Newfound Lake
Watershed Master Plan

GIS Technical Report

Prepared for the Newfound Lake Region Association

Prepared By

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GreenFire GIS Mapping & Analysis

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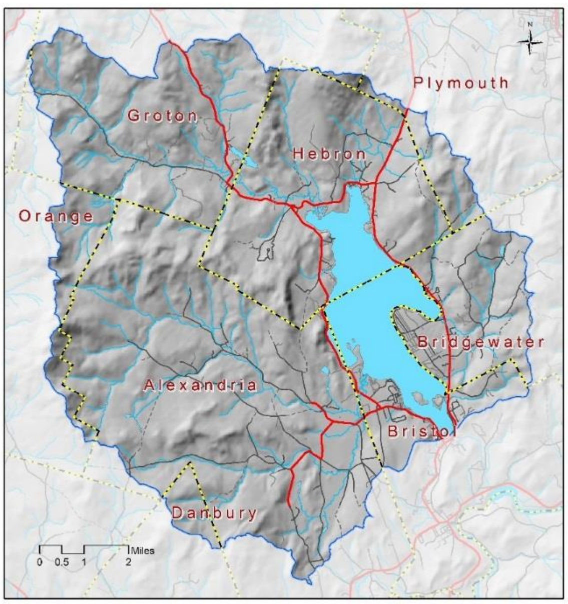
Executive Summary

Introduction

This report has been prepared in support of the Newfound Lake Watershed Master Plan as part of extensive GIS-based mapping and analysis performed in the course of the multi-year planning process. The information presented in the report covers two separate investigations:

- Mapping and analysis of a range of water quality-related natural resources has been conducted to identify those areas within the Newfound Lake watershed that are most suitable for future development and/or conservation; and,
- A "build-out analysis" for the Newfound Lake watershed that seeks to forecast development patterns and related water quality impacts within the watershed. This analysis included an example of local land-use planning with in-depth evaluation and recommendations for the Fowler River watershed, focusing on its high-yield aquifer and prime agricultural soils.

Study Area



The study area is the Newfound Lake watershed, a relatively small area compared to other lake watersheds in New Hampshire at a little more than 61,000 acres, or about 95 square miles in size. The watershed is defined by the topographical height of land surrounding the lake, and closes at the lake outlet at the dam in Bristol. The actual land area within the study area is 56,326 acres.

The map to the left shows the configuration of the watershed study area, and the municipalities included within the watershed. The topographic background illustrates the complex and often steep terrain found within the watershed. The land rises from a lake elevation of roughly 586', to the summit of Mt. Cardigan at about 3,120' which is part of the watershed boundary to the west of Alexandria.

Part 1: Resource Analysis & Co-Occurrence Mapping

Background

This study uses GIS technology to accomplish mapping and to perform statistical analysis of various features found in the maps. GIS relies upon digital versions of mapped data which are available from the state's geographic information data library at GRANIT, a program of the University of New Hampshire, as well as various state and federal agencies.

Twelve natural resource features were evaluated in this study. They can be grouped as follows, and are presented in this report in the following order:

- Surface Water Resources
- Drinking Water Resources
- Steep Slopes & Highly Erodible Soils
- Wildlife Habitat
- Prime Agricultural Soils & Most Productive Forest Soils

Highlights of Findings

A brief overview of the natural resources considered follows, with statistics on extent within the Newfound Lake watershed, and current protection status[1]. See the full report for more detailed information and mapping.

Surface Water Resources

Riparian Buffers are naturally vegetated corridors along streams and rivers that play a critical role in filtering sediment and nutrients before entering the water ecosystem. **Riparian buffers amount to 4.7% of the watershed, and are currently about 16% protected.**

Wetlands offer multiple benefits including flood water storage, biological purification, and important wildlife habitat for a number of species of plants and animals. **Wetlands cover 3.5% of the watershed, and are 14.2% protected.**

Floodplains provide flood water storage and transit, and are home to unique natural communities. **Floodplains involve 1.7% of the watershed, and are 13.4% protected.**

Drinking Water Resources

Sand & Gravel Aquifers underlie the Cockermouth and Fowler River valleys, and represent the most readily available groundwater supplies for public drinking water systems. **Aquifers cover 6.1% of the watershed, and are 8.9% protected.**

Favorable Gravel Well Sites with potential to provide uncontaminated water for future water supplies have been mapped by the N.H. Department of Environmental Services (NHDES) within the aquifer formations. **Future well sites on aquifers involve 1.8% of the watershed, and are 9.4% protected.**

Source Water Protection Areas around existing public water supplies have also been mapped by NHDES. The Bristol Water Works wellheads in the Fowler River aquifer currently serve more than 3,400 persons. **Collectively, source water protection areas cover 8.4% of the watershed, and are 15.1% protected.**

Steep Slopes & Highly Erodible Soils

Steep Slopes in this study are classified as greater than 25%, or a rise of one foot in a horizontal run of four feet. Slopes >25% are considered unbuildable, and if disturbed will rapidly erode, contributing

[1] Resources are considered to be protected if they are found on conservation and/or public land with legal agreements recorded to prevent development from affecting the resource.

significant sediment load to run-off. **Steep slopes >25% involve 22.2% of the watershed, and are 25.8% protected.**

Highly Erodible Soils have physical properties that make them prone to rapid erosion if disturbed, especially on steep slopes. **Highly erodible soils are widespread and common in the watershed at 68.5% of the land area, and are 20.2% protected at present.**

Wildlife Habitat

Wildlife Habitat Quality is a component of the N.H. Wildlife Action Plan (NHWAP) which has mapped areas statewide for intrinsic habitat quality and condition. Tier 1 areas are considered the best in the state; Tier 2 areas are best in the bio-region. **Tier 1 habitat zones cover 41% of the watershed, and are 22.8% protected. Tier 2 zones cover 10% of the watershed, and are 32.7% protected.**

Terrestrial Habitats of Concern in the Newfound Lake watershed include 9 of 16 habitat types mapped by the NHWAP. These are the least common habitat types, often found in small occurrences known as "patch habitats". **Grouped together, these habitats involve 34.1% of the watershed, and are 29.1% protected.**

Most Productive Farm & Forest Soils

Prime Agricultural Soils are rated by the National Resources Conservation Service (NRCS, formerly the Soil Conservation Service) as the most productive for croplands and forage production. **Prime agricultural soils are found on 3.7% of the watershed, and are 6.2% protected.**

Productive Forest Soils are also rated by NRCS for high-volume production of commercial timber species. **These soils are extensive within the watershed at 87.2% of land area, and are 16.9% protected.**

In summary, the Newfound watershed contains numerous high-value natural resources that are generally not well protected from development.

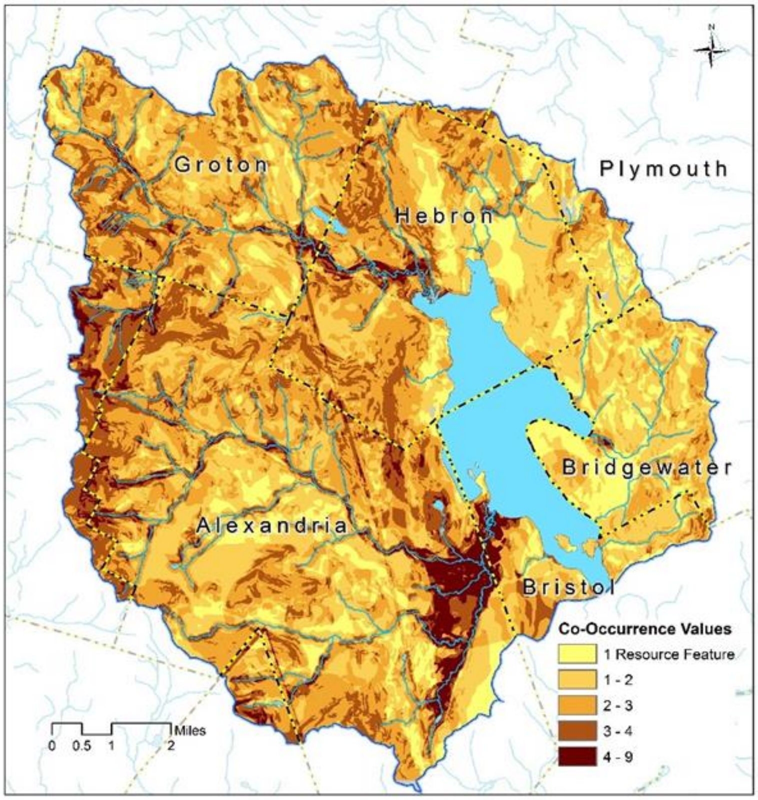
Co-Occurrence Mapping

The natural resources listed above have been combined in the GIS to produce a co-occurrence map that shows where one or more resource features are co-located, or are overlaid on one another. The map on the next page shows the results of that mapping exercise, with darker colors indicating where several resource features co-occur.

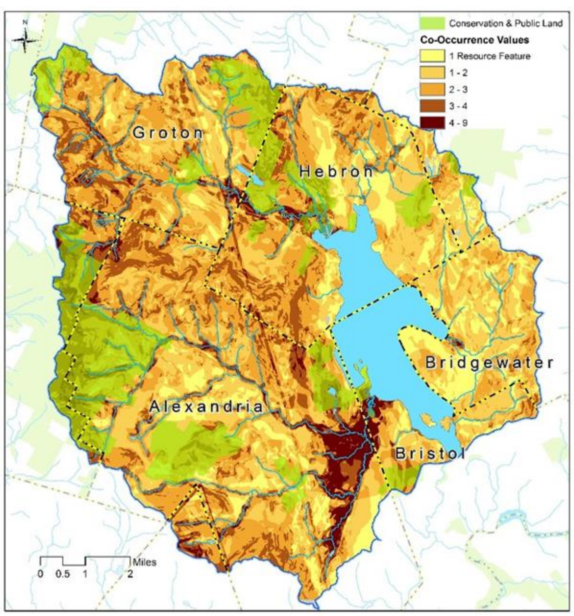
The areas with higher occurrences of natural resource features are important considerations for community planning for two reasons:

- Key resource features that provide eco-system services such as flood water storage and filtration, significant wildlife habitat, drinking water, and productive soils are high-priority for conservation; and,

- Resources that affect water quality in Newfound Lake and its tributary water courses such as steep slopes, highly erodible soils, and riparian buffers require recognition and stewardship in community development plans.



Resource Co-Occurrence Map



Resource Co-Occurrence Map

Statistical Analysis of Resource Analysis

The map to the left shows existing conservation and public lands (green) overlaid on the resource co-occurrence map. Using this data, the extent of each natural resource feature and its protection status has been determined for each of the five principal towns in the Newfound Lake watershed. Clearly, several areas of high importance in the co-occurrence map are not adequately protected. See **Section 4: Statistical Analysis** the main body of the report for the summary table and interpretation of the extent and protection status of the various natural resources considered in this study.

Part 2: Build-Out Analysis

Purpose

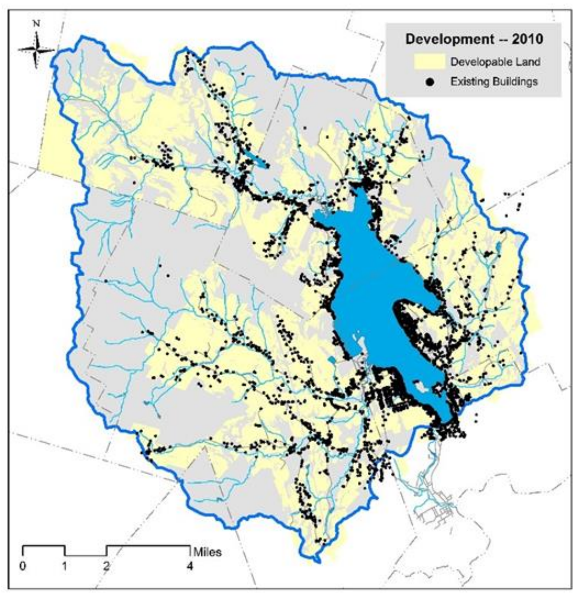
The purpose of conducting a build-out analysis is to predict with reasonable certainty how future development patterns are likely to occur in a given study area. Commonly used for community planning purposes, this build-out analysis addresses the entire Newfound Lake watershed by looking at historical development trends for entire towns within and outside the watershed, and land utilization within the watershed over time. Then, using realistic development constraints, the model systematically extrapolates those trends into various future time periods.

Methodology

A customized methodology for conducting a build-out analysis was designed for the Newfound Lake watershed due to the lack of local land use regulations such as zoning ordinances which determine lot sizes, frontage requirement, and density in some communities. This alternative approach used relies upon two sets of evaluation:

- Land considered **likely to develop** due to accessibility from existing roads and highways, constraints to development such as steep slopes, wetlands, floodplains, and utility rights-of-way, and/or current status as conserved land or land in institutional use; and,
- Prevailing patterns of recent subdivision and lot sizes which are used to assign varying densities of tract utilization for future development on land now undeveloped.

Using "multipliers" determined from the second analysis, undeveloped land deemed likely to develop in the future was "populated" with new housing using estimated growth rates and a utility in the GIS that generates a graphic representation of new development.

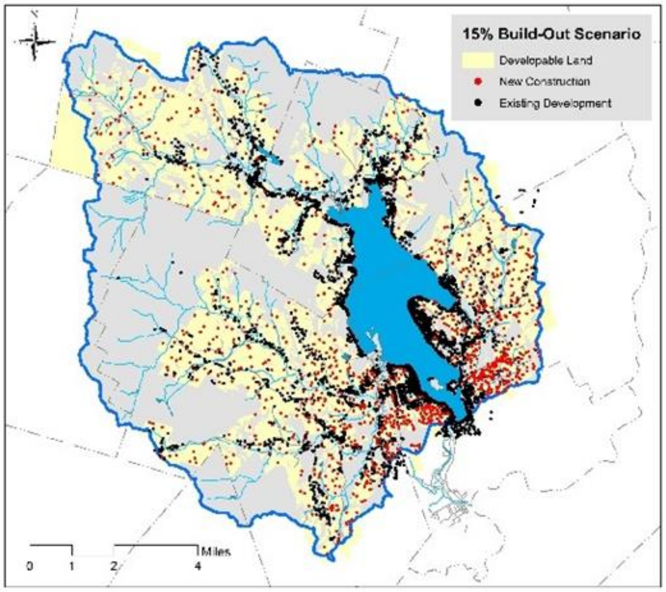


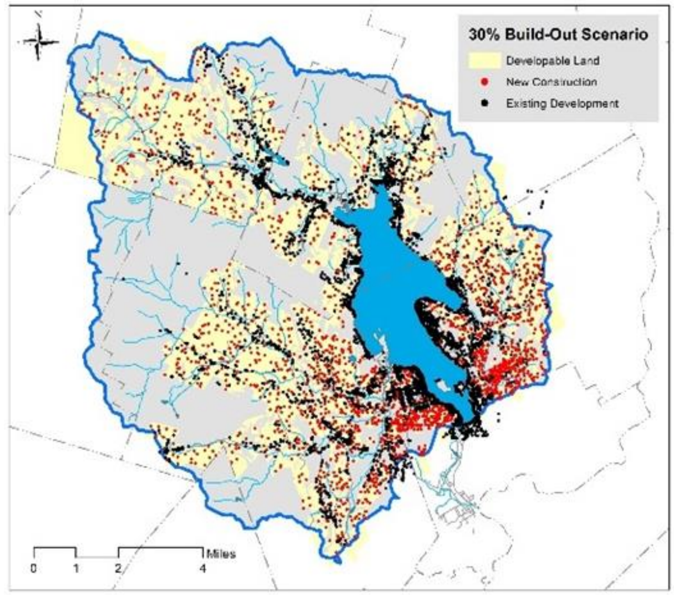
The map to the right shows a baseline inventory of existing buildings within the Newfound Lake watershed, based on 2010 high resolution aerial photography. The land most likely to develop is shown in the light yellow color.

A total of 3,740 building are recorded in the map, with about 95% of those classified as residential buildings.

The maximum build-out determined by the model run would result in more than 8,000 new building units in the watershed, or 215% growth over the 2012 base of about 3,740 buildings identified in the 2010 aerial photography.

The two maps on the next page show the results of the build-out analysis for two stages of development: 15% and 30% total build-out, which have been selected for study since the two scenarios represent potential near-term future possibilities.





The red dots in each map show where new development is likely to occur given the inputs to the build-out analysis model. Density is higher at the southern end of the lake, in keeping with current densities and recent subdivision experience. Lower densities in the 5-acre and greater lot range extent into all other areas. **The 15% scenario would add about 1,100 new buildings – mostly new homes – or about 30% more than current baseline conditions, and the 30% scenario would add 2,340 new buildings, or about 63% over baseline.**

In terms of timeframe for each scenario, given the prevailing average annual 1% rate of growth in watershed over the past decade and a half, it would take about **15 years to reach the 15% build-out, and perhaps 30 years for the 30% build-out to occur** if the regional growth rate stays constant.

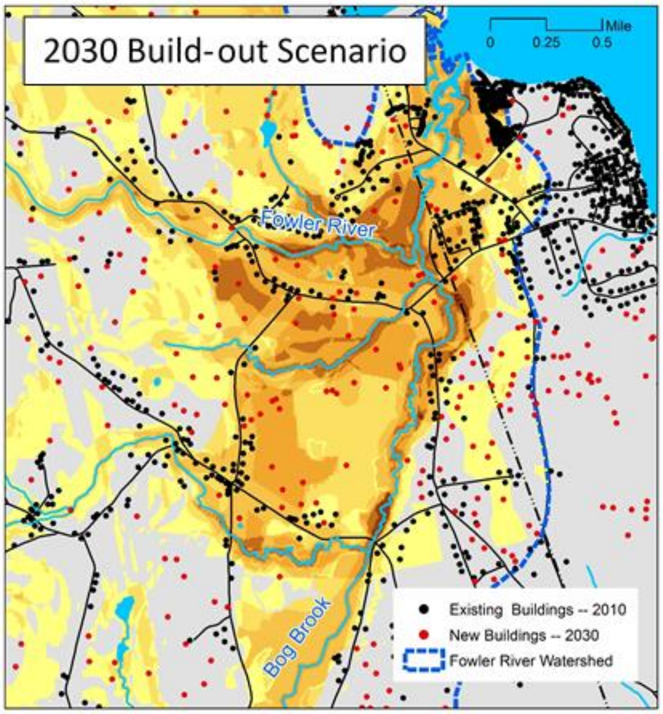
In both scenarios, the increase in impervious surfaces, lawns, etc., especially in the southern half of the lake watershed, will have obvious adverse effects on lake water quality if measures are not taken during design, construction and occupancy to avoid increased loading of sediment and nutrients.

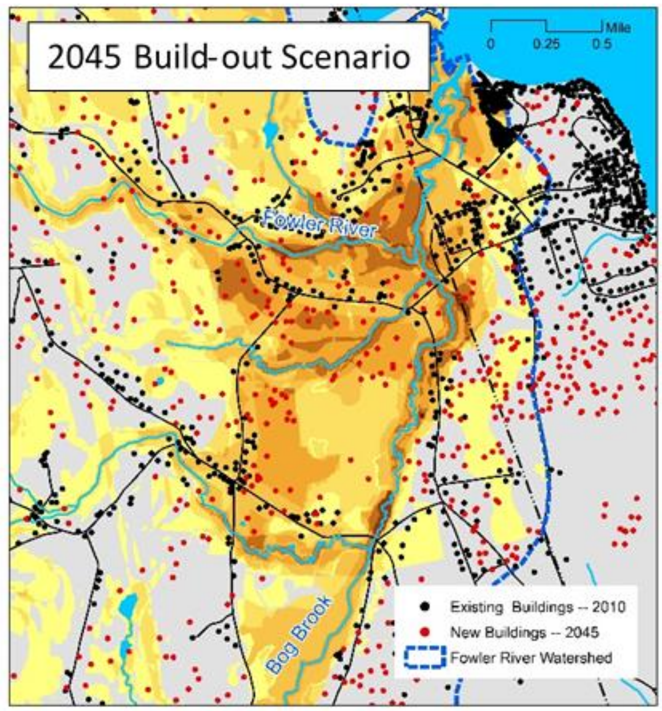
In summary, many of the watershed's most critical resources occur in more than one location, making large areas of land extremely sensitive to development. The analysis clearly indicates both areas that should be protected or very carefully developed, and areas where higher-impact development is more suitable.

Fowler River Development Study

As part of the watershed-wide build-out analysis, a special study of the Fowler River and Bog Brook valley and aquifer area in Alexandria and Bristol has been made to investigate how the resource information considered in the co-occurrence mapping relates to development scenarios in that area. The area is readily apparent as a high-scoring feature in the co-occurrence mapping, and it contains easily developed land in the path of the next wave of new construction. It is also a critical groundwater recharge zone for the Bristol Water Works wellheads (see body of report for more information). The method and recommendations from this analysis can be used as an example for other towns within the watershed.

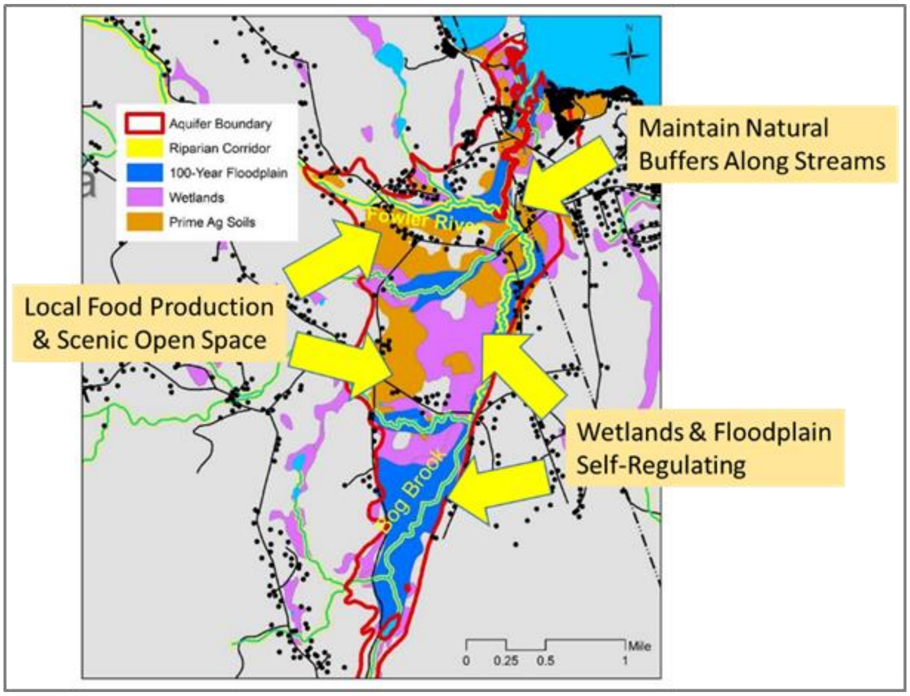
The maps below show development scenarios on the Fowler River aquifer area co-occurrence mapping near Newfound Lake for the 15% and 30% build-out scenarios (translated here for 2030 and 2045). The red dots are new development. Note the extensive development predicted on the aquifer itself which is defined by darker colors and along the river and its tributaries.





Various recommendations are presented in the report as an example of how communities can address this confluence of important natural resources in the context of planning for future development. However, a simple approach is illustrated on the nest page, where development constraints are identified (wetlands, floodplains), maintenance of natural filtration riparian buffers is emphasized, and prime agricultural soils are reserved for local food production and scenic farmland.

With this approach, development on the Fowler River aquifer can be limited and guided to the most suitable locations, while at the same time maximizing protection of water quality and clean drinking water for the existing Bristol Water Works and other potential water supply wells. **Using a similar approach to this analysis, communities can protect their critical resources and direct low-impact development through zoning, overlay districts, subdivision regulations, and conservation.**



Introduction

Background

This report has been prepared in support of the Newfound Lake Watershed Master Plan as part of extensive GIS-based mapping and analysis performed in the course of the planning process. Specifically, mapping and analysis of natural resources related to water quality maintenance and enhancement has been generated to investigate and identify those areas within the Newfound Lake watershed which result in adverse impacts to water quality if converted from currently stable environmental conditions. A separate mapping and analysis exercise addressed in this report seeks to forecast development patterns and related water quality impacts within the watershed.

The entire Newfound Lake watershed master plan, and other related studies can be reviewed the following link to the Newfound Lake Region Association website:

http://www.newfoundlake.org/index.php/protect-the-lake-watershed/publications

Study Purpose

The Newfound Watershed Master Plan (*Every Acre Counts*) studies are intended to provide a knowledge base for and guidance to local decision-makers from two perspectives: suitability of vacant land for development and land conservation priorities. By combining sound community planning with well-defined conservation priorities at community scale, both approaches can provide positive water quality benefits to Newfound Lake and to the long-term economic health of the region. This report is intended to supplement and amplify information found in mapping provided by the Newfound Lake Region Association (NLRA) to the five municipalities principally located within the Newfound Lake watershed: Alexandria, Bristol, Bridgewater, Groton, and Hebron. Each community is encouraged to utilize both the mapping and the analysis presented in this report to augment their local efforts at community planning, with emphasis on water quality and quantity, e.g., sufficient supply and flood-protection measures in both the stewardship of natural resources and thoughtful direction of future community growth. It is also important to recognize that the watershed itself should be viewed as a dynamic natural system, and that communities working cooperatively across municipal boundaries will have the greatest positive impact on the centerpiece of the watershed and its economy: Newfound Lake.

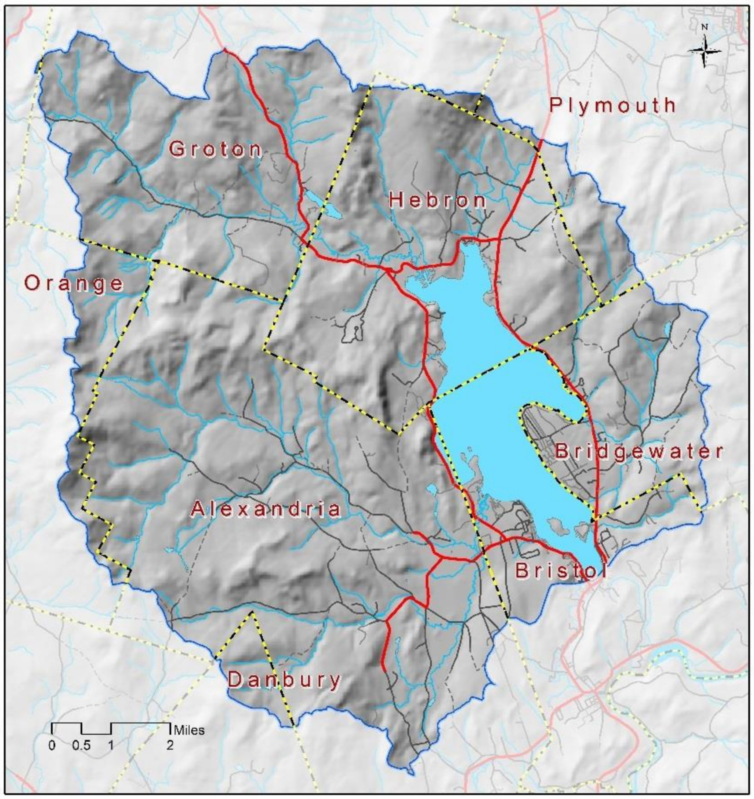
Study Area Definition

The study area is the Newfound Lake watershed, a relatively small region compared to other lake watersheds in New Hampshire at a little more than 61,000 acres[2], or about 95 square miles in size. The watershed is defined by the topographical height of land surrounding the lake, and closes at the outlet dam in Bristol. The actual land area within the study area is 56,326 acres. Alexandria has the largest share of the watershed with a little more than 22,000 acres, or about 39% of the land area. Hebron has the next largest share at about 11,400 acres, or 20% of the watershed, followed closely by Groton at 10,700 acres, or 19%. Bridgewater has about 5,300 acres in the watershed, and only a small portion of

[2] Previous studies of the Newfound Lake watershed used a watershed delineation based on the Newfound River drainage area. This report is based upon the land area of the watershed draining directly into the lake in order to conform to other water quality related studies conducted recently as part of the watershed master plan.

Bristol drains to the lake at about 2,500 acres. Small areas of the towns of Orange, Danbury, and Plymouth are also found within the watershed, all at the upper limits of the watershed.

The map below shows the configuration of the watershed study area, and the municipalities included within the watershed. The topographic background illustrates the complex and often steep terrain found within the watershed. The land rises from a lake elevation of roughly 586', to the summit of Mt. Cardigan at about 3,120' which is part of the watershed boundary to the west of Alexandria. Note also the drainages following the blue stream and river network, with local roads paralleling the drainage system in many locations.



Study Area

Report Organization

This report is divided into two major parts.

- **Part 1** addresses the mapping and analysis associated with the co-occurrence mapping of a range of important natural resource features within the watershed. The purpose of this analysis is to identify areas within the watershed that are important to consider when local communities are deciding suitability for future development and/or resource conservation priorities.
- **Part 2** is devoted to a "build-out" analysis for the entire watershed to illustrate probable development patterns over time. This analysis focuses primarily on new residential development since that has been the trend in recent decades. An in-depth analysis of the Fowler River watershed in Alexandria combines the resource information in Part 1 with predicted increase in

new development as an approach communities can take in guiding new development to the most suitable locations.

Both parts of this report discuss the study methodology and assumptions made in detail, as well as interpretation of the results of the study. Taken together, the two parts provide a knowledge base and powerful tools for community planning decisions, especially as related to maintaining and enhancing water quality in Newfound Lake and protecting the local economy.

Part 1: Co-Occurrence Mapping

Section 1: Overview of Natural Resources Considered

Twelve natural resource features were evaluated in this study. They can be grouped as follows, and are presented below in this order:

- Surface Water Resources
- Drinking Water Resources
- Steep Slopes & Highly Erodible Soils
- Wildlife Habitat
- Prime Agricultural Soils & Most Productive Forest Soils

This study uses GIS technology[3] to accomplish mapping and to perform statistical analysis of various features found in the maps. GIS relies upon digital versions of mapped data which are available from the state's geographic information data library at GRANIT, a program of the University of New Hampshire. Additional data has been provided by federal agencies, including the USGS and NRCS, as well as state agencies such as the N.H. Fish and Game Department and the N.H. Department of Environmental Services. Other data, such as tax parcel information, was obtained by from local municipalities. All data used in this study is the most current version available, as of this writing.

Surface Water Resources

Riparian Buffers

Riparian buffers zones are important wildlife habitat zones, and constitute the last and best line of defense in terms of maintaining water quality through filtration of stormwater moving overland to lakes, ponds, rivers and streams. This study uses a tiered buffer approach developed by the Center for Watershed Protection (CWP)[4] for all rivers and streams, adapted to the natural resources of the Newfound watershed. See the map to the right for extent and distribution of riparian corridors within the Newfound Lake watershed. Thicker lines indicate wider riparian buffers, based on CWP protocols (see below).

Riparian Buffers

It should be noted that the NH Wildlife Action Plan (NHWAP) uses a 300' buffer in its habitat

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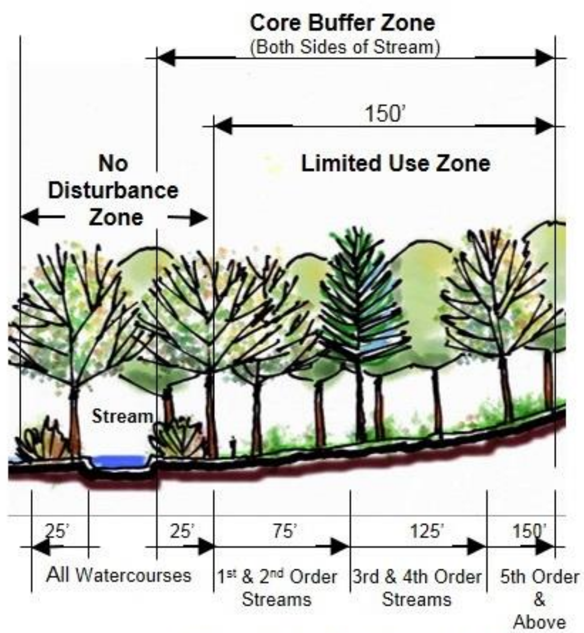
[3] GIS stands for Geographic Information Systems which uses digital versions of mapped data for mapping and selective processing within the GIS to study both the extent and distribution of mapped features and relationships among those features.

[4] Centers for Watershed Protection at http://cwp.org/. Adapted from the *Architecture of Urban Stream Buffers*, Article 39, Watershed Protection Techniques. 1 (4): 155 – 163.

modeling. This distance helps to ensure adequate wildlife movement corridors along water features, which are often home to unique natural communities. The 300' buffer is not included in the CWP riparian buffer layer, but is included in the NHWAP **habitat quality** data discussed below, and it is also found in the wildlife habitat **connectivity** data to a large degree. Thus, both concerns – water quality and wildlife habitat – are well represented in this study.

The CWP tiered buffer model is based on stream order[5], with a buffer of 75' for order 1 and 2, 125' for order 3 and 4, and 150' for stream order 5 and above (typically larger rivers). The 150' buffer is also applied to all lakes and ponds. Recent scientific studies show that these distances are more than adequate for maintaining water quality if kept in a natural land cover condition. However, wildlife corridors along riparian buffers needs to be wider, on the order of 300'.

The graphic below shows how the CWP tiered buffer concept works. Note that the intent is to maintain a 25' no disturbance zone on either side of a watercourse. The limited use zone extending out to 150' in the case of higher order watercourses is also intended as a natural stormwater "filter strip", but may be devoted to light human uses such as trails, natural recreation areas, and timber harvests.



Stream Order-based Setbacks

Riparian buffers account for about 2,600 acres, or 4.7%, of the study area, and are about 16% protected presently.

[5] Headwater streams highest in the watershed are Order 1; where two Order 1 streams combine, the watercourse becomes Order 2. Two Order 2 streams combine to make Order 3, and so forth down gradient.

Wetlands

Wetlands

Wetlands are delineated for this study using hydric soils – poorly-drained and very poorly drained soils – based on mapping from the NRCS. Both soils types are strong indicators of jurisdictional wetlands per state and federal regulations. The term jurisdictional indicates that State and Federal laws regulating wetland uses and impacts exist, providing some level of protection from development. While our approach does not specify **wetland types**, this is addressed to a large degree in the habitat data also used in this planning process. See **Special Wildlife Types** below for more information.

Wetlands are important natural features in conservation planning not only for their many habitat values but also for maintaining water quality as "natural filters", and for floodwater storage.

The map above displays hydric soils in the study area. Note how the pattern of wetlands across the study area is somewhat concentrated in certain areas, especially associated with watercourses such as the Fowler River and the Cockermouth River. Compare the wetlands map with the riparian buffers map above.

Wetlands are total about 1,970 acres, or 3.5% of the study area, and are currently about 14% protected.

Floodplains

The map to the right displays the location of all 100-year floodplain areas in the Newfound Lake watershed, as determined by floodplain insurance mapping originally developed by USGS. Typically 100-year floodplains are found in close association with larger streams and rivers such as the Fowler River and Cockermouth River. A series of wetlands along Dick Brown Brook in Bridgewater form a complex of wetlands that also serve as natural flood storage areas. Note that the lake itself is subject to water level fluctuations, and most shoreline margins fall into the floodplain category.

Floodplains

Since floodplains provide critical eco-system services in terms of flood water management, as well as providing habitat opportunities for unique natural communities and wildlife corridors, maintaining natural land cover and conditions within them is an important conservation priority.

Floodplains are cover about 960 acres, or 1.7% of the study area, and are about 13% protected.

<u>Drinking Water Resources</u>

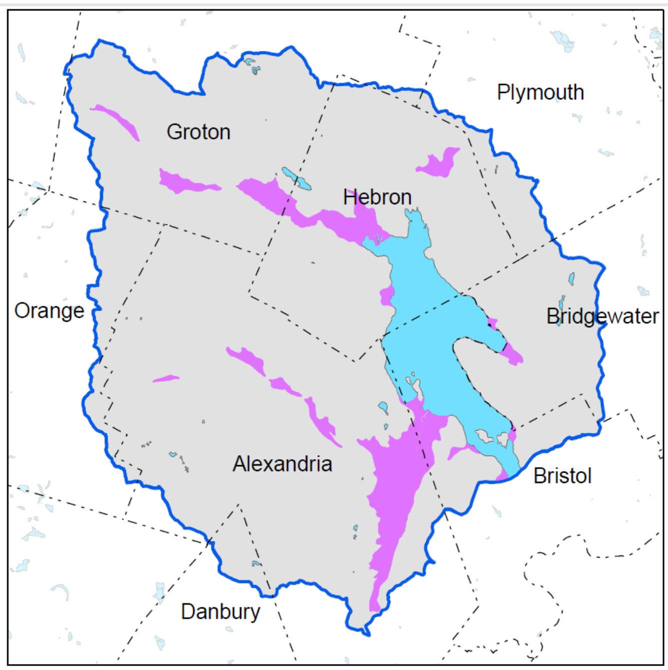
<u>*Sand & Gravel Aquifers*</u>

Extensive sand and gravel aquifers exist in New Hampshire, and within the study area, as a result of sediment deposition in major river valleys following the last glacial age. As opposed to bedrock aquifers, these surficial deposits represent one of the most important groundwater resources in the state, and have been developed for high-yield municipal water wells in many communities. The entire land surface overlying the aquifers represents a ***primary recharge zone*** with obvious implications for groundwater quality and quantity depending upon land cover and land uses occurring on this recharge zone.

Due to the nature of materials and the thickness of an aquifer, some areas indicate greater potential flow (transmissivity) of groundwater water to a well, and therefore a greater water supply productivity. These zones are also most prone to the rapid movement of contaminants that find their way into the groundwater, and therefore retaining natural land cover and non-commercial/industrial land uses is important.

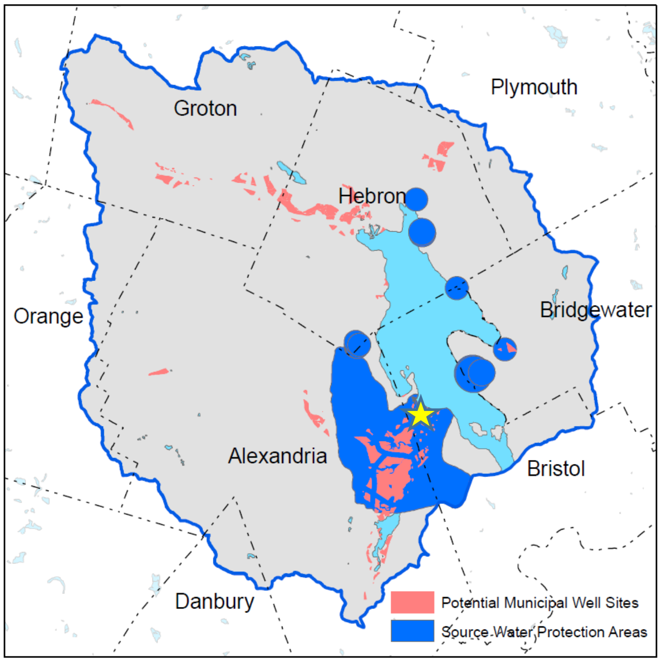
The map to the right shows the aquifer zones in pink. Note the large formations in the Fowler River and Cockermouth River valleys. Other smaller aquifers exist in the Georges Brook area of Hebron, in several locations immediate to the Newfound Lake shore, and along tributaries of the Fowler River. See also the mapping and discussion on **drinking water resources** below.

Aquifer recharge zones are involve about 3,400 acres or 6.1% of the study area, and are currently about 9% protected.



Aquifers

Favorable Gravel Well Sites



Drinking Water Protection

The N.H. Department of Environmental Services (NHDES) has mapped areas of sand and gravel aquifers statewide that have the potential to provide municipal water supplies. The mapping and analysis removes all areas representing a contamination risk (roads, known and potential contamination threats such as gasoline stations, landfills, etc.). It also focuses on those portions of the aquifers thought to have sufficient transmissivity and groundwater recharge to provide a reliable water supply.

The areas shown in pink in the map to the left are those portions of the aquifer that may be suitable to provide water supply at a sustainable minimum of 75 gallons per minute, subject to confirmation by a hydro-geologic engineering study.

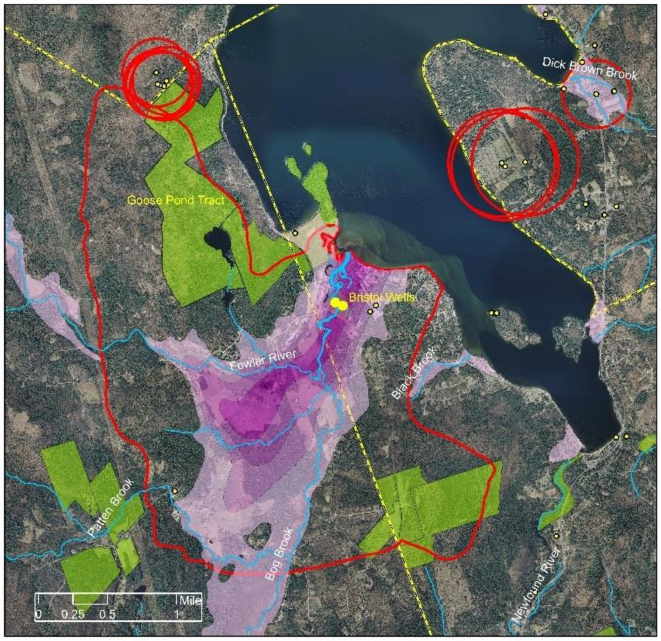
Favorable gravel well sites account for about 1,000 acres, or 1.8% of the watershed land area, and are about 9% protected.

Source Water Protection Areas

The **Drinking Water Protection** map above also shows **source water protection areas** (public drinking water supplies), typically wells, along with a large source water protection zones (blue color) delineated by the NHDES. There are seven public water supply sources in the Newfound Lake watershed classified by NHDES as active community water supplies. One of those is the Bristol Water Works with wells near the Fowler River (see **yellow star** in map). The others are private water supply services to residential and commercial developments.

The Bristol Water Works serves a total of 3,327 persons according to the most recent data from NHDES, and another 490 persons depend upon the remaining six private community water supplies. Note the large size of the source water protection area associated with the Bristol wellheads; it has been delineated by NHDES according to calculations of surface water recharge to the Fowler River groundwater aquifer zone from which Bristol pumps water. Note also the extensive, high-transmissivity areas favorable for future high-yielding wells trending southwest of the Bristol wells.

While the NHDES does not require municipalities to permanently protect drinking water supply zones (except for a small sanitary radius), the **best approach to ensure drinking water supply and quality in the long term is to maintain these zones in natural land cover**, and to limit development within the zones, particularly land uses with a high risk of contaminant release or extensive impermeable surfaces.



In addition to maintaining clean drinking water, locating suitable future water supplies is a difficult, costly, and uncertain endeavor should existing wells become contaminated.

The figure to the left illustrates the source water protection area associated with the Bristol water supply wells in more detail. The wells are shown as **yellow dots** and the wellhead protection zone is outlined in red. The wellhead protection zones for water supply wells at The Ledges residential area are represented as circles to the north end of the Bristol protection zone, and other community water supply protection zones are found across the lake at Whittemore Point.

The Fowler River aquifer formation feeding the wells appears in pink/purple colors, with the darker colors being areas with higher transmissivity. The green areas are conservation and public lands which serve to protect the natural land cover of the source water protection area. Note that the majority of the area within the source water protection area is not currently protected. The recent conservation of the 400+ acre Goose Pond Tract (green area north of the aquifer) adds significantly to the protected upland surface water flows into the Fowler River aquifer. **However, note that none of the land overlying the aquifer is protected.**

For a more detailed look at the Fowler River aquifer and related natural resources, see the **Fowler River Development Study** in **Part 2** of this report.

NHDES source water protection areas total about 4,700 acres, or 8.4% of the study area, and are about 15% protected at present.

Steep Slopes & Highly Erodible Soils

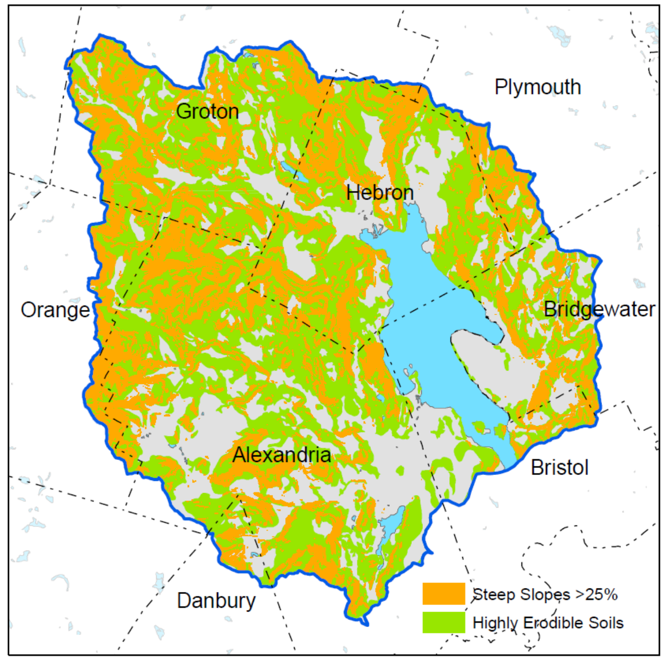
Steep Slopes

It is a widely accepted community planning standard that slopes in excess of 25% gradient are not buildable due to limitations and elevated risks of severe land disturbance from siting roads and buildings. Slopes in the range of 15% to 25% are deemed a cautionary zone, and require careful engineering design to mitigate impacts, especially stormwater runoff and erosion.

Steep slope areas are also home to unique natural communities in certain places where nutrients have accumulated in pockets, or where cliffs and talus slopes have formed. Such formations also offer den sites for a number of wildlife species, and are important winter sunning sites for bobcats.

Slopes in excess of 25% gradient are shown in orange in the map to the right. Note that much of the terrain within the Newfound Lake watershed is classified as steep slopes and is also associated with highly erodible soils (see below). **Approximately 22% of the watershed has slopes greater than 25%**, and as can be seen in the map, these areas are extensively distributed all across the watershed with the exception of the river valley bottoms along the Fowler River and Cockermouth River, and two or three areas in Hebron, Bristol and Bridgewater.

Steep slope areas cover about 12,500 acres, or 22.2% of the watershed land area, and are currently about 26% protected.



Steep Slopes & Highly Erodible Soils

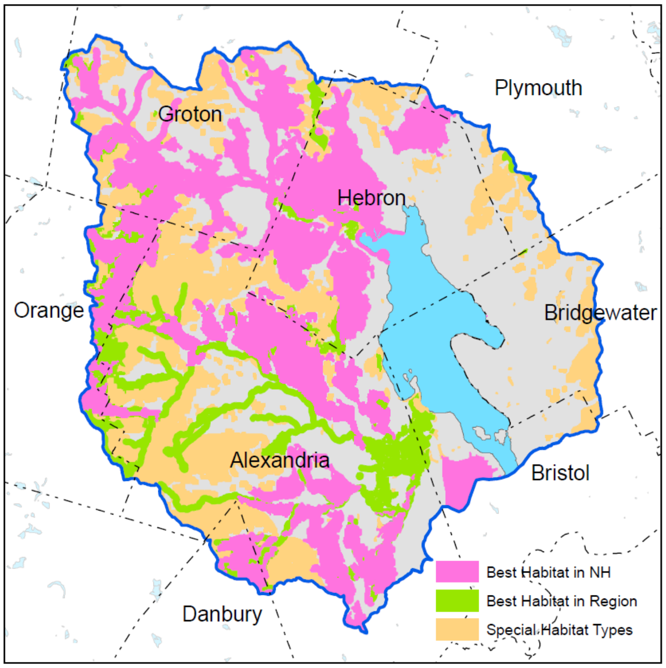
Highly Erodible Soils

The NRCS has rated soils for erosion potential as part of a national program to identify highly erodible soils requiring special management. These soils are known to erode rapidly and extensively if disturbed, due to their physical properties and slope conditions. Highly erodible soils are of great importance to water quality as they may cause adverse impacts from sediment and nutrient loading in lakes, ponds, and streams. **About 68% of the watershed has highly erodible soil conditions.**

Of special concern are lands where steep slopes and highly erodible soils are both present. The map above shows slopes greater than 25% overlaid on the highly erodible soils. These areas should be of high priority for land conservation to preserve the natural land cover and ensure that headwater streams are not impacted by erosion. Limiting or prohibiting development on steep slopes through land use regulations (zoning, subdivision regulations, road design standards, etc.).

The coincidence of steep slopes and highly erodible soils totals about 12,000 acres watershed-wide, and is found on about 95% of all steep slope areas shown in the map. The coincidence of steep slopes and highly erodible soils amounts to about 21% of the entire study area, but is just 26% protected.

Wildlife Habitat



NHWAP Habitat Types & Quality

Wildlife Habitat Quality

The N.H. Fish and Game Department has extensively studied[6] habitat types and condition stateside in order to help set conservation priorities that support their programs. The New Hampshire Wildlife Action Plan (NHWAP) has classified aggregate habitat types by relative condition and quality statewide in three tiers:

- **Tier 1** represents the best habitat statewide;
- **Tier 2** represents the best habitat in the several biological regions found across the state; and,
- **Tier 3** is designated as supporting landscapes that act as a buffer to protect the integrity of the first two tiers.

The map above displays these the top two tiers according to the 2010 update of the NHWAP, with pink showing Tier 1 areas and green showing Tier 2. Extensive Tier 1 habitat areas are found west and north of Newfound Lake, largely due to the undeveloped nature of the area and large, unfragmented blocks of forest. Tier 2 areas are typically associated closely with Tier 1 designation and certain stream networks of high habitat quality which account for the aquatic habitat component of the NHWAP model and mapping; note the Tier 2 areas associated with the Fowler River drainage in Alexandria.

Much of the study area did not qualify for any tier, largely due to the more developed nature of the land, especially in portions of Bridgewater and Bristol. Note that Tier 3 supporting landscapes are not mapped here; instead a composite of wildlife habitat types has been substituted for scoring purposes in the co-occurrence mapping (see **Section 2** below). However, no Tier 3 areas are found in the eastern half of the watershed, so no significant data has been eliminated by not mapping Tier 3 in those communities.

Tier 1 habitat areas cover about 23,100 acres, or 41% of the watershed land area, and are about 23% protected. Tier 2 areas add another 5,600 acres, or 10% of the watershed land area, and are about 33% protected.

Special Habitat Types

The light orange areas of the map above include several specific wildlife habitats of concern due to scarcity or unusual value. This zone is comprised of nine distinct habitat types, three of which are

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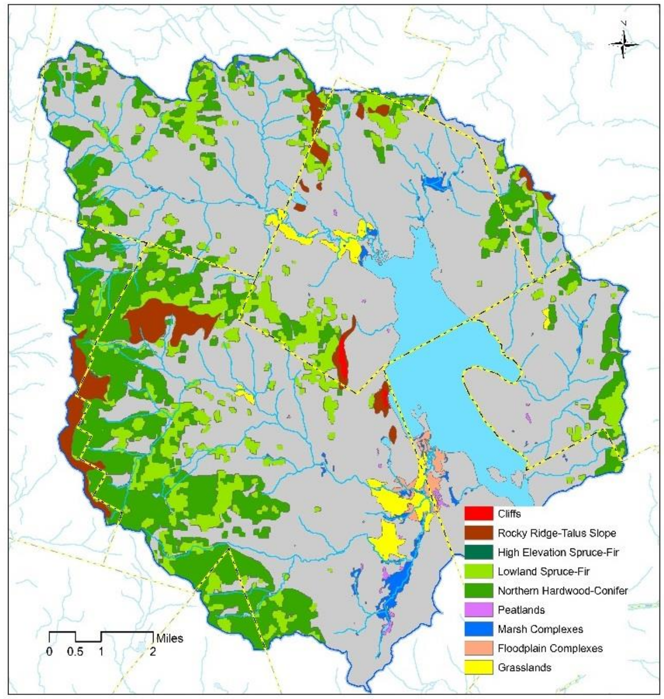
[6] NH Wildlife Action Plan: http://www.wildlife.state.nh.us/Wildlife/wildlife_plan.htm

forest habitat types not common in the watershed. Others, such as cliff and talus slopes, are rare statewide and involve relatively small number of occurrences and land area. Taken together, these habitats can be thought of as “patch habitats” within the watershed. Areas not within the habitat type mapping are either widespread “matrix habitats” or are developed.



NHWAP Habitat Types

The map to the right displays the location of these nine special habitat types present in the watershed. Some habitat types overlap one another, e.g., rocky ridge-talus slopes are intermixed with the three forest habitat types, but they are arranged in the map to best show extent and location.

Note how the three forest types tend to occupy the higher elevation around the watershed rim, and how cliffs and talus communities are associated with steeper terrain. On the other hand, grasslands, wetlands, and floodplains follow the river valleys at lower elevation.

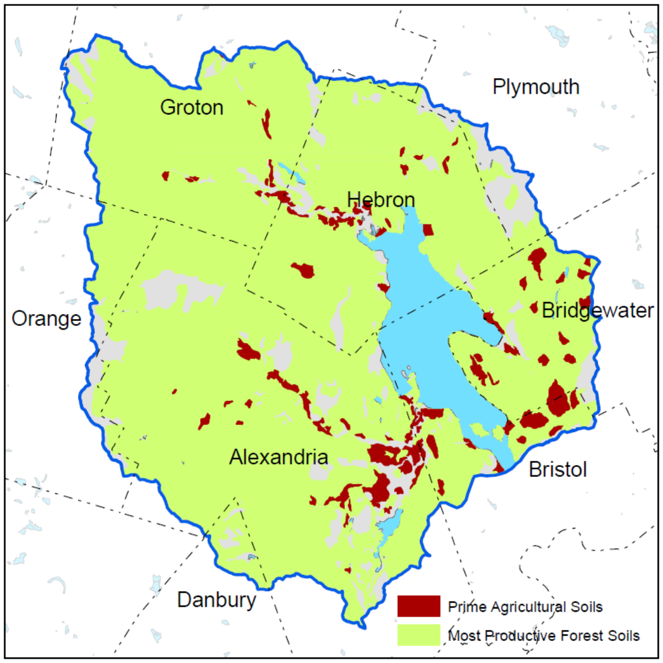
The table below summarizes the nine special habitat types by extent and protection status, arranged in rank order from least common within the watershed to more common. Note the low levels of conservation for several habitat types with relatively low percentage of land cover in the watershed. In addition, aquatic habitat types associated with water quality enhancement (floodplain communities, marsh complexes, and peatlands) are not well protected in the watershed.

Habitat Type	Total Acres	Percent of Watershed	Acres Protected	Percent Protected
Cliffs	59	0.1%	11	19.3%
Peatlands	111	0.2%	8	7.2%
High Elevation Spruce-Fir Forest	322	0.6%	322	100.0%
Floodplain Complexes	409	0.7%	69	16.8%
Marsh Complexes	715	1.3%	59	8.3%
Grasslands	1,105	2.0%	89	8.1%
Rocky Ridge-Talus Slopes	1,771	3.1%	950	53.7%
Lowland Spruce-Fir Forest	6,763	12.0%	1,563	23.1%
Northern Hardwood-Conifer Forest	10,033	17.8%	3,347	33.4%

For more detailed descriptions of these habitat types and their ecological importance see: http://www.wildlife.state.nh.us/Wildlife/Wildlife_Plan/habitat_types.htm

Most Productive Farming & Forest Soils

Prime Agricultural Soils



Productive Soils

New Hampshire's most productive agricultural soils are scarce statewide, comprising only about 6.5% of the state's land area, and typically occurring in small and scattered pockets of soil.

The 6.5% figure above relates to two NRCS classes of agricultural soils: prime agricultural soils (the best soils), and soils of statewide significance (second tier but also productive), at 3.5% and 3%, respectively. Prime soils and soils of statewide importance are shown in brown in the map to the left.

Some of these soils are currently being farmed, notably in the Fowler River Valley, where farmland contributes significantly to the scenic quality of the community. Others are associated with existing grass meadows which provide important wildlife habitat for certain species. Several areas with prime agricultural soils are already developed for non-farm land uses, as in Bristol and Bridgewater. It is important to consider the potential for future local food production as one of several conservation priorities in the watershed.

Prime agricultural soils account for about 2,100 acres, or 3.7% of the watershed, of which only about 6% is currently protected.

Most Productive Forest Soils

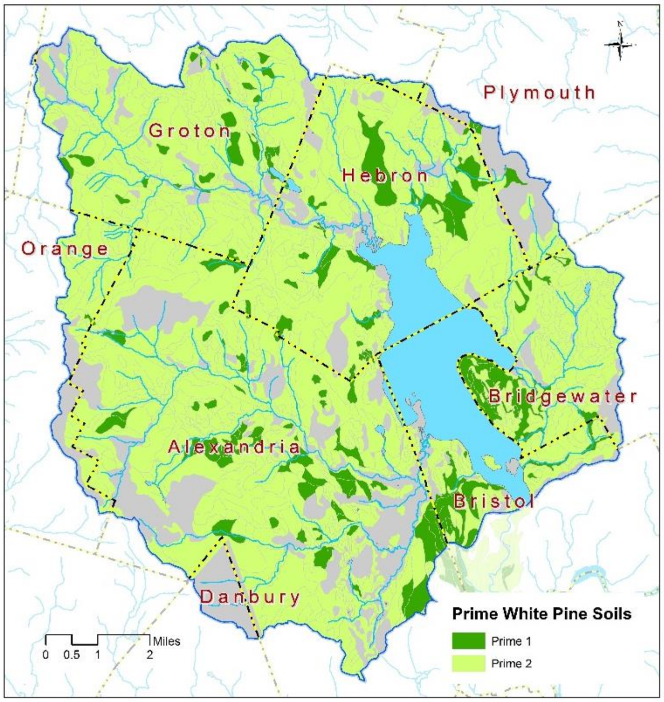
Economic forestry in another resource-related aspect of the Newfound Lake watershed. The area is heavily forested, and timber harvests represent a significant, sustainable income for both landowners and those working in the forest products industry in New Hampshire.

The relative productivity of forest soils is an important consideration for both economic forestry and ecological significance since productive soils tend to exhibit more diverse natural communities.

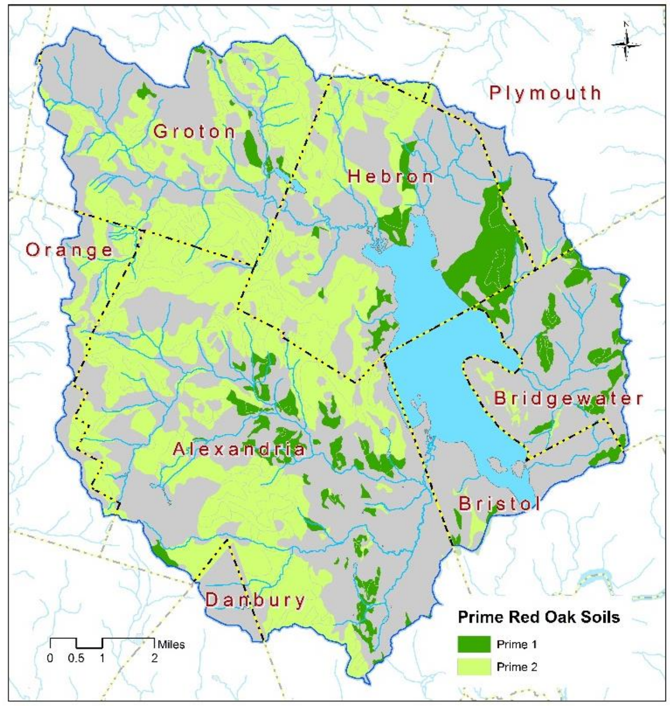
This study uses the NRCS **site index rating** for production of wood volume on soils, supplemented with other site considerations. Two valuable commercial forest tree species are rated: white pine and red oak.

Classifications are assigned based on volume of wood that can be expected in a 50 year time period. Prime 1 soils can be considered the very best timber-producing soils in the area; Prime 2 soils are also important, with timber volume estimates about 20% lower than Prime 1.

The previous map (**Productive Soils**) merges the Prime 1 and 2 soils for both white pine and red oak into a single resource feature for purposes of co-occurrence mapping (see light green color). The two maps below provide more detail on the extent and distribution of Prime 1 and 2 forest soils for white pine and red oak separately.



Most Productive Forest Soils: White Pine



Most Productive Forest Soils: Red Oak

Note that the locations of Prime 1 soils differs somewhat from map to map, but that large areas within the watershed area rated Prime 2 for both species.

Prime forest soils cover about 49,000 acres, or 87% of the study area, and are currently about 17% protected.

Section 2: Co-Occurrence Mapping

Methodology

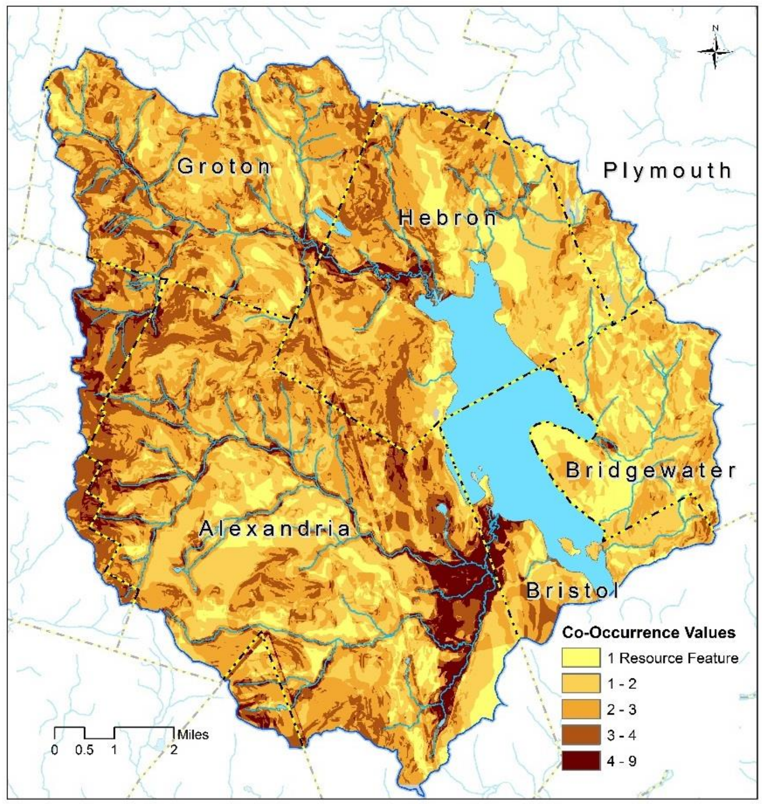
As described in the previous section of the report, twelve natural resource map datasets[7] have been factored into the co-occurrence mapping analysis of the Newfound Lake watershed. The purpose of the co-occurrence analysis and mapping is to identify areas where several resource features share the same location, or are "co-located", indicating constraints to development and/or high-priority conservation values for consideration in community planning, depending upon the resources present.

[7] The transmission line right-of-way traversing Groton and Alexandria is also a factor in the co-occurrence map due to building constraints, but is not detailed in this report.

Each of the twelve natural resource datasets has been merged to remove internal classifications since this analysis uses a simple additive approach without regard to relative important values[8]. For example, the two tiers in the NHWAP habitat quality data count as a single feature, and all the habitat types in the NHWAP data are merged into a single entity. In more sophisticated co-occurrence mapping, each aspect of a resource dataset would be weighted by local decision-makers, and final appearance of the map would be significantly different (see comments on developing a "shared vision" community plan at the end of this report). Therefore, the additive approach should be viewed as general and conservative.

Each resource dataset was assigned a value of "1", and all twelve datasets were processed in the GIS (by adding the layers) to generate a co-occurrence map. The map below shows the result of the scoring in a map with a color gradient from light to dark colors. Darker colors indicate areas of higher aggregate values, and therefore higher priority for conservation versus new development.

The GIS processing involves a geographically-referenced grid with each grid cell measuring 30'x30', or a resolution of about 1/5th of an acre. Close inspection of the mapped data shows this grid at the edges of some features. This resolution is appropriate to regional-scale mapping and analysis.



Resource Co-Occurrence Map

Interpretation

Most evident in the co-occurrence map of natural resource features is the Fowler River valley in Alexandria, and Bristol. A review of the various natural resources highlighted in the previous section of this report gives an idea of which factors are aggregating to produce the darker color in that area – with water quality related features chief among them: floodplain, aquifer, wetlands, riparian buffers, drinking water protection areas, and future water supplies. Prime agricultural soils and wildlife habitat values are also significant in this area. The situation is similar, but geographically more limited in the Cockermouth River valley.

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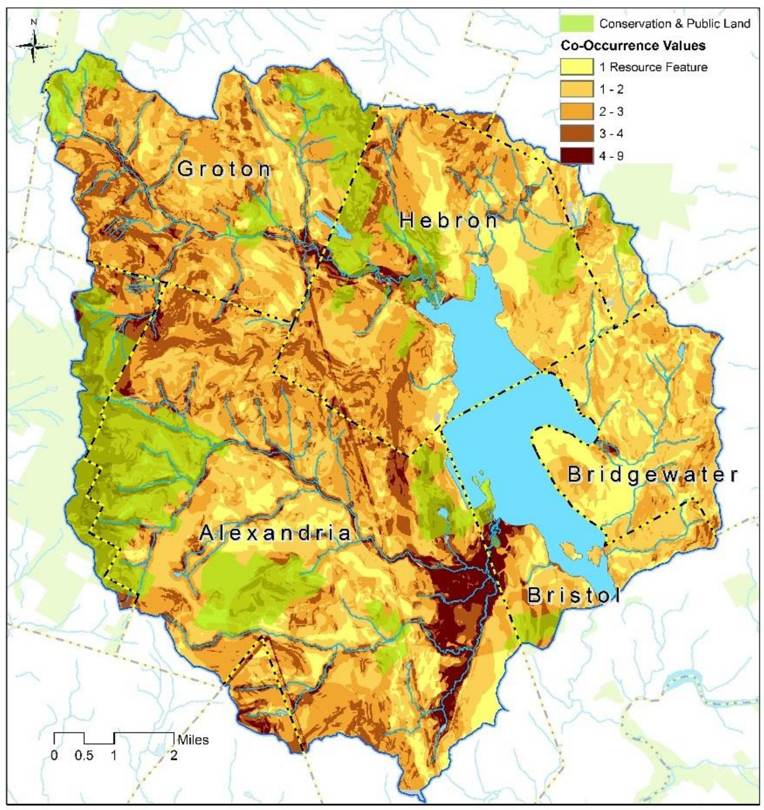
[8] Community conservation commissions are encouraged to expand and refine this analysis by engaging in a consensus-built version of the co-occurrence mapping using weighted values decided by community participants in a special voting process.

Middle to high co-occurrence values also are found in the high elevation areas in western Alexandria and Groton, and along the height of land separating the Fowler River and Cockermouth River watersheds (the so-called “Spruce Ridge”).

The eastern portion of the watershed has conspicuously lower co-occurrence values, especially parts of Hebron, Bridgewater and Bristol. It is important to recognize that this does not mean there are no natural resources worthy of conservation, nor that there are no constraints to development. The scale of the various data used in the mapping and analysis is broad and somewhat coarse, so at the community-scale significant features likely exist that warrant stewardship. Also, the NHWAP habitat quality data used in this study is statewide in its analysis and ranking; a closer analysis of the eastern watershed at regional scale would no doubt discover wildlife habitat values not present in the statewide study. Finally, with regard to water quality in Newfound Lake, the tributaries flowing into the lake along the eastern shore are all contributors of phosphorus(and other nutrients), and at community scale have elevated importance for riparian and wetland protection.

To assess how well the natural resource features considered in the analysis are currently protected, the map to the right shows the co-occurrence values overlaid with conservation and public lands in green. The green color is somewhat transparent, so the darker colors of the co-occurrence map can be seen, giving an idea of where high-value resources are conserved. The high-elevation areas shared by Alexandria and the town of Orange to the west are fairly well protected at present, as are lands along the border of Groton and Hebron. Resources in the Fowler River and Cockermouth River valleys are not well protected, nor is the high ground (Spruce Ridge) separating those two watersheds. The higher value areas in the western portion of Groton also not currently well-protected.



Resource Co-Occurrence Map

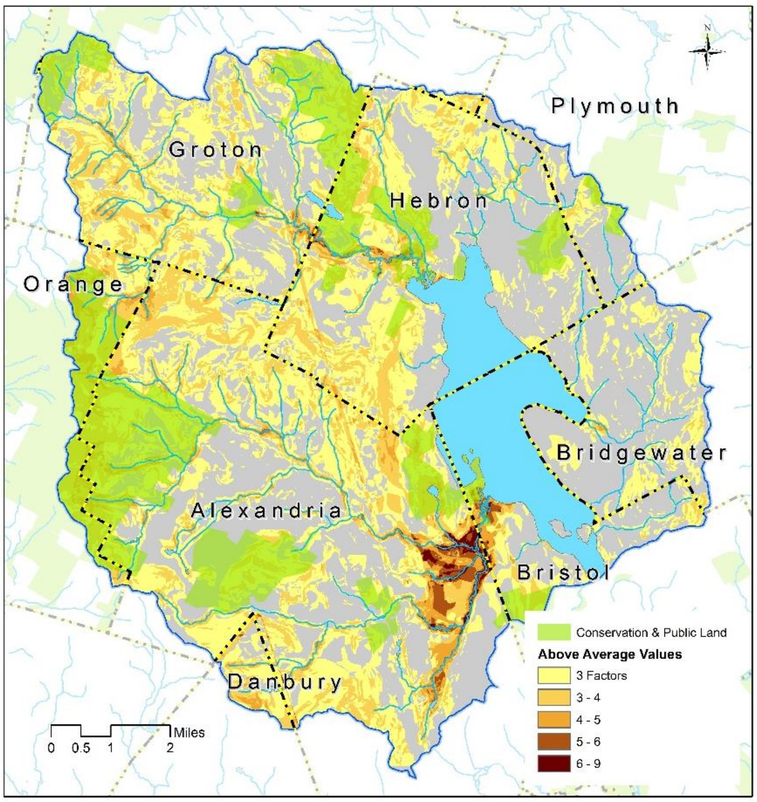
The Fowler River valley area is addressed in more detail in **Part 2** of this report as part of the build-out analysis for the watershed. See also the summary of resource protection by community in **Part 1: Section 4** of this report.

Section 3: Delineating High-Priority Conservation Focus Areas

Methodology

With a study area of more than 56,326 acres, and varied natural resource co-occurrence values across the entire watershed, it is helpful to further refine the co-occurrence mapping to delineate areas with higher priority for conservation. These areas are also typically less suitable or totally unsuitable for future development.

A simple approach is to identify those areas of the co-occurrence map that are "above average" aggregate value. The average value for all scoring cells (value > 0) in the map is 2.8; however it is not possible to map 2.8 since the co-occurrence values are based on whole integers. Therefore, the average value is rounded up to 3. The map below shows all resource co-occurrence values of 3 or higher.



High-Value Resource Co-Occurrence Map

Interpretation

Note the dramatic difference between this map and the previous co-occurrence map. The gray color indicates areas with only one or two resource features, while the color gradient from yellow to brown zeroes in on the higher-value areas (co-occurrence value of 3 and higher). The Fowler and Cockermouth River valleys display higher scoring, as does the height of land separating these two rivers in northern Alexandria. The darker colors in the Fowler River valley clearly highlight the importance of this area. This map is useful in making strategic decisions with regard to building suitability and conservation priorities, at both the watershed scale, and within each community. Note that additional high-value resources will likely be identified by community-scale studies.

Section 4: Statistical Analysis

Summary of Resource Protection

In making decisions important to community planning and/or conservation planning at community-scale, considering the existing level of resource protection is often critical. **Table 1** (below) summarizes the area of each resource feature, as well as the current level of permanent protection, for each community and for the watershed as a whole. All known conservation transactions have been included in the analysis, most recently the Goose Pond tract in Alexandria. The statistics will change as more land comes under permanent protection; for example, Hebron will see a dramatic change when the so-called Green Acres Woodlands conservation easement tract in the northern portion of town is consummated.

Interpretation

The following are highlights-oriented interpretations of the data in **Table 1**.

- Bridgewater has no land conserved within the Newfound Lake watershed. While the town's land area represents only about 10% of the entire watershed, natural resource features exist in Bridgewater that are critical to water quality in the lake, including wetlands, riparian buffers, steep slopes and highly erodible soils.

- Several natural resource features amount to relatively small percentages of the watershed land area. These include wetlands, riparian buffers, floodplains, aquifers, drinking water protection zones, future water supply areas, and prime agricultural soils. Note that while these features involve small land areas, the level of protection is also very low, generally less than 15%. Most of these features are also critical to maintaining water quality.

- The overall level of resource protection within the Newfound Lake watershed is relatively low at about 18%. At community-scale, the percentages range from 13% in Bristol to about 21% in Alexandria.

- Inspection of the percent of resource conserved in each town shows a wide range of levels of protection; many are less than 20% despite the fact that the resource area itself is quite large, e.g., aquifers and high quality wildlife habitat in Alexandria, or highly erodible soils in Hebron and Groton.

The natural question when looking at resource protection figures is: *How much is enough?*. The answer is: *It depends*. One perspective is to consider how critical a particular resource is to the eco-system services[9] provided for human use. Drinking water is an obvious critical factor, and the importance with regard to the Bristol water supplies has been discussed above. Prime agricultural soils may not seem important at this time given the state of farming in New Hampshire, but sound planning at a community level would reserve this resource for future food production and ancillary benefits such as scenic values. Finally, when thinking about water quality, several resource features deserve elevated attention,

[9] "Eco-system services" are community benefits provided by natural systems functioning at peak performance, such as clean water from forested watersheds, flood storage in floodplains and wetlands, etc..

including protection of riparian buffers (**probably the single most important tool in maintaining water quality**), wetlands, floodplains, aquifer areas, and steep slopes with highly erodible soils. Protection of these critical resources will yield the greatest benefits.

See **Table 1** on the following page.

Table 1

Status of Resource Protection in the Newfound Lake Watershed -- 2014

Municipality	Land Area (Ac)	Wetlands	Riparian Buffer	Floodplains	Aquifer	Steep Slopes >25%	Highly Erodilble Soils	Future Well Sites	Wellhead Protection Areas	NHWAP Tier 1	NHWAP Tier 2	Special Habitat Types	Prime Ag Soils	Prime Forest Soils
Alexandria	22,084	737	1,054	350	1,637	4,323	14,671	596	3,015	6,017	4,040	9,321	755	19,107
Bridgewater	5,322	315	197	55	95	877	2,709	9	401	0	3	938	443	4,860
Bristol	2,473	226	91	127	385	252	1,009	30	950	502	241	391	452	2,105
Danbury	855	57	30	0	0	192	486	0	0	477	87	766	0	686
Groton	10,672	159	610	171	530	2,838	8,508	107	0	7,920	261	3,089	114	9,927
Hebron	11,392	432	486	259	785	2,530	8,067	265	344	6,138	292	2,318	300	10,331
Orange	2,057	1	111	0	0	933	1,869	0	0	1,954	631	1,798	0	1,574
Plymouth	1,469	43	47	0	0	551	1,240	0	0	83	62	588	0	507
Watershed Total	**56,326**	**1,970**	**2,626**	**961**	**3,432**	**12,497**	**38,559**	**1,007**	**4,710**	**23,091**	**5,618**	**19,210**	**2,065**	**49,098**
Percent of Watershed		**3.5%**	**4.7%**	**1.7%**	**6.1%**	**22.2%**	**68.5%**	**1.8%**	**8.4%**	**41.0%**	**10.0%**	**34.1%**	**3.7%**	**87.2%**
	Total Acres Conserved	**Acres of Resource Conserved In Each Municipality**												
Alexandria	4,583	39	169	0	22	1,271	3,337	15	458	767	1,040	2,928	32	4,226
Bridgewater	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bristol	322	79	7	21	60	4	64	3	255	157	32	47	39	280
Danbury	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Groton	1,837	57	98	1	13	582	1,622	3	0	1,411	149	640	0	1,484
Hebron	1,675	103	94	107	211	515	1,262	73	0	1,716	82	434	57	1,315
Orange	1,456	1	46	0	0	760	1,339	0	0	1,208	477	1,406	0	992
Plymouth	151	0	0	0	0	87	146	0	0	0	59	133	0	6
Watershed Total	**10,024**	**279**	**415**	**129**	**306**	**3,220**	**7,770**	**95**	**713**	**5,258**	**1,838**	**5,587**	**127**	**8,304**
		279.2												
	Percent Conserved	**Percent of Resource Conserved In Each Municipality**												
Alexandria	20.8%	5.3%	16.1%	0.0%	1.3%	29.4%	22.7%	2.6%	15.2%	12.7%	25.7%	31.4%	4.2%	22.1%
Bridgewater	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Bristol	13.0%	34.9%	7.6%	16.9%	15.6%	1.4%	6.3%	11.5%	26.8%	31.2%	13.1%	11.9%	8.5%	13.3%
Danbury	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Groton	17.2%	35.7%	16.1%	0.4%	2.5%	20.5%	19.1%	2.6%	0.0%	17.8%	57.1%	20.7%	0.0%	14.9%
Hebron	14.7%	23.9%	19.3%	41.2%	26.8%	20.4%	15.6%	27.6%	0.0%	28.0%	28.0%	18.7%	19.0%	12.7%
Orange	70.8%	100.0%	42.0%	0.0%	0.0%	81.5%	71.6%	0.0%	0.0%	61.8%	75.5%	78.2%	0.0%	63.0%
Plymouth	10.3%	0.0%	0.4%	0.0%	0.0%	15.8%	11.8%	0.0%	0.0%	0.0%	95.8%	22.6%	0.0%	1.2%
Percent Protected	**17.8%**	**14.2%**	**15.8%**	**13.4%**	**8.9%**	**25.8%**	**20.2%**	**9.4%**	**15.1%**	**22.8%**	**32.7%**	**29.1%**	**6.2%**	**16.9%**

Part 2: Build-Out Analysis

Introduction

Purpose

The purpose of conducting a build-out analysis is to predict with reasonable certainty how future development patterns are likely to occur in a given study area. Commonly used for community planning purposes, this build-out analysis addresses the entire watershed by looking at historical development trends and land utilization over time, and then systematically extrapolating those trends into various future time periods using locally-estimated development rates.

Reader Orientation

The following description of the build-out analysis involves several stages of data development which in turn require several assumptions and steps that must be explained in some detail. The narrative in **Section 1 i**ncludes discussion of the following:

- The process used to determined land most suitable and likely to develop within the Newfound Lake watershed;
- The results of mapping existing development baseline conditions using aerial photography;
- Analysis of 17 recent subdivisions in several communities to better understand local land utilization and typical lot sizes and densities;
- Application of the build-out analysis model watershed-wide with an emphasis on new residential development on suitable tracts of land; and,
- Extrapolation of recent growth trends and rates in the watershed communities to predict the probable timeframe for various development scenarios.

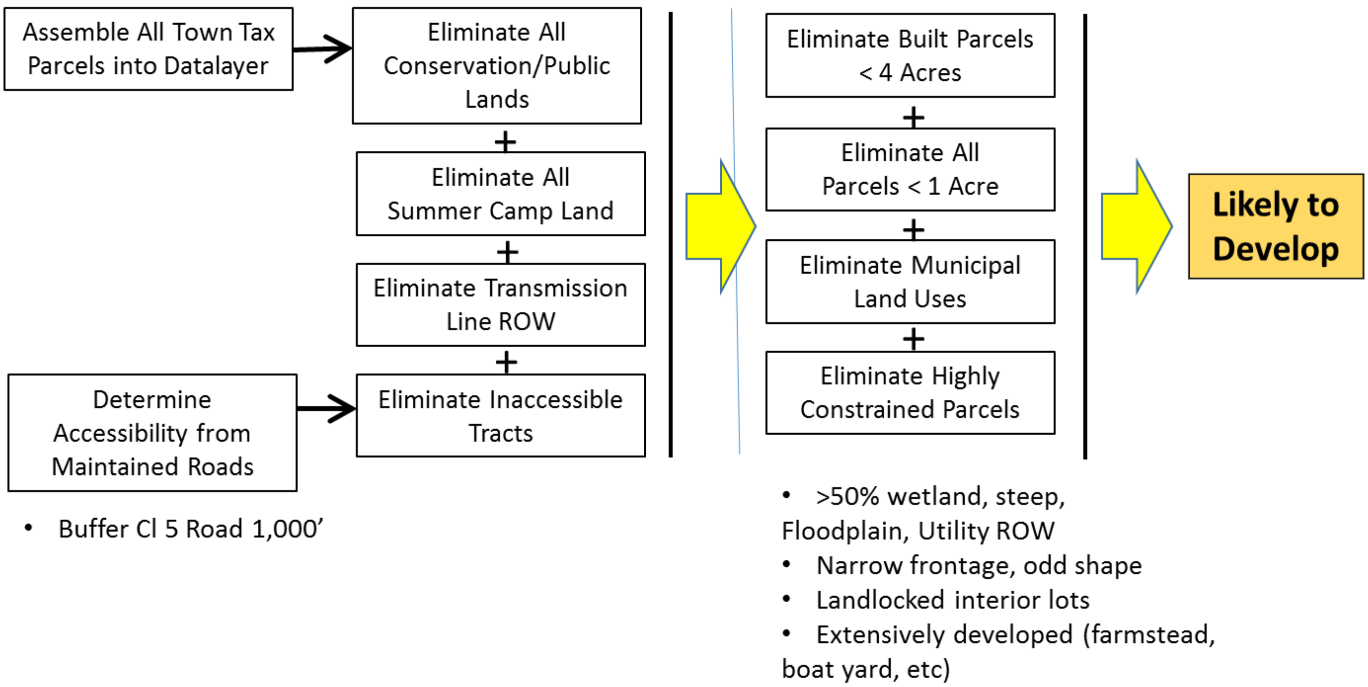
A more detailed look at the impact of predicted growth and development within the Fowler River aquifer area is presented in **Section 2** as a suggested community planning strategy that merges the insights gained in the co-occurrence mapping and the results of the build-out analysis.

Section 1: Approach Methodology

Determining Developable Land

Build-out analyses are typically tied to local land use regulations, especially zoning ordinances which define the allowed types of development and densities (minimum lot size, road frontage, etc.). However, due to the lack of such regulations in some of the watershed communities, another approach has been designed for this study that relies on an analysis of historical and recent land use, particularly the configuration of recent subdivisions, to arrive at various ratios of land area devoted to lot layouts versus road construction (see the discussion on “multipliers” below). Combined with knowledge of high-value natural resources and the desire to balance protection with development. This innovative, scientific and objective approach can be used to effectively guide local land use planning regulations, and future subdivision design.

Special consideration of certain land uses and constraints to development is also required to assure that development scenarios produced by the analysis are realistic. The chart below lays out the steps involved in creating a baseline of lands appropriate for future development, with an emphasis on the working concept that these lands are "most likely to develop". Actual development of vacant land is dependent upon landowner attitude and decisions, market conditions that drive new construction, and in many cases, support from the community in terms of local board reviews and approvals.



Note in the chart that several steps are necessary to identify the most likely and appropriate areas for future development. Accessibility from existing maintained local roads and highways is a key first step; this study assumes that land within 1,000' of existing roads and highways is most likely accessible for development. Given the limited road network in the Newfound Lake watershed and based on this criterion, large areas of some communities are not likely to develop and were removed from further study.

A second step eliminates tracts of land that are accessible but cannot be developed for various reasons (constraints). This includes all conservation and public land under permanent legal protection from development, and land associated with the major electric transmission line that traverses Groton and Alexandria. Several private summer camps for boys and girls exist in the northeast portion watershed, some with extensive tracts of land and waterfront. Development of these lands for other than camp purposes is deemed unlikely given the long history of these camps in the area.

The third step is to systematically eliminate tracts that cannot be developed without special exceptions. This study assumes that a buildable area of two acres is necessary for new construction; this is the typical minimum lot size specified in rural community zoning ordinances across New Hampshire. Therefore, all existing built tax lots less than four acres are removed from the baseline data as they cannot be subdivided to form a new two-acre parcel. There are small lots less than four acres scattered around the watershed that are currently undeveloped. These are included as buildable, but all undeveloped tracts of less than one acre are eliminated due to the fact that they are unlikely to meet State septic system and well protection criteria.

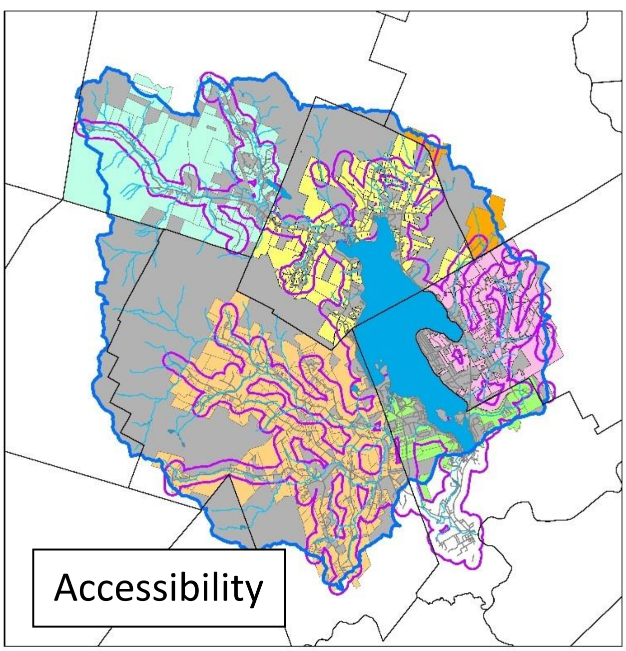
Fourth, all lands identified as municipally-owned have been removed, regardless of size or development status. In the final data selection and analysis step, some tax lots or portions of lots have been removed or modified due to the presence of severe constraints to development. These constraints have been applied as follows:

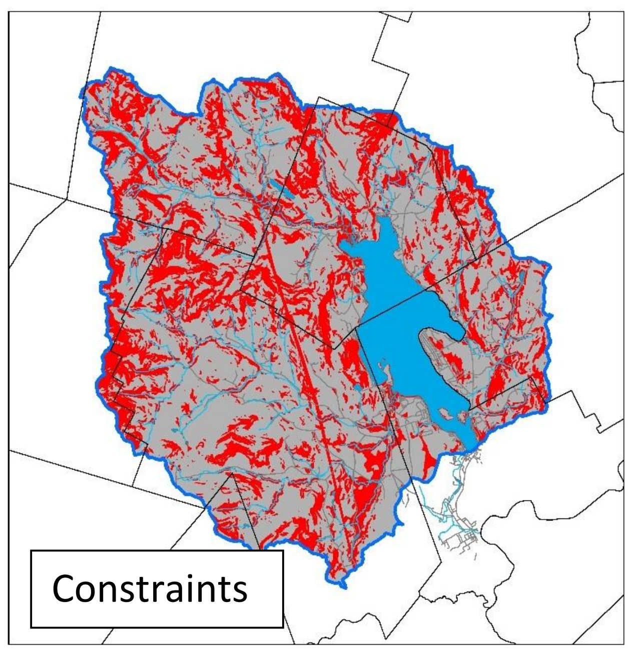
- Lots with greater than 50% area in wetlands, all floodplains, all steep slopes >25%, and/or all transmission line rights-of-way;
- Lots with very narrow road frontage and/ odd shapes that tend to preclude development;
- Landlocked interior lots with no apparent access; and,
- Lots that are already extensively developed such as farmstead complexes, boat yards, etc..

The **need** for these adjustments has been determined by close inspection of high-resolution aerial photography (NHDOT, 2010) to ascertain the range of lot configuration and utilization within the Newfound Lake watershed, augmented by sound community planning standards. The **goal** has been to determine those tracts of land which are reasonably most likely to develop over time.

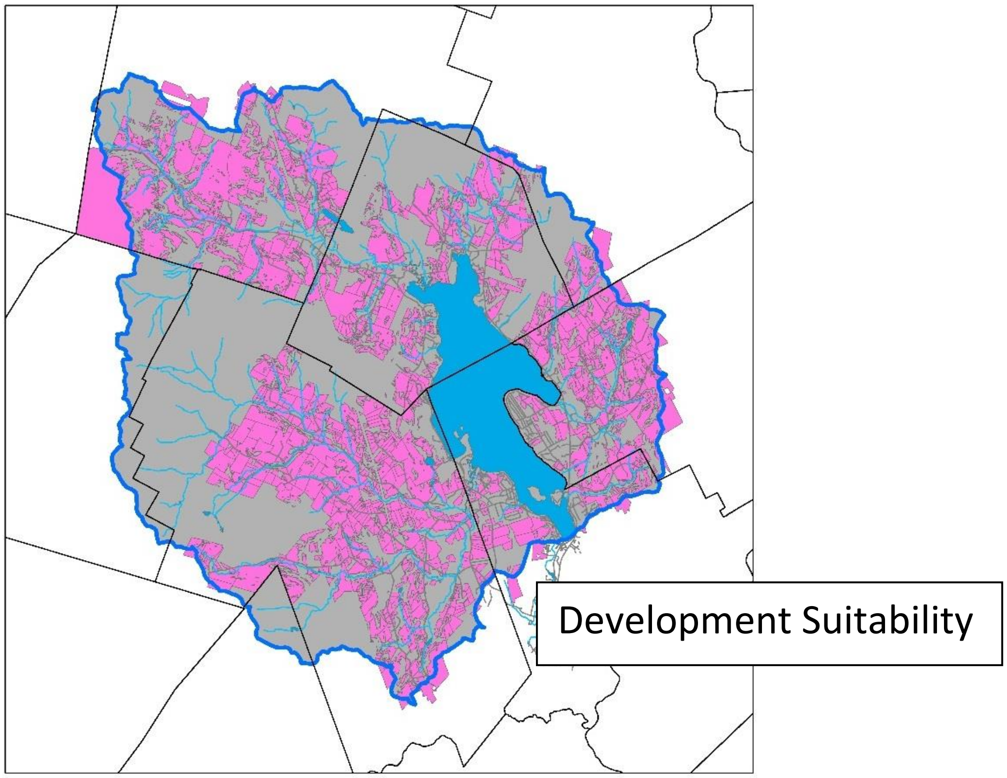
The map titled **Accessibility** below shows the result of applying the road accessibility factor to a composite of municipal tax maps within the watershed. Note that large areas of Alexandria, Groton, and Hebron "drop out" from further consideration for development as they are farther than 1,000' from a public road.

The second map titled **Constraints** gives an idea of the constraints to development mentioned above, with wetlands, floodplains, and steep slope areas merged into a single overlay. Note the north-south trending electrical transmission corridor that roughly bisects the watershed.





The **Development Suitability** map below shows the results of applying the constraints to development, plus elimination of lots not likely to develop. Some lots extend beyond the watershed boundary in this map as remainders, or in the case of Groton, due to interest in particular lots; in the next step of the build-out mapping process, these areas are shown only within the watershed. Using the criteria and rationale outlined above **the total land area suitable for development is 21,467 acres, or about 38% of the land area of the entire watershed.**



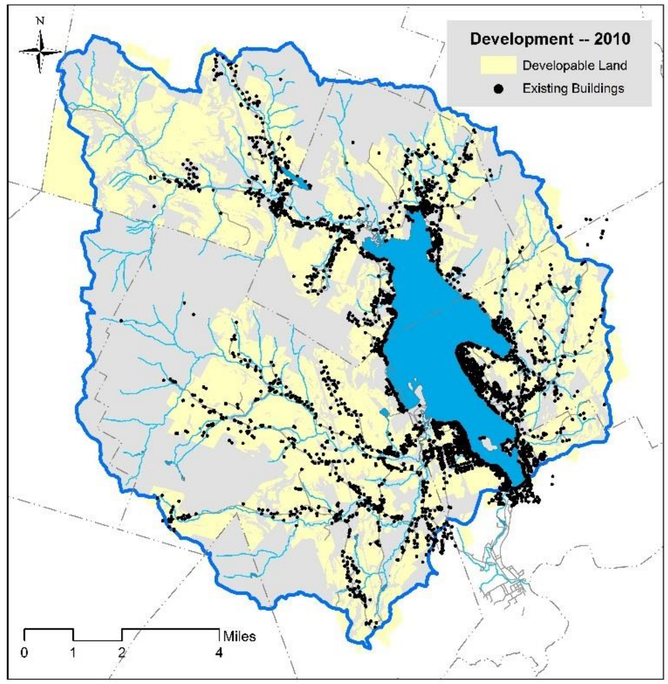
Section 2: Projecting Future Growth

Baseline Conditions

With the most likely to develop land area determined, the next step in the build-out analysis is to calculate the likely number of new residences to be constructed over a reasonable period of time. This study is limited to residential development because it is typical of most of the historical and recent growth within the watershed. Other land uses, particularly commercial and office developments exist within the watershed and provide a variety of services to residents of the area. However, the most recent development trends have been residential as growth moves outward from the well-established corridor along Route 3A in Bridgewater and in Bristol near the lake. Some limited service-related development (convenience stores, highway services, etc.) could occur in the future within the watershed, but will likely replace residential development predicted on certain tracts of land.

The first step in assessing historic and future growth patterns involved digital mapping of all visible **buildings**, observed using 2010 aerial photography[10]. Not all buildings are residential land uses; some are barns, outbuildings, commercial enterprises, and other non-residential land uses. Inspection of the aerial photography, and comparison with house-count data maintained by the N.H. Office of Energy and Planning, indicates that about 95% of all current buildings mapped are residential. Therefore, the following maps and discussion can be regarded simply as addressing residential development.

The map to the right displays the results of mapping all buildings existing in 2010, overlaid upon the land determined to be suitable for development, as discussed above. Note how development follows the road network outward from the lake, and is typically less dense as distance from the lake increases, and how the key model assumption (proximity to public roads) is supported by these data.



The 2010 building count shown on the Development -- 2010 map totals 3,740 buildings within the watershed.

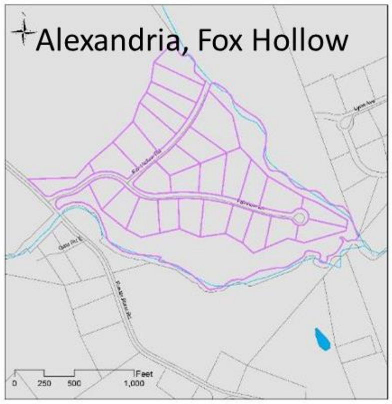
Modeling Regional Growth

The final step in the build-out analysis was to decide on the most likely patterns of growth, and to calculate a "multiplier" that will reasonably predict the number of new residences likely on any given tract of land. To address both concerns, an analysis was made of various subdivisions within the watershed to build a database of typical lot sizes and building densities. The range of lot sizes and density of development is striking when moving along a continuum from older, more intensively developed areas with smaller lots at the south end of the lake (Bristol and Bridgewater), towards more rural settings away from the lake, e.g, in Alexandria and Groton, where larger lots are the norm.

The inset maps below show the variety of subdivision configurations and densities found. Note that the scale in each inset is the same in order to highlight the relative lot size differences.

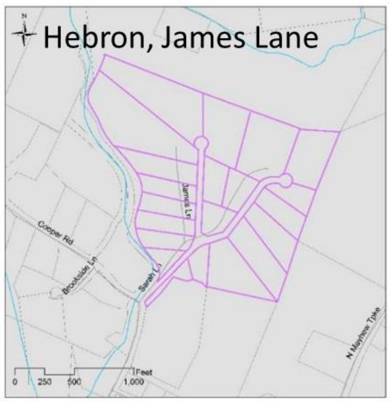
[10] The aerial photography used is "leaf-off" imagery, which aids in identifying buildings under trees. However, buildings under conifers might not be visible, so the mapping conducted is approximate.

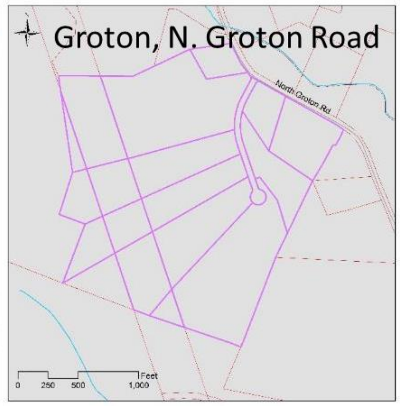
Average Lot Size: 1.3 Ac.



Average Lot Size: 1.7 Ac.

Average Lot Size: 3.0 Ac.





Average Lot Size: 13.1 Ac.

Table 2 below summarizes the results of the review of 17 different subdivisions in the five communities directly relating to Newfound Lake. Municipal tax maps were used to locate the subdivisions studied. There is significant variability evident within the table, but analyzing for average lot size, lot size range high to low, and land area devoted to internal road right-of-way does provide enough information to stratify the recent development trends from small lot developments to larger lot-size subdivisions.

Table 2

Municipality	Location	Total Tract Acres	ROW	Open Space Set Aside	Number of Lots	Average Lot Size	Lot Size Low	Lot Size High	Ratio ROW to Total Tract	Lot Layout Area
Alexandria	Fox Hollow/Farview	54.3	3.8	18.8	27	1.3	1	2.6	7.0%	93.0%
	Mountain View Drive	26.5	2.3		16	1.5	1.45	1.55	8.7%	91.3%
	Morrison Road	31.6	2.2		17	1.7	1	3.9	7.0%	93.0%
	Newfound Hills Road	70.9	0		12	5.9	5.2	8.2	0.0%	100.0%
	Mt. Cardigan Road	92.9	0		14	6.6	5	11	0.0%	100.0%
Bridgewater	Ridgeview Drive	49.2	3.2		10	4.5	2.1	5.7	6.5%	93.5%
	Meadowbrook/Ledgewood	80.8	10.42		30	2.7	1.25	5.65	12.9%	87.1%
Bristol	Upper Birch Drive	58.9	4.9		32	1.7	1.1	5	8.3%	91.7%
	Crodem Drive	17.9	1.35		9	1.8	1.1	2.3	7.5%	92.5%
Groton	Off North Groton Road	80.1	1.4		6	13.1	4.6	22.5	1.7%	98.3%
	Jewell Hill Road	110	2.7		17	5.5	5.5	10.5	2.5%	97.5%
	Beaver Pond Road	74.6	3.5		13	5.5	1.6	22.3	4.7%	95.3%
Hebron	Valley View/Eagle Ridge	275	11.3		29	8.9	1.5	27	4.1%	95.9%
	Stoney Brook Road	16.5	0.96		18	0.85	0.62	1.9	5.8%	94.2%
	Brookside Lane	14.8	0.23		6	2.4	1.7	4.8	1.6%	98.4%
	Smith Lane/James Lane	80.4	2.75	1.06	19	3	1.4	5.9	3.4%	96.6%
	North Mayhew Turnpike	51.1	0		7	7.3	1.9	10.7	0.0%	100.0%

The most intensively developed subdivisions typically are comprised of lots less than two acres, and often as low as about one acre. These are found at the south end of the lake. Larger lots are typical of subdivisions with frontage on existing roads and/or located further away from the lake. Land areas devoted to road rights-of-way were carefully measured in each specimen subdivision in order to understand local subdivision design trends. **This information is critical to determining the actual amount of land on any given tract that could be built-upon**. Some subdivision designs analyzed for this study made efficient use of roadway layouts, often in conjunction with larger lots, and therefore show less land taken up in roadways (on the order of 3% or less). Others are located on difficult terrain, with extensive complicated road systems to serve the lots in the subdivision, required more land for longer roadways (in the range of 9% to 13%). The entire frontage of two subdivisions was on existing roads, so no road construction was necessary.

Note also the range in **lot sizes** and **subdivision density**, which are a critical factors in conducting a build-out analysis. The Stoney Brook Road development in Hebron has 18 lots on about 16 acres of land, with an average lot size of 0.82 acre; this represents a very high density development. Similar densities are found in both older and more current developments in several locations around the shore of the lake, but the Hebron example is located at the more rural north end of the lake. A middle zone of density is found at approximately two to five acres per unit in several subdivisions, and lot sizes greater than 5 acres are common in subdivisions in more outlying areas.

To predict future **numerical development trends**, the build-out analysis requires a set of "multipliers" that reasonably reflects the typical number of residential units expected on vacant tracts of land at varying densities. Based on typical tract utilization for a range of subdivision densities determined above, the following table lists the break-points of lot size and available lot layout area used to finally "populate" developable land in the watershed (previously determined and discussed above) with potential new housing. Lower density developments with larger lots sizes are therefore assumed to have less land devoted to new road development. At the other end of the scale, the higher density subdivisions – ranging up to condominium-style developments – are assumed to have more land utilized for roads and in some cases parking.

Subdivision Density	Range of Lot Size Per Unit	Percent of Tract Available for Lot Layout
Low	> 5 Acres	97%
Medium	2 - 5 Acres	95%
High	1 - 2 Acres	93%
Very High	<1 Acre	90%

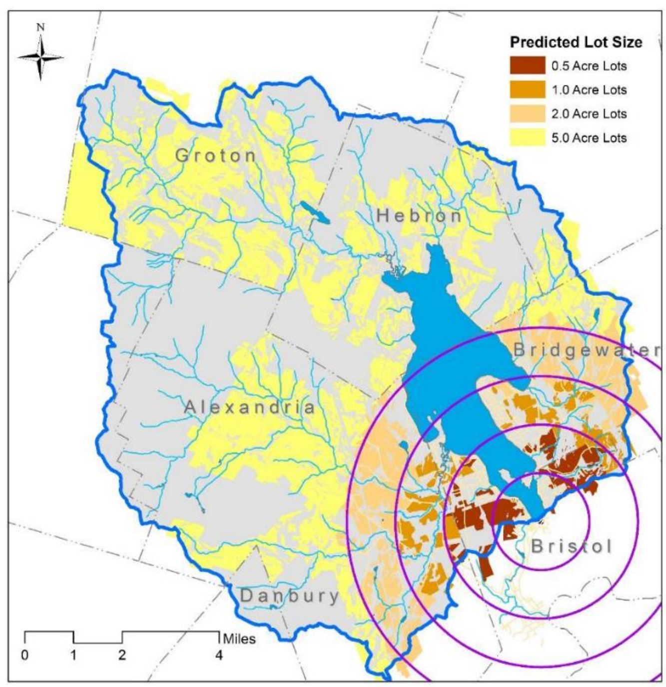
Determining Density

One last question must be answered before the build-out model can be run: **where in the watershed will certain subdivision densities be most likely to occur?** The clues to that pattern are found in the locations of the 17 subdivisions already discussed, and even more readily, by examining the municipal tax parcel mapping for the entire watershed.

One conclusion from examining the data and the land use patterns in the watershed is that it is unlikely that any significant new development will occur near the lake shore itself since it is already "built-out", and in fact has seen steady conversion of older, lower density residential tracts into higher density developments over the last two or three decades. New development ***could*** occur near the lake given the amenity value of the property, but for the purposes of this study it is assumed that this is not as likely as development in nearby locations around the lake.

A second observation is that the southern end of the lake, especially Bristol and Bridgewater, has seen subdivisions and development activity in the higher density ranges. This is true of older "camp lot" areas, and more recent subdivisions fairly near the lake shore. Bristol and Bridgewater are also the towns with services typically needed by denser development. There is also a significant echo of this development density in Hebron, at the north end of the lake in several small subdivisions clustered together.

Third, most of the more recent subdivisions in the areas away from the lake are larger lot sizes, typically in the 5 to 10 acres and greater range. This is most probably due to the prevailing market demand in the last couple of decades for year-round living arrangements, as well as preference for more rural home settings. Alexandria has seen several such low-density developments, especially in the southern portion of town abutting Bristol. Subdivisions in the same time period in Groton are also typically low-density



The map to the right displays the assumptions about predicted lot size and subdivision density that flow from this analysis. Again, to make numerical predictions of future development, a reasonable framework is necessary. The yellow-to-brown background in the map is the **land most likely to develop** as determined and discussed previously.

The four purple circles represent one-mile intervals from the foot of Newfound Lake; these distances correspond well to observed changes in historical and more recent subdivision lot densities evident in tax parcel mapping, and these areas are the most likely to experience "in-fill" development which converts lower density developed land into higher density utilization. Beyond the last circle, away from services and built-up areas around the lake, it is likely that larger lot sizes will be the norm.

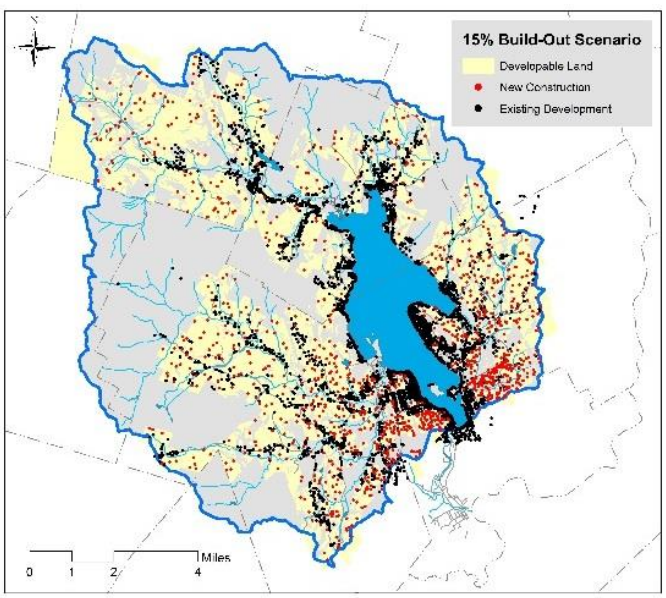
Section 3: Model Results

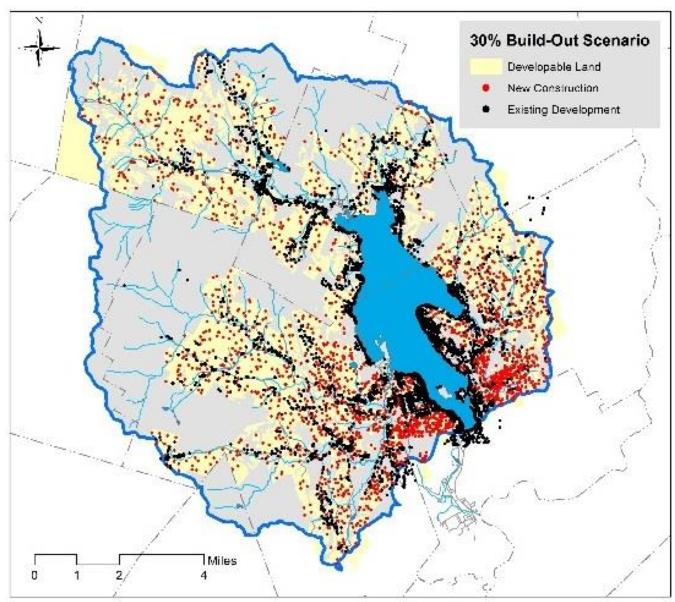
Predicted Change

With reasonable future land use assumptions decided, and all numerical parameters in place, the actual build-out model can be processed in the GIS using a function that randomly locates a mathematically-determined number of points (new homes) in each tract of developable land. The first pass in "populating" the vacant tracts results in the **maximum development** probable given the inputs; the second pass breaks this maximum down into percentages to better understand how incremental growth would play out across the Newfound Lake watershed.

Using the model parameters discussed above, the maximum build-out would result in more than 8,000 new building units in the watershed, or 215% growth over the base of about 3,740 buildings identified in the 2010 aerial photography. However, this prediction is a mathematical and theoretical artifact; it is not likely that full build-out will ever be achieved in the watershed. Earlier stages of likely development towards that maximum are better indicators of development patterns.

The maps on the next page show development at 15% and 30% of maximum build-out. Note how the density of red dots (new construction) increases near the south end of the lake, consistent with the predicted lot density assumptions reviewed above. The increase in impervious surfaces, lawns, etc., in this area will have significant adverse effects on lake water quality if measures are not taken during design, construction, and occupancy to avoid increased sediment and nutrient loading.





Probable Time Frame

A next logical question would be: how long will it take to meet the 15% and 30% scenarios? To answer the question, analysis of growth trends in the watershed is required. These trends are illustrated in the chart below and in **Table 3** which summarizes the changes in housing for the Newfound

Lake region communities for the period 2000 to 2012.[11] **<u>Important note:</u> the chart and the data in the table below reflect the <u>total</u> housing stock and growth trends for <u>entire</u> land area of the five municipalities listed both within and outside of the Newfound Lake watershed. However, these data are readily and reasonably used to predict growth given the large share of housing located within the watershed.**

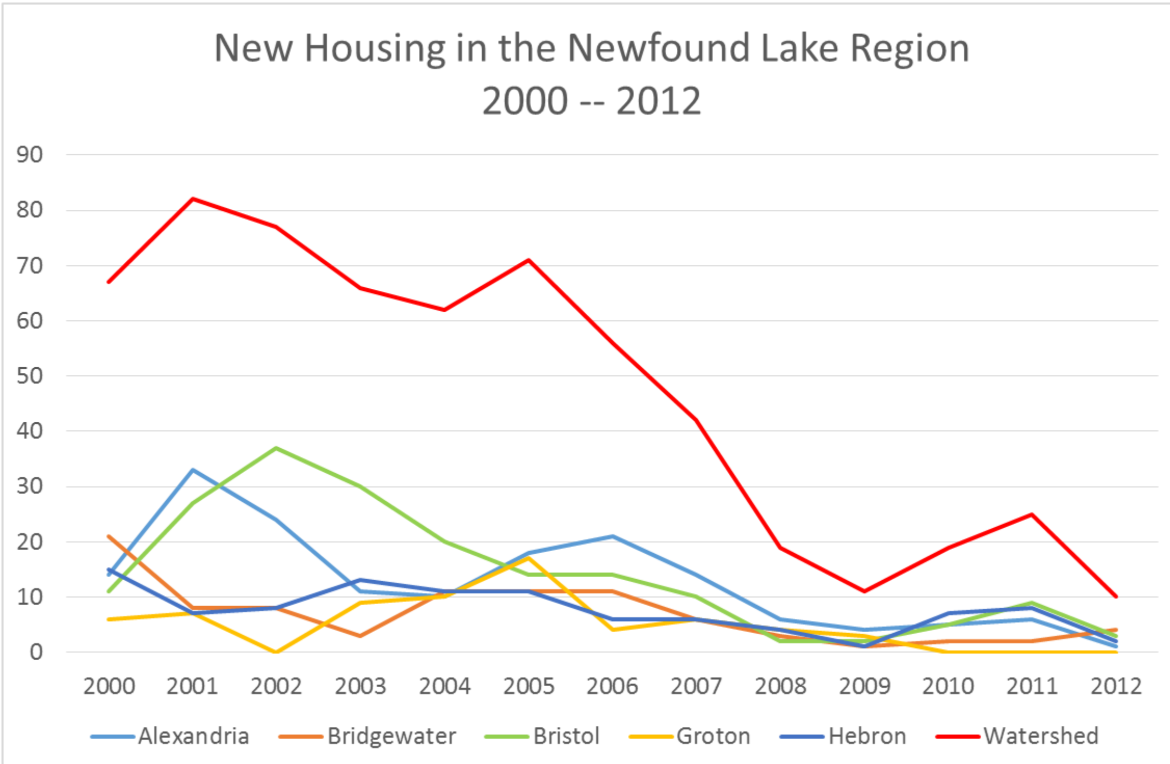


Table 3

Rates of Housing Change in Newfound Lake Watershed Communities 2000 - 2012

Municipality	2000 Total	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2012 Total	Percent Change
Alexandria	783	14	33	24	11	10	18	21	14	6	4	5	6	1	950	**21.3%**
Bridgewater	850	21	8	8	3	11	11	11	6	3	1	2	2	4	941	**10.7%**
Bristol	2,073	11	27	37	30	20	14	14	10	2	2	5	9	3	2,257	**8.9%**
Groton	342	6	7	0	9	10	17	4	6	4	3	NA	NA	NA	408	**19.3%**
Hebron	517	15	7	8	13	11	11	6	6	4	1	7	8	2	616	**19.1%**
	4,565	**67**	**82**	**77**	**66**	**62**	**71**	**56**	**42**	**19**	**11**	**19**	**25**	**10**	**5,172**	**13.3%**

The red line in the chart is the total new housing construction for the time period; the growth trends of the five principal municipalities around the lake are clustered below the watershed totals. Clearly, the effects of economic recession appears around the 2007 to 2008 period in both the chart and the summary, but new development typically follows boom-and-bust cycles, and these data represent a "snapshot in time". Using these data**, the average annual growth rate for the 2000 to 2012 period is about 1%**[12]. Therefore, the 15% build-out scenario would require about 15 years to reach given this

[11] Based on housing trends data published by the N.H. Office of Energy and Planning. Note that these figures are for the entire municipality, including areas <u>outside</u> the Newfound Lake watershed.

[12] This growth rate is also typical of the statewide change for the time period per N.H. Office of Energy and Planning data.

growth rate, and the 30% scenario could stretch out to 30 years. Beyond the 30-year horizon, the results of the build-out projections are too uncertain to predict.

The two tables below show the share of new housing predicted for each of the five communities for both the 15% and 30% development scenarios. Note that Alexandria – the municipality with the greatest developable land area and currently minimal zoning – shows the greatest potential for new construction both numerically and percentage-wise. Bristol and Bridgewater with higher density inputs into the model but less land area also are predicted to add significant new building development.

15% Development

Municipality	# New Buildings	Percent Share
Alexandria	382	34.3%
Bridgewater	245	22.0%
Bristol	277	24.9%
Groton	125	11.2%
Hebron	84	7.5%
	1,113	

30% Development

Municipality	# New Buildings	Percent Share
Alexandria	827	35.2%
Bridgewater	491	20.9%
Bristol	550	23.4%
Groton	281	12.0%
Hebron	200	8.5%
	2,349	

The 15% scenario results in a little more than 1,100 new housing units, or an increase of 30% over existing baseline, in a span of 15 years. The 30% scenario adds about 2,350 new units for an increase of 63% over existing baseline.

Section 4: Fowler River Development Study

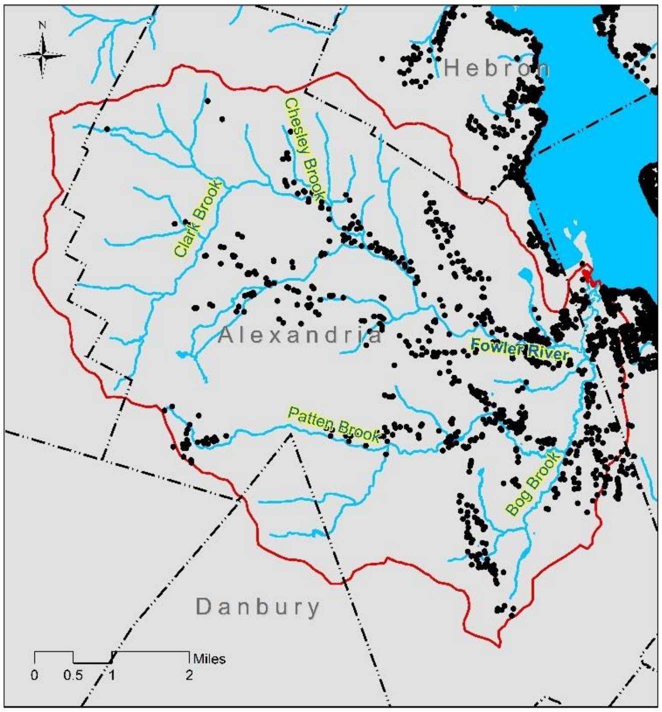
Introduction

The Fowler River watershed has been chosen for more detailed study and scenario planning related to the build-out analysis for the following reasons:

- The Fowler River drainage area totals about 36 square miles, or 37% of the total Newfound Lake watershed;
- It contains a rural-to-urban land use continuum that matches the watershed-wide development character;
- As noted above, Alexandria is predicted to have the largest share and a significant numerical increase in new construction based on the build-out model; and, perhaps most importantly,
- Watershed master plan water quality measurements have shown that the **Fowler River watershed contributes 48% of total phosphorus loading to Newfound Lake based on existing conditions**.

Furthermore, as was noted in **Part 1** of this report, a number of natural resource features important to maintaining water quality and/or representing constraints to future development exist in the lower section of the Fowler River watershed. This alone should trigger more in-depth consideration of the potential impacts of future development. It is hoped that this "cameo study" of the Fowler River will demonstrate a general process that communities surrounding Newfound Lake can use to assess both development and conservation priorities, arriving at a sound balance of both in the best interest of their personal and public property, of Newfound Lake, and of the local economy.

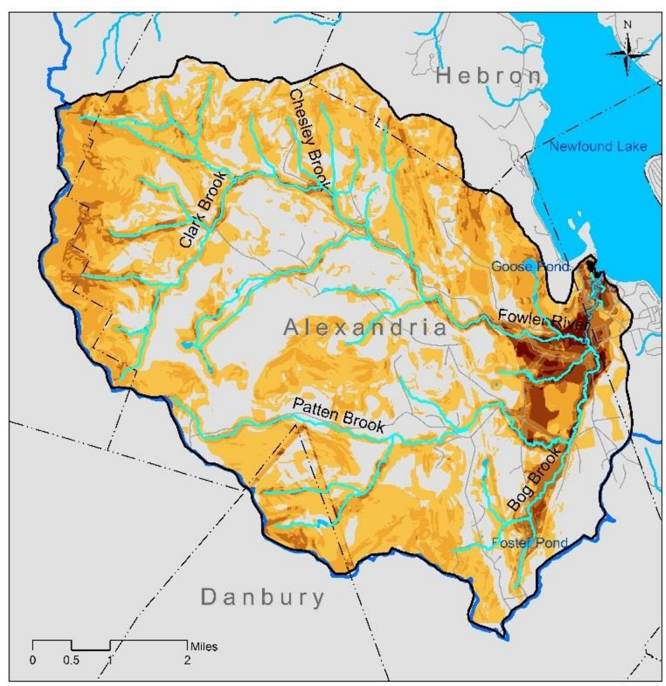
Study Area



The map to the left shows the Fowler River watershed and the limits of the study area for this analysis. This sub-watershed covers about 36 square miles, and is comprised of several smaller tributary stream watersheds. Clark Brook and Chelsey Brook are headwaters streams that join to form the Fowler River. Patten Brook and Bog Brook are significant tributaries that join the Fowler River near Newfound Lake. The black dots in the map are buildings mapped from 2010 aerial photography. **There are 940 buildings in the Fowler River watershed, totaling 99% of all housing in Alexandria, and about 25% of all buildings in the Newfound Lake watershed**.

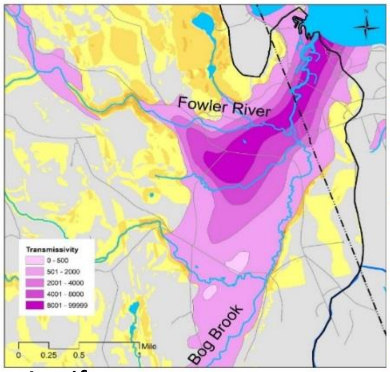
Focus Area

The map to the right shows the watershed co-occurrence mapping in the Fowler River watershed; the color gradient from light orange to dark brown represents the higher two-thirds of scores from the total co-occurrence mapping, with highest values evident in the lower portion of the Fowler River and along Bog Brook. The lack of color (gray) in much of Alexandria does not mean that there are no concerns there for water quality or future development; the selective use of the co-occurrence scores simply emphasizes those locations where priority considerations are most needed. The area with darker colors therefore is the focus area for the balance of this analysis.

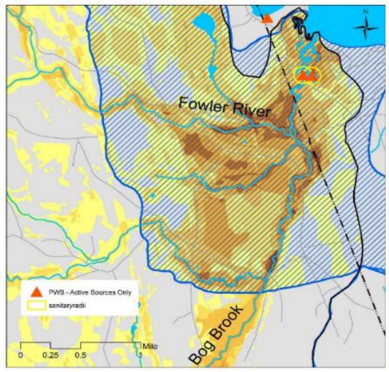


Review of Natural Resource Features

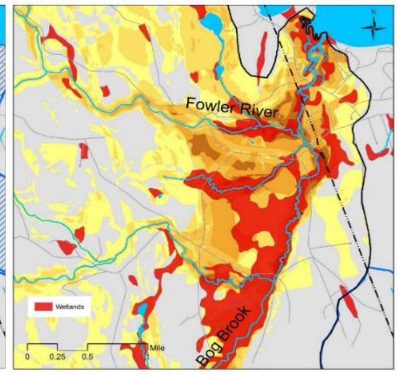
It is helpful to make a closer inspection of the key natural resource features that additively make the focus area significant. These are addressed in more detail in **Part 1** of this report, but are displayed in the following map series in greater detail. For illustration and brevity, only 6 of 12 resources are shown below, but all 12 are used in the analysis and mapping. Note how the features in each map appear again and again in the same focus area, overlaid on each other.



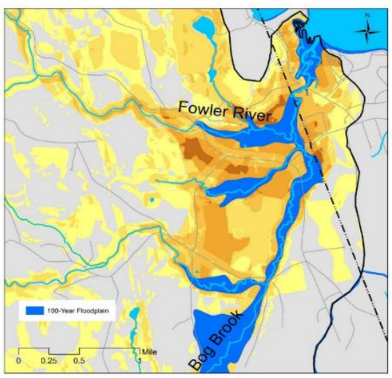
Aquifer



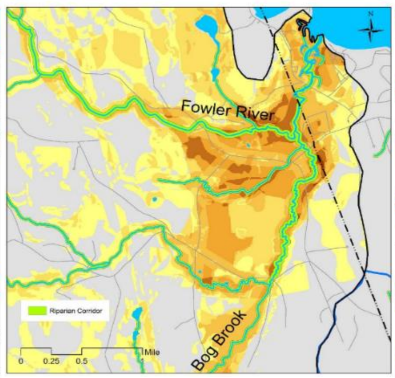
Drinking Water Protection



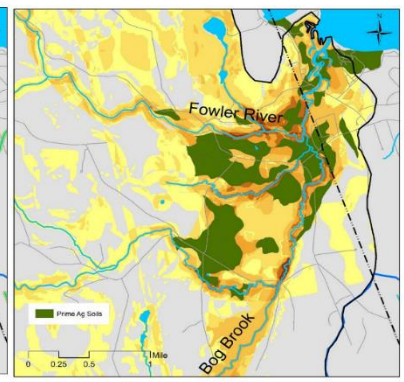
Wetlands



Floodplain

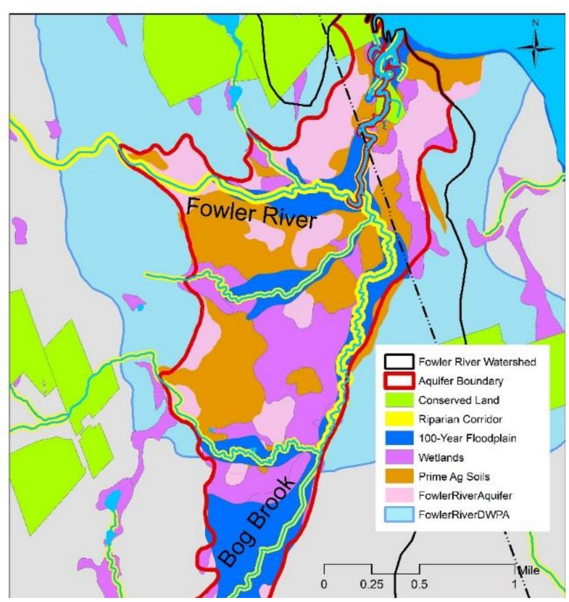


Riparian Buffers

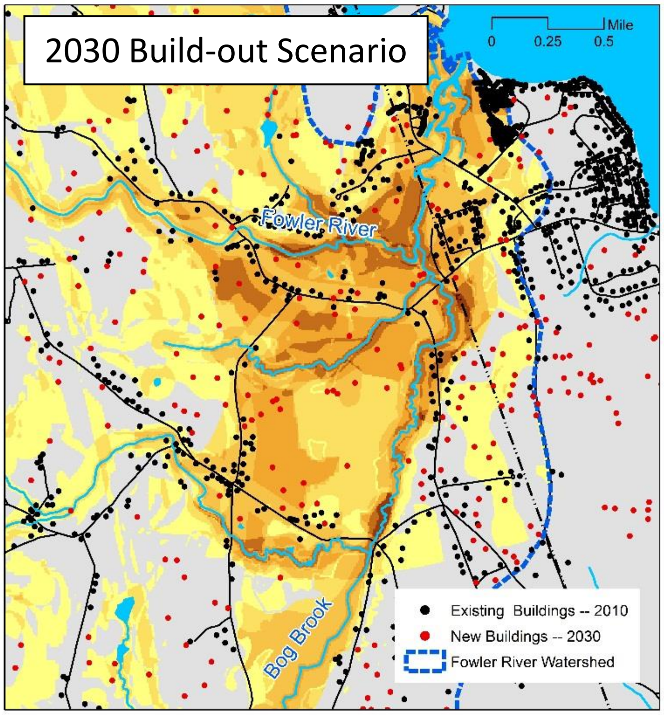


Prime Farmland Soils

The map to the right displays these six resource features overlaid on one another in the focus area to best show how the features cluster and interact. The bright green shapes are conservation and public lands; note how little of the Fowler River watershed is currently protected from development, especially within the aquifer area (red boundary).



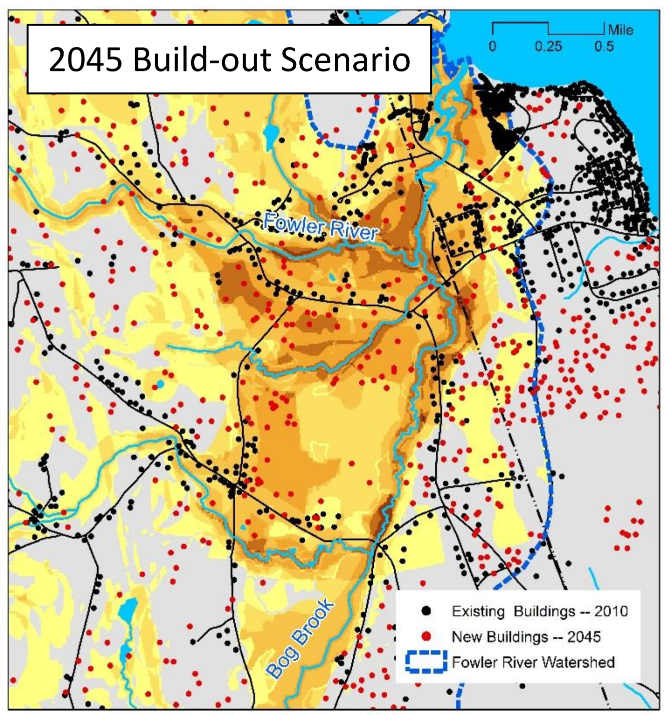
Future Development Scenarios



The map to the left shows the same area of the Fowler River study area, but returns to the color gradient scheme of the co-occurrence mapping which shows where more or less resource features are co-located.

The black dots are buildings mapped from the 2010 aerial photography. The red dots represent potential new development build-out by 2030 – just fifteen years from now (this is the 15% build-out scenario). Recall that the red dots do not precisely locate each new building, but rather are a graphic pattern of new construction determined by the build-out model.

For comparison, the map below shows the 30% build-out scenario, approximately 30 years from now (2045). In both scenarios, new construction has taken place on land currently undeveloped for residential land use. Note how the red dots scatter over much of the darker color tones in the co-occurrence mapping where multiple natural resources are found.

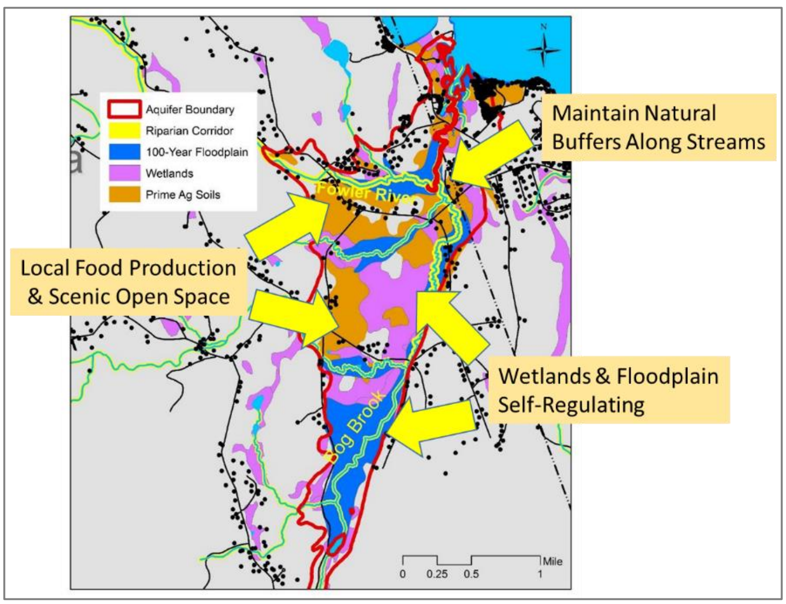


Wetlands and floodplains are automatically eliminated per the build-out model qualifications, hence the absence of red dots in some locations. However, note that considerable development is predicted on the aquifer, prime agricultural soils, within the Bristol Water Works wellhead protection area, and close to riparian buffers in this critical downstream segment of the Fowler River drainage.

Recommendations

Communities within the Newfound Lake watershed are encouraged to use the build-out analysis information provided in this report, in concert with separate mapping of the co-occurrence of various natural resources provided to each community that supplements this report, to conduct more in-depth community and conservation planning. The Fowler River development study presented here is one approach which can be replicated in other areas within the watershed, including the Cockermouth River valley in Groton and Hebron, the headwaters areas of Alexandria, and various sub- watersheds in Hebron and Bridgewater.

Understanding the importance of natural resource features as they relate to water quality in the lake and its tributaries, as well as constraints to development, can lead to relatively simple planning solutions useful to decision-makers in each community. Using the Fowler River and Bog Brook aquifer area as an example, the map below illustrates a few key points to guide development to the most suitable locations while simultaneously protecting water quality and other key natural resources.



The single most important resource feature in the Fowler River watershed is the aquifer, which provides drinking water to the Bristol Water Works, and a potentially excellent water supply for Alexandria's future growth. An overarching goal, therefore, would be to limit potential contamination sources and to prevent construction of impermeable surfaces (such as buildings, roads, and parking areas) as much as possible by keeping the land overlying the aquifer and within the aquifer recharge area in a natural condition.

Maintaining natural vegetation in riparian buffers along the river and streams is the most effective way to protect surface water quality. Wetlands and floodplains, which cover much of the aquifer area and are inter-connected with the riparian buffers, are self-protecting to a large degree because their use and development is regulated by State agencies.

The prime agricultural soils found over the aquifer offer an important choice to community decision-makers. On the one hand, the land is open and invites relatively easy development of roads and buildings. On the other hand, the high quality of the soil is unique in New Hampshire and the region, and warrants a long future perspective with local food production in mind. Keeping this land in farming will also help to preserve the excellent and prized scenic quality of the Fowler River valley that gives Alexandria much of its rural character. An alternative might be to work towards a balance of development and farm land preservation using clustered residential development and conservation subdivisions that set aside a significant amount of farmland for the future, while also considering cumulative scenic quality.

Updating community master plans to reflect the findings of this and other Newfound Lake Watershed Master Plan studies is an important starting point for pro-active community planning. The natural resource data needed for updating town master plans is essentially complete, thanks to the watershed master plan process led by NLRA and its many partners. Each community can tailor their own "shared vision" using various group process consensus-building techniques[13], and the region-wide co-occurrence mapping can be refined and focused upon local values and priorities. The over-arching watershed master plan will continue to work as a unifying force in the region, while each community's vision defines the approach to local decisions that will affect both the quality of municipality and the economic benefits provided by clean water, healthy forests, and rural character of Newfound Lake for decades to come.

[13] For more information on how to start a "shared vision" community planning process, contact the Newfound Lake Region Association at 603-744-8689, or info@NewfoundLake.org