DRAFT TMDL SUMMARY

Mosher Brook

WATERSHED DESCRIPTION

This **TMDL** applies to a 2.03 mile section of Mosher Brook, located in the Town of Gorham, Maine. The impaired segment of Mosher Brook begins in the western portion of the watershed in wooded area, flows east crossing Mosher Road, then enters agriculture. Mosher Brook then flows through another forested area and meets the Presumpscot River. The Mosher Brook watershed covers an area of 1.26 square miles.

- Runoff from agricultural land concentrated along Mosher Road and Dolloff Road is likely the largest source of **nonpoint source (NPS) pollution** to Mosher Brook. Runoff from cultivated lands, active hay lands, and pasture can transport nitrogen and phosphorus to the nearest section of the stream.
- The Mosher Brook watershed is predominately non-developed (76.3%). Forested areas (40.1%) within the watershed absorb and filter pollutants helping protect both water quality in the stream and stream channel stability.
- Non-forested areas within the watershed are predominantly agricultural (36.2%) and are located in the eastern portion of the watershed.
- Developed areas (23.7%) with impervious surfaces in close proximity to the steam may impact water quality.
- Mosher 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_607R08

Town: Gorham, ME

County: Cumberland

Impaired Segment Length: 2.03 miles

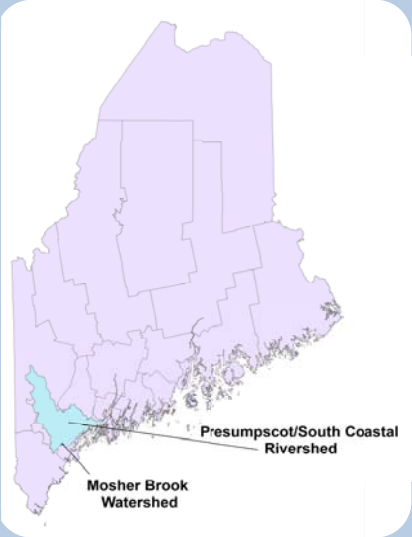
Classification: Class B

Direct Watershed: 1.26 mi^2 (806 acres)

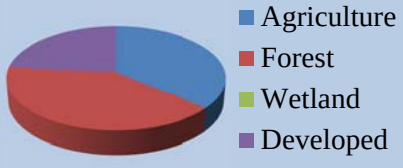
Impairment Listing Cause: Dissolved Oxygen

Watershed Agricultural Land Use: 36.22%

Major Drainage Basin: Presumpscot River



Watershed Land Uses



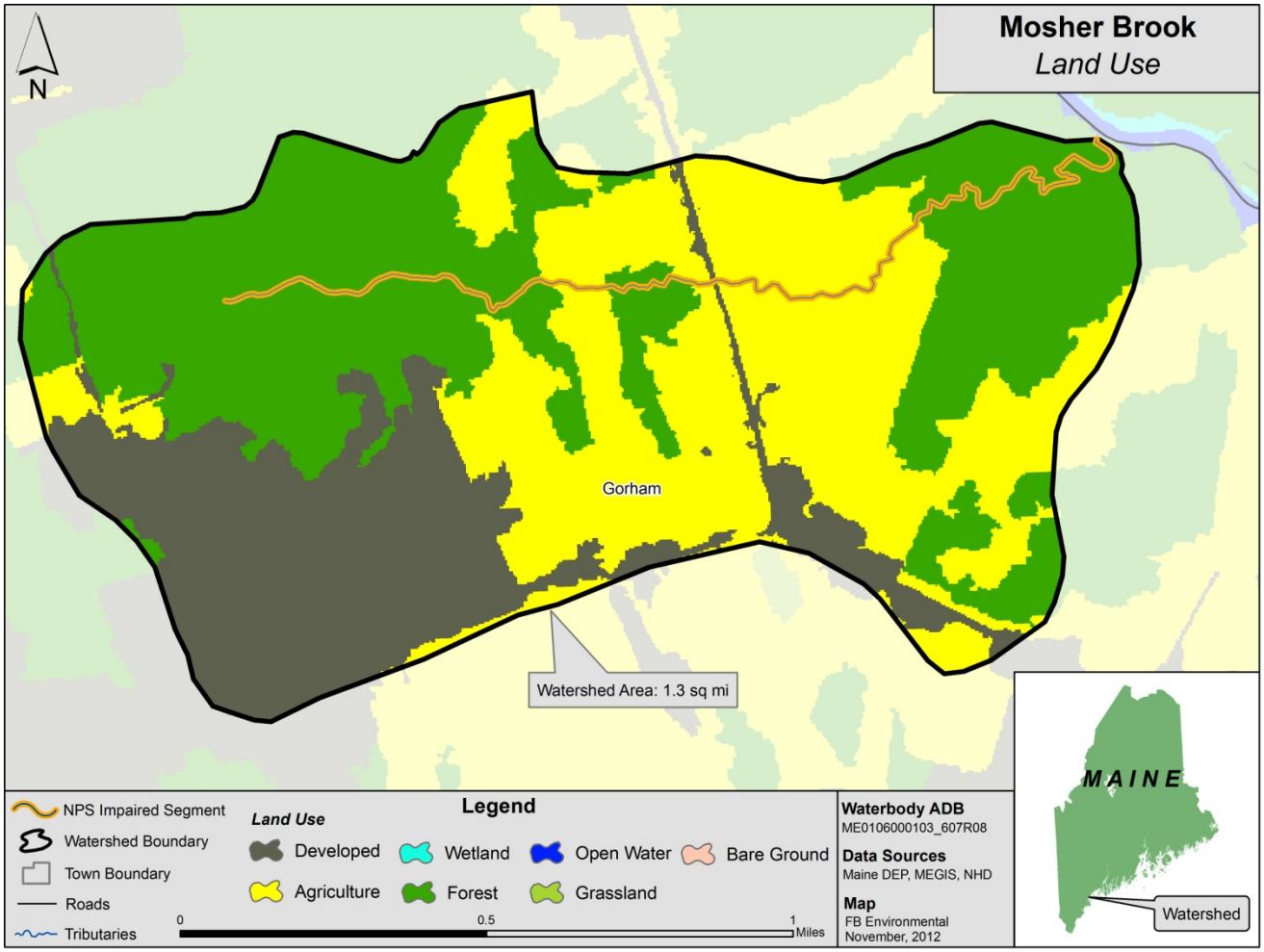


Figure 1: Land Use in the Mosher Brook Watershed

WHY IS A TMDL ASSESSMENT NEEDED?

Mosher 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.

Mosher Brook *at Station RMS11 near the Mosher Road crossing. Photo: FB Environmental*

Agricultural land in the Mosher Brook watershed makes up 36% of the total watershed area. This is only slightly larger than the area of developed land (23.7%). However, the majority of the developed land area is located in the southwestern corner of the watershed, furthest away from the impaired segment of Mosher Brook (Figure 1). Furthermore, 48% of the impaired stream segment length passes through agricultural land. Agriculture is therefore likely to be the largest 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.

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 Mosher Brook is based on historic dissolved oxygen data. Additionally, dissolved oxygen data collected at station RMS11 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, Mosher Brook received a score of 144 out of a total 200 for quality of habitat. Higher scores indicate better habitat. The range in habitat assessment scores of attainment streams was 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 Mosher Brook watershed, the downstream sample station was located in a small, isolated area of forest. Immediate riparian zone was that of a floodplain wetland. However dominant surrounding vegetation was Maple, Alder and Pine. The stream here was very embedded and water was documented as quite turbid. Velocity was very slow, and aquatic vegetation included pickerelweed and sedges with lily pads observed is pool areas. New residential developments were observed to the west of Mosher Brook and may be a source of sedimentation to the stream.

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

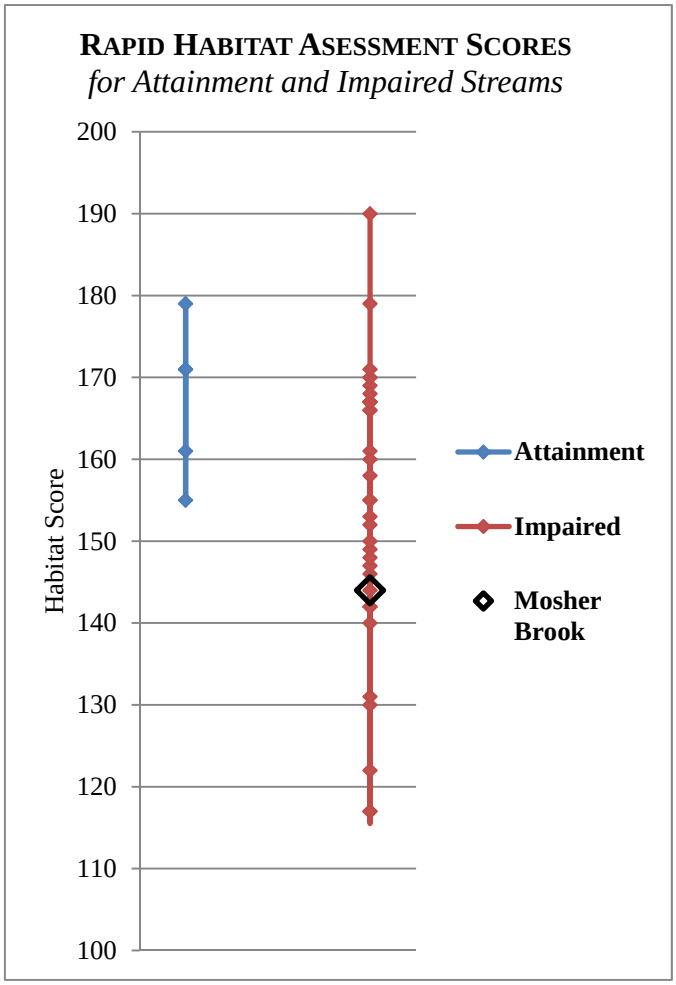


Figure 2: Habitat Assessment Scores

Pollution Source Identification

Pollution source identification assessments were conducted for Mosher Brook (impaired) and all 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 Mosher Brook was completed on July 25, 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 Mosher Brook Watershed

Potential Source			Notes
ID#	**Location**	**Type**	
1	Gateview Commons Drive	Residential Development	• Newer development. Trees in most areas, but not densely forested. • Storm drains and manholes observed.
3	Wagner Farm Road	Residential Development	• Brand new development with current construction observed. • Only a few small trees in development. • No sewers.
4	Dolloff Road	Agriculture	• Inactive fields and hay fields.
5	Mosher Road	Agriculture	• Hay and corn fields adjacent to Mosher Brook to the south with minimal buffer.
5b		Agriculture & Power lines	• Large hay fields and power line crossing to the north of Mosher Brook. • No buffer.
7	Dolloff Road	Road Crossing	• Minimal buffer. • Turbid.
9	Mosher Road	Gravel Pit	• Large gravel operation on northern border of watershed.

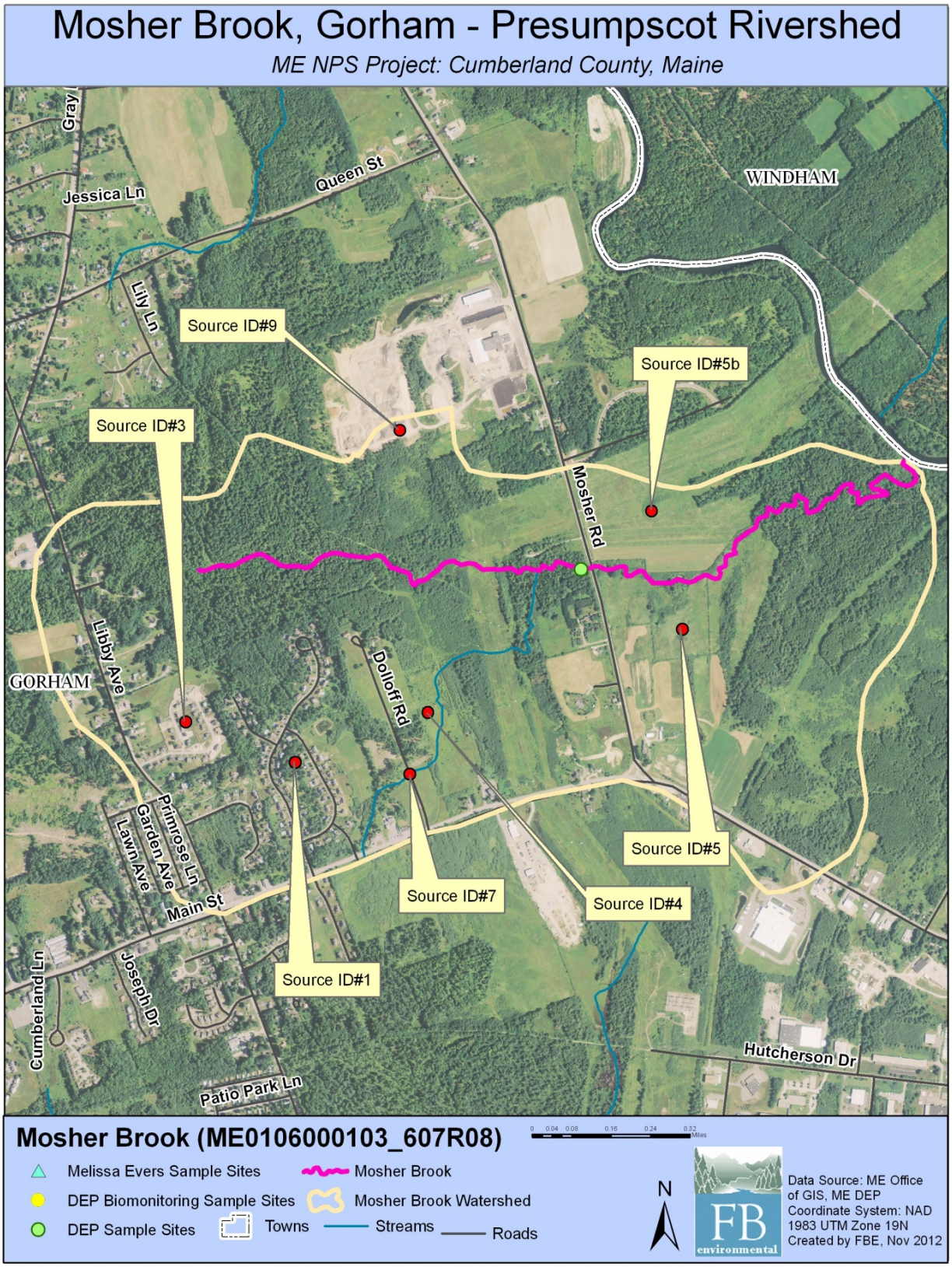


Figure 3: Aerial Photo of Source ID locations in the Mosher Brook Watershed

NUTRIENT LOADING – MAPSHED ANALYSIS

The MapShed model was used to estimate stream loading of sediment, total nitrogen and total phosphorus in Mosher 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) shows that no livestock (numbers of animals) were found in the watershed, based on direct observations made in the watershed, plus other publicly available data.

Table 3: Livestock Estimates in the Mosher Brook Watershed

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

The Mosher Brook watershed is forested, with substantial mixed agricultural land and residential development. Hay and corn fields dominate the agricultural land uses and no livestock was observed.

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.

Mosher Brook is a 2.0 mile-long impaired segment as listed by Maine DEP. As modeled, the total stream miles (including tributaries) within the watershed was calculated as 2.6 miles. Of this total, 1.0 stream miles are located within agricultural areas and 0.06 miles or 6% 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%.

Table 4: Summary of Vegetated Buffers in Agricultural Areas.

Mosher Brook
• 2.6 stream miles in watershed (includes ephemeral streams) • 1.0 stream miles in agricultural areas • **6%** of agricultural stream miles have a vegetated buffer

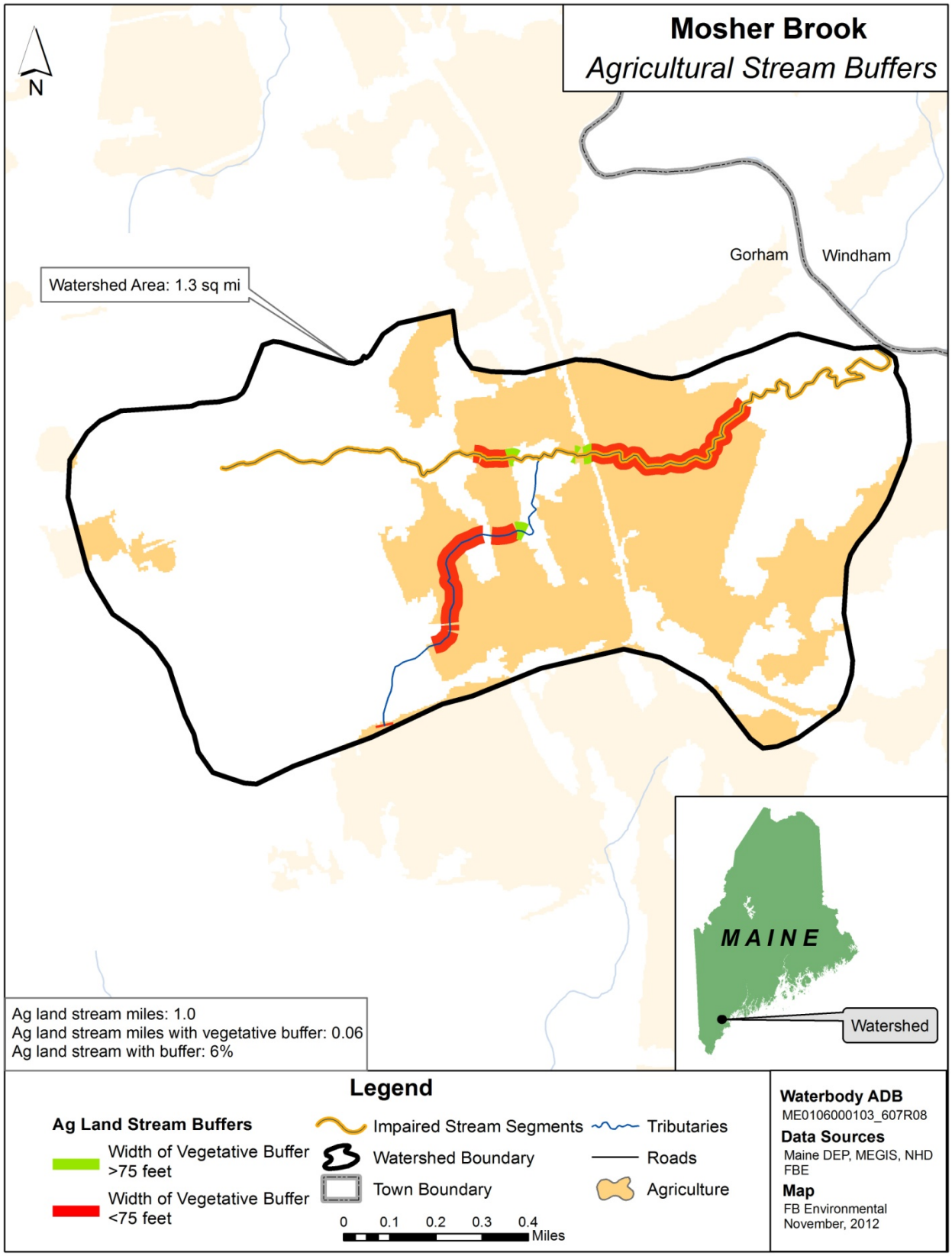


Figure 4: Buffered Agricultural Stream Miles in the Mosher Brook Watershed

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. There are no major wetlands within the Mosher 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 Mosher 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 Mosher Brook watershed is mainly derived from crop land which accounts for 94% of the total sediment load. Combined agricultural sources contribute 97% of the sediment load in Mosher Brook (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 Mosher Brook* (below) for loading estimates that have been normalized by watershed area.

Table 5: Total Sediment Load by Source

Mosher Brook	Sediment (1000kg/year)	Sediment (%)
Source Load		
Hay/Pasture	4.88	3%
Crop land	150.45	94%
Forest	1.51	1%
Wetland	0	0%
Disturbed Land	0	0%
Low Density Mixed	2.61	2%
Medium Density Mixed	0	0%
High Density Mixed	1.32	1%
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:	**160.77**	**100%**
Pathway Load		
Stream Banks	4.07	-
Subsurface / Groundwater	0	-
Total Watershed Mass Load:	**164.84**	

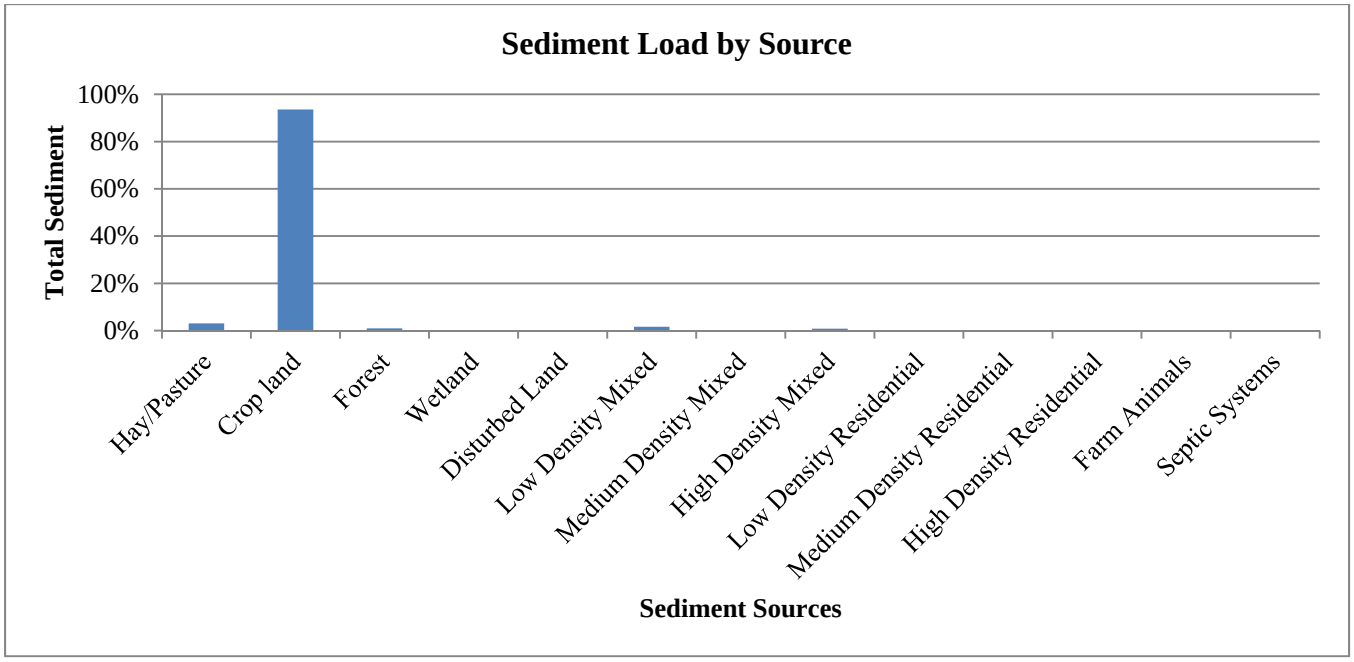


Figure 5: Total Sediment Loads by Source in the Mosher Brook Watershed

Total Nitrogen

Nitrogen loading is attributed to crop land with combine agricultural sources contributing almost 80% of the total nitrogen load to Mosher Brook. Table 6 and Figure 6 (below) shows estimated total nitrogen load in terms of mass and percent of total, and by source, in Mosher Brook. Total loads by mass cannot be directly compared between watersheds due to differences in watershed area. See section *TMDL: Target Nutrient Levels for Mosher Brook* (below) for loading estimates that have been normalized by watershed area.

Table 6: Total Nitrogen Loads by Source

Mosher Brook	Total N (kg/year)	Total N (%)
Source Load		
Hay/Pasture	81.9	5%
Crop land	1312.3	74%
Forest	83.0	5%
Wetland	0	0%
Disturbed Land	0	0%
Low Density Mixed	68.8	4%
Medium Density Mixed	0	0%
High Density Mixed	51.2	3%
Low Density Residential	0	0%
Medium Density Residential	0	0%
High Density Residential	0	0%
Farm Animals	0	0%
Septic Systems	175.2	10%
Source Load Total:	**1772.4**	**100%**
Pathway Load		
Stream Banks	2.0	-
Subsurface / Groundwater	3389.1	-
Total Watershed Mass Load:	**5163.6**	

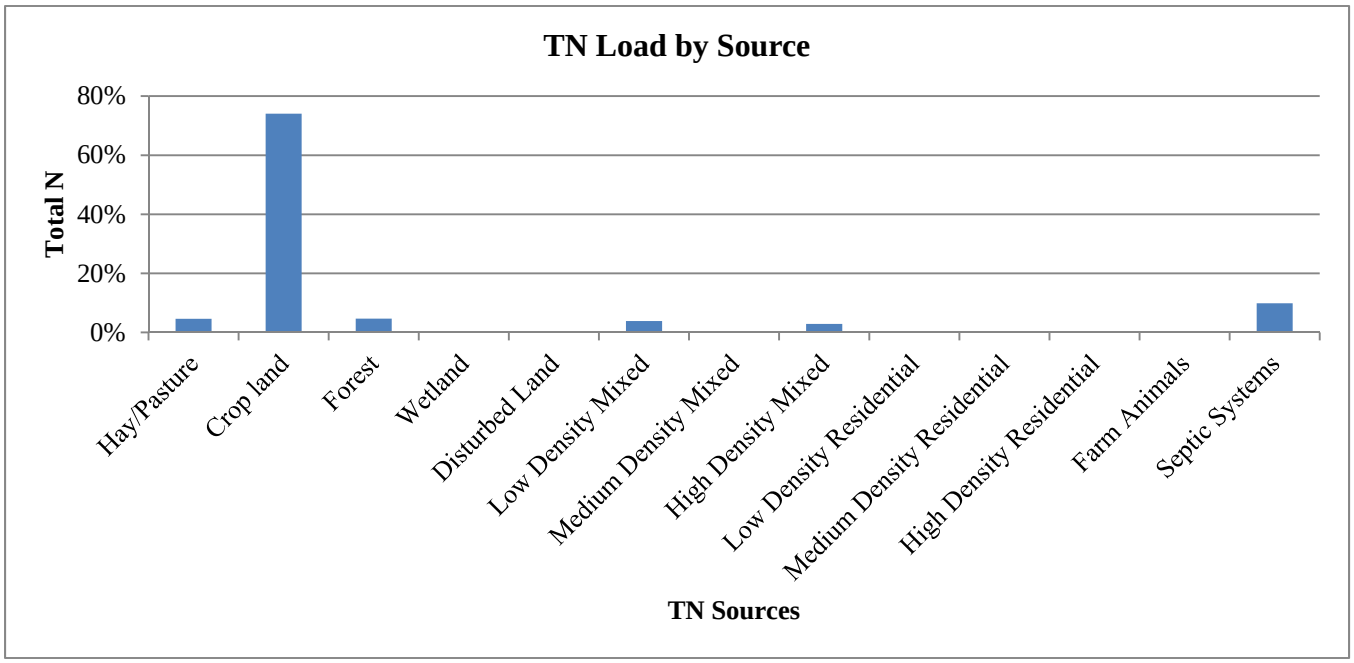


Figure 6: Total Nitrogen Loads by Source in the Mosher Brook Watershed

Total Phosphorus

Phosphorus loading within the watershed is attributed primarily to crop land with combined agricultural sources contributing 93% of the total phosphorus load in Mosher Brook. Phosphorus loads are presented in Table 7 and Figure 7. Total loads by mass cannot be directly compared between watersheds due to differences in watershed area. See section *TMDL: Target Nutrient Levels for Mosher Brook (*below) for loading estimates that have been normalized by watershed area.

Table 7: Total Phosphorus Loads by Source

Mosher Brook	Total P (kg/year)	Total P (%)
Source Load		
Hay/Pasture	37.2	12%
Crop land	253.7	81%
Forest	5.6	2%
Wetland	0	0%
Disturbed Land	0	0%
Low Density Mixed	7.9	3%
Medium Density Mixed	0	0%
High Density Mixed	5.4	2%
Low Density Residential	0	0%
Medium Density Residential	0	0%
High Density Residential	0	0%
Farm Animals	0	0%
Septic Systems	1.7	1%
Source Load Total:	**311.4**	**100%**
Pathway Load		
Stream Banks	1.0	-
Subsurface / Groundwater	52.9	-
Total Watershed Mass Load:	**365.4**	

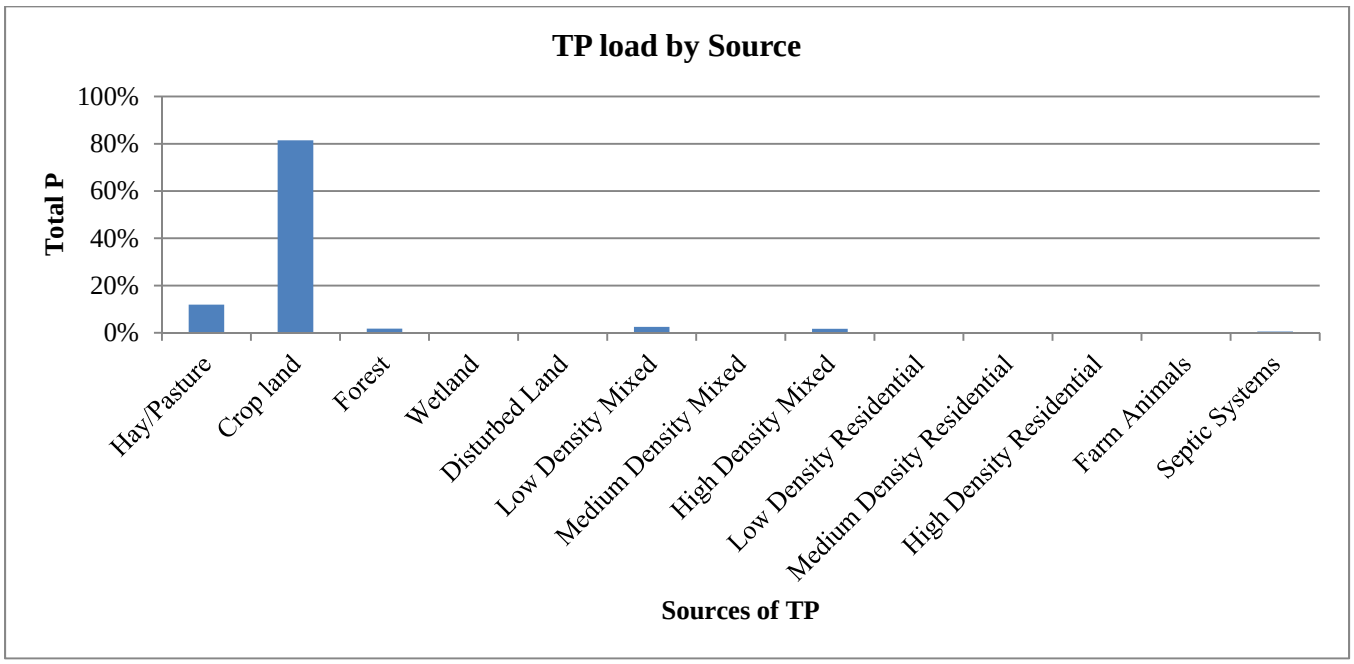


Figure 7: Total Phosphorus Loads by Source in the Mosher Brook Watershed

TMDL: TARGET NUTRIENT LEVELS FOR MOSHER BROOK

The existing loads for nutrients and sediments in the impaired segment of Mosher 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 Mosher 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 Mosher Brook Pollutant Loading

TMDL POLLUTANT LOADS Annual Loads per Unit Area	**Estimated Loads Mosher Brook**	**Total Maximum Daily Load**	**TMDL % REDUCTIONS Mosher Brook**
Sediment Load *(1000 kg/ha/year)*	**0.506**	**0.030**	**94%**
Nitrogen Load *(kg/ha/year)*	**15.84**	**5.19**	**67%**
Phosphorus Load *(kg/ha/year)*	**1.21**	**0.24**	**78%**

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 Mosher 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 Mosher 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 Mosher Brook. It is recommended that municipal officials, landowners, and conservation stakeholders in Gorham 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 Mosher Brook;
- Address existing nonpoint source problems in the Mosher Brook watershed by instituting BMPs where necessary; and
- Prevent future degradation of Mosher 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 Mosher Brook

Mosher Brook				
	Area ha	**Sediment 1000kg/yr**	**TN kg/yr**	**TP kg/yr**
Land Uses				
Hay/Pasture	35	4.9	81.9	37.2
Crop land	84	150.5	1312.3	253.7
Forest	127	1.5	83.0	5.6
Wetland	0	0.0	0.0	0.0
Disturbed Land	0	0.0	0.0	0.0
Low Density Mixed	70	2.6	68.8	7.9
High Density Mixed	10	1.3	51.2	5.4
Other Sources				
Farm Animals			0.0	0.0
Septic Systems			175.2	1.7
Pathway Loads				
Stream Banks		4.1	2.0	1.0
Groundwater			3389.1	52.9
Total Annual Load		165 x 1000 kg	5163.6 kg	365 kg
Total Area	326 ha			
Load per Unit Area		**0.506 1000kg/ha/year**	**15.84 kg/ha/year**	**1.12 kg/ha/year**

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