



TMDL SUMMARY

APPENDIX B-11

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.

- Otter Brook is on Maine’s 303(d) list of Impaired Streams as referenced in the 2016 Integrated Report (Maine DEP, 2018).
- The Otter Brook watershed is predominately non-developed (51%). Forested areas (38%) within the watershed absorb and filter pollutants helping protect both water quality in the stream and stream channel stability. Wetlands (11%) also help filter nutrients.
- Non-forested areas within the watershed are predominantly developed (30.4%) and agricultural (18.3%).
- Developed areas (30.4%) exist on the periphery of the watershed; those areas with impervious surfaces in close proximity to the stream, or which create concentrated flow are likely sources of **nonpoint source (NPS) pollution** to the stream.
- Runoff from agricultural land located throughout the central portion of the watershed where Otter Brook flows is also a likely source of nonpoint source pollution to the stream. Runoff from active hay lands and pasture can transport sediment, nitrogen, and phosphorus to the stream.

Waterbody Facts

Segment ID:

ME0106000103_607R09

Town: Windham, ME

County: Cumberland

Impaired Segment Length: 2.16 miles

Classification: Class B

Direct Watershed: 2.14 mi² (1,370 acres)

Impairment Listing Cause: Dissolved Oxygen

Watershed Agricultural Land Use: 18%

Major Drainage Basin: Presumpscot River



Watershed Land Uses



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.

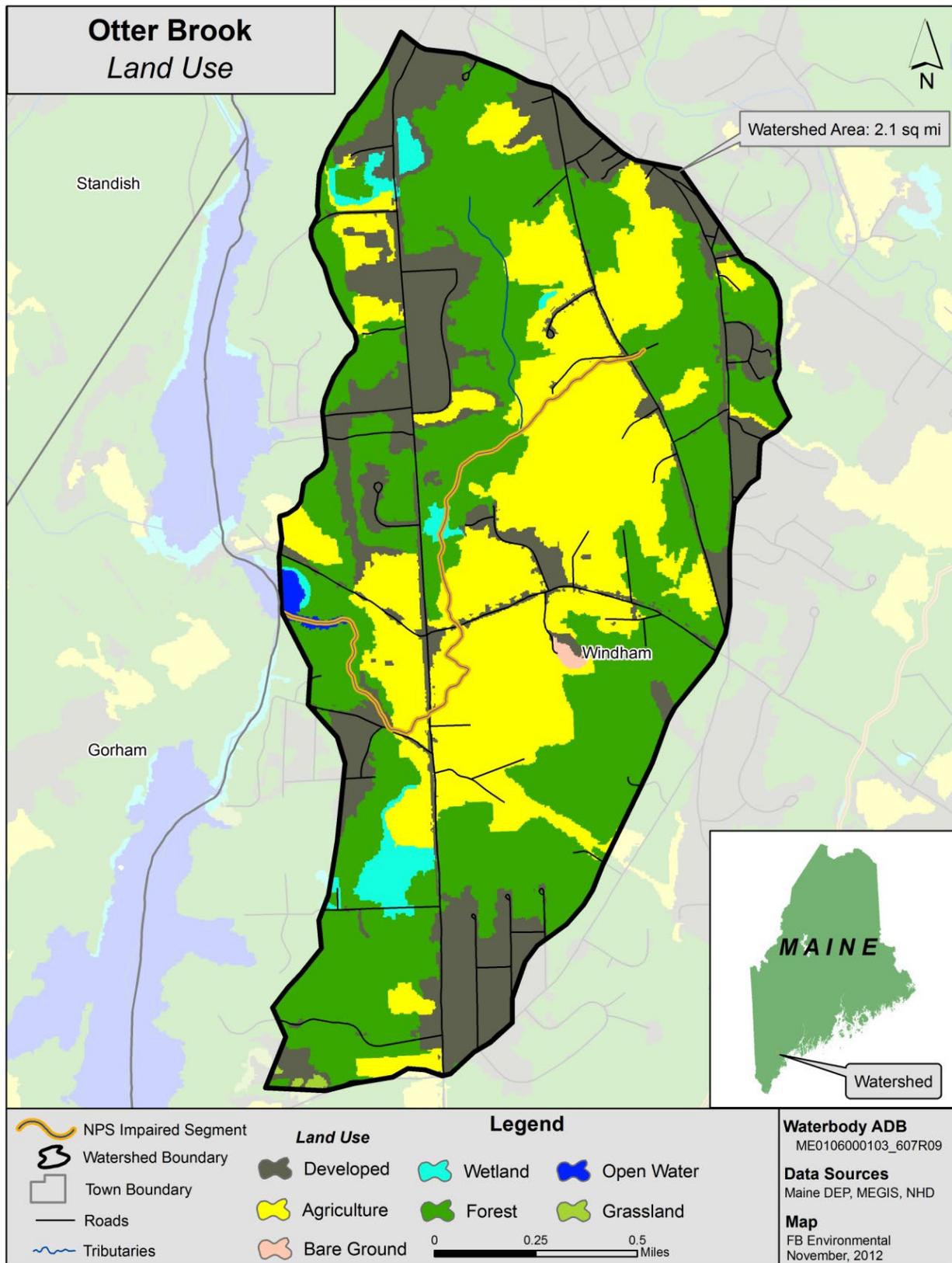


Figure 1: Land Use and Land Cover (from 2011) in the Otter Brook Watershed

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.

Agricultural land area (primarily hay/pastureland) in the Otter Brook watershed makes up about 18% of the watershed. This is slightly larger than the one-half of developed land area (30.4%). However, 41% of the impaired stream segment length passes through agricultural land (Figure 1). Agriculture and developed areas therefore, are likely 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.



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

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). For benthic macroinvertebrates, DEP makes aquatic life use determinations using a statistical model that incorporates 30 variables of data collected from rivers and streams, including the richness and abundance of streambed organisms, to determine the probability of a sample meeting Class A, B, or C conditions. Biologists use the model results and supporting information to determine if samples comply with the numeric aquatic life criteria of the class assigned to the stream or river (Davies and Tsomides, 2002). Maine DEP uses an analogous model to aid in the assessment of algal communities but makes aquatic life use determinations based on narrative standards.

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 AND SEDIMENT 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, an online nutrient loading model, *Model My Watershed* (v. 1.32.0), was used to estimate the sources of pollution based on well-established hydrological equations (Stroud Water Research Center 2017). *Model My Watershed* makes use of the GWLF-enhanced model engine. The model incorporates detailed maps of soil, land use, and slope, daily weather and localized weather data (from the

period 2009-2020), and direct observations of agriculture and other land uses within the watershed. *Model My Watershed* is derived from its parent MapShed developed by Evans and Corradini (2012). *Model My Watershed* replaced MapShed in 2017-2018.

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 Model My Watershed Outputs (2021) for Attainment Streams

Attainment Streams	Town	Total P Load (kg/ha/yr)	Total N Load (kg/ha/yr)	Sediment Load (kg/ha/yr)
Footman Brook	Exeter	0.17	1.73	35.2
Martin Stream	Fairfield	0.13	2.98	57.9
Moose Brook	Houlton	0.18	1.59	48.5
Upper Kenduskeag Stream	Corinth	0.16	1.72	100.5
Upper Pleasant River	Gray	0.16	4.26	86.5
Total Maximum Daily Load		0.16	2.46	65.7

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 (right) 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.

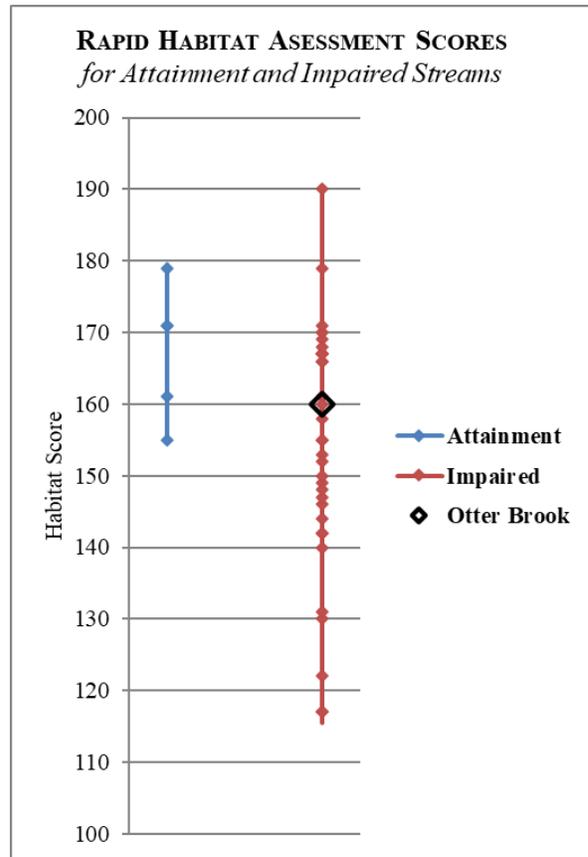


Figure 2: Habitat Assessment Scores for Otter Brook (2012) Compared to Region

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 in July 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: Potential Pollution Source ID Assessment (2012) for the Otter Brook Watershed

Potential Source			Notes
ID#	Location	Type	
2	River Road & Windham Center Road	Agriculture	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • Lush, green lawns. • Established buffer in most places.
7	Pope Road & Center Brook Drive	Agriculture	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • The stream flows through field with minimal shading is most areas. Fields on the horse stable property are close by.

NUTRIENT AND SEDIMENT LOADING – *MODEL MY WATERSHED* ANALYSIS

The *Model My Watershed* model was used to estimate stream loading of total phosphorus, total nitrogen, and sediment in Otter Brook watershed. The model estimated nutrient loads over a 12-year period (2009-2020), which was determined by local (Portland Jetport USW00014764) weather data inserted into *Model My Watershed*. This extended period captures a recent but wide range of hydrologic conditions to account for variations in nutrient and sediment loading over time. Loads for the attainment watersheds (five total; Table 1) were computed using the same model with the same recent inputs (i.e., regional weather, 2016 land use and land cover, 2016 wetland extent, and BMPs similar to the impaired watersheds).

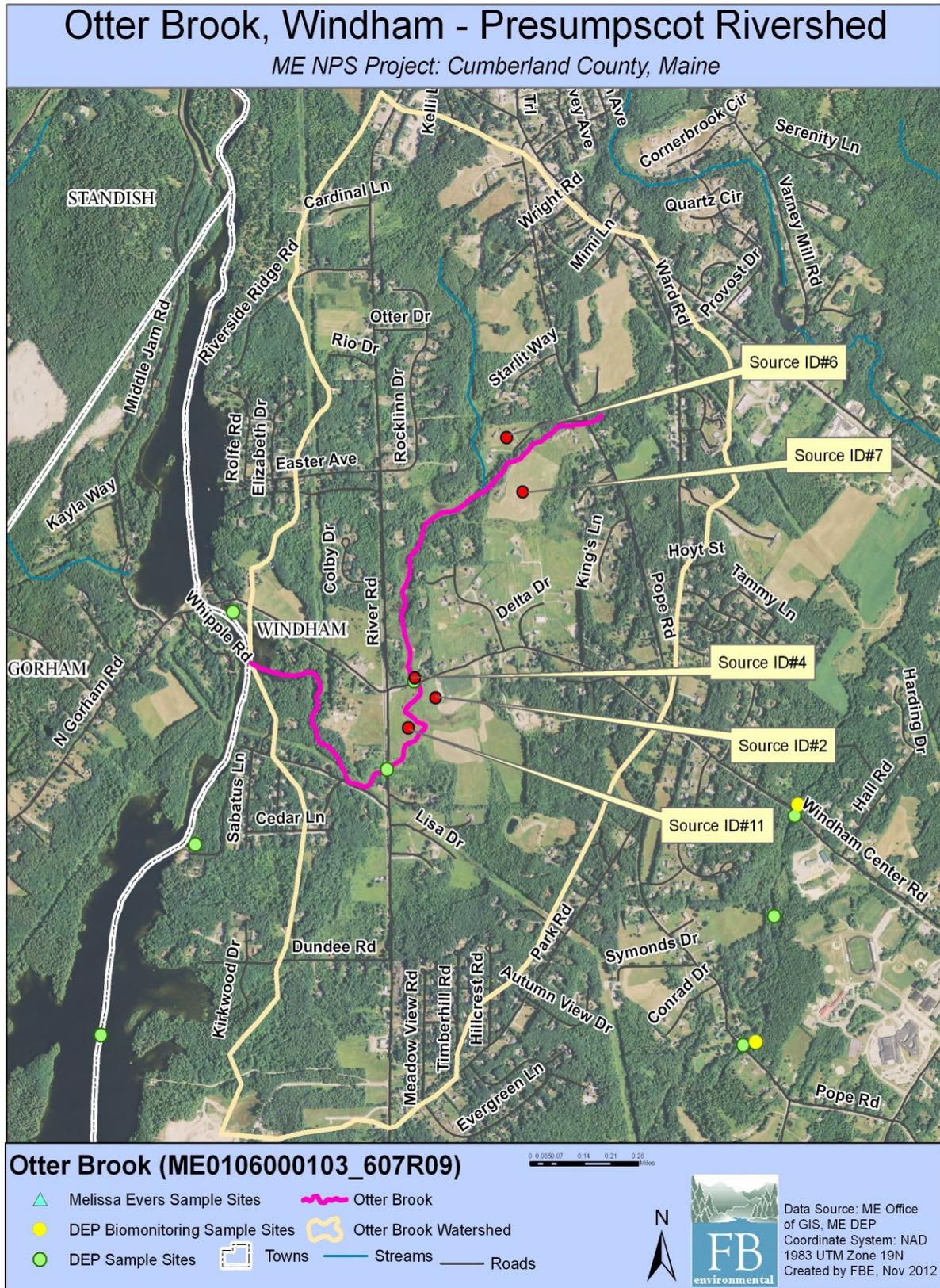


Figure 3: Aerial Photo of Potential Source ID Locations (identified in 2012) in Otter Brook Watershed

Many quality assured and regionally calibrated input parameters are provided with *Model My Watershed*. However, several updates to some of the default parameters were made in this TMDL effort, and namely more recent land use/cover using **MRLC-NLCD 2016**¹, more recent and local weather (precipitation and temperature) data (as described above), and more regional estimates of Best Management Practices (BMPs; see ensuing discussion). Because land use/cover is more recent, the estimated filtration fraction of wetland and open water and the amount of stream buffer in agricultural land should be more accurate. It is also worth noting that improved classification algorithms were employed by MRLC in the NCLD 2016 and these new algorithms were used in the revisions of all previous NLCD versions (including the first version in 2001).

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 livestock (numbers of animals) in the watershed based on the USDA National Agricultural Statistics Service (NASS) estimation for 2012. Some of these totals were modified by direct observations made in the watershed in the 2012 survey. To generate watershed-based livestock counts, NASS county-based livestock totals are converted to a per unit area (based on the total area of the county). The unit area amount is then multiplied by the total watershed area to derive a watershed total count (as seen in Table 3).

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	1
Beef Cows	2
Broilers	2
Layers	10
Hogs/Swine	2
Sheep	6
Horses	12
Turkeys	0
Other	8 (goats)
Total	43

¹ MRLC-NLCD 2016 : Multi-Resolution Land Characteristics – National Land Cover Dataset (version 2016) provided by the MRLC Consortium (Jin et al. 2019).

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 and Corradini 2012). *Model My Watershed* considers natural vegetated stream buffers within agricultural land areas as providing nutrient load attenuation. A width of approximately 98 feet (30 m) on one side of a stream is required to be considered a streamside buffer per the *Model My Watershed* technical manual (Stroud Water Research Center 2017). Analysis of recent aerial photos was used to estimate the number of agricultural land 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 (2012)

Otter Brook
<ul style="list-style-type: none"> • Agricultural Land Stream Length = 0.9 mi • Agricultural Land Stream Length with Buffer = 0.3 mi (or 33.3% of total agricultural land stream length) • Percentage of total stream length flowing through non-buffered agricultural land = 27.3%

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 of that area *appear* to have a 98 foot or greater vegetated buffer (Table 4, Figure 4). From a watershed perspective, this equates to 0.6 miles or 27.3% of the total stream length running through agricultural land with less than a 98 foot buffer. By contrast, for attainment stream watersheds, the percentage of total stream miles running through agricultural land without a 75 foot vegetated buffer ranged from 0% to 3.9% with an average of 1.3%. Note, a minimum vegetated buffer width of *75 feet* was used in an earlier (2012) effort to produce Figure 4 shown here. Differences in stream length estimates using a 98-foot or 75-foot buffer were practically insignificant.

Home Septic System Loads

Loads for “normally functioning” septic systems are calculated in *Model My Watershed* using an estimate of the average number of persons per acre in “Low-Density Mixed” areas. In these areas, it is assumed that the populations therein are served by septic systems rather than centralized sewage systems. All homes in such areas are assumed to be connected to “normally functioning” systems rather than those that experience “surface breakouts” (surface failures), “short-circuiting” to underlying groundwater (subsurface failures), or have direct conduits to nearby water bodies. Non-functioning systems would be modeled with a higher load contribution to the waterbody.

Best Management Practices (BMPs)

Best management practices (BMPs) are typically instituted to reduce the loading of sediment and nutrients from upland (i.e., non-point) sources. Ideally, information on BMPs for a specific watershed from local and regional sources would improve this component of the water quality model. Maine DEP sought information on BMP use in early 2021 from local, regional, and state agricultural agencies for rural BMPs and from nearby municipalities for urban BMPs. Very little to no information was returned in the solicitation. Hence, estimates for typical New England watersheds were derived from information available from Vermont. An upper limit of BMP use was garnered from watersheds entering the Chesapeake Bay where BMP use is intensive.

Four agricultural BMPs were used in this modeling effort and in the following manner:

- *Cover Crops*: Cover crops are the use annual or perennial crops to protect soil from erosion during time periods between harvesting and planting of the primary crop. The percent of cropland area in a cover crop BMP deployed was estimated at 25% and selected as the low end of the range (25 to 30 percent) expected for cropland in New England. This value was assigned to the five attainment watersheds.
- *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. This BMP was estimated to occur in 25% of cropland. This value was assigned to the five attainment watersheds.
- *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. Both interview sources suggest this practice is minimal to non-existent for New England watersheds. Hence, no BMP of this type was used in this modeling effort. This value was assigned to the five attainment watersheds.
- *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. Both interview sources were not aware of this practice being active and is likely minimal for New England watersheds. Hence, no BMP of this type was used in this modeling effort for both impaired and attaining watersheds.

Note that other agricultural and development BMPs likely exist in the watershed but their location and type were not available in a watershed-wide format that is necessary to include in the model. Agricultural BMPs recommended by Maine DEP to reduce sediment and nutrient loads include vegetated buffers, covered manure storage facilities, and stream exclusion fencing. BMPs for developed areas recommended by the Maine DEP include vegetated buffers, stormwater BMPs, and minimization of impervious cover.

Pollutant Load Attenuation by Lakes, Ponds and Wetlands

Depositional environments such as lakes, ponds, and wetlands can attenuate watershed sediment and nutrient loading. This information is entered into the nutrient loading model by a simple percentage of watershed area draining to a lake, pond, or wetland. The Otter Brook watershed is 11.1% wetland and open water, per the 2016 NLCD land use/cover. There are a few wetlands that surround tributaries throughout the watershed. It is estimated that 22.2% of land area within the watershed drains to wetlands and open water. The percent of watershed draining to a wetland in the attainment watersheds, based on the 2021 analysis, ranged from 26 to 58 percent, with an average of 40%.

NUTRIENT AND SEDIMENT MODELING RESULTS

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 watershed indicate significant reductions for sediment and phosphorus and a moderate reduction for nitrogen are needed to improve water quality. Below, loading for nitrogen, phosphorus and sediment are discussed individually. There are two categories of loads, sources and pathways. The pathways represent additional loads from streambank erosion and subsurface flow. Sediment and nutrient loads produced by eroding streambanks are estimated using an approach developed by Evans et al. (2003). Subsurface losses are calculated using dissolved N and P coefficients for shallow groundwater contributions to stream nutrient loads.

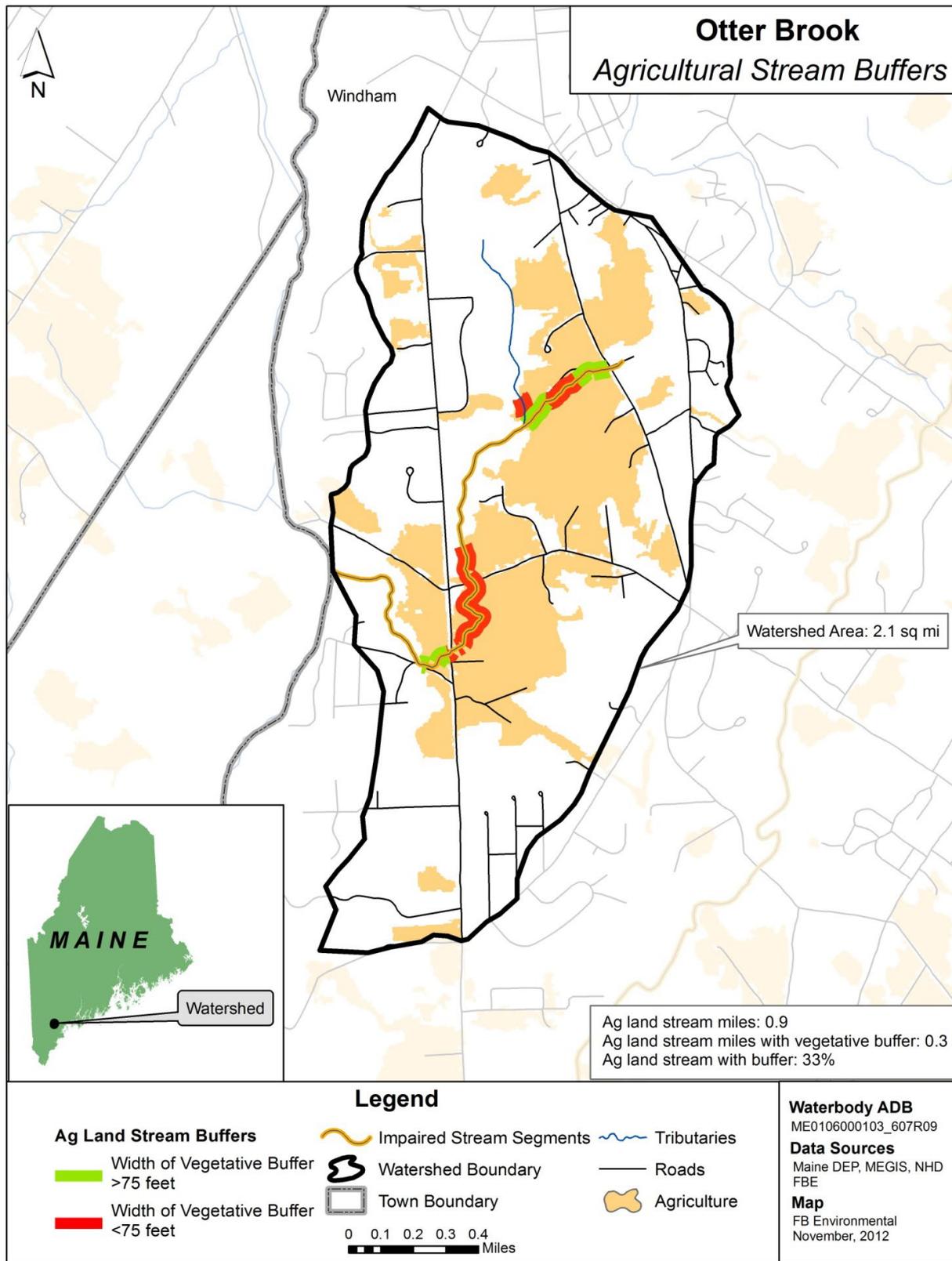


Figure 4: Agricultural Stream Buffers (from 2012) in the Otter Brook Watershed

Sediment

Table 5: Total Sediment Load by Source

Aside from stream bank erosion which contributes 53% of the total sediment load, the major source load in Otter Brook watershed originates from hay/pasture land (71.7% of total sources). Residential sources contribute 25.5% of the source load.

Note that total loads by mass cannot be directly compared between watershed TMDLs due to differences in watershed area. See section *TMDL: Target Nutrient and Sediment Levels for Otter Brook* below for loading estimates that have been normalized by watershed area.

Otter Brook	Sediment (1000 kg/year)	Sediment (%)
Source Load		
<i>Hay/Pasture</i>	26.3	71.7%
<i>Cropland</i>	0	0
<i>Wooded Areas</i>	0.4	1.1%
<i>Wetlands</i>	0.1	0.4%
<i>Open Land</i>	0.5	1.2%
<i>Barren Areas</i>	0.002	0.005%
<i>Low-Density Mixed</i>	2.7	7.4%
<i>Medium-Density Mixed</i>	2.1	5.8%
<i>High-Density Mixed</i>	0.2	0.4%
<i>Low-Density Open Space</i>	4.3	11.8%
<i>Farm Animals</i>	0	0
<i>Septic Systems</i>	0	0
Source Load Total:	36.7	100%
Pathway Load		
<i>Stream Bank Erosion</i>	42.1	-
<i>Subsurface Flow</i>	0	-
Total Watershed Mass Load:	79	

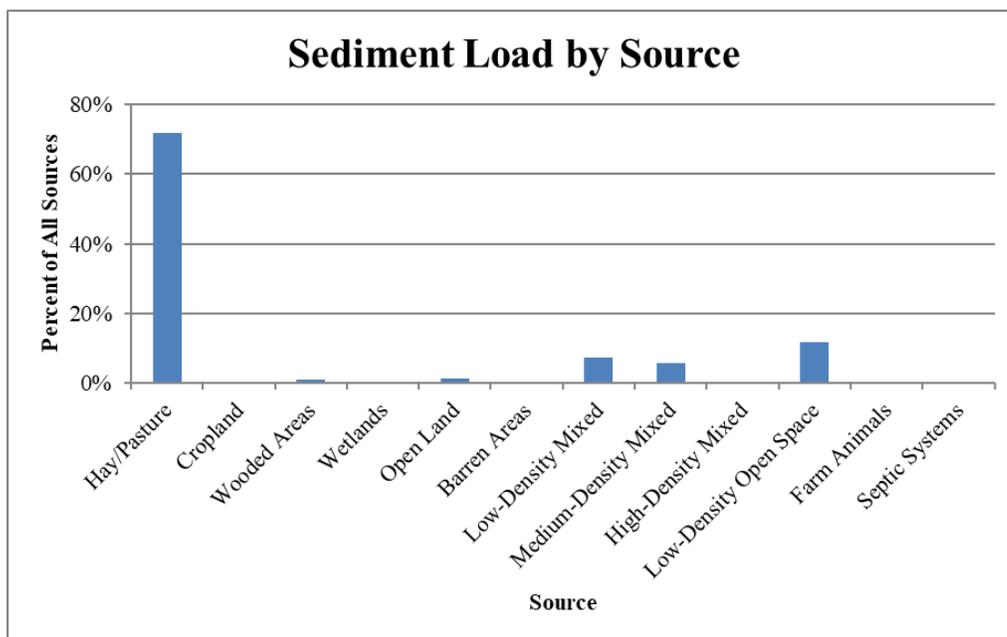


Figure 5: Total Sediment Load by Source in the Otter Brook Watershed

Total Nitrogen

Table 6 and Figure 6 (below) show the estimated total nitrogen load, in terms of mass and percent of total by source, in the Otter Brook watershed. Hay and pasture lands are the largest source of nitrogen loading contributing 37.3% of the source load of total N. Residential areas combined contribute equally with 34.2% of the source load, or if septic systems are included, 39.2%. Farm animals contribute 10% of the source load. Lastly, wetlands contribute 7% and wooded areas contribute 3.9% of the source load.

Note that total loads by mass cannot be directly compared between watershed TMDLs due to differences in watershed area. See section *TMDL: Target Nutrient and Sediment Levels for Otter Brook* below for loading estimates that have been normalized by watershed area.

Table 6: Total Nitrogen Load by Source

Otter Brook	Total N (kg/year)	Total N (%)
Source Load		
Hay/Pasture	277	37.3%
Cropland	0	0
Wooded Areas	29	3.9%
Wetlands	52	7.0%
Open Land	17	2.3%
Barren Areas	2	0.3%
Low-Density Mixed	79	10.6%
Medium-Density Mixed	46	6.2%
High-Density Mixed	4	0.5%
Low-Density Open Space	125	16.9%
Farm Animals	74	10.0%
Septic Systems	37	5.0%
Source Load Total:	742	100%
Pathway Load		
Stream Bank Erosion	41	-
Subsurface Flow	734	-
Total Watershed Mass Load:	1,517	

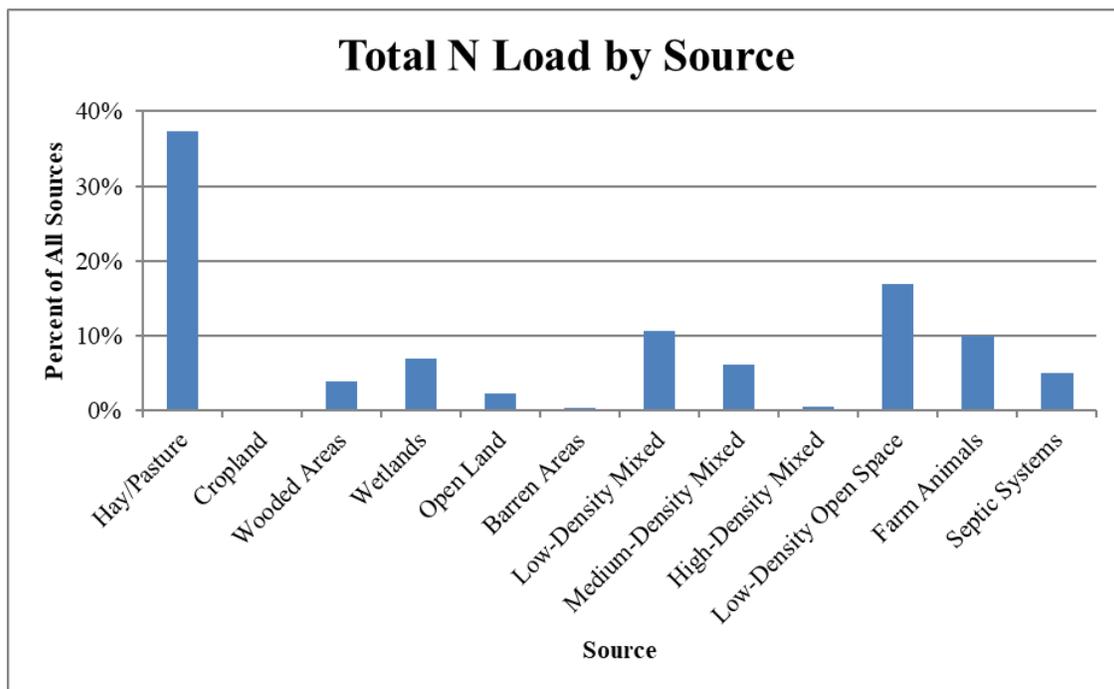


Figure 6: Total Nitrogen Load by Source in the Otter Brook Watershed

Total Phosphorus

Table 7 and Figure 7 (below) show the estimated total phosphorus load in terms of mass and percent of total by source, in the Otter Brook watershed. Hay and pasture lands are the largest source of phosphorus loading contributing just under 60% of the source load. Residential areas combined contribute 22.2% of the source load. Farm animals contribute 15.6% of the source load of total P.

Note that total loads by mass cannot be directly compared between watershed TMDLs due to differences in watershed area. See section *TMDL: Target Nutrient and Sediment Levels for Otter Brook* below for loading estimates that have been normalized by watershed area.

Table 7: Total Phosphorus Load by Source

Otter Brook	Total P (kg/year)	Total P (%)
Source Load		
<i>Hay/Pasture</i>	68.1	57.9%
<i>Cropland</i>	0	0
<i>Wooded Areas</i>	1.7	1.4%
<i>Wetlands</i>	2.7	2.3%
<i>Open Land</i>	0.6	0.5%
<i>Barren Areas</i>	0.1	0.09%
<i>Low-Density Mixed</i>	8.2	7.0%
<i>Medium-Density Mixed</i>	4.5	3.8%
<i>High-Density Mixed</i>	0.3	0.3%
<i>Low-Density Open Space</i>	13.1	11.1%
<i>Farm Animals</i>	18.3	15.6%
<i>Septic Systems</i>	0	0
Source Load Total:	117.6	100%
Pathway Load		
<i>Stream Bank Erosion</i>	8.0	-
<i>Subsurface Flow</i>	29.5	-
Total Watershed Mass Load:	155	

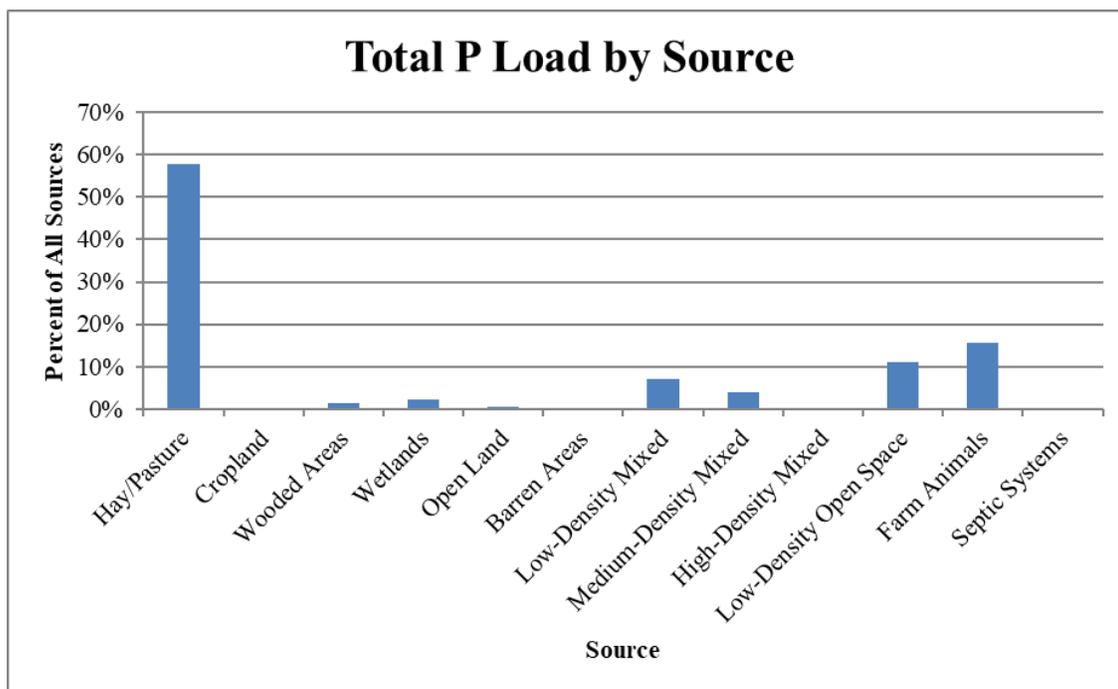


Figure 7: Total Phosphorus Load by Source in the Otter Brook Watershed

TMDL: TARGET NUTRIENT AND SEDIMENT LEVELS FOR OTTER BROOK

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: Otter Brook Pollutant Loading Compared to TMDL Targets

Otter Brook			
Pollutant Load	Existing Load	TMDL	Reduction Required
Total Annual Load per Unit Area		Attainment Streams	
Sediment (kg/ha/yr)	143.1	65.72	54.1%
Total N (kg/ha/yr)	2.75	2.46	10.8%
Total P (kg/ha/yr)	0.28	0.16	43.2%

Future Loading

The prescribed reduction in pollutants discussed in this TMDL reflects reduction from estimated existing conditions. Expansion of agricultural and development activities in the watershed have the potential to increase runoff and associated pollutant loads to Otter Brook. To ensure that the TMDL targets are attained, future agricultural and development activities will need to meet the TMDL targets. Between 2012 to 2017 in Cumberland County, the growth in agricultural lands was decreasing, with a 7% decrease in the total number of farms and a 20.2% decrease in total farm area. Average farm size has also declined significantly (13.8%) during this time period. These values are extracted from the most recent (2017) Census of Agriculture (USDA 2017). Human population in Cumberland County increased by 4.8% from 2000 to 2019 (US Census 2020). 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;
- Run a “Hot-Spot Analysis” in *Model My Watershed* to determine sub-watershed locations of higher existing contributions of sediment and nutrients to the outlet of Otter Brook watershed; then focus BMP mitigation in these hot-spot sub-areas of the watershed;
- 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: Annual Loads by Land Use, Other Sources, and Pathways for Otter Brook Based on Modeling

Otter Brook				
	Area (ha)	Sediment (1000 kg/yr)	Total N (kg/yr)	Total P (kg/yr)
Land Uses				
<i>Hay/Pasture</i>	101	26.3	277	68.1
<i>Cropland</i>	0	0.0	0	0.0
<i>Wooded Areas</i>	211	0.4	29	1.7
<i>Wetlands</i>	60	0.1	52	2.7
<i>Open Land</i>	9	0.5	17	0.6
<i>Barren Areas</i>	3	0.002	2	0.1
<i>Low-Density Mixed</i>	60	2.7	79	8.2
<i>Medium-Density Mixed</i>	10	2.1	46	4.5
<i>High-Density Mixed</i>	1	0.2	4	0.3
<i>Low-Density Open Space</i>	96	4.3	125	13.1
Total Area	551			
Other Sources				
<i>Farm Animals</i>		0.0	74	18.3
<i>Septic Systems</i>		0.0	37	0.0
Pathway Load				
<i>Stream Bank Erosion</i>		42.1	41	8.0
<i>Subsurface Flow</i>		0.0	734	29.5
Total Annual Load		79	1,517	155
Total Annual Load per Unit Area		0.143	2.75	0.28
		1000 kg/ha/yr	kg/ha/yr	kg/ha/yr

REFERENCES

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