Total Maximum Daily Load (TMDL) Report

Prestile Stream (& Christina Reservoir) Aroostook County, Maine

Prepared for:

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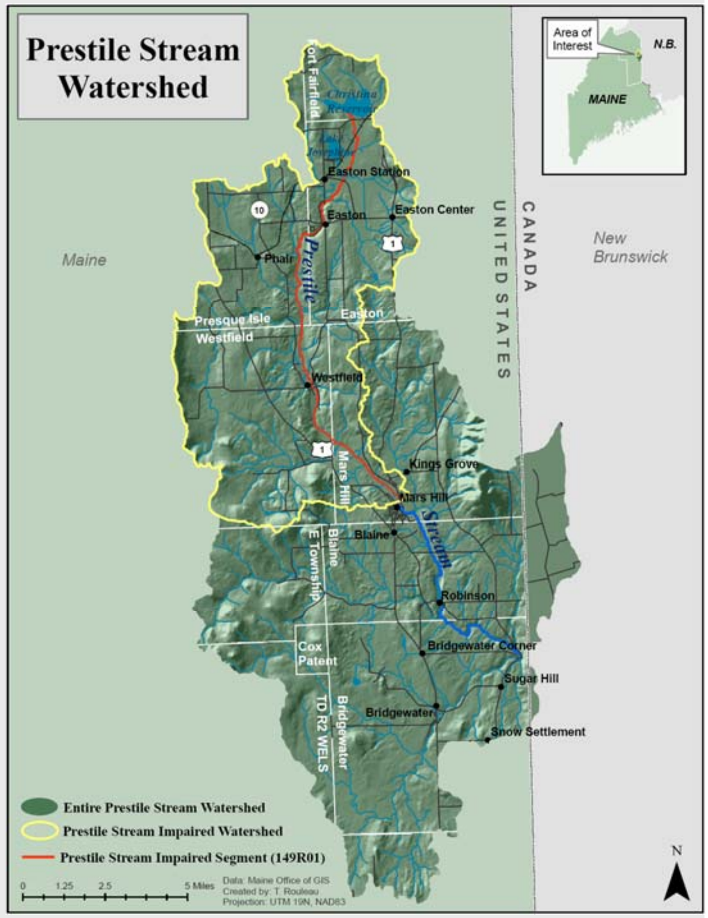
Description of the Watershed

Prestile Stream originates at the outlet of Christina Reservoir, a 309-acre (125 ha) manmade impoundment (Midas # 9525) located in the Town of Fort Fairfield in Aroostook County, Maine. The stream flows out of Christina Reservoir, and then south through the small Town of Easton, the City of Presque Isle, and the Town of Westfield, and then southeasterly through the Town of Mars Hill to the Maine-New Brunswick border near Bridgewater. It joins the main stem of the St. John River approximately 14 miles from the U.S. border, and 22.3 miles from its headwaters at Christina Reservoir (Figure 1). The Prestile Stream watershed contains fourteen small ponds (Christina Reservoir being the largest) and 150 miles of tributaries, as well as 5 impoundments. The impaired segment of Prestile Stream is a 15.8-mile stretch of Class A water from the Christina Reservoir Dam in Fort Fairfield to the Mars Hill Dam in Mars Hill (right).



Land use in the watershed is a mix of forested areas and agriculture with sparse residential development along the major roadways. The area is defined by gently rolling hills and lowlands with elevations around 700-800 feet, much of which has been cleared for agriculture. Potatoes are the most prominent crop in the region. Farmers also produce grains, broccoli, soybeans, canola and hay.

Why do a 'TMDL' on Prestile Stream and Christina Reservoir?

Prestile Stream and Christina Reservoir are impaired by nonpoint source (NPS) runoff as a result of both historical and present day pollutants from the many anthropogenic activities within the watershed. All land disturbances have the potential to contribute runoff, but the degree of disturbance associated with agricultural land is likely the greatest contributor of silt and nutrient enrichment to stream. Waters, such as Prestile Stream, that do not meet Maine's water quality standards are called impaired and placed on the 303(d) list. Prestile Stream violates Maine's standards for aquatic life and dissolved oxygen, while Christina Reservoir is listed as impaired for primary contact recreation as a result of high nutrient (phosphorus) levels and frequent algal blooms. The Clean Water Act requires that all 303(d) listed waters undergo a TMDL, or Total Maximum Daily Load assessment that describes the impairments and identifies the measures needed to restore water quality. The goal is for all waterbodies to comply with the State's water quality standards.

Sampling Results & Pollutant Sources

The Prestile Stream TMDL is based on sampling data collected between 1999 and 2006, which includes monitoring of the macroinvertebrate community and water chemistry. Sampling results were compared to Maine's statutory Class A water quality standards and the stream was listed due to non-attainment of aquatic life criteria. Macroinvertebrate populations indicate a combination of intricate environmental factors. Maine's 2008 303(d) report lists a "eutrophic lake source" (Christina Reservoir) and agricultural NPS as factors leading to the poor water quality of Prestile Stream. Aquatic life impairment is probably due to sedimentation and runoff containing a variety of pollutants associated with agricultural stormwater runoff. Agricultural land encompasses the largest land area in both the Prestile Stream and Christina Reservoir watersheds, making it potentially the greatest contributor of silt and nutrient enrichment to the stream. The close proximity of these land uses to the stream increases the likelihood that the disturbed and bare soil will reach the stream.

A Generalized Watershed Loading Function Model (GWLF) was used to simulate the nonpoint source loading of the pollutants of concern, i.e. nitrogen, phosphorus and sediment. Maine does not have numeric water quality standards for nutrients or sediment so numeric endpoints were developed by comparing Prestile Stream to unimpaired (attainment) watersheds with similar land use characteristics. To further characterize loading to Prestile Stream, the watershed was divided into nine subwatersheds to help characterize which upstream waterbodies (including Christina Reservoir) the pollution is stemming from, and help target specific areas of the watershed for improvement. It is assumed that the GWLF model results will provide reasonable targets to achieve attainment in Prestile Stream and Christina Reservoir.

Required TMDL Elements and GWLF Modeling Results

The GWLF model results indicate significant reductions of nutrients and sediments are needed to improve the water quality of Prestile Stream and Christina Reservoir. Cropland is by far the largest estimated source of sediment and nutrients to Prestile Stream and its tributaries, accounting for a predicted 96% of the total sediment load within the Prestile Stream watershed, and 94% of sediment delivered to Christina Reservoir. Cropland is also estimated to be the dominant source of phosphorus in both Christina Reservoir and Prestile Stream, while nitrogen loading is attributed to both groundwater and cropland.

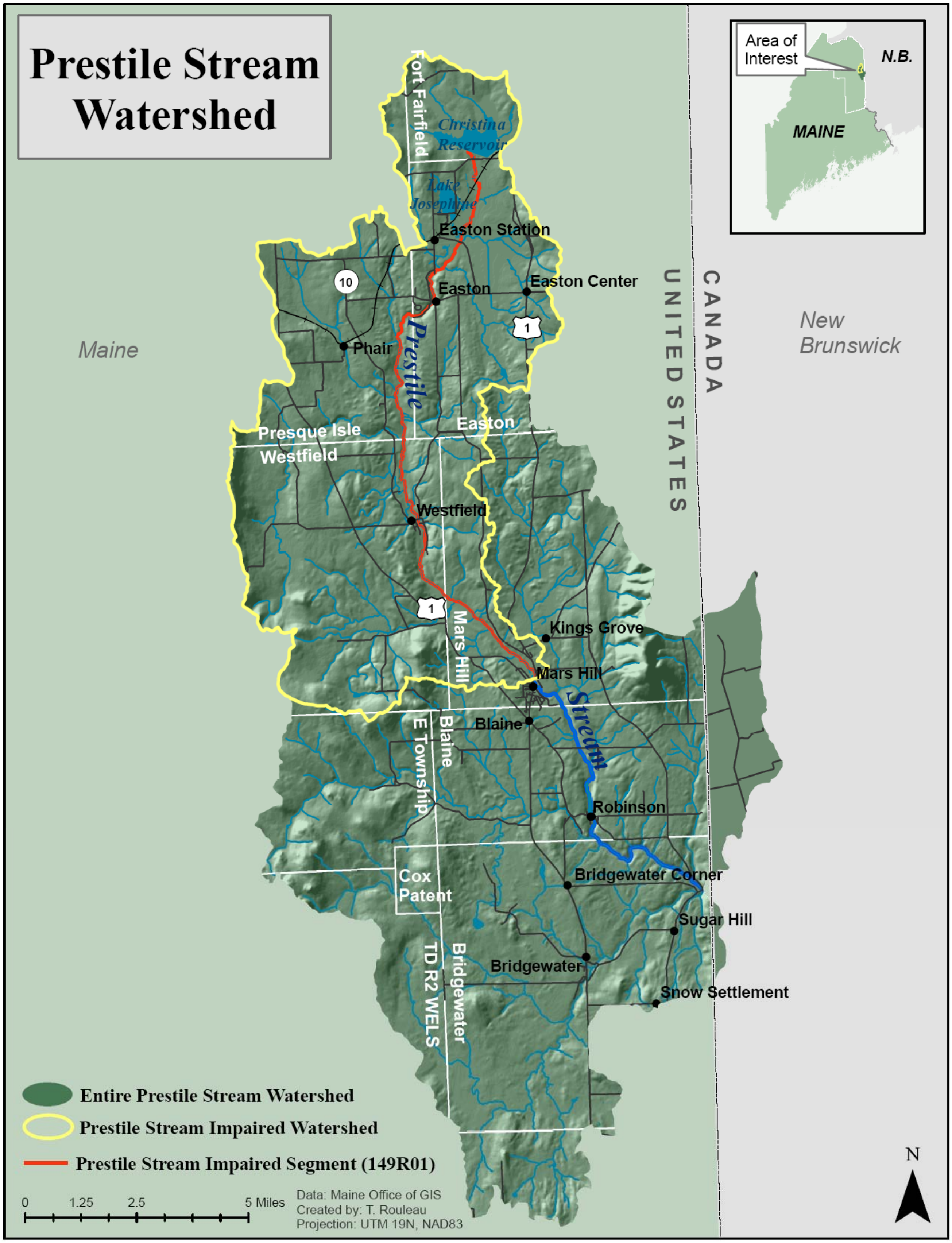
Estimated Reductions Needed by Pollutant Type for Prestile Stream and Christina Reservoir

TMDL POLLUTANT LOADS	TMDL% REDUCTIONS	
Annual Unit Area Loads	**Prestile Stream**	**Christina Reservoir***
Phosphorus Load (kg/ha/year)	50%	57%
Nitrogen Load (kg/ha/year)	51%	59%
Sediment Load (tons/ha/year)	69%	50%

** The TMDL for Christina Reservoir is set for Total Phosphorus only.*

The Prestile Stream and Christina Reservoir TMDL report contains elements required by the Clean Water Act. The ultimate goal of the TMDL process is to attain water quality standards, which includes attainment of both the macroinvertebrate and dissolved oxygen regime. The target goals above provide technical guidance to initiate a strategy for BMP implementation. Reversing long term degradation from anthropogenic activities in these watersheds will require careful planning and effort that should include local stewardship, instream restoration and attention to cumulative impacts. A comprehensive subwatershed approach should look to all potential nutrient and sediment sources with a major emphasis on implementing Best Management Practices on agricultural land.

Figure 1. Map of the Prestile Stream watershed showing Christina Reservoir at its headwaters and the impaired stream segment above the Mars Hill Dam.



1. DESCRIPTION OF WATERBODY, POLLUTANT OF CONCERN, POLLUTANT SOURCES AND PRIORITY RANKING

Description of Waterbody and Watershed

The Mars Hill Dam in Mars Hill, is one of five impoundments on Prestile Stream.

Prestile Stream originates at the outlet of Christina Reservoir, a 309-acre (125 ha) manmade impoundment located in the Town of Fort Fairfield in Aroostook County, Maine. The stream flows out of Christina Reservoir, south through the small Town of Easton, the City of Presque Isle, and the Town of Westfield, and then southeasterly through the Town of Mars Hill to the Maine-New Brunswick border near Bridgewater. It joins the main stem of the St. John River approximately 14 miles from the U.S. border, and 22.3 miles from its headwaters at Christina Reservoir (Figure 1). The entire stream drains approximately 208 square miles (133,000 acres), 35 of which are located in Canada. The Prestile watershed contains sixteen small lakes and ponds (including 5 impoundments), Christina Reservoir being the largest, and 150 miles of tributaries (Alverson 2005a, Basley and Lucas 1989). Land use in the watershed is a mix of forested areas and agriculture with sparse residential development along the major roadways. The area is defined by gently rolling hills and lowlands with elevations around 700-800 feet, much of which has been cleared for agriculture. Potatoes are the most prominent crop in the region, yet farmers also produce grains, broccoli, soybeans, canola, and hay (Alverson 2005a).

Prestile Stream (looking downstream) flows out of Christina Reservoir through a culvert.

From its headwater at Christina Reservoir to the U.S. border, Prestile Stream changes about 330 feet in elevation for an average gradient of 15 ft/mile (Basley and Lucas 1989). For the most part, the stream flows through a vegetated softwood corridor with intermittent sections of hardwoods (Basley and Lucas 1989). A habitat study conducted in 1989 by Basley and Lucas showed that streambanks along the Prestile were well-vegetated and stable. The dominant habitat type is pool/run (57%), and the dominant substrate type consists of gravel, or a combination of gravel/sand/rubble/boulder (83%). The underlying bedrock of the Prestile Stream watershed is unique regionally in that it consists of unmetamorphosed limestone, and limy shale, and interbedded limestone and pelite formations overlain by boulder till (Alverson 2005a, Basley and Lucas 1989).

Wildlife

Christina Reservoir, Lake Josephine, and the related wetlands in the Prestile Stream watershed are home to one of the most productive waterfowl areas in Maine. This area is the only known breeding location in the State for several waterfowl species (Ruddy Duck, Northern Pintail, Redhead and Northern Shoveler), and one of only a handful for others (Gadwall, American Wigeon). Thousands of ducks and geese are raised in these wetlands annually.

As an example of the exceptional diversity of this region, 144 different bird species have been documented in Christina Reservoir. Similarly, 138 species have been documented in Lake Jospehine since 1990 (see Appendix for full list). These include the endangered Peregrine Falcon and threatened Bald Eagle, which hunt these areas regularly, as they are attracted by the concentrations of waterfowl. Many shorebirds feed on the shores of these impoundments during migration.

The habitat characteristics of the area partially explain the abundance and diversity of waterfowl. There are hundreds of acres of well buffered wetlands in the upper Prestile watershed. However, it's the productivity that sets this area apart from others. Macroinvertebrate sampling by Maine DEP has shown that there are few other spots in Maine with a higher density of macro-invertebrates. These invertebrates are an important protein source for the growing waterfowl. The ease with which ducks can feed and raise their young is evidenced by the density of breeding waterfowl seen here. More than 540 ducklings of 9 species were counted on a single morning in Lake Josephine (Sheehan 2008). The ducks were feeding mostly on emergent and aquatic invertebrates.

Though this is nearly all private land, access is minimally restricted and can be used for recreation by waterfowl hunters as well as non-consumptive wildlife enthusiasts (birders, butterfly and dragonfly watchers and wildlife photographers). Recreational birders can access an on-line resource to find out more about bird watching at Lake Josephine and Christina Reservoir: http://www.mainebirdingtrail.com/Aroostook.htm.

Fisheries

Prestile Stream and its tributaries have long been recognized as a high quality brook trout fishery. Stocking of hatchery trout was conducted through the 1950's, but deemed unnecessary in the 1960's since natural reproduction of the wild brook trout population was enough to support the sport fishery (Basley and Lucas 1989).

Voluntary records kept by anglers show that the average size of brook trout is 8.5 inches in Prestile Stream and many of the tributaries that enter the stream .

Each of the impoundments on Prestile Stream downstream of Christina Reservoir act as a trap for nutrients and sediments, adding to the diminished water quality above Mars Hill. The Maine DIFW have documented both positive and negative effects of impoundments on the brook trout fishery in Prestile Stream. Electrofishing and gill net techniques were used to capture and count fish above and below the community impoundment in Easton between 1987 and 1990. Results showed higher numbers of trout and fewer suckers where the stream flowed naturally compared to low numbers of trout and high numbers of suckers caught in the impoundment (Basley 2008). On the positive side, the dam at Mars Hill is now an important barrier in restricting the movement of small mouth bass (not native to the drainage) further upstream, which could negatively affect the native trout population.

Watershed History

View of Christina Reservoir from its outlet, looking north-east toward the operational potato processing plant.

The Prestile Stream watershed has a history of agricultural and industrial activities that have negatively affected the water quality. Causes of impairment are a direct result of industrial waste discharge and water withdrawals. Beginning in the 1950's, discharge of industrial waste from starch factories in Westfield and Mars Hill depleted dissolved oxygen concentrations causing fish kills. A potato processing plant that discharged waste to Prestile Stream in Easton caused numerous fish kills between 1962-68. Prompted by the construction and operation of a sugar beet refinery, the State Legislature downgraded the stream classification from Class B to Class D in 1965 causing further declines in water quality (Basley and Lucas 1989). While the two starch factories and the beet factory were no longer operative by the early 1970's, the potato processing plant continues to operate to this day. In 1969, Prestile Stream was listed as Class C (Davies 2008).

In addition to direct discharge of industrial pollutants, the stream also received inputs of DDT, an insecticide used to ward off insect pests on agricultural and forestland following World War II. DDT and its residues washed into nearby waterways, where aquatic plants and fish absorbed it. It wasn't until 1972 that DDT was finally banned for its toxic effects to birds, fish and other species. Even today, the Prestile Stream has a fish consumption advisory of one fish meal/month as a result of DDT, which remains persistent in the watershed decades after being applied.

The outlet structure on the south end of Christina Reservoir allows constant overflow to Prestile Stream.

In the wake of the industrial development in the watershed, several impoundments, such as the Lake Christina Dam, were created to store and treat industrial wastes, and to provide supply water for operation of the processing plants. Secondarily, impounding the stream also provided the community with ponds for recreating, and fire protection. The Lake Christina Dam was built in 1966 to provide supply water to the potato processing plant. The outlet on the south end of the reservoir allows constant overflow to Prestile Stream at normal capacity (Basley and Lucas 1989).

An industrial waste pond known as Lake Josephine was created to store wastewater from the potato processing plant. For decades, one million cubic meters per year of wastewater was pumped to Lake Josephine and spray-irrigated onto approximately 680 acres of fields in and around Christina Reservoir and Lake Josephine (Whitford 2000). Due to concerns about nutrient enrichment of Prestile Stream as a result of spray-irrigation of effluent in the watershed of Christina Reservoir, the owners of the potato processing plant hired a consultant to conduct a detailed analysis of its effects on the water quality of Christina Reservoir, and the Prestile Stream. Results of this study showed that two of the four tributaries feeding Christina Reservoir were highly eutrophic and that soils were so saturated with nutrients (both phosphorus and nitrogen) that they could no longer filter waste discharge. The study also determined that the water quality of Prestile Stream mirrors that of Christina Reservoir, and that cessation of waste water irrigation in the Christina Reservoir watershed would improve water quality in the headwater reach of Prestile Stream (Whitford 2000).

Since 2000, wastewater from the potato processing plant is no longer spray-irrigated in the Christina Reservoir watershed, but treated and permitted for discharge in the Aroostook River (MEDEP 2008). Similarly, Lake Josephine no longer receives wastewater from the processing plant, but does receive some stormwater from the factory, and is utilized for minimum water withdrawals for area agricultural fields (MEDEP 2008). Field reconnaissance by Maine DEP staff concluded that Lake Josephine does not flow directly to Prestile Stream. However, 654 acres are currently licensed for land application of potato processing sludge, in both the Christina Reservoir watershed and the Lake Josephine watershed, with an additional 57 acres designated for sanitary sludge generated by the Easton potato processing plant (Duncan, personal communication).

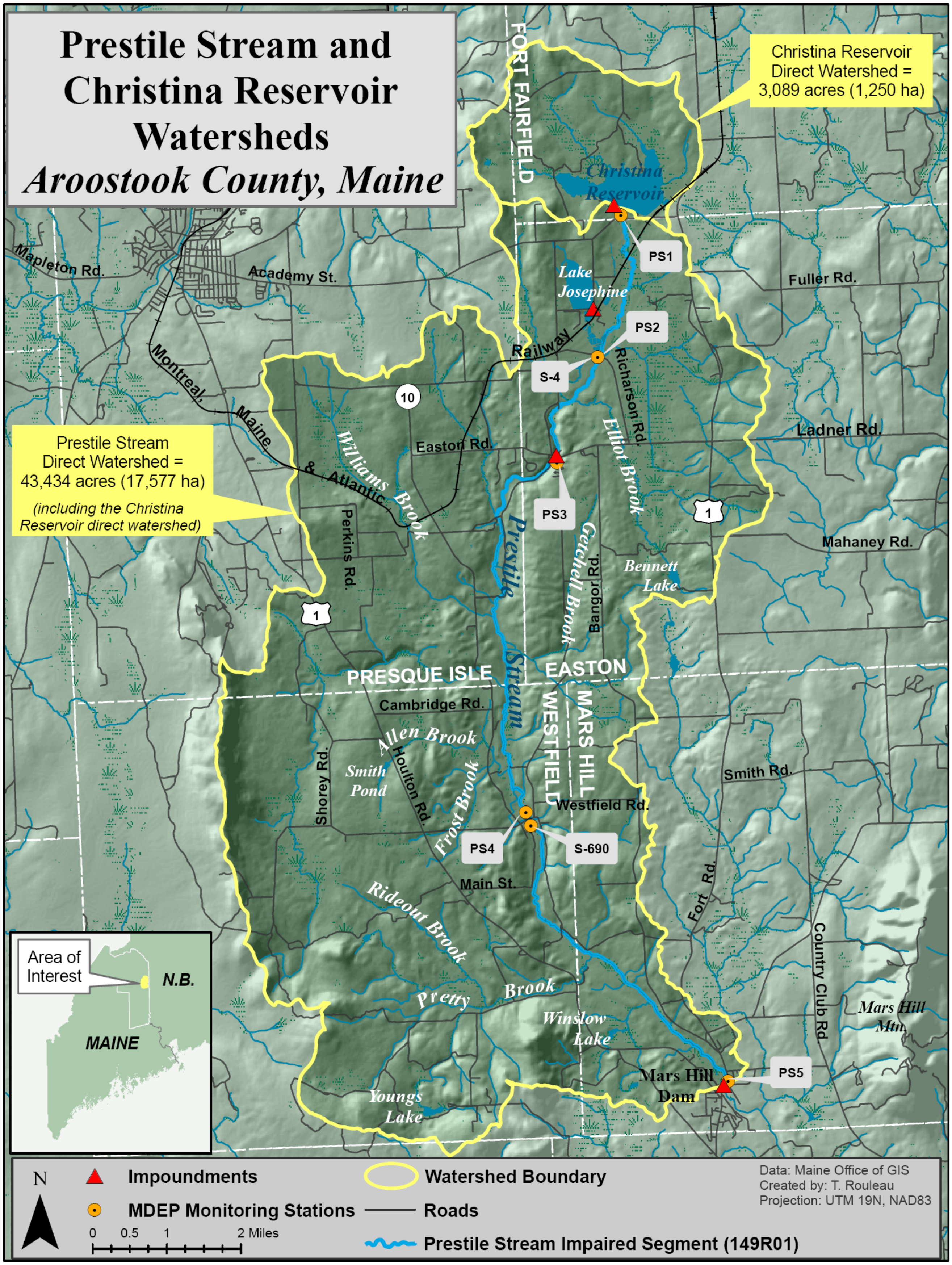
Despite changes to the irrigation of treated process water, both Christina Reservoir and Prestile Stream were subject to numerous unlicensed discharges as a result of leaky irrigation pipelines that spilled thousands of gallons/day of potato processing wastewater into Christina Reservoir, its tributaries, Prestile Stream, and area wetlands between 2000 and 2002 (Sheehan 2008). A single leak from Lake Josephine was estimated to discharge 6 million gallons of wastewater to the wetlands near the upper Prestile in one night. Since then, major changes have been made to remedy the problem, and treated process wastewater continues to be piped to the Aroostook River.

Land uses in the Prestile Stream watershed also contribute harmful nutrients to Prestile Stream in the form of nonpoint source pollution caused by soil erosion from agriculture and forestry practices, and recreational activities such as ATV trails. Other potential inputs stem from poorly maintained septic systems, waterfowl, and from the highly eutrophic Christina Reservoir which has acted as a nutrient sink for decades.

Sediment inputs from current land uses such as agriculture and forestry, can turn the water in the stream brown during storm events, and contribute harmful nutrients that affect water quality.

Photo: L. Alverson

Figure 2. Impaired watershed map, impoundments and Maine DEP sampling locations.



Impaired Waterbodies & Study Area

The Prestile Stream was listed as Class C in 1969, and was upgraded to Class A during the 1993-94 legislative session, and is considered Class "A" riverine water from the headwaters to Route 1A in Mars Hill, and Class B from Route 1A in Mars Hill to the U.S./Canadian border. Both Christina Reservoir and Prestile Stream are 303 (d) listed waterbodies.

<u>*Prestile Stream:*</u>

The impaired segment of *Prestile Stream* is a 15.8-mile stretch of Class A water from the Christina Reservoir Dam in Fort Fairfield to the Mars Hill Dam in Mars Hill. Violations to aquatic life criteria in Prestile Stream were documented most recently in 1999 and 2004. Dissolved oxygen violations were documented over a five-year period from 2002-2006. The 2008 303(d) indicates a "eutrophic lake source" (Christina Reservoir) as one of the factors leading to the poor water quality of the Prestile Stream (Table 1).

Table 1. The status of impairment for Prestile Stream and the TMDL development priority as documented in the

ADB ASSESSMENT UNIT ID	SEGMENT NAME	CAUSE	SEGMENT SIZE	SEGMENT CLASS	TMDL PRIORITY	COMMENTS
ME0101000501 _149R01	Prestile Stream above dam in Mars Hill	Benthic Macroinvertebrate Bioassessments (Streams)	15.78	Class A	2008	Eutrophic lake source: Agricultural NPS; non-attainment biocriteria
ME0101000501 _149R01	Prestile Stream above dam in Mars Hill	Nutrient/Eutrophication Biological Indicators	15.78	Class A	2008	
ME0101000501 _149R01	Prestile Stream above dam in Mars Hill	Dissolved Oxygen	15.78	Class A	2008	
ME0101000501 _149R01	Prestile Stream above dam in	DDT	15.78	Class A	2020	5D-legacy DDT sources

2008 303(d) List.

<u>*Christina Reservoir:*</u>

Christina Reservoir is a 309-acre (125 ha) impoundment (Midas # 9525) that flows into Prestile Stream near the Fort Fairfield/Easton border (Figure 2). The Reservoir is listed on the State's 303(d) list as impaired for primary contact recreation as a result of high nutrient loads and frequent algal blooms. Sampling data collected between 2000 and 2004 point to high concentrations of total phosphorus as a driving factor.

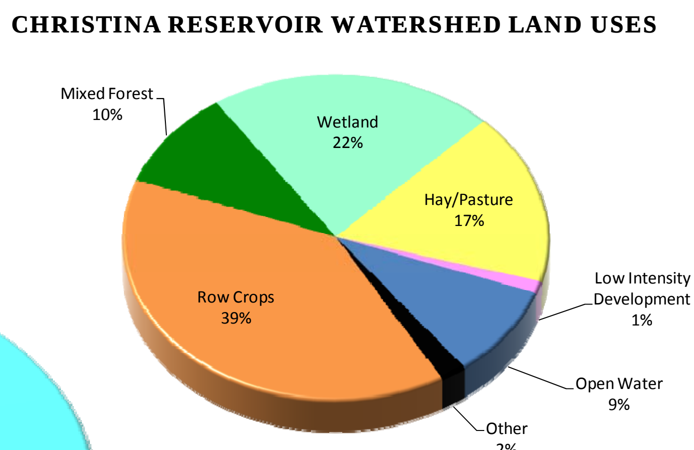
Christina Reservoir is a unique for its physical and chemical characteristics, and for its long history of recieving pollutants. While there is only one main outlet dam, Christina Reservoir was formed by damming three cold headwater tributary streams. The underlying substrate, fertile topsoil and productive water chemistry contributes to the nutrient rich environment of this shallow impoundment (a former wetland, stream and forested wetland), even without nonpoint source problems adding to it (Basley 2008). The concentrations of nutrients in the area soils, and in the sediments in the impoundment have been compounded by numerous instances of unlicensed discharges of potato processing wastewater into the tributaries of Christina, including direct irrigation into surrounding wetlands, and the reservoir itself (Sheehan 2008). The nutrient rich water has resulted in an abundance of invertebrate productivity which has a secondary effect in attracting numerous waterfowl to the area. These birds disturb sediments in the impoundment and create enough waste to be considered a net import of nutrients into the reservoir on the magnitude of pounds/day (Sheehan 2008).

Descriptive Land Use Information

Potatoes (shown here) and other row crops account for 40% of the land area in the Prestile Stream watershed . Photo: L. Alverson

Analysis using the 2004 land cover data from MDEP (MELCD) shows that land uses in the *Prestile Stream* watershed are dominated by agricultural land (46%) and forest land (Figure 4). Larger areas of mixed forest are located in the southern portion of the watershed near Pretty and Clark Brooks, and Young Lake. Including the land area of Christina Reservoir watershed, land uses in the Prestile Stream watershed include row crops (40%), mixed forest (35%), wetland (14%), and hay/pasture (6%).

The remaining 5% of the Prestile Stream watershed is comprised of low intensity development (a mixture of constructed materials and vegetation including small buildings such as single family housing units, farm out-buildings, large sheds, and streets and roads) (3%), open water (1%) and non-vegetated/disturbed land (1%) (Figure 3).



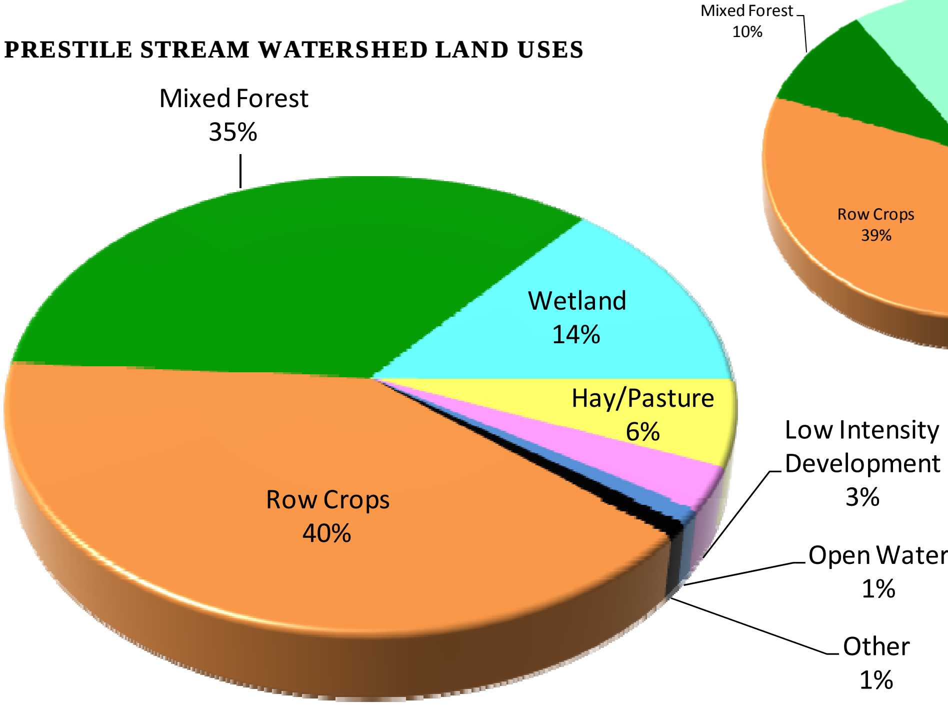
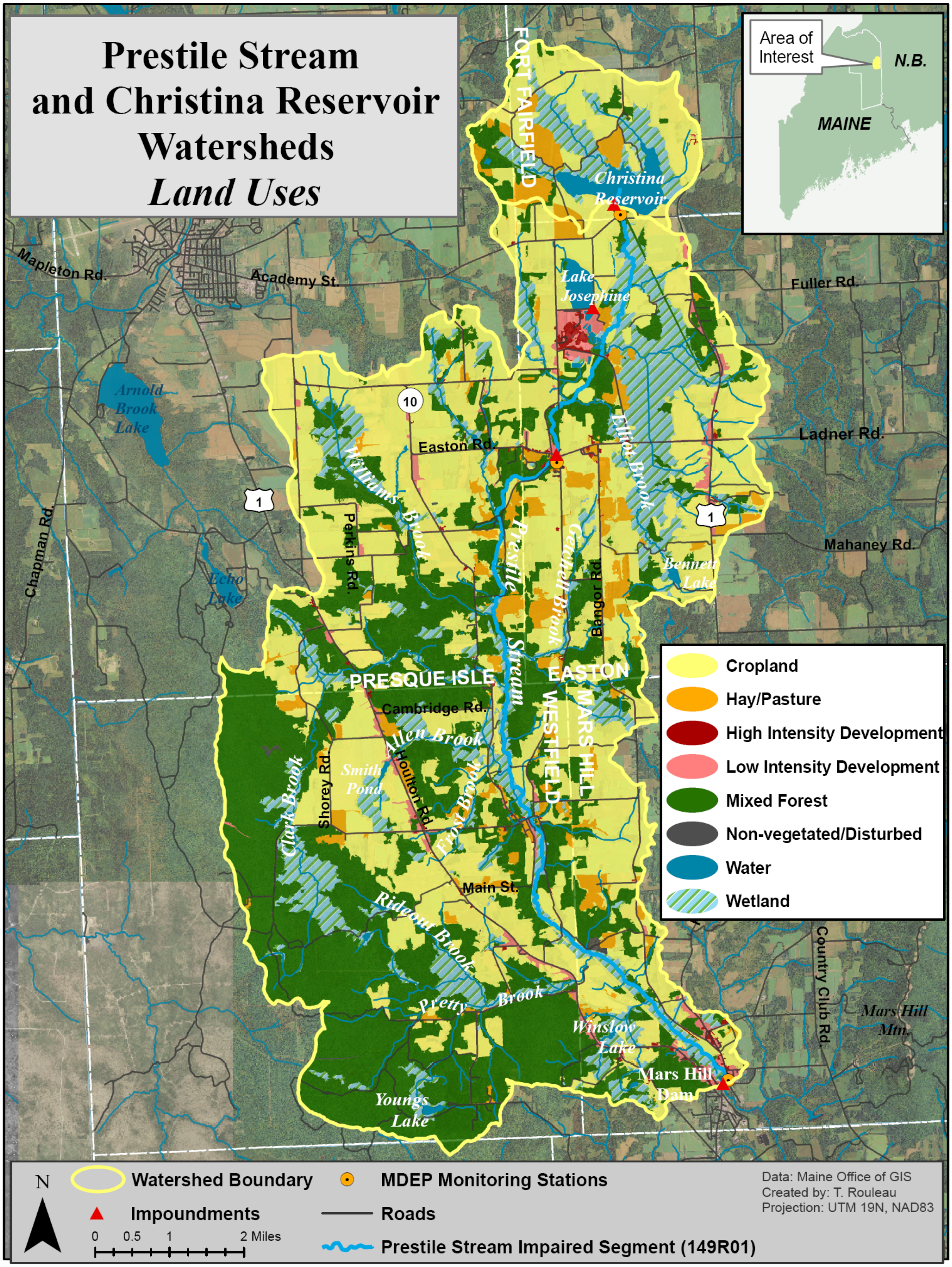


Figure 3. Land uses in the Prestile Stream and Christina Reservoir Watersheds.

Figure 4. Prestile Stream and Christina Reservoir land use map.



The *Christina Reservoir* watershed encompasses just 8% of the total land area of the Prestile Stream impaired watershed. Land uses in the Christina Reservoir watershed are dominated by agricultural land (56%) including row crops (39%) and hay/pasture (17%). Large wetland areas (22%) and patches of mixed forest (10%), surround tributaries flowing into the Reservoir. Christina Reservoir itself encompasses 9% of the land area. The remaining land area consists of low intensity development (1%) and non-vegetated/disturbed land (1%). Currently, 272 acres of hay and potato fields are licensed for land applied potato processing sludge from the local potato processing plant (see Appendix A for more information).

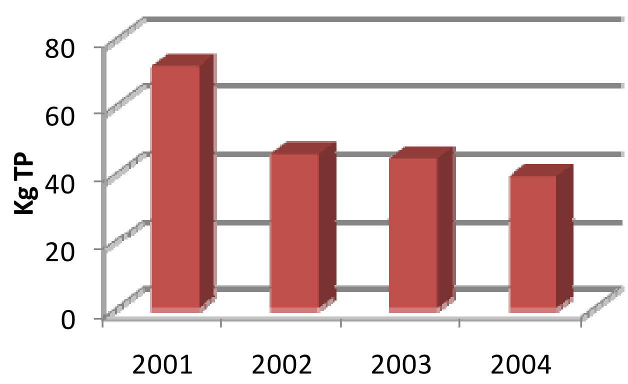
Pollutant Sources, Description of Impairments & Sampling Results

Prestile Stream is impaired by nonpoint source runoff from the many anthropogenic activities within the watershed. All land disturbances have the potential to contribute runoff, but the degree of disturbance associated with agricultural land is likely the greatest contributor of silt and nutrient enrichment to stream. The close proximity of these land uses to the stream increases the likelihood that the disturbed and bare soil will reach the stream. It's estimated that there are at least 100 farm animals in the Prestile Stream watershed, with the greatest concentration near Allen and Frost Brooks (see Appendix A for details). Cows with access to the brook (documented in the Allen/Frost Brook watershed) will denude riparian areas and break down stream banks, which can be a significant source of sediment.

<u>*Christina Reservoir*</u>

Of particular concern is the effect that Christina Reservoir has on Prestile Stream. Recent studies have shown that the water quality of the upper portion of Prestile Stream mirrors that of Christina Reservoir (Whitford 2000). This is no surprise considering that the reservoir is the source headwaters for the stream. While wastewater from the potato processing plant is no longer spray-irrigated in the Christina Reservoir watershed, there is concern that the high nutrient spray has saturated watershed soils, as well as the sediment within the reservoir (Bouchard 2007). Therefore, not only the external nutrient load (watershed load from land uses), but also the internal nutrient load from Christina Reservoir should be factored in as sources, since the suspended sediments and nutrients eventually make their way into Prestile Stream. The average internal load for Christina Reservoir is estimated at 50 kg of phosphorus/year based on data collected by Maine DEP from 2001-2004 (Figure 5). Other sources of nutrients to Prestile Stream via Christina Reservoir (Table 2) come from the air, and from waterfowl. Migratory waterfowl make their way to the many small lakes, ponds and wetlands in the area,

Figure 5. Average internal phosphorus load for Christina Reservoir (2001 - 2004).



**** 1 kilogram is equivalent to ~ 2.2 pounds***

Secchi Disk Transparency *- a vertical measure of the transparency of water (ability of light to penetrate water) obtained by lowering a black and white disk into the water until it is no longer visible.*

Total Phosphorus - *is one of the major nutrients needed for plant growth. It is generally present in small amounts and limits the plant growth in lakes. Generally, as the amount of lake phosphorus increases, the amount of algae also increases.*

including Christina Reservoir. Estimates of nutrient inputs from waterfowl in Christina Reservoir have been estimated at 30 kg, or 66 lbs. of dry feces/day from approximately 1,000 birds, resulting in a total of 390 kg of nitrogen and 130 kg phosphorus over the ice free season. These estimates may be high as the waterfowl are likely recycling nutrients from within the lake (Whitford 2000). No point sources were identified in the watershed.

Table 2. Sources of phosphorus in Christina Reservoir.

Sources of Phosphorus (P)	Annual Estimate
***External watershed load**	617 kg P
Waterfowl	130 kg P
Internal sediment load	50 kg P
Atmospheric Deposition	25 kg P
TOTAL	**822 kg P**

***For sources by category see Appendix A.

Maine DEP sampled Christina Reservoir at both the deep hole and at the dam outlet for a number of parameters including water clarity and total phosphorus between 2000 and 2004. Measurements of **Secchi Disk Transparency** were limited to two years at the deep hole (*Station 1*- 2000 and 2001) and two years at the outlet (*Station 98*- 2001 and 2003). Water clarity did not meet DEP minimum standards of 2 meters in three of the four sampling years. 2003 was the only year that water clarity met standards (2.3 m), however, only one measurement was taken in that year.

On average, **total phosphorus** concentrations in Christina Reservoir were higher at the deep hole than at the dam outlet. The average total phosphorus concentration for Christina Reservoir measures 52 ppb in the summer (July-September), and 35 ppb in the spring (May - June). Using these data, an average internal load of 50 kg of total phosphorus per year was determined to be recycled within the water column from the sediments. Interestingly, the average annual internal load appears to be dropping slightly since the cessation of aerial spraying of wastewater in the Christina Reservoir watershed in 2000 (Figure 5).

Maine DEP biologists sampled *Prestile Stream* for aquatic life or macroinvertebrate populations in both 1999 and 2004, which is a statutory Class A stream under Maine's Water Classification system. Sampling results in Table 3 (below) indicate that aquatic life did not meet the Class A criteria and consistently attained the lower Class C criteria at the Richardson Rd. site in Easton, and Class B for macroinvertebrates lower in the stream below Westfield Rd. in Westfield (Tsomides 1999, 2004).

Table 3. Maine DEP biomonitoring sampling results for Prestile Stream above Mars Hill Dam.

SAMPLING STATION	SAMPLING DESCRIPTION AND LOCATION	STATUTORY CLASS	SAMPLING RESULTS	DATE SAMPLED
Prestile Stream (S-4)	Richardson Rd., Easton	Class A	Class C	1999
Prestile Stream (S-4)	Richardson Rd., Easton	Class A	Class C	2004
Prestile Stream (S-690)	Below Westfield Rd., Westfield	Class A	Class B	2004

Biomonitoring results signaled enrichment conditions that exceed levels seen in all but one other highly degraded location in Maine (Tsomides, personal communication). Macroinvertebrate populations indicate a combination of intricate environmental factors, and no single factor is commonly the cause of macroinvertebrate impairments under the influence of nonpoint source stressors. Nutrient enrichment, and general degradation of the stream habitat due to sedimentation and physical alterations are essential contributors to the observed impairments.

Benthic algae covers the bottom of Prestile Stream at the Westfield monitoring site. Photo: K. Hoppe

Dissolved oxygen (DO) and temperature levels were intensively measured by Maine DEP from 2002 through 2006 using discreet (YSI handheld DO meter) monitoring equipment at five different sites within the impaired watershed section (Figure 2). Violations of the Class A DO standard of 7 ppm were measured at all but one of the five sites (Table 4). The two upstream sites (PS 1 and PS 2) were consistently below standards. However, the large wetland complex that stretches between Christina Reservoir and Bennett Lake could be a factor. Naturally low DO levels are commonly known to occur in wetlands and the headwaters of streams draining large wetlands.

A 2 ppm or greater difference between the daily maximum and minimum is another indicator of nutrient enrichment and algal growth (Mitnik, personal communication). Table 4 shows that all sites exhibited a 2 ppm or greater swing in DO at least once, with more frequent swings occurring at all but the Center Road site (PS 3). While the two lower sites (PS 4 and PS 5) had few to no DO violations, a relatively high number of days with DO fluctuations greater than 2 ppm indicate that impairment is occurring at these downstream sites as well.

Table 4. Dissolved Oxygen Monitoring Summary, Prestile Stream (2002 – 2006).

SAMPLING LOCATION	SITE DESCRIPTION	*No. of Minimum DO Violations < 7 ppm	**No. of Days with > 2ppm DO fluctuations
PS 1	Conant Road	17	7
PS 2	Richardson Road	10	4
PS 3	Center Road	1	1
PS 4	Westfield Road	0	6
PS 5	Mars Hill	1	5

* Based on 31 samples per site

** Based on 9 days with both am and pm sampling

A look at both DO and temperature measurements reveal a relative increase in DO and decrease in temperature from north to south (Figure 6, next page). Loadings from nonpoint sources are the primary contributor to the dissolved oxygen (DO) impairment, and sources include eroded soils, fertilizer and organic material associated with anthropogenic activities. Nutrients have also accumulated over time in bottom sediments of the slow flowing and ponded stream segments and may be periodically released into the water column.

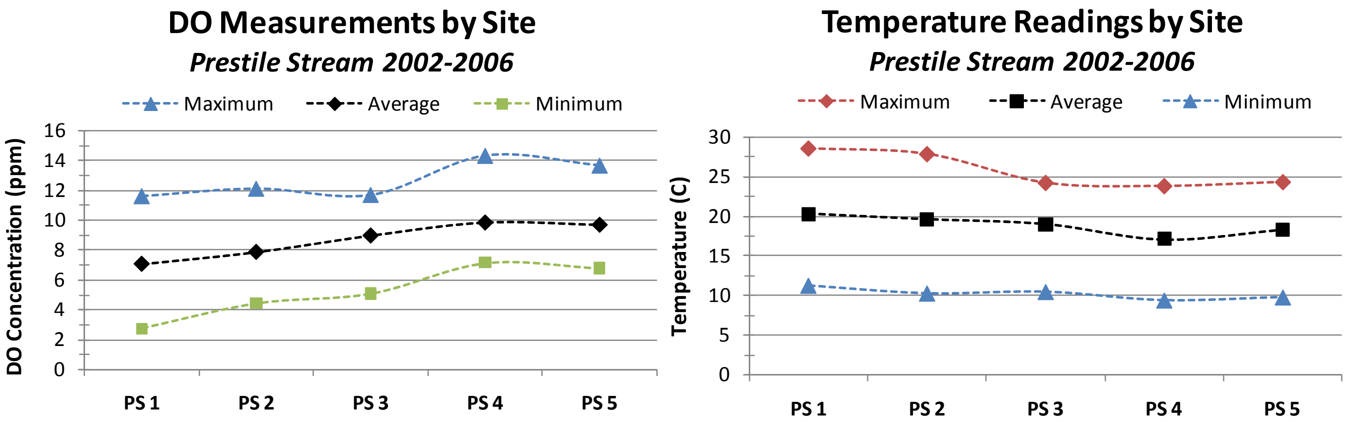


Figure 6. Dissolved oxygen and temperature readings for Prestile Stream by site (PS 1 represents the northern most site below Christina Reservoir, while PS 5 is the southern most site above the Mars Hill dam).

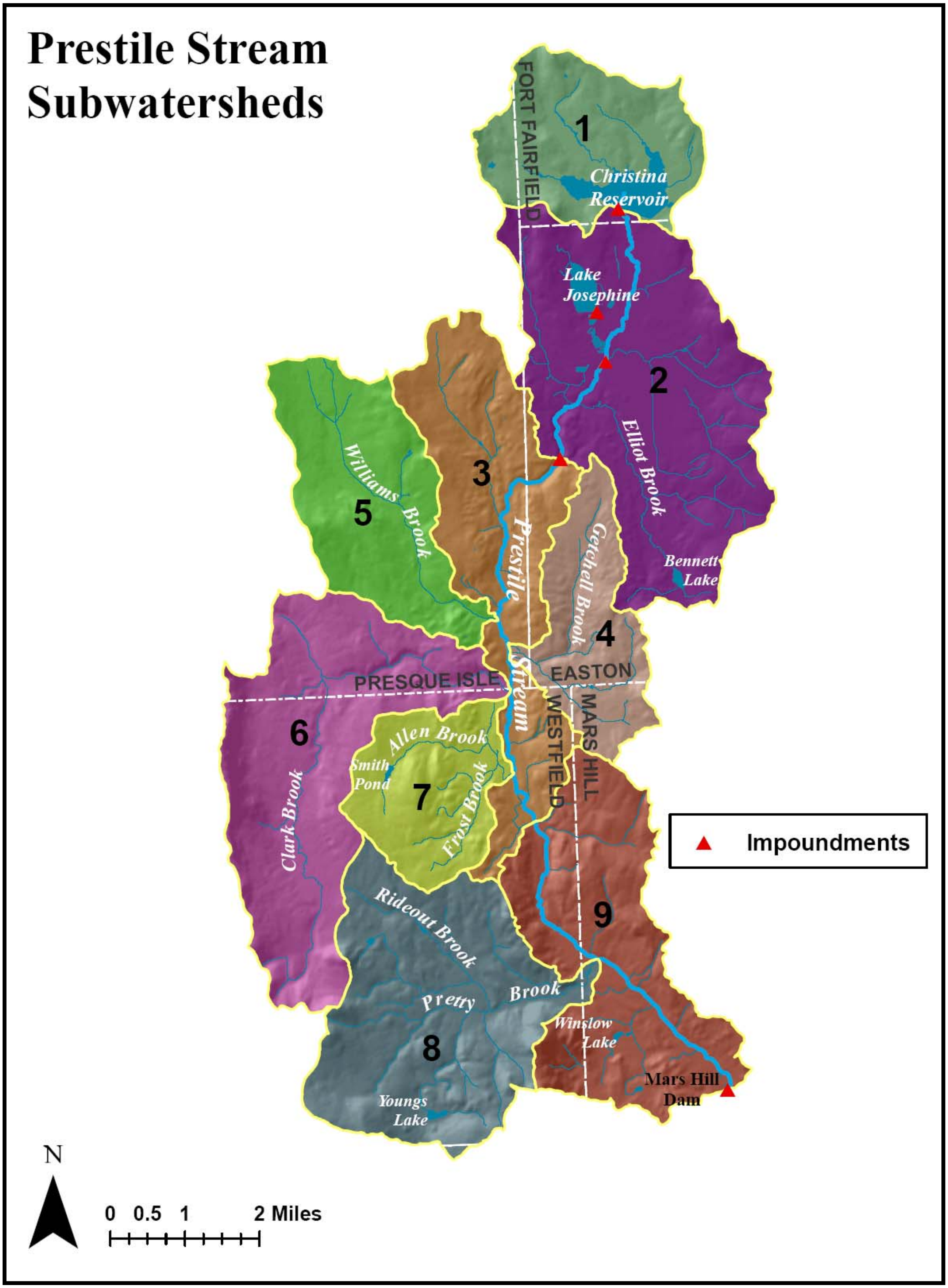
Pollutants of Concern

This TMDL addresses instream constituents for *Prestile Stream* that have been identified as the primary contributors to the observed DO violations and degradation of aquatic life. Elevated nutrient loading and sediment accumulation contributes to the excess algae growth, which consumes oxygen during respiration and depresses DO levels. Excess soil runoff provides sediment that contains a mixture of nutrients, inorganic and organic material that stimulate algal growth and contributes to the hyper-abundant populations of macroinvertebrates. Phosphorus and nitrogen are the limiting nutrients for algal growth and sediment laden run-off carries these adsorbed nutrients into the Prestile and is major contributor to the DO impairment. Phosphorus, nitrogen and sediment are pollutants of concern in Prestile Stream, while total phosphorus is the major limiting nutrient for water column algae in lakes and the pollutant of concern in Christina Reservoir.

Excess sediment contributions to the stream are symptomatic of habitat degradation and reduced suitability for a wide spectrum of aquatic life. Over time sedimentation alters habitat by filling in pools, embedding substrate in riffles and contributing nutrients. These factors then change the habitat suitability, which in turn shifts the composition of organisms adapted to living in the stream. While sediment is not the only factor affecting habitat in the dynamic stream environment, it is a significant contributor and provides a reasonable surrogate for aquatic habitat degradation in this TMDL. Habitat degradation and the nutrient cycling role of sediment means it is an additional pollutant of concern.

A watershed model, GWLF (Appendix A), was used to simulate the nonpoint source loading of the pollutants of concern, i.e. nitrogen, phosphorus and sediment. Numeric endpoints for nutrients and sediment were developed by comparing Prestile Stream to unimpaired (attainment) watersheds, with similar land use characteristics. To further characterize loading to Prestile Stream, the watershed was divided into nine subwatersheds (Figure 7). Using subwatersheds, it becomes possible to make comparisons about estimated sediment and nutrient loadings between individual drainages that contribute to Prestile Stream. This in turn may help characterize which up-stream waterbodies (including Christina Reservoir) the pollution is stemming from, and help target specific areas of the watershed for improvement.

Figure 7. The nine subwatersheds of Prestile Stream used for the GWLF model.



Priority Ranking and Listing History

The large numbers of streams listed for nonpoint source pollution on the 303(d) list requires Maine to set priority rankings based on a variety of factors. Factors include the severity of degradation, the time duration of the impairment, and the opportunities for remediation. Maine has set priority rankings for 303(d) listed streams by TMDL completion date, and has designated *Prestile Stream* for completion in 2008. *Christina Reservoir* is listed on the State's 2008 303(d) list of waters in non-attainment of Maine State water quality standards, and is one of the last remaining lakes that require a TMDL report.

Atmospheric Deposition

Atmospheric deposition of nutrients that fall within a watershed will reach a stream through runoff from land deposited material, and direct contact with rain and dry airborne materials that settle on the stream surface. It is assumed that the soil buffers and adsorbs most atmospherically deposited nutrients before they reach Prestile Stream through runoff processes (except in watersheds sensitive to acidification).

Atmospheric deposition accounts for 25 kg of the total phosphorus load to Christina Reservoir. Photo: K. Hoppe

Atmospheric deposition in open water, such as Christina Reservoir can be calculated using the lake basin surface area and a total phosphorus loading coefficient (0.16 kg/ha) representing the median of a range of values from Reckhow (1980) of 0.11 kg/ha to 0.21 kg/ha. This value is similar to values used for central Maine lakes in Kennebec County, and for nearby lakes including Echo Lake and Arnold Brook Lake. Surface waters for Christina Reservoir's direct watershed comprise 10% of the total land area (309 acres/125 ha) and account for an estimated 20 kg of total phosphorus per year, representing < 2% of the total direct watershed load entering Christina Reservoir.

Natural Background Levels

Prestile Stream is statutory Class A, and no reaches were found that consistently attain Class A. As is true of all watersheds with a history of human habitation, it is not pristine and nonpoint source loading has resulted from human related activities. Natural environmental background levels for Prestile Stream and Christina Reservoir were not separated from the total nonpoint source load because of the limited and general nature of available information. Without more and detailed site-specific information on nonpoint source loading, it is very difficult to separate natural background from the total nonpoint source load (USEPA 1999).

2. DESCRIPTION OF THE APPLICABLE WATER QUALITY STANDARDS AND NUMERIC WATER QUALITY TARGET

Maine State Water Quality Standard

The impaired section of the Prestile Stream above Mars Hill dam is classified as a Class A stream under Maine's Water Classification Program. Water quality standards and water quality classification of all surface waters of the State of Maine have been established by the Maine Legislature (Title 38 MRSA 464-467). By definition, discharges to Class A waters shall be of sufficient quality to support all aquatic species indigenous to the receiving water without detrimental changes in the resident biological community.

Maine State Water Quality Standard for nutrients requires Great Ponds Class A (GPA) waters, such as Christina Reservoir, to have a stable or decreasing trophic state (based on appropriate measures, e.g., total phosphorus, chlorophyll-a, Secchi disk transparency) subject only to natural fluctuations. These waters should be free of culturally induced algae blooms which impair their potential use and enjoyment. Maine DEP's functional definition of nuisance algae blooms include episodic occurrence of Secchi disk transparencies (SDTs) < 2 meters for lakes with low levels of apparent color (<30 SPU) and for higher color lakes where low SDT readings are accompanied by elevated chlorophyll a levels (>8 ppb). Christina Reservoir is a colored lake (average color 46 SPUs), with low late summer SDT readings (annual average of 1.3 meters), in association with high chlorophyll-a levels (21 ppb). Therefore, Christina Reservoir does not meet water quality standards.

Designated Uses and Antidegradation Policy

Prestile Stream is listed as Class A water and does not attain classification due to pollution from nonpoint sources. Class A and its designated uses are defined under Maine's Water Quality Classification Program, Maine Revised Statutes, Title 38, Article 4-A. Class A waters are generally designated for: drinking water after disinfection; fishing; agriculture; recreation in and on the water; industrial cooling water supply; hydroelectric power generation; navigation; water supply; and habitat for fish and aquatic life. Additionally, "The habitat shall be characterized as natural." Maine's anti-degradation policy requires that "existing in-stream water uses and the level of water quality necessary to sustain those uses, must be maintained and protected." MEDEP must consider aquatic life, wildlife, recreational use and social significance when determining 'existing uses'.

Similarly, Christina Reservoir is designated as a GPA (Great Pond Class A) water in the Maine DEP state water quality regulations. Designated uses for GPA waters in general include: water supply; primary/secondary contact recreation (swimming and fishing); hydro-electric power generation; navigation; and fish and wildlife habitat. No change of land use in the watershed of a Class GPA water body may, by itself or in combination with other activities, cause water quality degradation that would impair designated uses of downstream GPA waters or cause an increase in their trophic state. Maine's anti-degradation policy requires that "existing in-stream water uses, and the level of water quality necessary to sustain those uses, must be maintained and protected."

Table 5. Maine DEP Biomonitoring Sampling Results for Moose Brook and B Streams in Aroostook County.

STREAM	STATION, TOWN	DATE SAMPLED	SAMPLING PARAMETER	ANALYSIS/ RESULTS	CLASS ATTAINMENT
B Stream	464, Houlton & 465, Hammond	1999	Macroinvertebrate Protocols	Model	A
B Stream	464, Houlton & 465, Hammond	2000	Macroinvertebrate Protocols	Model	A
B Stream	464, Houlton	2004	Dissolved Oxygen	>7 pmm	A
Moose Brook	466, Houlton & 467, Ludlow	1999	Macroinvertebrate Protocols	Model	A
Moose Brook	466, Houlton & 467, Ludlow	2000	Macroinvertebrate Protocols	Model	A
Moose Brook	466, Houlton	2005	Dissolved Oxygen	>7 pmm	A
Moose Brook	467, Ludlow	2004	Dissolved Oxygen	>7 pmm	A

Source: Maine DEP Biomonitoring Database, 2008)

Numeric Water Quality Target

Prestile Stream: Numeric nutrient and sediment targets for Prestile Stream were established by comparing Prestile Stream to attainment watersheds in the same geographical region. In order to produce realistic targets the attainment watersheds need to share similar landscape, development and agricultural patterns. No statutory Class A stream could be found that share similar characteristics, but two nearby watersheds that attain Class A standards were selected. Moose Brook and B Stream are designated as statutory Class B streams, but have been documented to attain Class A standards for aquatic life and dissolved oxygen (Table 5). Since these streams attain Class A, it is assumed that the AVGWLF model results for these streams will provide reasonable targets to achieve attainment in Prestile Stream. Details of stream characteristics and model comparison can be found in the 'Modeling Report to Support TMDL Development for Prestile Stream and Christina Reservoir' (Appendix A).

Christina Reservoir: Spring-time (May - June) total phosphorus levels in Christina Reservoir historically (period of record) approximated 35 ppb, while summertime levels averaged 52 ppb. Numeric criteria for phosphorus do not exist in Maine's state water quality regulations. Methods used in previous TMDLs to determine an in-lake target concentration do not apply to Christina Reservoir (see explanation next section). The GWLF model results will provide a reasonable total phosphorus target that will attain the narrative water quality standard.

A comparative reference approach requires identical modeling procedures be applied to all watersheds, which is documented in Appendix A. Numeric endpoints are derived from modeling results for total phosphorus, total nitrogen and sediment in Moose Brook and B Stream (Table 6, next page). An average of the unit area loads was chosen for the numeric target needed to obtain designated uses.

Table 6. Numeric loading estimates for pollutants of concern based on GWLF modeling results (Appendix A).

POLLUTANTS	ATTAINMENT WATERBODIES		NUMERIC TARGET
Annual Unit Area Loads	**Moose Brook**	**B Stream**	**Average for Waterbodies**
Phosphorus Load (kg/ha/year)	0.24	0.17	0.21
Nitrogen Load (kg/ha/year)	5.75	3.84	4.80
Sediment Load (tons/ha/year)	0.03	0.01	0.02

** 1 kg/ha/year = 0.892 lbs/acre/year, and 1 ton/ha/year= 809.37 lbs/acre/year*

3. LOADING CAPACITY - LINKING WATER QUALITY AND POLLUTANT SOURCES

Loading Capacity & Linking Pollutant Loading to a Numeric Target

Prestile Stream: The loading capacity is the mass of constituent pollutants that Prestile Stream can receive over time and still meet numerical water quality targets. Loading capacity is expressed as an annual load rather than a daily load to normalize the spatial and temporal variation associated with instream nonpoint source pollutant concentrations. The loading capacity for Prestile Stream (including Christina Reservoir as a subwatershed) is based on a comparative reference approach to set the allotment for existing and future nonpoint sources that will ensure support for existing and designated uses. The GWLF model output (Appendix A) expresses pollutants in terms of instream loads which have been broken down into a unit area basis for comparative purposes. Table 7 lists the loading targets or assimilative capacity for comparisons between the attainment watersheds and Prestile Stream in subsequent TMDL analysis.

Christina Reservoir: Total Phosphorus (TP) serves as a surrogate measure of Maine's narrative water quality standards for lake trophic status. The Vollenweider type empirical model has been used for previous Maine Lake TMDLs to link watershed total phosphorus (external) loadings to existing in-lake total phosphorus concentrations. In the case of Christina Reservoir, the Vollenweider model was not a suitable fit due to the unique physical characteristics of the Reservoir. This shallow, impounded wetland has a history of watershed loading from both industrial processing wastewater and nonpoint source pollution, making it different from traditional Maine lakes. We expect that Christina Reservoir behaves more like a flooded wetland than a lake, therefore, it's expected that nutrient concentrations would normally be higher than concentrations of true lakes.

Several avenues were pursued to justify choosing a water quality target for Christina Reservoir. Using Best Professional Judgment, an in-lake concentration of 28 ppb was chosen based on the range of phosphorus concentrations collected from more than 100 wetlands across the state. This target was first presented to stakeholders and then tested using an accepted method for predicting reductions using mean annual discharge and pollutant concentrations (see Appendix A). Results of this exercise determined that the GWLF model results are the more conservative approach for choosing a water quality target for Christina Reservoir, and provide a reasonable total phosphorus target that will attain the narrative water quality standard.

The TMDL for Christina Reservoir presents the annual pollutant loads based on precipitation and streamflow within the GWLF model. A daily load can be calculated by dividing the annual load by 365. However, because the annual load of TP as a TMDL target is more easily aligned with the design of best management practices used to implement nonpoint source and stormwater TMDLs for lakes than daily loads of specific pollutants, this TMDL report recommends that the annual load target in the TMDL be used to guide implementation efforts. Ultimate compliance with water quality standards for the TMDL will be determined by measuring in-lake water quality to determine when standards are attained.

Table 7a and b. Estimated pollutant loads in Prestile Stream (a) and Christina Reservoir (b) compared toTMDL load allocations and the percent reductions required to achieve water quality standards.

(a)

TMDL POLLUTANT LOADS* Annual Unit Area Loads	Estimated Loads Prestile Stream **	Numeric Target Attainment Waterbodies	TMDL% REDUCTIONS Prestile Stream
Phosphorus Load (kg/ha/year)	0.42	0.21	50 %
Nitrogen Load (kg/ha/year)	9.80	4.80	51 %
Sediment Load (tons/ha/year)	0.06	0.02	69 %

(b)

TMDL POLLUTANT LOADS* Annual Unit Area Loads	Estimated Loads Christina R.	Numeric Target Attainment Waterbodies	TMDL% REDUCTIONS Christina R.***
Phosphorus Load (kg/ha/year)	0.49	0.21	57 %
Nitrogen Load (kg/ha/year)	11.70	4.8	59 %
Sediment Load (tons/ha/year)	0.04	0.02	50 %

** The TMDL loads can be expressed as a daily maximum load by dividing the annual averages above by 365.*

*** The Existing Load for Prestile Stream includes the load to Christina Reservoir.*

**** The TMDL for Christina Reservoir is set only for Total Phosphours. Nitrogen and Sediment reductions are for informational purposes only.*

Supporting Documentation - TMDL Approach

The TMDL approach includes measuring various environmental parameters and developing a water quality model to estimate pollutant loadings and reductions that will ensure attainment of Maine's water quality standards. The Prestile Stream and Christina Reservoir TMDL analysis uses the GWLF model to estimate pollutant loadings (Appendix A). GWLF is an established midrange modeling tool that uses landuse runoff coefficients, universal soil loss equations and rainfall inputs to compute flow and pollutant loads. The model was run for each of the nine subwatersheds of the larger Prestile Stream watershed above the Mars Hill dam for a 15 year period to capture a wide range of hydrologic conditions to account for variations in nutrient and sediment loading over time. To estimate the TMDL reductions needed to attain water quality standards, the GWLF model results are used to estimate the existing load in Prestile Stream (including Christina Reservoir) and the attainment watersheds. The difference in estimated pollutant loads between the impaired and attainment watersheds is the reduction needed to achieve water quality criteria for all nonpoint source pollutants of concern.

Strengths and Limitations

The TMDL uses a GWLF model analysis (Appendix A) of existing loads and target loads to compute reductions needed to achieve water quality standards.

Strengths:

- GWLF is an established midrange model that is commonly accepted to estimate pollutant loads in river and stream TMDLs.
- The GWLF model was created using regional input data to reflect local conditions to the greatest extent possible.
- The model makes best use of available landuse coverages to estimate nonpoint source loads.
- The model was run for a 15 year period to account for a wide range hydrologic conditions among years.
- A reference approach is a reasonable mechanism to establish criteria for pollutants of concern, where no regulatory numeric criteria exists.

Model Limitations:

- The GWLF model is a screening-level model that provides a general estimate of watershed nutrient-loading conditions.
- This GWLF model has not been calibrated to observations of nutrients, sediment, or streamflow volumes in Aroostook County watersheds.
- No effort has been made to account for changes to the conditions of the watershed that have occurred since the development of the data used to create model inputs.
- The GWLF model does not account for forested riparian buffers.

Critical assumptions used in the GWLF modeling report (Appendix A) include:

- Meteorological data were assumed to be representative of the watersheds, although the stations are located outside of the watershed.
- Septic system failure rates are assumed to be similar to failure rates for rural communities in upstate New York in 1990.
- Values for parameters reported in the Northeast GWLF report (Penn State 2007) are assumed to be representative of conditions in Aroostook County watersheds.
- Forest land in the model is considered naturally forested, and does not account for forestry operations.

Critical Conditions

The loading capacity for *Prestile Stream* is set to protect water quality and support uses during critical conditions, which are defined as environmental conditions that induce a stress response in aquatic life. Environmentally stressful conditions may occur throughout the year and depend on the biological requirements of the life stage of resident aquatic organisms. Traditionally, summer low flow periods are considered critical for aquatic organisms due the combination of low velocity, high temperatures and low dissolved oxygen.

All aquatic organisms that reside in the stream confront harsh winter conditions and winter often determines the success or failure of native salmonid species, such as brook trout, which have been observed in Prestile Stream. Seasonally, low flows occur in the winter and native fish are under stress as they compete for limited winter habitat, as defined by water velocity and unembedded substrate. Additionally, trout eggs are incubating in the gravel during the winter and have specific velocity and dissolved oxygen requirements that may be compromised by the addition of smothering sediment. Some species of stoneflies emerge and develop during the winter and remain vulnerable to chronic sediment. Critical condition is complex in flowing water and a major consideration

Table 8. GWLF sediment, nitrogen, and phosphorus loading estimates and recommended reductions for the nine subwatersheds of the impaired segment of Prestile Stream.

Sub-watershed	Name	Sediment (t/ha/yr)	Total N (kg/ha/yr)	Total P (kg/ha/yr)	Sediment % Reduction	Total N % Reduction	Total P % Reduction
	Reference Waterbodies[1]	0.02	4.80	0.21	-	-	-
1	Christina Reservoir	0.04	11.70	0.49	50%	59%	57%
2	Lake Josephine	0.06	11.30	0.49	67%	58%	57%
3	Prestile Main Stem 1	0.10	13.44	0.54	80%	64%	61%
4	Getchell Brook	0.12	14.38	0.67	83%	67%	69%
5	Williams Brook	0.08	14.81	0.63	75%	68%	67%
6	Clark Brook	0.04	6.76	0.26	50%	29%	21%
7	Allen/Frost Brooks	0.09	12.45	0.62	78%	61%	66%
8	Pretty/Rideout Brooks	0.05	6.80	0.26	60%	29%	19%
9	Prestile Main Stem 2	0.10	11.27	0.50	80%	57%	58%
	Total	***0.06***	***9.80***	***0.42***	***69%***	***51%***	***51%***

[1]Average of unit area loads for B Stream and Moose Brook. *1 t/ha/year = 809.37 lbs/acre/year and 1 kg/ha/year = 0.892 lbs/acre/year.*

in using an average annual load approach for these nonpoint source TMDLs.

Critical Conditions occur in *Christina Reservoir* during the late summer and early autumn, when the potential (both occurrence and frequency) of nuisance algal blooms are greatest. The target goal of a 57% reduction of total phosphorus was set to achieve desired water quality standards during this critical time period, and will also provide adequate protection throughout the year (see Seasonal Variation, p. 25).

TMDL Loading Calculations

The existing loads for nutrients and sediments in the impaired segment of Prestile Stream are listed in Table 8 (below). Appendix A, the 'Modeling Report to Support TMDL Development for Prestile Stream and Christina Reservoir', describes the GWLF modeling results and calculations used in Table 8 to define TMDL reductions, and compares these existing nutrient and sediment loads in Prestile Stream to TMDL endpoints derived from the attainment streams listed in Table 6. An annual time frame provides a mechanism to address the daily and seasonal variability associated with nonpoint source loads. As previously mentioned, it was not possible to separate natural background from nonpoint pollution sources in this watershed because of the limited and general nature of the available information.

Further, Table 8 lists nutrient and sediment load estimates for each of the nine subwatersheds of Prestile Stream (Figure 7, p. 16). In terms of unit area loads: the highest nitrogen loading occurs in the Getchell and Williams Brook watersheds; similarly, the highest phosphorus loading occurs in Getchell, Williams, and Allen/Frost Brook watersheds. The lowest loading for both nutrients occurs in the Clark Brook and Pretty/Rideout Brook watersheds. This is not surprising considering that the headwaters of these two streams are the most heavily forested of all of the subwatersheds. With the exception of Clark Brook, sediment loading from cropland in each of the remaining 9 subwatersheds ranges from 94-98% of the total sediment load to Prestile Stream.

Future Loading

The prescribed reduction in pollutants discussed in the TMDL reflects reduction from estimated existing conditions. Expansion of agricultural and development activities have the potential to increase runoff and associated pollutants. 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 minimal threat in the Prestile watershed because Aroostook County has declining population trends, with a 15% drop between 1990 and 2000, and a 2.3% from 2000 to 2007. The growth in agricultural lands is mixed, with a steady decline in the total acres farmed from 1974 to 1997, and a smaller increase from 1997 to 2002 (NMDC 2007). Future activities and BMPs that achieve TMDL reductions are addressed in the updated Watershed Management Plan (prepared by watershed stakeholders with support from Maine DEP).

Table 9. Load Allocations and Waste Load Allocations for pollutants in the TMDL.

TMDL= LA + WLA	**Nutrients**		**Sediment**
	Phosphorus Load (kg/ha/year)	Nitrogen Load (kg/ha/year)	Sediment Load (tons/ha/year)
Load Allocations (LA)	0.21	4.80	0.02
Waste Load Allocations (WLA)	0	0	0
Loading Capacity (TMDL)	0.21	4.80	0.02

4. LOAD ALLOCATIONS (LA's)

The load allocation (LA) for each of the candidate pollutants in *Prestile Stream* are listed in Table 9. On an annual basis, the LA represents the stream's assimilative capacity allocated to only nonpoint sources of nutrients and sediments. All pollutant sources in these calculations are assigned LAs, representing nonpoint sources from anthropogenic activities including roadways and agricultural inputs for which there are no associated discharge or general permits. The reported LA's represent all the sites within the impaired stream segment downstream of the outlet of Christina Reservoir (Figure 2).

Christina Reservoir

The annual total phosphorus load allocation for *Christina Reservoir* equals 28 ppb and represents, in part, that portion of the lake's assimilative capacity allocated to nonpoint (overland) sources of phosphorus. Direct external TP sources for Christina Reservoir (totaling 822 kg annually) have been identified and accounted for in the land-use breakdown portrayed in Figure 4. Further reductions in nonpoint source phosphorus loadings necessary to satisfy the load allocation will need to be produced from implementation of NPS best management practices for managed land in the Christina Reservoir watershed. As previously mentioned, it was not possible to separate natural background from nonpoint pollution sources in this watershed because of the limited and general nature of the available information. As in other Maine TMDL lakes, in-lake nutrient loadings in Christina Reservoir originate from a combination of direct external and internal (lake sediment) sources of total phosphorus.

5. WASTE LOAD ALLOCATIONS (WLA's)

No portion of the *Prestile Stream or Christina Reservoir* watershed is designated as an urban area and would not be subject to coverage under Maine's general permit for municipal separate stormwater sewer systems (MS4s). Stormwater associated with construction site activities over one acre would be subject to the MEPDES stormwater permit program, although those activities are expected to be short term and infrequent. Therefore, the waste load allocation is defined as 0 for all pollutants of concern.

6. MARGIN OF SAFETY (MOS)

A margin of safety was incorporated into the Prestile Stream TMDL through the selection of the numeric water quality target, based on watersheds (Moose Brook and B Stream) that attain Class A. These watersheds have a higher percentage of forested lands which results in relatively conservative pollutant targets. AVGWLF calculates pollutant loads with minimal losses to the absorptive capacity of landscape conditions that reduces the runoff the stream receives. Only BMPs with formal documentation were included in the model, but the Prestile contains riparian buffers and undocumented agricultural BMPs that were not covered in the modeling process, effectively reduce loading. A landuse runoff model, like AVGWLF, also does not account for instream processes that attenuate nutrients and settle sediments during transit, which reduces the pollutant load that moves through the system. These factors provide a MOS to account for uncertainty and reasonably insure that water quality standards will be attained in Prestile Stream.

Christina Reservoir

The TMDL expressed in terms of an annual load includes an implicit MOS through the relatively conservative selection of the numeric water quality target (based on results of the GWLF watershed loading model). It is assumed that results from the GWLF model provide a reasonable target (57% reduction of total phosphorus) that will assure future attainment of Maine DEP water quality goals of non-sustained and non-repeated blue-green summer-time algal blooms due to NPS pollution or cultural eutrophication and stable or decreasing trophic state, and improvements in the water quality of Prestile Stream.

The following factors could not be factored into the GWLF model, and therefore further support the conservative selection of the numeric target: 1) The high nutrient point-source pollutants discharged in the watershed were not factored into the model. These pollutants have attenuated in the sediments of Christina Reservoir and have shown trends that they may be diminishing overtime; 2) Stakeholder feedback suggests that the extent of documented BMPs in the watershed are underestimated; 3) A cursory analysis of riparian buffers in the watershed estimates, that on average, approximately 75% of all waterways in the watershed have buffers.

7. SEASONAL VARIATION

Seasonal variation is considered in the allowable annual loads of nutrients and sediment which protect macroinvertebrates and other aquatic life under the influence of seasonal fluctuations in environmental conditions such as flow, rainfall and runoff. All unregulated streams in Maine experience seasonal fluctuations in flow, which influences the concentration of nutrients and sediment. Typically high flows occur during spring and fall and low flows occur during the summer and winter. Snow and rainfall runoff may contribute variable amounts of nutrients and sediment, especially since much of the agricultural land is planted in late season crops such as potatoes, which are harvested late in the fall. This leaves fields bare from fall through spring, approximately eight months of the year (Alverson 2005b), making soil vulnerable to erosion. Large volumes of runoff may also dilute instream nutrients and sediment concentrations, depending on the source.

Christina Reservoir

The Christina Reservoir TMDL is protective of all seasons, as the allowable annual load was developed to be protective of the most sensitive time of year – during the summer, when conditions most favor the growth of algae and aquatic macrophytes. With an average flushing rate of 5.1 flushes/year, the average annual phosphorus loading to Christina Reservoir is most critical to the water quality. Maine DEP lake biologists, as a general rule, use more than six flushes annually (bi-monthly) as the cutoff for considering seasonal variation as a major factor (to distinguish lakes vs. rivers) in the evaluation of total phosphorus loadings in aquatic environments in Maine.

8. MONITORING PLAN (EPA approval request for past TMDLs)

Addressing the problems described in the TMDL will require future assessments of individual sites in order to develop site specific best management practices. The Central Aroostook Soil & Water Conservation District (CA-SWCD) has completed a watershed survey for Allen/Frost Brook (Alverson 2005b), one of the nine subwatersheds of Prestile Stream's impaired segment (Figure 7, p. 16). While fairly similar among subwatersheds, modeling results in Appendix A could be used as a starting point for conducting subwatershed surveys, beginning with the subwatersheds with the greatest input per unit load. Additional assessments should include stream monitoring to develop standards for pre and post application comparisons. Water quality monitoring should be conducted to gauge effectiveness of any BMPs or engineered design solutions, as recommended in the 'Implementation Plans' section. As restoration plans proceed, Maine DEP will check on the progress towards attainment of Maine's Class A water quality standards with both aqueous samples and biological monitoring evaluations. Also, Maine DEP's Biomonitoring Unit will check on water quality status or improvement in the future under the existing rotating basin sampling schedule.

Local stakeholders meet to discuss management strategies for Prestile Stream. Photo: L. Alverson, CA-SWCD

<u>*Christina Reservoir*</u>

The water quality of Christina Reservoir was monitored over a short four-year time span during open water periods from 2000–2004. Continued long-term water quality monitoring of Christina Reservoir will be conducted between the months of May to October, through the continued efforts of the Maine DEP. Under this planned, post-TMDL water quality-monitoring scenario, sufficient data will be acquired to adequately track future seasonal and inter-annual variation and long-term water quality trends in Christina Reservoir. A post-TMDL adaptive management report will be prepared five to ten years following EPA approval.

9. IMPLEMENTATION PLANS and REASONABLE ASSURANCES

The goal of this TMDL assessment on *Prestile Stream and Christina Reservoir* is to use a midrange water quality model, GWLF (Appendix A), to define pollutant loads and set water quality targets that will assure compliance with Maine's water quality standards. The nutrient and sediment reductions listed in the TMDL Allocations, Table 7, represent averages over the year (given the seasonal variation of runoff and ambient conditions), and demonstrate the need to reduce nutrient and sediment loads as the key to water quality restoration. The load reductions provide a guide for restoration plans and engineered solutions that will lower the content of nutrient and sediment in the runoff reaching the stream.

Water withdrawal for irrigation of cropland is a concern in Prestile Stream (Alverson 2005b).

Watershed Restoration Activities

With funding from an EPA Clean Water 319 NPS Grant in 2002, the Central Aroostook SWCD created a forty-member Steering Committee composed of residents, resource professionals, municipal officials and other interested parties. The Steering Committee held six meetings in 2004 with a goal of developing a Watershed Management Plan for Prestile Stream. In addition to the Steering Committee meetings, the group organized two public meetings. These meetings helped prioritize watershed issues into High, Medium and Low Priority categories (Alverson 2005a).

An Action Plan was created highlighting three major goals for improving the watershed:

1) To foster long-term stewardship of the Prestile Stream, its tributaries and watershed through collaboration, education, and public involvement;

2) To increase knowledge of Prestile Stream to determine the causes of poor water quality, and;

3) To improve water quality and aquatic habitats.

As part of the 319 nonpoint source control project, a high intensity watershed survey was conducted in 2004 by the CA-SWCD in the Allen/Frost Brook subwatershed. The watershed was selected as representative of the larger Prestile Stream watershed. Resource professionals identified and documented erosion, sedimentation, and other sources of pollutants to Allen and Frost Brooks. Survey results suggest that cropland contributes the bulk of sediments to the streams flowing into the Prestile. The Action Plan created by CA-SWCD (as part of the Prestile Stream Watershed Management Plan) emphasized the need for watershed surveys at the subwatershed level (as completed above for Allen/Frost Brooks), and for decreasing the sediment load to Prestile Stream and its tributaries. To date, the Action Plan has not been fully implemented due to lack of funding (Alverson, personal communication).

Improvements to agricultural practices in the watershed have been at the forefront of technical assistance programs provided by the USDA/Natural Resource Conservation Service (NRCS) for several decades. NRCS provides cost-share dollars to assist with installing Best Management Practices that reduce sediment and nutrient loading to both Christina Reservoir and Prestile Stream. A list of existing BMPs by subwatershed are listed in Appendix A (Section 3.3).

In 2007-2008, the NRCS conducted a Rapid Watershed Assessment (RWA) for Prestile Stream. A RWA provides initial estimates of where conservation investments would best address the concerns of landowners, conservation districts, and other community organizations and stakeholders (NRCS 2008). A public meeting was held in May, 2008 to discuss the results of the RWA. The principal form of data from the RWA is GIS data, including a wildlife habitat map, watershed boundaries, a slope map, land use map, and a buffer map that can be used to query information about buffers.

Recommendations for Future Work

Watershed inventory and watershed planning are important first steps toward reducing sediment and nutrient inputs in Prestile Stream and Christina Reservoir. Yet improving dissolved oxygen regimes and restoring a sustainable and functional aquatic community requires more than just planning and assessment. Reversing long term degradation from anthropogenic assaults over many decades will require planning and effort that include local stewardship, instream restoration and attention to small chronic problems. A comprehensive subwatershed approach should look to all potential nutrient and sediment sources including the impact of agricultural land, impervious surfaces (roads and roofs) and commercial developments.

Analysis of the dissolved oxygen and temperature data for Prestile Stream suggest a down stream improvement in water quality (Figure 6, p. 15). Upstream sampling locations, including the outlet of Christina Reservoir have the lowest dissolved oxygen levels, and highest temperatures, both of which are detrimental to aquatic life, and beneficial for algal growth. Some of these effects are a direct result of historic point-source discharges resulting in an excess of nutrients in the upper subwatersheds. Results of the GWLF model suggest that Getchell Brook and Williams Brook require the greatest reductions of total phosphorus. With these factors in mind, any subwatershed surveys should commence in these areas.

The Watershed Management Plan for the Prestile Stream lists a number of recommendations for improving water quality (Alverson 2005a). The high priority recommendations focus on strategies for water use management and low water levels; stormwater runoff from roads and gravel road erosion; Surface erosion for agriculture; fish consumption and historical pollutants; and streamside buffers, residential development and riparian management. Medium and low priority issues range from forestry operations and private septic waste, to recreation and beaver. Recommendations are provided for each of the topics. An updated Watershed Based Management Plan (WBMP) is forthcoming for Prestile Stream. The WBMP will update the 2005 plan, and provide modeling necessary to approximate the expected reductions after application of Best Management Practices throughout the watershed as part of EPA's nine elements of a comprehensive plan.

Meeting the challenges of restoration in Prestile Stream requires the participation of the human inhabitants of the watershed. One key to success for long term restoration is having residents and firms (McCain Foods and the several farming companies in the watershed) that care about the stream and are actively involved in the restoration process, or an active watershed organization. While a Steering Committee was formed to help develop the watershed management plan, there is no organized watershed group. Its been documented that water quality trends in Maine's lakes have shown improvement when citizen-based watershed groups actively pursue restoration strategies (Bouchard 2005). While typical aquatic restoration efforts do not include local watershed organizing, it should not be overlooked as an important component in improving water quality.

Recommendation Synopsis

⇒ Utilize results of GWLF model to prioritize a schedule for conducting subwatershed surveys starting with Christina Reservoir

⇒ Identify agricultural sources and install BMPs

⇒ Identify and address all sources of nutrient and sediment inputs

⇒ Inventory all water withdrawal locations and develop a standard for low flow conditions

⇒ Reestablish riparian buffers along Christina Reservoir, Prestile Stream and its tributaries

⇒ Provide education and technical assistance, targeting agricultural land owners and municipal officials

⇒ Provide additional cost-share assistance to farmers and determine effectiveness of existing BMPs

⇒ Conduct fish and sediment sampling to identify current extent of DDT contamination

⇒ Foster local stewardship and establish a viable watershed organization

10. PUBLIC PARTICIPATION

Public participation in the Prestile Stream TMDL development was ensured through several avenues:

- FB Environmental staff Jennifer Jespersen presented information about the TMDL at the RWA public meeting in Houlton in May, 2008.

- A two-week stakeholder review was distributed electronically on July 11, 2008 to the following individuals who expressed a specific interest, or helped develop the draft of the Prestile Stream & Christina Reservoir TMDL report: Maine DEP CMRO (Melissa Evers, Dave Courtemanch, Roy Bouchard, David Halliwell, Leon Tsomides, Tom Danielson and Jeff Dennis); Maine DEP NMRO (Kathy Hoppe, Nick Archer, Bill Sheehan, Jay Duncan and Sean Bernard); Central Aroostook SWCD (Linda Alverson and Steve Sutter); USDA/NRCS (Skip Babineau and Joe Weber); Houlton Band of Maliseets (Cara O'Donnell); USEPA-NERL (Greg Hellyer); Dept. of Inland Fish and Wildlife (Dave Basley); Civil Engineering Services (Dave Hopkins); Maine Potato Board (Tim Hobbs); Town of Mars Hill (Raymond Mersereau); Mars Hill Utility District (Steven Milliard); City of Presque Isle (George Howe); and private citizens (John Kilcollins and Steve Hitchcock).
- A four-week public review was distributed electronically on August 8, 2008 to the stakeholders listed above.
- The TMDL was presented at a public meeting at the offices of the Central Aroostook Soil and Water Conservation District in Presque Isle on August 11, 2008.
- The report was posted on the Maine DEP Internet Web site and a notice was placed in the 'legal' advertising of local newspapers. The following ad was printed in the Saturday editions of the Bangor Daily News on August 16th and 23rd, 2008:

PUBLIC NOTICE FOR PRESTILE STREAM and CHRISTINA RESERVOIR

In accordance with Section 303(d) of the Clean Water Act, and implementation regulations in 40 CFR Part 130 – the Maine Department of Environmental Protection has prepared a Total Maximum Daily Load (TMDL) report (DEPLW 2008-0923) for impaired water quality in Prestile Stream located in Fort Fairfield, Easton, Presque Isle, Westfield and Mars Hill, and Christina Reservoir, located in Fort Fairfield, in Aroostook County, Maine. This TMDL report estimates nonpoint source loadings of nutrients and sediments and the reductions needed to restore Prestile Stream and Christina Reservoir to meet Maine's Water Quality Criteria.

*A Public Review draft of the report may be viewed at the Maine DEP Offices in Presque Isle (1235 Central Drive, Skyway Park) or (Augusta (Ray Building, Hospital St., Rt. 9) or on-line at: http://www.state.me.us/dep/blwq/comment.htm. Send all written comments – by **September 5, 2008,** to Melissa Evers, Stream TMDL's, Maine DEP, State House Station #17, Augusta, ME 04333 or email: melissa.evers@maine.gov.*

PUBLIC REVIEW Comments Received

Comments Bill Sheehan (Maine DEP, NMRO) reviewed the Public Review document and provided comments, which were responded to by Melissa Evers (Maine DEP, Augusta). (See Appendix D for list of comments and responses.)

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APPENDICES

FIGURES

TABLES

TABLES Continued...

APPENDIX A:
Modeling Report to Support
Total Maximum Daily Load (TMDL) Development for Prestile Stream and Christina Reservoir

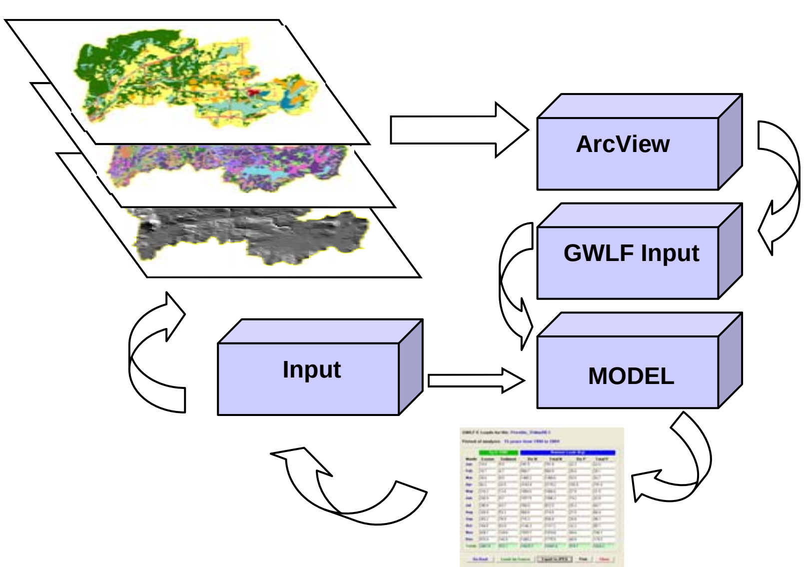
1. MODEL DESCRIPTION

As a component of the Prestile Stream TMDL, landuses for the watershed were modeled using Northeast AVGWLF (Generalized Watershed Loading Function with an ArcView (AV) geographic information systems (GIS) interface). The Arcview interface facilitates the development of model input data for GWLF, the core watershed simulation model, which uses hydrology, land cover, soils, topography, weather, pollutant discharges, and other critical environmental characteristics to model sediment and nutrient (N and P) transport within a watershed.

The AVGWLF model is an aggregate distributed/lumped parameter watershed model. For surface loading, it is distributed in that it allows multiple land use/cover scenarios. However, loads originating from the watershed are lumped and spatial routing of nutrient and sediment loads is not available. For example, all farmland is lumped together and defined by one set of parameter values, and all forested land is lumped together and defined by a different set of parameter values. The model does not account for active forest operations within forested areas. Other factors that affect the nutrient balance of a watershed such as groundwater, point-sources, and septic systems are also lumped together and each is treated as one unique source.

GWLF uses existing conventions and data to model surface runoff and soil erosion. The Soil Conservation Service Curve Number (SCS-CN) coupled with daily precipitation and temperature from the National Climatic Data Center (NCDC) is used to model surface runoff and streamflow. Evapotranspiration is determined using daily weather data and a cover factor dependent on land use/cover type. The Universal Soil Loss Equation (USLE) is used to model monthly erosion and sediment loss. Nutrients (nitrogen and phosphorus) are modeled

Figure 1.1. *AVGWLF model structure.*



With the ArcView interface, GIS data sets are loaded and the user is prompted to provide information related to "non-spatial" model parameters (e.g., beginning and end of the growing season; and the months during which manure is spread on agricultural land). This information is subsequently used to automatically derive values for required model input parameters, which are then written to the transport and nutrient input files needed to execute the GWLF model. Also accessed through the interface are Excel files that contain temperature and precipitation information used to create the necessary weather input file for a given watershed simulation. Both the transport and nutrient. input files can be edited via the use of an edit screen, and watershed-specific information such as livestock numbers and existing BMPs can be incorporated.

using export coefficients for both the dissolved and solid phases from each type of land use. (Evans et al. 2002, 2008). The general modeling approach for this TMDL was as follows: **1)** derive input data for GWLF for use in the impaired watersheds, **2)** simulate nutrient and sediment loads within the impaired watersheds, and **3)** compare simulated loads within the impaired watersheds against loads simulated within the watersheds of two nearby unimpaired attainment streams (Moose Brook and B Stream) that exhibit similar landscape, development and agricultural patterns. A TMDL target for the impaired watershed was established by comparing model results to the average annual nutrient and sediment loads calculated for the attainment watersheds.

The model evaluation was screening level, as model predictions represent rough estimates based on empirical data and are not calibrated to site specific data. Therefore, model predictions provide planning level estimates rather than exact predictions of loads entering streams. Specification of key model parameters is described in Section 3.

2. Approach and Background

A reference watershed approach was used to establish numeric endpoints for nitrogen and phosphorus non-point source loadings in nine subwatersheds of Prestile Stream (Figure 2.1.). The subwatershed approach was used to characterize which upstream waterbodies that nonpoint source pollution is stemming from, and to provide a basis for targeting specific areas of the watershed for improvement. The total loading from each of the subwatersheds was calculated as the total for the impaired stream as a whole. The approach was based on selecting two non-impaired watersheds that share similar land use and soil characteristics with the impaired watershed. Stream conditions in the attainment watersheds were assumed to be representative of the conditions needed for the impaired stream to obtain its designated uses. The numeric endpoint can be derived from the most representative attainment watershed or from the average of both attainment watersheds.

Two unimpaired attainment watersheds, Moose Brook and B Stream (Figure 2.2.), were identified based on watershed size, land cover, and recommendations from Maine DEP. These watersheds were selected because they had similar land use/land cover (primarily forested and agricultural) and bio-monitoring data indicated they support healthy benthic communities. A descrip-

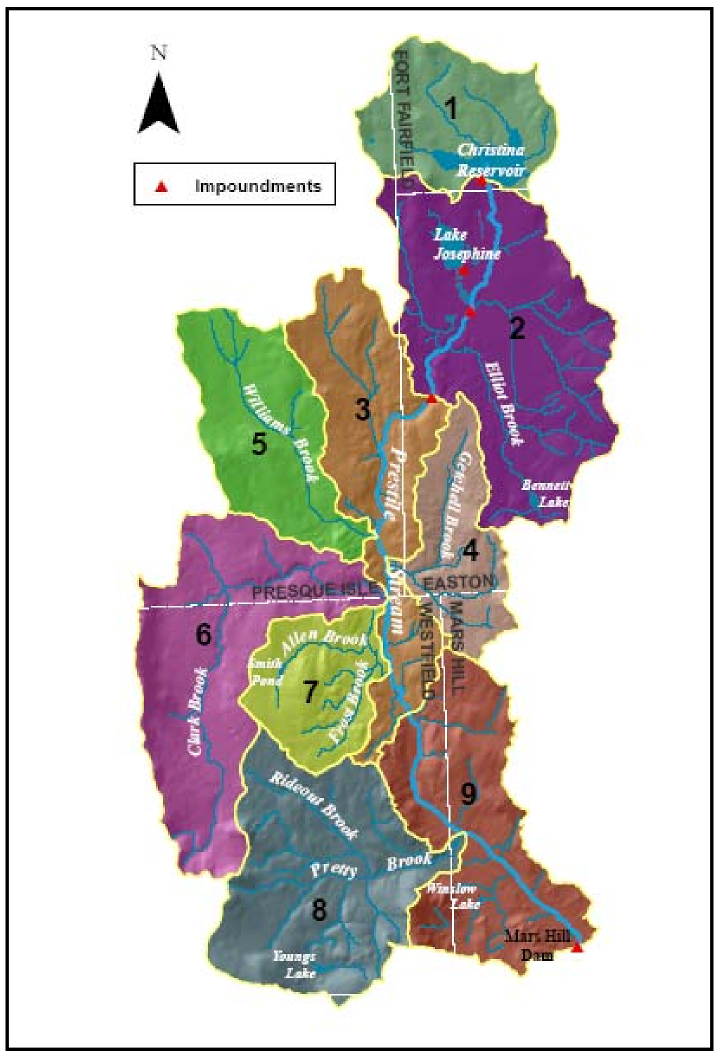


Figure 2.1. *The nine subwatersheds of Prestile Stream used in the GWLF model.*

tion of the impaired watershed and two attainment streams is provided in Table2.1.

Figure 2.2. *B Stream and Moose Brook watershed map.*

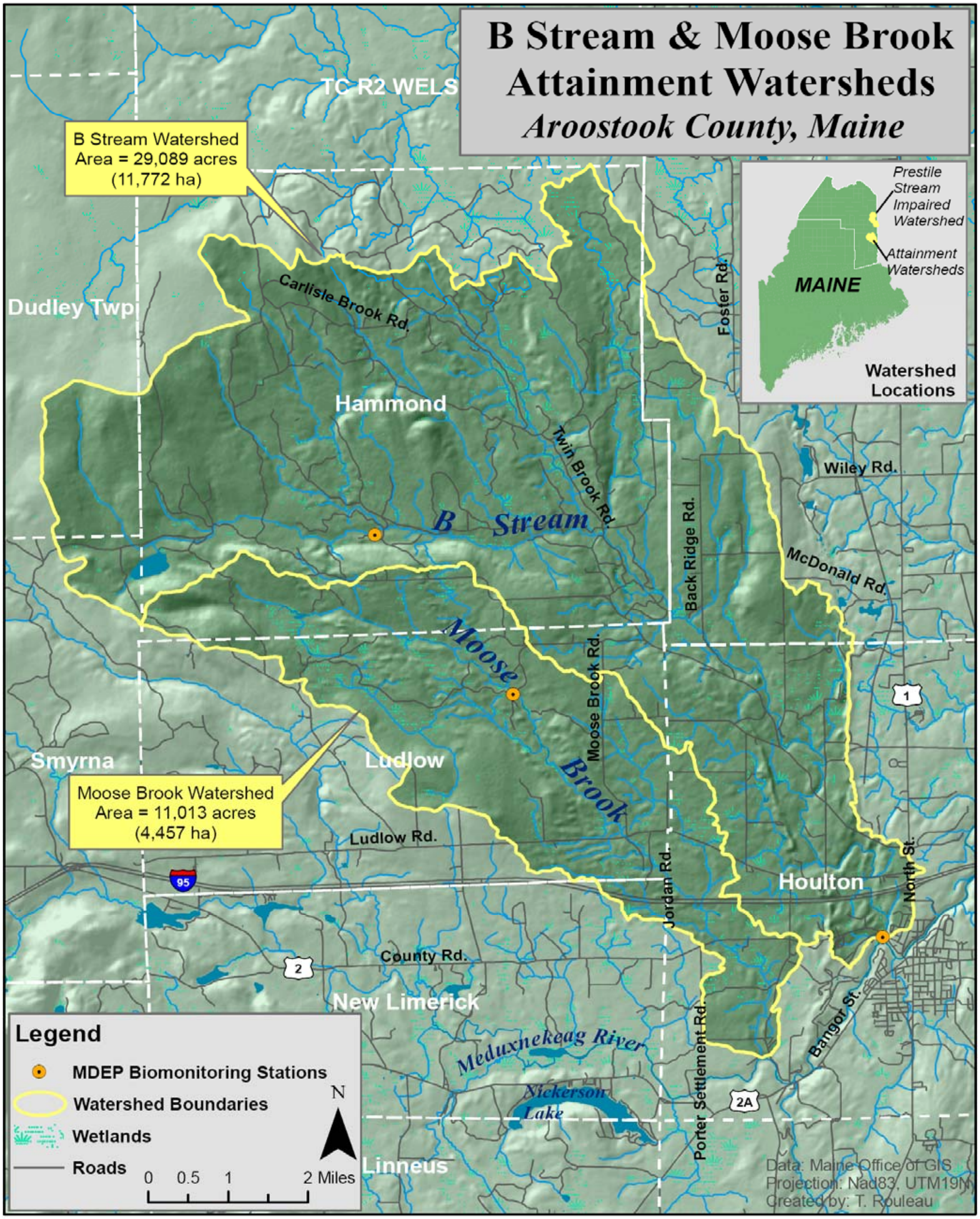


Table 2.1. *Watershed descriptions for B Stream, Moose Brook, and Prestile Stream.*

Watershed	Description
B Stream (Attainment Stream)	The B Stream watershed is part of the Big Presque Isle and Meduxnekeag Stream watershed (HUC 0101005) in Maine and New Brunswick. It's headwaters begin in the Town of Hammond, Maine. It flows southeast through Littleton and Houlton before termination at its confluence with Meduxnekeag Stream just south of U.S. Route 2 in Houlton. B Stream is approximately 17 miles in length and has a drainage area of 29,089 acres (11,772 ha).
Moose Brook (Attainment Stream)	The Moose Brook watershed is part of the Big Presque Isle and Meduxnekeag Stream watershed (HUC 0101005) in Maine and New Brunswick. It's headwaters begin in the Town of Hammond, Maine. It flows southeast through Ludlow and Houlton before termination at its confluence with Meduxnekeag Stream just south of U.S. Route 2A in Houlton. Moose Brook is approximately 11 miles in length and has a drainage area of 11,013 acres (4,457 ha).
Prestile Stream (Impaired Stream)	The Prestile Stream watershed is part of the Big Presque Isle and Meduxnekeag Stream and the larger St. John watershed (HUC 0101005) in Maine and New Brunswick. Its headwaters begin in the Town of Fort Fairfield, Maine at the outlet of Christina Reservoir. The impaired segment flows south through Easton, Presque Isle, Westfield and Mars Hill ending at the Mars Hill Dam. Below Mars Hill, the stream flows southeasterly to the Maine/New Brunswick Border where it joins the main stem of the St. John River. Prestile Stream is approximately 16 miles in length above the Mars Hill Dam, and has a drainage area of 43,434 acres (17,577 ha).

3. MODEL INPUTS

3.1 GIS Data

The modeling approach for the Prestile Stream watershed relied on the use of GIS shapefiles and grids developed for use with Northeast AVGWLF in New York and New England. Watershed boundary shapefiles and land use/cover data were obtained from the Maine Office of GIS (MEGIS) and all other GIS data was obtained from the New England Interstate Water Pollution Control Commission (NEIWPCC) website (Table 3.1). The GIS land use layer used for this analysis was created at the request of the Maine DEP Bureau of Land and Water Quality (BLWQ). The data is primarily derived from Landsat Thematic Mapping imagery from the years 1999-2001, and was further refined using panchromatic imagery from the spring and summer months of 2004. Land cover data for the watersheds was further edited and verified using 2006 National Agriculture Imagery Program (NAIP) aerial orthoimagery, and land use classes were recoded for use in AVGWLF. All GIS data were projected as follows:

- Projection: Custom GEOGCS, GCS_North_American_1983
- Datum: North_American_1983
- Unit: meters

Table 3.1. *GIS data used in the Prestile Stream AVGLWF application.*

File Names	Description	Required
Shape Files		
Weather stations	Weather station locations (points)	Y
Basins	Watershed boundary (polygons)	Y
Streams	Map of stream network (lines)	Y
Roads	Road map (lines)	N
Counties	County boundaries - for USLE data (polygons)	N
Septic Systems	Septic system numbers and types (polygons)	N
Animal density	Animal density (in AEUs per acres) (polygons)	N
Soils	Contains various soil-related data (polygons)	Y
Physiographic provinces	Contains hydrologic parameter data (polygons)	N
Grid Files		
Land use/cover	Map of land use/land cover (16 classes)	Y
Elevation	Elevation grid	Y
Groundwater-N	Background estimate of N in mg/l	N
Soil-P	Estimate of P in mg/kg (total or soil test P)	N

3.2 Input Files

As described earlier, the AVGWLF interface is used to create input files for the GWLF model. For execution, the GWLF model requires three separate input files containing transport parameters, nutrient parameters, and weather related data. The following sections summarize the model input parameters and the sources of data used for each file for the Prestile Stream and attainment watershed applications.

3.2.1 Weather

The weather file contains daily precipitation and temperature values. These data are available from the NCDC for a number of weather stations in Maine. For GWLF modeling of Prestile Stream and Christina Reservoir, data from Presque Isle (Station 6937) were used. For the attainment watersheds, B Stream and Moose Brook, weather data from Houlton (Station 3944) were used. Both sites have a record of concurrent precipitation and temperature data from 1990 to 2004. All model simulations were conducted over this 15-year period.

3.2.2 Transport

The transport file contains information about the physical properties of the watershed including landuse and soils, as well as information about the effects of the hydrologic cycle on the movement of water and sediment through the watershed.

AVGWLF model inputs for transport parameters are described in Table 3.2 and watershed-specific transport parameters generated for each watershed are shown in subsequent tables. These parameters include global transport parameters, seasonal transport parameters, and source area transport parameters. **Global parameters** apply to all source areas in the watershed and include the unsaturated water capacity, saturated storage capacity, initial snow amount, seepage coefficient, recession coefficient, and SDR. The unsaturated water capacity is a function of the maximum watershed rooting depth and the soil available water storage capacity. The seepage coefficient is a function of the loss of water to the deep aquifer. The recession coefficient is a function of the basin's hydrologic response to a precipitation event. The SDR specifies the percentage of eroded sediment delivered to surface water, and is a function of watershed area. These parameters were set to suggested default values for the Northeast AVGWLF model (Penn State 2007).

Table 3.2. *AVGWLF Transport file parameters.*

Parameter	Source	Value
Basin size	GIS/derived from basin boundaries	watershed-specific
Land use/cover distribution	GIS/derived from land cover map	watershed-specific
Curve numbers (CN) by source area	GIS/derived from land cover and soil maps	watershed-specific
USLE (KLSCP) factors by source area	GIS/derived from soil, DEM, and land cover	watershed-specific
ET cover coefficients	GIS/derived from land cover	watershed-specific
Erosivity coefficients	GIS/ derived from physiography map	watershed-specific
Daylight hrs. by month	Computed automatically	based on latitude
Growing season months	Input by user	assumed May-September
Initial saturated storage	Default value	0 cm
Initial unsaturated storage	Default value	10 cm
Recession coefficient	Default value	0.03
Seepage coefficient	Default value	0
Initial snow amount	Default value	0 cm
Sediment delivery ratio	GIS/based on basin size	watershed-specific
Soil water (available water capacity)	GIS/derived from soil map	watershed-specific

Source area transport parameters describe the spatial variation in hydrology, erosion, and nutrient loading in the watershed and include landuse areas, curve numbers, and Universal Soil Loss (USLE) parameters K, LS, C, and P. Land use areas were derived directly using the landuse GIS layer. The curve number (CN) parameter determines the amount of precipitation that infiltrates into the ground or enters surface water as runoff. Based on specified combinations of landuse and hydrologic soil type, CN is calculated directly using landuse and soil GIS layers. The USLE equation parameters, derived from the NRCS Natural Resources Inventory Database (NRI), determine soil erodibility. Source area transport parameters are listed below for Prestile Stream, B Stream, and Moose Brook.

Table 3.3. *Prestile Stream (Impaired Stream) Source Area Transport Parameters.*

Landuse	Area (hectares)	Percentage of Watershed	CN	K·LS·C·P
Hay/Pasture	975	6	75	0.0016
Cropland	7130	41	82	0.0109
Mixed Forest	6322	36	73	0.0001
Wetland	2464	14	87	0.0001
Non-vegetated/Disturbed[1]	58	<1	0	0
Low Intensity Development	543	3	83	0.0012
High Intensity Development	85	<1	93	0.0011
Total	***17,577***	***100***		

[1]Includes transitional land, gravel pits, and mines.

Table 3.4. *B Stream (Attainment Stream) Source Area Transport Parameters.*

Landuse	Area (hectares)	Percentage of Watershed	CN	K·LS·C·P
Hay/Pasture	239	2	75	0.0011
Cropland	807	7	82	0.0099
Mixed Forest	9,503	81	73	0.0043
Wetland	892	8	87	0.00004
Non-vegetated/Disturbed[1]	53	0	0	0
Low Intensity Development	230	2	83	0.0011
High Intensity Development	48	0	90	0.0010
Total	***11,772***	***100***		

Table 3.5. *Moose Brook (Attainment Stream) Source Area Transport Parameters.*

Landuse	Area (hectares)	Percentage of Watershed	CN	K·LS·C·P
Hay/Pasture	88	2	75	0.0009
Cropland	754	17	82	0.0105
Mixed Forest	2,820	63	73	0.0001
Wetland	703	16	87	0.00004
Non-vegetated/Disturbed[1]	5	<1	0	0
Low Intensity Development	82	2	83	0.0010
High Intensity Development	5	<1	90	0.0010
Total	***4,457***	***100***		

[1]Includes transitional land, gravel pits, and mines.

1 hectare = 2.47 acres

Model inputs for the **seasonal transport parameters** (below) account for seasonal variability in hydrology, erosion, and sedimentation. The monthly evapotranspiration cover coefficient, day length, and erosivity coefficient are calculated automatically within the model based on regional literature values (Haith et al. 1992).

Table 3.6. *Moose Brook (Attainment Stream) Source Area Transport Parameters.*

Month	Evapotranspiration Cover Coefficient	Daylight (hours)	Growing Season (0=no, 1=yes)	Erosivity Coefficient
January	0.60	8.7	0	0.07
February	0.65	9.9	0	0.07
March	0.68	11.7	0	0.07
April	0.70	13.5	0	0.13
May	0.88	15	1	0.13
June	0.99	15.7	1	0.13
July	1.05	15.3	1	0.13
August	1.09	14.1	1	0.13
September	1.11	12.3	1	0.13
October	0.95	10.5	0	0.07
November	0.85	9	0	0.07
December	0.80	8.3	0	0.07

Table 3.7. *B Stream and Moose Brook (Attainment watersheds) Seasonal Transport Parameters.*

	B Stream	Moose Broook			
Month	Evapotranspiration Cover Coefficient	Evapotranspiration Cover Coefficient	Daylight (hours)	Growing Season (0=no, 1=yes)	Erosivity Coefficient
January	0.63	0.65	9.2	0	0.07
February	0.68	0.70	10.3	0	0.07
March	0.71	0.73	11.7	0	0.07
April	0.72	0.75	13.3	0	0.13
May	0.88	0.91	14.5	1	0.13
June	0.97	1.00	15.1	1	0.13
July	1.02	1.05	14.8	1	0.13
August	1.05	1.08	13.7	1	0.13
September	1.07	1.10	12.3	1	0.13
October	0.93	0.96	10.7	0	0.07
November	0.85	0.88	9.5	0	0.07
December	0.81	0.84	8.9	0	0.07

3.2.3 Nutrients

The nutrient file specifies loading parameters for phosphorus and nitrogen in runoff and sediment. Dissolved nutrients, associated with overland runoff, point sources and subsurface discharges to the stream, are obtained by multiplying runoff volumes by average dissolved concentrations for both nitrogen and phosphorus. Sediment nutrients originate from point sources, soil erosion, and wash-off of material from impervious areas. AVGWLF model inputs for nutrient parameters are described in Table 3.8., and watershed-specific nutrient parameters generated for land uses in each watershed are shown in Table 3.9. Typical concentrations of nutrients in runoff are reported in the GWLF User's Manual and have been used in the Aroostook County AVGWLF model application.

Table 3.8. *AVGWLF Nutrient file parameters.*

Parameter	*Source*	*Value*
Dissolved N in runoff by land cover type	Default values/adjusted using AEU density	watershed-specific
Dissolved P in runoff by land cover type	Default values/adjusted using AEU density	watershed-specific
N/P concentrations in manure runoff	Default values/adjusted using AEU density	watershed-specific
Background N/P concentrations in GW	GIS/derived from groundwater N map	watershed-specific
Background P concentrations in soil	GIS/derived from soil P loading map	watershed-specific
Background N concentrations in soil	Based on map in GWLF Manual	3000 mg/kg
Months of manure spreading	Input by user	assumed June-September
Population on septic systems	GIS/derived from census tract map	watershed-specific
Per capita septic system loads (N/P)	Default values	12 g N/day, 2.5 g P/day

The nutrient file also contains parameters that define septic system loads such as the number of people who are serviced, the state of failure of the systems, per capita nutrient contributions, and the uptake of nutrients by plants during the growing season. Estimates of the septic systems in the watershed (Table 3.10) were generated based on 1990 Census data contained in the census GIS layer.

Table 3.9. *Nutrient Concentrations for watershed land uses.*

Rural Landuse	Dissolved Nitrogen (mg/L)	Dissolved Phosphorus (mg/L)
Hay/Pasture	2.9	0.331
Cropland	2.9	0.331
Forest	0.19	0.006
Wetland	0.19	0.006
Non-vegetated/Disturbed[1]	2.9	0.2
Manure	2.44	0.38
Urban Landuse Accumulation	**Nitrogen (kg/ha/day)**	**Phosphorus (kg/ha/day)**
Low Intensity Development	0.012	0.002
High Intensity Development	0.101	0.011

[1]Includes transitional land, gravel pits, and mines.

Table 3.10. *Prestile Stream, B Stream, and Moose Brook watershed septic status.*

Watershed	Population on Septic	Normal Systems	Ponding Systems	Short Circuit
Prestile Stream *(Impaired Stream)*	599	580	0	19
B Stream *(Reference Stream)*	419	384	0	35
Moose Brook *(Reference Stream)*	164	149	0	15

3.3 Additional Model Inputs

3.3.1 Farm Animals

Data on animal populations can be entered in GWLF via two mechanisms: 1) via direct typing of values into the appropriate cells, or 2) via use of GIS layer that contains farm animal density information. For the Northeast AVGWLF, county-level GIS data on animal populations and weights were developed using data from the National Agricultural Statistics Service. In this data layer, animal density is expressed in terms of animal equivalent units (AEUs) per acre, where one AEU is equal to 1000 pounds of animal weight. The GIS layer was used to determine animal densities in the attainment stream watersheds, while subwatershed-level estimates of farm animal populations were obtained from Maine DEP for Prestile Stream (Table 3.11). AVGWLF includes an option for adding detailed data on farm animal populations and utilizing this data to more directly calculate nutrient loads associated with these animals. Farm animal load calculations are made based on the assumption that nitrogen and phosphorus produced by farm animal populations can be transported to nearby water bodies via

Table 3.11. *Farm animals in the Prestile Stream watershed by subwatershed.*

Subwatershed	Name	Cattle	Horses	Pigs
1	Christina Reservoir	0	0	0
2	Lake Josephine	0	0	0
3	Prestile Main Stem 1	0	0	0
4	Getchell Brook	0	6	0
5	Williams Brook	9	0	0
6	Clark Brook	0	6	4
7	Allen/Frost Brooks	50	14	10
8	Pretty/Rideout Brooks	0	0	0
9	Prestile Main Stem 2	0	0	0
	Prestile Watershed Total:	***59***	***20***	***14***

In each case, it is assumed that there are typical production rates associated with different animal types that can be used to estimate the total amounts of nitrogen and phosphorus generated by the animal populations within a given watershed on a yearly basis. It is also assumed that there are different loss rates associated with each nutrient and transport mechanism that can be used to estimate the nitrogen and phosphorus loads delivered to surface water bodies each year as well..

3.3.2 Existing BMPs

Within GWLF, it is possible to estimate any load reductions that might result from existing BMPs and mitigation activities in a watershed. Reductions made are based on the extent to which different measures are applied and the reduction coefficients (Table 3.12) associated with those measures.

Pollutant-specific reduction coefficients associated with each BMP are used to decrease initial animal-generated loads on an annual basis.

	Typical Pollutant Removal (percent)		
BMP Type	Nitrogen	Phosphorus	Sediment
Vegetated Buffer Strips[1]	54	52	58
Crop Rotations	7	40	55
Cover Crops	43	32	15
Terraces and Diversions	44	42	71
Pasture Land Management	43	34	13
Streambank Protection	65	78	76
Nutrient Management[2]	19	28	*
Livestock AWMS[2]	75	75	*
Grassed Waterways[3]	30	30	48
Sediment Basin[3]	65	65	65

[1]Also called *Filter Strips* .
[2]Includes *Waste Storage Facilities* .
[3]Source: US EPA 1993 (median values).

Table 3.12. *Estimated BMP efficiencies in the Prestile Stream AVGWLF application by pollutant type.*

Based on information about existing BMPs from the Natural Resources Conservation Service (NRCS), the BMP efficiencies listed above were used to estimate load reductions in the Prestile Stream subwatersheds. Existing BMPs applied in these watersheds are listed in Table 3.13. The BMP efficiencies above are primarily based on information found in Evans et al. (2008), with additional estimated efficiencies for Grassed Waterways and Sediment Basins from US EPA (1993).

Table 3.13. *Existing BMPs in the subwatersheds of Prestile Stream**

Subwatershed/BMP Applied	Area	% of Watershed
#1 Christina Reservoir		
Cover Crop	61.1 ac	5%
		5%
#2 Lake Josephine		
Crop Rotation	96.6 ac	2%
Cover Crop	96.6 ac	2%
Nutrient Management	96.6 ac	2%
Waste Storage Facility	4225 sq ft	1%
		8%
#3 Prestile Mainstem 1		
Crop Rotation	392.4 ac	15%
Cover Crop	470.1 ac	18%
Nutrient Management	575.5 ac	22%
Grassed Waterway	0.6 ac	1%
		56%
#5 Williams Brook		
Crop Rotation	26 ac	2%
Cover Crop	26 ac	2%
		4%
#6 Clark Brook		
Crop Rotation	104.4 ac	8%
Cover Crop	104.4 ac	8%
Grassed Waterway	0.3 ac	1%
		17%
#8 Pretty/Rideout Brooks		
Crop Rotation	75.8 ac	6%
Cover Crop	75.8 ac	6%
Nutrient Management	75.8 ac	6%
Grassed Waterway	0.3 ac	1%
		18%

** Due to AVGWLF model limitations, not all existing BMPs could be incorporated into the model. These include irrigation related practices (irrigation pipeline, sprinkler) and subsurface drains.*

Values represent estimated percent reductions in surface runoff-associated loads. No sediment reduction value is given for nutrient management in the model since this BMP is typically not used for sediment reduction. As soil erosion control plans are an integral part of Maine Department of Agriculture's requirements for the development of nutrient management plans (Duncan 2008), we can expect that some sediment reduction is occurring on those farms with nutrient management plans. Therefore, sediment estimates may be slightly lower than reported in the watersheds with nutrient management plans. Similarly, local stakeholders suggests that the extent of documented BMPs provided by NRCS underestimates the number of practices that have been installed throughout the watershed, suggesting that reductions should be greater on agricultural land.

3.3.3 Lakes, Ponds, and Wetlands

For each of the watersheds, the pollutant-attenuating effects of lakes, ponds and wetlands were accounted for. This was achieved by estimating the total land area drained by lakes and wetlands, based on percentage of area upslope of each wetland or lake. For sediment and nutrient retention within these areas, the retention coefficients used were as follows: nitrogen (0.12), phosphorus (0.25), and sediment (0.90) (Penn State 2007). This goal of this simple methodology is to account for losses that occur as a result of wetlands and lakes in each watershed, not to simulate the complex processes that influence the transport of nutrients and sediment in watersheds where these features exist. In cases where such processes and losses are significant, not accounting for them could potentially result in overestimation of nutrient and sediment loads. The estimated percentage of land area drained by lakes, ponds, and wetlands in the watersheds are as follows: B Stream (10%), Moose Brook (20%), Prestile Stream (10%). Percentages for each of the nine subwatersheds of Prestile Stream are listed in Table 3.14.

T

Name	% Land Drained by Lakes/Ponds/Wetlands	Hectares Drained by Lakes/Ponds/Wetlands	Acres Drained by Lakes/Ponds/Wetlands
Christina Reservoir	70%	963	2380
Lake Josephine	40%	1307	3230
Prestile Main Stem 1	5%	105	259
Getchell Brook	10%	106	262
Williams Brook	35%	560	1384
Clark Brook	20%	527	1302
Allen/Frost Brooks	10%	103	255
Pretty/Rideout Brooks	10%	254	628
Prestile Main Stem 2	15%	331	818
Prestile Watershed Total:	***10%***	***4,256***	**10,517**

3.3.4 Sludge Application

McCain Foods has approximately 654 acres licensed for the utilization of food (potato solids) sludge in both the Christina Reservoir and Lake Josephine subwatersheds. Another 57 acres are licensed for spreading sanitary waste sludge. The acreage is used on a rotational basis so that not all acreage is used in a given year. For example, in 2007, only 160 acres were used for land application of food processing sludge, and only one acre was used for the land application of sanitary (sewage) sludge (Duncan 2008).

The Maine Department of Environmental Protection (DEP) approved a request by McCain Foods for a program license to beneficially and agronomically utilize digested food (potato) processing waste and a minor amount of treated sewage sludge on separate portions of existing agricultural land in the Christina Reservoir and Lake Josephine subwatersheds. The purpose of the program license under the *Maine Solid Waste Management Rules*: *General Provisions*, 06-096 CMR 400, and *Agronomic Utilization of Residuals*, 06-096 CMR 419, is to establish a monitoring program for the residual; assess the benefits of utilization; establish management protocols to protect public health, welfare, and the environment; and determine if site-specific licenses are necessary for utilization or storage of the residual.

In approving McCain Foods request for a program license, DEP concluded that McCain Foods operated the utilization program in accordance with applicable operating standards. Review and approval by the DEP must be obtained for new utilization sites. In approving various site-specific licenses for crop land on which the residual is land applied, DEP concluded that McCain Foods has the technical ability to operate the project in a manner consistent with State environmental standards; the project(s) fit harmoniously into the existing natural environment and will not adversely effect existing uses, scenic character, air quality, water quality or other natural resources; and will be on suitable soil types and will not cause unreasonable erosion of soil or sediment, nor inhibit the natural transfer of soil.

The various licensing criteria, operating standards, etc. include that residuals are evenly applied at or less than maximum allowable application rates for nitrogen and plant uptake rates for phosphorus. Nitrogen load rate calculations must account for mineralized (carry-over) nitrogen. Furthermore, crops must be harvested and removed from the field prior to continued utilization, unless the next year’s nutrient budget is adjusted to account for the nutrients returned by the crop. Operating and siting standards require that specific distances, land slopes and soil depths, setbacks and buffers from surface waters (including drainage features such as ditches, swales, etc), bedrock and outcrops, be maintained from the boundary of the project site.

McCain Foods is required to report annually the volume of residual generated, utilized and/or stored, a list of (licensed) utilization sites and loading rates at those sites, as well as analytical data and soil test report(s). In addition to reviewing the information provided in the annual report, the DEP also performs facility and utilization site inspections on a routine basis to assure compliance with the applicable operating and siting requirements/standards.

Frequent compliance inspections by DEP staff indicate that McCain Foods has and continues to operate their licensed residual utilization program and cropland sites in significant compliance with applicable requirements and standards (Duncan 2008). Therefore, careful application of current practices is not expected to have a marked effect on nutrient loading in the Prestile Stream watershed (Duncan 2008).

Similarly, Naturally Potatoes, located in the southern end of the Prestile Stream watershed (Prestile Mainstem 2 subwatershed), is licensed to spray irrigate potato processing effluent in the Pretty Brook/Rideout Brook subwatershed. From spring through fall, the waste is sprayed on 111 acres (45 ha) at a rate of 54,300 gallons/acre/week. During the winter, the waste is sprayed as snow-fluent on 7.5 acres (3 ha) at a rate of 24 million gallons per month. Estimating the actual loading from these land uses practice cannot be done accurately using the existing watershed loading model.

Since these land uses are not expected to have a marked effect on nutrient loading in the Prestile Stream watershed, and the model does not account for this type of land use, sludge and waste water application of both processing and sanitary waste were not included in the total nutrient load to Prestile Stream or Christina Reservoir.

4. RESULTS

The impaired watershed (Prestile Stream) and attainment watersheds (B Stream and Moose Brook) models were run for a 15-year period (1990 to 2004). It was assumed that this period captured sufficient hydrologic and weather conditions to account for typical variations in nutrient loading conditions. Model results are presented as annual loads rather than monthly loads since the model is not calibrated to account for frozen ground, and since monthly loading is the least accurate aspect of the model (Evans 2008). The 15-year means for total nitrogen, and total phosphorus, and sediment loads by land use were determined for the attainment streams and Prestile Stream watershed (Tables 4.1 - 4.3, Figures 4.1 - 4.2), as well as for Prestile Stream by subwatersheds (Tables 4.4 - 4.6, Figure 4.3). Estimated reductions for Prestile Stream are presented by subwatershed in Table 4.7.

Watershed Nitrogen, Phosphorus, and Sediment Loads by Source:

Table 4.1. *Watershed Nitrogen loads by source for Prestile Stream and attainment streams.*

	B Stream		Moose Brook		Prestile Stream	
Source	Total N (kg/year)	Total N (%)	Total N (kg/year)	Total N (%)	Total N (kg/year)	Total N (%)
Hay/Pasture	857	2%	312	1%	3289	2%
Cropland	4985	11%	4645	18%	40129	21%
Forest	1954	4%	577	2%	807	<1%
Wetland	501	1%	391	2%	1255	1%
Bare Land	0	0%	0	0%	220	<1%
Farm Animals	0	0%	0	0%	388	<1%
Groundwater	36752	81%	19644	77%	141472	75%
Septic Systems	176	<1%	73	<1%	122	<1%
Total	***45,225***	***100%***	***25,642***	***100%***	***187,682***	***100%***
Unit Area Loads	***3.84***		***5.75***		***9.80***	

1 kilogram is equivalent to ~ 2.2 pounds

Figure 4.1. *Prestile Stream nitrogen loads by source.*

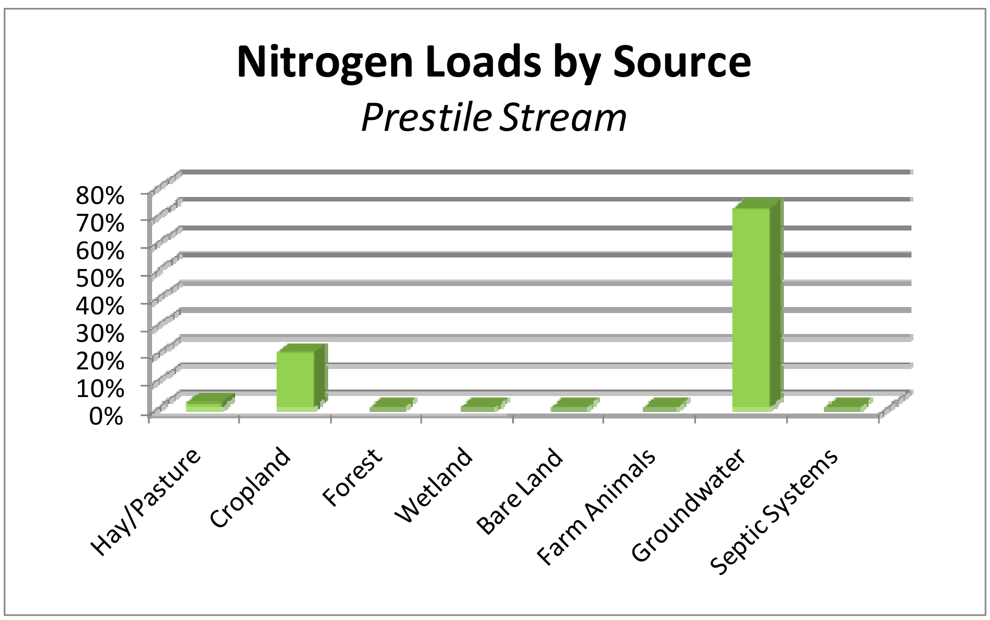


Table 4.2. *Watershed Phosphorus loads by source for Prestile Stream and attainment streams.*

Source	B Stream		Moose Brook		Prestile Stream	
	Total P (kg/year)	Total P (%)	Total P (kg/year)	Total P (%)	Total P (kg/year)	Total P (%)
Hay/Pasture	91	5%	33	3%	390	5%
Cropland	564	28%	532	49%	5469	67%
Forest	64	3%	20	2%	34	<1%
Wetland	16	1%	12	1%	40	<1%
Bare Land	0	0%	0	0%	27	1%
Farm Animals	0	0%	0	0%	110	1%
Groundwater	1251	62%	482	44%	2044	25%
Septic Systems	29	1%	12	1%	14	<1%
Total	***2,015***	***100%***	***1,091***	***100%***	***8,128***	***100%***
Unit Area Loads	***0.17***		***0.24***		***0.42***	

1 kilogram is equivalent to ~ 2.2 pounds

Figure 4.2. *Prestile Stream phosphorus loads by source.*

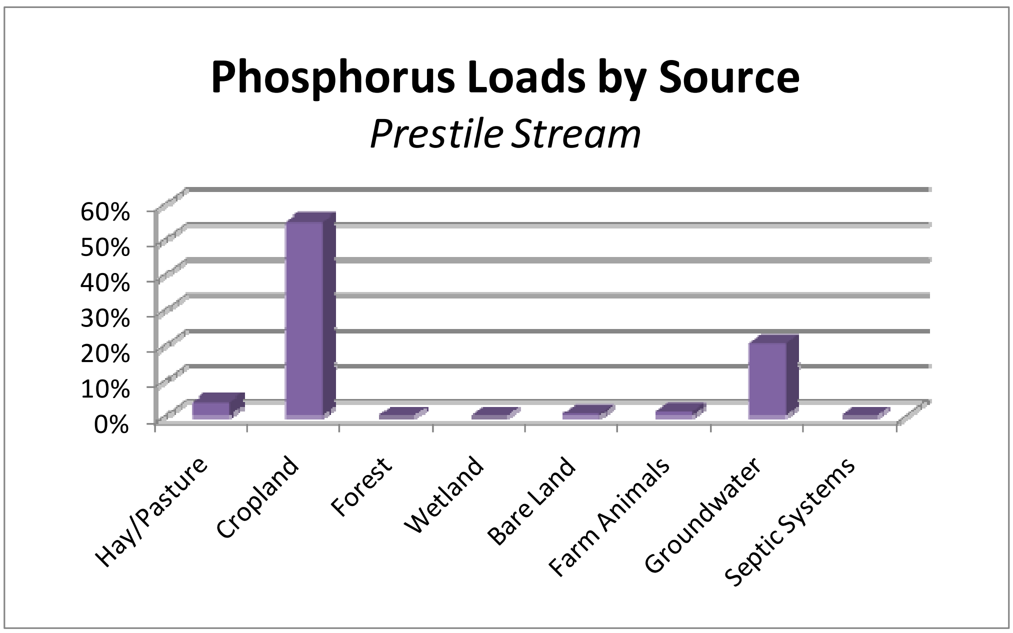


Table 4.3. *Watershed Sediment loads by source for Prestile Stream and attainment streams.*

Source	B Stream		Moose Brook		Prestile Stream	
	Sediment (t/year)	Sediment (%)	Sediment (t/year)	Sediment (%)	Sediment (t/year)	Sediment (%)
Hay/Pasture	3	3%	1	1%	22	2%
Cropland	88	92%	104	92%	1191	95%
Forest	5	5%	3	3%	12	1%
Wetland	0	0%	1	<1%	2	<1%
Bare Land	0	0%	4	4%	17	2%
Total	***95***	***100%***	***113***	***100%***	***1,244***	***100%***
Unit Area Loads	***0.01***		***0.03***		***0.06***	

Table 4.4. *Watershed Nitrogen loads by source for the nine subwatersheds of Prestile Stream.*

	1 Christina Reservoir		2 Lake Josephine		3 Prestile Mainstem 1		4 Getchell Brook		5 Williams Brook	
Source	**Total N (kg/year)**	**Total N (%)**	**Total N (kg/year)**	**Total N (%)**	**Total N (kg/year)**	**Total N (%)**	**Total N (kg/year)**	**Total N (%)**	**Total N (kg/year)**	**Total N (%)**
Hay/Pasture	812	6%	570	2%	604	2%	412	3%	48	<1%
Cropland	3271	22%	8680	24%	4978	18%	3369	22%	5441	23%
Forest	25	<1%	85	<1%	116	<1%	49	<1%	81	<1%
Wetland	146	1%	397	1%	101	<1%	55	<1%	74	<1%
Bare Land	0	0%	0	<1%	10	<1%	10	<1%	10	<1%
Farm Animals	0	0%	0	0%	0	0%	0	0%	49	0%
Groundwater	10275	71%	26313	73%	22340	79%	11296	74%	17978	76%
Septic Systems	12	<1%	30	<1%	14	<1%	7	<1%	9	<1%
Total	***14,541***	***100%***	***36,074***	***100%***	***28,164***	***100%***	***15,197***	***100%***	***23,689***	***100%***
Unit Area Loads	*11.7*		*11.3*		*13.4*		*14.4*		*14.8*	

	6 Clark Brook		7 Allen/Frost Brooks		8 Pretty/Rideout Brooks		9 Prestile Mainstem 2		**Prestile Stream Watershed Total**	
Source	**Total N (kg/year)**	**Total N (%)**	**Total N (kg/year)**	**Total N (%)**	**Total N (kg/year)**	**Total N (%)**	**Total N (kg/year)**	**Total N (%)**	**Total N (kg/year)**	**Total N (%)**
Hay/Pasture	203	1%	170	1%	87	1%	383	2%	3289	2%
Cropland	2944	17%	2818	22%	3001	20%	5627	23%	40129	21%
Forest	127	1%	58	<1%	123	1%	145	1%	807	<1%
Wetland	158	1%	82	1%	118	1%	125	1%	1255	<1%
Bare Land	57	<1%	10	<1%	21	<1%	102	0%	220	<1%
Farm Animals	37	<1%	303	2%	0	0%	0	0%	388	<1%
Groundwater	14276	80%	9398	73%	11475	77%	18122	74%	141472	75%
Septic Systems	15	<1%	7	<1%	14	<1%	13	0%	122	<1%
Total	***17,817***	***100%***	***12,845***	***100%***	***14,838***	***100%***	***24,518***	***100%***	***187,682***	***100%***
Unit Area Loads	*6.8*		*14.4*		*6.8*		*11.3*		*9.8*	

1 kilogram is equivalent to ~ 2.2 pounds

Table 4.5. *Watershed Phosphorus loads by source for the nine subwatersheds of Prestile Stream.*

	1 Christina Reservoir		2 Lake Josephine		3 Prestile Mainstem 1		4 Getchell Brook		5 Williams Brook	
Source	**Total P (kg/year)**	**Total P (%)**	**Total P (kg/year)**	**Total P (%)**	**Total P (kg/year)**	**Total P (%)**	**Total P (kg/year)**	**Total P (%)**	**Total P (kg/year)**	**Total P (%)**
Hay/Pasture	88	14%	67	4%	77	7%	54	8%	6	1%
Cropland	400	65%	1150	73%	771	68%	499	71%	778	77%
Forest	1	<1%	3	<1%	4	<1%	2	<1%	3	<1%
Wetland	4	<1%	12	1%	3	0%	2	0%	2	<1%
Bare Land	0	0%	0	0%	1	<1%	1	<1%	1	<1%
Farm Animals	0	0%	0	0%	0	0%	0	0%	11	1%
Groundwater	122	20%	342	22%	281	25%	144	20%	211	21%
Septic Systems	1	<1%	4	<1%	2	<1%	1	<1%	1	<1%
Total	***617***	***100%***	***1,578***	***100%***	***1,140***	***100%***	***703***	***100%***	***1,014***	***100%***
Unit Area Loads	***0.49***		***0.49***		***0.54***		***0.67***		***0.63***	

	6 Clark Brook		7 Allen/Frost Brooks		8 Pretty/Rideout Brooks		9 Prestile Mainstem 2		**Prestile Stream Watershed Total**	
Source	**Total P (kg/year)**	**Total P (%)**	**Total P (kg/year)**	**Total P (%)**	**Total P (kg/year)**	**Total P (%)**	**Total P (kg/year)**	**Total P (%)**	**Total P (kg/year)**	**Total P (%)**
Hay/Pasture	22	3%	21	3%	9	1%	45	4%	390	5%
Cropland	357	51%	390	61%	360	55%	764	70%	5469	67%
Forest	7	1%	2	<1%	6	<1%	6	1%	34	<1%
Wetland	5	1%	3	0%	4	<1%	4	<1%	40	<1%
Bare Land	7	1%	1	<1%	2	<1%	12	1%	27	0%
Farm Animals	9	1%	89	14%	0	0%	0	0%	110	1%
Groundwater	284	41%	130	20%	267	41%	262	24%	2044	25%
Septic Systems	2	<1%	1	<1%	2	<1%	2	<1%	14	<1%
Total	***694***	***100%***	***636***	***100%***	***650***	***100%***	***1,095***	***100%***	***8,128***	***100%***
Unit Area Loads	***0.26***		***0.62***		***0.26***		***0.50***		***0.42***	

1 t/ha/year = 809.37 lbs/acre/year and 1 kg/ha/year = 0.892 lbs/acre/year

Table 4.6. *Watershed Sediment loads by source for the nine subwatersheds of Prestile Stream.*

	1 Christina Reservoir		2 Lake Josephine		3 Prestile Mainstem 1		4 Getchell Brook		5 Williams Brook	
Source	**Sediment (t/year)**	**Sediment (%)**	**Sediment (t/year)**	**Sediment (%)**	**Sediment (t/year)**	**Sediment (%)**	**Sediment (t/year)**	**Sediment (%)**	**Sediment (t/year)**	**Sediment (%)**
Hay/Pasture	3	6%	2	1%	6	3%	5	4%	0.2	0%
Cropland	50	94%	187	98%	206	97%	122	95%	130	99%
Forest	0.2	<1%	0.4	<1%	1	<1%	0.4	<1%	0.4	<1%
Wetland	0.2	<1%	0.5	<1%	0.2	<1%	0.1	<1%	0.1	<1%
Bare Land	0	0%	0	0%	1	<1%	1	1%	1	<1%
Total	***53***	***100%***	***190***	***100%***	***213***	***100%***	***129***	***100%***	***131***	***100%***
Unit Area Loads	*0.04*		*0.06*		*0.10*		*0.12*		*0.08*	

	6 Clark Brook		7 Allen/Frost Brooks		8 Pretty/Rideout Brooks		9 Prestile Mainstem 2		**Prestile Stream Watershed Total**	
Source	**Sediment (t/year)**	**Sediment (%)**	**Sediment (t/year)**	**Sediment (%)**	**Sediment (t/year)**	**Sediment (%)**	**Sediment (t/year)**	**Sediment (%)**	**Sediment (t/year)**	**Sediment (%)**
Hay/Pasture	2	2%	1.1	1%	0.4	<1%	3	1%	22	2%
Cropland	91	88%	91.1	97%	118	96%	196	95%	1191	96%
Forest	4.4	4%	0.4	<1%	3	3%	1.5	1%	12	1%
Wetland	0.3	<1%	0.2	<1%	0.3	<1%	0.2	<1%	2	<1%
Bare Land	5	5%	1	1%	2	1%	7	3%	17	1%
Total	***103***	***100%***	***94***	***100%***	***123***	***100%***	***207***	***100%***	***1,244***	***100%***
Unit Area Loads	*0.04*		*0.09*		*0.05*		*0.10*		*0.06*	

Figure 4.3. *Percent of sediment delivered by cropland within the subwatersheds of Prestile Stream.*

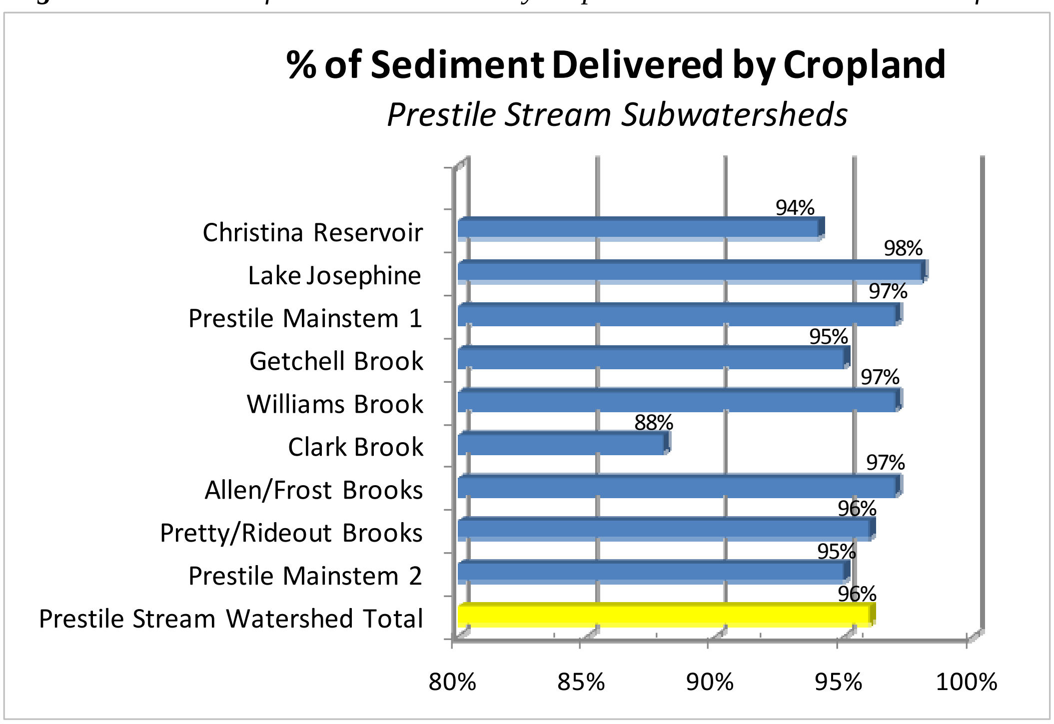


Table 4.7. *Estimated load reductions needed for Prestile Stream by subwatershed, and for total watershed.*

Sub-watershed	Name	Sediment (t/ha/yr)	Total N (kg/ha/yr)	Total P (kg/ha/yr)	Sediment % Reduction	Total N % Reduction	Total P % Reduction
	Reference Waterbodies[1]	0.02	4.80	0.21	-	-	-
1	Christina Reservoir	0.04	11.70	0.49	50%	59%	57%
2	Lake Josephine	0.06	11.30	0.49	67%	58%	57%
3	Prestile Main Stem 1	0.10	13.44	0.54	80%	64%	61%
4	Getchell Brook	0.12	14.38	0.67	83%	67%	69%
5	Williams Brook	0.08	14.81	0.63	75%	68%	67%
6	Clark Brook	0.04	6.76	0.26	50%	29%	21%
7	Allen/Frost Brooks	0.09	12.45	0.62	78%	61%	66%
8	Pretty/Rideout Brooks	0.05	6.80	0.26	60%	29%	19%
9	Prestile Main Stem 2	0.10	11.27	0.50	80%	57%	58%
	Total	***0.06***	***9.80***	***0.42***	***69%***	***51%***	***51%***

[1]Average of unit area loads for B Stream and Moose Brook.

1 t/ha/year = 809.37 lbs/acre/year and 1 kg/ha/year = 0.892 lbs/acre/year

APPENDIX B. Alternate Computational Methods for Setting the Water Quality Target for Christina Reservoir

All pollutant sources are calculated as one existing load, representing non-point and stormwater or general watershed runoff. The allocations include the entire watershed, upstream of the end of the impaired segment. The phosphorus load for Christina Reservoir was calculated for aqueous concentrations in samples collected from both the deep hole and the dam outlet between 2001- 2004. Mean annual discharge of the reservoir was determined using stream flow calculations from Dudley (2004). A number of parameters were required for input into these formulas including: Drainage area; % of significant sand and gravel aquifers; distance from the watershed to a predetermined line off the Maine coast; and mean annual precipitation. These parameters were determined using GIS (ArcGIS 9).

Load Calculations:

Aqueous Concentration (mg/L) * Discharge (L/seconds) = Load (mg/seconds)

Load in 'mg/seconds' converts to 'kg/year'

Load Reduction Calculation:

[(EL-LC)/EL] * 100 = % Reduction

EL = Existing In-Stream Load

LC = Loading Capacity

Nutrient	Target Concentration	Allowable Load	Avg. Measured Concentration	Avg. Measured Load	% Reduction
	mg/L	kg/L	mg/L	kg/L	
Total Phosphorus	0.028	205	0.052	396	48

The target concentration of 0.028 mg/L was chosen based on a goal set by Maine DEP staff, as described in Section 3 of this report. Reductions calculated using this method show that the reductions determined using the AVGWLF model are more conservative and therefore will be used to set the Christina Reservoir TMDL.

APPENDIX C. Bird Species Seen in Christina Reservoir and Lake Josephine from 1990-2008 (Sheehan 2008).

SPECIES SEEN
All Dates ~ in Christina Res. ~ 144 seen

LOONS
Common Loon
GREBES
Pied-billed Grebe
Red-necked Grebe
CORMORANTS
Double-crested Cormorant
HERONS, EGRETS AND BITTERNS
Great Blue Heron
Great Egret
Green Heron
Least Bittern
American Bittern
DUCKS, GEESE AND SWANS
Snow Goose
Canada Goose
Wood Duck
American Wigeon
Gadwall
Green-winged Teal
Mallard
American Black Duck
Northern Pintail
Blue-winged Teal
Northern Shoveler
Ring-necked Duck
Greater Scaup
Lesser Scaup
Common Eider
Long-tailed Duck
Surf Scoter
Common Goldeneye
Hooded Merganser
Red-breasted Merganser
Common Merganser
Ruddy Duck
OSPREY
Osprey
HAWKS, EAGLES AND KITES
Bald Eagle
Northern Harrier
Cooper's Hawk
Northern Goshawk
Broad-winged Hawk
Red-tailed Hawk
Rough-legged Hawk
FALCONS AND CARACARAS
American Kestrel
Merlin
Peregrine Falcon
GROUSE, PTARMIGAN, PRAIRIE-CHICKENS
Ruffed Grouse
RAILS, GALLINULES AND COOTS
Virginia Rail
Sora
Common Moorhen
American Coot
PLOVERS AND LAPWINGS
American Golden-Plover
Black-bellied Plover
Semipalmated Plover
Killdeer
SANDPIPERS
American Woodcock
Wilson's Snipe
Short-billed Dowitcher
Upland Sandpiper
Greater Yellowlegs
Lesser Yellowlegs
Solitary Sandpiper
Spotted Sandpiper
Semipalmated Sandpiper
Least Sandpiper
Pectoral Sandpiper
Dunlin
GULLS
Ring-billed Gull
Great Black-backed Gull
Herring Gull
Bonaparte's Gull
TERNS
Common Tern
Black Tern
PIGEONS AND DOVES
Rock Dove
Mourning Dove
OWLS
Snowy Owl
Short-eared Owl
HUMMINGBIRDS
Ruby-throated Hummingbird
KINGFISHERS
Belted Kingfisher
WOODPECKERS
Yellow-bellied Sapsucker
Downy Woodpecker
Hairy Woodpecker
Northern Flicker
Pileated Woodpecker
TYRANT FLYCATCHERS
Olive-sided Flycatcher
Eastern Wood-Pewee
Alder Flycatcher
Least Flycatcher
Great Crested Flycatcher
Eastern Kingbird
SWALLOWS
Tree Swallow
Bank Swallow
Cliff Swallow
Barn Swallow
WAGTAILS AND PIPITS
American Pipit
WAXWINGS
Cedar Waxwing
WRENS
Marsh Wren
MOCKINGBIRDS AND THRASHERS
Gray Catbird
Northern Mockingbird
THRUSHES
Veery
Hermit Thrush
American Robin
CHICKADEES AND TITS
Black-capped Chickadee
NUTHATCHES
Red-breasted Nuthatch
SHRIKES
Northern Shrike
CROWS AND JAYS
Blue Jay
American Crow
Common Raven
STARLINGS
European Starling
VIREOS AND ALLIES
Blue-headed Vireo
Warbling Vireo
Red-eyed Vireo
WOOD WARBLERS
Nashville Warbler
Yellow Warbler
Chestnut-sided Warbler
Black-throated Blue Warbler
Yellow-rumped Warbler
Black-throated Green Warbler
Blackburnian Warbler
Palm Warbler
Blackpoll Warbler
Black-and-white Warbler
American Redstart
Ovenbird
Northern Waterthrush
Common Yellowthroat
SPARROWS, TOWHEES, JUNCOS
American Tree Sparrow

SPECIES SEEN
All Dates ~ in Christina Res. ~ 144 seen

Chipping Sparrow
Savannah Sparrow
Song Sparrow
Swamp Sparrow
White-crowned Sparrow
White-throated Sparrow
Dark-eyed Junco
Snow Bunting

SALTATORS, CARDINALS AND ALLIES

Rose-breasted Grosbeak

BLACKBIRDS, ORIOLES, GRACKLES, ETC.

Bobolink
Red-winged Blackbird
Eastern Meadowlark
Common Grackle
Brown-headed Cowbird
Baltimore Oriole

FINCHES, SISKINS, CROSSBILLS

Pine Grosbeak
Purple Finch
Common Redpoll
Pine Siskin
American Goldfinch
Evening Grosbeak

////------- STATISTICS -------/////

Species seen - 144

SPECIES SEEN
All Dates ~ in Lake Josephine ~ 138 seen

LOONS
Common Loon
GREBES
Pied-billed Grebe
Red-necked Grebe
Horned Grebe
CORMORANTS
Double-crested Cormorant
HERONS, EGRETS AND BITTERNS
Great Blue Heron
Great Egret
American Bittern
DUCKS, GEESE AND SWANS
Canada Goose
Wood Duck
Eurasian Wigeon
American Wigeon
Gadwall
Green-winged Teal
Mallard
American Black Duck
Northern Pintail
Blue-winged Teal
Northern Shoveler
Redhead
Ring-necked Duck
Greater Scaup
Lesser Scaup
Common Eider
Long-tailed Duck
Black Scoter
Surf Scoter
White-winged Scoter
Common Goldeneye
Bufflehead
Hooded Merganser
Red-breasted Merganser
Common Merganser
Ruddy Duck
OSPREY
Osprey
HAWKS, EAGLES AND KITES
Bald Eagle
Northern Harrier
Sharp-shinned Hawk
Northern Goshawk
Red-tailed Hawk
Rough-legged Hawk
FALCONS AND CARACARAS
American Kestrel
Merlin
Peregrine Falcon
RAILS, GALLINULES AND COOTS
Virginia Rail
Sora
Common Moorhen
American Coot
PLOVERS AND LAPWINGS
American Golden-Plover
Black-bellied Plover
Semipalmated Plover
Killdeer
SANDPIPERS
Wilson's Snipe
Short-billed Dowitcher
Upland Sandpiper
Greater Yellowlegs
Lesser Yellowlegs
Solitary Sandpiper
Spotted Sandpiper
Semipalmated Sandpiper
Least Sandpiper
White-rumped Sandpiper
Pectoral Sandpiper
Dunlin
Stilt Sandpiper
GULLS
Ring-billed Gull
Great Black-backed Gull
Iceland Gull
Herring Gull
Bonaparte's Gull
TERNS
Common Tern
PIGEONS AND DOVES
Rock Dove
Mourning Dove
HUMMINGBIRDS
Ruby-throated Hummingbird
KINGFISHERS
Belted Kingfisher
WOODPECKERS
Downy Woodpecker
Hairy Woodpecker
Northern Flicker
Pileated Woodpecker
TYRANT FLYCATCHERS
Alder Flycatcher
Least Flycatcher
Eastern Phoebe
Eastern Kingbird
LARKS
Horned Lark
SWALLOWS
Tree Swallow
Bank Swallow
Cliff Swallow
Barn Swallow
WAGTAILS AND PIPITS
American Pipit
KINGLETS
Golden-crowned Kinglet
Ruby-crowned Kinglet
WAXWINGS
Cedar Waxwing
MOCKINGBIRDS AND THRASHERS
Gray Catbird
THRUSHES
Veery
American Robin
CHICKADEES AND TITS
Black-capped Chickadee
CROWS AND JAYS
Blue Jay
American Crow
Common Raven
STARLINGS
European Starling
VIREOS AND ALLIES
Blue-headed Vireo
Warbling Vireo
Red-eyed Vireo
WOOD WARBLERS
Tennessee Warbler
Nashville Warbler
Northern Parula
Yellow Warbler
Chestnut-sided Warbler
Magnolia Warbler
Yellow-rumped Warbler
Black-throated Green Warbler
Blackpoll Warbler
Black-and-white Warbler
American Redstart
Northern Waterthrush
Common Yellowthroat
SPARROWS, TOWHEES, JUNCOS
American Tree Sparrow
Chipping Sparrow
Savannah Sparrow
Song Sparrow
Swamp Sparrow
White-crowned Sparrow
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All Dates ~ in Lake Josephine ~ 138 seen

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FINCHES, SISKINS, CROSSBILLS

Pine Grosbeak
Purple Finch
White-winged Crossbill
Common Redpoll
Pine Siskin
American Goldfinch
Evening Grosbeak

////------- STATISTICS -------/////

Species seen - 138

APPENDIX D. Public Review Comments Received and Responses

Comments on the Prestile Stream and Christina Reservoir TMDL Public Draft dated August 2008.

Bill Sheehan
Division of Water Quality Management
MDEP, Northern Maine Regional Office

Here are my comments regarding the draft Total Maximum Daily Load (TMDL) report for the Prestile Stream and Christina Reservoir. I have considered this TMDL document an important one, since it addresses the water quality of a watershed that contains a large portion of this region's farmland, industrial facilities that constitute three of the largest employers in the area and a wetland complex that is exceptional in the eastern US in its diversity and numbers of wildlife species it supports. The watershed is also regionally important for the recreational opportunities it currently supports. This TMDL is intended to provide an accurate characterization of the causes of impairment in this watershed and will provide guidance for water quality improvement activities and attempt to direct our limited resources toward the appropriate restorative measures. I assume that the TMDL will decisions regarding any wastewater discharges, industrial, commercial and residential development agriculture and other stormwater management activities in the watershed for the foreseeable future.

I assume the Department wants to assure the impairment is well documented and understood and that the conclusions and recommendations provided by the TMDL are correct ones. However, I am concerned that the Department and its contractor have not yet provided a document that has thoroughly addressed the impairment situation in the upper Prestile. Below I have listed some items that I feel were either inadequately treated or inappropriately omitted from the document .

In general, I feel the Department has not well supported its assertion that non-point source (NPS) pollution is the cause of the impairment in the upper Prestile and hasn't thoroughly examined other possibilities for the water quality conditions observed here. The Department appears unclear that the recommendations made by the TMDL will attain the stated goal of achieving an "A" classification and there seems to be doubt among staff that the Prestile is correctly classified as a Class A stream.

The use of GWLF model and the comparative watershed approach seems problematic. The use of Moose Brook and B Stream (which are characteristically very different from the Prestile) as reference watersheds has resulted in recommendations of apparently unrealistic percentage reduction goals to achieve attainment.

The process for producing this TMDL also seems somewhat rushed and not thorough. The Department should take the time to consider other data not included in the analysis offered this draft.

Source(s) of impairment in Christina and the Prestile Stream.

The latest public draft of the Prestile Stream TMDL identifies the source of the impairment of Christina Reservoir and Prestile Stream as nonpoint source pollutants (NPS) associated with agricultural lands in the watershed.

"Prestile Stream is impaired by nonpoint source runoff from the many anthropogenic activities within the watershed. All land disturbances have the potential to contribute runoff, but the degree of disturbance associated with agricultural land is likely the greatest contributor of silt and nutrient enrichment to stream" Page 1

"Aquatic life impairment is probably due to sedimentation and runoff containing a variety of pollutants associated with agricultural stormwater runoff" Page 2

"Prestile Stream is listed as Class A water and does not attain classification due to pollution from nonpoint sources" page 18

The assumption that agricultural NPS pollution is the source of impairment seems to have been started with the Department's 303(d) report. This listing of impaired waters identified the impairment was due to sedimentation and runoff containing a variety of pollutants associated with agricultural stormwater runoff. But the TMDL does not present data that support this assertion well and the other potential sources of apparent impairment are not examined by the report. These should be addressed.

1. Are the low Dissolved Oxygen (DO) levels measured in the stream due to the natural effects of wetlands? *All but one* of the 29 DO violations listed in Table 4 of the report were measured at sampling points in or within 100 yards downstream of significant wetland complexes. Indeed, the only sampling point without any depressed DO's (PS4) is the only site without significant wetlands upstream of the point. The TMDL notes on page 14 that the wetlands are known to have naturally low DO and this may be a factor yet no further mention is made of it in the report. The TMDL should explain why the presence of extensive wetlands in the upper watershed are not the predominant cause of the depressed DO measurements.

2. Are the low DO levels measured in the stream due to the effects of impoundments? While the TMDL notes several of the impoundments along the upper Prestile on the map of Figure 4, several significant natural and manmade impoundments are not noted. Three significant impoundments are located between the outlet of Christina Reservoir and the Richardson Road. (It is this reach where most of the low DO's were measured). Beaver dams exist just below the Conant Road (PS-1) and at the bridge where the railroad crosses the Prestile. A manmade dam impounds the Prestile immediately above the Richardson Road (PS-2). All were present during the time when the Department was measuring DO. All DO related impairment was measured at locations directly below impounded segments of the stream. The TMDL notes that DO increases and temperature measurements increase from north to south. This would seem to point to impoundment-related warming of the waters affecting DO concentrations rather than agricultural activities. The TMDL should explain why impounded waters are not the predominant cause of the depressed DO measurements.

3. Is enrichment of Christina Reservoir caused in part by naturally occurring nutrient addition from waterfowl waste? Waterfowl waste has been documented as a cause of nutrient enrichment and water quality degradation in several Midwestern states. Christina Reservoir and the upper Prestile has been documented as having the highest concentrations of breeding and migrating waterfowl in the state. Phosphorous additions from waterfowl are mentioned in the draft as a possible contributor to the enriched conditions seen here. The TMDL estimated as much as130 Kg/ha could be contributed to the system but then added that this estimate may be high since it was thought likely that the waterfowl were recycling nutrients within the system. It should be noted that three of the most abundant waterfowl species using Christina Reservoir during migration (Canada Goose, Mallard and American Black Duck), in fact, feed in agricultural fields within and outside the watershed and then return to the pond to roost during the midday and at night. This would most likely result in an import of nutrients to the system.

It is not evident in Appendix 1 that the Department's estimate of waterfowl-origin phosphorous contributions were used as nutrient inputs in the model. It would seem that the estimated large contribution of waterfowl origin phosphorous (larger than atmospheric and internal sediment loadings) would be an important input value for the model. The Department should clarify why nutrient enrichment and non attainment in the upper Prestile watershed is not caused, in large part, by naturally occurring populations of waterfowl.

4. Why does the exceptional enrichment indicated by the biomonitoring results at the Richardson Road sampling site indicate agricultural NPS-caused non-attainment? According to the TMDL (page 13) "Biomonitoring results signaled enrichment conditions that exceed levels seen in all but one other highly degraded location in Maine" I understand that the other similarly degraded site in Maine was impacted by point source discharge of pollutants. As shown in the land use pie charts on page 10 of the TMDL, Rowcrops (identified as the greatest contributor of pollutants in the watershed model) exist as a nearly identical land use percentage in the upper (Christina Reservoir) and lower (Prestile Stream) watersheds. However, bio-monitoring in the Westfield sample station was not noted as highly degraded.

This would seem to point to differing non-attainment sources in the upper and lower sections of the TMDL watershed. Indeed the TMDL states that "…nutrient enrichment and general degradation of the stream habitat due to sedimentation and physical alterations are essential contributors to the non-attainment." The TMDL should explain why agricultural NPS would produce exceptional enrichment in the upper portion of the watershed and not in the lower reaches. If past historical nutrient loads from spray irrigation, wildlife impacts, industrial stormwater or impacts from impoundments or wetlands are judged to be the cause of the biomonitoring non-attainment, is it appropriate to use the GWLF model (a model developed to define agricultural NPS pollutant loads) to set water quality targets? The TMDL should better examine possible causes of *exceptional non-attainment* in this location and explain and support the use of GWLF model in this application.

5. The documented historical overapplication of nutrients through the potato processing spray irrigation system should be thoroughly examined as the source of the algal blooms in Christina Reservoir and biomonitoring problems in the upper Prestile. As late as 2002, McCain Foods was spray irrigating millions of gallons of partially treated wastewater daily across nearly 1000 acres of the ag-land in the upper Prestile. The Department documented numerous occasions when there was direct application of this wastewater into wetlands, breaches of wastewater lines into waterways and contaminated groundwater in many locations across the site. The phosphorous concentrations in this wastewater was so high it was measured in parts per million and hundreds of pounds of excess phosphorous were added to the system weekly. Because of these issues, the Department encouraged the processor to change their wastewater disposal method and the company has now established a multi million dollar wastewater treatment plant providing tertiary treatment of the wastewater generated. The effluent is now discharged outside of the Prestile watershed.

Much of the Departments monitoring data was collected in few years immediately following the removal of these large nutrient inputs and it is likely the effects of this legacy of enrichment was still being witnessed. Figure 5 of the report shows a rapidly decreasing phosphorous load in Christina Reservoir as actually measured by the Department. Phosphorous levels measured in this Lake in the 1990's were at over 170 ppb. *It would appear that the trophic state is decreasing quite rapidly and attainment may be reached just through the already-accomplished removal of the spray irrigation system and its wastewater discharges to the upper Prestile*.

The TMDL notes spray irrigation caused some nutrient enrichment but does not attribute the non-attainment of water quality in Christina Reservoir or the upper Prestile to this source. Further examination of this scenario is necessary and the TMDL should explain why these excessive nutrient loadings were not the cause the apparent non-attainment in the upper Prestile.

6. Use of "Days with >2 ppm fluctuations in Dissolved Oxygen" as and indicator of non-attainment. Table 4 (page 14) of the TMDL offers a data indicating the number of days that the DO fluctuated more than two parts per million as an indication that the stream was impaired. I understand that the fluctuation of DO has been considered by some Department staff as indicator of impairment, but this is not currently an accepted standard for water classification in Maine's Water Classification System. It should be noted, water quality monitoring done by the Department on several other streams and rivers in northern Maine have shown diurnal fluctuations of dissolved oxygen greater than two parts per million while attaining all other water quality standards (Mitnik, Aroostook River Study 2002, page 8). The study stated that fluctuations of DO are probably related to the geomorphology of Aroostook County streams and that wide, shallow streams (like the Prestile) receive more sunlight to support photosynthesis by benthic algae and are more susceptible to wider fluctuations of temperature as the water warms on sunny days. More examination of this parameter as an indicator of non-attainment is warranted. It does not appear appropriate to use this parameter as an indicator of impairment until the Department has thoroughly examined its applicability in *all* Maine waters and the parameter has been accepted as a Standard in the Water Classification System.

7. Present all water quality monitoring data as an Appendix. The report does not offer a tabulation of the water quality monitoring data available for the watershed. Summary tabulations and graphical representations of calculated values offered in the report prevent, or make it difficult, to confirm the Department's interpretations. All biomonitoring results (including the ones that show attainment) from the watershed should be presented. It should be noted with all results presented in Tables and Figures if these are measured or modeled values.

8. **Present documentation of siltation and runoff events in the Prestile watershed.** To support the repeated assertion that siltation and stormwater runoff has created the non-attainment within the watershed, the Department should offer some documentation (or at least anecdotal accounts) of siltation and agricultural runoff discharges and when and where they are occurring in the watershed. No specifics have been offered in the report.

Classification of the Prestile Stream as Class A

It appears the Department may have erred when it upgraded the upper Prestile Stream watershed to a Class A in the late 1990's No other streams within the Central Aroostook area that share similar landscape, development and agricultural patterns are classified as A and attain this designation. Most are classified as B and most attain this designation. Department staff have expressed doubt that the Prestile can ever attain this classification without landscape scale changes in land use. No class A watershed with similar characteristics could be found as a reference watershed for producing nutrient loading targets. The Department should clearly address this unusual circumstance and either defend the classification (including how realistic it is to achieve) or propose a path to correct this error.

AVGWLF/comparative watershed approach: problems

The use of the GWLF model for this determining sediment and nutrient transport within the watershed and the comparative watershed approach for setting numeric goals for nutrient reductions seems problematic.

Some problems:

1. Despite being a GIS interface version of the GWLF model, it **appears the model is unable to account for the spatial distribution of various landuses within the watershed.** Thus any given acreage of agricultural land (whether it was located on the shore of the stream or at a well buffered location distant from the water) was expected to contribute the same amount of nutrients and sediment to the waterbodies. For example in the Lake Josephine subwatershed 98% of the sediment load is expected to be contributed by cropland despite nearly all of the cropland is well buffered from the Prestile stream.

   This would seem to yield imprecise estimates of inputs from any given land use. The Department should clarify why buffer quality and distance from receiving waters are not important input values for land uses in a watershed like the Prestile.

2. **The model treats many acres of forested wetland (1000+acres within the upper watershed) as wetland only** and ignores the likelihood that these areas would be harvested and could have significant contributions of sediment and nutrients from forestry roads and other activities. Since most of these areas are privately owned, its unlikely professional management and use of accepted BMP's for wood harvesting and other forestry activities to occur in these places. Again the Lake Josephine subwatershed has similar acreages of forestland and cropland and yet the model would show 98% of the sediment coming from cropland and forestland less than 1%. The TMDL should clarify how the model can account for forestry inputs and if so, why these are not significant.

3. In Figure 4.2 of Appendix 1, **the model indicates that phosphorous contributions by groundwater are a significant (almost 20%) load to the upper Prestile watershed**. Even though this modeled result dwarfs the combined contributions of farm animals, hay and pastureland, wetlands, septic systems and forestry within the entire watershead, the TMDL makes no comment on this curious result. The Department should confirm this result and affirm it is correct that apparently soluble forms of phosphorous are a significant contributor to the non-attainment in this watershed.

4. **The values for parameters reported in the northeast GWLF model report were assumed to be similar for New York and southern new England and Aroostook county in northern Maine**. One possible significant issue with this assumption is that this would apparently assume an agricultural landuse where dairy and other animal husbandry is a substantial component. It appears that manure application to most farmland and substantial leaching of excess nutrients are expected parts of hayland, pasture and cropland

model values. Central Aroostook county has very few domestically reared animals on the landscape. Most farming activity is the raising of grain and potato crops and nutrient additions are most likely to be in the form of expensive chemical fertilizers purchased by the farmer. These are much less likely to be applied in excess with substantial residual available for leaching and runoff. The Department should affirm that use of this model is appropriate in northern-most New England and that these model output values are not overestimating loads from agricultural land uses.

5. **Target nutrient concentration levels for Christina Reservoir appear unusually low**. The TMDL notes that Department behaves more like a wetland than a lake and suggests that a target level of 27-30 ppb total phosphorous. This was judged by the Department as appropriate because this was the level seen in other Maine wetlands. A study of 42 central Aroostook county wetlands found substantially higher levels of total phosphorous exist in the environment than the Departments suggested target (Longcore et al. 1998). Longcore found an average background level of 39 ppb TP in wetlands with forested landscapes and a level of 62 ppb in local wetlands with agriculturally impacted landscapes. It would appear the Department would consider locally collected background data in setting the targets for this waterbody.

6. **The watersheds used for comparison with the Prestile are very different in character**. The use of Moose Brook and B Stream as reference watershed for establishing numeric endpoint goal seems inappropriate. These are largely forested watershed with very different distribution of agricultural vs forested lands. While the Prestile watershed is over 40 % cropland, the percentage is only 7 % in B Stream and 17% in the Moose Stream watershed. These large landscape size differences have resulted in huge recommended reductions in nutrients and sedimentation that are impractical to implement and unknown in our experience. It would appear that the TMDL is recommending the reforestation of large portions of the Prestile watershed.

The process.

The Department clearly needs further time to better assess the causes of non-attainment of water quality standards in the upper Prestile watershed and needs to revisit the use of the GWLF model in developing recommendations and targets. The accelerated process with the goal of producing a report for submittal to the EPA as soon as possible does not serve the Department, the public or the watershed well. This is an important document for the northern Maine region and it is intended to effect industrial, recreational, agricultural landuses and the existing superlative wildlife and fisheries within the watershed for a long time to come. It is critical the DEP be correct when it completes its assessments. I hope the Department will take the time to consider the issues raised here.

Response to Comments:

September 26, 2008

Melissa Evers
Division of Environmental Assessment
MDEP
SHS #17
Augusta, ME 04333

Bill Sheehan
Division of Water Quality Management
MDEP, Northern Maine Regional Office
1235 Central Drive, Skyway Park
Presque Isle, Maine 04769

RE: Response to Bill Sheehan's Comments on Prestile Stream and Christina Reservoir TMDL, Public Draft

Dear Mr. Sheehan,

Thank you for providing comments regarding your concerns on the draft Prestile Stream and Christina Reservoir TMDL. The comments indicate a basic disagreement with the foundational premises of the TMDL:

- the stream classification as Class A
- 303 d list designation as impaired
- agricultural contribution to the impairments

I hope the responses to your questions will increase your understanding of the development of the TMDL and the interpretations of the existing information. I will address each of your numbered comments from your original submittal and will include both the comments (in italics) and the response in the TMDL.

> *1.* ***Are the low Dissolved Oxygen (DO) levels measured in the stream due to the natural effects of wetlands?*** *All but one of the 29 DO violations listed in Table 4 of the report were measured at sampling points in or within 100 yards downstream of significant wetland complexes. Indeed, the only sampling point without any depressed DO's (PS4) is the only site without significant wetlands upstream of the point. The TMDL notes on page 14 that the wetlands are known to have naturally low DO and this may be a factor yet no further mention is made of it in the report. The TMDL should explain why the presence of extensive wetlands in the upper watershed are not the predominant cause of the depressed DO measurements.*

1The TMDL does acknowledge the presence and potential influence of wetlands on DO, but the sites monitored are representative of stream conditions in the Prestile and not highly influenced by upsteam wetlands. The photo on page 14 shows a mat of benthic algae or periphyton at site PS4 and the respiration of a periphyton mass of this size will dominate the instream DO dynamics. While low DO is common in wetlands, the supersaturation of DO as reported in Figure 6, is not. Wetlands discharge low DO water that stays low on a diurnal basis, so the wide swings and supersaturation observed are attributed to nutrient enrichment capable of supporting large algal populations.
2

> *2.* ***Are the low DO levels measured in the stream due to the effects of impoundments?*** *While the TMDL notes several of the impoundments along the upper Prestile on the map of Figure 4, several significant natural and manmade impoundments are not noted. Three significant impoundments are located between the outlet of Christina Reservoir and the Richardson Road. (It is this reach where most of the low DO's were measured). Beaver dams exist just below the Conant Road (PS-1) and at the bridge where the railroad*

crosses the Prestile. A manmade dam impounds the Prestile immediately above the Richardson Road (PS-2). All were present during the time when the Department was measuring DO. All DO related impairment was measured at locations directly below impounded segments of the stream. The TMDL notes that DO increases and temperature measurements increase from north to south. This would seem to point to impoundment-related warming of the waters affecting DO concentrations rather than agricultural activities. The TMDL should explain why impounded waters are not the predominant cause of the depressed DO measurements.

Under natural, open water conditions, DO remains saturated and does not go low in unstratified lakes or shallow impoundments, such as those found on the Prestile. Any low DO found under these conditions would be the result of respiration associated with excess accumulation of organic matter or algal growth due to nutrient enrichment. Therefore the low DO in the impoundment would be an integral part of the observed impairments.

3. Is enrichment of Christina Reservoir caused in part by naturally occurring nutrient addition from waterfowl waste? *Waterfowl waste has been documented as a cause of nutrient enrichment and water quality degradation in several Midwestern states. Christina Reservoir and the upper Prestile has been documented as having the highest concentrations of breeding and migrating waterfowl in the state. Phosphorous additions from waterfowl are mentioned in the draft as a possible contributor to the enriched conditions seen here. The TMDL estimated as much as130 Kg/ha could be contributed to the system but then added that this estimate may be high since it was thought likely that the waterfowl were recycling nutrients within the system. It should be noted that three of the most abundant waterfowl species using Christina Reservoir during migration (Canada Goose, Mallard and American Black Duck), in fact, feed in agricultural fields within and outside the watershed and then return to the pond to roost during the midday and at night. This would most likely result in an import of nutrients to the system.*

It is not evident in Appendix 1 that the Department's estimate of waterfowl-origin phosphorous contributions were used as nutrient inputs in the model. It would seem that the estimated large contribution of waterfowl origin phosphorous (larger than atmospheric and internal sediment loadings) would be an important input value for the model. The Department should clarify why nutrient enrichment and non attainment in the upper Prestile watershed is not caused, in large part, by naturally occurring populations of waterfowl.

This is an interesting point, and as stated, they are 'naturally occurring populations of waterfowl'. Waterfowl represents 16% of sources to Christina identified in Table 2, which is noteworthy, but not enough to be responsible for the nonattainment. The in-lake loads of Christina were not part of the AVGWLF model, which modeled the nutrient contribution from landuse runoff in the watershed using commonly accepted runoff coefficients and NRCS soil loss equations. Christina was treated as open water for the purposes of modeling and assigned the commensurate coefficient within the model. Using this approach may underestimate the contribution of nutrients from Christina to the Prestile, but the nutrient attenuation of the reservoir is also a factor. While this may be weakness of the model, it has other conservative assumptions and the TMDL has a Margin of Safety to balance minor transgressions.

As with any ecosystem model, it is not a perfect representation of all the sources of pollutants, but it provides a reasonable estimate of NPS pollutants. Using a standard comparative modeling approach is a reasonable way to derive the reductions needed to achieve attainment. All the estimates are compared using the same assumptions and the relative numbers take on more significance than the absolute numbers estimated for each watershed in computing TMDL reductions.

4. Why does the exceptional enrichment indicated by the biomonitoring results at the Richardson Road sampling site indicate agricultural NPS-caused non-attainment? *According to the TMDL (page 13) "Biomonitoring results signaled enrichment conditions that exceed levels seen in all but one other highly degraded location in Maine". I understand that the other similarly degraded site in Maine was impacted by point source discharge of pollutants. As shown in the land use pie charts on page 10 of the TMDL, Row-crops (identified as the greatest contributor of pollutants in the watershed model) exist as a early identical* *land use percentage in the upper (Christina Reservoir) and lower (Prestile Stream) watersheds. However, bio-monitoring in the Westfield sample station was not noted as highly degraded.*

This would seem to point to differing non-attainment sources in the upper and lower sections of the TMDL watershed. Indeed the TMDL states that "…nutrient enrichment and general degradation of the stream habitat due to sedimentation and physical alterations are essential contributors to the non-attainment." The TMDL should explain why agricultural NPS would produce exceptional enrichment in the upper portion of the watershed and not in the lower reaches. If past historical nutrient loads from spray irrigation, wildlife impacts, industrial stormwater or impacts from impoundments or wetlands are judged to be the cause of the biomonitoring non-attainment, is it appropriate to use the GWLF model (a model developed to define agricultural NPS pollutant loads) to set water quality targets? The TMDL should better examine possible causes of exceptional non-attainment in this location and explain and support the use of GWLF model in this application.

The extreme abundance of macroinvertebrates found at the Richardson Road site is a signal of nutrient enrichment that is associated with either agricultural runoff or point source inputs. The TMDL attributes the enrichment to agriculture because it is currently the major source of nutrient input in the watershed and the legacy of historical point source contributions is difficult to quantify. The differences observed between Richardson Road and the Westfield site could be due to this legacy or attenuation of nutrients in impounded waters, but the data does not exist to make this distinction. Macroinvertebrate populations generally recover quickly in Maine waters when point source contributions have been curtailed or eliminated. The time elapsed has now been sufficient to allow for aquatic life to recover from the influence of eliminated sources. If the exceptional nonattainment is due to historical contributions, then the next scheduled round of macroinvertebrate sampling in 2009 or 2010 should be able to detect the improvements. If sampling finds the macroinvertebrate populations are in attainment, then the TMDL prescribed reductions will no longer be needed. The landuse contributions of nutrients are relatively high in the Prestile watershed based on the comparative modeling results and supports the contention that agricultural activity is a major contributor to the observed impairments. Regardless of how nutrient sources are assigned, the long term health of the Prestile stands to benefit from reductions in agricultural runoff through the implementation of BMPs.

5. ***The documented historical overapplication of nutrients through the potato processing spray irrigation system should be thoroughly examined as the source of the algal blooms in Christina Reservoir and biomonitoring problems in the upper Prestile**. As late as 2002, McCain Foods was spray irrigating millions of gallons of partially treated wastewater daily across nearly 1000 acres of the ag-land in the upper Prestile. The Department documented numerous occasions when there was direct application of this waste-water into wetlands, breaches of wastewater lines into waterways and contaminated groundwater in many locations across the site. The phosphorous concentrations in this wastewater was so high it was measured in parts per million and hundreds of pounds of excess phosphorous were added to the system weekly. Because of these issues, the Department encouraged the processor to change their wastewater disposal method and the company has now established a multi million dollar wastewater treatment plant providing tertiary treatment of the wastewater generated. The effluent is now discharged outside of the Prestile watershed.*

Much of the Departments monitoring data was collected in few years immediately following the removal of these large nutrient inputs and it is likely the effects of this legacy of enrichment was still being witnessed. Figure 5 of the report shows a rapidly decreasing phosphorous load in Christina Reservoir as actually measured by the Department. Phosphorous levels measured in this Lake in the 1990's were at over 170 ppb. It would appear that the trophic state is decreasing quite rapidly and attainment may be reached just through the already-accomplished removal of the spray irrigation system and its wastewater discharges to the upper Prestile.

The TMDL notes spray irrigation caused some nutrient enrichment but does not attribute the non-attainment of water quality in Christina Reservoir or the upper Prestile to this source. Further examination of this scenario is necessary and the TMDL should explain why these excessive nutrient loadings were not the cause the the apparent non-attainment in the upper Prestile.

See the response to question 4 that explains some of the issues surrounding historical contributions and the ensuing implications.

The excess nutrient loading in Christina due to McCain Foods spray irrigation was not factored into the TMDL nutrient loads for several reasons:

- Nutrients are assumed to be assimilated and bound up in the soil and vegetation within a few years of spray cessation
- Recent soil tests on the land spray irrigated showed high, but not excessive levels of phosphorus, which indicates this contribution is diminishing over time

The TMDL does acknowledge the McCain Foods activities as a contributor to observed impairments, but not the exclusive source. Because MDEP effectively removed that nutrient source, it makes sense for the TMDL to identify existing and ongoing sources of nutrients. An effective TMDL identifies and addresses sources that can be reduced in the future to improve water quality and for that reason does not focus on eliminated sources. Eliminating the McCain's source undoubtedly had a beneficial effect on the nutrient dynamics in Christina and the Prestile. This act alone is unlikely to restore either waterbody given the other ongoing sources in the watershed, as demonstrated in the TMDL. If the declining trend of internal phosphorus in Christina results in attainment of water quality targets and the Prestile meets attainment for DO and aquatic life in the near future due to the elimination of McCain's sources, then the need for reductions is moot.

The TMDL makes a compelling case that agriculture contributes significant nutrients, but this question, and others, implies that the McCain's discharges in the watershed are the primary cause of nonattainment. Since this source has been eliminated, the implication is that time alone should alleviate the problems and the TMDL's focus on agriculture as the primary source is unnecessary. This will have been proven true if compliance with Class A standards is realized in the next few years and agriculture will no longer need to implement BMPs for the purpose of achieving TMDL reductions. This scenario is possible, but unlikely given the extent of agriculture and the complex nutrient dynamics that exist in the watershed.

> ***6. Use of "Days with >2 ppm fluctuations in Dissolved Oxygen" as and indicator of non-attainment.*** *Table 4 (page 14) of the TMDL offers a data indicating the number of days that the DO fluctuated more than two parts per million as an indication that the stream was impaired. I understand that the fluctuation of DO has been considered by some Department staff as indicator of impairment, but this is not currently an accepted standard for water classification in Maine's Water Classification System. It should be noted, water quality monitoring done by the Department on several other streams and rivers in northern Maine have shown diurnal fluctuations of dissolved oxygen greater than two parts per million while attaining all other water quality standards (Mitnik, Aroostook River Study 2002, page 8). The study stated that fluctuations of DO are probably related to the geomorphology of Aroostook County streams and that wide, shallow streams (like the Prestile) receive more sunlight to support photosynthesis by benthic algae and are more susceptible to wider fluctuations of temperature as the water warms on sunny days. More examination of this parameter as an indicator of non-attainment is warranted. It does not appear appropriate to use this parameter as an indicator of impairment until the Department has thoroughly examined its applicability in all Maine waters and the parameter has been accepted as a Standard in the Water Classification System.*

Water quality assessments in TMDL's are not limited to water quality standards and there is ample evidence in DEP sampling data and reports that DO swings in excess of 2 ppm indicates water quality problems. Ironically the TMDL uses a different reference to Mitnik's work in which he determined the 2 ppm swing to be problematic. Mitnik's observation on the Aroostook bears greater consideration in the future, but the weight of evidence supports the use of 2ppm DO swings as evidence of impairment (though not formal nonattainment). In fact many of the DO swings in the Prestile significantly exceeded the 2 ppm DO swing and typify respiration in waters with excessive algal populations.

> ***7. Present all water quality monitoring data as an Appendix.*** *The report does not offer a tabulation of the water quality monitoring data available for the watershed. Summary tabulations and graphical representations of calculated values offered in the report prevent, or make it difficult, to confirm the*

Department's interpretations. All biomonitoring results (including the ones that show attainment) from the watershed should be presented. It should be noted with all results presented in Tables and Figures if these are measured or modeled values.

This is a good point and the Stream TMDL Program will try to develop a standard data summary to include in future TMDL reports. The reason the data is not specifically included in the TMDL is that the data does not form the basis of the AVGWLF model, which is based on the landuse runoff characteristics derived from GIS landuse coverages. The modeling results provide the basis for the loading reductions required in TMDL calculations.

8. Present documentation of siltation and runoff events in the Prestile watershed. *To support the repeated assertion that siltation and stormwater runoff has created the non-attainment within the watershed, the Department should offer some documentation (or at least anecdotal accounts) of siltation and agricultural runoff discharges and when and where they are occurring in the watershed. No specifics have been offered in the report.*

This is a good suggestion on how to document connection between sediment in the model and actual observations. The original assertion I attribute to DEP's NMRO Staff, primarily Kathy Hoppe. She has repeatedly identified sedimentation in many streams in the Prestile watershed, but you are correct that no specifics are provided in the TMDL. I thought it was a commonly accepted local condition and therefore no formal citation was needed.

Classification of the Prestile Stream as Class A

It appears the Department may have erred when it upgraded the upper Prestile Stream watershed to a Class A in the late 1990's No other streams within the Central Aroostook area that share similar landscape, development and agricultural patterns are classified as A and attain this designation. Most are classified as B and most attain this designation. Department staff have expressed doubt that the Prestile can ever attain this classification without landscape scale changes in land use. No class A watershed with similar characteristics could be found as a reference watershed for producing nutrient loading targets. The Department should clearly address this unusual circumstance and either defend the classification (including how realistic it is to achieve) or propose a path to correct this error.

The potential mis-classification of the Prestile as Class A is outside the scope of issues addressed in a TMDL report. Downgrading the classification of a waterbody is more difficult than upgrading, and a re-class on the Prestile would require a Use Attainability Analysis, as defined under the Clean Water Act. This is a fairly arduous undertaking and EPA would probably require DEP to demonstrate that a TMDL has been fully implemented before any re-class would be seriously considered. The TMDL could therefore be viewed as a necessary step in any path towards the re-classification of the Prestile.

AVGWLF/comparative watershed approach: problems

The use of the GWLF model for this determining sediment and nutrient transport within the watershed and the comparative watershed approach for setting numeric goals for nutrient reductions seems problematic.

Some problems:

1. Despite being a GIS interface version of the GWLF model, ***it appears the model is unable to account for the spatial distribution of various landuses within the watershed.*** *Thus any given acreage of agricultural land (whether it was located on the shore of the stream or at a well buffered location distant from the water) was expected to contribute the same amount of nutrients and sediment to the waterbodies. For example in the Lake Josephine subwatershed 98% of the sediment load is expected to be contributed by cropland despite nearly all of the cropland is well buffered from the Prestile stream.*

This would seem to yield imprecise estimates of inputs from any given land use. The Department should clarify why buffer quality and distance from receiving waters are not important input values for land uses in a watershed like the Prestile.

AVGWLF is a midrange model that provides a reasonable estimate of pollutants for comparative purposes. It is not capable of modeling the juxtaposition of various landuse and nesting transport parameters within a given subwatershed, this is a limitation. All ecosystems models have limitations and I am not aware of a landuse based model that is capable of producing accurate transport dynamics given the resources DEP has to develop NPS models. DEP accepts the conventional wisdom that NPS parameters are highly variable and using an expensive higher level model, would not produce significantly better results, so why expend greater resources. DEP continues to review emerging modeling techniques and remains open to better modeling approaches for NPS parameters.

DEP is confident that AVGWLF is one of the best modeling tools available and provides results that direct stakeholders towards solutions that will ultimately attain water quality standards. Another consideration in choosing the model is how the results will be applied. Highly certain nutrient reduction values are of little use for the application of BMPs to landuse practices. Generalized numbers and targets are suitable for the adaptive management approach described in the implementation section and will be used for on the ground fixes. The goal of TMDL recommendations is attainment of water quality standards. The percent reductions provide a clear direction, not a measurement of success.

*2. **The model treats many acres of forested wetland (1000+acres within the upper watershed) as wetland only** and ignores the likelihood that these areas would be harvested and could have significant contributions of sediment and nutrients from forestry roads and other activities. Since most of these areas are privately owned, its unlikely professional management and use of accepted BMP's for wood harvesting and other forestry activities to occur in these places. Again the Lake Josephine subwatershed has similar acreages of forestland and cropland and yet the model would show 98% of the sediment coming from cropland and forestland less than 1%. The TMDL should clarify how the model can account for forestry inputs and if so, why these are not significant.*

The model does use average forest runoff values but there is a significant difference between forestry and agriculture in runoff characteristics. Forestry operations typically last only a season or two, while agriculture contributes nutrients and sediments every year. In any given year, active forest operations represent a small percent of the landuse and active operations are the ones most likely to contribute runoff.

*3. In Figure 4.2 of Appendix 1, **the model indicates that phosphorous contributions by groundwater are a significant (almost 20%) load to the upper Prestile watershed**. Even though this modeled result dwarfs the combined contributions of farm animals, hay and pastureland, wetlands, septic systems and forestry within the entire watershead, the TMDL makes no comment on this curious result. The Department should confirm this result and affirm it is correct that apparently soluble forms of phosphorous are a significant contributor to the non-attainment in this watershed.*

This result is typical of AVGWLF and groundwater estimates are one of the strengths of the model. Most models only predict surface runoff values, including the models used on point sources such as QUAL2E, so generally this component is neglected or lumped into another category. The Prestile model developer, Tricia Rouleau from FB Environmental, did contact the Northeast AVGWLF model developer, Barry Evans about this result. He thought these numbers were consistent with landuse and rainfall input values.

4. ***The values for parameters reported in the northeast GWLF model report were assumed to be similar for New York and southern new England and Aroostook county in northern Maine**. One possible significant issue with this assumption is that this would apparently assume an agricultural landuse where dairy and other animal husbandry is a substantial component. It appears that manure application to most farmland and substantial leaching of excess nutrients are expected parts of hayland, pasture and cropland model values. Central Aroostook County has very few domestically reared animals on the landscape. Most farming activity is the raising of grain and potato crops and nutrient additions are most likely to be in the form of expensive chemical fertilizers purchased by the farmer. These are much less likely to be applied in excess with substantial residual available for leaching and runoff. The Department should affirm that use of this model is appropriate in northern-most New England and that these model output values are not overestimating loads from agricultural land uses.*

As justified in the previous responses, this model is appropriate and was calibrated using northern New England watersheds in Maine, Vermont and New Hampshire as well as southern New England. Additionally, DEP is charged with making best use of limited public resources and this model was judged to have an adequate number of regional calibration watersheds for use in Aroostook. If the model had been specifically calibrated for Aroostook County, there would be a higher degree of confidence in the result, but there is not enough calibration data available for Aroostook County. Additionally, the final results would likely have been only marginally different between an Aroostook specific and a regionally calibrated model.

*5. **Target nutrient concentration levels for Christina Reservoir appear unusually low**. The TMDL notes that Department behaves more like a wetland than a lake and suggests that a target level of 27-30 ppb total phosphorous. This was judged by the Department as appropriate because this was the level seen in other Maine wetlands. A study of 42 central Aroostook county wetlands found substantially higher levels of total phosphorous exist in the environment than the Departments suggested target (Longcore et al. 1998). Longcore found an average background level of 39 ppb TP in wetlands with forested landscapes and a level of 62 ppb in local wetlands with agriculturally impacted landscapes. It would appear the Department would consider locally collected background data in setting the targets for this waterbody.*

These target numbers are significantly greater than those used in other lake TMDLs in Maine. The Longcore results are interesting but many questions remain regarding the derivation of those numbers and this makes them problematic for use in the TMDL. We chose a target based on data collected by the Division of Environmental Assessments Wetland Program. The documentation behind the collection of those values means they are easy to justify should the TMDL come under legal scrutiny.

*6. **The watersheds used for comparison with the Prestile are very different in character**. The use of Moose Brook and B Stream as reference watershed for establishing numeric endpoint goal seems inappropriate. These are largely forested watershed with very different distribution of agricultural vs forested lands. While the Prestile watershed is over 40 % cropland, the percentage is only 7 % in B Stream and 17% in the Moose Stream watershed. These large landscape size differences have resulted in huge recommended reductions in nutrients and sedimentation that are impractical to implement and unknown in our experience. It would appear that the TMDL is recommending the reforestation of large portions of the Prestile watershed.*

The reason for choosing those watersheds has been revised in the final TMDL but DEP is legally obligated to set targets based on attainment waters. The choice of these watersheds remains firm. Given the data, these were the only watersheds available regionally that met the appropriate criteria. DEP is recommending that BMPs be applied to the landscape so that runoff characteristics are similar to the attainment watersheds.

The TMDL has one goal- attaining water quality standards- through a technical analysis of water quality data and pollutant sources. This TMDL will be followed by an update of the existing Watershed Management Plan with a BMP application model. This model exercise will provide a framework for the type and density of BMPs needed in the watershed to achieve the TMDL targets. MDEP hopes this response has clarified the decisions and rationale behind the TMDL and the way water quality restoration is viewed through the provisions of the Clean Water Act.

Sincerely,

Melissa Evers
ES III
Maine DEP

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