DRAFT TMDL SUMMARY

Otter Brook

WATERSHED DESCRIPTION

This **TMDL** applies to a 2.16 mile section of Otter Brook, located in the Town of Windham, Maine. The impaired segment of Otter Brook begins in the northern portion of the watershed just upstream of Pope Road and flows south through residential neighborhoods and agriculture. It crosses Center Brook Drive, Windham Center Road, and River Road. Otter Brook meets the Presumpscot River just upstream of Dundee Pond. The Otter Brook watershed covers an area of 2.14 square miles.

- Runoff from agricultural land located throughout the central portion of the watershed is likely the largest source of **nonpoint source (NPS) pollution** to Otter Brook. Runoff from cultivated lands, active hay lands, and pasture can transport nitrogen and phosphorus to the nearest section of the stream.
- The Otter Brook watershed is predominately non-developed (78.7%). Forested areas (45.2%) within the watershed absorb and filter pollutants helping protect both water quality in the stream and stream channel stability. Wetlands (2.2%) may also help filter nutrients.
- Non-forested areas within the watershed are predominantly agricultural (31%) and are located throughout the central portion of the watershed.
- Developed areas (21.3%) with impervious surfaces in close proximity to the steam may impact water quality.
- Otter Brook is on Maine's 303(d) list of Impaired Streams (Maine DEP, 2012).

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 are typically transported by rain or snowmelt runoff.*

Waterbody Facts

Segment ID: ME0106000103_607R09

Town: Windham, ME

County: Cumberland

Impaired Segment Length: 2.16 miles

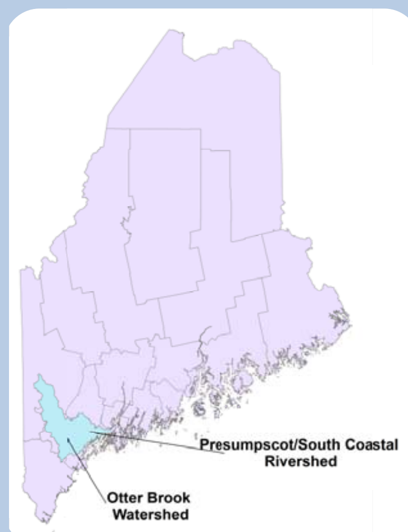
Classification: Class B

Direct Watershed: 2.14 mi^2 (1,370 acres)

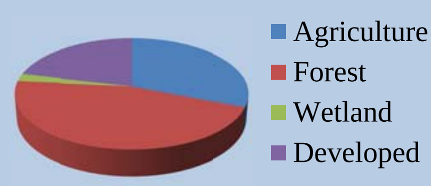
Impairment Listing Cause: Dissolved Oxygen

Watershed Agricultural Land Use: 30.99%

Major Drainage Basin: Presumpscot River



Watershed Land Uses



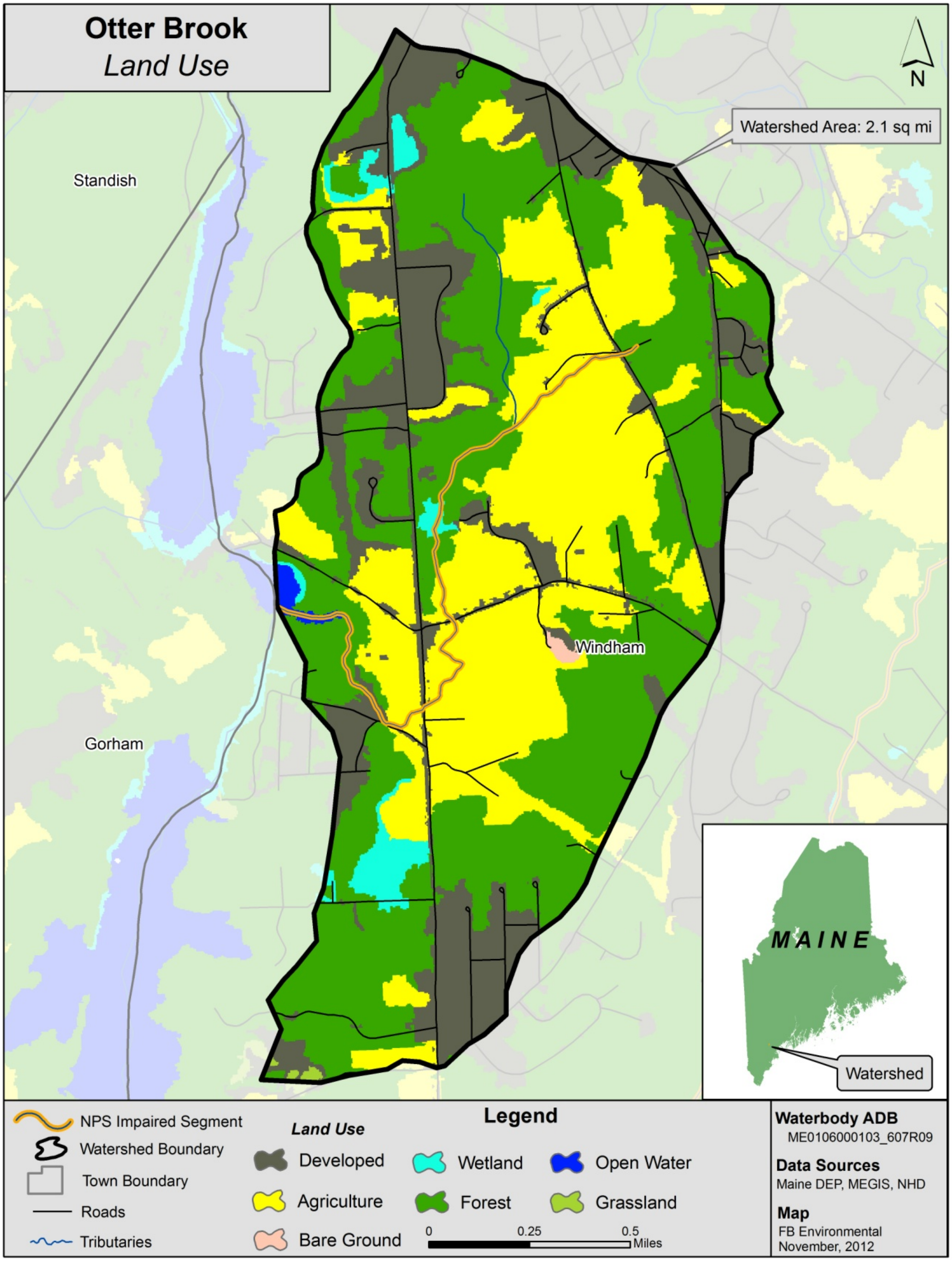


Figure 1: Land Use in the Otter Brook Watershed

WHY IS A TMDL ASSESSMENT NEEDED?

Otter 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.

***Otter Brook** sample reach near Presumpscot Road.*
Photo: FB Environmental

Agricultural land area in the Otter Brook watershed makes up about 31% of the watershed. This is slightly larger than the area of developed land at about 21%. However, 40% of the impaired stream segment length passes through agricultural land (Figure 1). Agriculture, therefore, likely to be the largest contributors 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. A horse stable located on Windham Center Road and significant erosion and lack of riparian buffer at a stream crossing at Windham Center Road adjacent to active hay land are potential hotspots for nonpoint source pollution.

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 Otter Brook is based on historic data. Additionally, dissolved oxygen data collected at station ROT06 in 2009-2011 and ROT07 in 2007 corroborates the impairment.

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, nutrient 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 Streams and Wadeable 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, physical characterization and visual assessment of in-stream and riparian habitat quality.

Based on Rapid Bioassessment protocols for low gradient streams, Otter Brook received a score of 160 out of a total 200 for quality of habitat. Higher scores indicate better habitat. The range in habitat assessment scores for attainment streams is 155 to 179.

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 Otter Brook watershed, the downstream sample station was located downstream of the River Road stream crossing and DEP sample station ROT06. The sample reach was accessed via Presumpscot Road. The immediate surrounding riparian zone is dominated by grasses and is adjacent to a power line corridor. The water was documented as being slightly turbid and minimal sediment deposits were observed.

Figure 2 (below) shows the range of habitat assessment scores for all attainment and impaired streams, as well as for Otter Brook. The overlapping attainment and impaired stream scores indicate that factors other than habitat should be considered when addressing the impairments in Otter Brook. Consideration should be given to major "hot spots" in the Otter Brook watershed as potential sources of NPS pollution contributing to the water quality impairment.

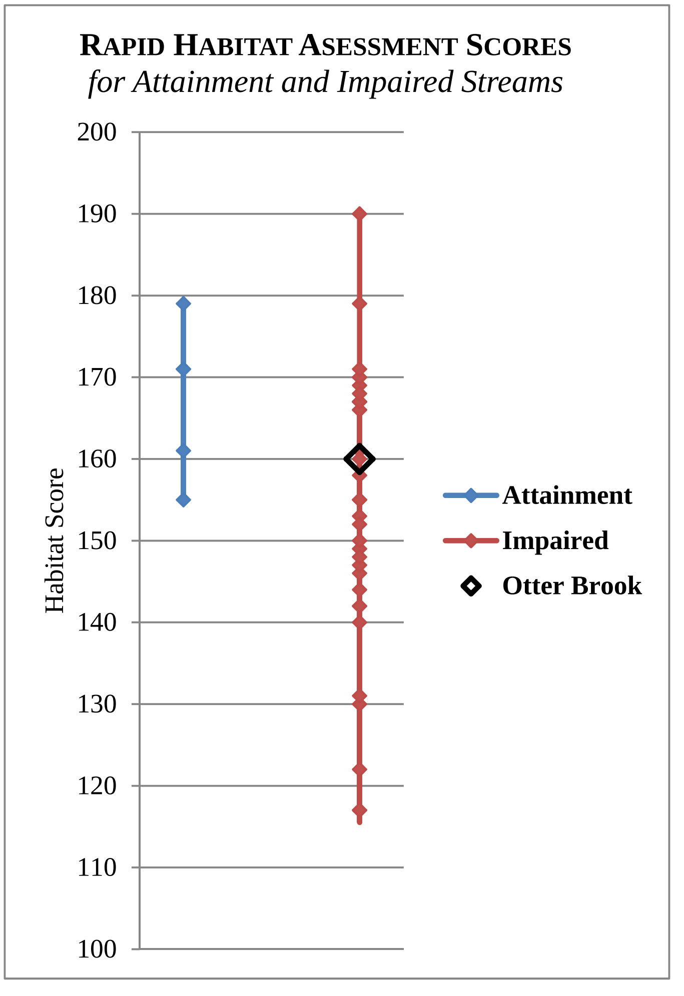


Figure 2: Habitat Assessment Scores

Pollution Source Identification

Pollution source identification assessments were conducted for both Otter 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 for Otter Brook was completed on July 11, 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 Otter Brook Watershed

Potential Source			Notes
ID#	**Location**	**Type**	
2	River Road & Windham Center Road	Agriculture	• A large horse stable was observed off Windham Center Road. • A training areas/paddock and barn are located on the property. Construction was taking place during visit. • Pasture and hay fields surround facilities.
4	Windham Center Road	Road Crossing	• Significant gully erosion along Windham Center road transports runoff directly into stream. • Limited buffers were noted here. • Hay land on adjacent horse stable property (ID# 2) is actively harvested to the streams edge.
6	Center Brook Drive	Neighborhood	• Lush, green lawns. • Established buffer in most places.
7	Pope Road & Center Brook Drive	Agriculture	• Large hay field in close proximity to stream. • Unknown width of buffers in most places (marked private – no trespassing).
11	River Road	Wetland/inactive field	• The stream flows through field with minimal shading is most areas. Fields on the horse stable property are close by.

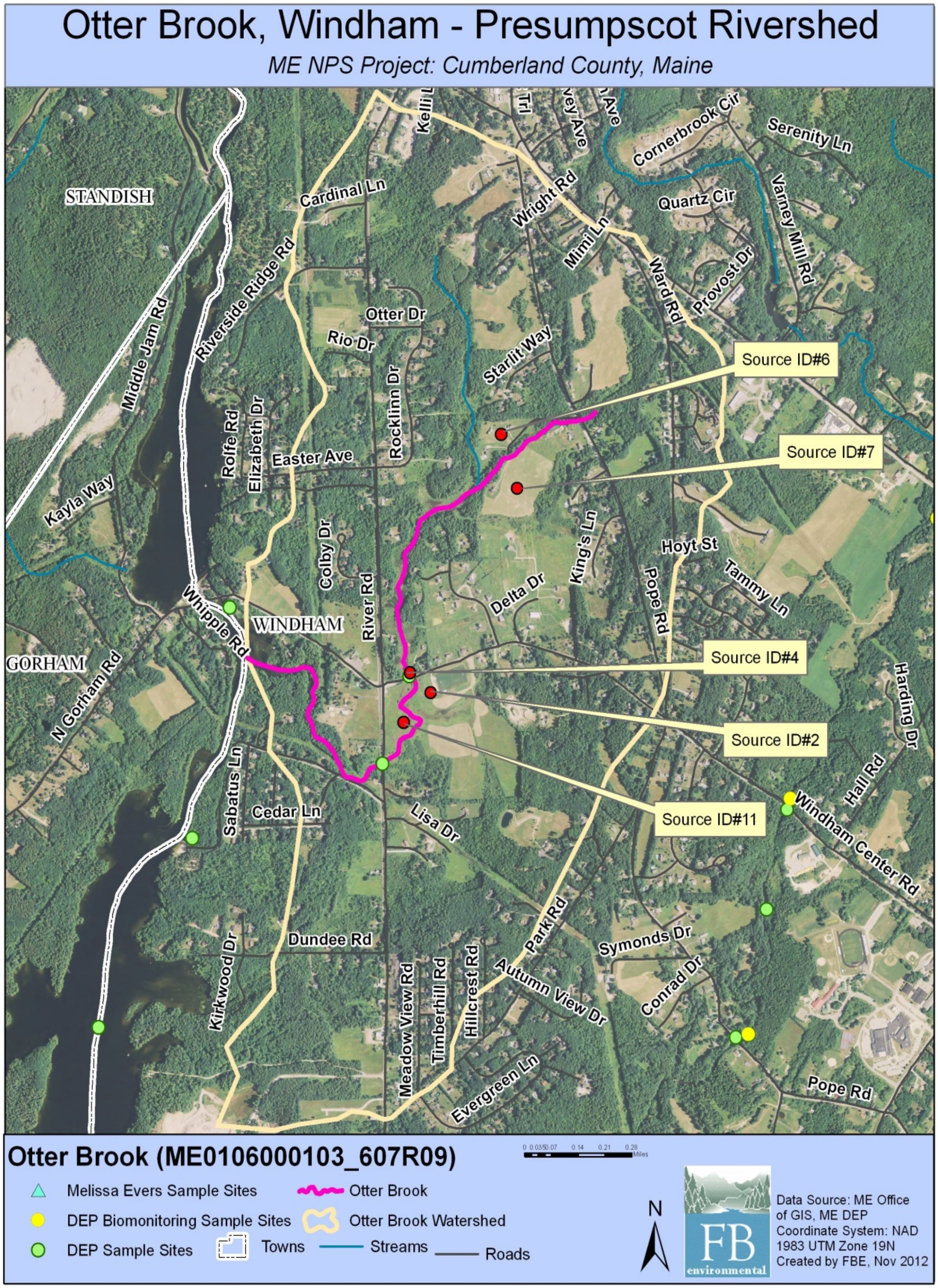


Figure 3: Aerial Photo of Source ID locations in the Otter Brook Watershed

NUTRIENT LOADING – MAPSHED ANALYSIS

The MapShed model was used to estimate stream loading of sediment, total nitrogen and total phosphorus in Otter Brook (impaired), plus five attainment watersheds throughout the state. The model estimated 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 section on Habitat Assessment and Pollution Source Identification. These manually adjusted parameters included estimates of livestock animal units, agricultural stream miles with intact vegetative buffer, Best Management Practices (BMPs), and estimated wetland retention and/or drainage areas.

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.

The Otter Brook watershed contains large areas of agriculture. Hay fields were the dominant agricultural use, and few animals were observed. A horse stable and training facility is located on the corner of River Road and Windham Center Road. About 12 horses were observed grazing in pasture here, but number of horses may fluctuate due to nature of the horse boarding business. Hay on this property had been cut to the banks of Otter Brook near Windham Center Road. Eight goats were also observed on a property on the west side of Pope Road, however, this area was well set back from Otter Brook and surrounded by forest.

Table 3: Livestock Estimates in the Otter Brook Watershed

Type	Otter Brook
Dairy Cows	
Beef Cows	
Broilers	
Layers	
Hogs/Swine	
Sheep	
Horses	12
Turkeys	
Other	8 (goats)
Total	**20**

Vegetated Stream Buffer 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

Otter Brook
• 2.5 stream miles in watershed (includes ephemeral streams) • 0.9 stream miles in agricultural areas • **33%** of agricultural stream miles have a vegetated buffer

Otter Brook is a 2.2 mile-long impaired segment as listed by Maine DEP. As modeled, the total stream miles (including tributaries) within the watershed was calculated as 2.5 miles. Of this total, 0.9 stream miles are located within agricultural areas and 0.3 miles or 33% of the stream shows 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%.

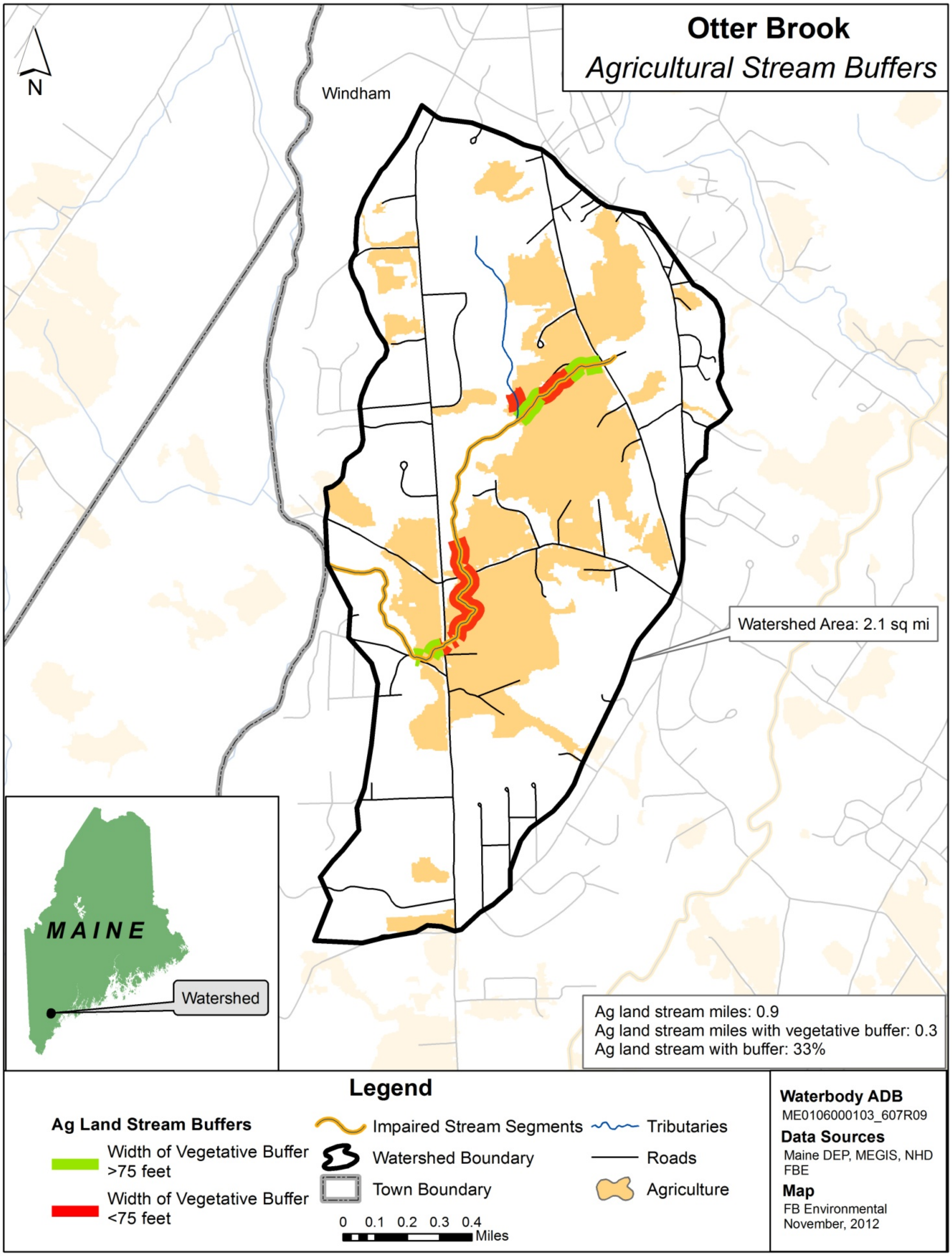


Figure 4: Buffered Agricultural Stream Miles in the Otter Brook Watershed

Best Management Practices (BMPs)

For this modeling effort, four commonly used BMPs were entered based on literature values. These estimates are 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. There are no major wetlands within the Otter Brook watershed, therefore zero percent of the watershed drains to wetlands. Percent of watershed draining to a wetland in the attainment 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 Otter Brook indicate significant reductions of nutrients and sediment are needed to improve water quality. Below, loading for sediment, nitrogen and phosphorus are discussed individually.

Sediment

Sediment loading in the Otter Brook watershed is mainly derived from cropland (36%), with combined agricultural sources accounting for almost 50% of the total sediment load. Development also contributes a significant portion of the load at 40%, respectively (Table 5 and Figure 5). Total loads by mass cannot be directly compared between watersheds due to differences in watershed area. See section *TMDL: Target Nutrient Levels for Otter Brook* (below) for loading estimates that have been normalized by watershed area.

Table 5: Total Sediment Load by Source

Otter Brook	Sediment (1000kg/year)	Sediment (%)
Source Load		
Hay/Pasture	2.38	13%
Crop land	6.54	36%
Forest	1.86	10%
Wetland	0.01	0%
Disturbed Land	0	0%
Low Density Mixed	3.14	17%
Medium Density Mixed	0	0%
High Density Mixed	4.23	23%
Low Density Residential	0.04	0%
Medium Density Residential	0	0%
High Density Residential	0	0%
Farm Animals	0	0%
Septic Systems	0	0%
Source Load Total:	**18.20**	**100%**
Pathway Load		
Stream Banks	4.72	-
Subsurface / Groundwater	0	-
Total Watershed Mass Load:	**22.92**	

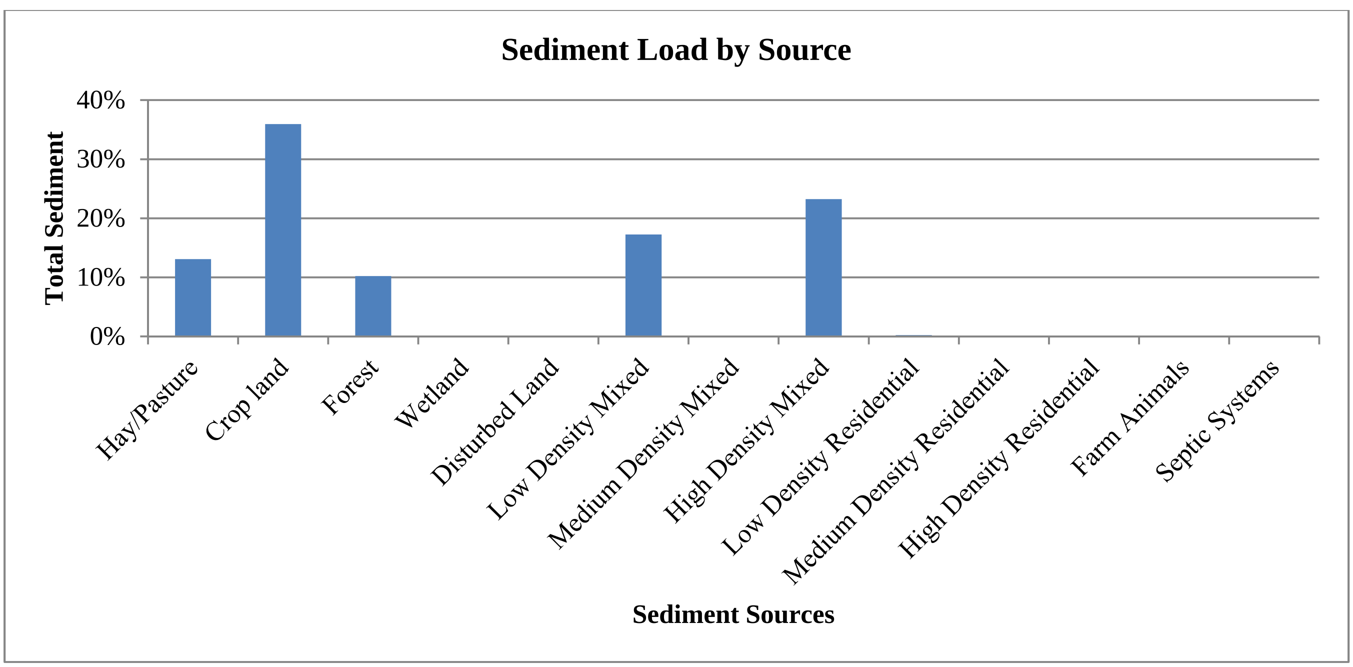


Figure 5: Total Sediment Loads by Source in the Otter Brook Watershed

Total Nitrogen

Nitrogen loading is attributed to hay and pasture (27%), with combined agricultural sources making up 43% of the total nitrogen load to Otter Brook. Development also contributes a significant portion of the load and is a secondary source of nitrogen at 27% of the nitrogen load. Septic systems within the watershed contribute 16%. Table 6 and Figure 6 (below) shows estimated total nitrogen load in terms of mass and percent of total, and by source, in Otter 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 Otter Brook* (below) for loading estimates that have been normalized by watershed area.

Table 6: Total Nitrogen Loads by Source

Otter Brook	Total N (kg/year)	Total N (%)
Source Load		
Hay/Pasture	248.2	27%
Crop land	77.5	8%
Forest	111.4	12%
Wetland	13.8	2%
Disturbed Land	0	0%
Low Density Mixed	82.6	9%
Medium Density Mixed	0	0%
High Density Mixed	164.0	18%
Low Density Residential	1.0	0%
Medium Density Residential	0	0%
High Density Residential	0	0%
Farm Animals	68.9	8%
Septic Systems	149.7	16%
Source Load Total:	**917.0**	**100%**
Pathway Load		
Stream Banks	2.0	-
Subsurface / Groundwater	5230.5	-
Total Watershed Mass Load:	**6149.5**	

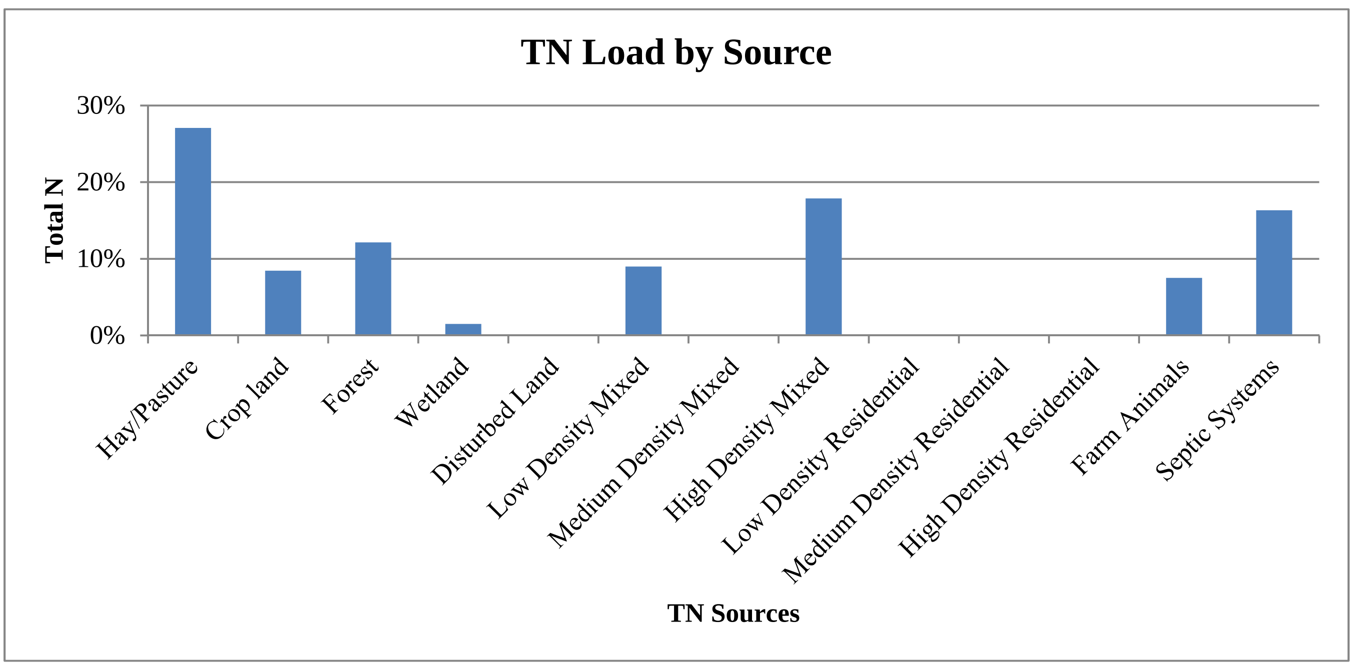


Figure 6: Total Nitrogen Loads by Source in the Otter Brook Watershed

Total Phosphorus

Phosphorus loading within the watershed is attributed primarily to hay and pasture (59%), with combined agricultural sources accounting for 77% of the total load in Otter Brook. Phosphorus loads are presented in Table 7 and Figure 7. Development is a secondary source of nitrogen and contributes 17% of the load, respectively. Total loads by mass cannot be directly compared between watersheds due to differences in watershed area. See section *TMDL: Target Nutrient Levels for Otter Brook* (below) for loading estimates that have been normalized by watershed area.

Table 7: Total Phosphorus Loads by Source

Otter Brook	Total P (kg/year)	Total P (%)
Source Load		
Hay/Pasture	95.4	59%
Crop land	11.1	7%
Forest	7.1	4%
Wetland	0.7	0%
Disturbed Land	0	0%
Low Density Mixed	9.4	6%
Medium Density Mixed	0	0%
High Density Mixed	17.2	11%
Low Density Residential	0.1	0%
Medium Density Residential	0	0%
High Density Residential	0	0%
Farm Animals	17.8	11%
Septic Systems	3.4	2%
Source Load Total:	**162.2**	**100%**
Pathway Load		
Stream Banks	1.0	-
Subsurface / Groundwater	90.7	-
Total Watershed Mass Load:	**253.9**	

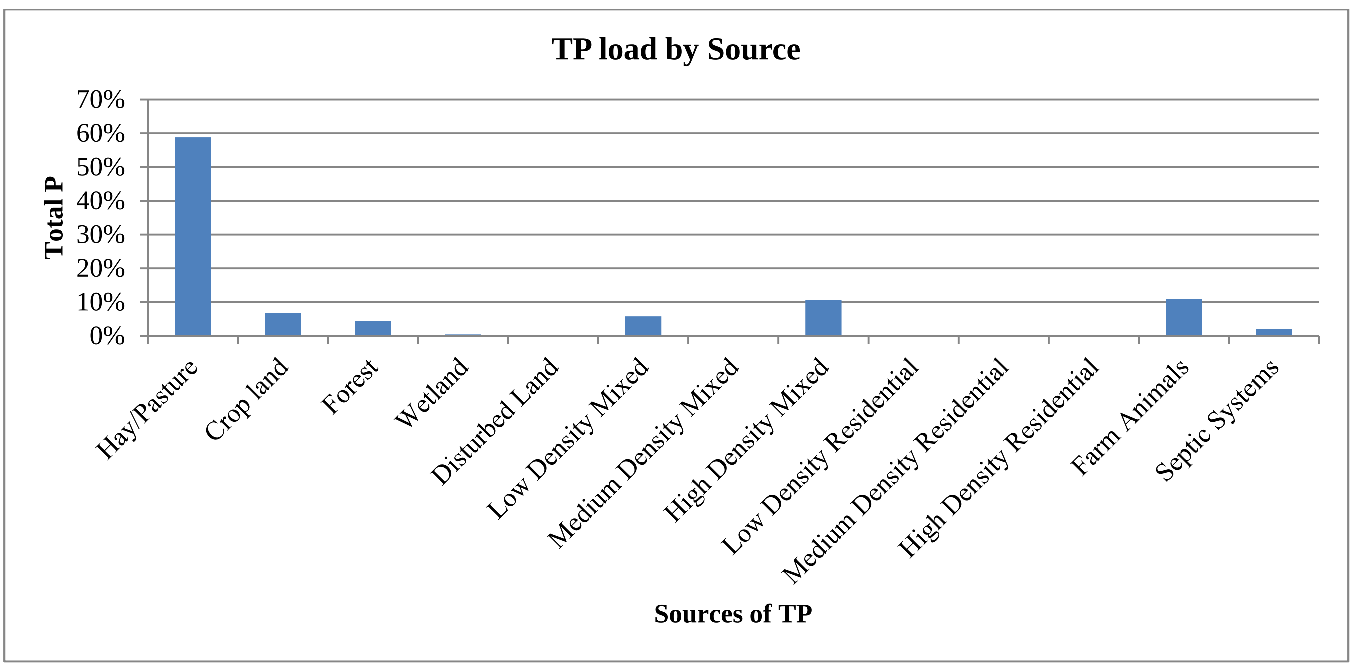


Figure 7: Total Phosphorus Loads by Source in the Otter Brook Watershed

TMDL: TARGET NUTRIENT LEVELS FOR OTTER BROOK

The TMDL numeric targets The existing loads for nutrients and sediments in the impaired segment of Otter Brook are listed in Table 8, along with the TMDL which was calculated from the average loading estimates of five attainment watersheds 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 nutrient and sediment loads in Otter 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 Otter Brook Pollutant Loading

TMDL POLLUTANT LOADS Annual Loads per Unit Area	**Estimated Loads Otter Brook**	**Total Maximum Daily Load**	**TMDL % REDUCTIONS Otter Brook**
Sediment Load *(1000 kg/ha/year)*	**0.042**	**0.030**	**28%**
Nitrogen Load *(kg/ha/year)*	**11.14**	**5.2**	**53%**
Phosphorus Load *(kg/ha/year)*	**0.46**	**0.24**	**47%**

Future Loading

The prescribed reduction in pollutants discussed in this TMDL reflects reduction from estimated existing conditions. Expansion of agricultural and development activities have the potential to increase runoff and associated pollutant loads to the Otter Brook. To ensure that the TMDL targets are attained, future agriculture or development activities will need to meet the TMDL targets. Future growth from population increases is a moderate threat in the Otter Brook watershed because Cumberland County has increasing population trends, with a 3.9% increase between 2000 and 2008 (USM MSAC, 2009). The growth in agricultural lands is also increasing, with a 6% increase in the total number of farms in Cumberland County between 2002 and 2007. However, a decrease of 5% was seen in the land (acres) in farms between 2002 and 2008, and a 10% decrease occurred in the average farm size in this time period as well (USDA, 2007a). Future activities and BMPs that achieve TMDL reductions are addressed below.

Next Steps

The use of agricultural and developed area BMP's can reduce sources of polluted runoff in Otter Brook. It is recommended that municipal officials, landowners, and conservation stakeholders in Windham 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 Otter Brook;
- Address existing nonpoint source problems in the Otter Brook watershed by instituting BMPs where necessary; and
- Prevent future degradation of Otter Brook through the development and/or strengthening of local Nutrient Management Ordinance.

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

Otter Brook				
	Area ha	**Sediment 1000kg/yr**	**TN kg/yr**	**TP kg/yr**
Land Uses				
Hay/Pasture	166	2.4	248.2	95.4
Crop land	6	6.6	77.6	11.1
Forest	251	1.9	111.4	7.1
Wetland	12	0.0	13.8	0.7
Disturbed Land	0	0.0	0.0	0.0
Low Density Mixed	84	3.1	82.6	9.4
High Density Mixed	32	4.2	164.0	17.2
Low Density Residential	1	0.0	1.0	0.1
Other Sources				
Farm Animals			68.9	17.8
Septic Systems			149.7	3.4
Pathway Loads				
Stream Banks		4.7	2.0	1.0
Groundwater			5230.5	90.7
Total Annual Load		23 x 1000 kg	6149 kg	254 kg
Total Area	552 ha			
Total Maximum Daily Load		**0.042 1000kg/ha/year**	**11.14 kg/ha/year**	**0.46 kg/ha/year**

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