# *Brackett Brook*

## Watershed Description

This **TMDL** applies to a 2.74 mile section of Brackett Brook, located in the Towns of Palmyra and Newport, Maine. Brackett Brook begins in an agricultural field near Libby Hill Road and flows south through a predominantly forested area, crossing Route 2. The stream then passes through agriculture and enters a small ponded wetland before crossing I-95. The stream continues through a wetland, flows by an agricultural field, and crosses Oxbow Road (Route 11), entering into another forested area before its confluence with the East Branch Sebasticook River. The Brackett Brook watershed covers an area of 2.61 square miles. The majority of the watershed is located within the Town of Palmyra, however, small portions of the watershed lie within the surrounding Town of Newport.

- Runoff from agricultural land located in the areas of Main Street, Oxbow Road, and large maintained lawns on Libby Hill Road, are likely the largest sources of **nonpoint source (NPS) pollution** to Brackett Brook. Runoff from cultivated lands, maintained lawns, active hay lands, and grazing areas can transport nitrogen and phosphorus to the nearest section of the stream.
- The Brackett Brook watershed is predominately non-developed (72%). Forested areas (41.5%) within the watershed absorb and filter pollutants helping protect both water quality in the stream and stream channel stability. Wetlands (6.6%) may also help filter nutrients.
- Non-forested areas within the watershed are predominantly agricultural (23.9%) and are concentrated in the central and northern portion of the watershed along Main Street, Oxbow Road, and Libby Hill Road.
- Developed areas (28%) with impervious surfaces in close proximity to the steam may impact water quality.
- Brackett Brook is on Maine's 303(d) list of Impaired Streams (Maine DEP, 2013).

### *Definitions*

- ***Total Maximum Daily Load (TMDL)*** *represents the total amount of pollutants that a waterbody can receive and still meet water quality standards.*
- **Nonpoint Source Pollution** *refers to pollution that comes from many diffuse sources across the landscape, and is typically transported by rain or snowmelt runoff.*

## *Waterbody Facts*

**Segment ID:** ME0103000308_325R02

**Town:** Palmyra and Newport, ME

**County:** Somerset

**Impaired Segment Length:** 2.74 miles

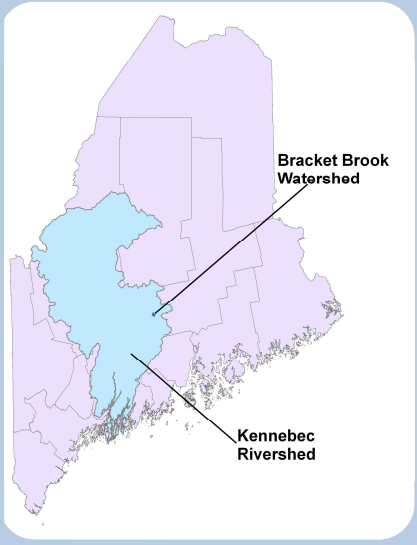
**Classification:** Class B

**Direct Watershed:** 2.61 $mi^2$ (1670 acres)

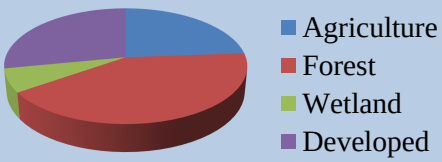
**Impairment Listing Cause:** Dissolved Oxygen

**Watershed Agricultural Land Use:** 23.9%

**Major Drainage Basin:** Kennebec River




**Watershed Land Uses**



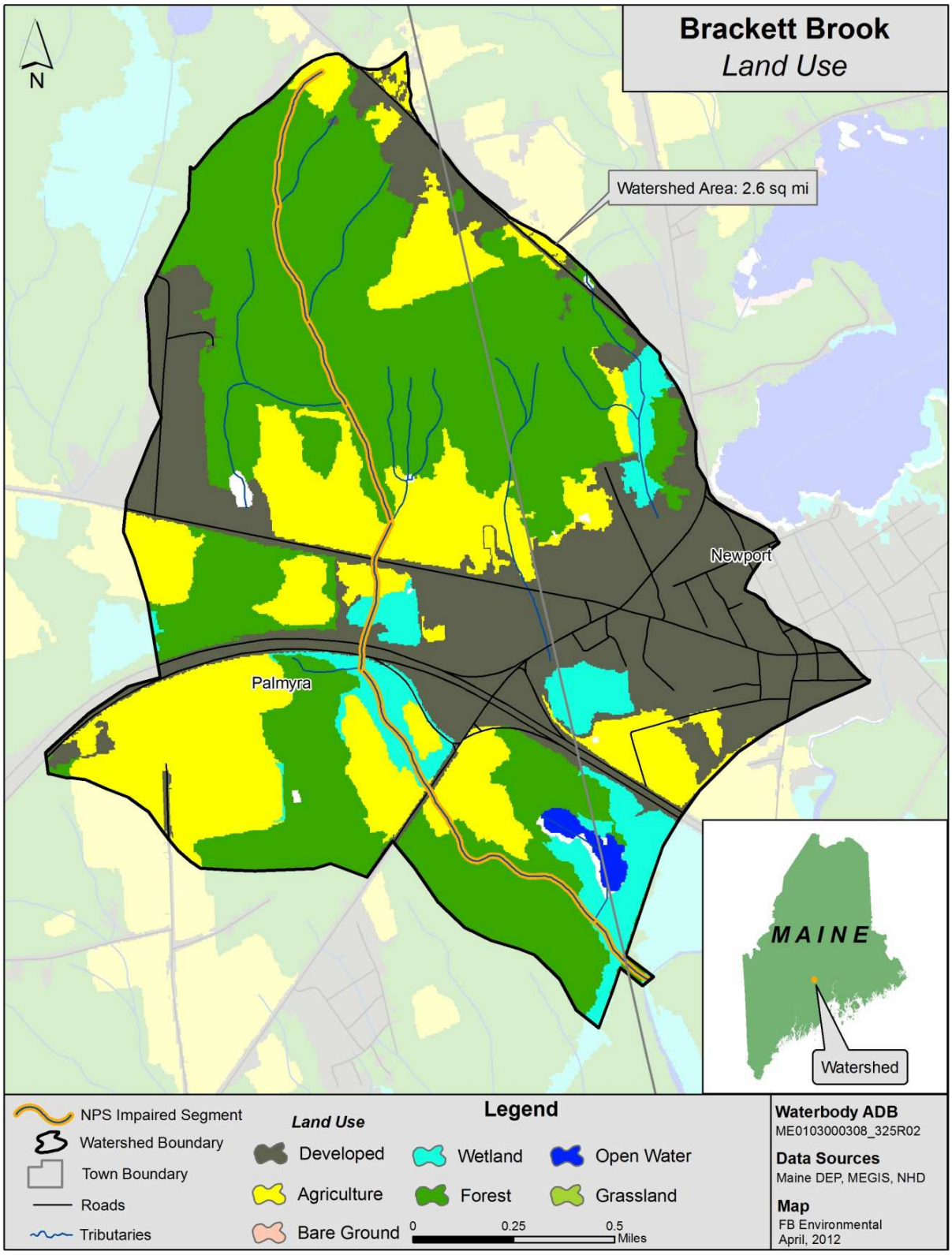



**Figure 1:** Land Use in the Brackett Brook Watershed

## WHY IS A TMDL ASSESSMENT NEEDED?

Brackett Brook, a Class B freshwater stream, has been assessed by Maine DEP as not meeting water quality standards for the designated use of aquatic life, and placed on the 303(d) list of impaired waters under the Clean Water Act. The Clean Water Act requires that all 303(d)-listed waters undergo a TMDL assessment that describes the impairments and establishes a target to guide the measures needed to restore water quality. The goal is for all waterbodies to comply with state water quality standards.

***Brackett Brook** near Oxbow Road crossing. Photo: FB Environmental*

Agriculture in the Brackett Brook watershed accounts for 24% of total land area in the watershed, and 29% of the impaired stream segment passes through agricultural land (Figure 1). Agriculture is therefore likely to be a large contributor of sediment and nutrient enrichment to the stream. The close proximity of many agricultural lands to the stream further increases the likelihood that nutrients from disturbed soils, manure, and fertilizers will reach the stream. Developed land within the watershed accounts for 28% of total land area, suggesting that development and impervious surfaces are also a contributor of sediment and nutrients in Brackett Brook.

## WATER QUALITY DATA ANALYSIS

Maine DEP uses a variety of data types to measure the ability of a stream to adequately support aquatic life, including; dissolved oxygen, benthic macroinvertebrates, and periphyton (algae). The aquatic life impairment in Brackett Brook is based on historic dissolved oxygen data.

## TMDL ASSESSMENT APPROACH: NUTRIENT MODELING OF IMPAIRED AND ATTAINMENT STREAMS

NPS pollution is difficult to measure directly, because it comes from many diffuse sources spread across the landscape. For this reason, a nutrient loading model, MapShed, was used to estimate the sources of pollution based on well-established hydrological equations; detailed maps of soil, land use, and slope; many years of daily weather data; and direct observations of agriculture and other land uses within the watershed.

The nutrient loading estimates for the impaired stream were compared to similar estimates for five non-impaired (attainment) streams of similar watershed land uses across the state. The TMDL for the impaired stream was set as the mean nutrient loading estimate of these attainment stream watersheds, and units of mass per unit watershed area per year (kg/ha/year) were used. The difference in loading estimates between the impaired and attainment watersheds represents the percent reduction in nutrient loading required under this TMDL. The attainment streams and their nutrient and sediment loading estimates and TMDL are presented below in Table 1.

**Table 1:** Numeric Targets for Pollutant Loading Based on MapShed Model Outputs for Attainment Streams

| Attainment Streams | Town | TP load (kg/ha/yr) | TN load (kg/ha/yr) | Sediment load (1000 kg/ha/yr) |
|---|---|---|---|---|
| Martin Stream | Fairfield | 0.14 | 3.4 | 0.008 |
| Footman Brook | Exeter | 0.33 | 6.4 | 0.058 |
| Upper Kenduskeag Stream | Corinth | 0.29 | 5.6 | 0.047 |
| Upper Pleasant River | Gray | 0.22 | 4.6 | 0.016 |
| Moose Brook | Houlton | 0.25 | 5.9 | 0.022 |
| **Total Maximum Daily Load** | | **0.24** | **5.2** | **0.030** |

## RAPID WATERSHED ASSESSMENT

### Habitat Assessment

A Habitat Assessment survey was conducted on both the impaired and attainment streams. The assessment approach is based on the *Rapid Bioassessment Protocols for Use in Wadeable Streams and Rivers* (Barbour et al., 1999), which integrates various parameters relating to the structure of physical habitat. The habitat assessments include a general description of the site and physical characterization and visual assessment of in-stream and riparian habitat quality.

Based on Rapid Bioassessment protocols for low gradient streams, Brackett Brook received a score of 149 out of a total 200 for quality of habitat. Higher scores indicate better habitat. The range of habitat assessment scores for the attainment streams was between 155 and 179, with an average of 167.

Habitat assessments were conducted on a relatively short sample reach (about 100-200 meters for a typical small stream) near the most downstream Maine DEP sample station in the watershed. For both impaired and attainment streams, the assessment location was usually near a road crossing for ease of access. In the Brackett Brook watershed, the downstream sample station was located upstream of the Oxbow Road stream crossing. Tall grasses and cattails dominated the riparian zone and the stream channel was documented as being quite degraded.

Figure 2 (right) shows the range of habitat assessment scores for all attainment and impaired streams, as well as for Brackett Brook. Though these scores show that habitat is clearly an issue in the impairment of Brackett Brook, it is important to look for other potential sources within the watershed leading to impairment. Consideration should be given to major "hot spots" in the Brackett Brook watershed as potential sources of NPS pollution contributing to the water quality impairment.

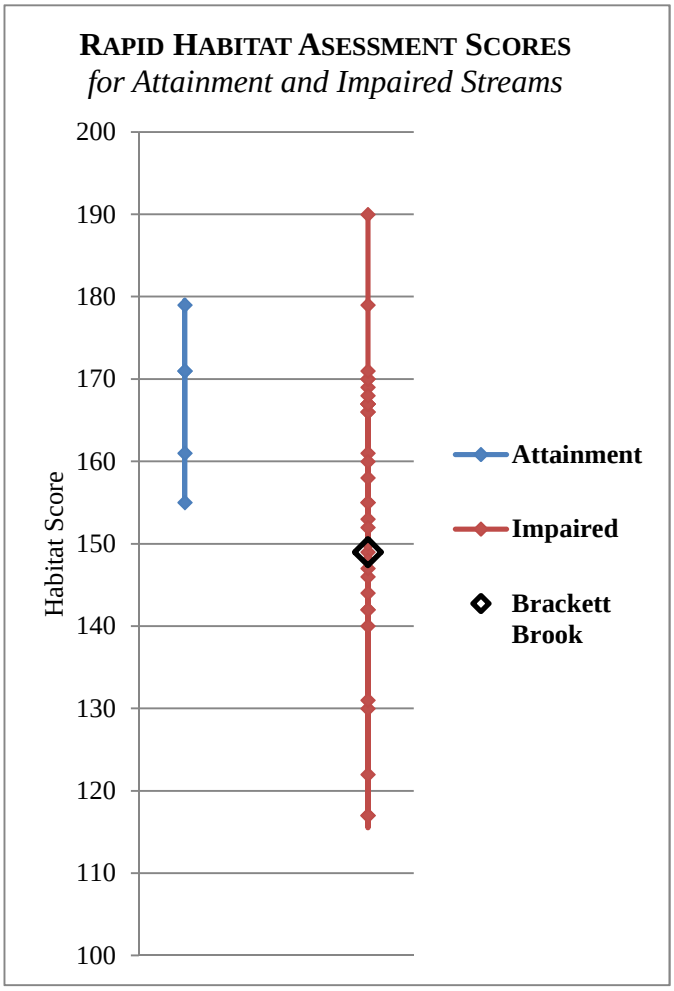



**Figure 2:** Habitat Assessment Scores

**Pollution Source Identification**

Pollution source identification assessments were conducted for both Brackett Brook (impaired) and the attainment streams. The source identification work is based on an abbreviated version of the Center for Watershed Protection's Unified Subwatershed and Site Reconnaissance method (Wright, et al., 2005). The abbreviated method includes both a desktop and field component. The desktop assessment consists of generating and reviewing maps of the watershed boundary, roads, land use and satellite imagery and then identifying potential NPS pollution locations, such as road crossings, agricultural fields, and large areas of bare soil. When available, multiple sources of satellite imagery were reviewed. Occasionally, the high resolution of the imagery allowed for observations of livestock, row crops, eroding stream banks, sediment laden water, junkyards, and other potential NPS concerns that could affect stream quality. As many potential pollution sources as possible were visited, assessed and documented in the field. Field visits were limited to NPS sites that were visible from roads or a short walk from a roadway. Neighborhoods were assessed for NPS pollution at the whole neighborhood level including streets and storm drains (where applicable). The assessment does not include a scoring component, but does include a detailed summary of findings and a map indicating documented NPS sites throughout the watershed.

The watershed source assessment Brackett Brook was completed on July 2, 2012. In-field observations of erosion, lack of vegetated stream buffer, extensive impervious surfaces, high-density neighborhoods and agricultural activities were documented throughout the watershed (Table 2, Figure 3).

**Table 2:** Pollution Source ID Assessment for the Brackett Brook Watershed

| Potential Source | | | Notes |
|---|---|---|---|
| **ID#** | **Location** | **Type** | |
| **1** | Libby Hill Road | Residential | • Large, very green lawns. Highly maintained. |
| **2** | Main Street | Agriculture | • Active hayfield. |
| **3** | Main Street | Commercial Development | • Wal-Mart shopping center located adjacent to brook. |
| **4** | Main Street | Road Crossing | • Road crossing with wetlands and hayfields surrounding. |
| **6** | Interstate 95 | Road Crossing | • I-95 runs east-west through the Brackett Brook watershed. |
| **8, 9 & 10** | Oxbow Road & Smith Road | Agriculture | • The south west portion of the watershed is highly agricultural.<br>• Potato and corn crops were observed.<br>• Active hayfields located at the corner of Oxbow Road and Smith Road.<br>• Possible forestry activities taking place. Activity unknown. |
| **11** | Main Street | Agriculture | • Active hayfield. |
| **14** | East end of Main Street | Residential & Commercial Development | • Large neighborhoods located at the very eastern edge of the watershed.<br>• Lawns normal; not highly maintained.<br>• Large shopping plazas located at the intersection of Route 11 and Main Street. |

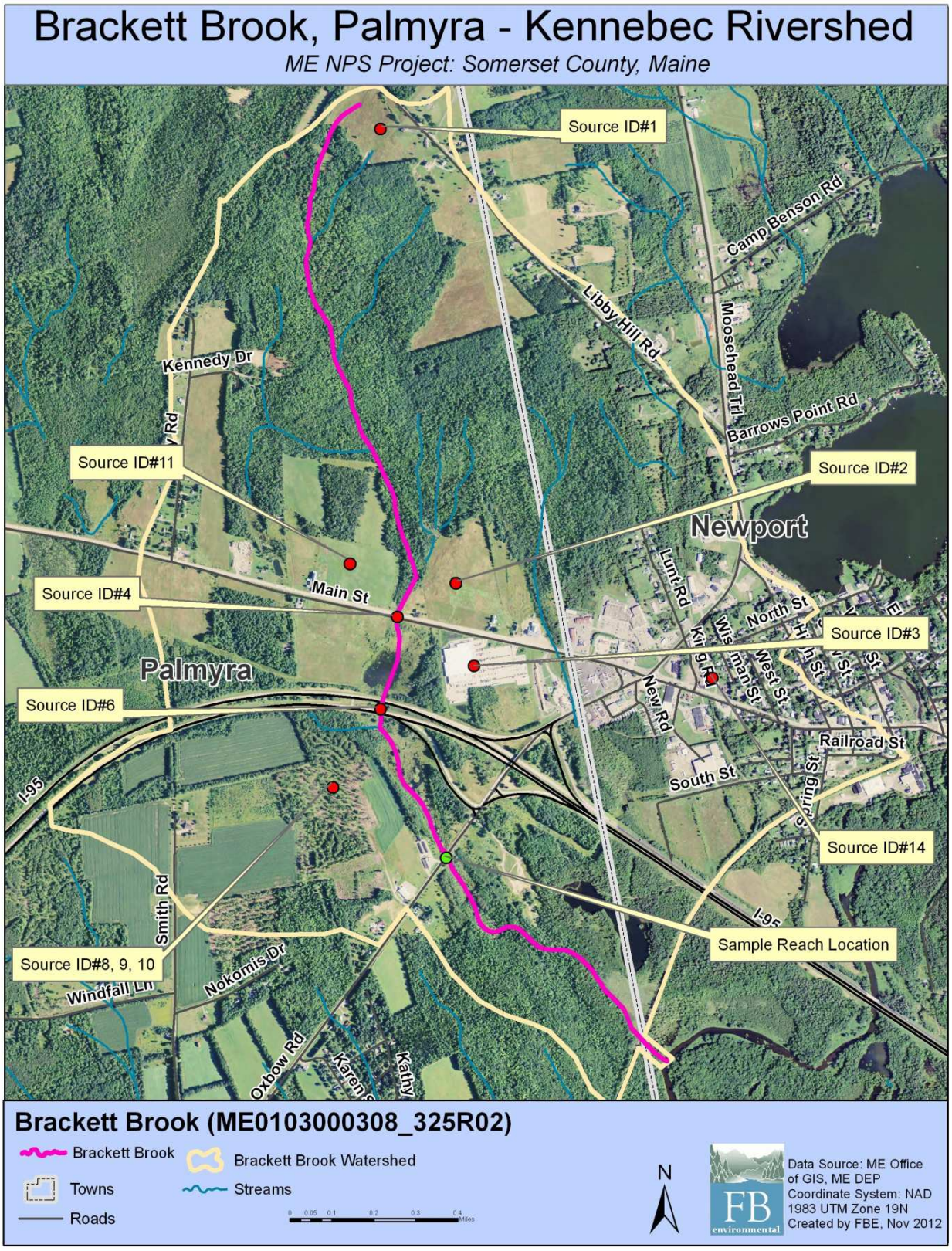



**Figure 3:** Aerial Photo of Source ID locations in the Brackett Brook Watershed

## NUTRIENT LOADING – MAPSHED ANALYSIS

The MapShed model was used to estimate stream loading of sediment, total nitrogen and total phosphorus in Brackett Brook (impaired), plus 5 attainment watershed throughout the state. The model estimated daily nutrient loads over a 15-year period (1990-2004), which was determined by the available weather data provided within MapShed. This extended period captures a wide range of hydrologic conditions to account for variations in nutrient and sediment loading over time.

Many quality assured and regionally calibrated input parameters are provided with MapShed. Additional input parameters were manually entered into the model based on desktop research and field observations, as described in the sections on Habitat Assessment and Pollution Source Identification. These manually adjusted parameters included estimates of livestock animal units, and agricultural stream miles with intact vegetative buffer.

### *Livestock Estimates*

Livestock waste contains nutrients which can cause water quality impairment. The nutrient loading model considers numbers and types of animals. Table 3 (right) provides estimates of livestock (numbers of animals) in the watershed, based on direct observations made in the watershed, plus other publicly available data.

**Table 3:** Livestock Estimates in the Brackett Brook Watershed

| Type | Brackett Brook |
|---|---|
| Dairy Cows | 0 |
| Beef Cows | 0 |
| Broilers | 0 |
| Layers | 0 |
| Hogs/Swine | 0 |
| Sheep | 0 |
| Horses | 0 |
| Turkeys | 0 |
| Other | 0 |
| **Total** | **0** |

Agricultural activities were most commonly open fields and active hayfields with the exception of potato and corn crops located in the south west portion of the watershed. No livestock was observed within the watershed, although some may have been present that were not observed.

### *Vegetated Stream Buffers in Agricultural Areas*

Vegetated stream buffers are areas of trees, shrubs, and/or grasses adjacent to streams, lakes, ponds or wetlands which provide nutrient loading attenuation (Evans & Corradini, 2012). MapShed considers natural vegetated stream buffers within agricultural areas as providing nutrient load attenuation. The width of buffer strips is not defined within the MapShed manual, and was considered to be 75 feet for this analysis. Geographic Information System (GIS) analysis of recent aerial photos along with field reconnaissance observations were used to estimate the number of agricultural stream miles with and without vegetative buffers, and these estimates were directly entered into the model.

**Table 4:** Summary of Vegetated Buffers in Agricultural Areas

| Brackett Brook |
|---|
| • 12.8 stream miles in watershed (includes tributaries) |
| • 0.78 stream mile in agricultural areas |
| • 67% of agricultural stream miles have a vegetated buffer |

Brackett Brook is a 2.74 mile-long impaired segment as listed by Maine DEP. As modeled, the total stream miles (including tributaries) within the watershed was calculated as 12.8 miles. Of this total, 0.78 stream miles are located within agricultural areas; of this length, 0.52 miles (67%) show a 75-foot or greater vegetated buffer (Table 4, Fig. 4). By contrast, agricultural stream miles (as modeled) with a 75-foot vegetated buffer in the attainment stream watersheds ranged from 34% to 92% with an average of 61%.

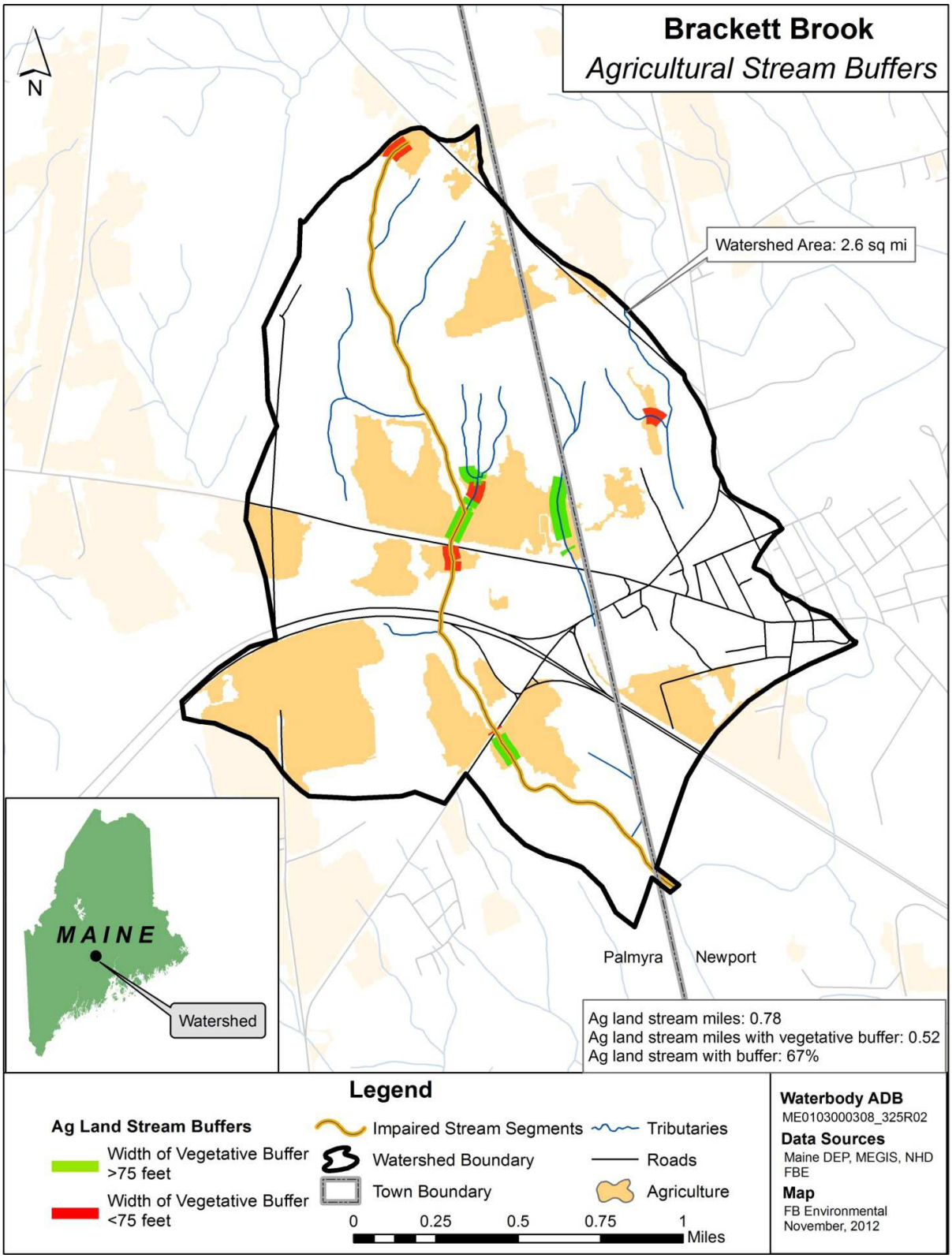



**Figure 4:** Agricultural Stream Buffer in the Brackett Brook Watershed

***Best Management Practices (BMPs)***

For this modeling effort, four commonly used BMPs were entered based on literature values. These estimates were applied equally to impaired and attainment stream watersheds. More localized data on agricultural practices would improve this component of the model.

- *Cover Crops:* Cover crops are the use of annual or perennial crops to protect soil from erosion during time periods between harvesting and planting of the primary crop. The percent of agricultural acres cover crops used within the model is estimated at 4%. This figure is based on information from the 2007 USDA Census stating that 4.1% of cropland acres is left idle or used for cover crops or soil improvement activity, and not pastured or grazed (USDA, 2007b).
- *Conservation Tillage:* Conservation tillage is any kind of system that leaves at least 30% of the soil surface covered with crop residue after planting. This reduces soil erosion and runoff and is one of the most commonly used BMPs. This BMP was assumed to occur in 42% of agricultural land. This figure is based on a number given by the Conservation Tillage Information Center's 2008 Crop Residue Management Survey stating that 41.5% of U.S. acres are currently in conservation tillage (CTIC, 2000).
- *Strip Cropping / Contour Farming:* This BMP involves tilling, planting and harvesting perpendicular to the gradient of a hill or slope using high levels of plant residue to reduce soil erosion from runoff. This BMP was assumed to occur in 38% of agricultural lands, based on a study done at the University of Maryland (Lichtenberg, 1996).
- *Grazing Land Management:* This BMP consists of ensuring adequate vegetation cover on grazed lands to prevent soil erosion from overgrazing or other forms of over-use. This usually employs a rotational grazing system where hays or legumes are planted for feed and livestock is rotated through several fenced pastures. In this TMDL, a figure of 75% of hay and pasture land is assumed to utilize grazing land management. This figure is based on a study by Farm Environmental Management Systems of farming operations in Canada (Rothwell, 2005).

***Pollutant Load Attenuation by Lakes, Ponds and Wetlands***

Depositional environments such as ponds and wetlands can attenuate watershed sediment loading. This information is entered into the nutrient loading model by a simple percentage of watershed area draining to a pond or a wetland. The Brackett Brook watershed contains a riparian wetland southwest of I-95 crossing, and a forested wetland to the southeast, with overall 5% of the watershed draining to wetlands. The percent of watershed draining to a wetland in the attainment stream watersheds ranged from 15% to 60%, with an average of 35%

## NUTRIENT MODELING RESULTS

The MapShed model simulates surface runoff using daily weather inputs of rainfall and temperature. Erosion and sediment yields are estimated using monthly erosion calculations and land use/soil composition values for each source area. Below, selected results from the watershed loading model are presented. The TMDL itself is expressed in units of kilograms per hectare per year. The additional results shown below assist in better understanding the likely sources of pollution. The model results for Brackett Brook indicate that significant reductions of sediment and nutrients are needed to improve water quality. Below, loading for sediment, nitrogen and phosphorus are discussed individually.

***Sediment***

Sediment loading in the Brackett Brook watershed is mainly derived from high density mixed development which accounts for 63% of the sediment load (Table 5 and Figure 5). The secondary source of sediment in Brackett Brook is low density mixed development which contributes 31% of the total load. Note that total loads by mass cannot be directly compared between watersheds due to differences in watershed area. See section *TMDL: Target Nutrient Levels for Brackett Brook* below for loading estimates that have been normalized by watershed area.

**Table 5:** Total Sediment Loads by Source

| **Brackett Brook** | **Sediment (1000kg/year)** | **Sediment (%)** |
|---|---|---|
| **Source Load** | | |
| *Hay/Pasture* | 0.06 | 0% |
| *Crop land* | 0.72 | 6% |
| *Forest* | 0.01 | 0% |
| *Wetland* | 0 | 0% |
| *Disturbed Land* | 0 | 0% |
| *Low Density Mixed* | 3.84 | 31% |
| *Medium Density Mixed* | 0 | 0% |
| *High Density Mixed* | 7.87 | 63% |
| *Low Density Residential* | 0 | 0% |
| *Medium Density Residential* | 0 | 0% |
| *High Density Residential* | 0 | 0% |
| *Farm Animals* | 0 | 0% |
| *Septic Systems* | 0 | 0% |
| ***Source Load Total:*** | **12.50** | **100%** |
| | | |
| **Pathway Load** | | |
| *Stream Banks* | 18.03 | - |
| *Subsurface / Groundwater* | 0 | - |
| | | |
| ***Total Watershed Mass Load:*** | **30.53** | |

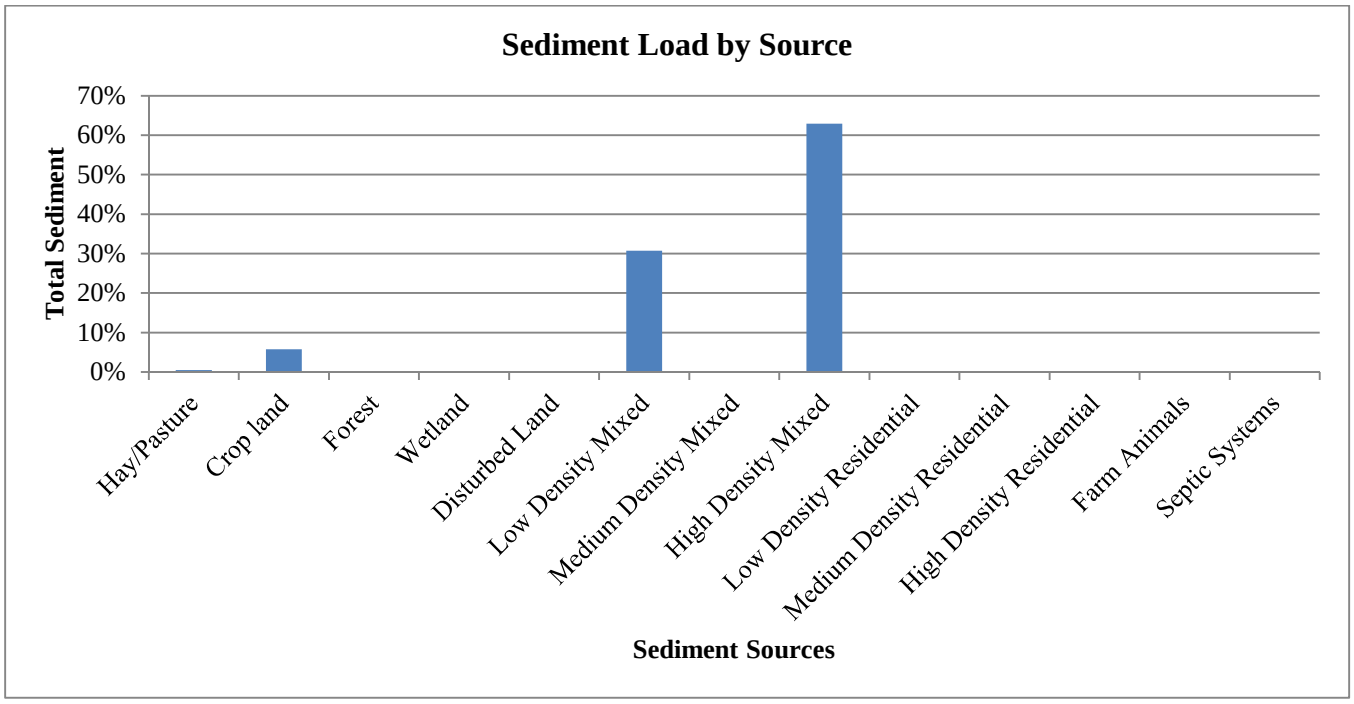



**Figure 5:** Total Sediment Loads by Source in the Brackett Brook Watershed

### *Total Nitrogen*

Nitrogen loading is primarily attributed to crop land, which contributes 47% of the nitrogen load to the stream. High density mixed development also contributes 23% of the total load and low density mixed development contributes 8%. Table 6 and Figure 6 show estimated total nitrogen load in terms of mass and percent of total, and by source in Brackett Brook. Note that total loads by mass cannot be directly compared between watersheds due to differences in watershed area. See section *TMDL: Target Nutrient Levels for Brackett Brook* below for loading estimates that have been normalized by watershed area.

**Table 6:** Total Nitrogen Loads by Source

| **Brackett Brook** | **Total N (kg/year)** | **Total N (%)** |
|---|---|---|
| **Source Load** | | |
| *Hay/Pasture* | 106.0 | 8% |
| *Crop land* | 643.3 | 47% |
| *Forest* | 133.1 | 10% |
| *Wetland* | 41.4 | 3% |
| *Disturbed Land* | 0 | 0% |
| *Low Density Mixed* | 105.7 | 8% |
| *Medium Density Mixed* | 0 | 0% |
| *High Density Mixed* | 317.0 | 23% |
| *Low Density Residential* | 0 | 0% |
| *Medium Density Residential* | 0 | 0% |
| *High Density Residential* | 0 | 0% |
| *Farm Animals* | 0 | 0% |
| *Septic Systems* | 9.5 | 1% |
| ***Source Load Total:*** | **1356.1** | **100%** |
| | | |
| **Pathway Load** | | |
| *Stream Banks* | 9.9 | - |
| *Subsurface / Groundwater* | 6182.1 | - |
| | | |
| ***Total Watershed Mass Load:*** | **7548.1** | |

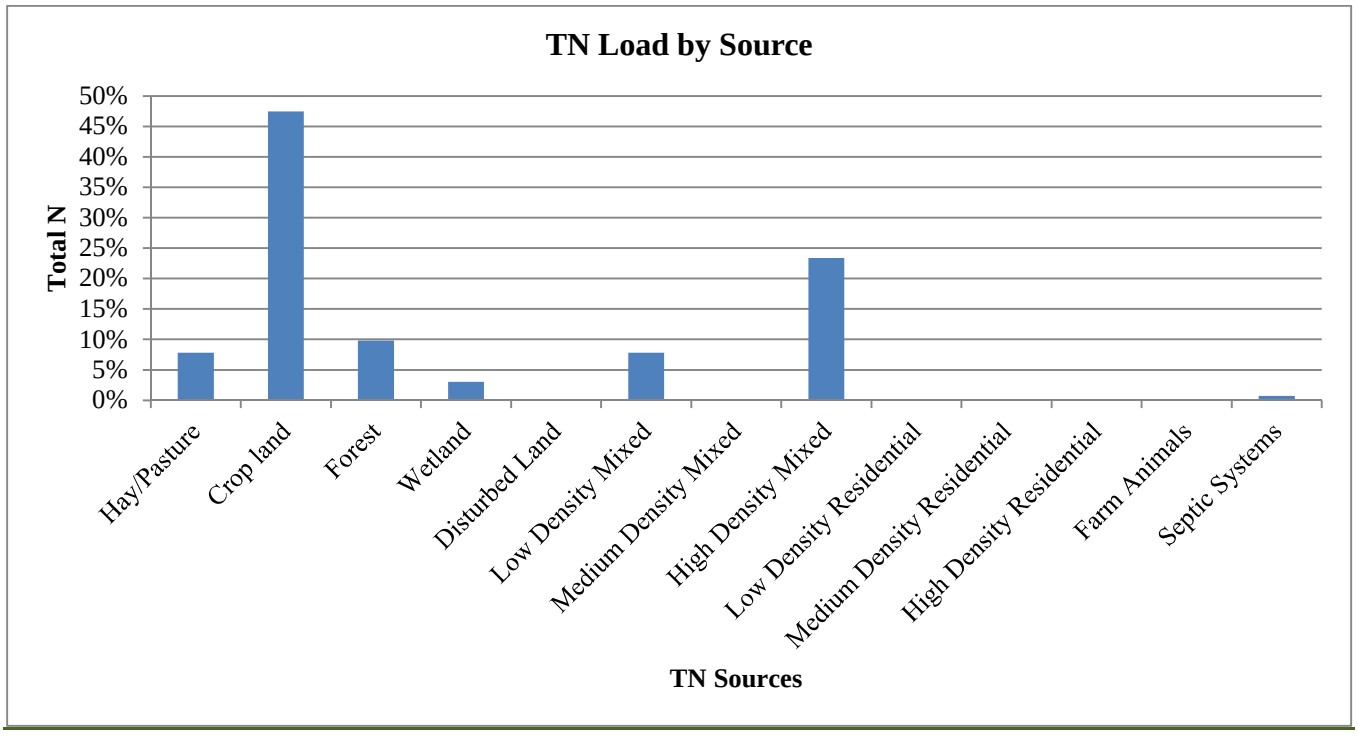



**Figure 6:** Total Nitrogen Loads by Source in the Brackett Brook Watershed

### *Total Phosphorus*

Phosphorus loading in the Brackett Brook watershed is attributed primarily to agricultural sources, with crop land and hay/pasture, combined, accounting for 67% of the total phosphorus load. High and low density mixed developments contribute a combined 27%. Phosphorus loads are presented in Table 7 and Figure 7. Note that total loads by mass cannot be directly compared between watersheds due to differences in watershed area. See section *TMDL: Target Nutrient Levels for Brackett Brook* below for loading estimates that have been normalized by watershed area.

**Table 7:** Total Phosphorus Loads by Source

| **Brackett Brook** | **Total P (kg/year)** | **Total P (%)** |
|---|---|---|
| **Source Load** | | |
| *Hay/Pasture* | 45.3 | 27% |
| *Crop land* | 66.2 | 40% |
| *Forest* | 7.0 | 4% |
| *Wetland* | 2.2 | 1% |
| *Disturbed Land* | 0 | 0% |
| *Low Density Mixed* | 11.9 | 7% |
| *Medium Density Mixed* | 0 | 0% |
| *High Density Mixed* | 33.0 | 20% |
| *Low Density Residential* | 0 | 0% |
| *Medium Density Residential* | 0 | 0% |
| *High Density Residential* | 0 | 0% |
| *Farm Animals* | 0 | 0% |
| *Septic Systems* | 0 | 0% |
| ***Source Load Total:*** | **165.5** | **100%** |
| | | |
| **Pathway Load** | | |
| *Stream Banks* | 3.9 | - |
| *Subsurface / Groundwater* | 96.7 | - |
| | | |
| ***Total Watershed Mass Load:*** | **266.1** | |

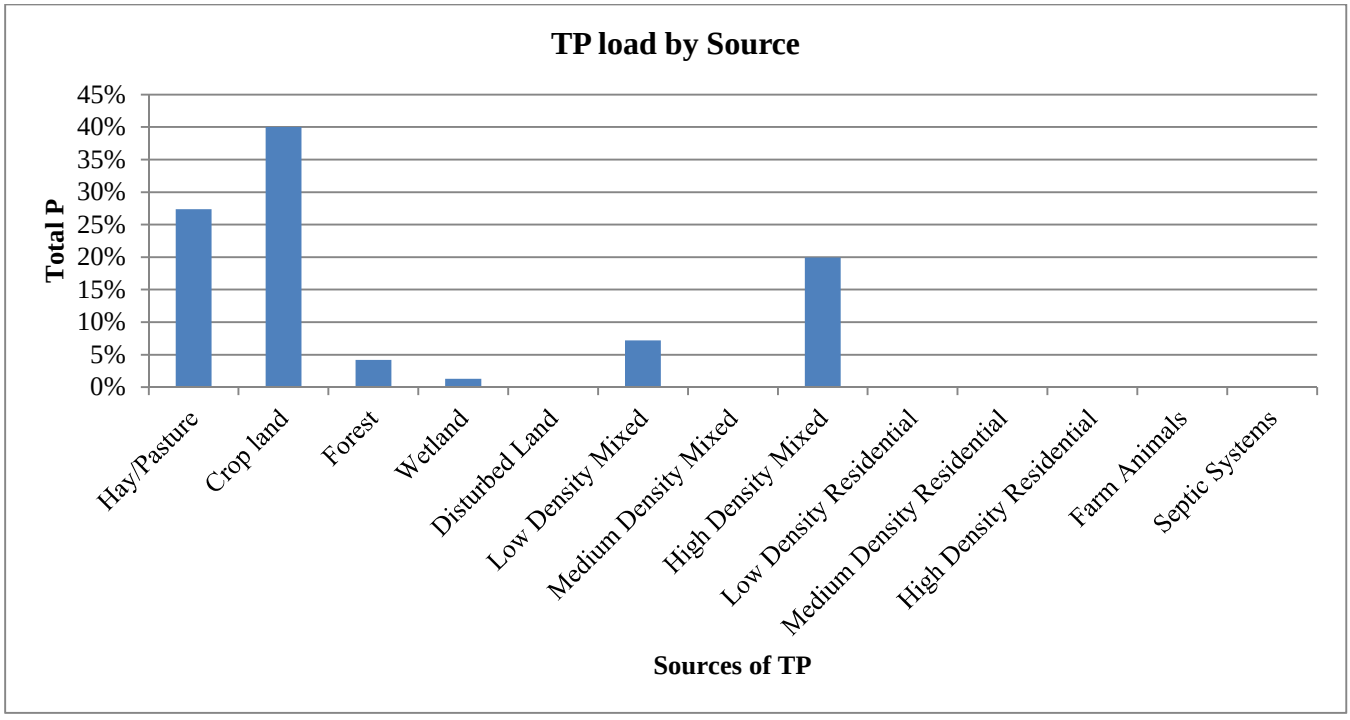



**Figure 7:** Total Phosphorus Loads by Source in the Brackett Brook Watershed

## TMDL: TARGET NUTRIENT LEVELS FOR BRACKETT BROOK

The existing loads for sediments and nutrients in the impaired segment of Brackett Brook are listed in Table 8, along with the TMDL numeric target which was calculated from the average loading estimates of five attainment watersheds located throughout the state. Table 9 presents a more detailed view of the modeling results and calculations used in Table 8 to define TMDL reductions, and compares the existing sediment and nutrient loads in Brackett Brook to TMDL endpoints derived from the attainment waterbodies. An annual time frame provides a mechanism to address the daily and seasonal variability associated with nonpoint source loads.

**Table 8:** TMDL Targets Compared to Brackett Brook Pollutant Loading

| **TMDL POLLUTANT LOADS** Annual Loads per Unit Area | **Estimated Loads Brackett Brook** | **Total Maximum Daily Load Numeric Target** | **TMDL % REDUCTIONS Brackett Brook** |
|---|---|---|---|
| ***Sediment Load*** *(1000 kg/ha/year)* | **0.045** | **0.030** | **33%** |
| ***Nitrogen Load*** *(kg/ha/year)* | **11.1** | **5.2** | **53%** |
| ***Phosphorus Load*** *(kg/ha/year)* | **0.39** | **0.24** | **38%** |

### Future Loading

The prescribed reduction in pollutants discussed in this TMDL reflects reduction from estimated existing conditions. Expansion of agricultural and development activities has the potential to increase runoff and associated pollutant loads to Brackett Brook. To ensure that the TMDL targets are attained, future agriculture or development activities in the watershed will need to meet the TMDL targets. Future growth from population increases is a moderate threat in the Brackett Brook watershed because Somerset County has increasing population trends, with a 1% increase between 2000 and 2008 (USM MSAC, 2009). The growth in agricultural lands are also increasing, with a 12% increase in the total number of farms in Somerset County between 2002 and 2007, and a 1% increase in the land (acres) in farms between 2002 and 2007. However, a 10% decrease occurred in the average farm size in this time period (USDA, 2007a). Future activities and BMPs that achieve TMDL reductions are addressed below.

### Next Steps

The use of agricultural and developed area BMPs can reduce sources of polluted runoff in Brackett Brook. It is recommended that municipal officials, landowners, and conservation stakeholders in Palmyra and Newport work together to develop a watershed management plan to:

- Encourage greater citizen involvement through the development of a watershed coalition to ensure the long term protection of Brackett Brook;
- Address existing nonpoint source problems in the Brackett Brook watershed by instituting BMPs where necessary; and
- Prevent future degradation of Brackett Brook through the development and/or strengthening of a local Nutrient Management Ordinance.

**Table 9:** Modeling Results Calculations for Derived Numeric Targets and Reduction Loads for Brackett Brook

| **Brackett Brook** | | | | |
|---|---|---|---|---|
| | **Area ha** | **Sediment 1000kg/yr** | **TN kg/yr** | **TP kg/yr** |
| **Land Uses** | | | | |
| *Hay/Pasture* | 68 | 0.06 | 106.0 | 45.3 |
| *Crop land* | 93 | 0.72 | 643.34 | 66.2 |
| *Forest* | 278 | 0.01 | 133.05 | 6.95 |
| *Wetland* | 45 | 0.0 | 41.4 | 2.16 |
| *Disturbed Land* | 0 | 0.0 | 0.0 | 0.0 |
| *Low Density Mixed* | 124 | 3.84 | 105.74 | 11.92 |
| *High Density Mixed* | 68 | 7.87 | 317.03 | 32.98 |
| **Other Sources** | | | | |
| *Farm Animals* | | | 0.0 | 0.0 |
| *Septic Systems* | | | 9.49 | 0.0 |
| **Pathway Loads** | | | | |
| *Stream Banks* | | 18.08 | 9.94 | 3.94 |
| *Groundwater* | | | 6182.13 | 96.68 |
| Total Annual Load | | 30.53 x 1000 kg | 7548.13 kg | 266.13 kg |
| Total Area | 678 ha | | | |
| **Total Maximum Daily Load** | | **0.045 1000kg/ha/year** | **11.13 kg/ha/year** | **0.39 kg/ha/year** |

**REFERENCES**

Barbour, M.T., J. Gerritsen, B.D. Snyder, and J.B. Stribling. 1999. Rapid Bioassessment Protocols for Use in Wadeable Streams and Rivers: Periphyton, Benthic Macroinvertebrates and Fish, Second Edition. EPA 841-B-99-002. U.S. Environmental Protection Agency; Office of Water; Washington, D.C.

Conservation Tillage Information Center (CTIC). 2000. Crop Residue Management Survey. National Association of Conservation Districts. Retrieved from: http://www.ctic.purdue.edu .

Davies, S. P., and L. Tsomides. 2002. Methods for Biological Sampling of Maine's Rivers and Streams. DEP LW0387-B2002, Maine Department of Environmental Protection, Augusta, ME.

Evans, B.M., & K.J. Corradini. 2012. MapShed Version 1.0 Users Guide. Penn State Institute of Energy and the Environment. Retrieved from: http://www.mapshed.psu.edu/Downloads/MapShedManual.pdf

Lichtenberg, E. 1996. Using Soil and Water Conservation Practices to Reduce Bay Nutrients: How has Agriculture Done? Economic Viewpoints. Maryland Cooperative Extension Service, University of Maryland at College Park and University of Maryland Eastern Shore, Department of Agricultural and Resource Economics, 1(2).

Maine Department of Environmental Protection (Maine DEP). 2013. Draft 2012 Integrated Water Quality Monitoring and Assessment Report. Bureau of Land and Water Quality, Augusta, ME.

Rothwell, N. 2005. Grazing Management in Canada. Farm Environmental Management in Canada. http://publications.gc.ca/Collection/Statcan/21-021-M/21-021-MIE2005001.pdf.

University of Southern Maine Muskie School of Public Service, Maine Statistical Analysis Center (USM MSAC). December, 2009. Retrieved from: http://muskie.usm.maine.edu/justiceresearch/Publications/County/Somerset.pdf

United States Department of Agriculture (USDA). 2007a. 2007 Census of Agriculture: Somerset County, Maine. Retrieved from: http://www.agcensus.usda.gov/Publications/2007/Online_Highlights/County_Profiles/Maine/cp23025.pdf

United States Department of Agriculture (USDA). 2007b. 2007 Census of Agriculture: State and County Reports. National Agricultural Statistics Service. Retrieved from: http://www.agcensus.usda.gov/Publications/2007/Full_Report/Volume_1,_Chapter_1_State_Level/Maine/st23_1_008_008.pdf

Wright, T., C. Swann, K. Cappiella, and T. Schueler. 2005. Unified Subwatershed and Site Reconnaissance: A User's Manual. Center for Watershed Protection. Ellicott City, MD.