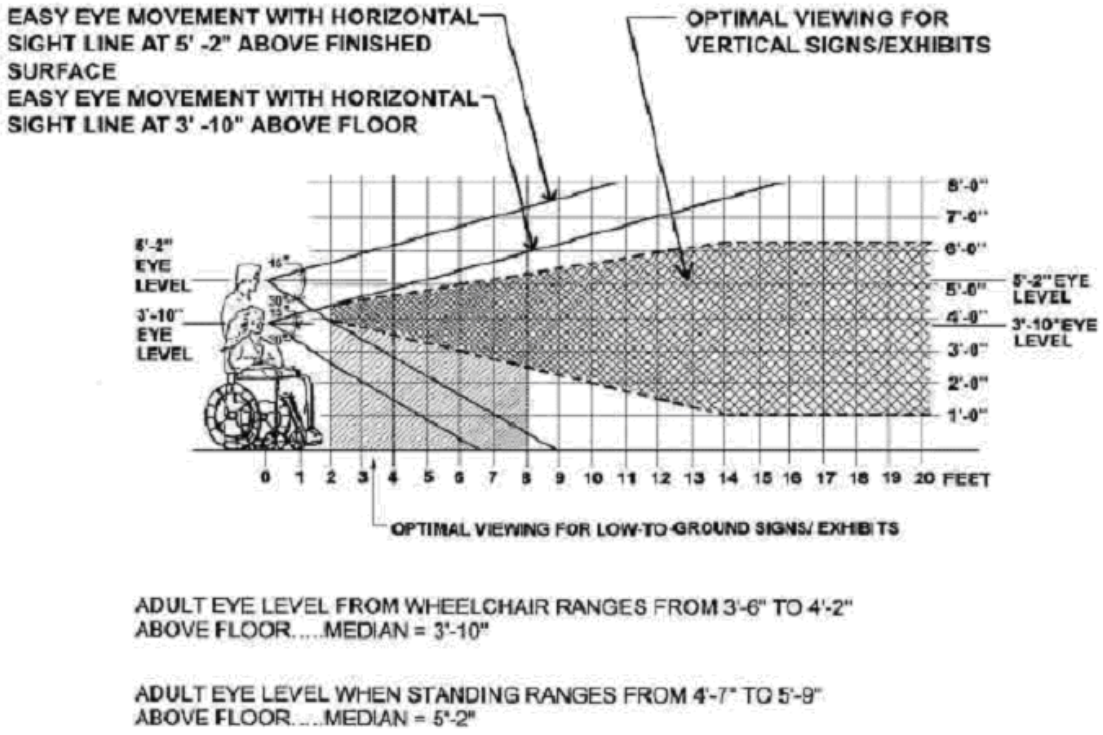


Figure 2 (Optimal Field of Vision for Sitting and Standing Adults)

2.10.3.2. Ridges and Boards for Guidance Along Wilderness Trails

To guide a visually impaired trail user who walks with a cane along the trail, a ridge or board can be used. A board placed along the edge of a trail and a minimum of 3” above the surface of it enables a blind trail user with a cane to feel where the edge of the trail is. The idea is the same as with a rope or handrail, but only works for users who walk with canes. A subtler and aesthetically pleasing alternative to the use of a board is to place a ridge along the edge of the trail. The main drawback of this method is that the ridge

requires more maintenance than a board as it can wash away during a storm. Problems also arise when ensuring that users will not trip over the ridge. Both methods of guidance need to be carefully implemented to avoid turning the trail into a river by not permitting water to drain off the side (http://www.access-board.gov/outdoor/outdoor-rec-rpt.htm).

2.10.3.3. Handrails and Ropes to Follow Around the Wilderness Trails

A trail user who has no vision and does not walk with a cane requires a special form of guidance. A method which is used by several other parks is a simple rope or handrail that the user can follow. The rope or handrail is placed just above hand-level and the user simply walks along the trail while resting his hand on it. Signs, trail blazes, and points of interest are placed along the rail. To indicate to the user that there is a sign or blaze, the rope changes to a different texture. In the case of a handrail, there is a bump or notch.

2.10.4. Elevated Walkways for use in Wilderness Trail Construction

When considering the aesthetic aspects of a trail, an elevated walkway has an air of elegance. They can be built to look beautiful and if built properly can last a very long time. Provided the water level does not raise more than a few inches the elevated walkway will remain a dry passage, where paved trails or improved footpaths would normally sink. Another advantage to constructing trails using elevated boardwalk is the mobility of the trail itself. If in later years the Sanctuary decides to relocate the trail they can reuse the sections of boardwalk. Boardwalks also do not require the removal of roots the way paved walkways and improved footpaths do, this makes them more environmentally friendly.

2.10.4.1. Costs Related to of Elevated Walkway Materials and Installation

Elevated walkways are commonly built from wood. There are many different types of wood that can be used, all of which will need maintenance every few years. Choosing the right wood is critical in the strength and durability of the walkway. We live in a good area for construction with wood as there is an abundance of available tree types that are durable. Following is a list of wood types in order of strength (how much weight they can hold). This list omits certain woods that are absolutely out of the question for lack of durability.

(These measures were taken at 12% water content)

Species	Weight (lbs)
White ash	3.4
White oak	4.2
Yellow Pine	3.4
Douglas Fir	2.9
Teak	3.5
Huckaback	3.1
Cypress	2.8
Sitka Spruce	2.4
Northern white Spruce	2.4
Port Oxford cedar	2.4
Alaska cedar	2.6
White cedar	1.9

(Forest Products Laboratory, USDA Forest Service, 1994)

A good wood for constructing elevated walkways should be both strong and light. If built with a light wood, the walkway can be relocated with less difficulty. Using ~~"H~~ard" wood is often preferable as it is more attractive and less prone to infestation. More durable wood is obtained if the trees that are cut from were felled in the winter (U.S. Navy Bureau of Ships Staff, 1983).

2.10.4.2. Maintenance Requirements of Elevated Walkways

It is important to take precautions that will prevent wood from decaying. If the boards in the elevated walkway rot they will be potential hazards to walkers. There are two principle properties in preventing rot: Wood will not decay in any wood species if the moisture content is below twenty percent, and no decay will occur in wood that is totally submerged in water (Forest Products Laboratory, U.S. Department of Agriculture, 2000). Although these ideas seem contradictory, they have been proven and their backings are sound: Wood that is dry cannot rot because there is no moisture. Wood that is completely submerged cannot rot because there is no air.

2.10.4.3. Advantages and Disadvantages of Using Elevated Walkways for Wilderness Trails

Advantages	Disadvantages
• Trails can be relocated to other parts of the Sanctuary • Installation does not require destructions of roots • Trail are still passable when the water table is high	• High Cost • Difficult Construction • Distraction From Surroundings • Slippery in Winter

2.10.5. Improved Footpaths for use in Wilderness Trail Construction

The most innovative and non-intrusive method of trail construction is probably the ~~"i~~improved" footpath. These paths are made out of completely natural materials, often times found right in the surrounding area, making them easy to obtain. They have a natural look and are comfortable to walk on.

Materials used in improved footpaths often consist of gravel, pine needles, mulched pinecones, crushed shells and sap (http://www.gatorsport.org/travel_nature.html). The trail is first graded and widened. Then, to help prevent it from washing away, the sides are lined with wooden planking. Then the ingredients are mixed and packed tightly together until a hard, walk-able, natural looking surface is produced.

Another form of improved footpath is used with surface treatments. Surface treatments are used with crushed stone products; they form a chemical bond with the aggregates, to construct walking paths that are firm and stable. They are a more efficient and effective way to keep trails long lasting and less maintenance. Paul Mastro uses a popular surface treatment called Stabilizer, made of psyllium ground up from the plantago plant (Personal Communication, November 20, 2002).

2.10.5.1. Costs related to Improved Footpaths Materials and Installation

Improved Footpaths are less costly than other types of trail construction but the cost of materials delivery can equal to or exceed the cost of the material itself. Depending on what aggregates are being used, the price can vary from $1 per square foot to $4. Stone aggregates are more expensive.

Using a surface treatment will add to the price of constructing an improved footpath. The price of surface treatments can vary from $0.05 to $1 per square foot for different products. Surface treatments need to be re-applied every few years.

2.10.5.2. Maintenance Issues of Improved Footpaths

The Improved footpath is prone to some problems. Rainwater and time can cause the paths quality to degrade to the point of making the trail impassable for wheelchairs and unpleasant for hikers. Using a surface treatment will greatly improve your maintenance issues. A surface treatment binds with the aggregate providing a strong firm surface. These treatments need to be re applied every 1 to 2 years and only on the sections of heavy wear and tear.

The NCA performed a study on surface treatments and erosion. (http://www.ncaonline.org/). The intent of the NCA study is to look at the quality of surface treatments for creating a trail accessible to people with mobility impairments. Below is a sample of the results of the two-year study, and the ANSI requirements for a firm and stable soil. As shown, the soil proved the least stable and firm, while the treatment was a great deal more effective.

Application	Penetration
Quarter Minus Limestone with Mountain Grout SoilStabilizer	.009-.03 inches
Quarter Minus Limestone with Road Oyl ResinModified Emulsion	.05-.08 inches
Quarter Minus Limestone	.10-.90 inches
Soil and Mountain Grout Soil Stabilizer	.21-.87 inches
Quarter Minus Limestone with Stabilizer	.36-.59 inches
50% #11 Limestone and 50% soil	.45-1.2 inches
Soil	.35-1.80 inches

ANSI/RESNA Standards for Firmness and Stability

	Very Firm/Stable	Moderately	Not Firm/Stable
Firmness	0.3 inch or less	>0.3 & <0.5 inch	>0.5 inch
Stability	0.5 inch or less	>0.5 & <1.0 inch	>1.0 inch

2.10.5.3. Advantages and Disadvantages of Using Improved Footpaths

Advantages	Disadvantages
• This type of trail is ideal for longer distance trails in true wilderness areas. • The "improved" footpath trail is the easiest to construct. • This type of trail is the best hope that wheelchair users have of gaining true access to wilderness areas. • Its one of most inexpensive to construct and install.	• They require constant maintenance. * • They can become impassable to wheelchair users in a matter of days if they are not carefully managed. * • This type of trail may become environmentally destructive because it is prone to erosion.

* The disadvantages of using Improved Footpaths are only with out surface treatments.

2.10.6. Paved Walkway for use in Wilderness Trail Construction

Recent activity to provide more trails for bikers, joggers, walkers and roller bladers have provided more government funding and more use for asphalt and concrete pavement. Paved paths are more readily obtained and can provide a stable support for everyone.

2.10.6.1. Costs for Paved Walkway Materials and Installation

The cost of asphalt or concrete is costly compared to other materials. The constructions costs below will vary depending on project specifics, grading requirements, location and local pricing difference, and distance from concrete or asphalt supplier plants.

Cost Comparison of Asphalt Vs. Concrete (September, 2000):

10' Wide Path- (Cost Per Linear Foot)

Pavement Thickness	Asphalt	Concrete	Asphalt Savings
Minimum Use Concrete = 4" Asphalt = 3"	$7.50 to $9.50	$16.00 to $18.00	50 %

10' Wide Path- (Cost Per Linear Foot) (In a remote area)

Pavement Thickness	Asphalt	Concrete	Asphalt Savings
Minimum Use Concrete = 4" Asphalt = 3"	$13.00 to $15.00	$34.00 to $38.00	60 %

* Cost estimates obtained from CO contractors and are for paving costs only, assuming a fine graded mix.

2.10.6.2. Maintenance Issues Pertaining to Paved Walkways

The long term maintenance cost depends on the need for and extent of maintenance. One maintenance issue that is sometimes overlooked in the design phase is that when concrete requires maintenance, it is very costly, whether this is slab replacement or joint grinding. Asphalt pavement maintenance is kept to a minimum through proper design and construction. A significant advantage over concrete pavement is asphalt's ability to be repaired quickly and inexpensively. According to Patrick Olsen, a Landscape Architect with Ciavonne & Associates in Grand Junction in areas where poor soil conditions exist, concrete slab movement caused by differential settlement can be costly to repair, requiring grinding of edges and/or expensive slab section replacement. Asphalt pavement repairs can be made quickly and inexpensively. These repairs are blended into

the existing pavement structure. These sections, when constructed with asphalt pavement, are not nearly as expensive to replace.

2.10.6.3. Advantages and Disadvantages of Using Paved Walkways

Advantages	Disadvantages
• This type of wilderness trail is the most wheelchair friendly. • The paved trail is easily navigated in a wheelchair. • This type of trail is ideal in city and state parks, within campgrounds, around small lakes, and as access to and from facilities.	• This type of wilderness trail is the most wheelchair friendly. • The paved trail is easily navigated in a wheelchair. • This type of trail is ideal in city and state parks, within campgrounds, around small lakes, and as access to and from facilities.

2.11. Summary

We conducted background research on the different factors that influence the recommendations we will make to the Broad Meadow Brook Wildlife Sanctuary concerning an All Persons nature trail. This background research includes questions about why this project exists in the first place, as to find a good solution we wanted to start at the root of the problem at hand. The group that this project was focused on is All Persons. All Persons was broken down, analyzed, and re-defined for this project to include many different groups of people. We looked at different nature trail requirements for different disabilities. We researched work done in existing case studies, and existing All Persons, or partially All Persons facilities. Careful consideration was taken when planning the route of the new trails to cause as little environmental damage as possible for both the wildlife and plant life. Maps containing valuable information about the land and its layout were gathered from various sources. Finally, we looked at different

materials commonly used in the construction of nature trails and determined the All Persons acceptability for these materials. This research has given us a firm understanding of the underlying principals in All Persons wilderness trail construction which has helped in the implementation of our methodology.

3. Methodology

The goal of this project was to assess the various alternatives for an All Persons trail considering the characteristics of the Broad Meadow Brook Wildlife Sanctuary. This goal was broken down into several main objectives:

1. Make recommendations for upgrading existing trails to All Persons standards
2. Make recommendations for connecting the Broad Meadow Brook Wildlife Sanctuary with the Blackstone River Valley National Heritage Corridor expansion
3. Estimate conversion costs for making trails All Persons accessible

We made recommendations for upgrading existing trails to All Persons standards. This section discusses the methods by which our research was conducted. These include: survey methodology, GIS and GPS use and analysis, determining trail grades and inclinations, and systematically recording our data. By using surveys, we obtained a better understanding of the thoughts and feelings of people who were currently visiting the Sanctuary. GPS and GIS data were used to help us map the existing trails as well as our proposed changes to them. To ensure that we have met the regulations that specify acceptable trail grades and inclinations, we measured and calculated the grades and inclinations of the trails. All of the data we collected had to be recorded in an organized manner so it would be useful and easy to understand for our data analysis.

3.1 Questionnaire

Questionnaires are a powerful and useful tool for collecting data on public opinion (Singleton, 1999). In our research we needed to know what our target population, the

people who use the Sanctuary, want from our proposed All Persons trail. The most efficient way to acquire this data was through the use of a questionnaire.

3.1.1 The Questionnaire's Target Population

We selected a sufficient number of people for our questionnaire, ensuring that the quantity of people who answer are representative of our population. A sufficient number has been reached when adding more questionnaires does not affect the standard deviation of the set. Our data analysis section notes that the questionnaire did not yield an acceptable number of responses. In this survey, our unit of analysis was the people who visited the Broad Meadow Brook Wildlife Sanctuary. Trail users came from a wide range of ages and backgrounds. They all had the common interest of enjoying the wilderness and outdoors. We surveyed users of the Sanctuary because they are the people who will be most affected by renovations to the trail network. Doing a general population survey would not have been as useful, as the general population is not familiar with the trails and the environment of the Sanctuary.

3.1.2 Sampling Design

The sampling design refers to the part of the research plan that indicates how cases are to be selected for observation (Singleton, 1999). Our sampling frame was the people who hike the Sanctuary's trails in the time period that we were surveying. It would have been expensive and time consuming to survey the general population. Instead, we asked those

who registered at the visitors center to take part in our questionnaire. We used a cross sectional design where data on a sample, or "cross section," of respondents chosen to represent a particular target population is gathered at essentially one point in time. This was the most effective way to get a high response rate.

3.1.3 Questionnaire Design

We organized our questionnaire in a funnel sequence, this means that the questionnaire was ordered from the easier, less thought provoking questions, to the more complicated questions (Singleton, 1999). This created commitment and momentum for answering the questionnaire, before the respondent became tired or bored. A thought provoking topic or mind taxing question appearing early in a questionnaire may cause the respondent to think in a way that will affect later responses. We also considered the length of our questionnaire. It was long enough to acquire the information we need, but short enough so that people who filled it out will get all the way through. We chose questions that were pertinent and relevant to our intended goal (See Questionnaire in Appendix A). The nature of the questionnaire was quantitative rather than qualitative. In a qualitative questionnaire, the questions are open-ended and warrant unique responses. This can be time consuming and cumbersome for both parties. It involves more writing for the person answering the questionnaire and those wishing to use the data must spend valuable time interpreting the meaning of the response. In a quantitative questionnaire, answers are chosen from a set of given responses. It was easier to compile statistics on responses with a finite set of answers as they compare to each other uniformly. We

administered quantitative questionnaires as they are quicker, easier, and provide better data.

3.1.4 Questionnaire Procedure

Questionnaires are the best approach to collect our data on public opinion. We used a self-administered questionnaire for data collection, where the questionnaire was filled out individually. The questionnaires were set up next to the registration at the visitors center. There was a sign and receptionist that asked them to fill it out after they sign in. The questionnaire was administered within the time allotted for our project. From there, we collected the results and analyzed our data.

3.1.5 Questionnaire Limitations

There were limitations to using the questionnaire. Participants may not have truthfully reported their attitudes; this may have been due to social desirability. Social desirability is when people feel obligated to respond a certain way because of the questions asked (Singleton, 1999). There were also people who may have chosen not to participate for reasons that were directly related to their opinion on the survey. Lastly, the sampling frame might not have encompassed everyone in our target population.

3.2 Interviewing

One of the oldest and most highly regarded methods of obtaining research is face to face interviewing. It has a number of advantages including high response rate and dependable data. The interviewer has the ability to clarify or restate questions that the respondent does not understand. One of the reasons for the high response rate is the attractiveness of being interviewed; the difficulty of saying ―no" to someone asking for something in person. It is more difficult for an interviewee to pass over sensitive or difficult questions than it is in a questionnaire. The major disadvantage of this method is the cost, especially with time. Interviews take a long time to complete and to compute the information. We decided to choose interviews with experts or professionals in different fields that are relevant to our project. Each type of expert was interviewed below:

- An expert on people with cognitive disabilities
- An expert on people with physical disabilities
- An expert in trail construction and materials
- An expert in GIS/GPS mapping

3.3 Planning the Trail

Plotting the route for a trail involves more than simply taking a walk and marking off the ―nice" areas. To plot our trail, we used a combination of GPS and GIS technologies, along with more traditional mapping techniques. The combination of these methods allowed us to create a trail map that will be helpful for both the Sanctuary's current trail network and for future All Persons trail construction.

3.3.1 Using Global Positioning Systems

The use of a GPS device was essential for the generation of the map of our trail. To locate areas of visual interest and of suitable slope, we hiked the Sanctuary's trail with a GPS unit. Without the use of GPS data, plotting the trail on a map would largely be an act of estimation and ~~"b~~est guessing," along with hours of surveying work. Using GPS data also allowed us to retrace routes exactly as we had traversed them originally, so we could verify their content.

3.3.1.1 Using the GPS Unit

We recorded our GPS data by using a Windows based laptop and a Magellan Meridian Platinum Edition GPS unit. We made the recommendation to buy the Platinum Edition because we thought we were going to assess grades using the elevation feature, which is unique to the Platinum Edition. We soon found that the elevation feature of the GPS unit was not very accurate and decided to use more conventional surveying methods to assess grades.

After the software had been setup, which is covered in the next section, the laptop was put in a backpack and the GPS unit was duct taped to a four foot stick. Early in the project we would simply hold the GPS unit close to our bodies, but soon realized that we were receiving inconsistent data and were locked to very few satellites, even on the

clearest of days. Eventually, we used duct tape to fix the GPS unit to the end of a stick and found that our data was both more consistent and more accurate. This enabled us to lock on to more than the three satellites required to triangulate a location. The more satellites the GPS unit is locked to, the more accurate the data because the location is averaged amongst all the triangulation possibilities.

We had to walk around the parking lot for three to four minutes each morning to receive a lock on our position. With time, more and more satellites would be locked and eventually our location would be found. The line generated by the computer software was more accurately drawn than the one on the small GPS unit's screen.

3.3.1.2 Using Computer Software to Record GPS Data

We used MapInfo Professional v6.5 to map the existing trail network at the Sanctuary. Although it is a very powerful program, MapInfo is incapable of receiving live GPS data without a third party piece of software. The interface between MapInfo and the GPS unit was a program called The Geographic Tracker. Opening MapInfo by using the GEOTRACK.MBX file enabled The Geographic Tracker to be opened as well. If opened separately, the two programs would not interact with each other and thus not record the data from the GPS unit.

The connection between the laptop and the Magellan Meridian Platinum Edition GPS unit was a standard 9-pin serial port connection, while the connection to the GPS unit was a proprietary connection that featured a single screw.

The steps needed to record a session of live GPS data:

1. From the **File** menu in MapInfo Professional create a **New Table**

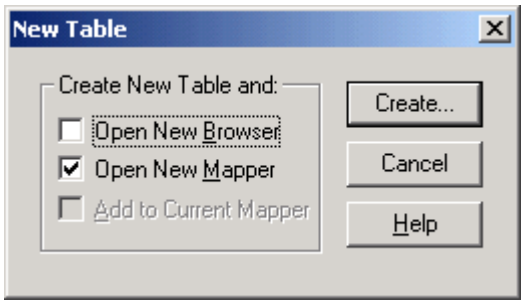


Figure 3 (New Table Dialog Box)

2. Add seven Fields: Latitude, Longitude, Elevation, Heading, Speed, Time, and PDOP, making sure the field type of each is Float.

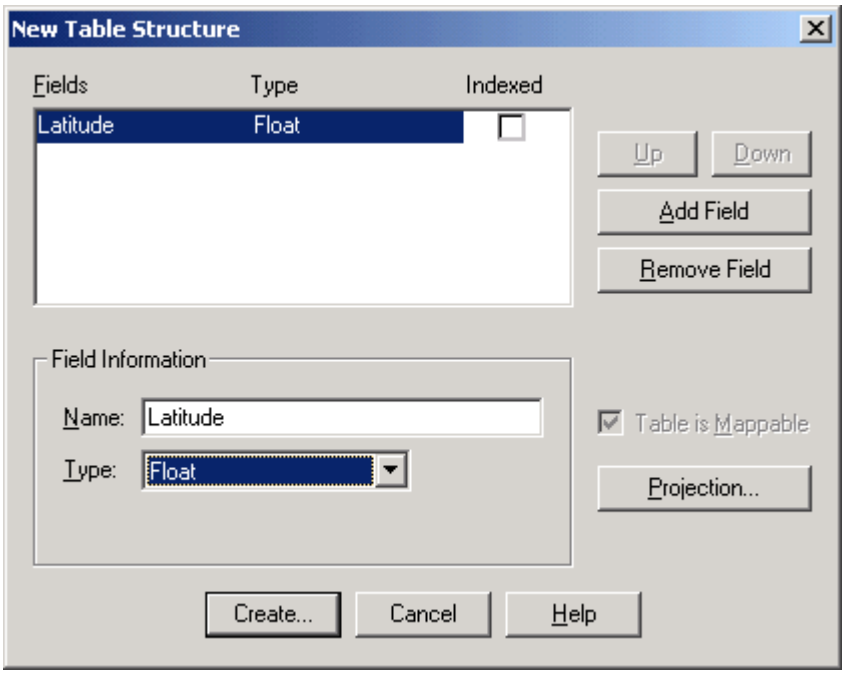


Figure 4 (New Table Structure Box)

3. When finished adding all seven fields, push **Create.** Choose a file name for the new table

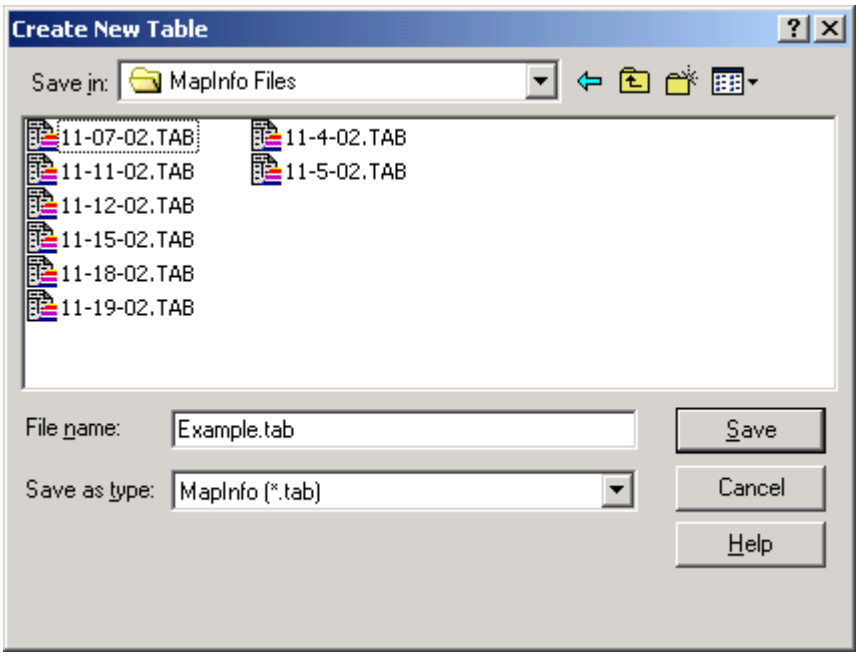


Figure 5 (Create New Table Dialog Box)

4. From the **GPS** menu, select **Setup GPS GeoCoding**… and match each **Field Assignment** to its match from the drop menus.

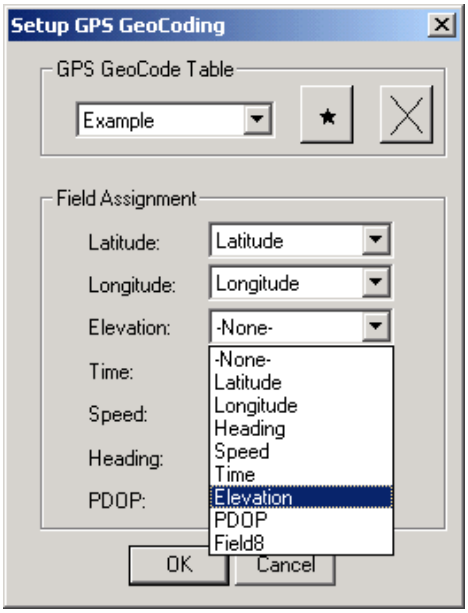


Figure 6 (Setup GPS GeoCoding Dialog Box)

5. From the **GPS** menu, select **Setup Tracking**… and select **Polyline**

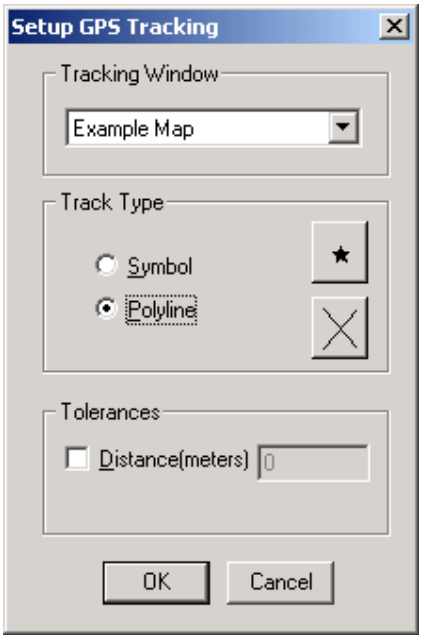


Figure 7 (Setup GPS Tracking Dialog Box)

6. Using **The Geographic Tracker** program, from the **File** menu select **Record GPS Data**…

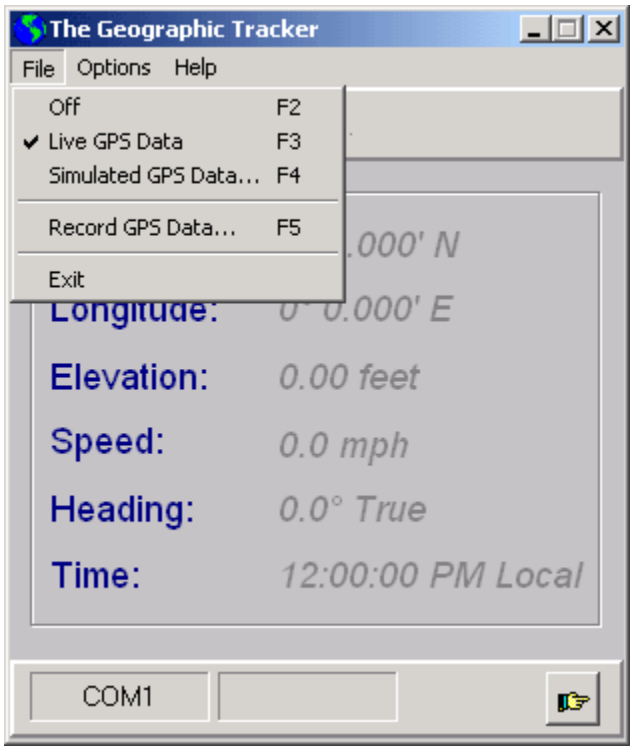


Figure 8 (The Geographic Tracker Program)

7. Choose a name for the GPS Log:

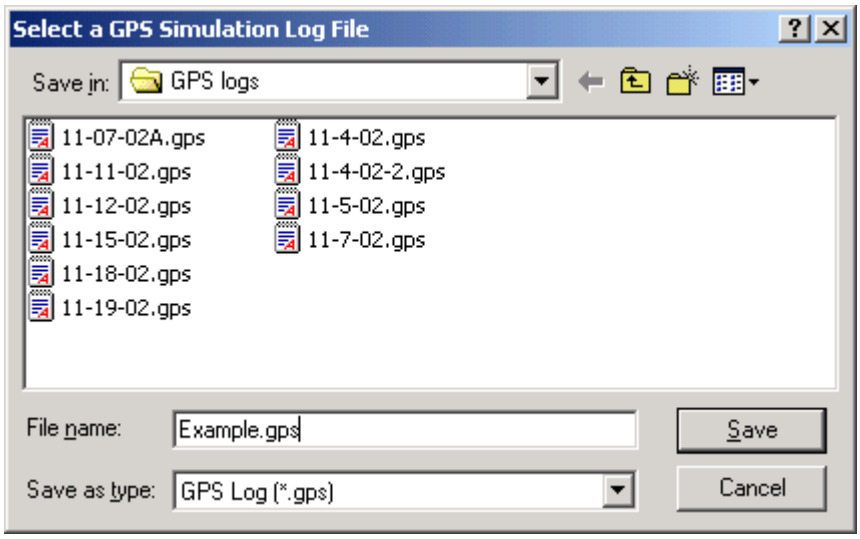


Figure 9 (Select a GPS Simulation Log File Dialog Box)

8. Select **Live GPS Data** from the **File** Menu

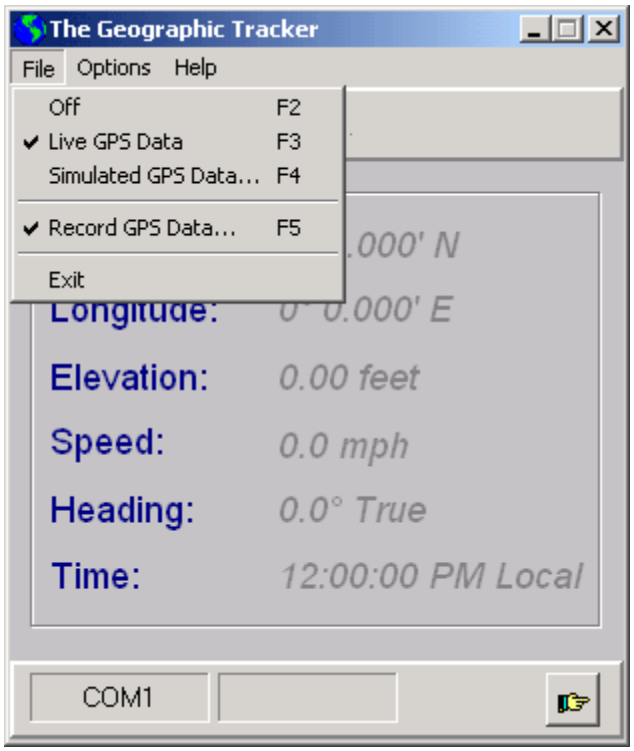


Figure 10 (The Geographic Tracker Dialog Box)

9. In **MapInfo Professional** select the **Polyline** tool.

Figure 11 (Polyline Tool Box Button)

10. By selecting the **Thumbtack,** a star in the mapper appears where your current location is. A line should now appear on the map as the GPS unit is moved.

Figure 12 (Thumbtack Tool Box Button)

3.3.2 Using GIS to Map the Area

The Greater Worcester Land Trust had extensive geographic data for the Broad Meadow Brook area. The data was in the form of GIS maps. We were able to use several of these, including the ones containing topographic data, roads, property lines, bodies of water, and landmarks. We also made a few layers of our own. In combination with our GPS data, we generated a more detailed GIS map of the trail network. When our proposed routes, which we plotted with GPS, were overlaid on our various GIS maps we were able to verify the suitability of a given route.

3.3.2.1 Choosing Layers that are Appropriate for Planning a Wilderness Trail

Before we began working with GIS data, we had to decide which data and layers we should use. The selection process consisted of making a list of possible layers, and then eliminating the ones which were either redundant or not useful. Some of the layers that we eliminated were the plant life, animal life, and trail smoothness layers.
The final list of layers is: Existing Trails, Topology, Roads, Property Lines, and Lakes, Steams, and Water.

3.3.2.2 Trail Layer on a Geographical Information System Map

The trail layer of our GIS map is the layout of the current trails at the Broad Meadow Brook Wildlife Sanctuary. The data for this map was obtained through the use of GPS. We hiked the trails with a GPS receiver and a laptop recording the data. The data was then averaged for accuracy before being plotted onto a GIS layer. This is the most accurate trail map that the Sanctuary has had.

3.3.2.3 Topography Layer on a Geographical Information System Map

A GIS layer containing a topographic map of Worcester was obtained from Colin Novick of the Great Worcester Land Trust. The lines on the map represent a two-foot change in elevation. When this data is displayed with the trail map on top of it, it becomes clear which areas of the trails need switchbacks. This topographic data can also be used for identifying areas that may have drainage or flooding problems. The data in the topographic layer is also far more accurate than the elevation data obtained from the GPS unit.

3.3.2.4 Road Layer on a Geographical Information System Map

The Greater Worcester Land Trust provided a GIS layer that shows the location of the roads in the area. Road location was useful for locating and illustrating the trail which connects the Sanctuary to Rte 146. The roads also help to give an understanding of where

the Sanctuary is located and how the Sanctuary's trails are laid out with in its boundaries. Mapping the roads also showed possible alternative access points to the Sanctuary.

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3.3.2.5 Lakes, Streams, Water Layer on a Geographical Information System

Because the trail surface is sensitive to moisture during construction, knowing where the sources are is important. The layer that we have has the locations of the lakes, ponds, and streams in the sanctuary. Using this layer, we identified areas with a predisposition towards flooding. These areas were avoided when plotting our All Persons trail.

3.3.3 Determining Trail Grades and Inclinations

We have established that trail grades and inclinations are of great concern when planning a wilderness trail for All Persons. It is important to discuss the methods by which trail grade and cross slope are gathered. While there are many surveying techniques that are acceptable for this process, only the ones that were used or considered are mentioned here. To be gather data each of these processes breaks the trail into segments. A segment of the trail is a section of consistent slope or, when line of sight is necessary, a section where line of sight is obtainable.

3.3.3.1 Using Clinometer Readings in Wilderness Trail Assessment

The clinometer is a device for assessing slopes. The device consists of a hand level, protractor, and sight attached to each other. To determine the degree of slope, a user needs a clinometer and two sticks of equal length. The assessor stands at one end of the trail segment holds the clinometer level to the ground at the stick's length above the ground. The sight is lined up with a stick at the opposite end of the trail segment, and the degrees can be read directly off of the side of the clinometer. Making measurements at a "sticks length" off of the ground prevents this line of sight method from being bothered by debris on the ground.

3.3.3.2 Using Geometry for Grade Assessment

A method used to assess most of the grades in the trail network requires a measuring stick, measuring tape, and peep sight. Standing at one end of the trail segment a person holds the measuring stick vertically and, using the peep sight, finds the feet of another person standing at the other end of the segment. The height that the peep sight has to be at to find the other end of the trail is recorded. The measuring tape is then used to measure the distance between the recorded point on the stick and the feet. This gives the lengths of two sides of a triangle. Using basic trigonometry the angle can be calculated.

3.3.3.3 Using Inclinometer Readings in Wilderness Trail Assessment

Similar to how a derivative measures the instantaneous slope of a given function an inclinometer measures the instantaneous grade at a given point on the tread. An inclinometer is a level that has a digital reading. When the slope at a specific point was needed, or when determining a cross slope, we used an inclinometer. It is highly inefficient to use a sight level and measuring stick when determining a cross slope because the distance is rarely more than five feet and generally the slope is not enough to calculate.

3.3.3.4 Determining Cross Slopes of Wilderness Trails

Cross slope is the slope of the trail tread perpendicular to the direction of travel. The grade of the cross slope needs to be determined because it affects the level of access for trail users. The cross slope is determined using an inclinometer or a level. As the entire trail will need to be resurfaced to provide adequate firmness for All Persons the cross slope will be changed upon resurfacing. The people constructing the new trail need to take care not to exceed the limits of $\pm$ 5 percent.

3.3.3.5 Measuring Trail Length

One useful set of data on a trail map is how long a given trail is. To figure out the length of each trail, we used a rolawheel. A rolawheel is a wheel of known circumference with a

ticker inside. Every time the wheel does a complete revolution, the count on the ticker goes up. To measure the trails, we pushed the wheel along the trails and recorded the count on the ticker. We were careful to avoid running the rolawheel over trail features like roots and rocks. Going over these features would have included the height of these features in our measurements, thus making them inaccurate.

3.4 Systematically Recording our Data

When gathering large amounts of information, it becomes important to organize that information in a manner that is usable. Working separately, we could each come up with an effective method for recording the data we obtained, but when it came time to merge our work together the data might not be conducive to combination. We needed to have a common method for recording data that we could all understand and could be interpretable by others who use our research. The following is a discussion of the methods used record each type of data.

3.4.1 Recording Questionnaire Results

The results of our survey have been recorded into a Microsoft Access database. Each of the fields on the survey was given an appropriate field in the database. As more surveys were filled out, they were entered into the database and assigned a "Questionnaire ID number" unique to that survey. The ID number was then written on the paper survey

itself and filed accordingly. This allows us to find the actual survey that corresponds to an entry in the database should it be necessary.

3.4.2 Recording Surveying Results

We recorded the information collected in surveying the nature trails in a tabular format on paper and then transferred it to Microsoft Excel. This data was recorded in two columns, one holding length horizontally in feet and tenths of feet (not inches), and the other column holding length vertically in feet and tenths of feet. Using tenths of feet allowed us to make calculations easily without concerning ourselves with 1/12 feet for every inch. On segments of trail that had a consistent slope we measured in even segments to make calculations easier. The data was then inputted into Excel where it could be compiled and analyzed. We also recorded the trail length with a rolawheel, making a hash on a piece of paper for every 100 foot marker, and then later summed the hashes.

3.5 Methodology Summary

Our methodology discussed the various processes used to accomplish our objectives. We looked at the ideas behind surveying our population to get opinions on our proposed All Persons nature trail. Strategies for gathering information about grade and length of the trails were discussed. We also looked into the planning of the trail by investigating GIS,

GPS and trail construction needs. An integral part of our methodology was organizing our data in an appropriate manner; this organization provided easy to use data which is analyzed in the next section.

4. Data Analysis

Through the implementation of our methodology we have acquired copious amounts of data. This data has been broken down and compiled in a format that is easy to process and draw conclusions from. The data was gathered through a questionnaire, interviews with experts, calling materials vendors and contractors, conventional surveying techniques, and GPS devices. These data collection methods, while effective, produce a crude type of data that only when refined can be used effectively.

4.1. Interviews

Most of the useful data was obtained through interviews with experts. The four primary experts that we interviewed are: Kathryn Maietta, Paul Mastro, Holly Ault, and Colin Novick.

Kathryn Maietta is a Licensed Clinical Social Worker (LCSW). She has experience with Forensic Social Work. She is a registered Maine Guide in Recreation and Sea Kayaking. Since earning her masters in Social Work at Boston University she has worked with patients of all ages specializing in people with cognitive disabilities.

Paul Mastro is a highly experienced constructor of accessible wilderness trails using primarily improved footpaths. While the improved footpath has been used for accessible trails in other parts of the country extensively, Paul Mastro has been the foremost in using Stabilizer based trails in the northeast.

Holly Ault Ph.D. is experienced in designing things to be functional for people with disabilities. These items include fishing rods for the handicapped, as well as devices to help those with impairments enjoy bowling. She has also worked with a school specifically designed for people with physical or cognitive impairments.

Colin Novick, head of the Greater Worcester Land Trust, is familiar with the ArcView GIS software package, for which he has detailed GIS maps that he shared with us. He also has an in-depth knowledge of nearby land owners and their motives related to our project.

4.1.1. Documented Suggestions Made by the Interviewees

Kathryn Maietta made suggestions about the reading level of the signs marking our All persons trail. She mentioned that if the trails are lined with signs that are difficult to understand, people with cognitive disabilities or children (two groups encompassed by All Persons) will not be able to use them effectively.

Paul Mastro had intelligent answers for all of the questions we presented. Included in his suggestions for methods of dealing with steep slopes and alternatives to switchbacks he

mentioned using fill to make the land level. Inexpensive raw material can be brought in by the truckload and laid down to make the ground more level. Paul Mastro also introduced us to some ideas involving wetlands. Previously we had considered improved footpaths a poor solution to an All Persons trail in areas that have a high water table. Flooding can cause erosion and damage to the trail. Some minimal work with water flow control, inserting large crushed stone under the path to allow water to flow, and burying pipes to allow water to cross the path in necessary areas, can keep the water out of the trail and prevent damage.

Holly Ault mentioned ideas for conveying information on signs to the visually impaired. She expressed concern that if a Braille solution was used, not enough of the visually impaired population will be able to read the writing. Audio boxes were discussed as a possible alternative to Braille. These boxes would consist of a speaker, tape recording and button. Pushing the button would cause the speaker to play the tape recording. Holly Ault also warned us about using words or phrases that might be taken offensively to groups with disabilities.

Colin Novick helped us to determine the parcel ownership that our proposed connection to the bike path following the Blackstone River will lie upon. Some of the parcels that the current proposed trail will go on are privately owned. These owners will need to be talked into giving the sanctuary permission to use their land, and will be responsible for decisions made and the ultimate fate of the land.

4.1.2. Research the Feasibility of the Suggestions

Kathryn Maietta's insight into the reading level of those with cognitive disabilities proved quite useful. The Sanctuary's current sign system contains very few difficult to read or understand words. Our proposed All Persons upgrades will require the installation of new signs that can be potentially difficult to understand.

Paul Mastro's understanding of improved footpath materials was helpful. The material that he uses in wilderness trail construction, Stabilizer, is considered one of the most well designed materials in the industry. Made from the Plantago plant, the soil stabilizer Psyllium is capable of hardening any aggregate into a suitable surface for the support of wheelchairs, strollers, and other devices that aid mobility. The combination of Stabilizer and angulated aggregates (aggregates that are cut to have many sharp angles) form a superior surface of solidity.

In discussing alternatives for conveying sign meanings to the visually impaired with Holly Ault, audio boxes that say the contents of the sign were discussed. Upon further examination, the implementation of these audio boxes would require some source of electricity being brought out into the woods, this is impractical. The use of cassette tape players that could be carried along the hike is still a possibility.

4.2. Choosing a Trail Surface

To decide upon a trail surface, a ranking and scoring system was developed. The scoring is done on a 10 point scale. The best option in each category is given the minimum score of 1 point. The other materials are then given a score which is based on how close to the top choice they are. For example, in the cost per square foot category the best option was Permazyme. Permazyme was given 1 point for this. The next option costs 2.5% more, so it was given a score that is 2.5% higher. To prevent a single bad score in a given criterion from dominating, and thus skewing, the results, the highest score possible is 10.

4.2.1. Material Cost Per Square Foot

The cost of each potential trail surface was based on a 3 mile long trail that was, on average, 4ft wide. This gives 63360 square feet of trail that need to be improved. Below is a chart that gives the cost per square foot for each of the surfaces, and the resultant score for each. For the surface treatments, this is the cost for the stabilizer itself; it does not include installation or any other required materials such as the aggregate. For the recycled pavers, this is the price of the pavers themselves and does not include installation.

Name	Cost per sq ft	Score
Perma-Zyme	$0.039	1.00
Base Seal	$0.040	1.03
Klingstone 40/400	$0.150	3.85
Stabilizer	$0.340	8.72
Poly Pavement	$0.350	8.97
EnviroTac II	$0.350	8.97

Top-Seal	$0.410	10.00
T-NAPS	$0.470	10.00
2001	$0.550	10.00
Presto GeoWeb	$3.000	10.00
Tuff Roll	$3.500	10.00
SofScape Pavers	$5.000	10.00
SuperDeck	$9.500	10.00
EcoTrack/BikeTrack	$10.065	10.00

4.2.2. Aggregate Costs

Many surface treatments require the use of a special material for them to work optimally. This material is usually made of finely crushed granite (called decomposed granite) or angulated stone dust. These materials are referred to collectively as aggregate. What we found was that, with one exception, all of the surface treatments required the use of roughly the same amount of the same aggregate. Because the costs are very similar between the aggregates, and the price of each fluctuates regularly, this section is scored with a simple Yes or No. A Yes is worth three points, a No worth one.

Name	Aggregate?	Score
Poly Pavement	No	1
Stabilizer	Yes	3
EnviroTac II	Yes	3
T-NAPS	Yes	3
Base Seal	Yes	3
Klingstone 40/400	Yes	3
2001	Yes	3
Top-Seal	Yes	3
Perma-Zyme	yes	3

It should be noted that while Poly Pavement does not require an aggregate, it does work better with one.

4.2.3. Aesthetics

One important characteristic of any potential trail surface is how it looks. If the trail does not look natural, it is not a very good nature trail. Soil stabilizers are great for use in trails because the end product looks like nothing more than compacted dirt. The look of a trail made with a soil stabilizer is dependent upon the aggregate that is used. For this reason, all of the soil stabilzers except Base Seal and Perma-Zyme tie in this category. Base Seal and Perma-Zyme cause a slight discoloration in the aggregate they are used with.

Name	score
Stabilizer	1
EnviroTac II	1
T-NAPS	1
Klingstone 40/400	1
Poly Pavement	1
2001	1
Top-Seal	1
Base Seal	1.5
Perma-Zyme	1.5
Presto GeoWeb	5
EcoTrack/BikeTrack	6
Tuff Roll	6
SuperDeck	6
SofScape Pavers	6

The other possible trail surfaces have a very man-made look to them. BikeTrack is a heavy-duty plastic boardwalk. Presto GeoWeb is a plastic grid that holds the soil together. These don't look natural and were penalized for it.

4.2.4. Maintenance

There are many adversaries to a wilderness trail's long term survival. Some of these include erosion, freeze-thaw cycles, and root growth. The primary adversary is erosion.

Soil stabilizers were originally developed to combat erosion. For this reason, erosion of the trail is not a maintenance concern when using a soil stabilizer. Freeze-thaw cycles are when the water in and around the trail surface freezes and then thaws. This process can destroy a trail by creating frost heaves, cracks, and potholes. To combat this, the trail must be somewhat flexible.

Name	Score
Stabilizer	1
EnviroTac II	1
T-NAPS	1
Klingstone 40/400	1
Poly Pavement	1
2001	1
Top-Seal	1
Base Seal	2
Perma-Zyme	2
EcoTrack/BikeTrack	4
Presto GeoWeb	4
Tuff Roll	4
SuperDeck	4
SofScape Pavers	4

The cost of maintenance depends not only on frequency of repairs, but also how hard they are to make. In general, trails made with soil stabilizers are very easy to repair. For some stabilizers, filling in a crack is as simple as pouring some aggregate into it and then spraying the stabilizer on top. For others, a section of the trail surface must be removed and then replaced. To repair faults in a trail made with non-asphalt pavers, as long as the surface underneath is fine, simply pull up the damaged section and replace it with a new one.

4.2.5. Installed Cost

A proper install for a trail made with a soil stabilizer requires a fair amount of trail preparation. A good base must be laid, the grades must be smoothed out, and the aggregate must be brought in before a stabilized can be installed. With one exception, non-asphalt pavers do not require such a complicated installation. The existing trail requires minimal preparation before the pavers are laid on top. SofScape pavers require surface and base preparation which is similar to what a soil stabilizer requires.

Name	Install, per sq ft	Score
EcoTrack/BikeTrack	$1.50	1.00
Tuff Roll	$2.20	1.47
Presto GeoWeb	$3.00	2.00
SuperDeck	$3.00	2.00
SofScape Pavers	$6.52	4.35
Stabilizer	$7.50	5.00
EnviroTac II	$7.50	5.00
T-NAPS	$7.50	5.00
Base Seal	$7.50	5.00
Klingstone 40/400	$7.50	5.00
Poly Pavement	$7.50	5.00
2001	$7.50	5.00
Top-Seal	$7.50	5.00
Perma-Zyme	$7.50	5.00

4.2.6. Total Score

When the scores have been tallied, the surface that emerges in the lead is Perma-Zyme, followed very closely by Base Seal and Stabilizer. The top four surfaces are separated by less than half of a point. The non-asphalt paving options finished last for several reasons.

These are not only more expensive than soil stabilizers, but they are also far less aesthetically pleasing.

Name	Material Cost	Type	Warranty	Maintenance	Aesthetic	Aggregate	Install cost	Total
Perma-Zyme	1	2	7	2	1.5	3	5	21.5
Base Seal	1.03	2	7	2	1.5	3	5	21.53
Stabilizer	8.72	1	2	1	1	3	5	21.72
Klingstone 40/400	3.85	2	6	1	1	3	5	21.85
T-NAPS	10	2	2	1	1	3	5	24
EcoTrack/BikeTrack	10	2	1	4	6	0	1	24
Poly Pavement	8.97	2	6	1	1	1	5	24.97
Presto GeoWeb	10	2	3	4	5	0	2	26
2001	10	2	6	1	1	3	5	28
Top-Seal	10	2	6	1	1	3	5	28
SofScape Pavers	10	2	2	4	6	0	4.35	28.35
Tuff Roll	10	2	6	4	6	0	1.47	29.47
EnviroTac II	8.97	2	10	1	1	3	5	30.97
SuperDeck	10	3	6	4	6	0	2	31

It is our recommendation that Stabilizer be the soil stabilizer that is used. Unlike its competition, Stabilizer has a list of high-profile installations. Stabilizer is used in Central Park in New York City, as well as the Epcot Center in Walt Disney World. The installation in Central Park sees 18 million visitors every year and has had no problems with durability, despite this extremely high amount of traffic. Stabilizer has also been used in other parks in Massachusetts as well as other Mass Audubon sanctuaries, such as Broadmoor.

4.3. Information About the Current Trail Network

In an effort to assist our contact with various contractors, it was helpful to obtain extensive information on the existing trail network. We assessed the grades, trail mileage

and location of the entire trail network. The following information was complied over many weeks and complied into simple formats. A mileage matrix was constructed and a new trail map was developed.

4.3.1. Grades of Existing Trail Network

Using methods discussed earlier, we surveyed the trail network in an effort to obtain a greater knowledge of the trails. The grades were measured on an average of fifty foot intervals. Although these methods led to averaging the distance over fifty feet, thus adding a slight amount of inaccuracy, they were the only logical methods when dealing with trails in excess of one thousand feet. What follows is a series of tables designed to provide as much grade information as possible. Long trails are divided into small segments to provide a more accurate description of the trail's characteristics. The information given in the segments individual tables are pertinent to the segment being discussed and not to the trail as a whole. A table compiling segment information and a general trail table is also provided for every trail. We have also provided a map where the trail section being discussed is darker than the rest of the trail. There are a few exceptions, however, regarding the Sprague Extension Trail. In Figure 21 (Sprague Trail Grade Assessment 5) the trail extends beyond maintained land. Therefore, the trail turns into a thin red line. In this case the thin red line is equivalent to the thick dark line of the trail being mentioned.

Holdredge Trail (761 Feet or 0.14 Miles) - Visitor's Center to Frog Pond Trail

Figure 13 (Holdredge Trail Grades Assessment 1)

Grade	Length	Percent of Trail Length
0 – 5%	78	10.2%
5.1% - 8.33%	323	42.4%
8.34% - 10%	105	13.8%
10.1% - 12.5%	100	13.1%
12.6% - 14%	0	0%
14.1% and Greater	155	20.3%

Holdredge Trail (874 Feet or 0.17 Miles) – Frog Pond Trail to Enchanted Forest Trail

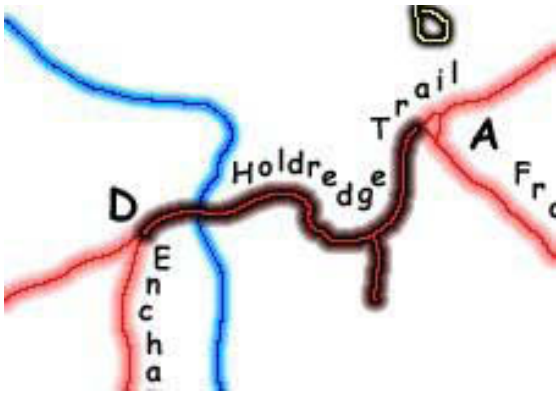


Figure 14 (Holdredge Trail Grade Assessment 2)

Grade	Length	Percent of Trail Length
0 – 5%	714	81.7%
5.1% - 8.33%	160	18.3%
8.34% - 10%	0	0%
10.1% - 12.5%	0	0%
12.6% - 14%	0	0%
14.1% and Greater	0	0%

Holdredge Trail (630 Feet or 0.11 Miles) – Enchanted Forrest Trail to Lady Slipper Trail

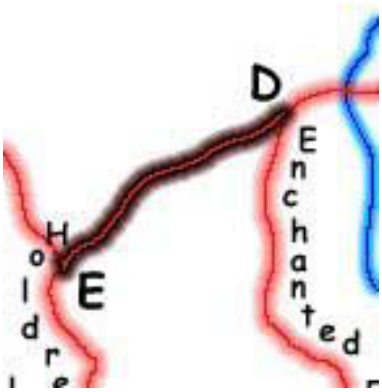


Figure 15 (Holdredge Trail Grade Assessment 3)

Grade	Length	Percent of Trail Length
0 – 5%	504	80%
5.1% - 8.33%	78	12.8%
8.34% - 10%	48	7.6%
10.1% - 12.5%	0	0%
12.6% - 14%	0	0%
14.1% and Greater	0	0%

Holdredge Trail (800 Feet or 0.15 Miles) – Sprague Lane Trail to Lady Slipper Trail

Figure 16 (Holdredge Trail Grade Assessment 4)

Grade	Length	Percent of Trail Length
0 – 5%	340	42.5%
5.1% - 8.33%	240	30%
8.34% - 10%	134	16.7%
10.1% - 12.5%	86	10.7%
12.6% - 14%	0	0%
14.1% and Greater	0	0%

Sprague Trail (752 Feet or 0.14 Miles) – Frog Pond Trail to Broad Meadow Brook

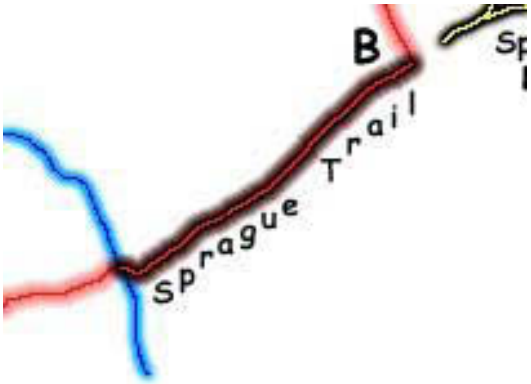


Figure 17 (Sprague Trail Grade Assessment 1)

Grade	Length	Percent of Trail Length
0 – 5%	752	100.0%
5.1% - 8.33%	0	0%
8.34% - 10%	0	0%
10.1% - 12.5%	0	0%
12.6% - 14%	0	0%
14.1% and Greater	0	0%

Sprague Trail (458 Feet or 0.09 Miles) – Broad Meadow Brook to Enchanted Forest Trail

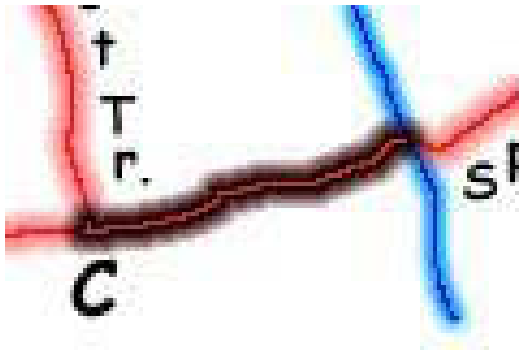


Figure 18 (Sprague Trail Grade Assessment 2)

Grade	Length	Percent of Trail Length
0 – 5%	300	66.0%
5.1% - 8.33%	100	22.0%
8.34% - 10%	0	0%
10.1% - 12.5%	50	11.0%
12.6% - 14%	0	0%
14.1% and Greater	0	0%

Sprague Trail (686 Feet or 0.13 Miles) – Enchanted Forest Trail to Holdredge Trail

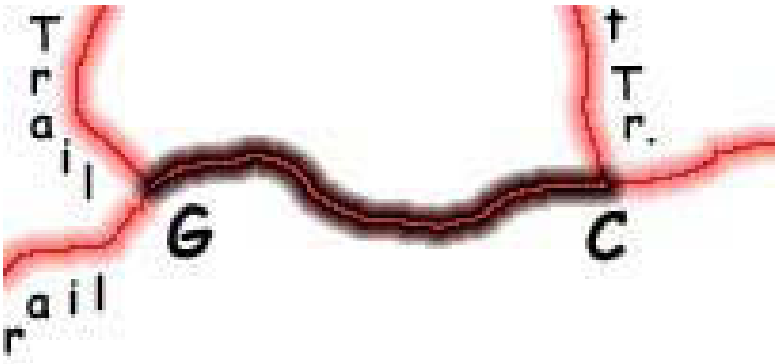


Figure 19 (Sprague Trail Grade Assessment 3)

Grade	Length	Percent of Trail Length
0 – 5%	333	48.5%
5.1% - 8.33%	101	14.7%
8.34% - 10%	46	6.7%
10.1% - 12.5%	0	0%
12.6% - 14%	126.8	18.5%
14.1% and Greater	79.2	11.5%

Sprague Trail (648 Feet or 0.12 Miles) – Holdredge Trail to Power Lines

Figure 20 (Sprague Trail Grade Assessment 4)

Grade	Length	Percent of Trail Length
0 – 5%	198	30.5%
5.1% - 8.33%	226	34.8%
8.34% - 10%	75	11.5%
10.1% - 12.5%	60	9.2%
12.6% - 14%	0	0%
14.1% and Greater	89	13.7%

Sprague Trail (2101 Feet or 0.40 Miles) – Power Lines to Sanctuary Boundary

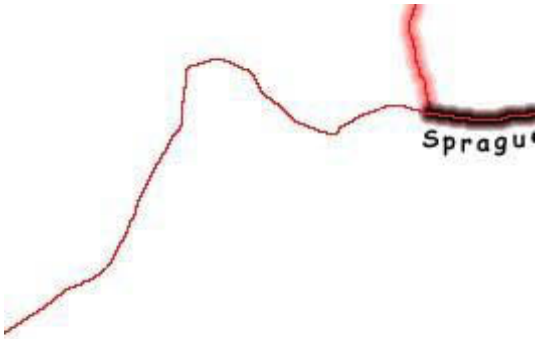


Figure 21 (Sprague Trail Grade Assessment 5)

Grade	Length	Percent of Trail Length
0 – 5%	1132	53.8%
5.1% - 8.33%	490	23.3%
8.34% - 10%	362	17.2%
10.1% - 12.5%	52	2.4%
12.6% - 14%	34	1.6%
14.1% and Greater	31	1.4%

Sprague Trail (3316 Feet or 0.63 Miles) – Sanctuary Boundary to Granite Street

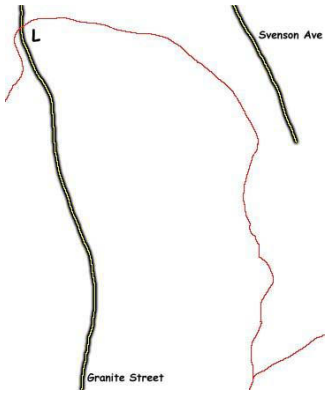


Figure 22 (Sprague Trail Grade Assessment 6)

Grade	Length	Percent of Trail Length
0 – 5%	2282	68.8%
5.1% - 8.33%	669	20.1%
8.34% - 10%	166	5.0%
10.1% - 12.5%	127	3.8%
12.6% - 14%	72	2.1%
14.1% and Greater	0	0%

Holdredge Trail (3065 Feet or 0.58 Miles)

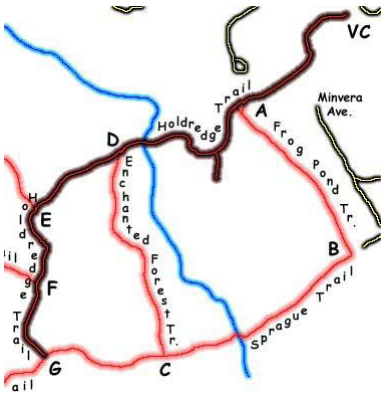


Figure 23 (Holdredge Trail Grade Assessment)

Grade	Length	Percent of Trail Length
0 – 5%	1636	53.3%
5.1% - 8.33%	801	26.1%
8.34% - 10%	287	9.3%
10.1% - 12.5%	186	6%
12.6% - 14%	0	0%
14.1% and Greater	0	0%

Frog Pond Trail (974 Feet or 0.18 Miles)

Figure 24 (Frog Pond Trail Grade Assessment)

Grade	Length	Percent of Trail Length
0 – 5%	974	100.0%
5.1% - 8.33%	0	0%
8.34% - 10%	0	0%
10.1% - 12.5%	0	0%
12.6% - 14%	0	0%
14.1% and Greater	0	0%

Enchanted Forest Trail (1324 Feet or 0.25 Miles)

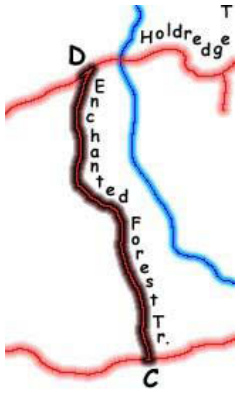


Figure 25 (Enchanted Forest Trail Grade Assessment)

Grade	Length	Percent of Trail Length
0 – 5%	463	65.0%
5.1% - 8.33%	323	35.%
8.34% - 10%	0	0%
10.1% - 12.5%	0	0%
12.6% - 14%	0	0%
14.1% and Greater	0	0%

Sprague Trail and Sprague Extension Trail (4645 Feet or 0.88 Miles)

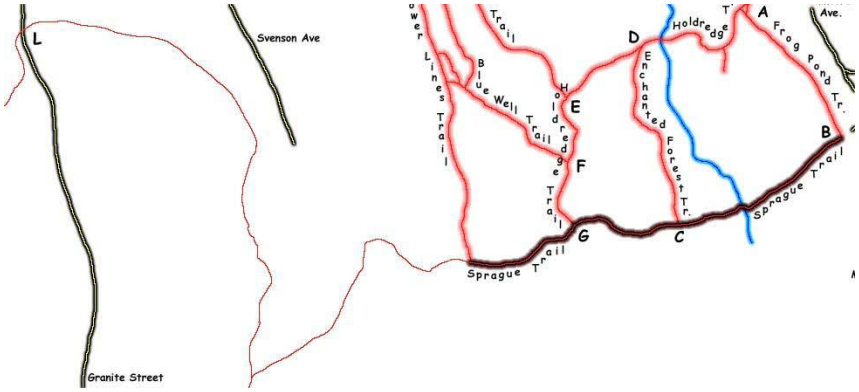


Figure 26 (Sprague Extension Grade Assessment)

Grade	Length	Percent of Trail Length
0 – 5%	3715	79.9%
5.1% - 8.33%	915	19.6%
8.34% - 10%	893	19.2%
10.1% - 12.5%	162	3.4%
12.6% - 14%	160.8	3.4%
14.1% and Greater	199.2	4.2%

Lady Slipper Trail (1754 Feet or 0.33 Miles)

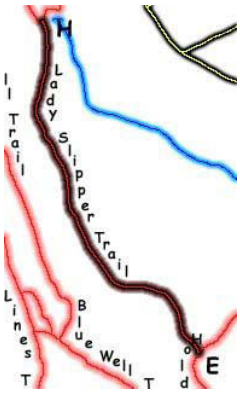


Figure 27 (Lady Slipper Trail Grade Assessment)

Grade	Length	Percent of Trail Length
0 – 5%	346	19.7%
5.1% - 8.33%	245	13.9%
8.34% - 10%	589	33.5%
10.1% - 12.5%	355	20.2%
12.6% - 14%	141	8%
14.1% and Greater	78	4%

Cardinal Trail (3932 Feet or 0.74 Miles)

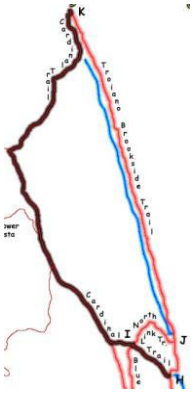


Figure 28 (Cardinal Trail Grade Assessment)

Grade	Length	Percent of Trail Length
0 – 5%	2345	59.6%
5.1% - 8.33%	1205	30.6%
8.34% - 10%	245	6.2%
10.1% - 12.5%	137	3.4%
12.6% - 14%	0	0%
14.1% and Greater	0	0%

Troiano Brookside Trail (3336 Feet or 0.63 Miles)

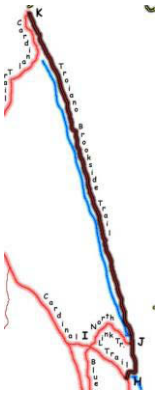


Figure 29 (Troaino Brookside Trail Grade Assessment)

Grade	Length	Percent of Trail Length
0 – 5%	3336	100%
5.1% - 8.33%	0	0%
8.34% - 10%	0	0%
10.1% - 12.5%	0	0%
12.6% - 14%	0	0%
14.1% and Greater	0	0%

North Link Trail (566 Feet or 0.10 Miles)

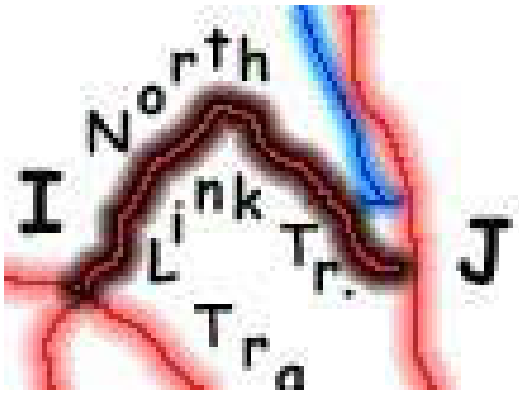


Figure 30 (North Link Trail Grade Assessment)

Grade	Length	Percent of Trail Length
0 – 5%	0	0%
5.1% - 8.33%	0	0%
8.34% - 10%	345	60.9%
10.1% - 12.5%	221	39.1%
12.6% - 14%	0	0%
14.1% and Greater	0	0%

Blue Well Trail (2552 Feet or 0.48 Miles)

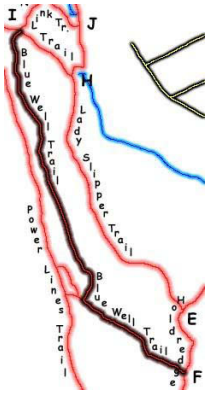


Figure 31 (Blue Well Trail Grade Assessment)

Grade	Length	Percent of Trail Length
0 – 5%	1254	49.1%
5.1% - 8.33%	698	27.3%
8.34% - 10%	500	19.6%
10.1% - 12.5%	66	2.5%
12.6% - 14%	34	1.3%
14.1% and Greater	0	0%

4.3.2. Distances of Existing Trail Network

Intersections were named as a simple way to plot distances. As seen on the new trail map, the intersections follow a logical progression away from the Visitor's Center. When multiple routes are possible from one intersection to another, the shortest possible route is provided. All distances are in miles.

VC	The Visitor Center
A	The Holdredge Trail's intersection with the Frog Pond Trail
B	The Frog Pond Trail's intersection with the Sprague Trail
C	Sprague Trail's intersection with the Enchanted Forest Trail
D	Holdredge Trail's intersection with the Enchanted Forest Trail
E	Holdredge Trail's intersection with Lady Slipper Trail
F	Holdredge Trail's intersection with the Blue Well Trail
G	Holdredge Taril's intersection with Sprague Trail
H	The Cardinal Trail's intersection with the Lady Slipper Trail
I	The Cardinal Trail's intersection with the North Link Trail
J	The North Link Trail's intersection with the Troiano Brookside Trail
K	The Cardinal Trail's intersection with the Troiano Brookside Trail
L	Sprague Extension's intersection with Granite Street
M	Sprague Extension's intersection with Route 146

	VC	A	B	C	D	E	F	G	H	I	J	K	L	M
VC		0.14	0.32	0.55	0.31	0.44	0.51	0.59	0.77	0.99	0.88	1.4	1.74	2.09
A	0.14		0.18	0.41	0.17	0.28	0.49	0.43	0.63	0.97	0.74	1.26	1.58	1.93
B	0.32	0.18		0.23	0.35	0.59	0.44	0.36	0.92	0.92	1.03	1.55	1.51	1.86
C	0.55	0.41	0.23		0.25	0.36	0.21	0.13	0.59	0.69	0.7	1.22	1.28	1.63
D	0.31	0.17	0.35	0.25		0.11	0.18	0.26	0.44	0.66	0.55	1.07	1.41	1.76
E	0.44	0.28	0.59	0.36	0.11		0.07	0.15	0.33	0.55	0.44	0.96	1.3	1.65
F	0.51	0.49	0.44	0.21	0.18	0.07		0.08	0.4	0.48	0.51	1.03	1.23	1.58
G	0.59	0.43	0.36	0.13	0.26	0.15	0.08		0.48	0.56	0.59	1.11	1.15	1.5
H	0.77	0.63	0.92	0.59	0.44	0.33	0.4	0.48		0.09	0.11	0.63	1.63	1.98
I	0.99	0.97	0.92	0.69	0.66	0.55	0.48	0.56	0.09		0.1	0.65	1.71	2.06
J	0.88	0.74	1.03	0.7	0.55	0.44	0.51	0.59	0.11	0.1		0.52	1.74	2.09
K	1.4	1.26	1.55	1.22	1.07	0.96	1.03	1.11	0.63	0.65	0.52		2.26	2.61
L	1.74	1.58	1.51	1.28	1.41	1.3	1.23	1.15	1.63	1.71	1.74	2.26		0.35
M	2.09	1.93	1.86	1.63	1.76	1.65	1.58	1.5	1.98	2.06	2.09	2.61	0.35	

4.3.3. GPS Mapping

We further increased our knowledge of the trails in the Sanctuary by mapping their location. Over the course of many weeks we mapped the Sanctuary's trails. As seen in the maps that follow, we became more comfortable using the unit and the data that it

produced became more reliable. The following are maps of our days hiking the trails, with descriptions of the triumphs and hardships faced each day:

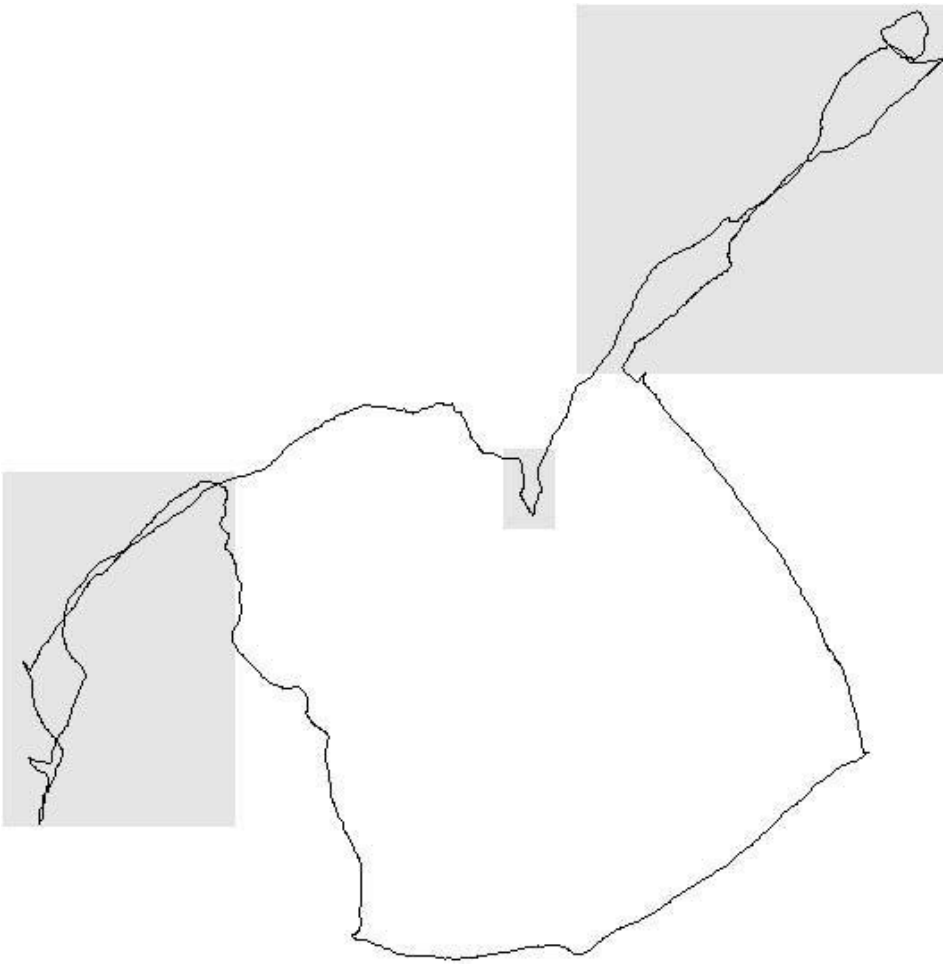


Figure 32 (Nov 4, 2002 GPS Mapping)

Following many days of testing the GPS unit in the parking lot and on the drive back to campus from the Sanctuary, our first day of substantial trail mapping was Monday, November 4th 2002. We were a little disappointed in the consistency of our data. The section in the top right gray box of Figure 32, which mapped the Holdredge Trail from the Visitor's Center to the start of the Frog Pond Trail, should have matched more closely

when we retraced our steps. The Overlook Trail denoted by the middle gray box of Figure 32, was a spur trail, where again we retraced our steps but did not see this on the map. The third grey box shows that the GPS unit yielded inconsistent data on the Holdredge Trail past its connection with the Enchanted Forest Trail. These clear inaccuracies in the data do not instill trust in the validity in the other sections we mapped that day. Although the Sprague Lane Trail from the Frog Pond Trail to the Enchanted Forest Trail and the Frog Pond Trail seem to follow the existing trail map fairly closely, it is hard to count on their accuracy as the sections where we retraced our steps were clearly not accurate. We held the GPS unit in one of our hands and simply walked with the unit at waist height, keeping the unit close to the torso. Later tests showed that this method was, although not the worst method, not the most effective in obtaining GPS accuracy.

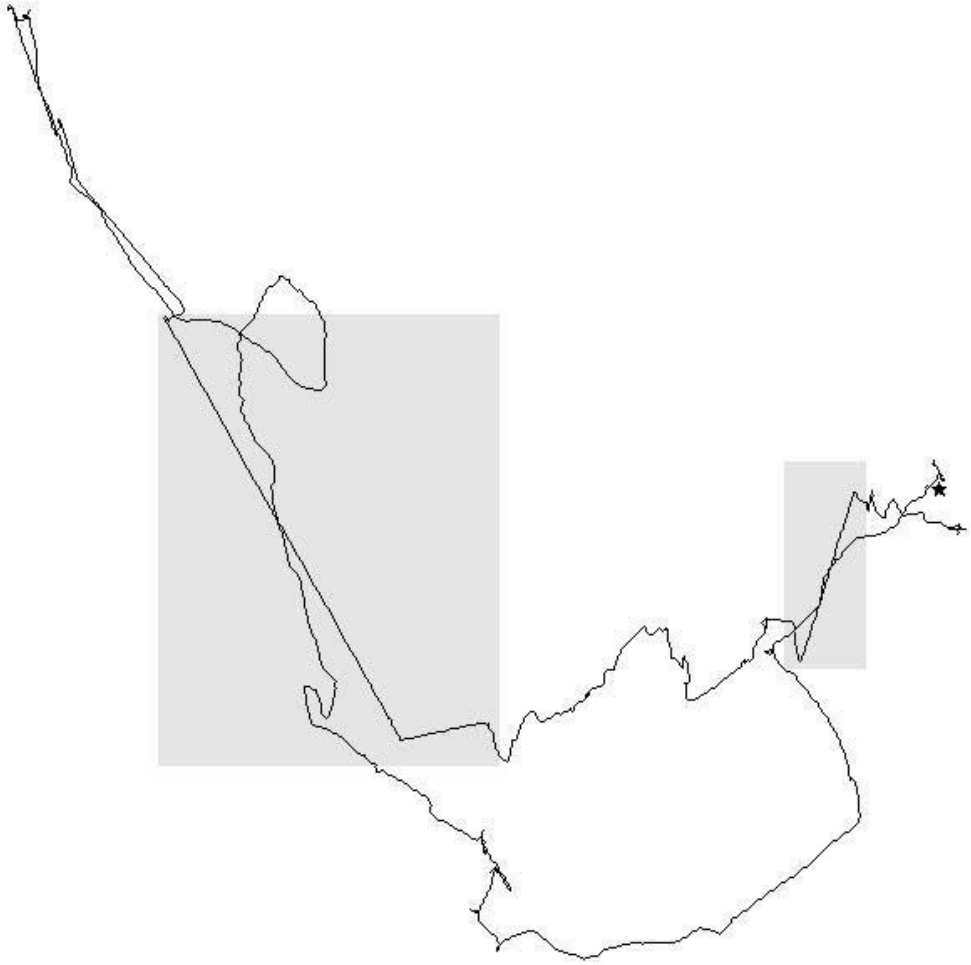


Figure 33 (November 5, 2002 GPS Mapping)

Our second day of mapping, Tuesday, November 5th 2002, was the day of our most inaccurate mapping throughout the project. We attempted to make our trail hiking simple by putting the GPS unit in the front pocket of one of our jackets. Putting the GPS unit into a pocket turned out to be a poor decision. We found out later that by covering the top half of the GPS unit we were severely disrupting its communication with the satellites orbiting the earth. The GPS unit would periodically lose and regain its lock with the satellites. As seen in both gray boxes of Figure 33 when the connection to the satellites would be lost, no data was recorded; when a connection had been reestablished it would

create a straight line from the last recorded data point. These straight lines are terrible inaccuracies, and were ultimately disregarded when averaging lines. We took the laptop out of the backpack to make sure that it had not gone into a dormant mode and stopped recording our live GPS data. Upon looking at the map, it became clearly evident that something was wrong. We concluded that having the GPS unit in a jacket pocket was not the best place to keep it. After taking the GPS unit out of the jacket pocket and holding it out in the open, it was locked to more satellites and gave us a better reading. However, we were still holding it at waist height, near the torso. Making this change significantly improved our accuracy, but doing the same thing the previous day also provided us with inaccurate data.

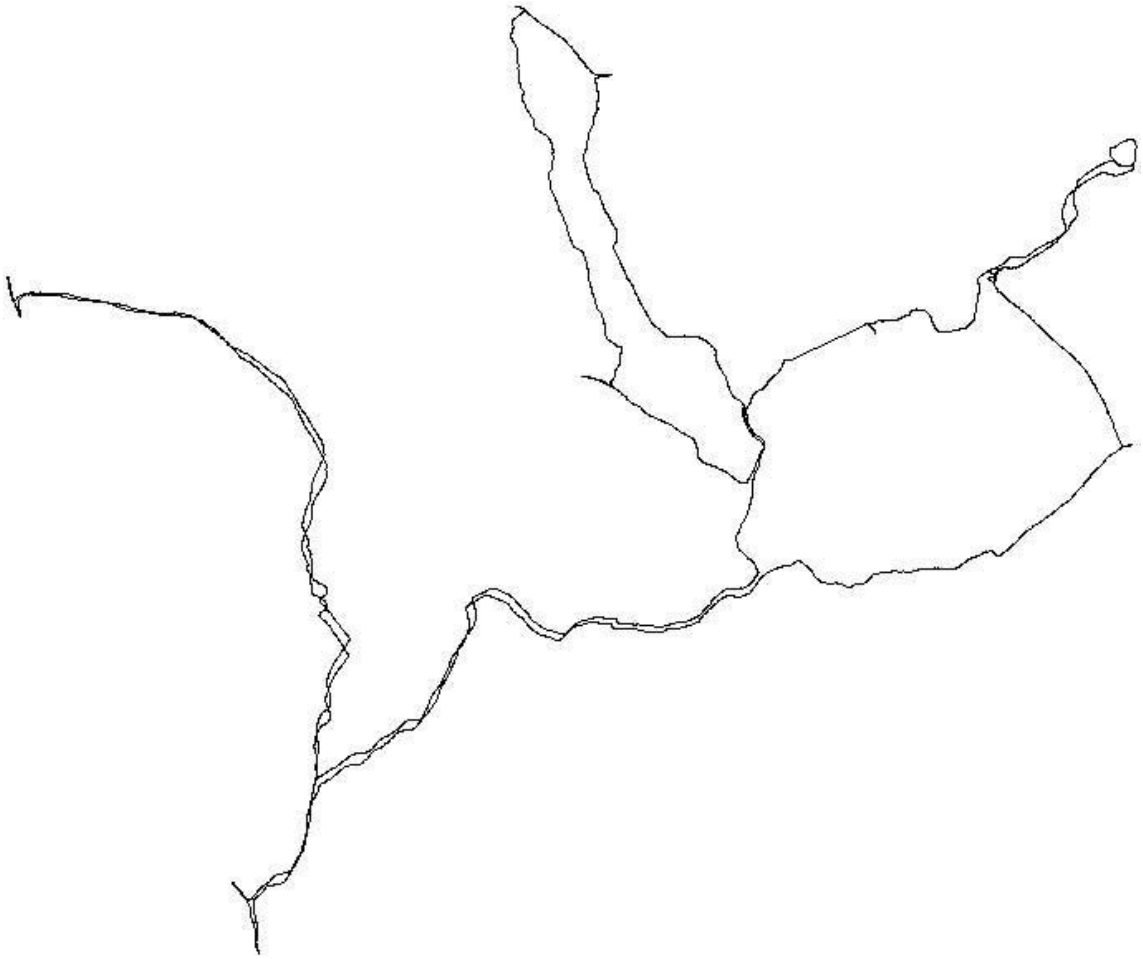


Figure 34 (November 7, 2002 GPS Mapping)

The first day of substantial trail mapping was Thursday, November 7th 2002. The breakthrough of the day was a discovery that holding the GPS unit above the head drastically increased the number of satellites it was in contact with. Based on information received, we believed that mapping the trails on a cloudy day was futile. We mapped an extensive amount of the trail network on a day that seemed as though it would have been poor to use the GPS unit. The previous day of mapping was heavily overcast and gave us terrible inaccuracies. However, with our new technique, we were able to obtain accuracy not yet seen in our mapping. The GPS unit was held as high as possible

with the carriers arm. The Sprague Lane Extension Trail was mapped to Granite Street. The spur trail connecting Park Hill Street to the Sprague Lane Extension Trail was also mapped. Figure 34 (November 7, 2002 GPS Mapping) shows the Sprague Lane Extension Trail as it extends beyond the existing trail map and Sanctuary boundaries. It also extends beyond trail blazes and onto private property. We remapped the Lady Slipper and Blue Well Trails after we discovered how accurate our data was. We would have mapped the entire trail network that day, however, the sun was setting, and although the GPS unit works at night, it is inconvenient and difficult to walk the trails in complete darkness.

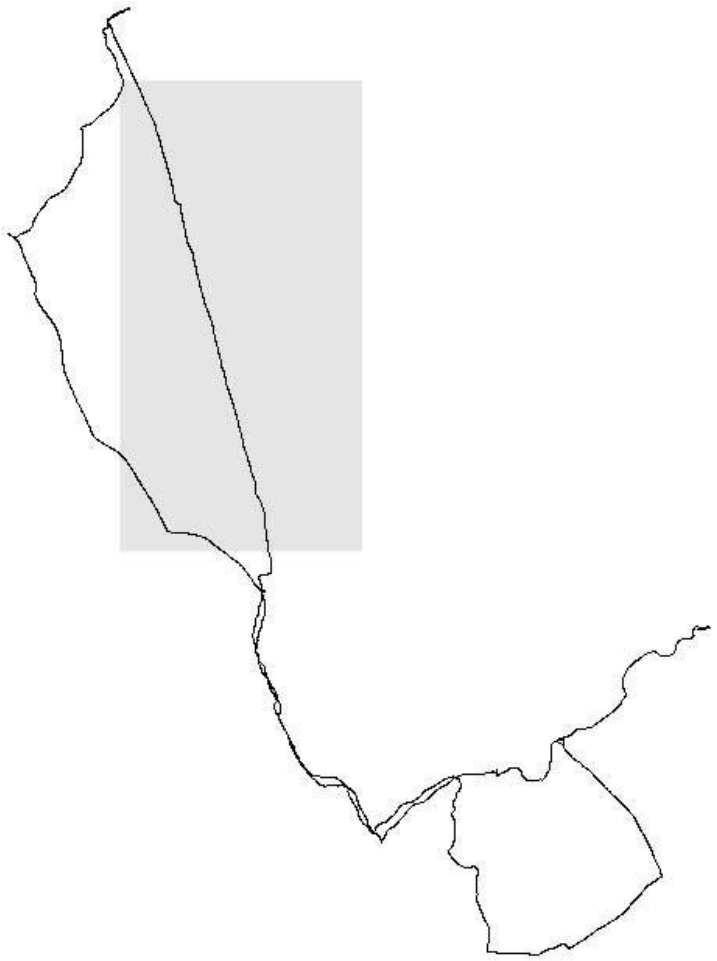


Figure 35 (November 11, 2002 GPS Mapping)

We attained great success again while mapping on Monday, November 11th 2002. As Figure 35 shows the north end of the trail network, the Cardinal and Troiano Brookside Trials, was mapped. We had heard rumors that a trail in the network was flooded by water buildup behind a beaver dam. As we made the sharp turn at the end of the Cardinal Trail, we noticed that it was the Troiano Brookside Trail which was flooded. The area denoted by the gray box in Figure 35 shows the area of the trail network that was flooded. There was a marsh to the left of the trail while heading back to the Visitor's Center which provided dry ground. Work had been done to build bridges with wooden pallets and

bundles of sticks, but overall the trail was in very poor condition. It is hard to make a recommendation on how to improve the drainage of the water behind the beaver dam without knowledge of how it will affect the ecosystem. Upon finishing our mapping on November 11th, we had mapped all the existing trails east of Granite Street. Treating the trail maps as layers, and combining them into one image, we are able to see how closely they lined up and how they compared with the Sanctuary's current trail map.

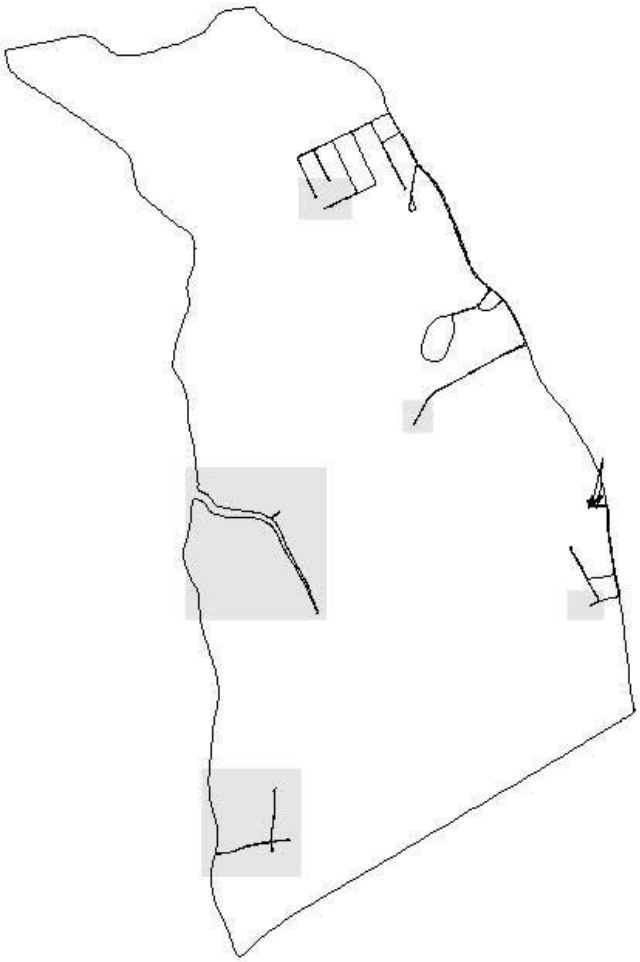


Figure 36 (November 11, 2000 GPS Mapping 2)

After completing our mapping of the Sanctuary's trail network, a map of the surrounding roads was created. We knew from mapping the Sprague Extension Trail beyond the

power lines that the trail came close to two roads that spurred off Granite Street. The end of one spur off the Sprague Trail was located at the end of Park Hill Street. As seen in the lowest box of Figure 36, Park Hill Street is a spur off Garnet Street, which is a spur itself off Granite Street. The largest box highlights Svenson Avenue. We stumbled upon Svenson Avenue the day we mapped the Sprague Extension Trail, but did not know exactly where in relation to Granite Street it was. The Sprague Extension Trail seemed to tread on a large amount of private property. The top most box of Figure 36 shows the area where Dunkirk Avenue intersects the Cardinal and Troiano Brookside Trails. In the box below, Dupuis Avenue is shown which ends in the driveway of a house. The Troiano Brookside Trail travels onto the private land of the homeowner, with signs alerting the user to pass at their own risk. Finally, in the right most box we see Sprague Lane. The Frog Pond Trail and the Sprague Trail intersect at the end of Sprague Lane.

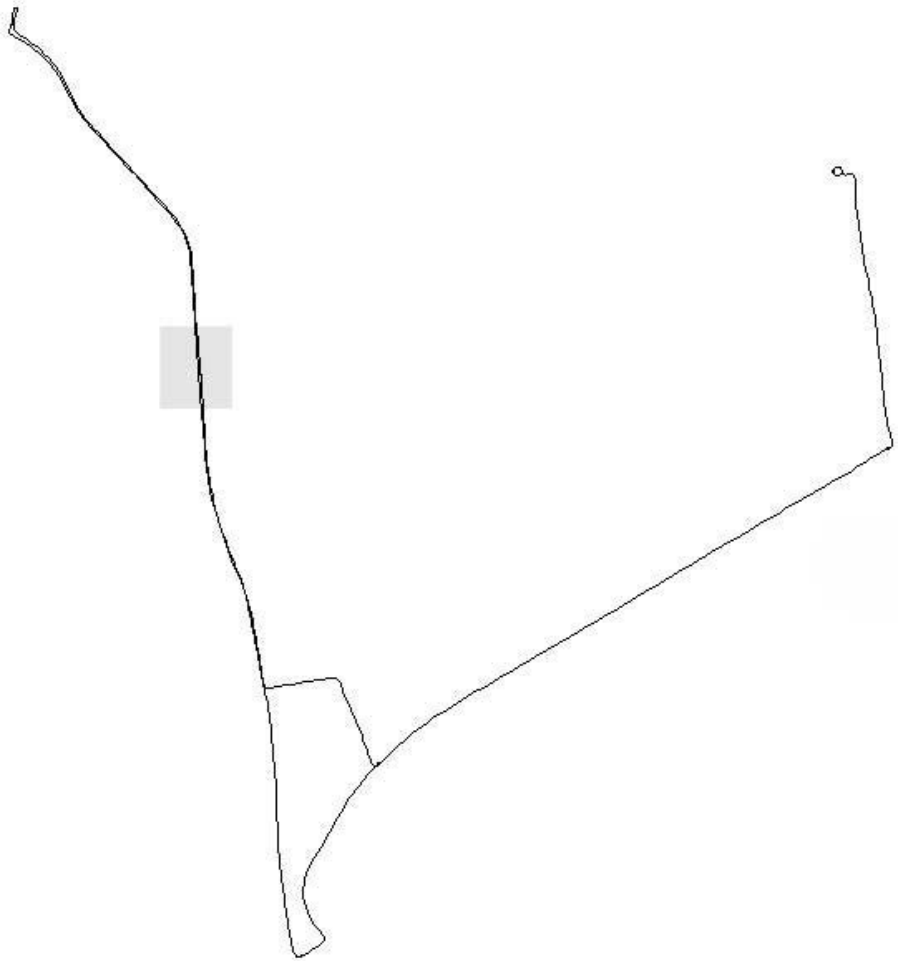


Figure 37 (November 15, 2002 GPS Mapping)

A short day of mapping was completed on Friday, November 15th 2002. We wanted to map Route 146, this would help us to estimate the distance between it and Granite Street. Cliff Street was also mapped and will be included to help visualize the positioning of the Sanctuary's trails. The box in Figure 37 highlights the intersection between Route 146 and the Millbury Street Bridge. The Blackstone River, flowing from Worcester to Providence, the bike path running parallel to the River, and Route 146 all converge at the Millbury Street Bridge. It is a goal of the Sanctuary to connect its trail network to the bike path near the Millbury Street Bridge.

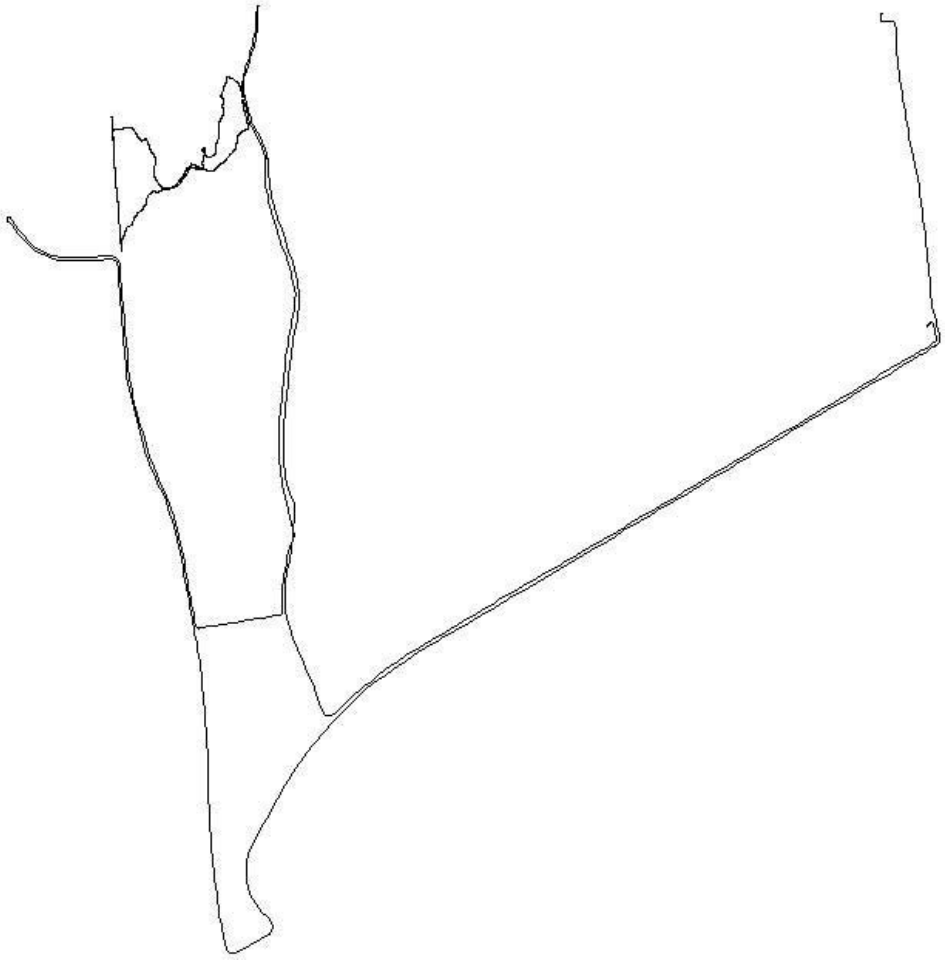


Figure 38 (November 18, 2002 GPS Mapping)

We continued mapping on Monday, November 18th 2002. The spur off Route 146 is Millbury Street shown in Figure 38. Above Millbury Street, we mapped the connection between Granite Street and Route 146. The upper line denotes the trail that crosses Granite Street at the terminus of the Sprague Extension Trail. There was not a well established trail; it was more a case of finding where a trail might have been located at some point. The trail ended at the Worcester Transfer Station approximately 500 feet away from the Millbury Street Bridge. We walked along the sidewalk to the bridge and made a direct line back to where we thought the trail was near the Worcester Transfer

Station. Upon connecting back to the trail we had mapped earlier, we attempted to find the easiest grade back to Granite Street.

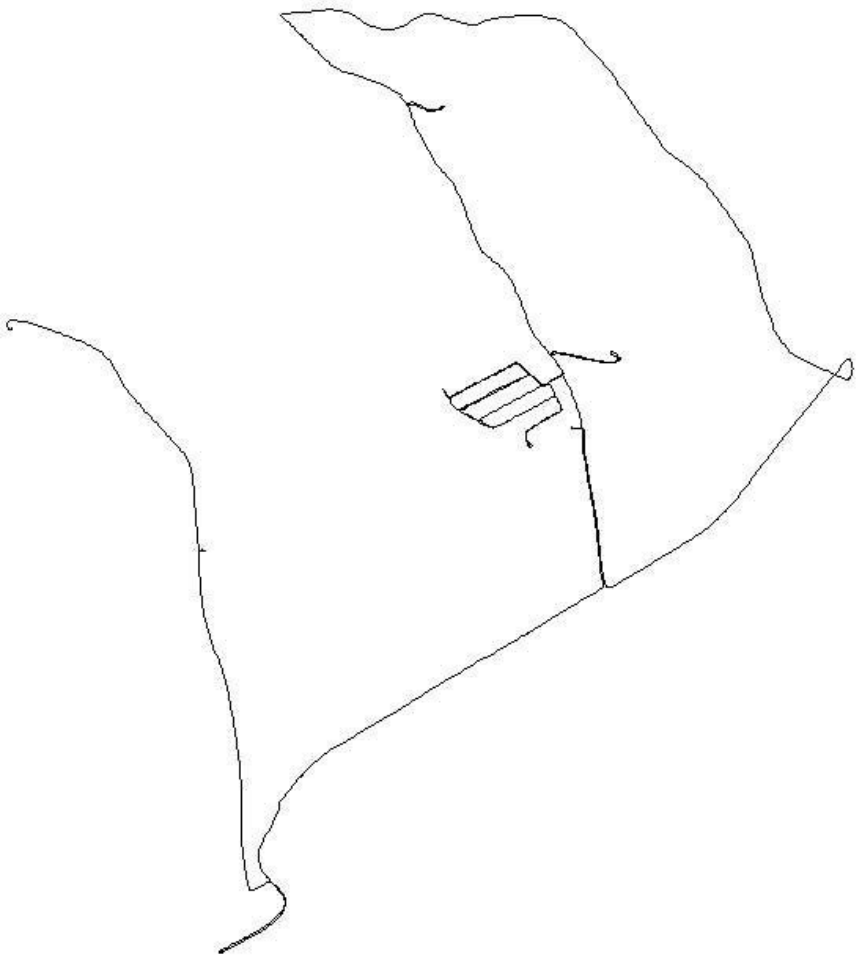


Figure 39 (December 4, 2002 GPS Mapping)

Meeting with Deb Cary on Wednesday, December 4th 2002, we discovered that there were a few roads that were missing from our new trail map. On our way home in the evening we mapped all the surrounding roads that we had missed before. This is shown in Figure 39. These roads included, but were not limited to: Blithewood Avenue,

Sunderland Avenue, Route 122 and the Massachusetts Turnpike. We also mapped the housing development adjacent to the Sanctuary.

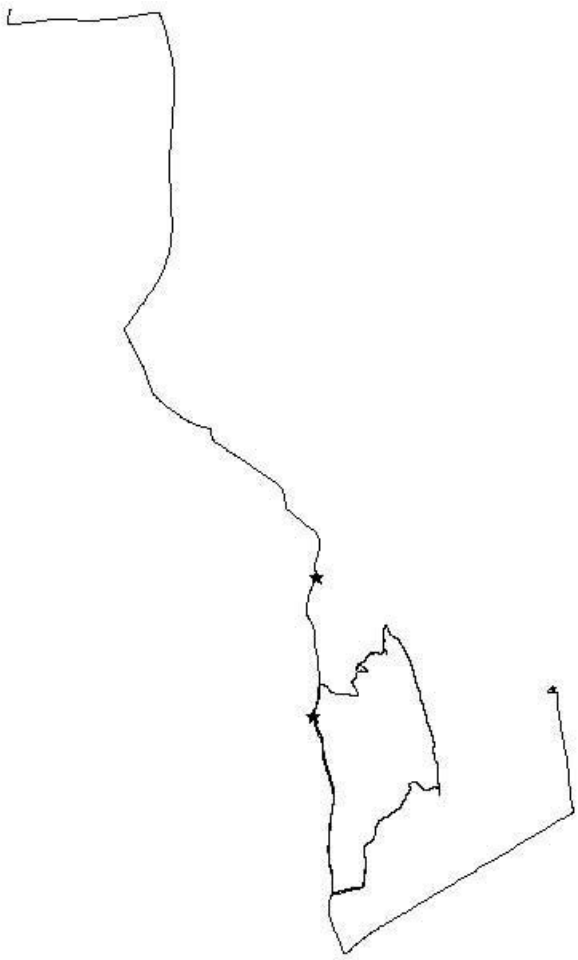


Figure 40 (December 5, 2002 GPS Mapping)

Our last day of mapping was on Thursday, December 5th 2002. Deb informed us there is a trail running parallel to the Power Lines that is on the most updated map. The trail map we were using to determine trails that had or had not been mapped, did not have the Power Line Trail on it. We were a little overloaded when we discovered we had more trail mapping to do considering the large snowstorm from the previous night. The

morning drive from campus to the Sanctuary was mapped to obtain further reference points for location purposes on the new trail map. Deb asked us to map an unmaintained trail that spurred from the Cardinal Tail near where it crossed under the power lines. The trail that we mapped was actually a different than the one that Deb asked us to map.

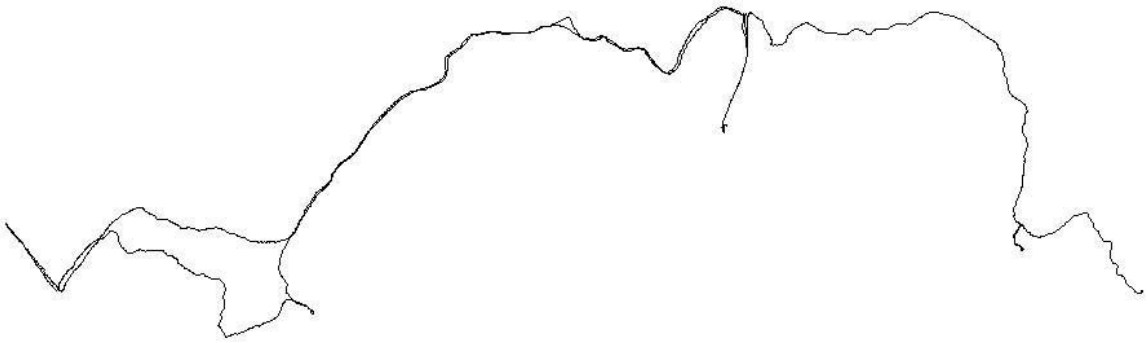


Figure 41 (December 5, 2002 GPS Mapping)

On the afternoon of Thursday, December 5th 2002 we met Deb Cay at the Granite Street crossing of the Power lines. We mapped the connection between the intersection of the Power Lines and Granite Street with the proposed Blackstone River Valley National Heritage Corridor Visitor's Center. Although a trail was marked with a series of pink ribbons affixed to the branches of small trees, it was useful to have Deb leading us as the trail was completely ensconced in snow. Upon returning to Granite Street, we crossed it and mapped a trail connecting to the Cardinal trail. This trail had not been mapped in the morning. Completing this day of mapping ended our mapping for the project.

4.4. Survey Information

We conducted a survey during the seven weeks of our project. The returns of the survey were minimal and therefore the results were not used as factors in the decisions made on our trails. Information about the survey and analysis of its statistics is presented in Appendix B

5. Conclusions And Recommendations

Through research into the background of our project, the discussion of methods used, and the analysis of the data acquired, we have explored all of the evident issues involved in the construction of four possible trails in the Broad Meadow Brook wildlife sanctuary. All of these trail's costs have been calculated with All Persons accessibility in mind. There are acceptable alternatives to our recommendation however our seven weeks of research have led us to a cost efficient and long lasting solution.

The four different recommendations can be easily visualized in the maps of the following section. These four recommendations include a sum of all the costs related to the trail construction: materials, ground preparation, and labor.

5.1. Placement of the Trails

The current trail network was laid out in a manner that did not anticipate future upgrading for All Persons accessibility. The trailhead in particular is extremely steep and will require much more work than simply creating a surface acceptable for wheelchairs. There is a section of the Enchanted Forest trail that is not acceptable for All Persons standards that needs to be addressed. The Sprague Trail Extension contains some considerably difficult grades for All Persons and will need to make use of some fill areas. Relocating difficult sections of the unblazed trails outside the Sanctuary will be as easy as clearing some brush and laying down the initial blazes. These are the main trails used in our recommendations.

Recommendation 1 – The Visitor's Center to Intersection A

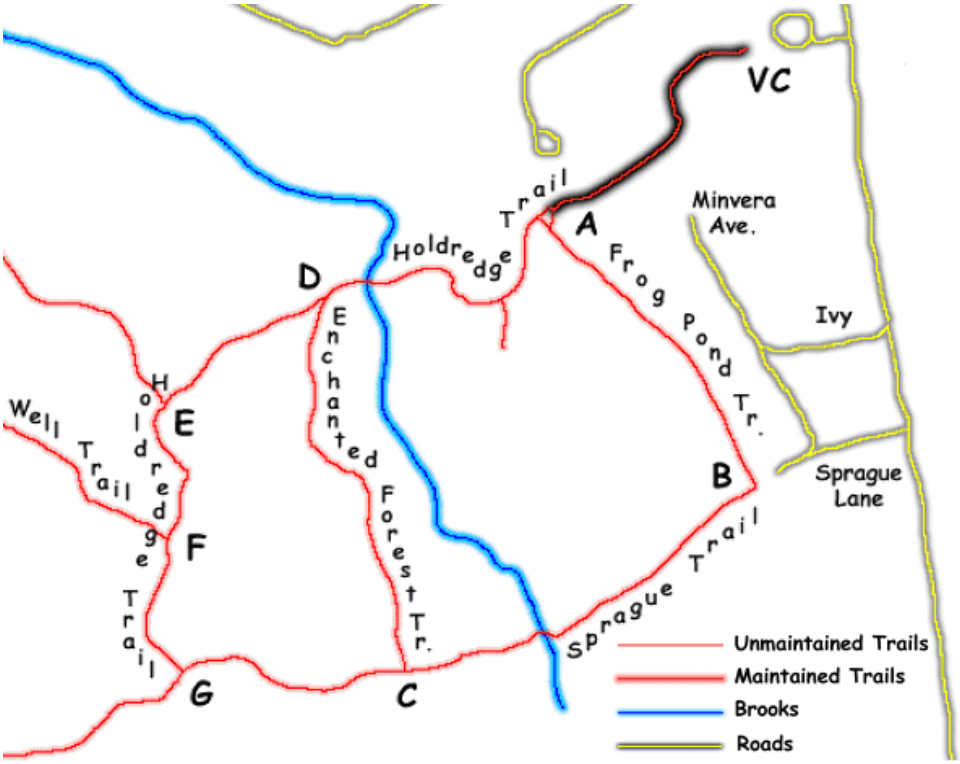


Figure 42 (Visitor Center to Intersection A)

Trails Included:

Holdredge Trail: Visitor's Center to A

Trail Length Before Modification:

0.14 miles or 761 feet

Grades Involved Before Trail Modification:

Grade	Length	Percent of Trail Length
0 – 5%	78	10.2%
5.1% - 8.33%	323	42.4%
8.34% - 10%	105	13.8%
10.1% - 12.5%	100	13.1%
12.6% - 14%	0	0%
14.1% and Greater	155	20.3%

Estimated Upgrading Cost:

$52,000

Natural Attractions:

This section provides the initial impression of the Sanctuary for users traveling from urban areas. In addition to being the first tract of forest users come in contact with, this section is also located on a steep hill. When walking down the trail one feels a sense of freedom entering this urban oasis. Many animals call this area home and thriving ecosystems are apparent at numerous points on the trail.

Advantages:

Of the four recommended trails that are under investigation, three require upgrading the section of the Holdredge Trail from the Visitor's Center to Intersection A. It is essential that users who are classified as All Persons be able to use the Visitor's Center. This trail is essential for any exploration into the trail network as it is the only trail leaving from the visitor center. Most users of the Sanctuary enter through the Visitor's Center, and it has been requested that when trails are upgraded to All Persons standards entrance is still controlled through it. If the goal of controlling entrance to the Sanctuary is going to be a

reality then upgrading this section is a necessity as simply upgrading the Sprague Spur trail would require the Sanctuary to allow access from a point other than the Visitor Center.

Disadvantages:

The cost involved in this short section of trail is high. When compared to other options, this section becomes markedly more expensive due in large part to the switchbacks involved and the large amount of fill needed to bring the grades to standard. While this section is under construction, it renders the rest of the trail network virtually unusable. People can access the trail network from points such as: Sprague Lane, Park Hill Street, Svenson Avenue and Granite Street. Although there are many alternative access points to the trail network other than the Visitor's Center, it requires a seasoned user to know where these access points are and to have either a trail map in hand or committed to memory. This section has the potential to be an eyesore to people visiting the Sanctuary's Visitor Center. The Sanctuary does not want to create trails that are cumbersome. Careful planning for the exact location of this section needs to be considered by the contractor so that the trail does not look out of place.

Recommendation 2 – Sprague Spur Trail

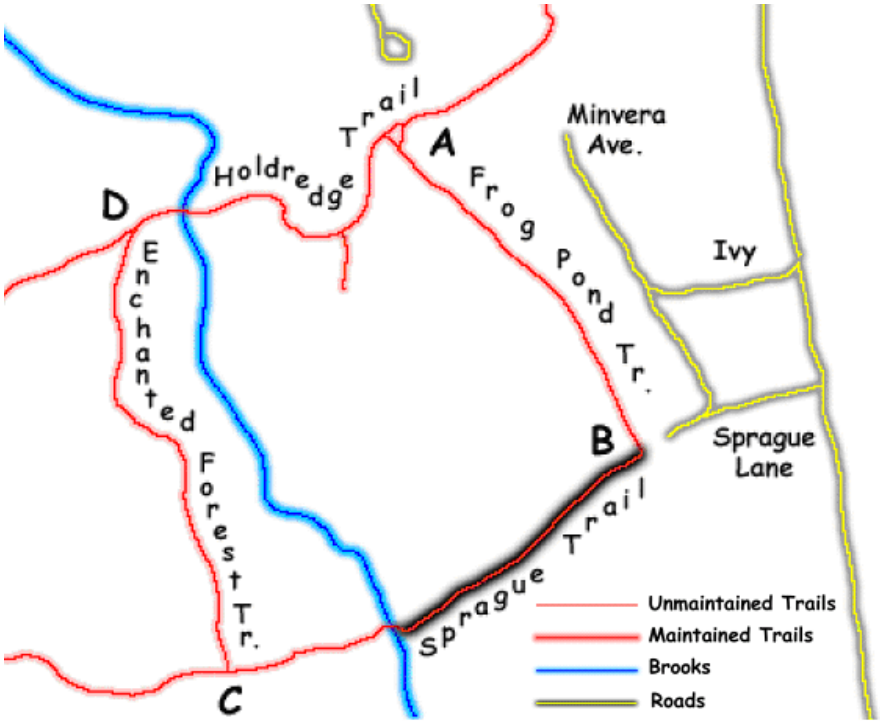


Figure 43 (Sprague Spur Trail)

Trails Included:

Sprague Trail: B to The Broad Meadow Brook

Trail Length Before Modification:

0.14 miles or 752 feet

Grades Involved Before Trail Modification:

Grade	Length	Percent of Trail Length
0 – 5%	752	100.0%
5.1% - 8.33%	0	0%
8.34% - 10%	0	0%
10.1% - 12.5%	0	0%
12.6% - 14%	0	0%
14.1% and Greater	0	0%

Estimated Upgrading Cost:

$25,200

Natural Attractions:

This section incorporates a portion of an old road bed which creates an atmosphere that is unique to this trail. The trail is mostly grass which is also unique. The end of this proposed section is at the Broad Meadow Brook, a environmental gem.

Advantages:

Upgrading this section of trail would be a great taste of All Persons access to the Sanctuary. This trail would be very easy to upgrade as the entire section is flat and located on a grassy plane. An All Persons trail to the Broad Meadow Brook would allow access to at least some part of the trail network. Access to the construction site would be very easy as it is at the end of Sprague Lane. The trail is already sufficiently wide, so minimal vegetation damage would be incurred. This section would be a great exploratory mission into All Persons interest at the Sanctuary. Countless surveys can be conducted, but until the respondents have a tangible trail to judge, it is hard to properly gauge their opinions. If the trail is constructed and people find that is unnecessary or ugly, it can be

dug up and new grass can be planted. Later, if Recommendation 1 is completed in conjunction with upgrading the Frog Pond Trail, this section could be tied in to make a spur from the Visitor's Center to the Broad Meadow Brook.

Disadvantages:

Although this section would be easy to upgrade, it would require an auxiliary parking lot at the end of Sprague Lane. Creation of a parking lot at the end of Sprague Lane has been opposed by land owners and the Sanctuary; if this section is upgraded special consideration should be made to keep control of trail network access in the Visitors Center and to keep the neighbors happy. We recommend that a parking lot not be installed to keep use of the Visitor's Center as high as possible. If this section were upgraded, it would have to be marketed towards those who are able to walk down the Holdredge Trail to the Frog Pond Trail, but would appreciate an upgraded trail in the network. When using this trail section, as it is only a spur, users are required to retrace their steps, which might be unsatisfying for some people.

Recommendation 3 – Enchanted Forest Loop

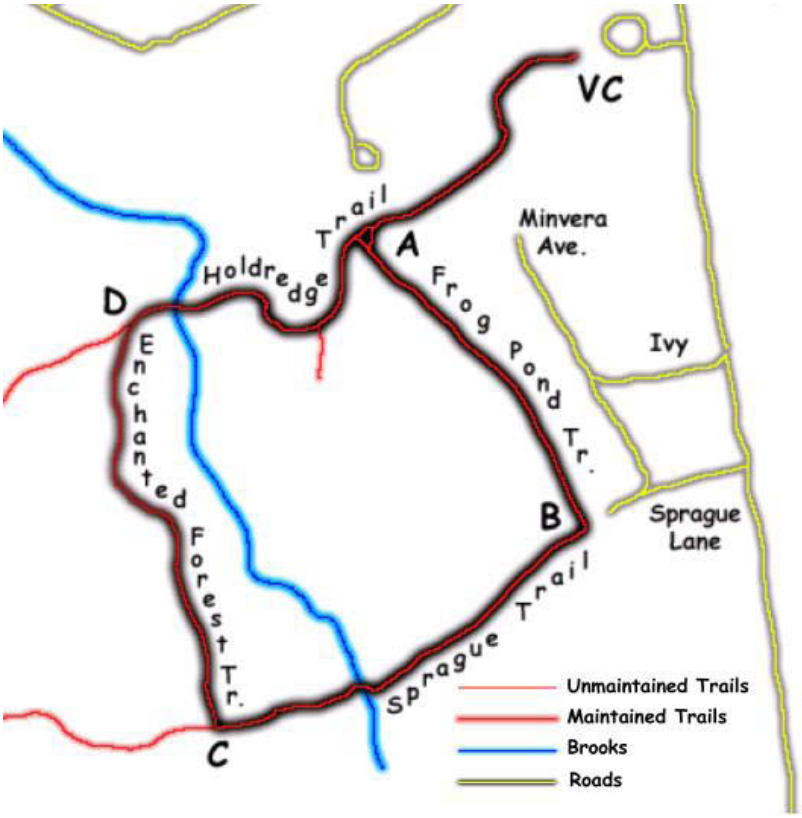


Figure 44 (Enchanted Trail Loop)

Trails Included:

Holdredge Trail: Visitor's Center to A

Frog Pond Trail: A to B

Sprague Trail: B to C

Enchanted Forest: C to D

Holdredge Trail: D to Visitor's Center

Trail Length Before Modification:

0.91 miles or 4908 feet

Grades Involved Before Trail Modification:

Grade	Length	Percent of Trail Length
0 – 5%	3059	62.3%
5.1% - 8.33%	1129	23%
8.34% - 10%	210	4.2%
10.1% - 12.5%	200	4.1%
12.6% - 14%	0	0%
14.1% and Greater	310	6.3%

Estimated Upgrading Cost:

$240,000

Natural Attractions:

This section incorporates the natural attractions of the initial trailhead near the Visitor's Center and the Sprague Spur Trail in addition to delving into the depths of the Sanctuary's woods. The previous two sections have not brought the hiker to a point where civilization is not apparent. Once in the depth of the loop, a true sense of solitude can be felt.

Advantages:

Completing this option incorporates Recommendations 1 and 2. Many people prefer walking a loop to retracing their steps. The highlight of this recommendation comes in the crossing of the Broad Meadow Brook twice. It crosses once on the Sprague Trail and one more on the Holdredge Trail. The Brook is an environmental gem that the Sanctuary

would like to share with those who have disabilities which would otherwise limit their access.

Disadvantages:

The Enchanted Forest Trail, although not a concern when dealing with grades, is fraught with many boulders and root systems. Once this section is upgraded, users who do not want to hike trails that have not been upgraded must walk on upgraded trails to get the outer, more undeveloped parts of the Sanctuary. This section crosses the Broad Meadow Brook twice, which is pleasant to the eye, but is not pleasant to the engineer. Currently there are beautiful stone bridges that are a great addition to the Sanctuary's landscape. It is a goal of the Sanctuary to obtain All Persons access over Broad Meadow Brook and keep the stone bridges. Combining these two is simply not possible with the nature of the bridges. Significant planning will be needed by the contractor to create an aesthetically pleasing bridge that is natural and accessible. These bridges will benefit from being located away from the current natural bridges in place at the Sanctuary, as they may be an eyesore.

Recommendation 4 – Connection to the Blackstone River Valley

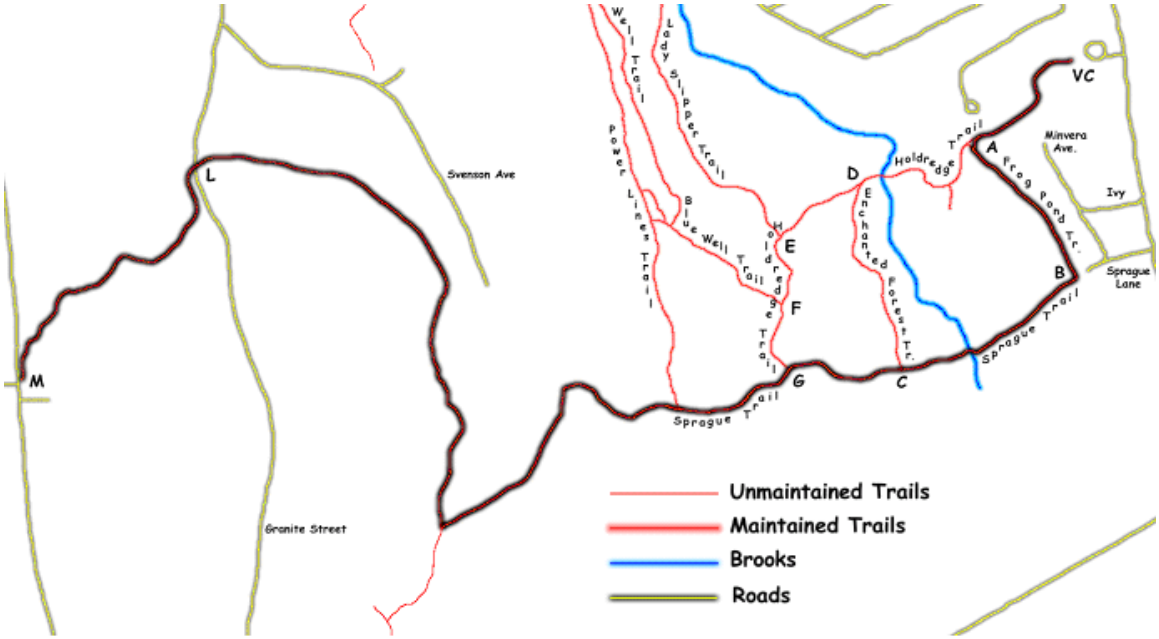


Figure 45 (Connection to the Blackstone River Valley)

Trails Included:

Holdredge Trail: Visitor's Center to A

Frog Pond Trail: A to B

Sprague Trail: B to M

Trail Length Before Modification:

2.15 miles or 11370 feet

Grades Involved Before Trail Modification:

Grade	Length	Percent of Trail Length
0 – 5%	5727	50.4%
5.1% - 8.33%	2038	17.9%
8.34% - 10%	1498	13.2%
10.1% - 12.5%	962	8.5%
12.6% - 14%	460.8	4.1%
14.1% and Greater	684.2	6.0%

Estimated Upgrading Cost:

$500,000

Natural Attractions:

The Sanctuary will become a main natural attraction for those using the bike path along the Blackstone River. Every natural aspect of the Sanctuary will be touched upon by this trail. A wide array of landscape characteristics and ecosystems will be seen when walking this trail.

Advantages:

The Massachusetts Audubon Society seeks to have a trail that connects the Visitor's Center at the Sanctuary and the Blackstone River Valley National Heritage Corridor. The northern end of Route 146, connecting to Interstate 290, is currently being upgraded to a four lane divided highway. A bike path is also being constructed running parallel to the Blackstone River. The Blackstone River, Route 146, and the bike path all converge at the intersection of Millbury Street and Route 146. With the revitalization of the Blackstone River Valley it is hoped that further interest in the Sanctuary is also created. Leaders at

the Sanctuary hypothesize that by connecting their trail network to the bike path near Route 146, it will be the catalyst for increased awareness and use of their trail network.

Disadvantages:

An All Persons trail of this magnitude is relatively untested in terms of popularity. We were told by a few people who live at the Sanctuary that in their years there, seeing countless people flow through the gates, they have never seen a single person with severe mobility impairments. It would be unfortunate if a large amount of funds were procured, the trail was built, and no one came to use it. Building a two mile trail without knowledge of how many people would legitimately use it is a risk. It is possible to survey people with disabilities and ask them if they would hypothetically use the trail if it were built, but it is hard to know how many will actually use it. It is our recommendation that the Sanctuary build another shorter option first. If there is interest in other trails and they attain a high level of use, then we recommend they consider upgrading the trail to the Blackstone River. It is big a risk to build a $500,000 trail when the need for any All Persons trail is unknown.

If the Audubon Society decides to proceed with this project, they may wish to take it on in stages, first starting with the Sprague Trail Spur, then adding the Enchanted Forest Trail loop, and based on the success of those two additions, add the connection to the Blackstone River Bike Trail.

5.2. Type of Trail

Originally we had planned on addressing each section of the trail as a candidate for each of the different possible types of trail: improved footpath, paved, or elevated boardwalk. This decision was made because it seemed that each of the trail types had their own set of advantages and disadvantages, and that these would result in one trail type being more optimal than another. After some research, we determined that a preferable solution is to prevent the problems that make any type of trail troublesome, and then to go with the most natural of all trail types. To help the Sanctuary preserve its natural look and feel, as well as save money, we opted for trail construction almost completely in improved foot path. The two main problems with improved footpaths are that they are low to the ground which permits flooding, and that they are prone to erosion. These two problems are related largely to the water in the surrounding area. If that water can be allowed to flow without disrupting the path then there will be no disadvantages to the improved footpath. In the area where water needs to flow across the trail pipes can be buried under the path. In areas where water needs to flow along the trail, crushed stone can be laid under the trail. If problems occur due to a high water level, any type of trail will be flooded. The Stabilizer product, however; does not fall apart when flooding occurs. The path will get spongy for a while until it dries out. Once dried, the path will return to its original state. The condition of the path can actually be improved by flooding as cracks in the path that have occurred from the ground shifting will have a chance to resettle and reseal themselves.

5.3. Material

The selection of the surface materials for our proposed trails was based on the several considerations. We had to consider the use and intensity of the trail, terrain, climate, design life, maintenance, cost, and availability. While analyzing our trail, we characterized it by the following:

Characteristic	**Our Trail**
Use and Intensity of Trail	Will be used by All Persons, and has to be able to withstand the wear and tear of people walking and using it constantly
Terrain	Rocky, roots, and with regular soil
Climate	Experience all 4 seasons, harsh winter and hot summer
Design Life	As long as possible
Maintenance	Very little maintenance
Cost	Moderate to low cost
Availability	Preferably local contractor

Looking at the needs and characteristics for our trails and considering the wide range of materials that we can use, we recommend using a soil treatment stabilizer for the entire length of the trail. There were many different types of surface treatments that could be used, but we had to take a major consideration in the availability and experience of the material and contractor. Taking this in consideration, there was a local contractor, Paul Mastro, who has had a lot experience in building trails with a soil stabilizer called Stabilizer. Stabilizer is a non-toxic organic soil additive for crushed stone surfaces. It is a colorless, odorless concentrated powder that is natural glue. Stabilizer binds and locks aggregate screenings to provide a firm natural surface for pathways. Stabilizer has also

been used in local Mass Audubon Sanctuary's as to larger more well known parks such as New York's Central Park. Stabilizer has all these characteristics and has been previously used; we believe this would be an ideal material for our trail.

5.4. Placement of Benches

The Sanctuary currently has several benches along the Holdredge Trail. These benches were placed near the more tiring sections of the trail. The current benches are adequate for the trailhead and Holdredge Trail, but inadequate for the entire park. The Enchanted Forest will benefit from the addition of a bench approximately half way between its two ends. The intersection of the Frog Pond trail and Sprague trail would be a good location for a bench as it has the easiest grades and therefore will attract the most people. The Sprague Extension Trail currently has no benches and has some more difficult grades. The trails that are not blazed on the far side of Granite Street will require benches and resting areas.

All of the bench locations should include an area to the side which is firm, level, and sufficiently large for wheelchair users to park and rest. These resting areas are a good location for informative signs about the surrounding animal or plant life as trail users will already be stopped and resting. These benches and resting areas should also be placed in coordination with difficult grades on the trail; trail users who have just traversed a steep hill will be tired and need a place to rest.

5.5. Proper Signage Along Wilderness Trails

Shown in Figure 46 is an example of a sign similar to the signs used at Dunn State Park. These signs are more than simple trail labels, they are guides to the condition and difficulty of each trail and an integral part of the trail network itself. These signs include information about the length, elevation, inclination, cross slope, width and firmness of the trails that they are marking.

This sign benefits from icons that illustrate what each of the words means. All of these icons have been taken from a standardized set of icons that were designed specifically to represent the words. These icons will help people with cognitive disabilities as well children and people with a low reading level, to understand the meaning and how difficult the trail really is. Whenever it is possible, helpful icons can make a sign more attractive and more accessible.

Signs should inform trial users about both average and maximum statistics. This way a trail user who thinks he can handle a steep slope for a small amount of time, can choose a trail with a low average but high maximum. Trail users who do not want to encounter any problems at all can go for trails with a low maximum.

It is important to include information about length as the primary concern for most users is how far they will have to travel. Second on the list are the inclinations that the trail

will have. Cross slope is an important statistic for people in wheelchairs or people who do not have good balance.

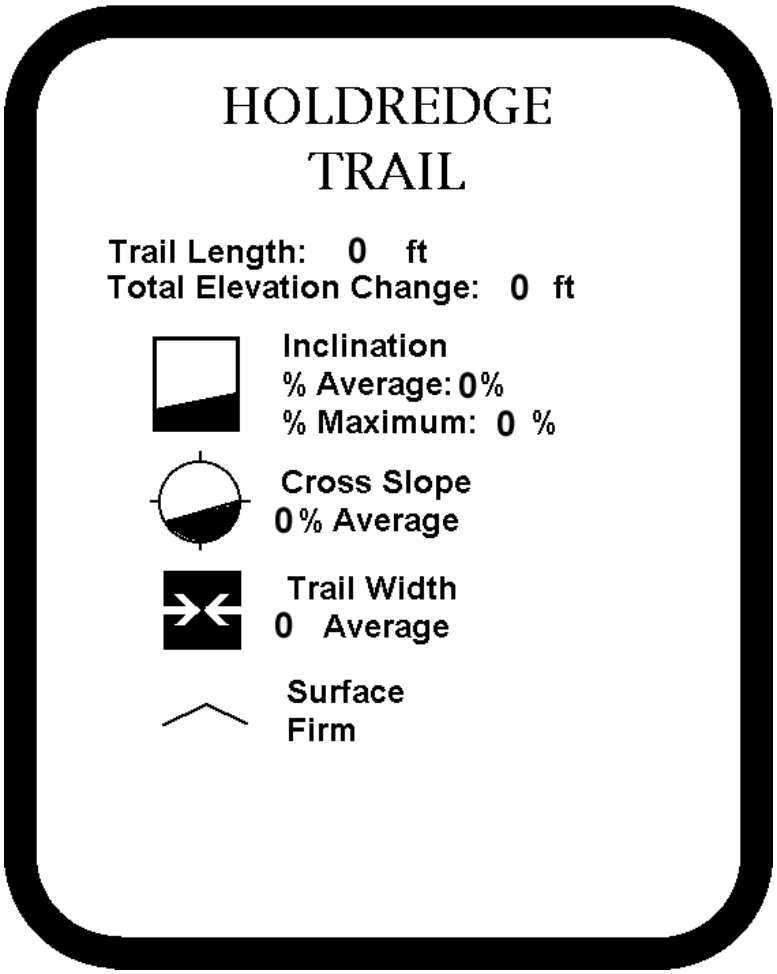
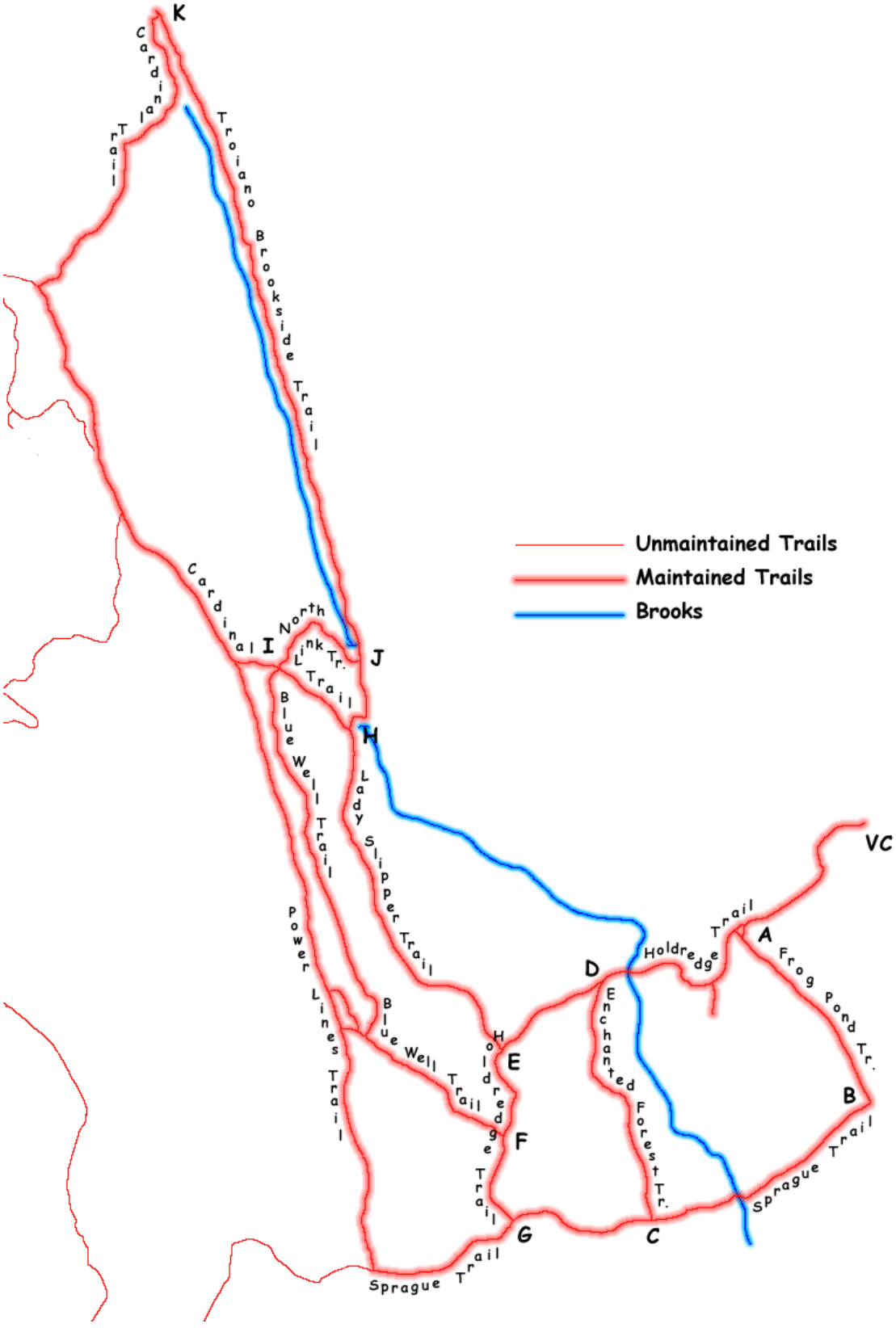
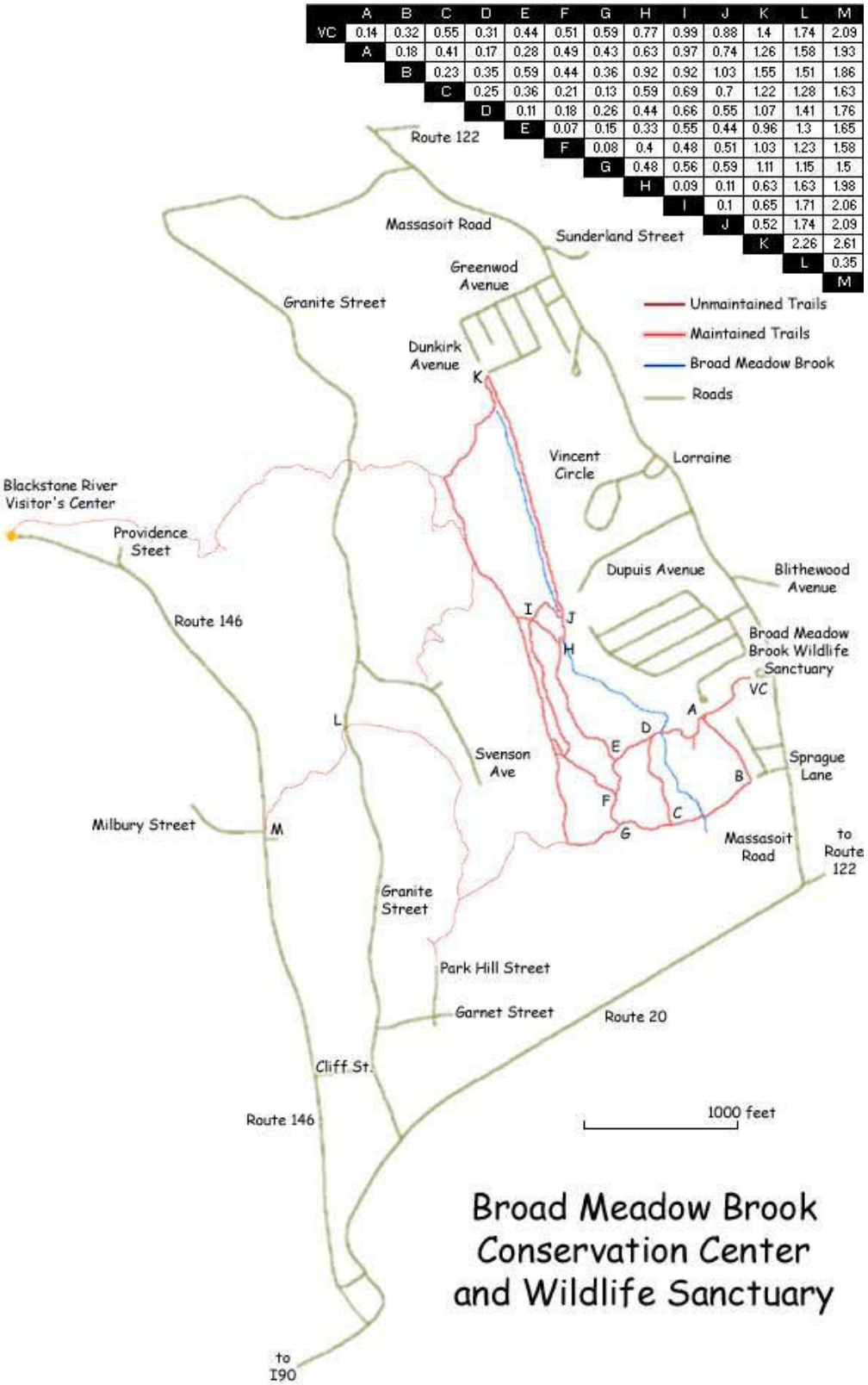


Figure 46 (Example of Standard Trail Sign)

5.6. Maps


K
Cardinal Trail
Troiano Brookside Trail
Unmaintained Trails
Maintained Trails
Brooks
Cardinal
I
North Link Tr.
J
Trail
H
Blue Well Trail
Lady Slipper Trail
VC
Power Lines Trail
Holdredge Trail
A
Frog Pond Tr.
D
Enchanted Forest Tr.
Blue Well Trail
Holdredge Trail
E
B
F
Sprague Trail
G
C
Sprague Trail
Sprague Trail



	A	B	C	D	E	F	G	H	I	J	K	L	M
VC	0.14	0.32	0.55	0.31	0.44	0.51	0.59	0.77	0.99	0.88	1.4	1.74	2.09
A		0.18	0.41	0.17	0.28	0.49	0.43	0.63	0.97	0.74	1.26	1.58	1.93
B			0.23	0.35	0.59	0.44	0.36	0.92	0.92	1.03	1.55	1.51	1.86
C				0.25	0.36	0.21	0.13	0.59	0.69	0.7	1.22	1.28	1.63
D					0.11	0.18	0.26	0.44	0.66	0.55	1.07	1.41	1.76
E						0.07	0.15	0.33	0.55	0.44	0.96	1.3	1.65
F							0.08	0.4	0.48	0.51	1.03	1.23	1.58
G								0.48	0.56	0.59	1.11	1.15	1.5
H									0.09	0.11	0.63	1.63	1.98
I										0.1	0.65	1.71	2.06
J											0.52	1.74	2.09
K												2.26	2.61
L													0.35
M													

Broad Meadow Brook Conservation Center and Wildlife Sanctuary

Through collecting data about the existing trail network at the Sanctuary we were able to construct a new trail map. The new map was made using Adobe Photoshop and the GIS map generated in MapInfo. The map we created is 40 inches in length and 30 inches in width, which we recommend being placed at an information kiosk. A smaller version was also created for addition to the trail map pamphlet that users of the Sanctuary carry while walking the trails.

Appendix A

Questionnaire

The Broad Meadow Brook Sanctuary seeks to add or modify some existing trails to be —AlPersons" accessible. In planning the trail we would like to incorporate your ideas and suggestions. Your input is very important to us. This survey is voluntary and you may omit answers to any particular question if you choose. No individual survey shall be identified or associated with their individual responses. This survey should take roughly less then 3 minutes to fill out. Thanks You!

1) How old are you?

( ) 18 or younger ( ) 19 to 40 ( ) 41-64 ( ) 65 or older

2) Are you currently a member of the Mass Audubon Society?

( ) Yes ( ) No

3) How often do you visit Broad Meadow Brook Sanctuary?

( ) Less than once a year
( ) About once or twice a year
( ) Several times a year
( ) About once a month
( ) Two or three times a month
( ) Every week
( ) Several times a week

4) What facilities do you use at Broad Meadow Brook Sanctuary? Check as many as apply

( ) Visitor Center ( ) Trails ( ) Programs

5) Do you have any physical disabilities that limit your use of the current trail network?

( ) Yes ( ) No

If yes, can you please describe them.

6) Do you believe an —AlPersons" trail would be beneficial to the Sanctuary?

( ) Yes ( ) No ( ) Don't Know

7) What qualities do you think are important to an —All Persons" trail? Please number 1-5 (1 being the least important, and 5 being the most important).

( ) More Benches and Resting Area ( ) Aesthetic Scenery of the Trail
( ) Level and Firm Surface ( ) Sign Coverage
( ) Slope of the Hills

8) Are the specific areas of the Sanctuary you would like to see have —All Persons" trails?

9) Do you have any comments or ideas for our —All Persons" trail?

Appendix B

Questionnaire Results

Ultimately our decision with the questionnaire results was that the obtained data was not substantial enough to merit truly valuable statistics. The section on questionnaires remains included as there are still generalities that can be drawn from it. If the questionnaire were in place for a longer period of time a more sufficient number of responses may have been obtained. The rate at which surveys were filled out yielded a total of 24 surveys over a period of 6 weeks.

Compile Statistics

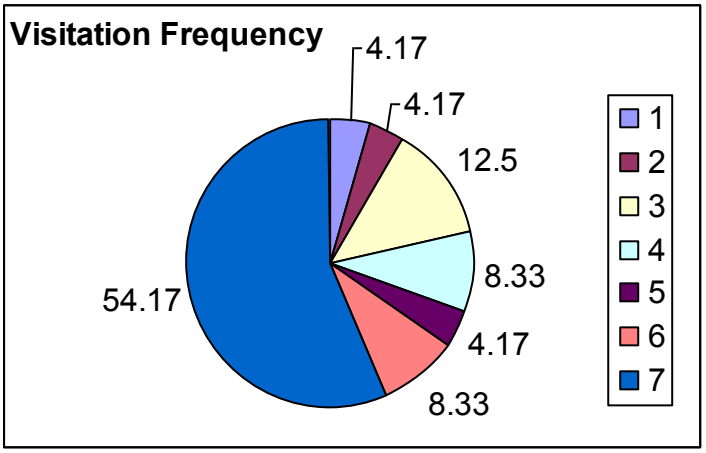
Although the questionnaire had a low response rate the data needs to be analyzed before to determine its usefulness. In analyzing the data there are several statistics of interest. Because the number of total questionnaires filled out was minimal, the survey statistics are compiled as percentages. For the purposes of this section, "the people visiting the Sanctuary" refers to the people who visited and filled out a survey. Figure 47 presents the tabular information from all of the surveys we received, information not conducive to this format, such as suggestions for trails to be upgraded, was not included.

Record #	Age Group	Member	Frequency	Visitor C	Trails	Programs	Disabled	Benificial	Benches	Asthetic	Level	Signs	Slope
2	2	☐	7	☐	☑	☐	☐	☑	1	4	5	3	2
3	2	☐	1	☐	☑	☐	☐	☑	2	3	1	4	5
4	2	☐	7	☑	☑	☐	☐	☑	2	3	5	1	4
5	2	☐	7	☑	☑	☑	☐	☑	3	5	1	4	2
6	1	☐	7	☑	☑	☐	☐	☐	3	2	4	1	5
7	2	☑	7	☑	☑	☑	☐	☑	3	1	5	2	4
8	2	☑	7	☑	☑	☐	☐	☑	3	5	5	2	4
9	3	☑	3	☑	☑	☑	☐	☐	0	0	0	0	0
10	2	☑	3	☑	☑	☐	☐	☑	2	5	1	4	3
11	3	☑	7	☑	☑	☑	☐	☑	2	3	4	1	5
12	3	☐	5	☑	☑	☑	☐	☐	2	1	3	5	4
13	2	☑	7	☑	☑	☑	☐	☑	2	1	5	3	4
14	2	☐	6	☑	☑	☐	☐	☑	1	3	4	2	5
15	3	☑	7	☑	☑	☑	☐	☑	3	1	5	2	4
16	3	☑	7	☑	☑	☑	☐	☑	3	1	4	2	5
17	3	☑	6	☑	☑	☑	☐	☑	4	5	5	5	4
18	3	☑	7	☑	☑	☑	☐	☑	4	1	4	1	4
19	2	☐	7	☐	☑	☐	☐	☐	1	2	3	4	5
20	3	☑	3	☑	☑	☑	☐	☑	4	2	1	3	5
21	3	☑	4	☑	☑	☐	☐	☐	3	3	3	3	3
22	1	☐	7	☑	☑	☐	☐	☑	4	5	1	2	3
23	2	☐	4	☑	☑	☐	☐	☑	4	5	2	1	3
24	2	☐	2	☐	☑	☐	☐	☐	2	5	1	4	3

Figure 47 (Questionnaire Data)

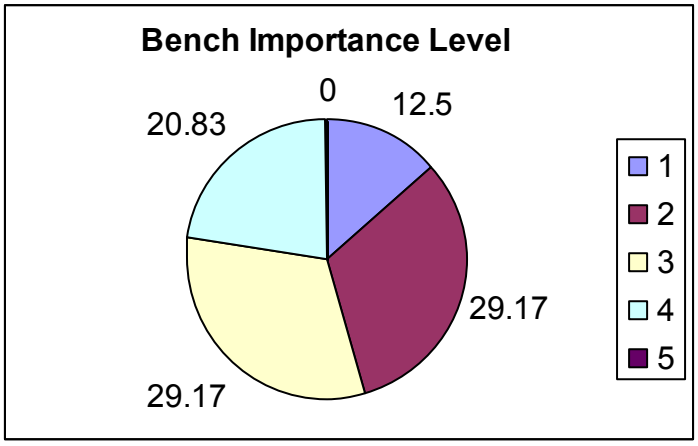
- Number of records: 24
- Average Age Group 19 to 40
- Age group distribution:
  - 8.33% Under 18
  - 50% 18-40
  - 37.5% 40-65
  - 0% Over 65

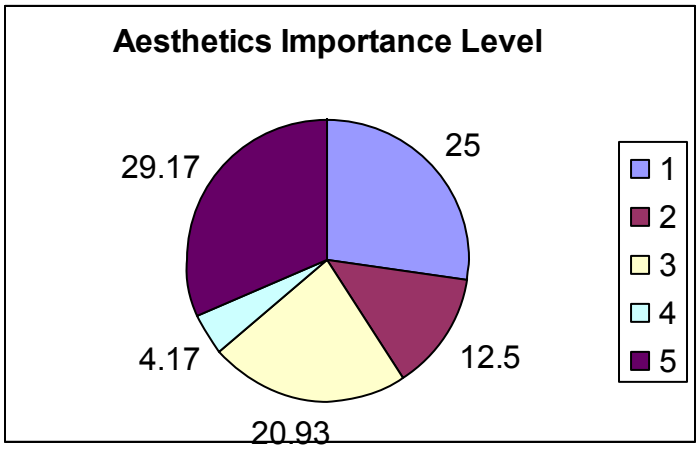
- Member percentage: 54.1%
- Average frequency: group 5.33
- Visitation frequency distribution:

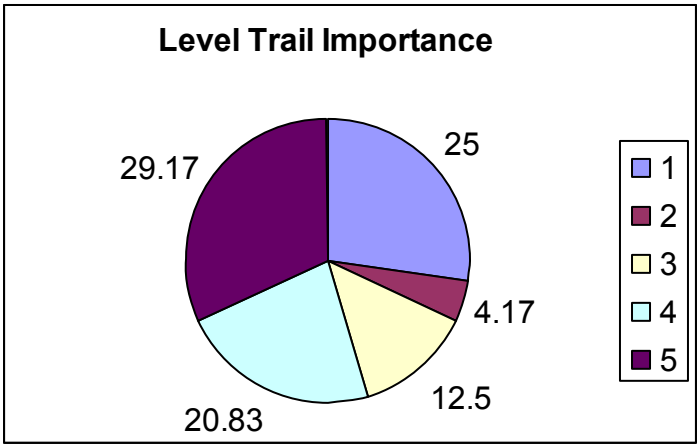


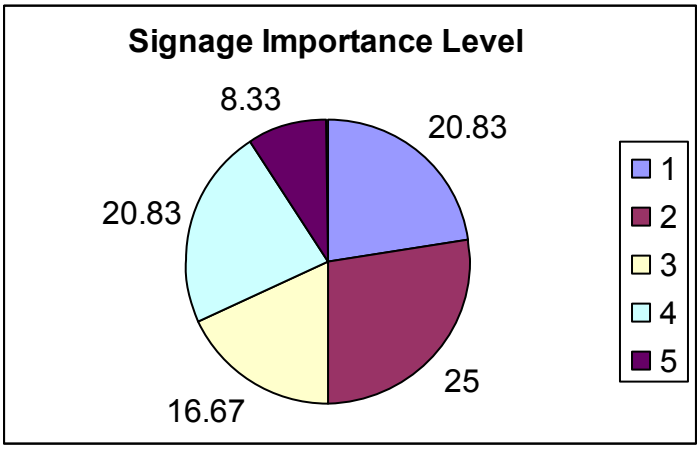
- Uses visitor center 83.3%
- Uses trails 100%
- Attends Sanctuary programs 45.83
- Disabled 0%
- Beneficial 75% think yes

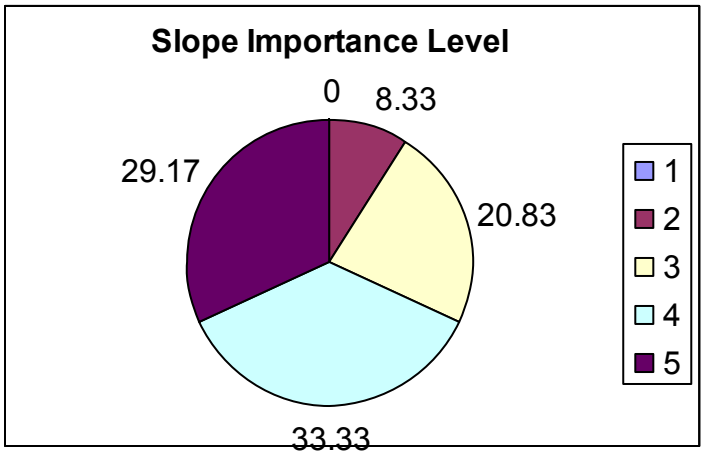
These pie charts represent the data acquired from our questionnaire in question 7 –What qualities do you think are important to an –All Persons" trail? Please number 1-5 (1 being the least important, and 5 being the most important)." (Appendix A) For example in the Bench Importance Level chart, 12.5 % of the people surveyed think that benches are the least important aspect in our All Persons trail.




Aesthetics Importance Level
25
29.17
12.5
4.17
20.93
1
2
3
4
5


Level Trail Importance
25
29.17
4.17
12.5
20.83
1
2
3
4
5


Signage Importance Level
8.33
20.83
20.83
25
16.67
1
2
3
4
5



Conclusions Drawn From the Questionnaire

Half of the population visiting the sanctuary was in the age group of 19 to 40 with 8.3% 18 and under and 37% over 40. None of the visitors to the sanctuary were over the age 65. This means that at lest two groups which the Sanctuary is trying to attract, the elderly and children, are not currently being enticed to come. An All Persons trail will make the sanctuary more desirable to these two groups.

54.1 % of the people who filled out the questionnaire were Audubon Society members, this is perhaps because members are more dedicated to the sanctuary and are more interested in its future. The large percentage of Audubon Society members filling out the questionnaire may also be caused because people who use the Sanctuary frequently have chosen to become members of the Audubon Society.

A dominating 54.2% of the people who filled out the questionnaire use the Sanctuary's facilities almost every day. People who use the Sanctuary quite frequently are more interested in the future of the organization. This may also be because people who work

for the Sanctuary took part in the questionnaire. Setting aside people who use the sanctuary every day, the majority of people use the sanctuary about one time every month, with a total of 12.5% The information regarding frequency of Sanctuary use can be applied to statistics gathered from other questions as well, a question answered by someone who uses the sanctuary quite frequently will have a more educated answer than a person who has only visited the sanctuary once.

Every person who came to the sanctuary uses the trails. This is an important statistic because it proves that the trails are the most vital part of the sanctuary. Of the people visiting the sanctuary 83.3% make use of the visitor center, because this number is so large our recommendation to place a parking lot in another location has been omitted. The incredibly high percentage of people who want to use the Sanctuary Visitor Center and the trail network enforces the necessity of an all persons trail connecting the two.

None of the people responding to our questionnaire had a disability that limited their use of the trail network. This is the expected response to this question, as people visiting the Sanctuary to use its trails most likely realized that they were in a suitable physical condition prior to leaving their homes. This statistic indicates that the sanctuary is not getting their desired amount of people with physical disability. The addition of an All Persons trail, especially when marketed towards people with disabilities, will attract this target group.

The set of questions asking people to order the importance of different trail features from least to most important for all persons yielded somewhat contradictory results. When deciding about the importance of aesthetics and level surfaced trails the surveyed population was broken up into two groups, with 25% of people thinking that they are un-important factors in trail construction, and 29.2% of people thinking that they are the most important thing to consider. This separation of opinions suggests that the people taking the survey did not understand the question or that there was some other factor making people feel strongly for, or strongly against taking extra consideration on aesthetics and level trails.

There was a general consensus regarding the importance of benches and slope considerations in All Persons wilderness trails, 33.3% of people said they thought slope was the second most important thing, and 29.2% of people thought it was the most important. This is possibly because when people think of disabilities they commonly think of mobility limitations. Over half of the people thought benches were the most or second most important thing to consider when planning the sanctuaries new trails.

Proper signage on wilderness trails was considered one of the least important factors. 45.8% of people thought it was the least important, or second least important. This is because the signs on a wilderness trail are often taken for granted. While the details of the trail itself are being noticed throughout a hike, the qualities of a sign are only noticed right at the beginning of a trail, or at an intersection.

Examples of Accessible Trails in Massachusetts

Arcadia Nature Center and Wildlife Sanctuary - The one-half improved footpath orchard trail is handicapped accessible for bird watching.

Ashland State Park - A quarter mile paved trail runs from parking lot to the reservoir and offers great views and benches.

D.A.R. State Forest - Features a one-half mile stabilized stonedust trail that travels through the woods alongside Upper Highland Lake. Includes benches, fishing pier, and lakeside views.

Dunn State Park - Features a three-quarter mile stonedust trail that leads through the forest.

Mt. Tom State Reservation - Features a one-half mile loop trail that winds along a section of Lake Bray and rambles through the forest and a large clearing. Includes fishing pier.

Pittsfield State Forest - A paved three-quarter mile trail known as the "Tranquility Trail" winds through the woods and crosses a brook. Taped audio tour available at park headquarters for visitors with visual impairments.

Savoy Mountain State Forest -A quarter mile of stabilized stonedust trail travels through woods and skirts the lake. Offers benches and views.

Scusset Beach State Reservation - A 7.5 mile paved walkway skirts the Cape Cod Canal and offers a fishing pier

Appendix D

Glossary

Americans with Disabilities Act of 1990 (ADA) — A Federal law prohibiting discrimination against people with disabilities. Requires public entities and public accommodations to provide accessible accommodations for people with disabilities.

Assistive Device - A device that assists users in accomplishing day-to-day functions (e.g. a wheelchair is an assistive device to assist a person who cannot walk).

Blaze – Small paint mark, symbol, or cut made in the bark of a tree to designate the trail location.

Braille - A system of writing, composed of raised dots in different patterns, that represents letters and numbers read with the fingertips by people who are blind. Grade II Braille is the most commonly used in North America.

Clinometer - A device for assessing slopes.

Cognition - The ability to perceive, recognize, understand, interpret, and respond to information.

Cognitive disability — Limitation of the ability to perceive, recognize, understand, interpret, and/or respond to information.

Cross Slope – Tilt of the trail surface toward one side of the trail or the lean of the trail left of right.

Developed trails - Trails that have been planned and prepared intentionally for use.

Disability - An individual is defined as having a disability when one or more of the following conditions apply: (1) a physical or mental impairment that limits one or more of the major life activities of an individual, or (2) a record of such an impairment, or (3) being regarded as having such an impairment.

Edge protection – Solid vertical edge used to define or limit the trail tread.

Geographic Information System (GIS) - A system of electronic maps that provide more information to the user than a conventional map would.

Global Positioning System (GPS) — A system that identifies position and elevation; a hand console is used to obtain data from an orbiting satellite.

Grade — The slope parallel to the direction of travel that is calculated by dividing the vertical change in elevation by the horizontal distance covered.

Inclinometer – A level that has a digital reading to measure the cross-slope.

Mobility impairment — A condition limiting physical ability; generally considered to include lack of a limb or loss of limb use due to disease, amputation, paralysis, injury, or developmental condition; or limitation of movement due to cardiovascular or other disease. Although visual or hearing impairments and cognitive disabilities can hamper ease of travel, people with sensory or cognitive impairments are not termed people with mobility impairments in this report.

Outdoor recreational access routes – A continuous unobstructed path designated for pedestrian use that connects accessible elements within a picnic area, camping area, or designated trailhead.

Passing space — A section of path wide enough to allow two wheelchair users to pass one another or travel abreast.

Protruding Object - Something that juts out or projects into a pathway and may cause injury or block access.

Rest area — A level portion of a trail that is wide enough to provide wheelchair users and others a place to rest and gain relief from prevailing grade and cross-slope demands.

Rolawheel - A wheel of known circumference with a ticker inside to measure the distance.

Surface type – The material that composes the majority of the best path of travel.

Switchback — A trail or road that ascends a steep incline by taking a winding course to reduce the grade of the path.

Trail — A path of travel for recreation and/or transportation within a park, natural environment, or designated corridor that is not classified as a highway, road, or street.

Trailhead - Location where users may enter or leave a trail.

Tread – The most traveled portion of the trail, cleared path of travel or the ~~–b~~eaten path."

Tread Surface -The surface of a pathway or upper horizontal part of a step.

Undeveloped trails - Trails that were created unintentionally by people frequently using a common route.

Universal Trail Assessment Process (UTAP) – Objectively documents the actual conditions in outdoor, natural environment. It is a tool that land managers, agencies and

individuals can utilize to learn about, monitor, improve, and use on any outdoor path of travel.

Visual impairment — Loss or partial loss of vision.

Appendix E

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Trails Surfaces and Manufacturers

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Soil Stabilization

Envirotac
Envirotac II(r) is a unique dust and erosion control product. When applied to the surface of any soil, it will penetrate down into the soil to create a tough layer of protection. Upon drying, Envirotac II(r) binds the soil's particles together forming a clear, plastic, resin bond. The level of Envirotac II(r) protection is determined by the amount used for each application. Contact vendor for pricing.
Environmental Products and Applications, Inc
PO Box 786
Gilbert, AZ 85299-0786
Phone: (480) 659-4747
Fax: (480) 892-7755
www.envirotac.com

Road Oyl
Resin Modified Emulsion. High bonding emulsion for use in pavement applications, dust control treatment and erosion control. Price varies with locations and quantity, contact vendor.
Road Products Corporation
329 East Jackson Avenue
Knoxville, TN 37915
Toll Free: (800) 685-0539
Phone: (865) 637-6227
www.roadproductscorp.com

T-NAPS
Total Natural Access Paving Systems. A natural oil emulsion derived from Pine trees, which binds aggregates. High strength non-petroleum binder used for flexible permanent

pavements and dust control. Price varies with locations and quantity, contact vendor.
George L. Throop Company
444 North Fair Oaks Avenue
PO Box 92405
Pasadena, CA 91109-2405
Toll Free: (800) 796-0285
Fax: (626) 796-4298
www.t-naps.com

Base Seal
Base Seal is a liquid soil stabilizer that was developed to bond and strengthen the subsurface of roads. Product has been used with clay, caliche, limestone, sandstone, or iron ore. Interacts as a powerful binder that keeps all particles cemented together. Environmentally safe. Non-toxic. Non-corrosive. Non-flammable. Non-allergenic. Approximate price $8.40 per gallon quantity discounts may apply.
Base Seal International, Inc.
15822 River Roads
Houston, TX 77079
Toll Free: (800) 729-6985
Phone: (281) 497-7743
Fax: (281) 497-1345
www.baseseal.com

Top Shield
Top Shield contains co-polymers developed to penetrate and create a hard resilient surface by cementing loose material into a tight bond. When properly applied, Top Shield will harden to remain dust free and moisture resistant. It provides a strong barrier against the effects of a freeze thaw cycle. Approximate price $8.40 per gallon quantity discounts may apply.
Base Seal International, Inc.
15822 River Roads
Houston, TX 77079
Toll Free: (800) 729-6985
Phone: (281) 497-7743
Fax: (281) 497-1345
www.baseseal.com

Klingstone 40
and Klingstone 400 (Formerly Known as Mountain Grout Soil Stabilizer)Klingstone is a one component liquid material designed to solidify or consolidate granular soils (and aggregates). It is a hydrophobic polyurethane. Can be applied simply by pouring directly onto surface. The cured surface is essentially inert. Allow for a cure time of 24 hours, although cure time is highly dependent on temperatures, moisture content and type of soil. Klingstone 40 is for sandy soils and Klingstone 400 is for aggregates. Approximate price $20 per gallon quantity discounts may apply.
Green Mountain International, Inc.

235 Pigeon Street
Waynesville, NC 28786
Toll Free: (800) 942-5151
Fax: (888) 632-5360
www.mountaingrout.com

PolyPavement
PolyPavement, the Natural Soil Pavement, is a non-toxic, non-corrosive, water-based polymeric compound. When applied to suitable soil, PolyPavement powerfully binds the soil particles forming a durable surface that is more supportive than asphalt, resists erosion, and looks completely natural. Approximate price for materials $0.35 per square foot at 2" thick.
PolyPavement
PO Box 36339
Los Angeles, CA 90036
Phone: (323) 954-2240
Fax: (323) 954-2244
www.polypavement.com

Stabilizer
Stabilizer is a non-toxic organic soil additive for dirt or crushed stone surfaces. It is a colorless, odorless concentrated powder that is a natural glue. Stabilizer binds and locks aggregate screenings to provide a firm natural surface for pathways. Stabilizer does not act directly on larger aggregate. Non-staining. Approximate price $2.25 per pound (contractor price), quantity discounts may apply.
Stabilizer, Inc.
205 South 28th Street
Phoenix, AZ 85034
Toll Free: (800) 336-2468
Phone: (602) 225-5900
Fax: (602) 225-5902
www.stabilizersolutions.com

2001
2001 is a complex polymer emulsion used for soil/aggregate stabilization that retains the adhesive characteristics of asphalt but offers more long-term protection from failure. Environmentally safe. Applied by spraying on surface, aerated, then compacted. Best to compact with vibratory compaction. Approximate price $9.98 per gallon quantity discounts may apply.
Enviroseal Corporation
1019 South East Holbrook Court
Port St. Lucie, FL 34952
Toll Free: (800) 775-9474
Phone: (772) 335-8225
Fax: (772) 335-3991
www.enviroseal.com

Terravest
Terravest is a liquid stabilizer used as a binder for single-size and multi-size dry sands, soils, and aggregates. Developed in Germany and is used on bike pathways. Liquid is mixed with material, then should be compacted or vibrated and will set within three hours. Long-term weathering resistance, high flexural strength, and resistance to de-icing salt. Environmentally safe. Approximate price $195.00 per 5 gallon bucket quantity discounts may apply.
Aqua-Shed Technologies
Fritz Kramer
PO Box 505
1304 Missouri Street
South Houston, Texas 77587
Toll Free: (800) 661-6646
Fax: (713) 947-9885
www.aqua-shed.com

Top-Seal
Top-Seal is environmentally safe, low cost chemical solution that is mixed with water and used to control and manage a variety of soil conditions. Top-Seal can be used to stabilize virtually any soil base by simply applying it in quantities that would be sufficient to bind and transform the base into a solid mass of tightly cemented soil particles. Creates a resistance to moisture. Quickly dries into a hardened membrane that will trap and bind soil particles and loose aggregate. Applied to the soil or aggregate and allowed to dry. Contains no chemicals harmful to humans, plants, animal life or equipment. Approximate price $16.00 per gallon quantity discounts may apply.
Soils Control International, Inc.
1711 East Central Texas Expressway
Suite 105
Killeen, TX 76541-9166
Phone: (254) 526-5550
Fax: (254) 554-5999
www.soilscontrol.com

Perma-Zyme
Perma-Zyme is a proprietary concentrated multi-enzymatic liquid soil stabilizer, manufactured exclusively by International Enzymes, Inc. It alters the properties of the earth material to create a dense bond. Perma-Zyme creates a highly compacted permanent base which will resist water penetration, rutting and washboarding, weathering and wear. The process typically takes two days, with a full cure over a 72 hour period. One gallon of Perma-Zyme will stabilize 165 cubic yards of base material. The approximate price is $350.00 per gallon ($0.039 per square foot for a 6-inch lift). Quantity discounts are available.
Enfra, LLC
4081 East La Palma Avenue, Suite A
Anaheim, CA 92807

Toll Free: (800) 501-9007
www.permazymeusa.com

Safety Deck
Safety deck tiles are made from recycled rubber tires. The 20" x 20" tiles interlock by five interlocking lugs on each tile. Openings in the tiles allow for grass growth. It can be paced on sod or a newly sown area. Approximate price $6.45 (black) or $6.95 (green) per square foot (retail).
Mat Factory
760 West 16th Street, Bldg. E
Costa Mesa, CA 92627-4319
Toll Free: (800) 628-7626
Phone: (949) 645-3122
Fax: (949) 645-0966
www.matfactoryinc.com

Geosynthetics
The Tenax Corporation produces a variety of "geogrids" used for soil stabilization, base reinforcement and soil confinement. Contact vendor for pricing.
Tenax Corporation
4800 East Monument Street
Baltimore, MD 21205
Toll Free: (800) 356-8495
Phone: (410) 522-7000
Fax: (410) 522-7015
www.tenaxus.com

Soil Saver
A heavy woven jute mesh that holds seed and soil intact on slopes, drainage ways, and other areas of concentrated water flow. It permits vegetation to grow through the mesh and is made from material that will decompose over time. Contact vendor for pricing.
Jim Walls Corporation
12820 Hillcrest Road, #109
Dallas, TX 75230-1516
Phone: (972) 239-8577

Presto Geoweb
A cellular soil confinement system with 8" diameter cells. The height of the cells range from 3" to 8". The product is sold in 8'x 20' sections. Approximate price $0.75-$2.00 per square foot depending on desired cell height.
Presto Geoblock
A plastic porous pavement system with a network of 3.1 in x 3.2 in cells (approx. 87% open area). The units are 1.64 ft x 3.28 ft. x 2 in (nominal). Approximate price is $3.00 per sq. ft.
Presto GeoRunner
A plastic open-mesh flexible access system for pedestrian or wheelchair

access. The plastic units weigh 8 lbs. and are approx. 2 ft x 4 ft. x ½ in.
Approximate cost is $1.75 per sq. ft.
Presto Products Company
670 North Perkins Street
Appleton, WI 54912-2399
Toll Free: (800) 548-3424
Phone: (920) 738-1118
www.prestogeo.com

Plastic Lumber

Bedford Plastic Timbers
Bedford Plastic Timbers are made of recycled plastic that are finished, non-toxic and have been laboratory tested for consistency and have been proven to be a superior alternative to treated wood, concrete, and steel. Lumber comes in a variety of sizes and colors. Requires no painting or staining, resists oils and chemicals, splinter-free, ultraviolet protected, environmentally safe, will not decompose, and saws and drills like wood. Approximate price per board $10.00-$29.00 depending on desired size and color.
Bedford Technology, LLC
2424 Armour Road
PO Box 609
Worthington, MN 56187-0565
Phone: (507) 372-5558
Fax: (507) 372-5726
www.bedfordtech.com

Dimensional Lumber
Dimensional lumber is 100% recycled plastic that provides an alternative to traditional lumber for use on boardwalks, decks, docks, and landscape projects. The dimensional lumber will not rot, crack, split or splinter. Can be cut, drilled or nailed using standard woodworking tools. Unlike treated lumber it does not leach chemicals that pollute surface and groundwater. Graffiti from magic markers, paint and dirt can be removed with soap and water or a commercial solvent and vandal carvings can be smoothed. Available in a variety of standard dimensions, lengths and colors. Approximate price per board $3.00-$103.00 depending on desired size and color. Government discounts available.
Plastic Recycling of Iowa Falls, Inc.
10252 Hwy. 65
Iowa Falls, Iowa 50126
Toll Free: (800) 338-1438
Phone: (641) 648-5073
Fax: (641) 648-5074
www.hammersplastic.com

Plastic Lumber
Plastic Lumber is a recycled high-density polyethylene formulation or a commingled formulation, which is available in a variety of lumber sizes and colors. The plastic lumber

will not splinter, rot, crumble or need painting saving in maintenance costs. Highly resistant to paint and marker graffiti. Approximate price per linear foot $0.80-$16.67 depending on desired size and color.
The Plastic Lumber Company
115 West Bartges Street
Akron, OH 44311
Toll Free: (800) 886-8990
Phone: (330) 762-8989
Fax: (330) 762-1613
www.plasticlumber.com

Mister Boardwalk
Semi-permanent modular system made of Trex decking, plastic lumber or wood material can be removed seasonally and is a "seamless" surface. Roll-Away walkway is made with treated pine and nylon cord. Contact vendor for pricing.
Mister Boardwalk
PO Box 789
Point Pleasant, NJ 08742
Toll Free: (800) 813-4050
www.misterboardwalk.com

Temporary Surfaces

Tuff Roll
Tuff Roll tiles are durable products designed with resilience and comfort in mind. Spike and weather resistant. Ideal for various indoor and outdoor applications. Can be loose laid or permanently adhered. Approximate price $3.50 per square foot.
Surface America
PO Box 157
Williamsville, NY 14231
Toll Free: (800) 999-0555
Phone: (716) 632-8413
www.surfaceamerica.com

Eco Trak
Eco Trak panels are polyethylene, 2' x 4' x 2" thick, with molded in traction pattern that promotes easy rolling, and drainage holes that help alleviate damage to existing environment as well as provide drainage. The panels can be permanently connected or - when portability or seasonality are issues- temporarily connected utilizing the Quick Connect system which permits assembly/disassembly without use of tools, electricity or specialized knowledge. The panels can be assembled in squares or rectangles for temporary event flooring, or in 4' or 8' wide paths for beach access or bike/ped/wheelchair paths. Cost determined by quantity. Bike Trak holds a Federal Supply Schedule contract with GSA.
Bike Track Incorporated
PO Box 235

Woodstock, VT 05091
Toll Free: (888) 663-8537
Phone: (802) 457-3275
Fax: (802) 457-3704
www.biketrack.com

Superdeck
These modular walk and deck panels are made of polyethylene with UV inhibitors. It can be laid directly on wetland areas or sand. Support floats of varying thickness can be added to increase floatation. Deck panels laid directly in a wetland or beach/sand area cost $9 - $10.00/sq. ft., adding optional flotation to the panels or "system", increases approximate cost to $22 - $24.00/sq. foot. Additional optional accessories such as railing assembly or curbing are sold per linear foot.
Aggressive Industries
8365 Sunset Road North East
Minneapolis, MN 55432
Toll Free: (800) 355-4093
www.superdecksystems.com

Portafloor
Roll-out flooring system which can be used to provide a firm, dry support base for a wide range of activities on a variety of ground surfaces. Little or no ground preparation is required and the rugged, non-slip surface incorporates drainage and ventilation slots. Contact vendor for pricing.
PortaFloor
Sport Court, Inc.
939 South 700 West
Salt Lake City, UT 84104
Toll Free: (800) 487-7655
Phone: (801) 972-0260
Fax : (801) 975-7752
www.portafloor.com

Mobi-mat
Lightweight, portable and flexible material to be used on sand surfaces. Contact vendor for pricing.
Deschamps
Usine de Bourisson B.P. 20
F-16400
La Couronne
France
International Phone: 33 (0) 545-677-030
International Fax: 33 (0) 545-678-160
www.deschamps.fr

Rollout Path System Kit
Originally designed for the beach, the lightweight Rollout Path System works on sand and a variety of other soft surfaces. 4-ft by 50-ft section is approximately $636.35.
P.A.T.H.S. (Providing Access Through Hard Situations)
30 Hedgewood Drive Unionville
Ontario, Canada
L3R 6J6
Phone: (416) 816-7130
Fax: (905) 943-7446
www.paths.com

Diamond Rubber Mats
Recycled rubber mats. Combines textured surfaces to provide cushioned comfort. Virtually maintenance free, they are easily installed in both new and existing facilities over any firm surface. Contact vendor for pricing.
Big Sun Equine Products, Inc.
Ocala, FL
Toll Free: (800) 366-9645
www.bigsunproducts.com

Privacy (Long Life) Lattice
Lattice available in a variety of styles and colors. 4-ft by 8-ft section retails at approximately $20.00 each.
Available at your local Lowe's store, or
Brite Manufacturing, Inc.
Corporate Head Office
2 Manchester Court,
Bolton, Ontario
Canada L7E 2J3
Phone: (905) 857-6021
Fax: (905) 857-3211

Materials

Brik-Trak
This product is most commonly used for baseball warning tracks. It is crushed brick and is often referred to as "brick dust". Manufacturer's suggested application is 1 ½" compacted product then apply another 1 ½"of product and compact. Cost $48.00 a ton; pick up only. Delivery not available.
General Shale Products
PO Box 3547
Johnson City, TN 37602
Toll Free: (800) 414-4661
www.generalshale.com

Brown Crushed Limestone
Same bonding properties as standard white limestone but offers a more natural look. Cost $5.50 a ton.
St. Paul Stone Corporation
519 South County Line Road
St. Paul, IN 47472-9431
Phone: (765) 525-6312

Wood Surfacing

Fibar
Fibar is a surface composed of 8" to 12" of specially shredded wood fibers and a patented drainage system underneath. The fibers lock together to form a solid surface resisting movement of material. Price quotes available upon request.
Fibar Systems
80 Business Park Drive, Suite 300
Armonk, NY 10504
Toll Free: (800) 342-2721
Phone: (914) 273- 8770
Fax: (914) 273-8659
www.fibar.com

Woodcarpet
Woodcarpet is an engineered wood fiber manufactured from fresh wood. Woodcarpet is an all-weather surface used in 50 states and 6 provinces, and it meets ASTM F 1951 for public playground surface accessibility. The recommended depth to install Woodcarpet is 6" to 8" after compaction for trails and 8" to 12" after compaction for playgrounds.
Zeager Bros., Inc.
4000 East Harrisburg Pike
Middletown, PA 17057
Phone: (800) 346-8524
Fax: (717) 944-7681
www.woodcarpet.com