TMDL SUMMARY APPENDIX B-4

Craig Brook

WATERSHED DESCRIPTION

This TMDL applies to the entire 7.2 mile (11.6 km) length of Craig Brook, which includes its north and south branches and a small tributary, and encompasses the village of Littleton, Maine. Craig Brook enters the Meduxnekeag River just downstream of Framingham Road. The Brook flows southeast from its headwaters. At 1.6 mile upstream of its mouth, Craig Brook splits into a north and south branch with both branches collecting nearly equal drainage areas (Figure 1). The watershed of the north branch has more wetland and wooded area relative to that of the mainstem or south branch. There exists a small length (0.8 mi) un-named tributary joining from the south end of the south branch and is considered part of the impaired segment. The Craig Brook watershed covers an area of 7.4 square miles.

- Craig Brook is on Maine's 303(d) list of Impaired Streams as referenced in the 2016 Integrated Report (Maine DEP, 2018).
- Runoff from row-crop agriculture (potato-grain rotation) and small livestock operations are likely the largest contributor of nutrients and sediment to Craig Brook. Agriculture is the largest and most intense land use comprising 44% of the watershed and is mostly situated in the periphery and near the watershed boundary (Figure 1).
- Just over half (51%) of the Craig Brook watershed is non-developed land (34% wetlands and 16% wooded). Wetlands both border and encompass the Craig Brook stream channel which can act as a buffer and potential filter for the stream from nutrients and sediment originating from the agricultural or developed land. Woodlands can also filter nutrients depending on their location. Timber harvesting has occurred on some of the woodlands; it does not appear to be clear-cutting or conversion from hardwood to softwood.
- Developed areas (5%) contain impervious surfaces (rooftops and roads) and home septic systems and when in close proximity to the stream may impact water quality.

Definitions

- ***Total Maximum Daily Load (TMDL)*** *represents the total amount of a pollutant 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: ME0101000504_152R02

Towns: Littleton, ME

County: Aroostook (southern)

Impaired Segment Length: 7.2 mi (includes north and south branches, un-named tributary)

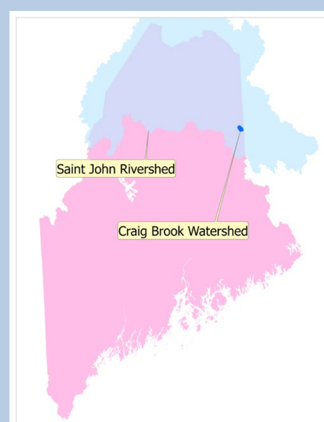
Classification: Class B

Direct Watershed: 7.4 mi^2 (4,736 acres)

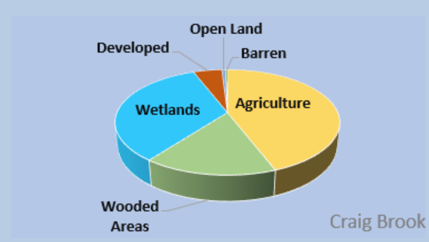
Impairment Listing Cause: Periphyton

Watershed Agricultural Land Use: 44%

Major Drainage Basin: Saint John River



Watershed Land Uses



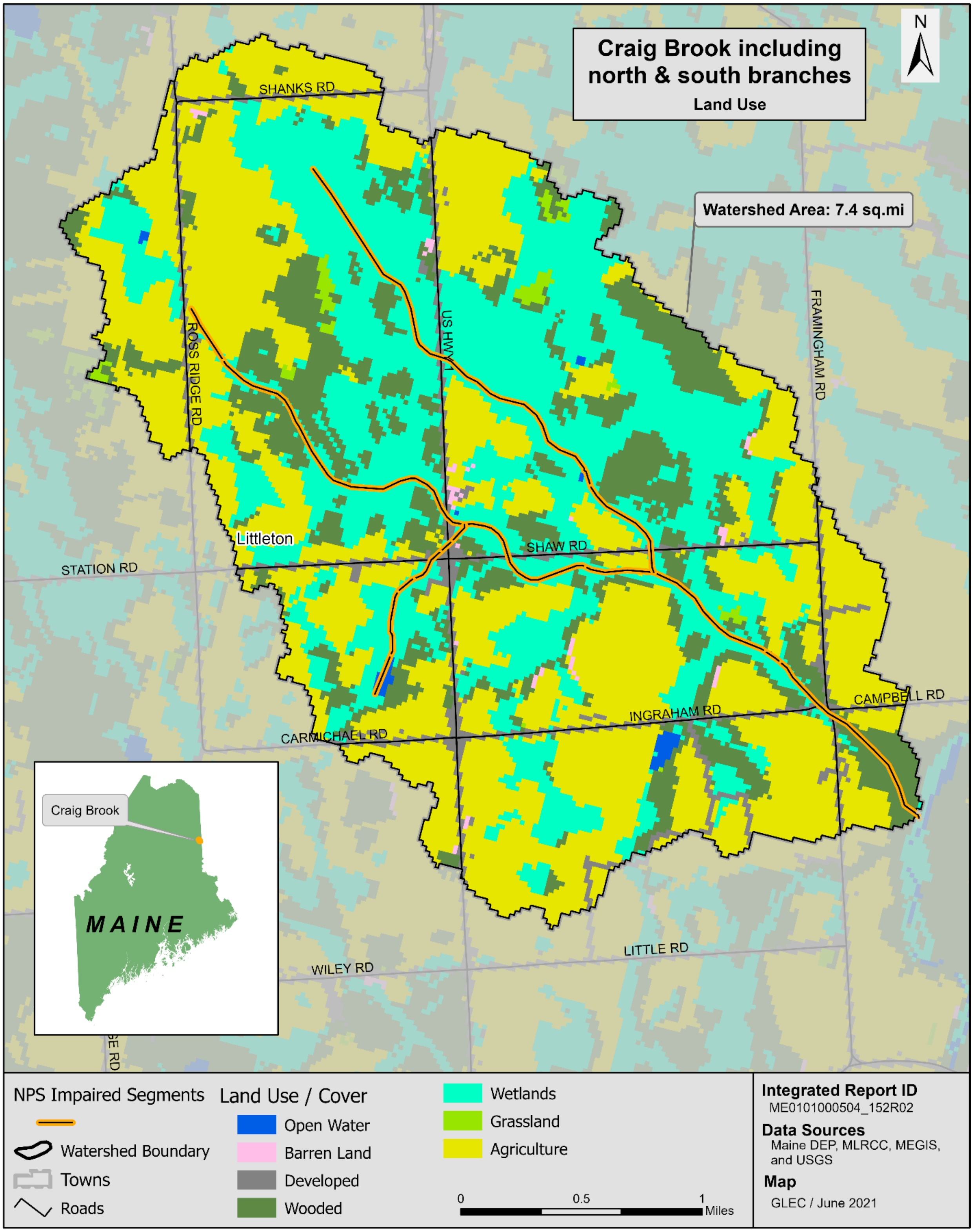


Figure 1: Land Use and Land Cover (2016) in the Craig Brook Watershed

WHY IS A TMDL ASSESSMENT NEEDED?

Craig Brook is a Class B Stream and 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 Total Maximum Daily Load (TMDL) assessment that describes the impairments and establishes a target to guide the actions needed to restore water quality. The goal is for all waterbodies to comply with state water quality standards.

Craig Brook *looking upstream at the upper part of the habitat assessment segment, just downstream of the Ingraham Road bridge. Photo: GLEC 2021*

Agriculture (cropland and hay/pasture), 44% of the watershed, is an intense land use activity. Due to the northern Maine climate with its short growing season, cultivated crop land is often left bare from harvest (September/October) to planting and emergence (May/June), resulting in long periods of soil exposure. In contrast, development which is also an intense land use activity is only 5% of the watershed. Concentrated flow in and around cropland (34% of the watershed) further increases the likelihood that nutrients and sediment will reach Craig Brook.

Craig Brook *in the middle of the habitat assessment segment, upstream of the Framingham Road bridge. Photo: GLEC 2021*

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 Craig Brook is based on macroinvertebrate and periphyton (algae) data collected from 2014 to 2017. The entire length of Craig Brook, including both north and south branches, has a Class B designation. Station S-1006 is located just downstream of Framingham Road (Figure 3). Here periphyton did not meet in both 2014 and 2017, and thus the segment is impaired. Macroinvertebrates met a *higher* designation (Class A) in 2014. As macroinvertebrate and algae data measure different trophic levels, it is not unusual in agriculturally dominated watersheds for the results of these assessments to differ.

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

Habitat assessment surveys were conducted on both impaired and attainment streams (Figure 2). 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 1) general description of the site and physical characterization and a 2) visual assessment of in-stream and riparian habitat quality. For both impaired and attainment streams, the assessment locations are typically near a road crossing for ease of access.

Craig Brook is an impaired stream (ME0101000504_152R02; Class B) and was surveyed just upstream (approximately 20 m) from the Framingham Road bridge crossing for a length of 100 m. The upstream-most point was approximately 20 m downstream of the Ingraham Road bridge crossing. The surveyed reach was clear of any obvious habitat alteration due to bridge structure at its downstream and upstream terminals. Based on the higher frequency of riffles versus runs or pools, a *high gradient* habitat assessment was performed on this 100 m length of stream segment. Craig Brook was biologically assessed just downstream of the Framingham Road bridge crossing. Craig Brook at Framingham Road is approximately 0.6 mi upstream from its confluence with the Meduxnekeag River.

The habitat survey for this impaired segment was located in dense vegetated riparian cover, while the overall watershed land use contained a mixture of cropland, wetlands, wooded, and some pasture with very small areas of developed land. However, the surveyed segment matches most of the Craig Brook riparian corridor which is wetland or wooded throughout its approximately 7.2 mi length, including the north and south branches.

Figure 2 (right) shows the range of habitat assessment scores for all attainment and impaired streams, as well as for Craig Brook segment discussed here.

Based on the *Rapid Bioassessment Protocols*, Craig Brook earned a score of 167. A higher score indicates better habitat. The range of habitat scores for attainment streams was 155 to 179.

Habitat parameters that scored high for Craig Brook include width of riparian vegetative zone, vegetated protection of streambank, and frequency of riffles. Parameters that scored low include velocity/depth regime and channel flow status.

Habitat does not appear to be an issue in the impairment of Craig Brook. Hence, 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 Craig Brook watershed as potential sources of NPS pollution contributing to the water quality impairment.

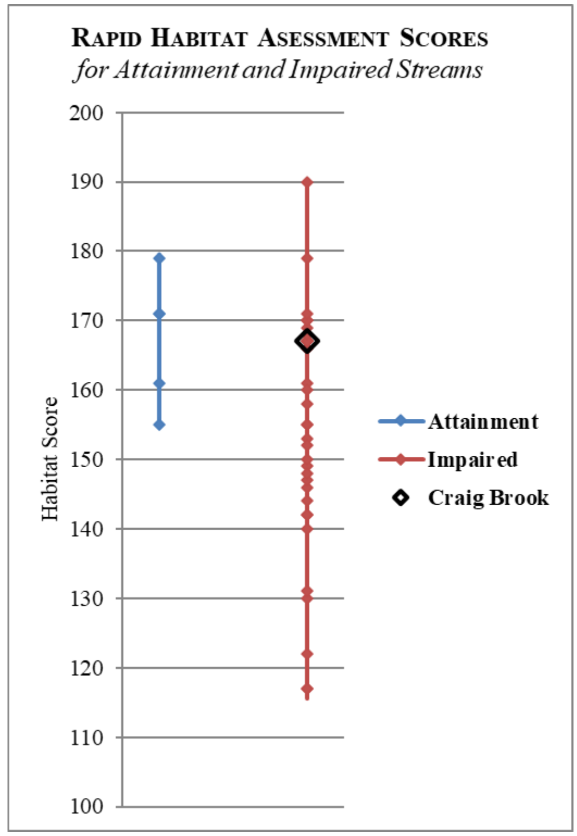


Figure 2: Habitat Assessment Score for Craig Brook (2021) Compared to Region

Pollution Source Identification

Pollution source identification assessments were conducted in May 2021 for the entire Craig Brook watershed. Attainment stream watersheds were assessed in 2012. 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.

Based on the May 2021 field and desktop assessment, several generalizations of the watershed land use for Craig Brook can be made. The stream riparian area is dominated by woods and wetlands with few fields immediately adjacent to the stream. Field observations confirmed extensive row crop agricultural activities, limited (usually less than seven animals), but still present, livestock and low density rural development (Table 2, Figure 3). All of these more intensive uses of the landscape contribute sediment and nutrients through runoff that eventually makes its way to Craig Brook.

Table 2: Potential Pollution Source ID Assessment (2021) for the Craig Brook Watershed

Potential Source			Notes
ID#	**Location**	**Type**	
1	Framingham Rd	Agriculture	Pasture of moderate spatial extent
2	Framingham Rd	Agriculture	Active cropping (grain) & tilled fields
3	US 1 & Shaw/Station Rds	Hotspot	Tractor-trailer wash
4	US 1 & Shaw/Station Rds	Hotspot	Trailer service & towing; numerous abandoned vehicles & trailers
5	Shaw Rd	Agriculture	Fenced pasture - horses; several abandoned vehicles
6	US 1 & Shaw/Station Rds	Hotspot	Fuel station
7	Station Rd	Agriculture	Potato storage
8	Station Rd	Hotspot	Collapsed house & extended structures; abandoned vehicles
9	Ross Ridge Rd	Agriculture	Several barns & manure piles present
10	Ross Ridge Rd	Agriculture	Vegetable crop storage facility (potato house)
12	Shank & Ross Ridge Rds	Agriculture	Several types of farm animals present; small pasture
14	US 1	Agriculture	Large livestock barns (4 total); covered & baled hay
15	US 1	Residential	Neighborhood (pre-1980) - home septic systems - minimal lawn care
16	US 1	Hotspot	Heavy equipment parking & storage; septic & slab installer; fuel tanks; abandoned vehicles
17	US 1	Residential	Neighborhood (pre-1980) - home septic systems - minimal lawn care
18	US 1	Hotspot	Fire department; vehicle washing
19	Ingraham Rd	Municipal	Sand storage piles - municipal origin
20	US 1	Agriculture	Barn with small pasture
21	Campbell Rd	Agriculture	Farm - seed potatoes, residue cover, other root crop or possibly cover crop, recent plowing
22	Carmichael Rd	Agriculture	Large pasture

Potential Source			Notes
ID#	Location	Type	
--	Throughout watershed	Agriculture	Row crop agriculture has the potential to deliver a significant load of sediment and nutrients. Soil often bare for 8 months of the year (crop canopy cover at best during June-September).
--	Throughout watershed	Municipal /Private	Numerous un-paved (gravel, sand, "dirt") roads where several cross Craig Brook and its tributary branches

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 Craig Brook watershed. The model estimated nutrient loads over a 12-year period (2009-2020), which was determined by local (Bangor International Airport USW00014606) 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).

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 MLRC in the NCLD 2016 and these new algorithms were used in the revisions of all previous NLCD versions (including the first version in 2001).

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

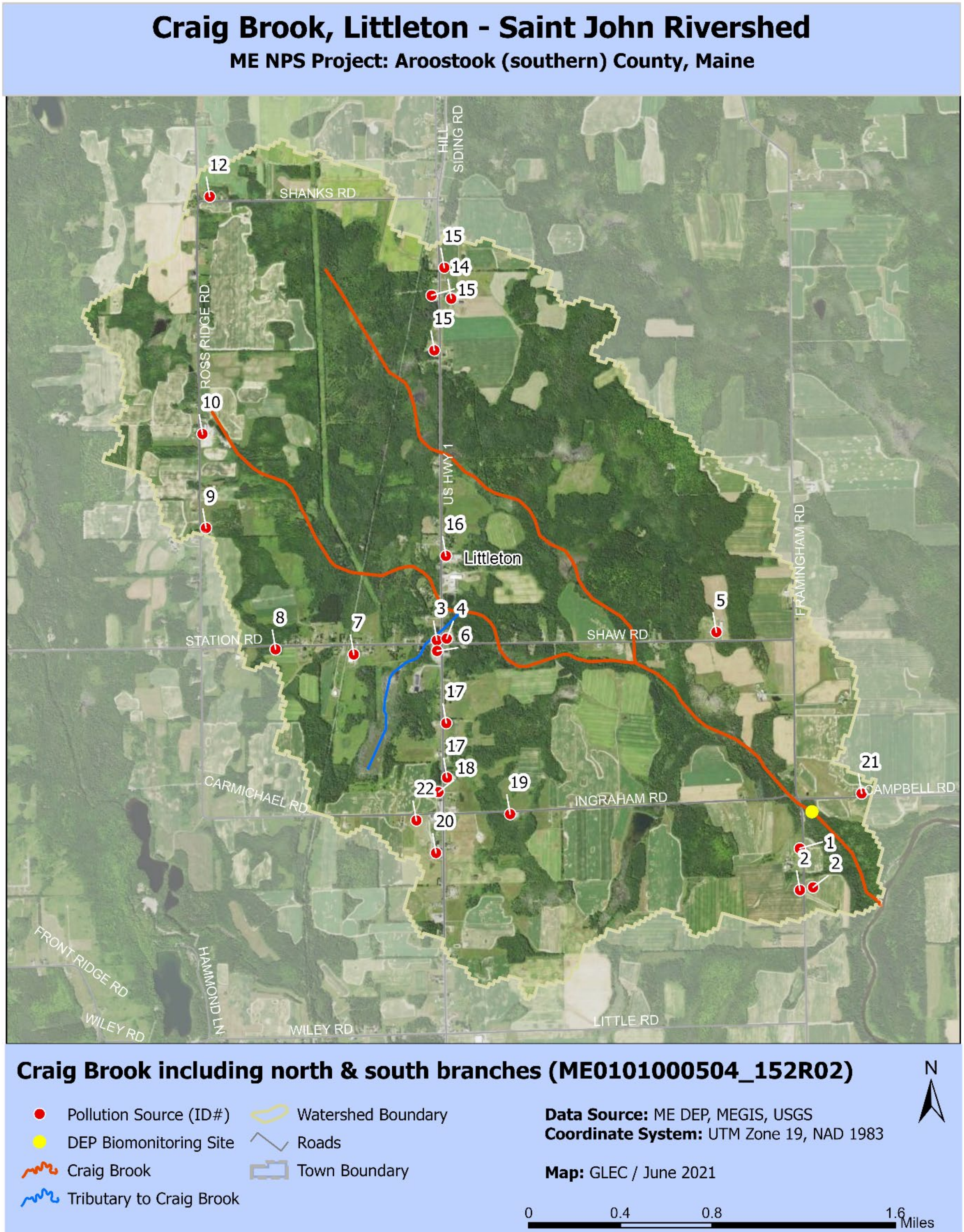


Figure 3: Aerial Photo of Potential Source Locations (identified in 2021) in the Craig Brook Watershed

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 2021 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).

Table 3: Livestock Count in the Craig Brook Watershed

Type	Craig Brook
Dairy Cows	0
Beef Cows	70
Broilers	20
Layers	3
Hogs/Swine	0
Sheep	0
Horses	18
Turkeys	0
Other	--
Total	**111**

The May 2021 field survey, for the most part, supports the livestock totals estimated through NASS as shown in Table 3. However, a local agricultural advisor (described in BMPs below) stated that 70 beef cattle exist from two operations in the watershed so Table 3 and the model inputs were updated. The same advisor also stated both operations have agricultural waste management systems, and that all livestock have access to pasture land in the watershed. All of this information was used in the current modeling effort.

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

Craig Brook
• Agricultural Land Stream Length = 1.19 mi (6,280 ft)
• Agricultural Land Stream Length *with Buffer* = (0.344 mi) 1,818 ft (or 28.9% of total agricultural land stream length)
• Percentage of total stream length flowing through non-buffered agricultural land = 11.7%

Craig Brook is a 7.2 mile-long impaired segment. The total stream miles (including tributaries) modeled within the watershed is also 7.2 miles (i.e., no other tributaries were considered). Of this total, 1.19 stream miles (6,280 ft) are located within agricultural areas and 0.34 miles (1,818 ft) of that area showed a 98 foot or greater vegetated buffer (Table 4, Figure 4). From a watershed perspective, this equates to 0.85 miles or 11.7% 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 below. 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. Information on BMP use was based on an interview with a local agricultural advisor in May 2021 who provided estimates for cover crops, conservation tillage, and strip cropping. Information on BMP use for the attainment watersheds was based on interviews from two sources (both made in February 2021). Estimates for attainment watersheds were based on typical New England watersheds and derived from information available from Vermont. An upper limit of BMP use in attainment watersheds 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, from the local interview source, at 80%. For the five attainment watersheds, an estimate of 25% was used and selected as the low end of the range (25 to 30 percent) expected for cropland in New England.
- *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, from the local interview source, to occur in 40% of cropland. A value of 25% was assigned to the five attainment watersheds as suggested by the other (non-local) two interview sources named above.
- *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. The local interview source suggested this practice does not exist in Craig Brook watershed. Hence, no BMP of this type was used in this modeling effort. This estimate was also assigned to the five attainment watersheds as suggested by the other (non-local) two interview sources named above.
- *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. The local agricultural advisor did not suggest this practice exists, though livestock do graze freely on pasture land in the Craig Brook watershed. The other (non-local) interview sources were not aware of this practice being active in New England watersheds. No BMP of this type was used in this modeling effort for both impaired and attaining watersheds.

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 Craig Brook watershed is 34.1% wetland and open water (less than 1% is open water). Multiple wetlands surround most of Craig Brook throughout the watershed, but most notably in the north and south branches (Figure 1). It is estimated that 68% 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

Selected results from the watershed loading model are presented here. 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 Craig Brook indicate a significant reduction of phosphorus and a moderate reduction in sediment 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. Sources are determined by land use/cover and the overland flow they generate, livestock counts by animal type, and home sewage treatment systems in developed areas. Pathways represent additional loads derived from subsurface flow and streambank erosion. Subsurface loads are calculated using dissolved N and P coefficients for shallow groundwater and are mainly derived from atmospheric inputs. Sediment and nutrient loads produced by eroding streambanks are estimated using an approach developed by Evans et al. (2003). This pathway is comprised of loads originating from five sources, and listed in order of decreasing importance: amount of developed land area, soil erodibility (K-factor), density of livestock, runoff curve number, and topographic slope. For any given model run, the amount of developed land in the watershed is responsible for just over 72% of the total streambank load, whereas soil erodibility and animal density are responsible for 21% and 7% of the total streambank load, respectively.

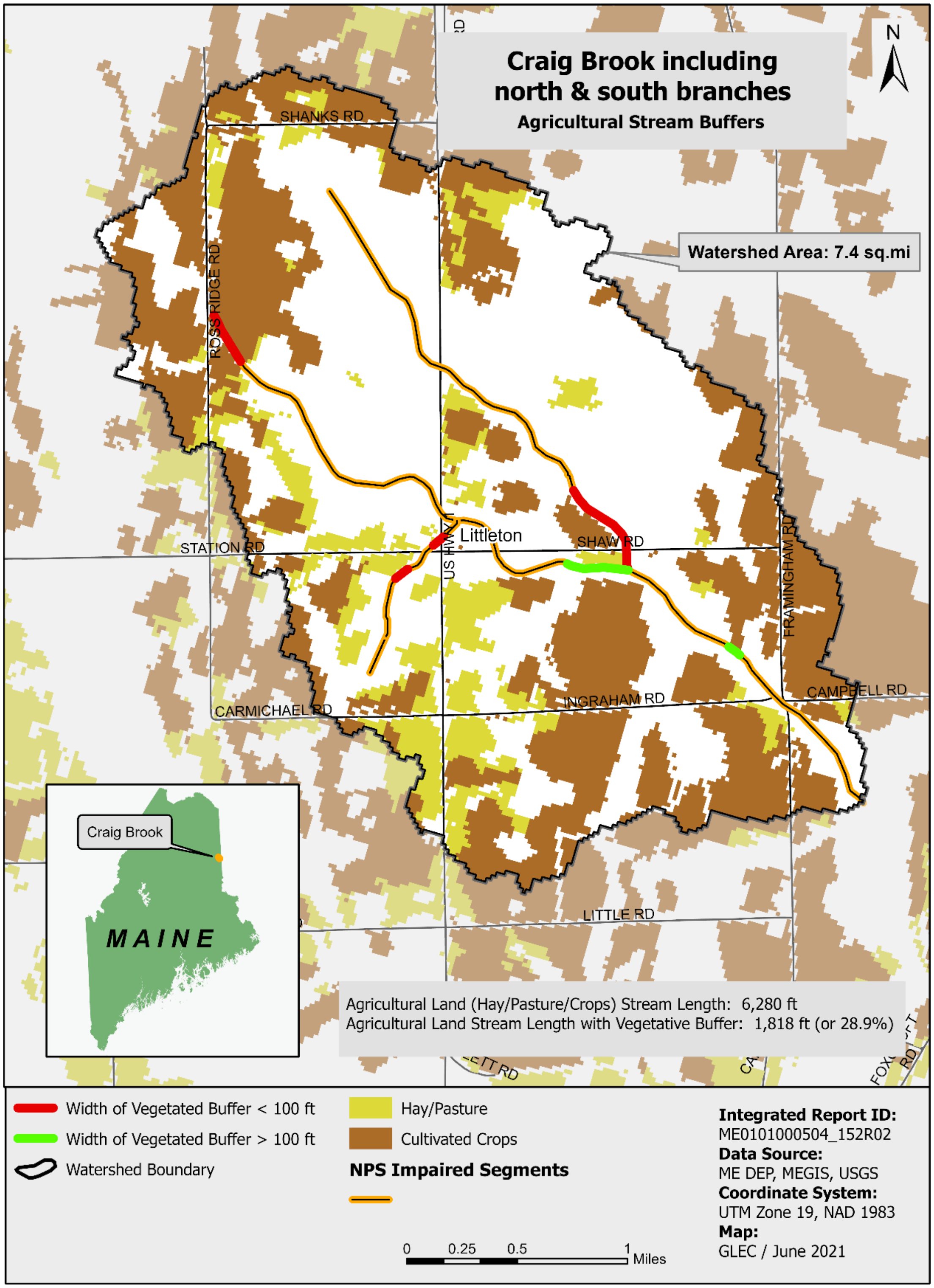


Figure 4: Agricultural Stream Buffers (from 2021) in the Craig Brook Watershed

Sediment

Sediment loading in the Craig Brook watershed is predominantly derived from agricultural land which makes up almost 98% of the total sediment load from sources (Table 5 and Figure 5). Developed land contributes less than 2% of the total source load. Of the entire watershed sediment load, stream bank erosion contributes 17%.

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

Table 5: Total Sediment Load by Source

Craig Brook	Sediment (1000 kg/year)	Sediment (%)
Source Load		
Hay/Pasture	4.1	2.7%
Cropland	145.4	95.0%
Wooded Areas	0.1	0.1%
Wetlands	0.2	0.2%
Open Land	0.1	0.1%
Barren Areas	0	0
Low-Density Mixed	0.9	0.6%
Medium-Density Mixed	0.9	0.6%
High-Density Mixed	0.2	0.1%
Low-Density Open Space	1.0	0.6%
Farm Animals	0	0
Septic Systems	0	0
Source Load Total:	**153.1**	**100%**
Pathway Load		
Stream Bank Erosion	31.4	-
Subsurface Flow	0	-
Total Watershed Mass Load:	**185**	

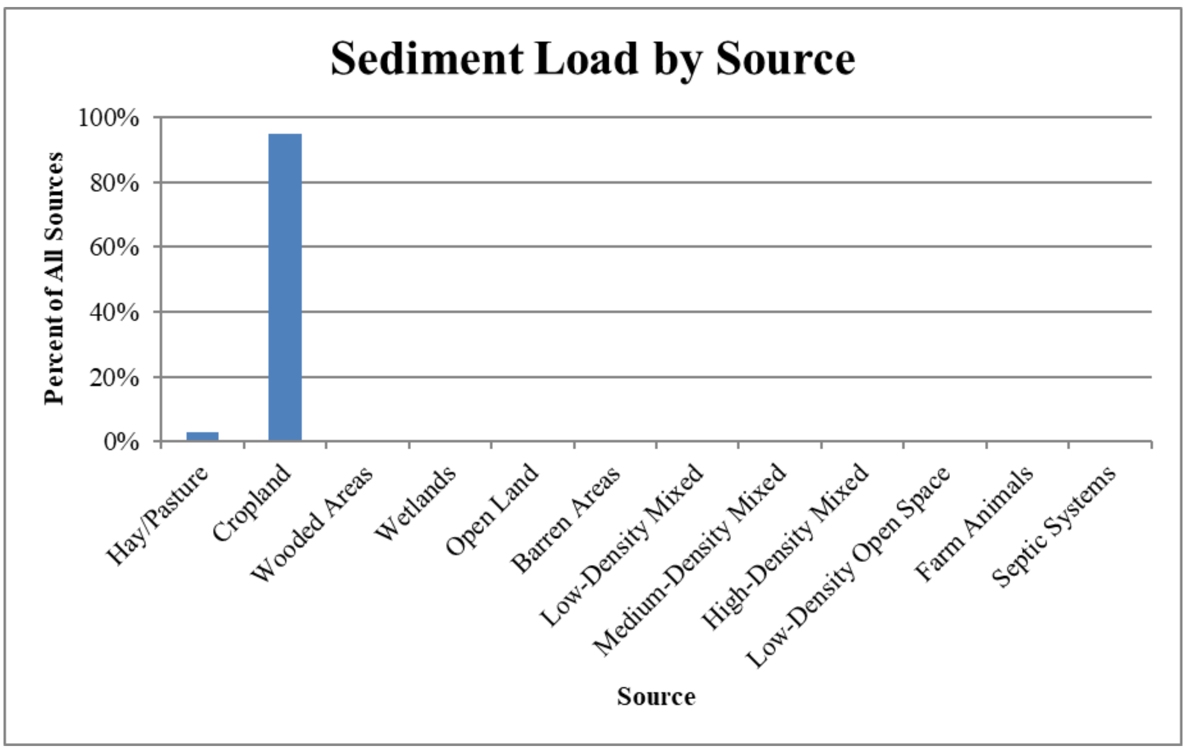


Figure 5: Total Sediment Load by Source in the Craig Brook Watershed

Total Nitrogen

Nitrogen loading is attributed primarily to cropland (59.3%) and farm animals (11.3%) (Table 6 and Figure 6). Combined agricultural sources account for over 77% of the total nitrogen load to Craig Brook. Note that from natural sources, wetlands contribute 14% of the total source load because of their extensive area in Craig Brook watershed.

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

Table 6: Total Nitrogen Load by Source

Craig Brook	Total N (kg/year)	Total N (%)
Source Load		
Hay/Pasture	201	6.7%
Cropland	1,791	59.3%
Wooded Areas	65	2.1%
Wetlands	422	14.0%
Open Land	18	0.6%
Barren Areas	0	0
Low-Density Mixed	51	1.7%
Medium-Density Mixed	40	1.3%
High-Density Mixed	9	0.3%
Low-Density Open Space	53	1.8%
Farm Animals	340	11.3%
Septic Systems	30	1.0%
Source Load Total:	**3,019**	**100%**
Pathway Load		
Stream Bank Erosion	9	-
Subsurface Flow	1,555	-
Total Watershed Mass Load:	**4,583**	

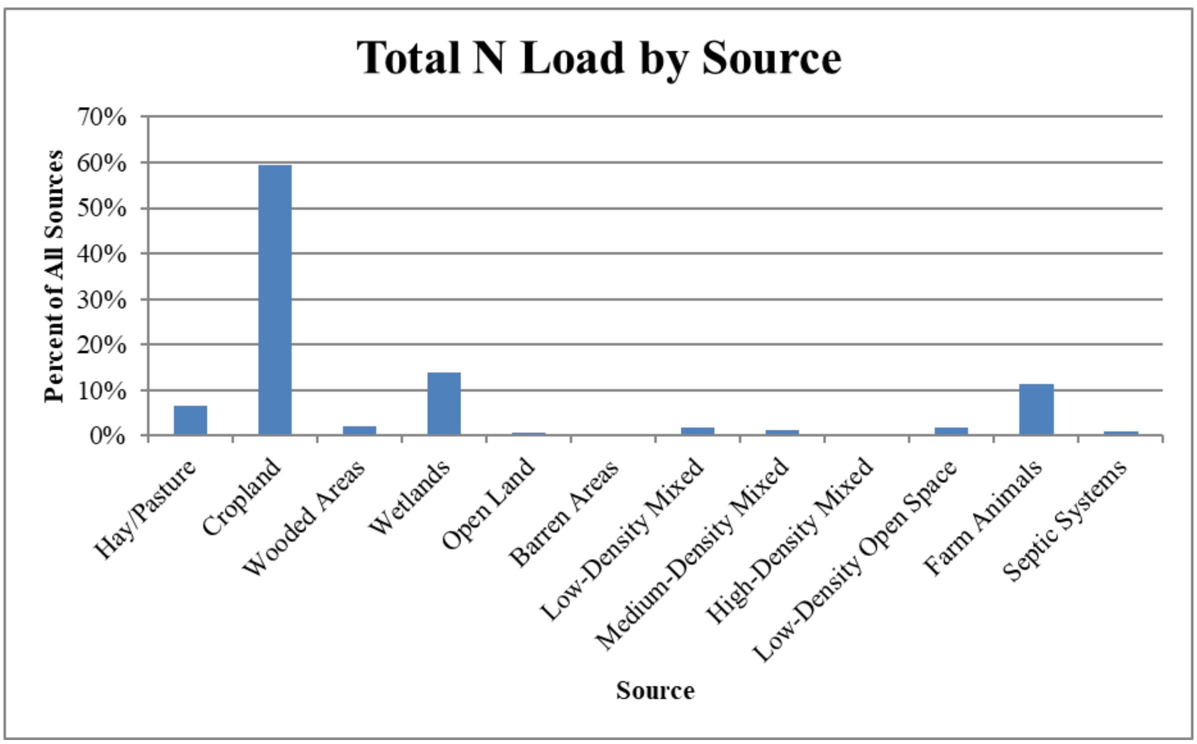


Figure 6: Total Nitrogen Load by Source in the Craig Brook Watershed

Total Phosphorus

Phosphorus loading within the watershed is attributed primarily to cropland (72.9%), hay/pasture land, and farm animals with combined agricultural sources accounting for 95% of the total phosphorus load. Developed land only accounts for just under 2% of the source load. Wetlands and wooded areas account for 3% of the total source load. Phosphorus loads are presented in Table 7 and Figure 7.

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

Table 7: Total Phosphorus Load by Source

Craig Brook	Total P (kg/year)	Total P (%)
Source Load		
Hay/Pasture	110.5	14.6%
Cropland	550.0	72.9%
Wooded Areas	3.3	0.4%
Wetlands	20.0	2.6%
Open Land	0.6	0.1%
Barren Areas	0	0
Low-Density Mixed	4.8	0.6%
Medium-Density Mixed	3.6	0.5%
High-Density Mixed	0.8	0.1%
Low-Density Open Space	5.0	0.7%
Farm Animals	56.3	7.5%
Septic Systems	0	0
Source Load Total:	**754.9**	**100%**
Pathway Load		
Stream Bank Erosion	21.0	-
Subsurface Flow	55.9	-
Total Watershed Mass Load:	**832**	

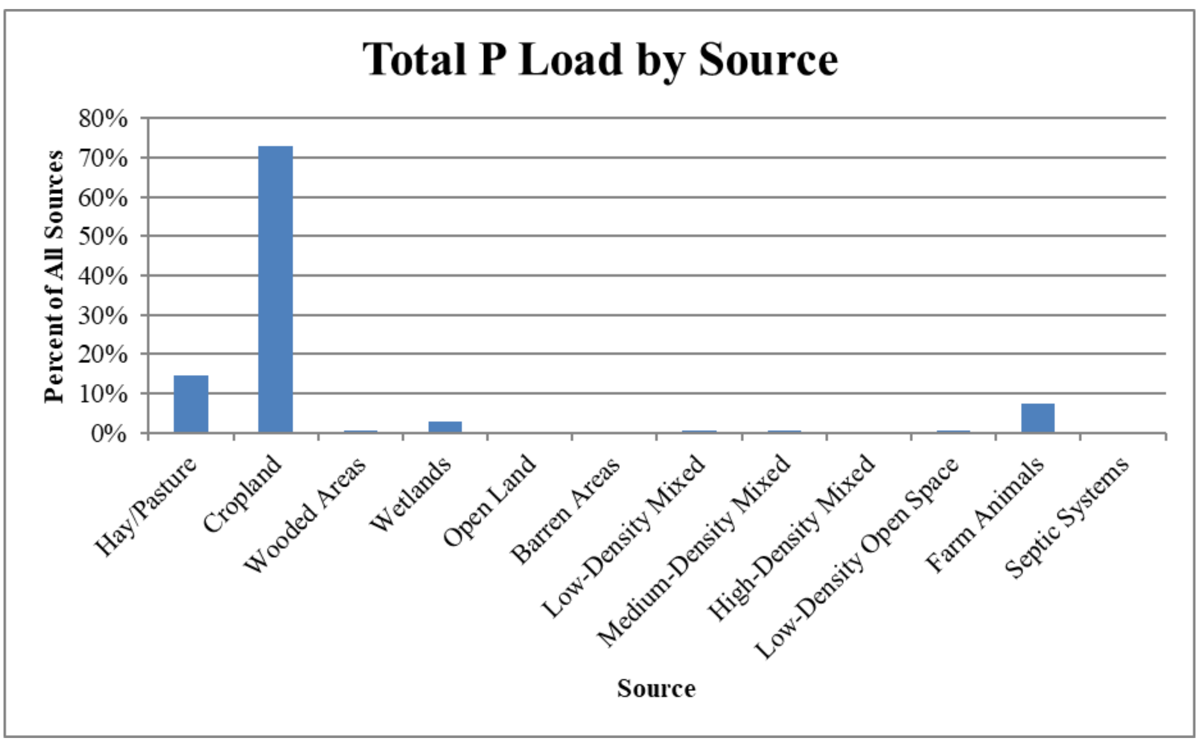


Figure 7: Total Phosphorus Load by Source in the Craig Brook Watershed

TMDL: TARGET NUTRIENT AND SEDIMENT LEVELS FOR CRAIG BROOK

The existing loads for nutrients and sediments in the impaired segment of Craig Brook are listed in Table 8, along with the TMDL (the allowable load) which was calculated from the average loading estimates of five attainment watersheds throughout the state. Table 8 also shows required reductions (as a percent) for each of sediment, total N, and total P pollutants. Table 9 presents a more detailed view of the modeling results and calculations used to compute the existing loads in Table 8. An annual time frame provides a mechanism to address the daily and seasonal variability associated with nonpoint source loads.

Table 8: Craig Brook Pollutant Loading Compared to TMDL Targets

Craig Brook			
Pollutant Load	**Existing Load**	**TMDL**	**Reduction Required**
Total Annual Load per Unit Area		Attainment Streams	
Sediment (kg/ha/yr)	96.2	65.72	31.7%
Total N (kg/ha/yr)	2.39	2.46	None
Total P (kg/ha/yr)	0.43	0.16	63.2%

Future Loading

The prescribed reduction in pollutants discussed in this TMDL reflects reduction from estimated existing conditions. With farmable land area at a premium and under high demand it is very likely that any tillable acreage in Craig Brook watershed is already in production. Between 2012 to 2017 in Aroostook County, the number of farms decreased by 14.4% and the number of acres decreased by 9.6% (USDA 2017). However, the average farm size increased by 5.6% in this time period. The County has seen a consolidation of farmland under fewer landowners with farms becoming larger. Human population in Aroostook County decreased by 6.48% from 2000 to 2019 (US Census 2020). To meet TMDL targets, current and future farm management practices will need to employ a combination of conservation practices.

Next Steps

The use of agricultural and developed land best management practices (BMP's) can reduce sources of polluted runoff in Craig Brook. It is recommended that municipal officials in Littleton and southern Aroostook county, landowners, and conservation stakeholders work together to:

- Implement the Meduxnekeag 2015 Watershed Management Plan.
- 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 Craig Brook watershed; then focus BMP mitigation in these hot-spot sub-areas of the watershed.
- Southern Aroostook Soil & Water Conservation District and USDA's Natural Resource Conservation Service work with agricultural landowners to implement BMPs through EQIP and CWA 319 grants program.
- Address existing nonpoint source problems in the Craig Brook watershed by implementing (e.g. increased crop rotations) or installing (e.g. grassed waterways) BMPs where necessary.

Table 9: Annual Loads by Land Use, Other Sources, and Pathways for Craig Brook Based on Modeling

Craig Brook				
	Area (ha)	**Sediment** (1000 kg/yr)	**Total N** (kg/yr)	**Total P** (kg/yr)
Land Uses				
Hay/Pasture	189	4.1	201	110.5
Cropland	657	145.4	1,791	550.0
Wooded Areas	310	0.1	65	3.3
Wetlands	649	0.2	422	20.0
Open Land	13	0.1	18	0.6
Barren Areas	6	0.000	0	0.0
Low-Density Mixed	40	0.9	51	4.8
Medium-Density Mixed	9	0.9	40	3.6
High-Density Mixed	2	0.2	9	0.8
Low-Density Open Space	42	1.0	53	5.0
Total Area	1,918			
Other Sources				
Farm Animals		0.0	340	56.3
Septic Systems		0.0	30	0.0
Pathway Load				
Stream Bank Erosion		31.4	9	21.0
Subsurface Flow		0.0	1,555	55.9
Total Annual Load		185	4,583	832
Total Annual Load per Unit Area		0.096	2.39	0.43
		1000 kg/ha/yr	kg/ha/yr	kg/ha/yr

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