Mill Stream

WATERSHED DESCRIPTION

This **TMDL** applies to a 2.17 mile section of Mill Stream, located in the Town of Albion, Maine. The impaired segment of Mill Stream begins just downstream of the Lovejoy Pond outlet and flows north through a mixture of agriculture and forest. The stream crosses Winslow Road where it widens before crossing Benton Road and continuing north where it converges with Fifteenmile Stream. The Mill Stream watershed covers an area of 13.04 square miles. The majority of the watershed is located within the Town of Albion, however, a small portion of the watershed lies within the surrounding town of China.

- Runoff from agricultural land located around Lovejoy Pond and along Taylor Road and East Benton Road is likely the largest source of **nonpoint source (NPS) pollution** to Mill Stream. Runoff from cultivated lands, active hay lands, and pasture can transport nitrogen and phosphorus to the nearest section of the stream.
- The Mill Stream watershed is predominately non-developed (93.7%). Forested areas (60.9%) within the watershed absorb and filter pollutants helping protect both water quality in the stream and stream channel stability. Wetlands (5.6%) may also help filter nutrients.
- Non-forested areas within the watershed are predominantly agricultural (27.2%) and are located in the northern portion of the watershed.
- Developed areas (6.3%) with impervious surfaces in close proximity to the steam may impact water quality.
- Mill Stream is on Maine's 303(d) list of Impaired Streams (Maine DEP, 2013).

Waterbody Facts

Segment ID: ME0103000309_327R01

Town: Albion, ME

County: Kennebec

Impaired Segment Length: 2.17 miles

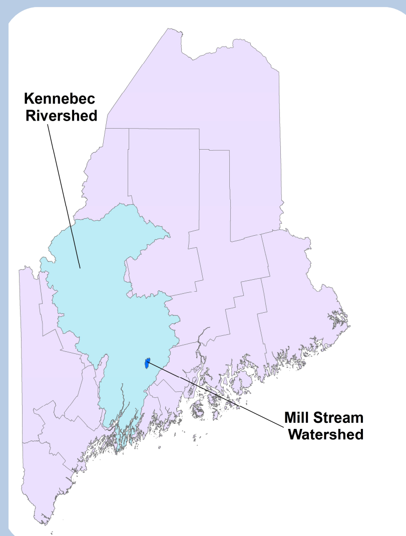
Classification: Class B

Direct Watershed: 13.04 mi^2 (8,346 acres)

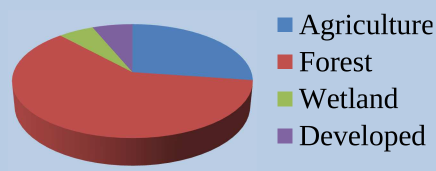
Impairment Listing Cause: Dissolved Oxygen

Watershed Agricultural Land Use: 27.2%

Major Drainage Basin: Kennebec 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 is typically transported by rain or snowmelt runoff.*

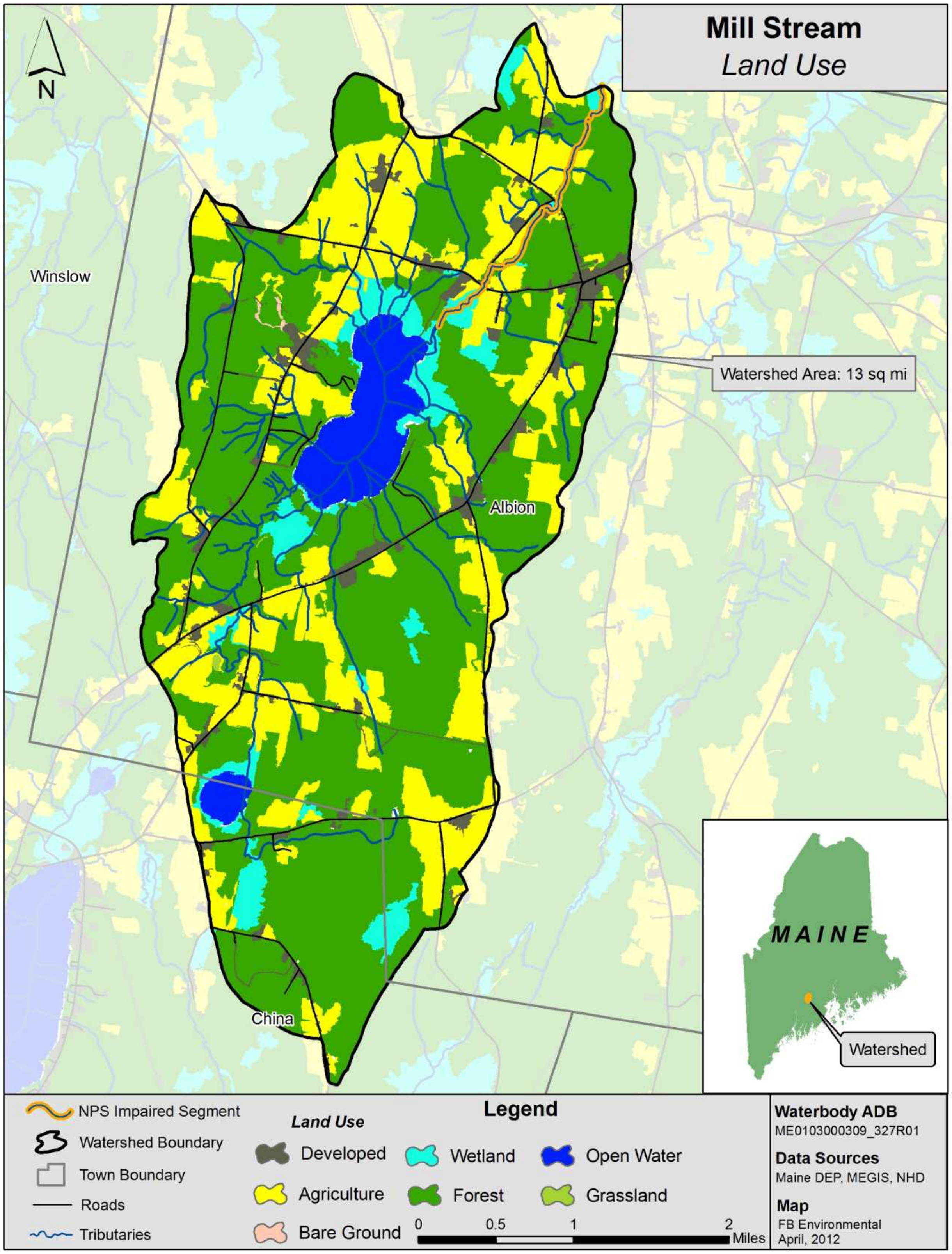


Figure 1: Land Use in the Mill Stream Watershed

WHY IS A TMDL ASSESSMENT NEEDED?

Mill Stream, 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.

***Mill Stream** downstream of the Benton Road crossing.*
Photo: FB Environmental

Agricultural land in the Mill stream watershed makes up about 27% of total watershed area. This is more than four times the area of developed land at 6% (Figure 1). Agriculture is therefore likely to be the largest contributor of sediment and nutrient enrichment to the stream, especially around Lovejoy Pond. Lovejoy Pond is also impaired due to the same source of pollutants and has a persistent, recurring algae bloom, which seasonally contributes algae and nutrients. 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 Mill Stream 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, physical characterization and visual assessment of in-stream and riparian habitat quality.

Based on Rapid Bioassessment protocols for low gradient streams, Mill Stream received a score of 155 out of a total 200 for quality of habitat. Higher scores indicate better habitat. The range of habitat assessment scores for 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 Mill Stream watershed, the downstream sample station was located in a forested portion of the stream; however, it is not densely forested. A roadway, and agricultural areas are near this location.

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

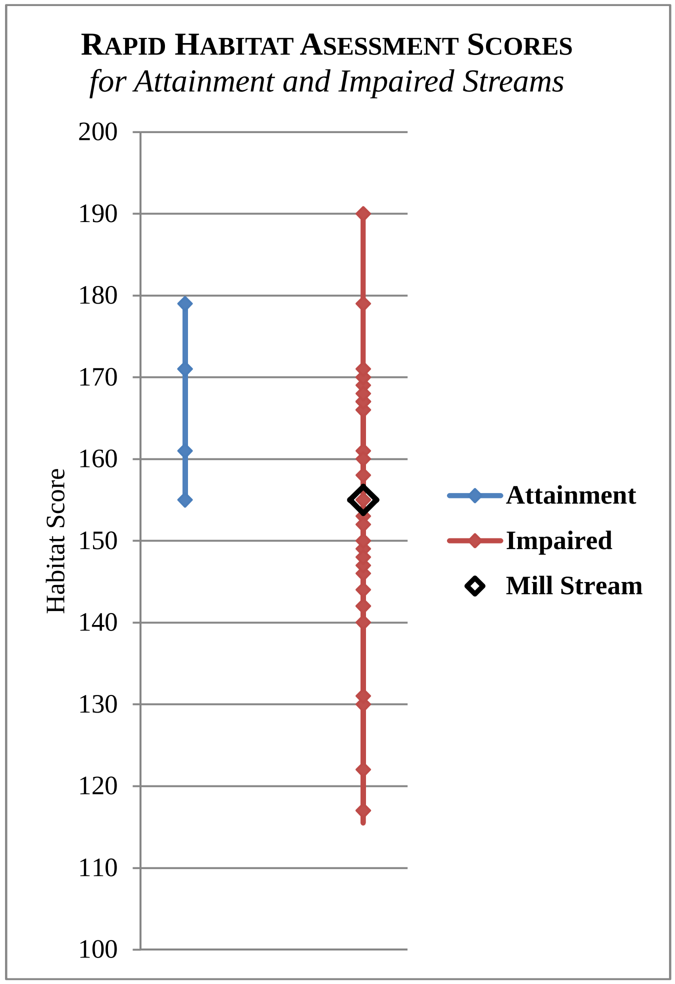


Figure 2: Habitat Assessment Scores

Pollution Source Identification

Pollution source identification assessments were conducted for both Mill Stream (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 Mill Stream was completed on July 6, 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 Mill Stream Watershed

Potential Source			Notes
ID#	**Location**	**Type**	
1	Winslow Road	Road Crossing	• Possibly undersized culvert impounding stream. • Floating and attached algae observed.
3	Benton Road	Road Crossing	• Habitat Assessment conducted downstream of bridge/dam. • Strong sulfur and manure odors were observed at the site. • Multiple piles of dirty foam throughout.
5	China Road	Agriculture	• Cows observed off China Road.
10	Pond Road	Agriculture	• Cow farms located along Pond Road in Albion. • Estimated 15 cows observed in pasture. • Grazing areas extending almost directly to Lovejoy Pond may be draining into Mill Stream.
12	Winslow Road & Crosby Road	Agriculture	• 2 cow farms observed near intersection of Winslow and Crosby Roads • About 50 cows estimated. • Large active fields intersect multiple tributaries that drain to Lovejoy Pond.
14	Benton Road (near crossing)	Agriculture	• A horse barn and pasture are located near the upstream impoundment of Mill Stream at the Old Mill Site (ID#3). • Estimated 4-5 horse observed. • Severe algal growth was documented at the impoundment and at some distance upstream. • Manure was spotted within the pasture, but it is unknown where the manure from the barn or other areas is stored. • Little buffer exists between horses and Mill Stream.
18	East Benton Road	Agriculture	• Hay and corn fields observed in multiple locations along East Benton Road. • Two possible livestock barns were also observed. One, in particular, was adjacent to a small pond with severe algal growth. • Fields in this area were very green and may be manured or fertilized. • Two tributaries to Mill Stream flow through this area.

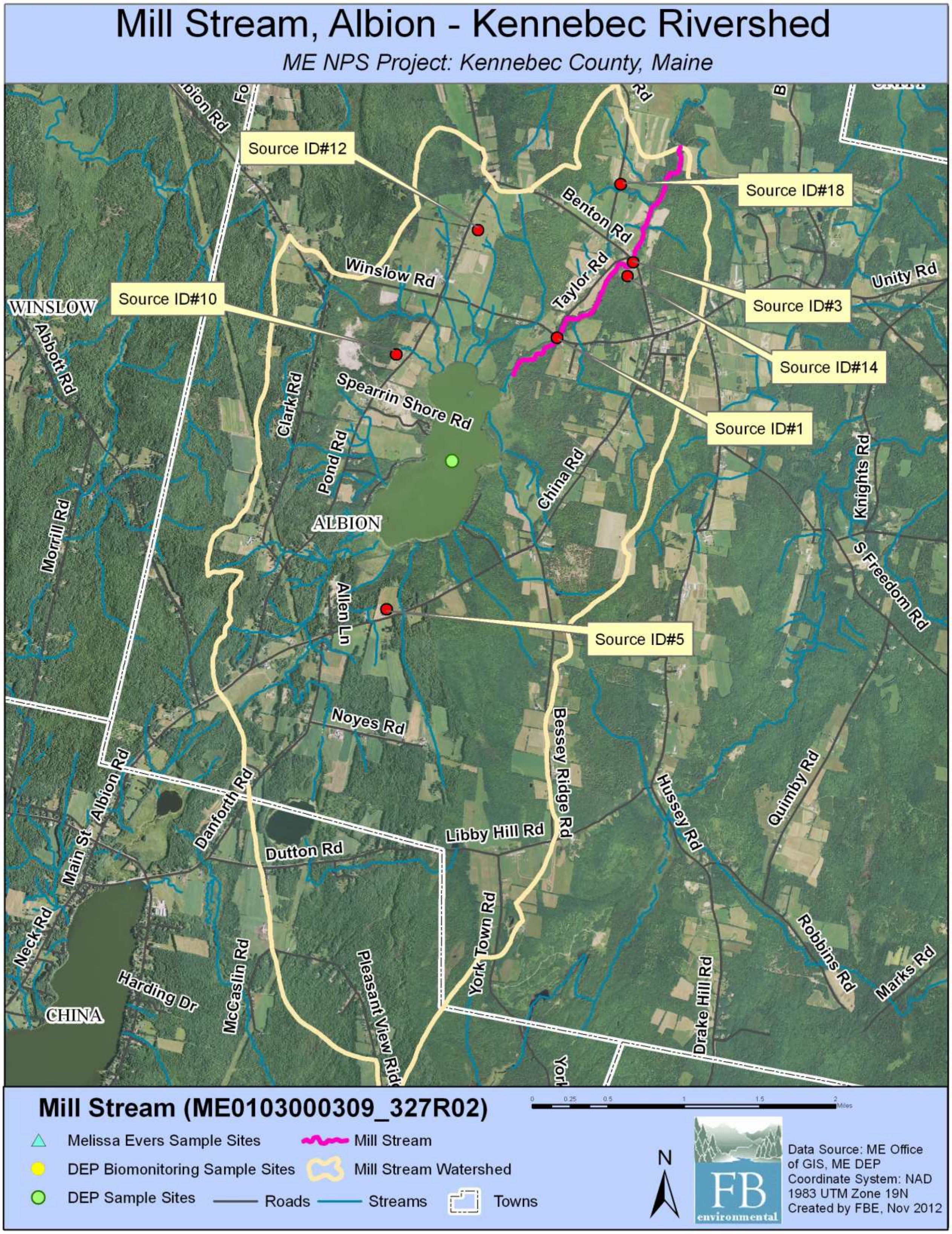


Figure 3: Aerial Photo of Source ID Locations in the Mill Stream Watershed

NUTRIENT LOADING – MAPSHED ANALYSIS

The MapShed model was used to estimate stream loading of sediment, total nitrogen and total phosphorus in Mill Stream (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 sections 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.

Table 3: Livestock Estimates in the Mill Stream Watershed

Type	Mill Stream
Dairy Cows	70
Beef Cows	
Broilers	
Layers	10
Hogs/Swine	
Sheep	
Horses	5
Turkeys	
Other	
Total	**85**

The Mill Stream watershed is predominantly forested, with some agriculture and development around Lovejoy Pond in Albion. A total of 70 dairy cows were observed in 4 different locations within the watershed. Two of these farms (total of 50 cows) are located near the intersection of Winslow and Crosby Road. Large active hay fields and grazing areas intersect multiple tributaries into Lovejoy Pond. Another farm with an estimated 15 cows located along Pond Road has grazing areas extending almost directly to Lovejoy Pond with only a minimal scrub-shrub buffer for runoff protection. A farm on Benton Road where 5 horses were observed is considered a hotspot for NPS pollution to Mill Stream, due to the very small buffer distance between the horses and Mill Stream and the presence of manure on the pasture. Additionally, a severe algal blooms observed in the stream nearby. Another horse barn and pasture are located near an upstream impoundment at the Benton Road stream crossing.

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.

Mill Stream
• 27.0 stream miles in watershed (includes ephemeral streams) • 9.3 stream miles in agricultural areas • 15% of agricultural stream miles have a vegetated buffer

Mill stream 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 27.0 miles. Of this total, 9.3 stream miles are located within agricultural areas; of this length, 1.4 miles (15%) 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%.

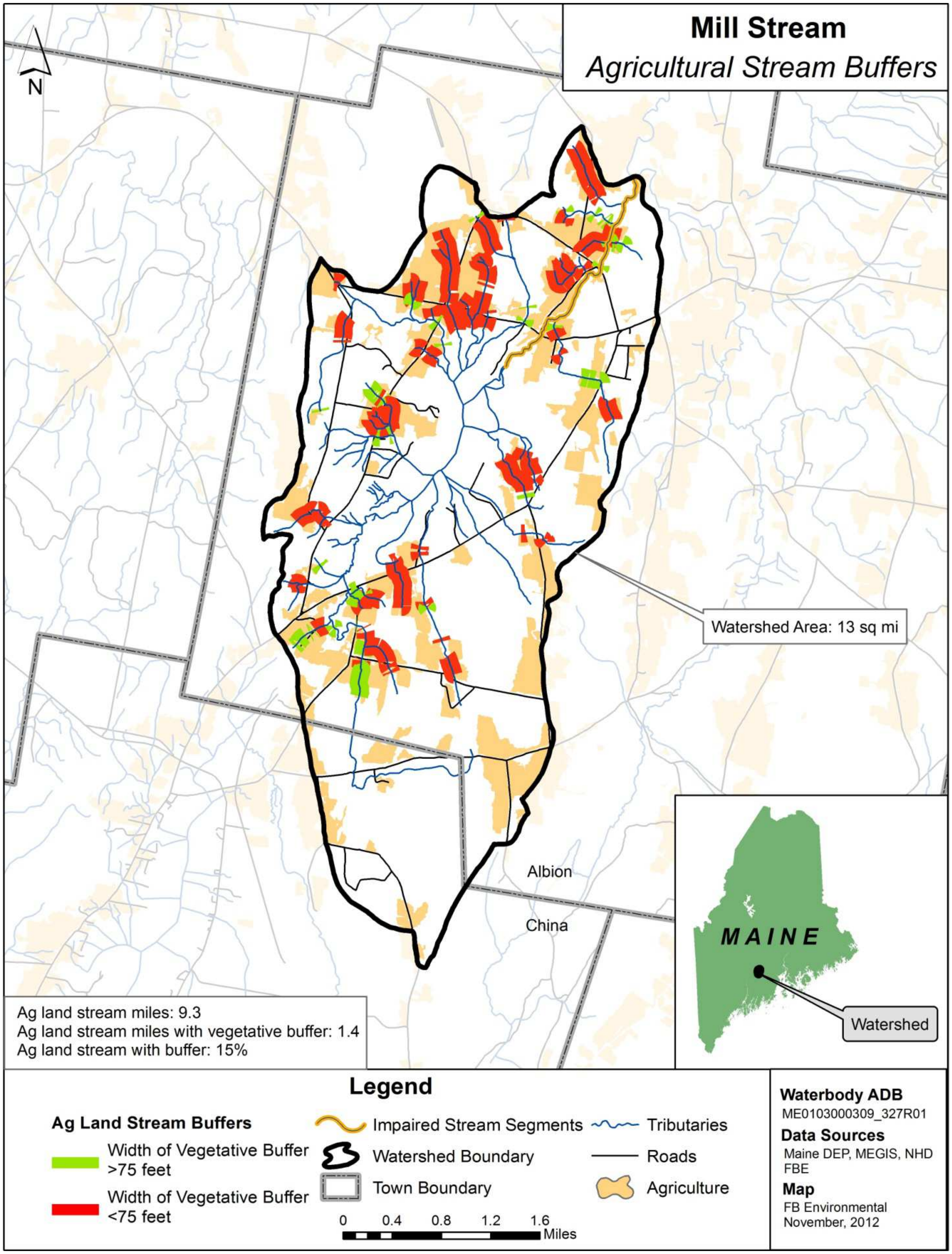


Figure 4: Agricultural Stream Buffer in the Mill Stream Watershed

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 in the model is estimated to be 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 Mill Stream watershed is 6% wetland, with Lovejoy Pond capturing much of the watershed drainage and resulting in overall 75% of the watershed draining to wetlands and ponds. 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 Mill Stream indicate significant reductions of nutrients are needed to improve water quality. Below, loading for sediment, nitrogen and phosphorus are discussed individually.

Sediment

Sediment loading in the Mill Stream watershed is mainly derived from agricultural sources which together make up 76% of the total sediment load in Mill Stream (Table 5 and Figure 5). Mixed development accounts for 18% 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 Mill Stream* below for loading estimates that have been normalized by watershed area.

Table 5: Total Sediment Loads by Source

Mill Stream	Sediment (1000kg/year)	Sediment (%)
Source Load		
Hay/Pasture	7.34	23%
Crop land	17.30	53%
Forest	1.84	6%
Wetland	0.08	0%
Disturbed Land	0	0%
Sandy Areas	0.01	0%
Low Density Mixed	0.75	2%
Medium Density Mixed	0	0%
High Density Mixed	5.12	16%
Low Density Residential	0.02	0%
Medium Density Residential	0	0%
High Density Residential	0	0%
Farm Animals	0	0%
Septic Systems	0	0%
Source Load Total:	**32.46**	**100%**
Pathway Load		
Stream Banks	3.78	-
Subsurface / Groundwater	0	-
Total Watershed Mass Load:	**36.24**	

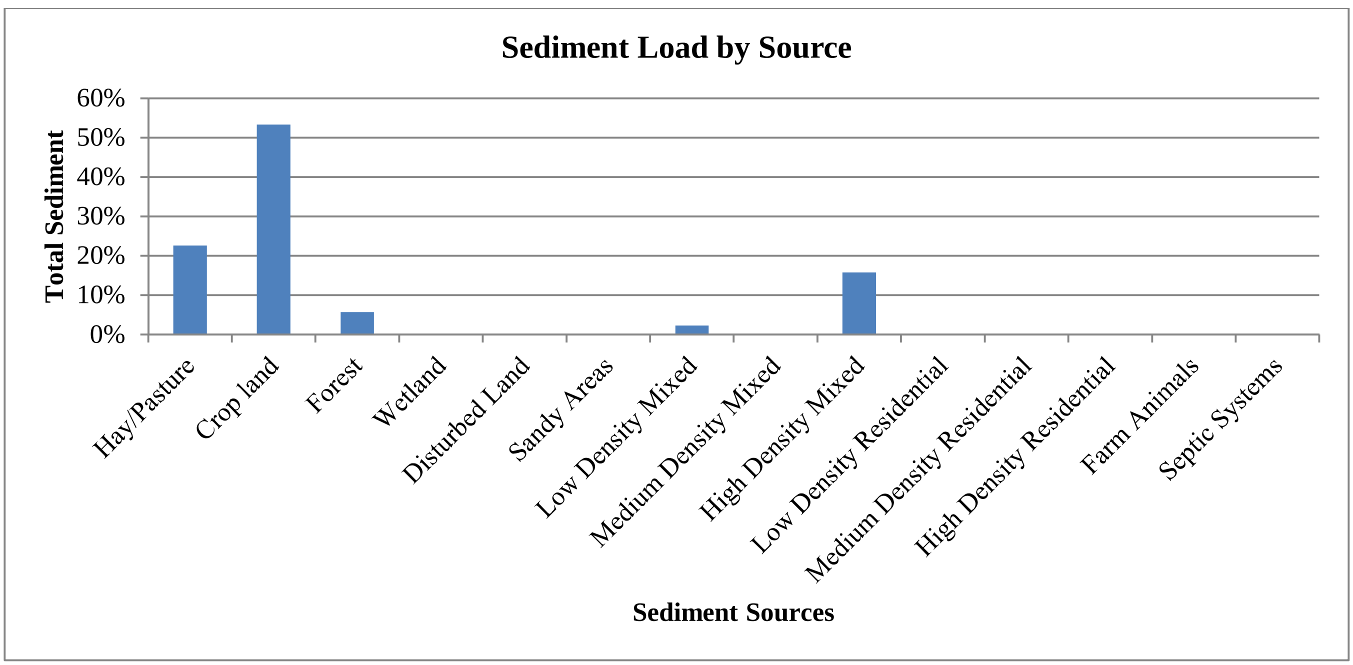


Figure 5: Total Sediment Loads by Source in the Mill Stream Watershed

Total Nitrogen

Nitrogen loading in the Mill Stream watershed is attributed primarily to agriculture with combined agricultural sources accounting for 67% of the total nitrogen load to Mill Stream. Mixed development accounts for 15% of the total load. Table 6 and Figure 6 show estimated total nitrogen load in terms of mass and percent of total, and by source. 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 Mill Stream* below for loading estimates that have been normalized by watershed area.

Table 6: Total Nitrogen Loads by Source

Mill Stream	Total N (kg/year)	Total N (%)
Source Load		
Hay/Pasture	602.0	18%
Crop land	1039.6	30%
Forest	319.7	9%
Wetland	103.1	3%
Disturbed Land	0	0%
Sandy Areas	0.0	0%
Low Density Mixed	50.3	1%
Medium Density Mixed	0	0%
High Density Mixed	490.1	14%
Low Density Residential	1.3	0%
Medium Density Residential	0	0%
High Density Residential	0	0%
Farm Animals	645.5	19%
Septic Systems	171.0	5%
Source Load Total:	**3422.7**	**100%**
Pathway Load		
Stream Banks	11.8	-
Subsurface / Groundwater	21245.6	-
Total Watershed Mass Load:	**24680.1**	

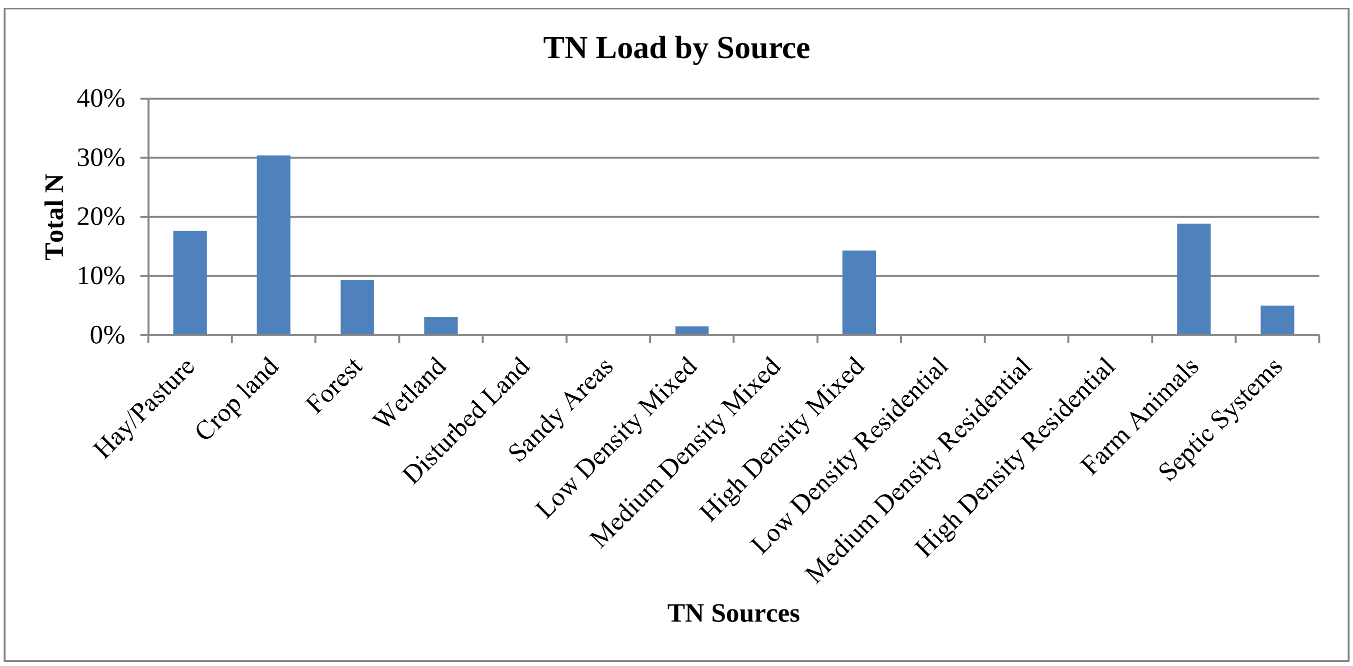


Figure 6: Total Nitrogen Loads by Source in the Mill Stream Watershed

Total Phosphorus

Phosphorus loading in the Mill Stream watershed is primarily attributed to agricultural sources which combined contribute 86% of the total load. 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 Mill Stream* below for loading estimates that have been normalized by watershed area.

Table 7: Total Phosphorus Loads by Source

Mill Stream	Total P (kg/year)	Total P (%)
Source Load		
Hay/Pasture	220.9	41%
Crop land	115.8	22%
Forest	17.4	3%
Wetland	4.8	1%
Disturbed Land	0	0%
Sandy Areas	0.0	0%
Low Density Mixed	4.8	1%
Medium Density Mixed	0	0%
High Density Mixed	44.2	8%
Low Density Residential	0.1	0%
Medium Density Residential	0	0%
High Density Residential	0	0%
Farm Animals	123.2	23%
Septic Systems	4.6	1%
Source Load Total:	**535.9**	**100%**
Pathway Load		
Stream Banks	3.9	-
Subsurface / Groundwater	316.5	-
Total Watershed Mass Load:	**856.3**	

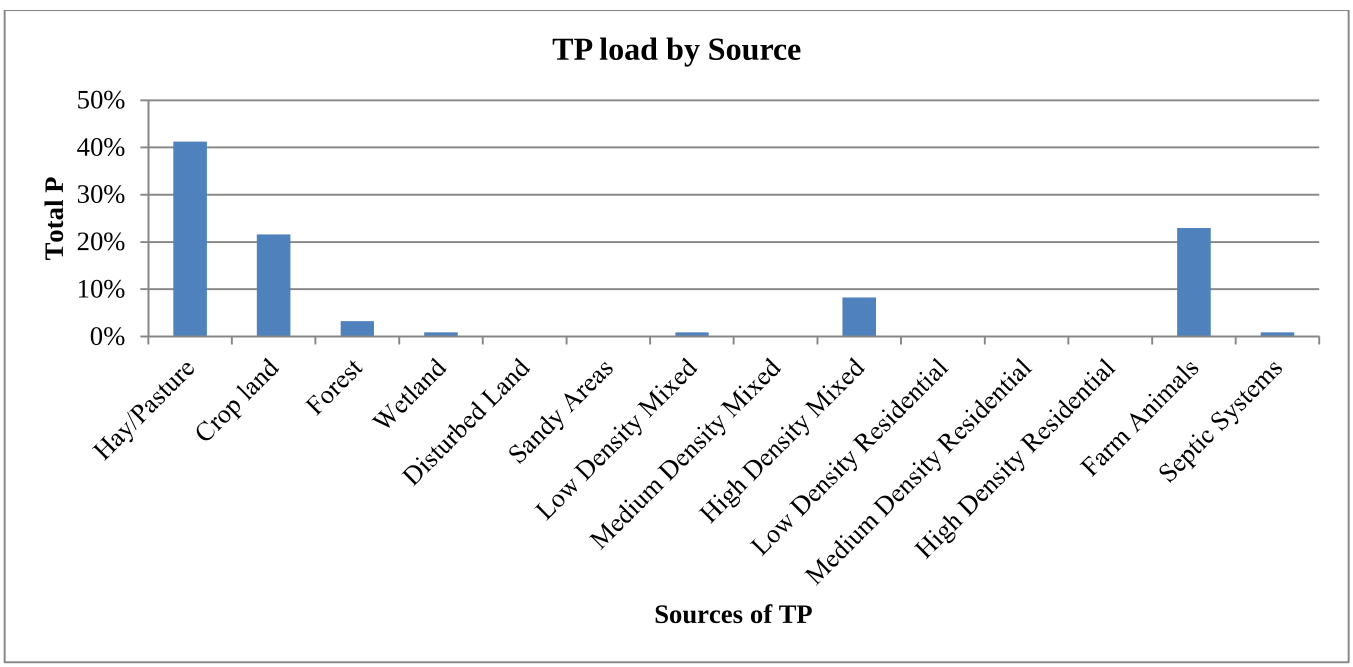


Figure 7: Total Phosphorus Loads by Source in the Mill Stream Watershed

TMDL: TARGET NUTRIENT LEVELS FOR MILL STREAM

The existing sediment and nutrient loads for in the impaired segment of Mill Stream are listed in Table 8, along with the TMDL numeric target 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 sediment and nutrient loads in Mill Stream 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 Mill Stream Pollutant Loading

TMDL POLLUTANT LOADS Annual Loads per Unit Area	**Estimated Loads Mill Stream**	**Total Maximum Daily Load Numeric Target**	**TMDL % REDUCTIONS Mill Stream**
Phosphorus Load *(kg/ha/year)*	**0.27**	**0.24**	**9%**
Nitrogen Load *(kg/ha/year)*	**7.70**	**5.2**	**33%**
Sediment Load *(1000 kg/ha/year)*	**0.011**	**0.030**	**No Reduction Needed**

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 Mill Stream. 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 Mill Stream watershed because Kennebec County has increasing population trends, with a 3.3% increase between 2000 and 2008 (USM MSAC, 2009). The growth in agricultural lands is also increasing, with a 13% increase in the total number of farms in Kennebec County between 2002 and 2007. However, a decrease of 4% was seen in the land (acres) in farms between 2002 and 2007, and a 15% 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 BMPs can reduce sources of polluted runoff in Mill Stream. It is recommended that municipal officials, landowners, and conservation stakeholders in Albion 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 Mill Stream;
- Address existing nonpoint source problems in the Mill Stream watershed by instituting BMPs where necessary; and
- Prevent future degradation of Mill Stream through the development and/or strengthening of local a Nutrient Management Ordinance.

Table 9: Modeling Results Calculations for Derived Numeric Targets and Reduction Loads for Mill Stream

Mill Stream				
	Area ha	**Sediment 1000kg/yr**	**TN kg/yr**	**TP kg/yr**
Land Uses				
Hay/Pasture	642	7.3	602.0	221.0
Crop land	229	17.3	1039.6	115.8
Forest	1949	1.8	319.7	17.4
Wetland	180	0.1	103.1	4.8
Disturbed Land	0	0.0	0.0	0.0
Low Density Mixed	76	0.8	50.3	4.8
High Density Mixed	122	5.1	490.1	44.2
Low Density Residential	2	0.0	1.3	0.1
Other Sources				
Farm Animals			645.5	123.2
Septic Systems			171.0	4.6
Pathway Loads				
Stream Banks		3.8	11.8	3.9
Groundwater			21245.6	316.5
Total Annual Load		36 x 1000 kg	24680 kg	856 kg
Total Area	3205 ha			
Total Maximum Daily Load		**0.011 1000kg/ha/year**	**7.70 kg/ha/year**	**0.27 kg/ha/year**

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