TMDL SUMMARY APPENDIX 6-12

Jock Stream

WATERSHED DESCRIPTION

This **TMDL** applies to a 9.43 mile section of Jock Stream, located in the Towns of Wales and Monmouth, Maine. The impaired segment of Jock Stream begins in the southern portion of the watershed just north of Beck Terrace in a predominantly forested area and flows north into an agricultural area crossing E Road (Old Route 126) twice, Ridge Road, Bonin Road, and Fish Hatchery Road. The stream then flows into a predominantly forested area and out of the impaired segment watershed and into the southern end of Cobbosseecontee Lake. The Jock Stream watershed covers an area of 11.93 square miles. The majority of the watershed is located within the Towns of Wales and Monmouth, however, a small portion of the watershed lies within the surrounding town of Litchfield.

- Runoff from agricultural land located throughout the northern and central portion of the watershed is likely the largest source of **nonpoint source (NPS) pollution** to Jock Stream. Runoff from cultivated lands, active hay lands, and pasture can transport nitrogen and phosphorus to the nearest section of the stream.
- The Jock Stream watershed is predominately non-developed (96.3%). Forested areas (61.1%) within the watershed absorb and filter pollutants helping protect both water quality in the stream and stream channel stability. Wetlands (4.5%) may also help filter nutrients.
- Non-forested areas within the watershed are predominantly agricultural (30.6%) and are located throughout the northern and central portion of the watershed.
- Developed areas (3.7%) with impervious surfaces in close proximity to the steam may impact water quality.
- Jock Stream is on Maine's 303(d) list of Impaired Streams (Maine DEP, 2013).

Definitions

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

Waterbody Facts

Segment ID: ME0103000311_334R03

Town: Wales and Monmouth, ME

County: Androscoggin

Impaired Segment Length: 9.43 miles

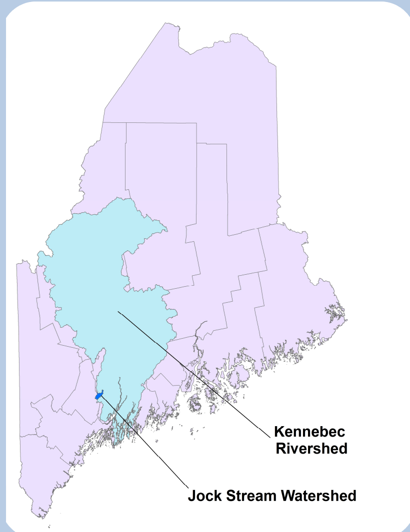
Classification: Class B

Direct Watershed: 11.93 mi^2 (7,635 acres)

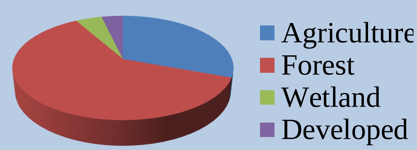
Impairment Listing Cause: Nutrient/Eutrophication Biological Indicators and Dissolved Oxygen

Watershed Agricultural Land Use: 30.63%

Major Drainage Basin: Kennebec River



Watershed Land Uses



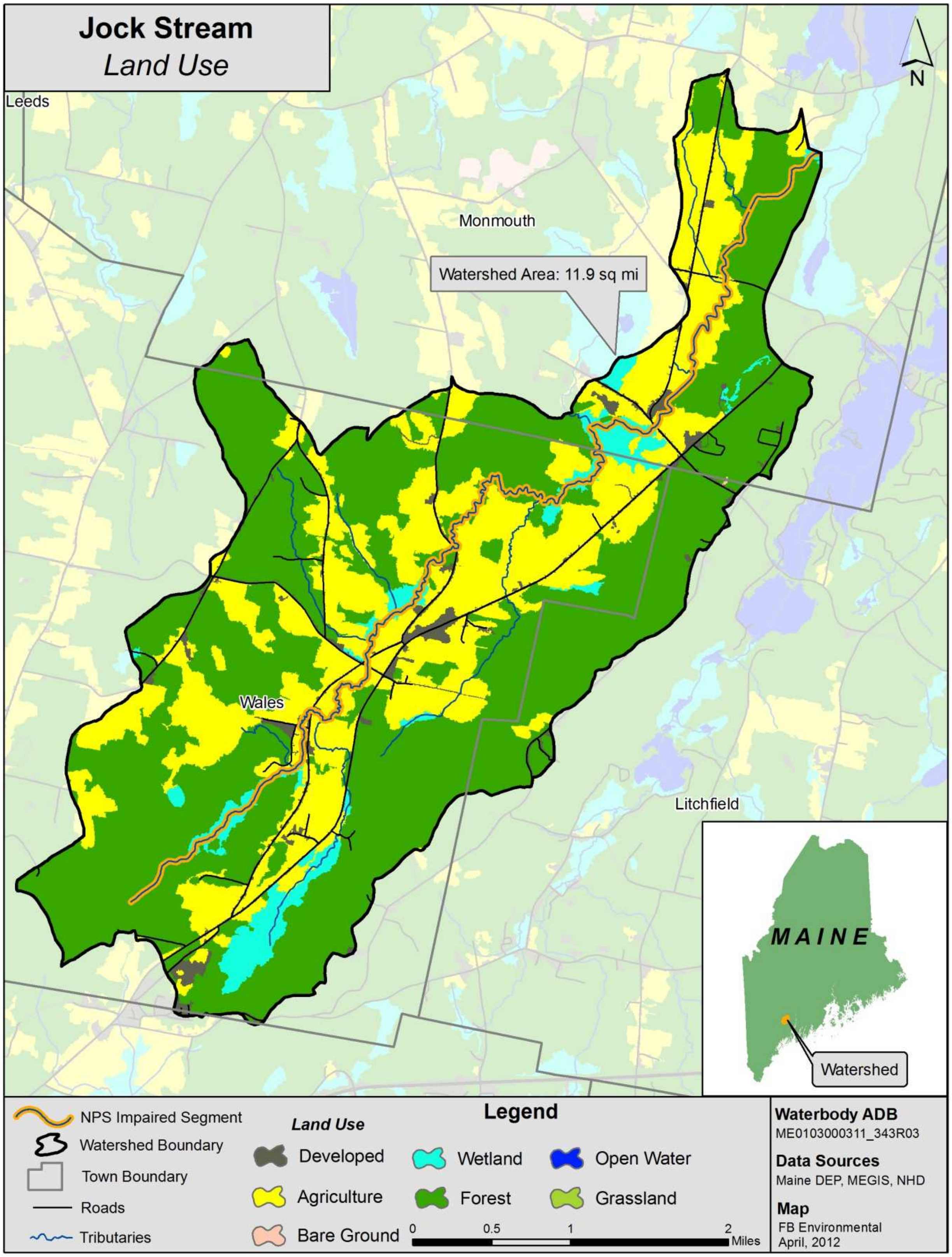


Figure 1: Land Use in the Jock Stream Watershed

WHY IS A TMDL ASSESSMENT NEEDED?

Jock Stream *near Avenue Road crossing. Photo: FB Environmental*

Jock 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.

Agricultural land in the Jock Stream watershed makes up about 31% of the total land area. This is about eight times the area of developed land area at 4% of the watershed (Figure 1). Agriculture, especially off of Old Route 126 and Collins Road, 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 Jock Stream is based on dissolved oxygen data collected in the past and observations of nutrient eutrophication.

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 stream. 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 and physical characterization and visual assessment of in-stream and riparian habitat quality.

Based on Rapid Bioassessment protocols for low gradient streams, Jock Stream received a score of 150 out of a total 200 for quality of habitat. Higher scores indicate better habitat. The range in 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 Jock Stream watershed, the downstream sample station was located in a forested portion of the stream with a thick buffer. The sample reach was very representative of the stream as a whole as Jock Stream flows through forested areas for a majority of its length remaining shaded in most areas except for when it enters wetland areas or flows adjacent to agricultural fields with minimal tree cover.

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

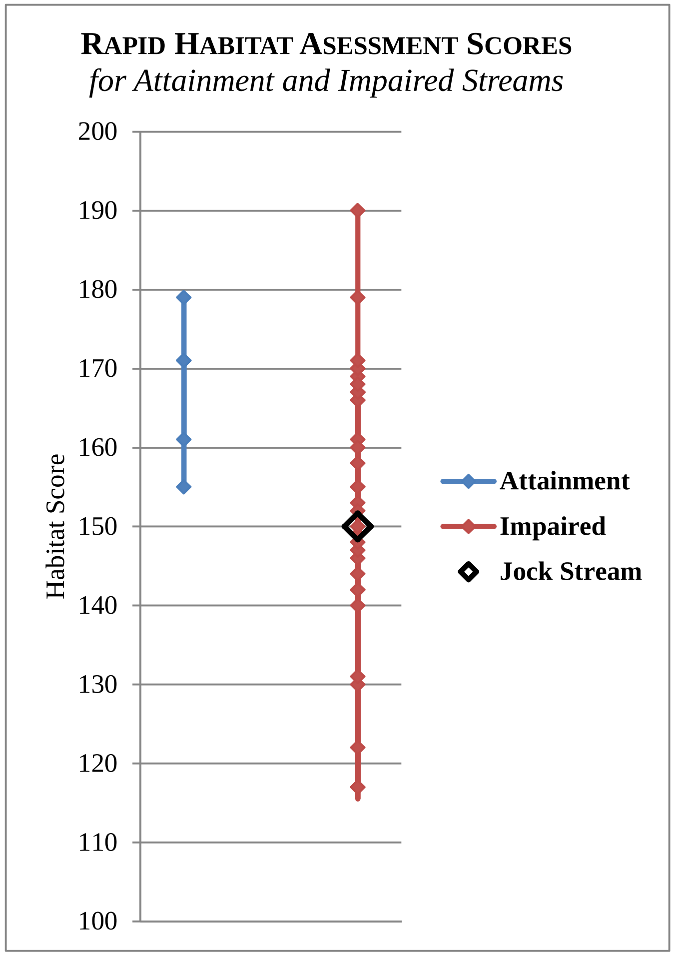


Figure 2: Habitat Assessment Scores

Pollution Source Identification

Pollution source identification assessments were conducted for both Jock 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 Jock Stream was completed on July 31, 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 Jock Stream Watershed

Potential Source			Notes
ID#	**Location**	**Type**	
4	Old Route 126 (East Road)	Agriculture	• Impounded stream behind large barn. • Mowed close to stream bank. • Possible livestock though none observed. • Large hay fields surrounding.
10	Old Route 126 (East Road)	Agriculture	• Stream flows through agricultural fields with minimal buffer.
17	Ridge Road	Road Crossing	• Crossing recently stabilized with stone. • Sediment bar formation along banks.
18	Farm Road off Gardiner Road	Agriculture/Road Crossing	• Gravel Farm Road crosses over Jock Stream via bridge. • Large active fields (hay or row crops unknown) adjacent. • No access to this location (posted private); observations based on aerial photographs.
20	Bonin Road (paved portion)	Road Crossing	• No buffer with adjacent lawn.
26	S. Monmouth Road	Agriculture/Stream Crossing	• Tributary flows through hay fields with very little buffer (2 ft) before crossing South Monmouth Road. • Large lawn on east side of road. • Road shoulders stabilized with cobble.
31	Route 126	Agriculture/Stream Crossing	• Southern tributary flows through large agricultural fields with very little buffer before crossing Route 126.

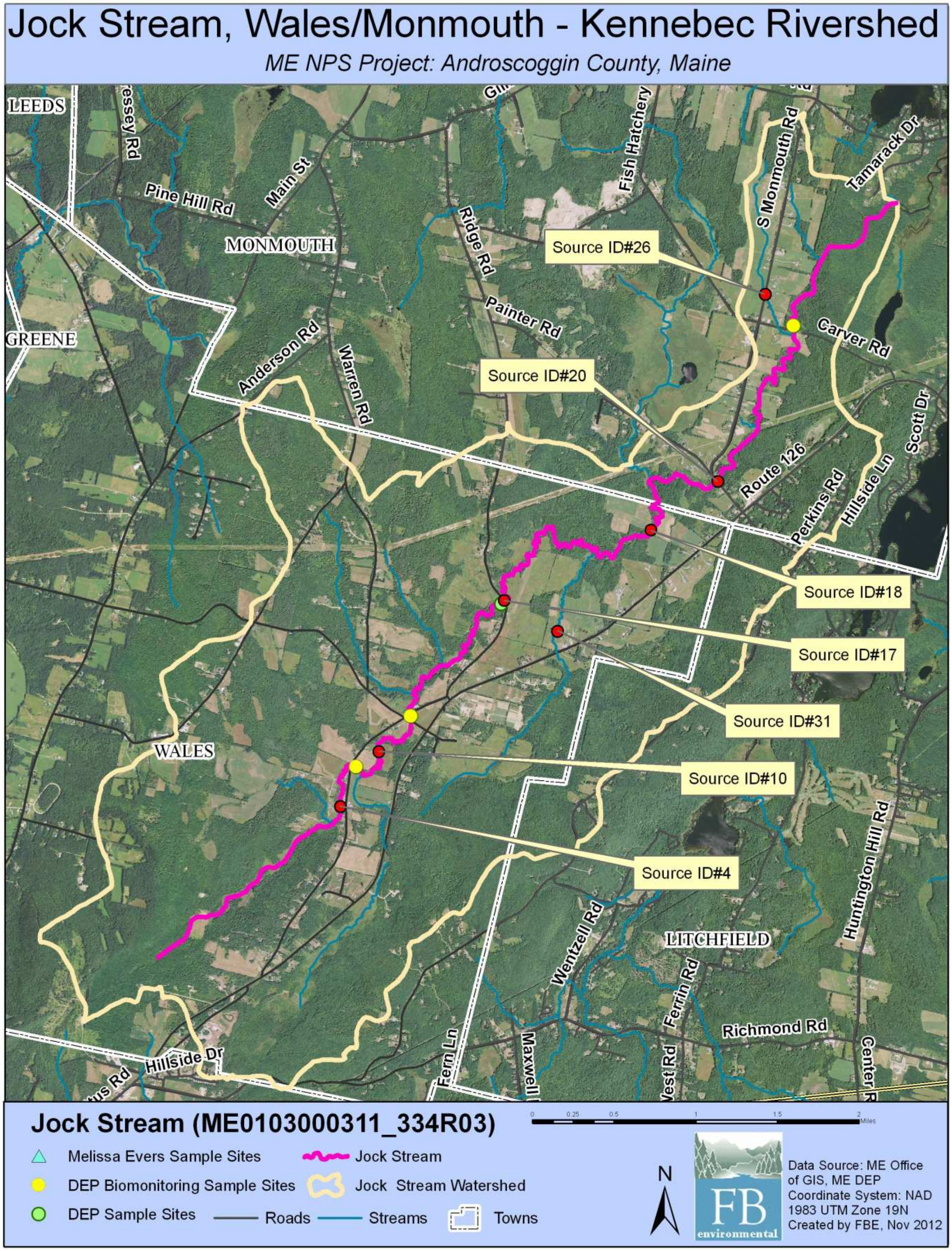


Figure 3: Aerial Photo of Source ID Locations in the Jock Stream Watershed

NUTRIENT LOADING – MAPSHED ANALYSIS

The MapShed model was used to estimate stream loading of sediment, total nitrogen and total phosphorus in Jock 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.

The Jock Stream watershed is predominantly forested, with significant agricultural land as well development. Though large agricultural areas were observed, they were mainly hay fields and some row crops. No livestock was observed during the field visit.

Table 3: Livestock Estimates in the Jock Stream Watershed

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

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

Jock Stream
• 16.4 stream miles in watershed (includes ephemeral streams) • 7.1 stream miles in agricultural areas • 39% of agricultural stream miles have a vegetated buffer

Jock Stream is a 9.43 mile-long impaired segment as listed by Maine DEP. As modeled, the total stream miles (including tributaries) within the watershed was calculated as 16.4 miles. Of this total, 7.1 stream miles are located within agricultural areas; of this length, 2.8 miles (39%) 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%.

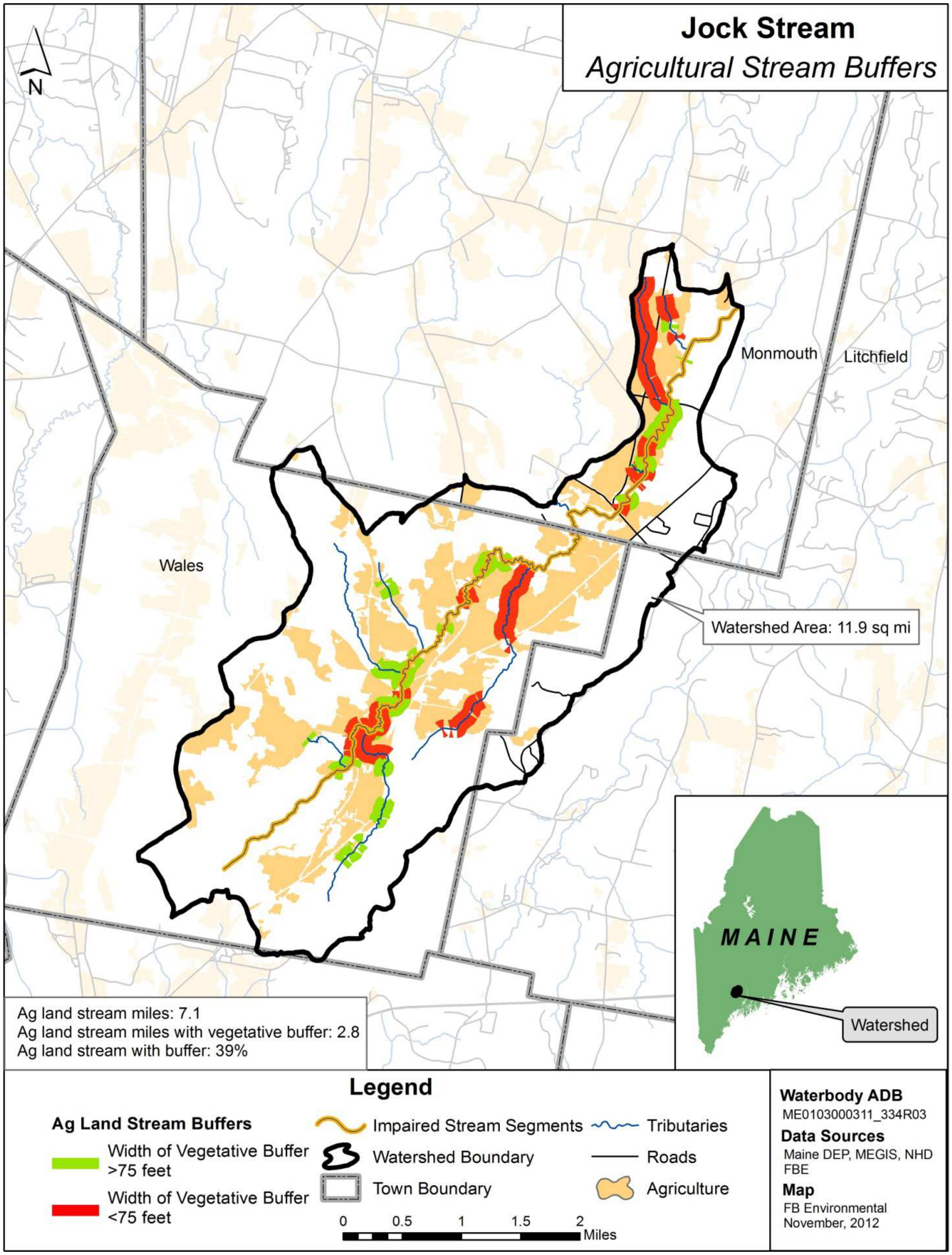


Figure 4: Agricultural Stream Buffer in the Jock Stream Watershed

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

Pollutant Load Attenuation by Lakes, Ponds and Wetlands

Depositional environments such as ponds and wetlands can attenuate watershed sediment loading. This information is entered into the nutrient loading model by a simple percentage of watershed area draining to a pond or a wetland. The Jock Brook watershed is 5% wetland, and overall 7% 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 Jock Stream indicate that reductions of nutrients are needed to improve water quality. Below, loading for sediment, nitrogen and phosphorus are discussed individually.

Sediment

Sediment loading in the Jock Stream watershed is primarily attributed to crop land and hay/pasture. These combined agricultural sources account for 75% of the total load (Table 5 and Figure 5). 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 Jock Stream* below for loading estimates that have been normalized by watershed area.

Table 5: Total Sediment Loads by Source

Jock Stream	Sediment (1000kg/year)	Sediment (%)
Source Load		
Hay/Pasture	30.69	39%
Crop land	28.07	36%
Forest	10.28	13%
Wetland	0.24	0%
Disturbed Land	0	0%
Low Density Mixed	0.88	1%
Medium Density Mixed	0	0%
High Density Mixed	7.67	10%
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:	**77.83**	**100%**
Pathway Load		
Stream Banks	10.79	-
Subsurface / Groundwater	0	-
Total Watershed Mass Load:	**88.62**	

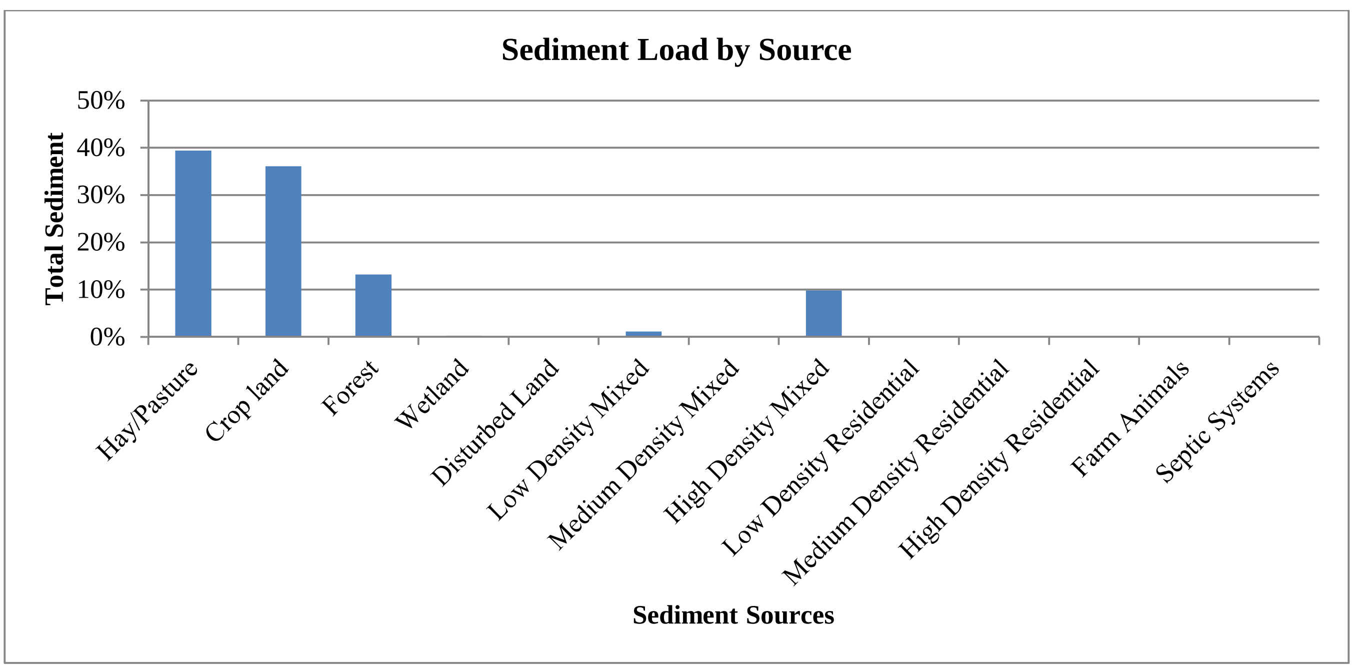


Figure 5: Total Sediment Loads by Source in the Jock Stream Watershed

Total Nitrogen

Nitrogen loading is attributed primarily to hay/pasture (29%), and septic systems (22%). Forested lands also contribute a significant portion of the load at 19%. Combined agricultural sources account for almost half of the total nitrogen load to Jock Stream. Table 6 and Figure 6 show estimated total nitrogen load in terms of mass and percent of total 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 Jock Stream* below for loading estimates that have been normalized by watershed area.

Table 6: Total Nitrogen Loads by Source

Jock Stream	Total N (kg/year)	Total N (%)
Source Load		
Hay/Pasture	924.3	29%
Crop land	443.7	14%
Forest	586.9	19%
Wetland	83.7	3%
Disturbed Land	0	0%
Low Density Mixed	24.9	1%
Medium Density Mixed	0	0%
High Density Mixed	314.1	10%
Low Density Residential	0	0%
Medium Density Residential	0	0%
High Density Residential	0	0%
Farm Animals	92.8	3%
Septic Systems	698.1	22%
Source Load Total:	**3168.6**	**100%**
Pathway Load		
Stream Banks	6.0	-
Subsurface / Groundwater	17676.9	-
Total Watershed Mass Load:	**20851.4**	

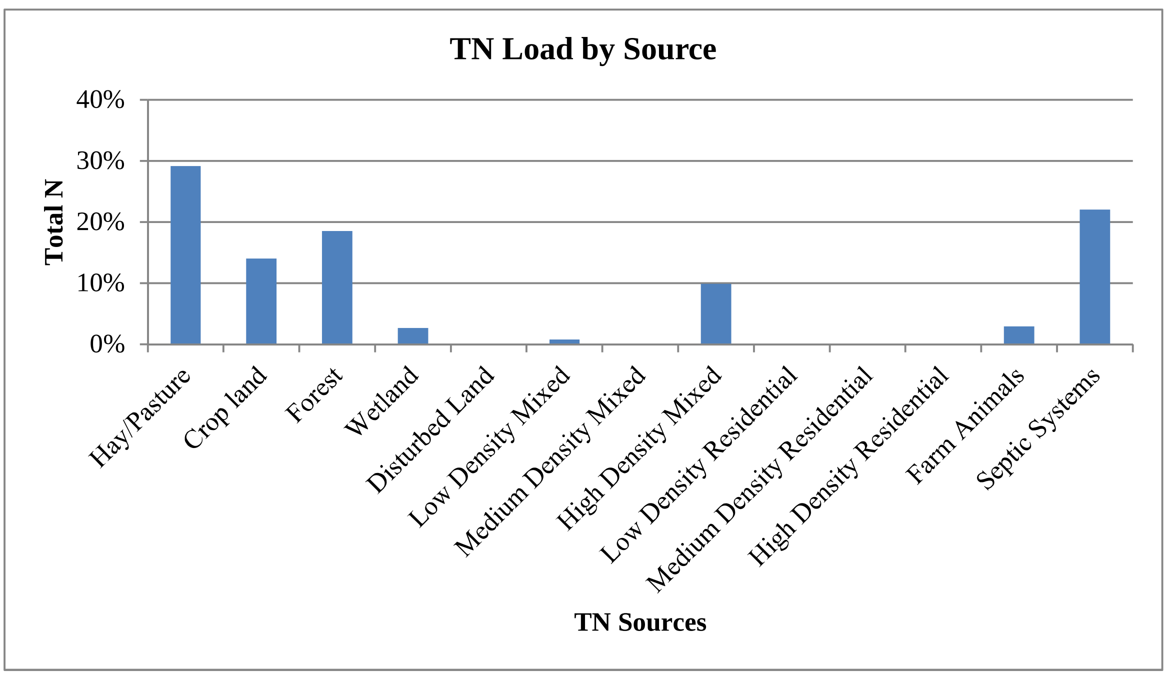


Figure 6: Total Nitrogen Loads by Source in the Jock Stream Watershed

Total Phosphorus

Phosphorus loading in the watershed is attributed primarily to hay/pasture (63%) with combined agricultural sources accounting for almost 80% of the total load to Jock Stream. 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 Jock Stream* below for loading estimates that have been normalized by watershed area.

Table 7: Total Phosphorus Loads by Source

Jock Stream	Total P (kg/year)	Total P (%)
Source Load		
Hay/Pasture	347.7	63%
Crop land	57.7	10%
Forest	37.3	7%
Wetland	4.5	1%
Disturbed Land	0	0%
Low Density Mixed	2.8	1%
Medium Density Mixed	0	0%
High Density Mixed	32.6	6%
Low Density Residential	0	0%
Medium Density Residential	0	0%
High Density Residential	0	0%
Farm Animals	31.5	6%
Septic Systems	37.0	7%
Source Load Total:	**551.1**	**100%**
Pathway Load		
Stream Banks	2.0	-
Subsurface / Groundwater	301.4	-
Total Watershed Mass Load:	**854.5**	

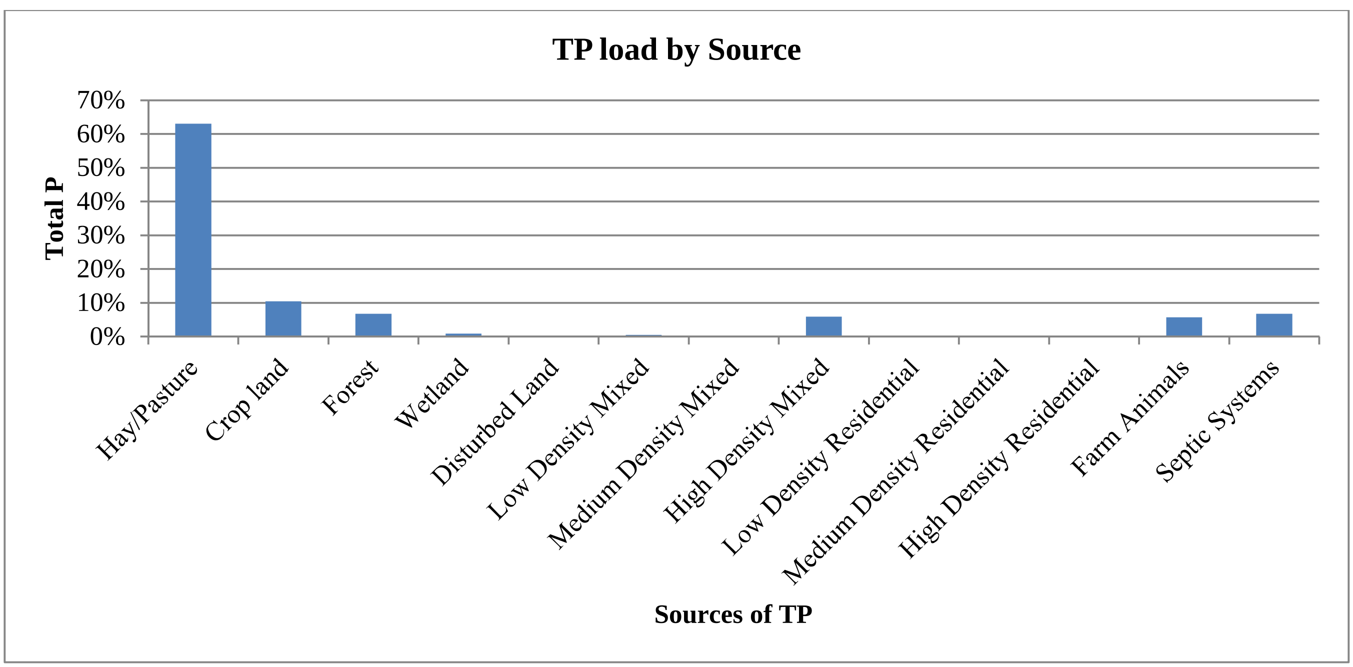


Figure 7: Total Phosphorus Loads by Source in the Jock Stream Watershed

TMDL: Target Nutrient Levels for Jock Stream

The existing sediment and nutrient loads in the impaired segment of Jock 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 Jock 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 Jock Stream Pollutant Loading

TMDL POLLUTANT LOADS Annual Loads per Unit Area	**Estimated Loads Jock Stream**	**Total Maximum Daily Load Numeric Target**	**TMDL % REDUCTIONS Jock Stream**
Sediment Load *(1000 kg/ha/year)*	**0.028**	**0.030**	**No Reduction Needed**
Nitrogen Load *(kg/ha/year)*	**6.69**	**5.2**	**23%**
Phosphorus Load *(kg/ha/year)*	**0.27**	**0.24**	**11%**

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 Jock 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 (Impaired stream name) watershed because Androscoggin County has increasing population trends, with a 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 Androscoggin County between 2002 and 2007. However, a decrease of 9% was seen in the land (acres) in farms between 2002 and 2007, and a 19% 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 Jock Stream. It is recommended that municipal officials, landowners, and conservation stakeholders in Wales and Monmouth 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 Jock Stream;
- Address existing nonpoint source problems in the Jock Stream watershed by instituting BMPs where necessary; and
- Prevent future degradation of Jock 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 Jock Stream

Jock Stream				
	Area ha	**Sediment 1000kg/yr**	**TN kg/yr**	**TP kg/yr**
Land Uses				
Hay/Pasture	882	30.7	924.2	347.7
Crop land	76	28.1	443.7	57.7
Forest	1902	10.3	586.9	37.3
Wetland	142	0.2	83.7	4.5
Disturbed Land	0	0.0	0.0	0.0
Low Density Mixed	36	0.9	24.9	2.8
High Density Mixed	78	7.7	314.1	32.6
Other Sources				
Farm Animals			92.8	31.5
Septic Systems			698.1	37.0
Pathway Loads				
Stream Banks		10.8	6.0	2.0
Groundwater			17677	301.5
Total Annual Load		87 x 1000 kg	20851 kg	855 kg
Total Area	3116 ha			
Total maximum Daily Load		**0.028 1000kg/ha/year**	**6.69 kg/ha/year**	**0.27 kg/ha/year**

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