Fish Brook TMDL Report

Maine Department of Environmental Protection

Report # DEPLW 0688

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Fish Brook TMDLTable of Contents

FIGURES & TABLES

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

Description of Waterbody and Watershed

Fish Brook is a small stream located in the town of Fairfield, Somerset County, Maine, and is a tributary of Messalonskee Stream, which drains in to the Kennebec River, Figure 1. The entire stream drains approximately 11 square miles and flows through a series of agricultural fields and dairy farms before reaching Messalonskee Stream. Landuse in the watershed is a rural mix of forested areas and agriculture with sparse residential development along the major roadways. The channel form of the stream varies between low gradient deadwater areas to moderate gradient areas with cobble substrate that are capable of supporting native brook trout *(Salvelinus fontinalis).*

A 1984 MDEP study (Sowles, 1984) found the Fish Brook watershed to be seriously impacted by nonpoint source pollution. Five major animal production operations (cows, dairy and pigs) are significant sources of polluted runoff within the watershed (White, 2000) and Figure 2 identifies the location of nonpoint-source problems. Other sources include roadways, gravel pits, residential development and timber harvesting. The 1984 diagnostic study of Fish Brook by MDEP reports that, according to the Maine Department of Inland Fisheries and Wildlife and the local Trout Unlimited Chapter, Fish Brook experienced a decline in its brook trout fishery in years prior to the study. Coincidental with this decline was the appearance of algae blooms and evidence of siltation in the brook's larger pools. The DEP found that total phosphorus levels in the brook are sufficient to cause algae blooms and there is evidence of nitrogen enrichment.

Descriptive Land Use Information

Figure 3 displays the distribution of landuse throughout the watershed. Landuse descriptions were derived from 'Maine_Combo', a GIS map layer developed by MEDEP staff that combines data from Maine Gap Analysis (GAP) and USGS Multi Resolution Landcover Characterization (MRLC) coverages. Both MRLC and GAP are based on 1992 LandSat TM satellite imagery and the metadata for Maine_Combo are maintained by MEDP's GIS Unit. Table 1 and Figure 4 clearly show the domination of forested land cover, followed by agriculturally managed lands, with a small amount of residential development. Though forested cover occupies the most of the land, agricultural operations dominate the lands directly adjacent to the brook.

Figure 1. Fish Brook with impaired segment and Stream TMDL Program sampling stations.

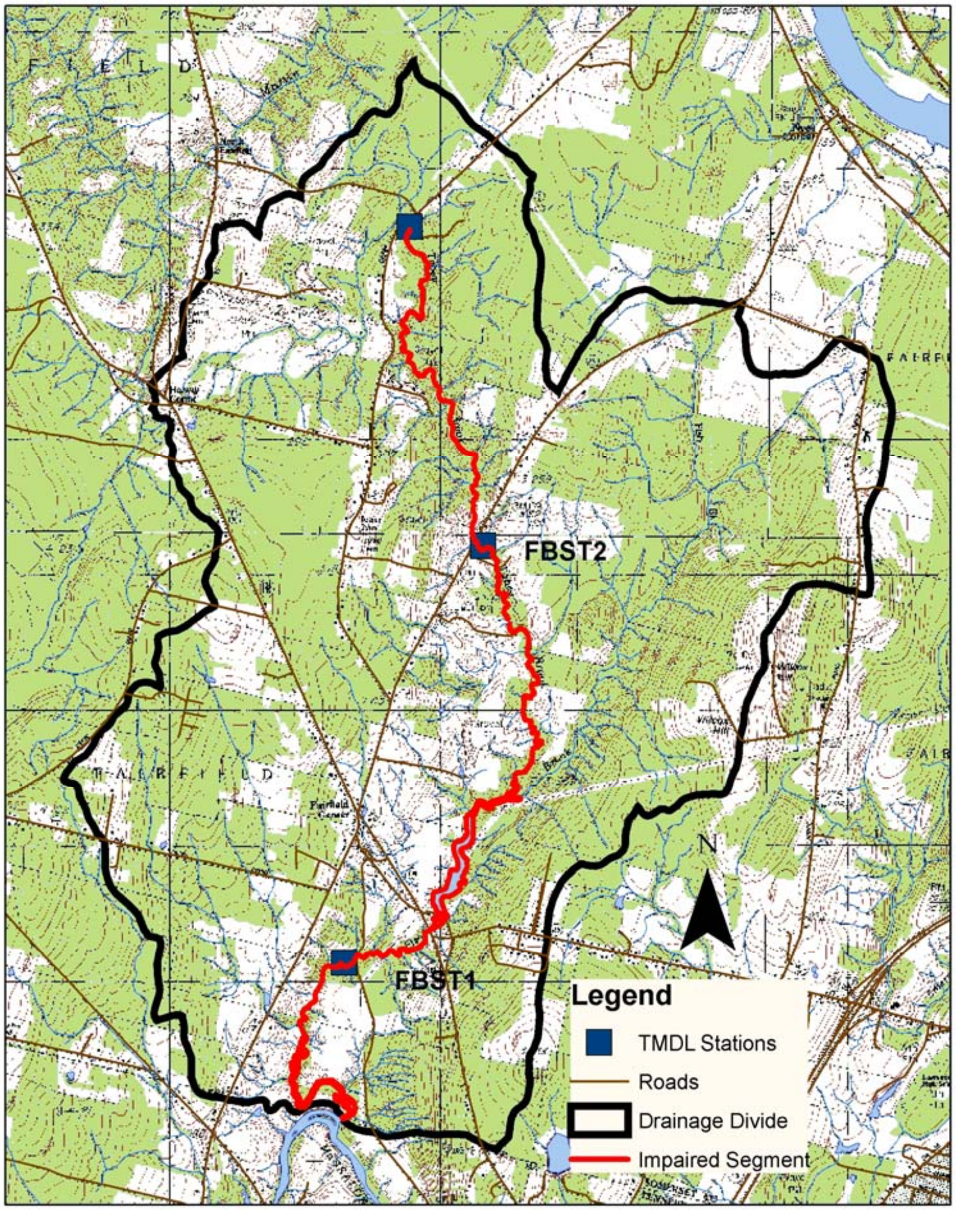


Figure 2. Aerial photo of the Fish Brook watershed with nonpoint source problem sites identified by Somerset County SWCD (map prepared by N. Sylvester, Kennebec County SWCD).

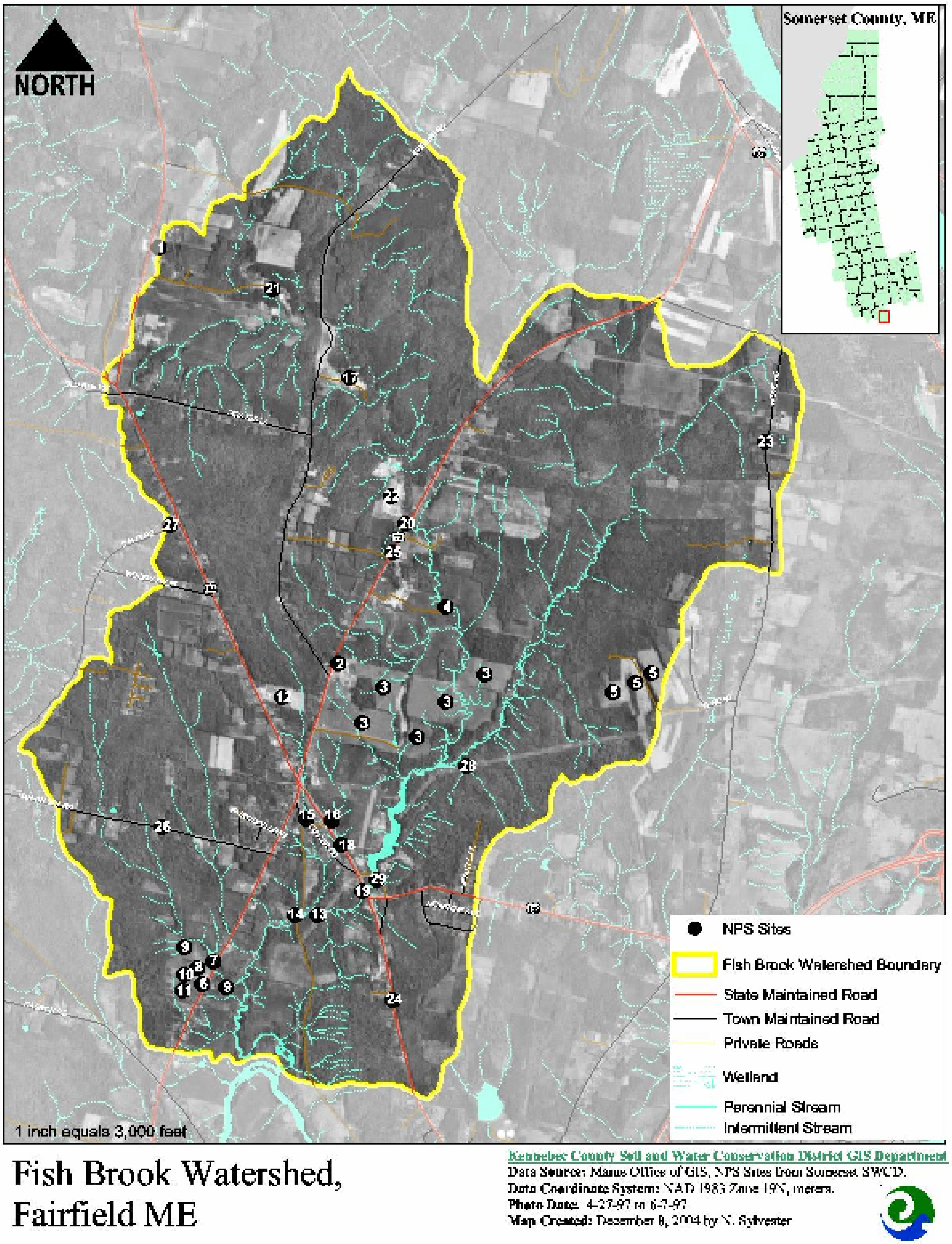


Figure 3. Fish Brook landuse map based on ‘Maine_Combo’, maintained in MEDEP’s GIS Layers.

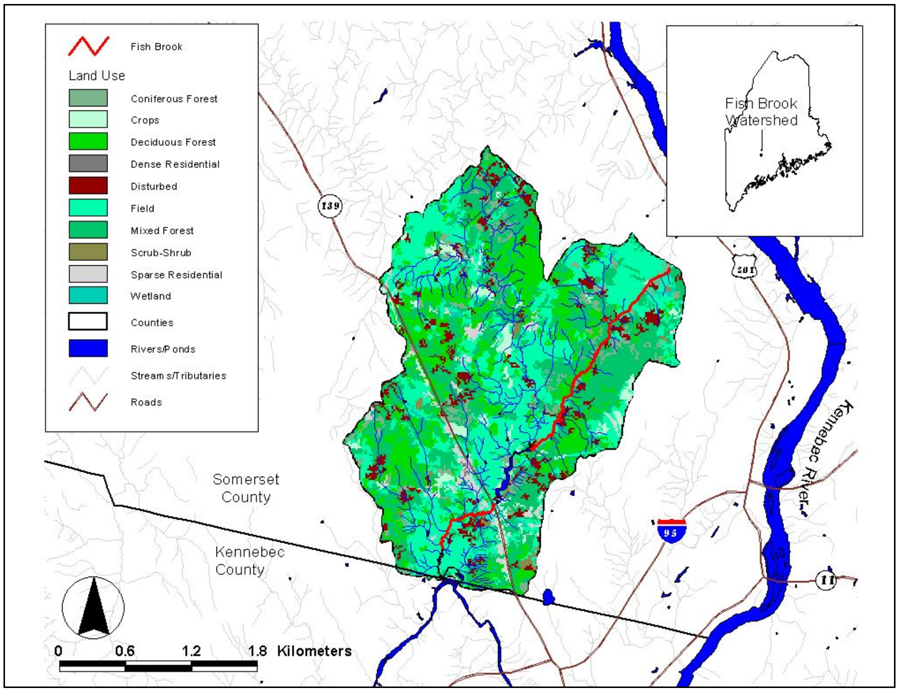
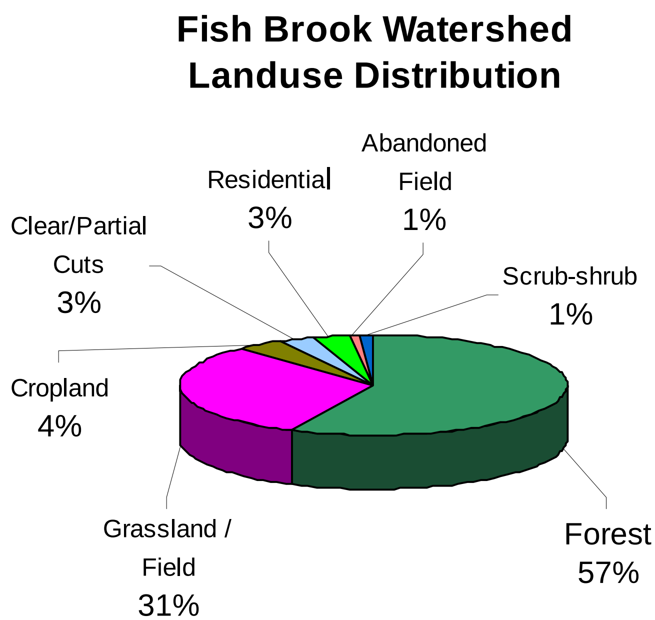


Table 1. The acreage of dominant landuse categories in Fish Brook watershed.

	Fish Brook	
Land Use	***Area (ha)***	***Percentage***
Forest	1,570	57%
Grassland / Field	854	31%
Cropland	110	4%
Clear/Partial Cuts	83	3%
Residential	83	3%
Abandoned Field	28	1%
Scrub-shrub	28	1%
Total	2,755	

Figure 4. The relative contributions of dominant landuses in Fish Brook watershed.



Pollutant Sources, Description of Impairments & Sampling Results

The stream is impaired by non-point source runoff from the many anthropogenic activities and development within the watershed. All land disturbances have the potential to contribute runoff, but the degree of disturbance associated with the large ongoing animal production operations is likely the greatest contributor of silt and nutrient enrichment. The close proximity of these operations to the brook also increases the likelihood that the disturbed and bare soil associated with agricultural operations will reach the brook. Cows with access to the brook will denude riparian areas and break down stream banks, which can be a significant source of sediment. An additional source of sediment may come from one of the many gravel pits in the watershed that are located close to the brook. Properly maintained gravel pits are internally drained and have no offsite runoff, but the age and proximity of the pits means that incremental amounts of runoff may reach the brook. No point sources were identified in the watershed.

Maine DEP biologists sampled Fish Brook for aquatic life or macroinvertebrate populations in 2000, which is a statutory Class B under Maine's Water Classification system. Sampling results in Table 2 indicate that aquatic life did not meet the Class B criteria and consistently attained the lower Class C criteria (Tsomides, 2002) Macroinvertebrate populations indicate a combination of intricate environmental factors, and no single factor is commonly the cause of macroinvertebrate impairments under the influence of non-point source stressors. General degradation of the stream habitat due to sedimentation and physical alterations is an essential contributor to the observed impairments.

Figure 5. MEDEP's Biomonitoring stations in Fish Brook.

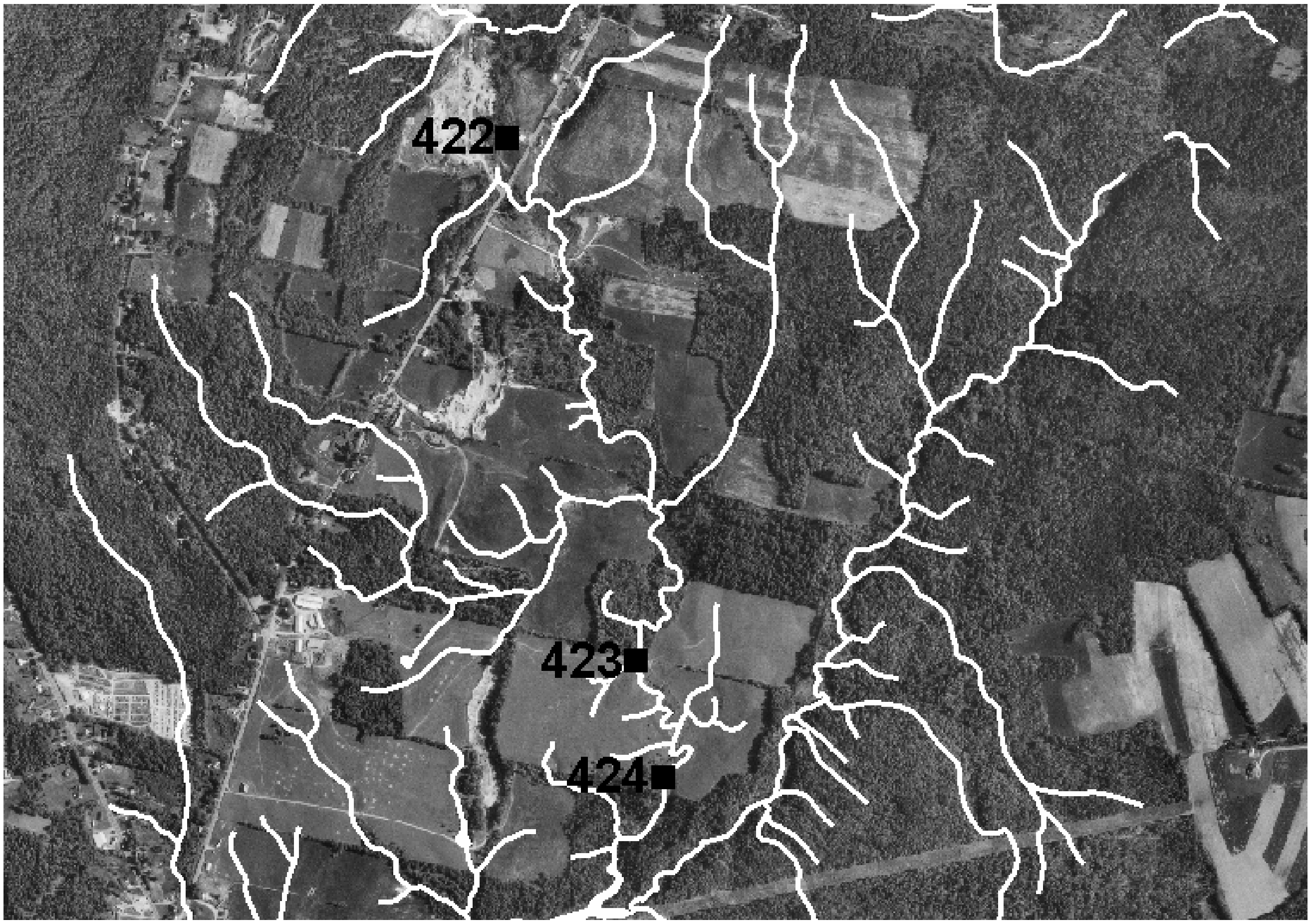


Table 2. MDEP Stream Biomonitoring sampling locations (Figure 3) and results, Fish Brook.

Sampling Station	**Site Description and Location** (ordered upstream to downstream)	**Statutory Class**	**Sampling Result**	**Date Sampled**
S422 (FB2)	50 meters upstream of Ohio Hill Rd, Rte 23 crossing	Class B	Class C	2000
S423 (FB3)	Upstream of cow crossing in pasture	Class B	Class C	2000
S424 (FB5)	West end of cow pasture, downstream of Station S423	Class B	Class C	2000

MDEP has measured levels of phosphorus capable of producing the observed algae blooms since the 1980's. Nutrient loadings from non-point 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 overtime in bottom sediments of the slow flowing and ponded stream segments and may be periodically released into the water column.

Dissolved oxygen levels were intensively measured by DEP during 2002 (Evers, 2003), with both discreet (YSI handheld DO meter) and continuous monitoring equipment (YSI datasonde). Violations of the Class B DO standard of 7 ppm were consistently measured at the downstream site with handheld meters, while the upstream site met DO standards, Table 3. Continuous monitoring data in Table 4 displays the same pattern of nonattainment at the downstream site. The upstream site narrowly missed attainment, but the DO's are generally higher and more conducive for biological life. A 2 ppm or greater difference between the daily maximum and minimum is another indicator of nutrient enrichment and algal growth (Paul Mitnik, personal communication, 2004). Figures 6 and 7 shows that both sites consistently exhibited a 2 ppm or greater swing in DO and are impaired by nutrients, with the greatest effects accumulating at the downstream site.

Table 3. Summary of MDEP Stream TMDL dissolved oxygen monitoring, sampling locations in Figure 1.

Stream TMDL Dissolved Oxygen Monitoring Summary August-October 2002			
Sampling Station	**Site Description- Locations on Figure 1**	**Number Site Visits with Discreet DO Measurements**	**Number of Minimum DO Violations, < 7ppm**
FBST2	Upstream- Downstream of Rte 23, Ohio Hill Rd	**7**	**0**
FBST1	Downstream- Downstream of Rte 139	**5**	**5**

Table 4. Daily minimum and maximums from continuous monitoring (Datasonde) equipment.

	Temperature C		DO ppm	
Date	**Minimum**	**Maximum**	**Minimum**	**Maximum**
Upstream Site, FBST2, Rte 23-Ohio Hill Rd Crossing				
08/19/02	18.5	20.2	6.9	9.4
08/20/02	15.9	18.9	6.9	9.4
08/21/02	13.6	18.1	7.3	10.2
08/22/02	14.0	16.5	7.5	9.7
Downstream Site, FBST1, Below Rte 139 Crossing				
08/22/02	20.2	21.8	5.2	7.3
08/23/02	18.7	24.8	3.5	7.1
08/24/02	18.0	21.4	4.0	6.8
08/25/02	17.6	24.0	3.8	6.3
08/26/02	17.9	24.3	3.6	6.1
08/27/02	18.4	23.6	3.7	5.9
08/28/02	17.4	22.5	3.4	7.6

Figure 6. Continuous monitoring (Datasonde) dissolved oxygen summary, upstream site.

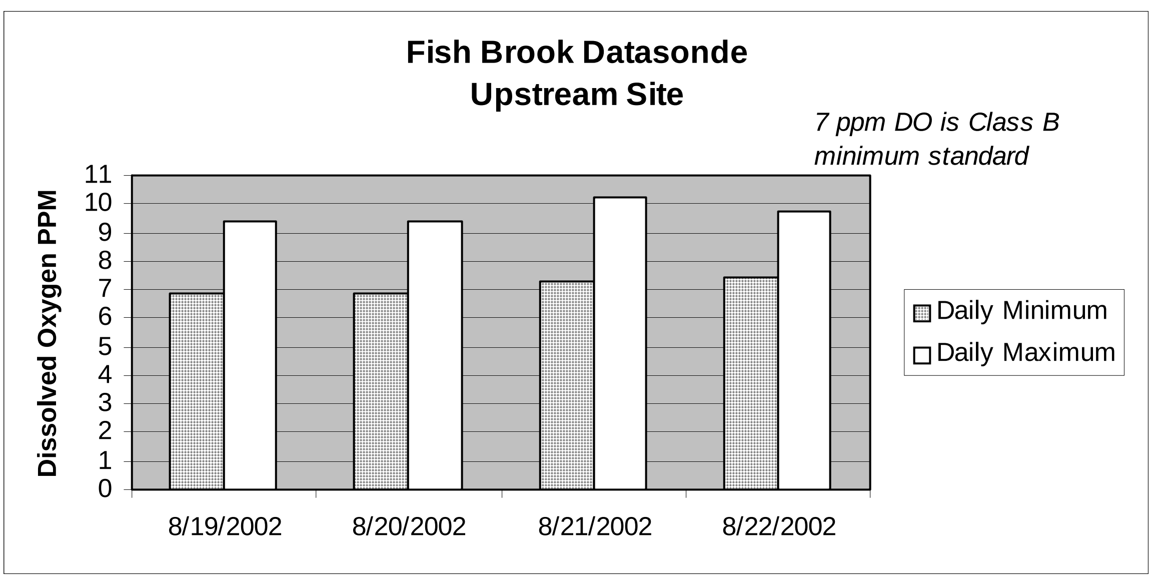
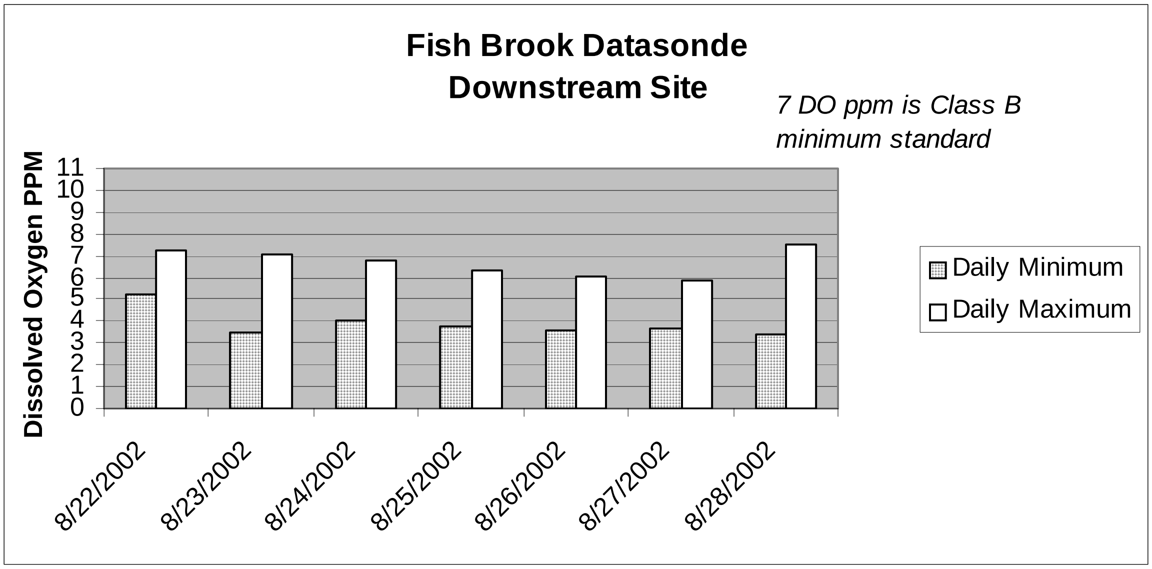


Figure 7. Continuous monitoring (Datasonde) dissolved oxygen summary, downstream site.



Pollutants of Concern

This TMDL addresses instream constituents that have been identified as the primary contributors to the observed DO violations and the habitat degradation that are the likely cause aquatic life violations. Elevated nutrient loading and accumulation contributes to the excess algae growth, which consumes oxygen during respiration and depresses DO levels. Phosphorus and nitrogen are the major limiting nutrients for algae growth and are pollutants of concern in Fish Brook.

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.

A watershed model, GWLF (Appendix 1), was used to simulate the non-point 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 Fish Brook to unimpaired (reference) watersheds, with similar landuse characteristics.

Impaired Stream Segment & Study Area

The 303 (d) listed segment of Fish Brook is a 4.9 mile stretch of Class B water from the Green Rd crossing to the confluence with Messalonskee Stream (Figure 1). Problems with DO and general water quality were first documented in the Fish Brook Study in 1984 and Fish Brook was included in Maine’s 1998 303 (d) list. As previously stated, violations to aquatic life criteria were documented in

2000 (Table 2) and in 2002 additional water quality parameters were collected in the impaired stream and the results included in this report.

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 Fish Brook for completion in 2004.

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 material that settles on the stream surface. It is assumed that the soil buffers and adsorbs most atmospherically deposited nutrients before they reach the stream through the runoff processes (except in watersheds sensitive to acidification). Regionally, our knowledge of atmospheric deposition of nutrients and sediment in flowing freshwaters is relatively limited.

Natural Background Levels

Fish Brook is statutory Class B and no upstream reaches were found that consistently attain Class B. The stream periodically dries up at the Green Rd crossing, leaving stagnant pools that do not attain water quality standards. 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 prior to the 1980's. 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

Fish Brook is classified as a Class B 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 B waters shall be of sufficient quality to support all aquatic species indigenous to the receiving water without detrimental changes in the resident biological community.

Designated Uses and Antidegradation Policy

Fish Brook is listed as Class B water and does not attain classification due to pollution from nonpoint sources. Class B and its designated uses are defined under Maine's Water Quality Classification Program, Maine Revised Statutes, Title 38, Article 4-A. Class B waters are generally designated for: water supply; primary/secondary contact recreation (swimming and fishing); hydro-electric power generation; navigation; and habitat for fish and aquatic life. Additionally, "The habitat shall be characterized as unimpaired." 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'.

Numeric Water Quality Target

Numeric nutrient and sediment targets were established by comparing Fish Brook to reference watersheds, since Maine does not have numeric standards for the pollutants of concern. The reference approach uses two watersheds that are designated as statutory Class B streams and have been documented to attain Class B standards or better for aquatic life (Tsomides, 2005). These reference watersheds also share similar land uses, soil characteristics and relative size with the impaired watershed. Since these streams attain Class B, it is assumed that GWLF model results for these streams will provide reasonable targets to achieve attainment in Fish Brook. Footman Brook and Allen Stream were chosen as reference watersheds and details of stream characteristics and model comparison can be found in the 'Modeling Report for Fish Brook' (Appendix 1).

A comparative reference approach requires identical modeling procedures be applied to all three watersheds, which is documented in Appendix 1. Numeric endpoints are derived from modeling results for total phosphorus, total nitrogen and sediment in Footman Brook and Allen Stream, Table 5. Though results were similar for both watersheds, an average of the unit area loads was chosen for the numeric target needed to obtain designated uses.

Table 5. Numeric loading endpoints for pollutants of concern based on GWLF modeling results (Appendix 1).

Pollutants	**Reference Waterbodies**		**Numeric Target**
Annual Unit Area Loads	Allen Stream	Footman Brook	Average for Waterbodies
Phosphorus Load (lb/acre/year)	0.29	0.33	0.31
Nitrogen Load (lb/acre/year)	2.97	2.83	2.90
Sediment Load (t/acre/year)	0.052	0.061	0.057

3. LOADING CAPACITY - LINKING WATER QUALITY AND POLLUTANT SOURCES

Loading Capacity & Linking Pollutant Loading to a Numeric Target

The loading capacity is the mass, of constituent pollutants, that Fish Brook 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 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 1) expresses pollutants in terms of instream loads which have been broken down into a unit area basis for comparative purposes. Table 5 lists the loading targets or assimilative capacity for comparisons between the reference watersheds and Fish Brook in subsequent TMDL analysis.

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 insure attainment of Maine's water quality standards. The Fish Brook TMDL analysis uses the GWLF model to estimate pollutant loadings (Appendix 1). GWLF is an established midrange modeling tool that basically uses landuse runoff coefficients, the universal soil loss equations and rainfall inputs to compute flow and pollutant loads. The model was run for all watersheds under consideration for a 12 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 calculate the existing load in Fish Brook and the reference watersheds. The difference between the impaired and reference watershed is the reduction needed to achieve water quality criteria for all nonpoint source pollutants of concern.

Strengths and Weaknesses

The TMDL uses a GWLF model analysis (Appendix 1) 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 calculate pollutant loads in rivers and streams TMDLs
- The GWLF model was created using regional input data to reflect local conditions to the greatest extent possible
- Makes best use of available landuse coverages to estimate nonpoint source loads
- The model was run for a 12 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

Weaknesses:

- Nutrient and sediment concentrations are extremely variable in flowing conditions and difficult to accurately depict
- The GWLF model approach is dependent on GIS based landuse coverages which contain some degree of error.
- Landuse runoff coefficients simplify the complex fluctuations in actual runoff based on erosion and land management practices
- GWLF modeling results were not calibrated to monitoring data, because of insufficient data and additional costs associated with that effort

Fish Brook TMDL

Critical assumptions used in the GWLF modeling report (Appendix 1) include:

- Total Phosphorus and Total Nitrogen were assumed to be an appropriate surrogate for the DO impairment
- Nutrient loading parameters for grasslands were assumed to be representative of nutrient loading from dairy farm operations.
- Meteorological data were assumed to be representative of the watersheds, although the stations are located outside of the watershed.
- Septic system failure rates were assumed to be consistent with percentages from rural communities in upstate New York.

Critical Conditions

The loading capacity for Fish Brook is set to protect water quality and support uses during critical conditions, which is 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 Fish Brook. 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 in using an average annual load approach for these nonpoint source TMDLs.

TMDL Loading Calculations

The existing loads for nutrients and sediments in the impaired segment of Fish Brook are listed in Table 6. Appendix 1, the ‘Modeling Report for Fish Brook’, describes the GWLF modeling results and calculations used in Table 6 and 7 to define TMDL reductions. An annual time frame provides a mechanism to address the daily and seasonal variability associated with non-point 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.

Table 6 also compares these existing nutrient and sediment loads in Fish Brook to TMDL endpoints derived from the reference streams and listed in Table 5. Figures 8 and 9 graphically compare the results between the watersheds and estimates of the reductions needed to achieve compliance with Maine’s Class B water quality standards in the impaired stream segment. The percent reductions will be applied to load and waste load allocations.

Table 6. Existing pollutant loads in Fish Brook compared to TMDL load allocations and the percent reductions required to achieve Class B water quality standards.

TMDL Pollutant Loads	**Existing Loads**	**Numeric Target**	**TMDL**
Annual Unit Area Loads	**Fish Brook**	**Reference Waterbodies**	**% Reductions**
Phosphorus Load (lb/acre/year)	0.50	0.31	38 %
Nitrogen Load (lb/acre/year)	4.04	2.90	28 %
Sediment Load (t/acre/year)	0.115	0.057	50 %

Figure 8. Nutrient load estimates compared between the watersheds and reductions needed to achieve compliance with Maine's Class B water quality standards in the impaired stream segment.

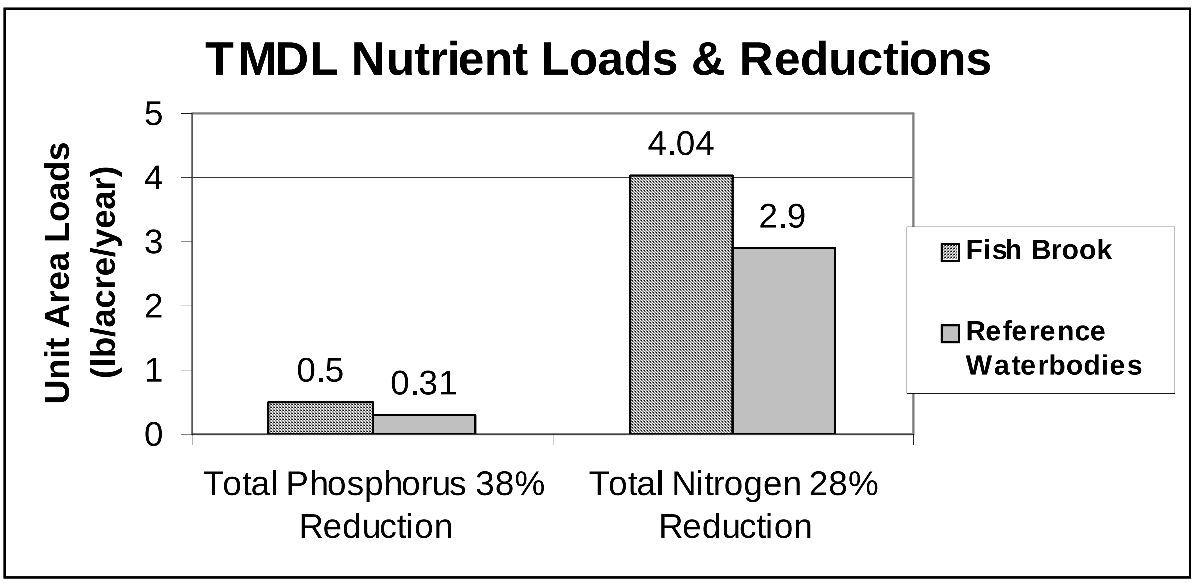
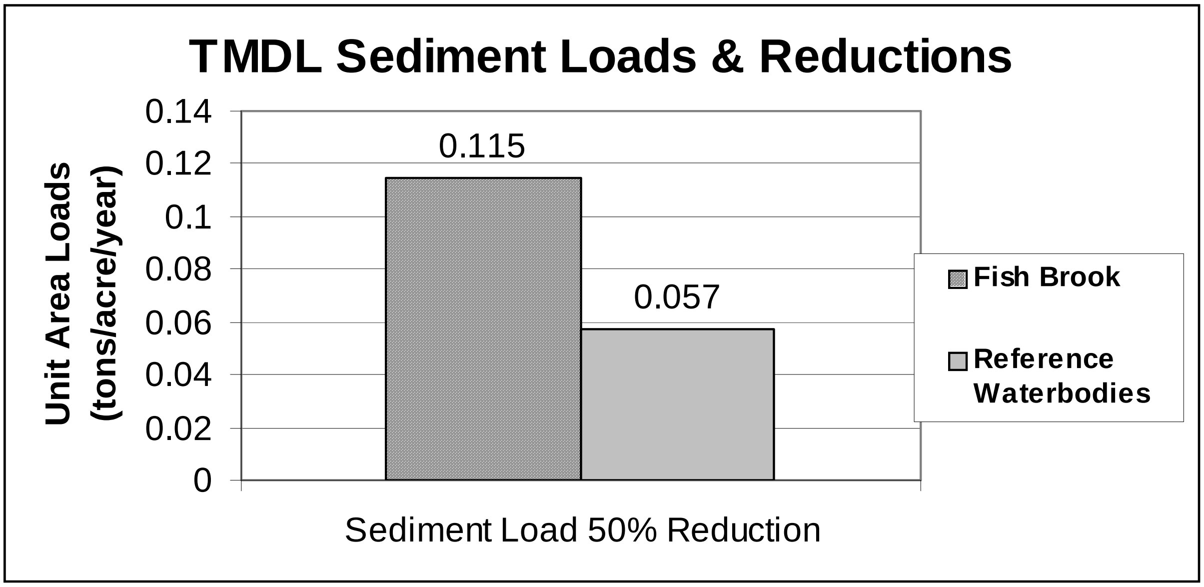


Figure 9. Sediment load estimates compared between the watersheds and reductions needed to achieve compliance with Maine's Class B water quality standards in the impaired stream segment.



4. LOAD ALLOCATIONS (LA's)

The load allocation (LA) for each of the candidate pollutants in Fish Brook are listed in Table 7. On an annual basis, the LA represents the stream's assimilative capacity allocated to only non-point sources of nutrients and sediments. All pollutant sources in these calculations are assigned LAs, representing non-point 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 that is downstream of the Green Road, Figure 1.

5. WASTE LOAD ALLOCATIONS (WLA's)

No portion of the Fish Brook watershed is regulated under Maine's National Pollution Discharge Elimination System (NPDES). Therefore the waste load allocation is defined as 0 for all the pollutants of concern in the runoff.

Table 7. Load Allocations and Waste Load Allocations for pollutant in the TMDL.

TMDL= LA +WLA	**Nutrients**		**Sediment**
	Phosphorus Load (lb/acre/year)	Nitrogen Load (lb/acre/year)	Sediment Load (t/acre/year)
Load Allocations (LA)	0.31	2.90	0.057
Waste Load Allocations (WLA)	0	0	0
Loading Capacity (TMDL)	0.31	2.90	0.057

6. MARGIN OF SAFETY (MOS)

A margin of safety was incorporated into the Fish Brook TMDL through the conservative selection of the numeric water quality target, based on reference watersheds (Allen Stream and Footman Brook) that are also designated as statutory Class B streams. Both Allen Stream and Footman Brook actually attained Class A aquatic life standard during 1997 and 2001 sampling events (Tsomides, 2005). Water quality targets were established using a comparison approach to reference streams that attain the higher aquatic life standard of Class A. This reasonably insures that Class B water quality standards and aquatic life standards will be attained.

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 flow occur during the summer and winter. Snow and rainfall runoff may contribute variable amounts of nutrients and sediment, while large volumes of runoff may also dilute instream nutrients and sediment concentrations, depending on the source.

8. MONITORING PLAN FOR TMDLS DEVELOPED UNDER THE PHASED APPROACH

Addressing the problems described in the TMDL will require future assessments of individual sites, such as the NPS farm sites displayed in Figure 2, to develop site specific best management practices. These assessments should include stream monitoring to develop standards for post and pre-application comparisons. Water quality monitoring should be conducted to gauge effectiveness of any BMP's 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 B 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.

9. IMPLEMENTATION PLANS and REASONABLE ASSURANCES

The goal of this TMDL assessment on Fish Brook is to use a midrange water quality model, GWLF (Appendix 1), 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.

Watershed Restoration Activities

Agricultural operations in the Fish Brook watershed are the subject of active restoration projects designed to curtail runoff. Working with MEDEP's Watershed Management Division (under the 319 NPS Grant Program), Somerset County Soil and Water Conservation District (White, 2000) detailed a schedule for installing BMP's and instituting practices to decrease nutrient inputs. In addition to BMP installation, Somerset County SWCD undertook a watershed survey to identify sediment and erosion problems in the watershed. Finalizing the survey and documenting problem sites is an important step in the ongoing restoration effort. As of March, 2005, Somerset County SWCD has been working with Kennebec County SWCD to develop a work plan of BMP implementation opportunities and finalize 319 reporting tasks (Sylvester, 2005). Currently, the Natural Resource Conservation Service has EQIP grant monies to fund the BMP's identified in the draft work plan (Marcotte, email communication, 2005). The combination of BMP's installed since 2000 and the proposed EQIP BMP implementation should control a significant number of nutrient and sediment inputs and provide considerable progress towards achieving TMDL targets.

Recommendations

Reducing sediment and nutrient inputs is an important step towards improving dissolved oxygen regimes in Fish Brook, but restoration of a sustainable and functional aquatic community requires a step beyond implementation of standard agricultural BMP's. Fish Brook has received anthropogenic assaults over many decades and reversing long term degradation will require planning and effort that include local stewardship, instream restoration and attention to small chronic problems. A comprehensive watershed approach should look to all potential nutrient/sediment sources which includes the impact of impervious surfaces (roads and roofs) and commercial developments (gravel pits, legacy dumps, auto dealers & recyclers).

The integrity of instream habitat is also integral to an effective restoration strategy. Years of agricultural development means that stream banks have eroded, sediment has filled in rocky substrate and channels have been altered. Stream habitat is negatively influenced by the access of concentrated cows in the stream which denude riparian zones and widen the stream. Once cows are excluded, these areas require instream manipulation to restore healthy channel characteristics. A geomorphological assessment would disclose channel deficiencies and identify instream/riparian restoration opportunities.

Fish Brook also contains at least one large impoundment that increases stream temperature and generates algae. Excess algal production is a significant contributor towards dissolved oxygen depletion as well limiting water clarity which directly affects organisms dependent on visual feeding mechanisms. Stream habitat in Fish Brook is a mixture of very low gradient stretches, deadwater reaches and moderate gradient riffles that reoxygenates the stream and provides critical habitat during that life of cycle of sensitive macro invertebrates and native salmonids. Impoundments often inundate important riffle habitat. They also interfere with macroinvertebrate population dispersion mechanisms that rely on downstream drift to maintain population levels. The combination of temperature, algal production, riffle habitat reduction, and dispersion interruption creates stress for populations attempting to recover. Removal of impoundments, which are not directly connected to human safety, would have measurable benefits for stream habitat.

Meeting the challenges of restoration in Fish Brook requires the participation of the human inhabitants of the watershed. One key to success for long term restoration is having residents that care about the stream and are actively involved in the restoration process, or an active watershed organization. Unfortunately, none exists in the watershed and this is true of most small stream watersheds in Maine. In a number of case, water quality trends have shown improvement in Maine's lakes with associations in actively pursuing restoration strategies (Bouchard, 2005). Organizing a watershed organization without the wellspring of local initiative is difficult and has met with mixed results in Maine. An example of that type of effort exists in Maine's Atlantic salmon watersheds where a State sponsored restoration plan recommended that salmon watersheds develop local associations (Maine Atlantic Salmon Task Force, 1997). The State and Federal governments began to foster and support local watershed organizations that continue to this day, with varying degrees success. 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

- **Continue to identify agricultural sources and install BMP's**
- **Identify and address all sources of nutrient and sediment inputs, beyond agriculture**
- **Assess instream habitat quality and identify channel restoration opportunities**
- **Remove impoundments not connected to human safety**
- **Foster local stewardship and establish a viable watershed organization**

10. PUBLIC PARTICIPATION

Public participation in the Fish Brook TMDL development is ensured through several avenues. A preliminary review draft TMDL was prepared and distributed to:

- MEDEP reviewers-
  - Dave Courtemanch, David Miller, Paul Mitnik and Barry Mower, Division of Environmental Assessment, Bureau of Land and Water
  - Norm Marcotte and Tony St. Peter, Watershed Management Division, Bureau of Land and Water

- Watershed stakeholder organizations-
  - Paul Blanchette, Town Manager, Fairfield, Maine
  - Jeff McCabe, Somerset County Soil and Water Conservation District
  - Nate Sylvester, Kennebec County Soil and Water Conservation District
  - Chris Huck, Planning Director, Kennebec Valley Council of Governments, Fairfield, Maine
  - Kathy Scott, Kennebec Valley Trout Unlimited, Norridgewock, Maine
  - John Gibson, Somerset County Trout Unlimited, Norridgewock, Maine

Paper and electronic forms of the *Fish Brook TMDL, Draft Report* were made available for public review through several avenues. 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 Sunday editions of the Augusta Kennebec Journal, Waterville Morning Sentinel and the Bangor Daily News on March 19th and March 26th. The U.S. Environmental Protection Agency (Region I) and interested public was provided a 30 day period to respond with draft comments (March 15 th, 2005 through April 19th, 2005).

> *PUBLIC NOTICE FOR FISH BROOK-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 2004-0688) for impaired water quality in Fish Brook, located in Fairfield, in Somerset County. This TMDL report estimates non-point source loadings of nutrients and sediments and the reductions needed to restore the stream to meet Maine's Water Quality Criteria.*
>
> *A Public Review draft of the report may be viewed at the Maine DEP Offices in 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 April 19, 2005, to Melissa Evers, Stream TMDL's, Maine DEP, State House Station #17, Augusta, ME 04333 or email: melissa.evers@maine.gov*

Response to Comments

No comments outside of Maine DEP and EPA were received.

LITERATURE

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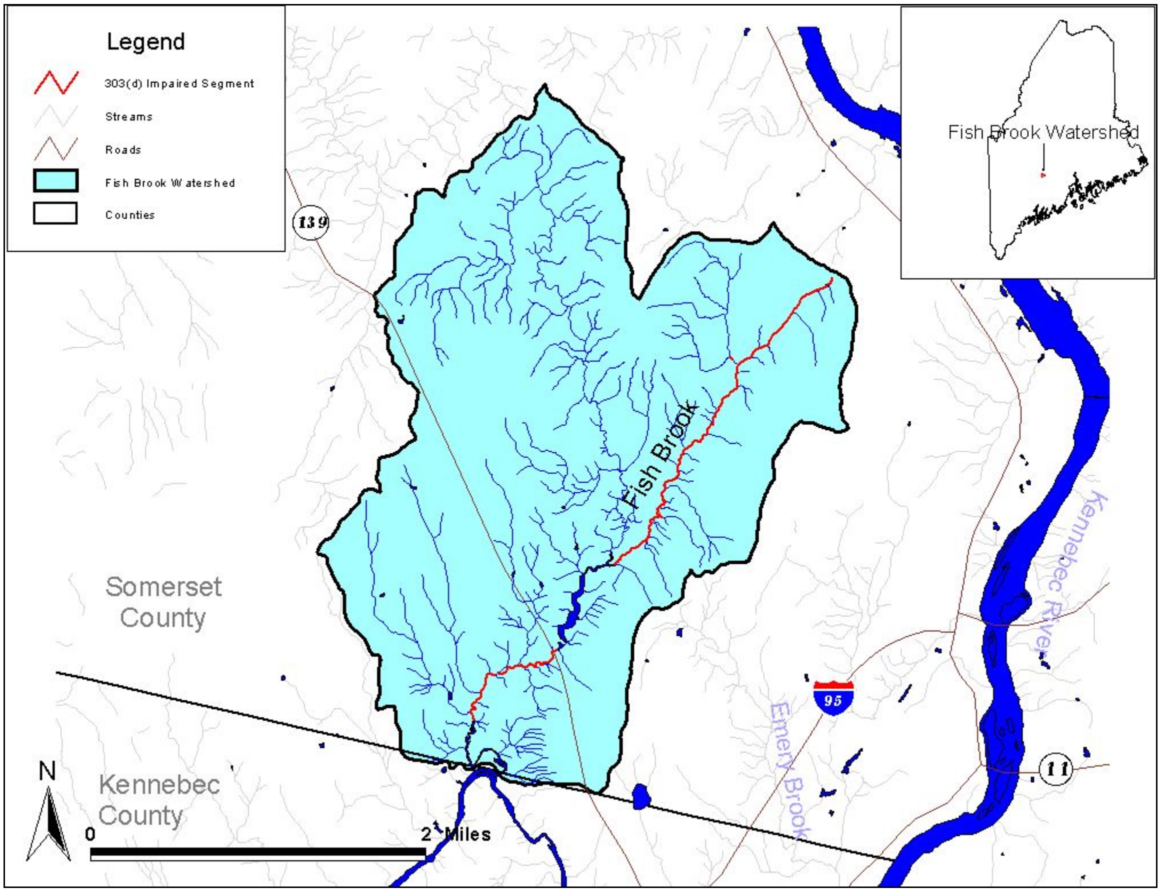
Appendix I. Modeling Report to Support Total Maximum Daily Load (TMDL) Development for Fish Brook

Modeling Report to Support Total Maximum Daily Load (TMDL) Development for Fish Brook

Dissolved Oxygen (DO) Impairment



Prepared for: **DRAFT**

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Maine Department of Environmental Protection

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1. Introduction

Fish Brook is listed on the Maine 1998 303(d) list as impaired for dissolved oxygen (DO) due to organic enrichment from non-point sources. Fish Brook is designated as Class B water under the standards for classification of fresh surface waters. Standards for classification and associated designated uses are provided in Table 1.1.

Table 1.1 Standards for Classification of Fresh Surface Waters and Designated Uses

Class	Description	Designated Uses
AA	Class AA shall be the highest classification applied to waters which are outstanding natural resources and which should be preserved because of their ecological, social, scenic or recreational importance.	- Drinking water supply after disinfection - Fishing - Recreation in and on the water - Navigation - Habitat for fish and other aquatic life* * The habitat shall be defined as free flowing and natural.
A	Class A waters shall be the second highest classification.	- Drinking water supply after disinfection - Fishing - Recreation in and on the water - Hydrologic power generation* - Navigation - Habitat for fish and other aquatic life * Except as prohibited under Title 12 Section 403.
B	Class B shall be the third highest classification.	- Drinking water supply after treatment - Fishing - Recreation in and on the water - Industrial Processes and Cooling water supply - Hydrologic power generation* - Navigation - Habitat for fish and other aquatic life * Except as prohibited under Title 12 Section 403.
C	Class C waters shall be the fourth highest classification.	- Drinking water supply after treatment - Fishing - Recreation in and on the water - Industrial Processes and Cooling water supply - Hydrologic power generation* - Navigation - Habitat for fish and other aquatic life * Except as prohibited under Title 12 Section 403.

Source: Maine Water Quality Standards

Total Maximum Daily Load (TMDL) development requires identification of impairment causes and the establishment of numeric endpoints that will allow for the attainment of designated uses and water quality criteria. According to Maine's 303(d) list, the probable impairment cause is organic enrichment from non-point source runoff. No point sources were identified in the watershed. Nutrient loading from non-point sources was identified as the primary contributor to the DO impairment. Therefore, a watershed model was used to simulate the loading of total nitrogen and total phosphorus from non-point sources. Maine does not have numeric water quality standards for total nitrogen and total phosphorus so numeric endpoints were developed based on unimpaired (reference) watershed total nitrogen and total phosphorus loading rates.

The watershed model used in this study was the Generalized Watershed Loading Function (GWLF) model (Haith and Shoemaker, 1987). GWLF modeling was accomplished using the BasinSim 1.0 watershed simulation program, which is a windows-based modeling system that facilitates the development of model input data and provides additional functionality (Dai et al. 2000).

2. Approach and Background

A reference watershed approach was used to establish numeric endpoints for nitrogen and phosphorus non point source loadings. 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 reference watershed 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 reference watershed or from the average of both reference watersheds.

Two unimpaired reference watersheds (Footman Brook and Allen Stream) were identified based on watershed size, land cover, and recommendations from Maine DEP (Figure 2.1). These watersheds were selected because they had similar land use / land cover (primarily forested and agricultural) and soils characteristics, and bio-monitoring data indicated they support healthy benthic communities. A brief description of the impaired watershed and two reference watersheds is provided in Table 2.1. More detailed land use / land cover and soil information is provided in the subsequent sections.

Table 2.1 Watershed Descriptions for Fish Brook, Allen Stream, and Footman Brook

Watershed	Description
Fish Brook (Impaired)	The Fish Brook watershed is part of the Messalonskee Stream watershed (HUC # 0103000310) in the state of Maine. Its headwaters begin in Somerset County approximately 4.3 miles northeast of the Somerset County/Kennebec County border. It flows southwestward and terminates at its confluence with the main stem of Messalonskee Stream at the Somerset County/Kennebec County border. Fish Brook is approximately 5.3 miles in length and has a drainage area of approximately 10.51 square miles.
Allen Stream (Reference)	The Allen Brook watershed is located is part of the Kenduskeag watershed (HUC # 0102000510) in the state of Maine and lies on the eastern border of the Footman Brook watershed. Its headwaters begin in Somerset County approximately 9.2 miles southeast of the northwest corner of Penobscot County It flows southeast and terminates at its confluence with the Kenduskeag Stream. Allen Brook is approximately 7.4 miles in length and has a drainage area of approximately 10.71 square miles.
Footman Brook (Reference)	The Footman Brook watershed is part of the Kenduskeag watershed (HUC # 0102000510) in the state of Maine. Its headwaters begin in Somerset County approximately 8.3 miles southeast of the northwest corner of Penobscot County. It flows southeast and terminates at its confluence French Stream. Footman Brook is approximately 4.5 miles in length and has a drainage area of approximately 7.4 square miles.

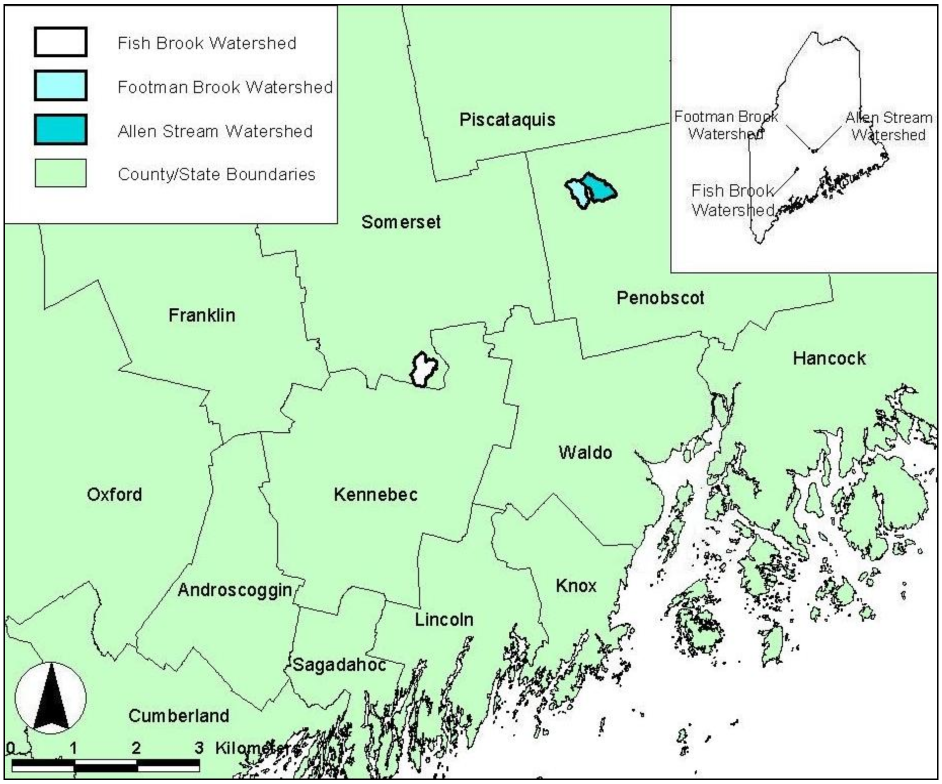

Figure 2.1 Watershed Locations

2.1 Land Use / Land Cover

Land use / land cover percentages were obtained from a data layer developed as part of the Maine Gap Analysis Project by the Maine Image Analysis Laboratory at the Department of Forest Management, University of Maine, 1998 (Table 2.2). The spatial distribution of land use / land cover for Fish Brook, Allen Stream, and Footman Brook is shown in figures 2.2, 2.3, and 2.4 respectively. The dominant land use / land cover in all three watersheds is forested. The primary distinction between the Fish Brook watershed and the two reference watersheds is the percentage of grassland / field. Grasslands cover approximately 31 percent of the Fish Brook watershed and approximately 13 and 14 percent of the Allen Stream and Footman Brook watersheds, respectively.

Table 2.2 Land Use Percentages for Fish Brook, Allen Stream, and Footman Brook

Land Use	Fish Brook		Allen Stream		Footman Brook	
	Area (ha)	Percentage	Area (ha)	Percentage	Area (ha)	Percentage
Forest	1,570	57%	1,967	71%	1,249	65%
Grassland / Field	854	31%	360	13%	269	14%
Cropland	110	4%	166	6%	134	7%
Clear/Partial Cuts	83	3%	111	4%	173	9%
Residential	83	3%	28	1%	19	1%
Abandoned Field	28	1%	28	1%	0	0%
Scrub-shrub	28	1%	83	3%	19	1%
Wetland	0	0%	0	0%	19	1%
Water	0	0%	0	0%	0	0%
Total	2,755		2,742		1,883	

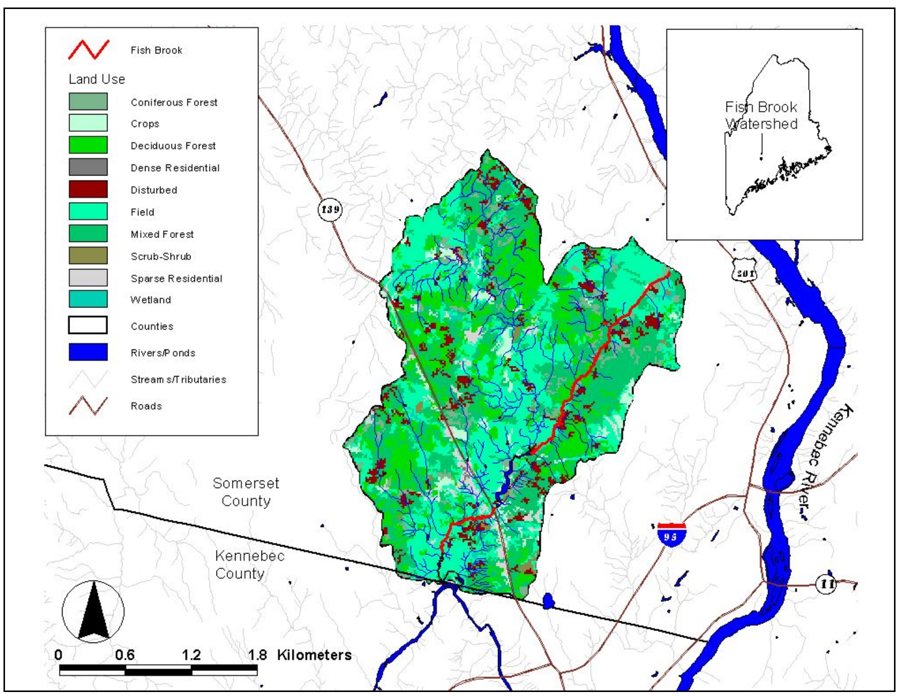

Figure 2.2 Land Use / Land Cover Areas for Fish Brook

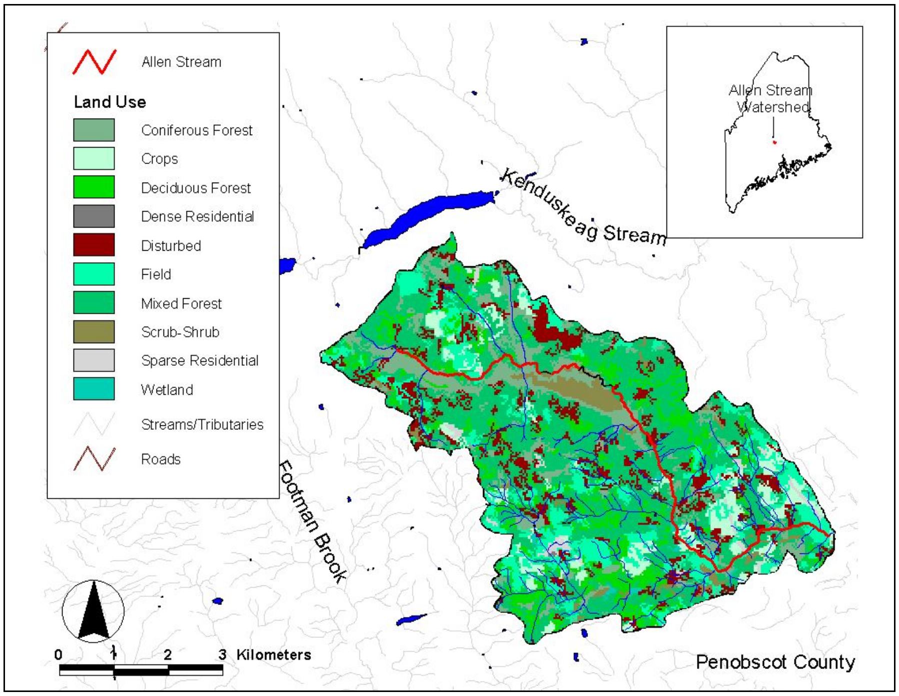

Figure 2.3 Land Use / Land Cover Areas for Allen Stream

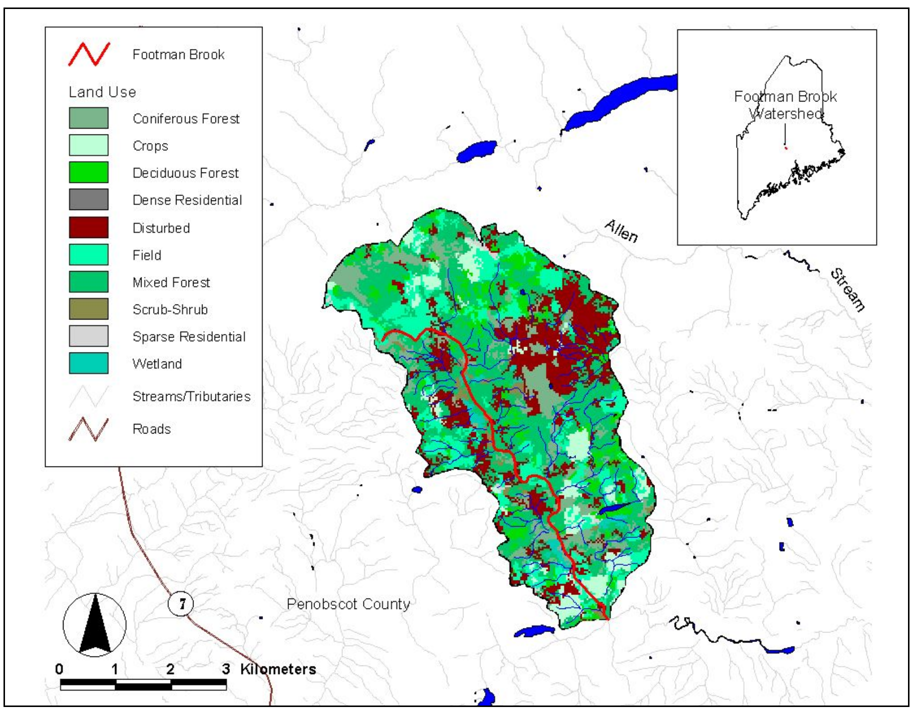

Figure 2.4 Land Use / Land Cover Areas for Footman Brook

2.2. Hydrologic Soil Groups

Soils data were obtained from the State Soil Geographic database (STATSGO) for Maine, as developed by the Natural Resources Conservation Services (NRCS). A description of the SCS soil hydrologic groups is provided in Table 2.3.

Table 2.3 Characteristics of SCS Soil Groups

Group	Runoff Potential	Infiltration Rates[a]	Soil Texture and Drainage
A	Low	High	Typically deep, well-drained sands or gravels
B	Moderately low	Moderate	Typically deep, moderately well to well-drained moderately fine to coarse-textured soils
C	Moderately high	Slow	Typically poorly drained, moderately fine to fine-textured soils containing a soil layer that impedes water movement or exhibiting a moderately high water table
D	High	Extremely slow	Typically clay soils with a high water table and high swelling potential that may be underlain by impervious material, have very slow infiltration rates

The hydrologic soil group percentages in the Fish Brook watershed, the Allen Stream watershed, and the Footman Brook watershed are shown in Table 2.4. The soils in the Fish Brook watershed fall into hydrologic group C. The soils in the reference watersheds fall into both hydrologic group C and hydrologic group D. Hydrologic group D soils cover approximately 48 percent and 4 percent of the Allen Stream and Footman Brook watersheds, respectively.

Table 2.4 Hydrologic Soil Group Percentages

Soil Hydrologic Group	Fish Brook	Allen Stream	Footman Brook
Hydrologic Group C	100%	52%	96%
Hydrologic Group D	0%	48%	4%

3. Technical Analysis

The Generalized Watershed Loading Function (GWLF) model was selected to estimate total phosphorus and total nitrogen loadings to Fish Brook, Allen Stream, and Footman Brook. Key characteristics of the GWLF model include:

- Hydrology simulation uses Curve Number method
- Sediment simulation uses standard Universal Soil Loss Equation (USLE) method
- Nutrient loading estimated using cover coefficient method
- Capable of representing heterogeneous land uses
- Predicts time-variable flow and constituent loading
- Contains extensive default parameter database derived from nationwide studies, which is useful in data-limited situations

3.1 Model Description

The GWLF model, which was originally developed by Cornell University (Haith and Shoemaker 1987, Haith et al. 1992), provides the ability to simulate runoff, sediment, and nutrient loadings from watersheds given variable-size source areas (e.g., agricultural, forested, and developed land). It also has algorithms for calculating septic system loads and allows for the inclusion of point source discharge data. GWLF is a continuous simulation model that uses daily time steps for weather data and water balance calculations. Monthly calculations are made for sediment and nutrient loads, based on daily water balance totals that are summed to give monthly values.

GWLF is an aggregate distributed/lumped parameter watershed model. For surface loading, it is distributed in the sense that it allows multiple land use/cover scenarios. Each area is assumed to be homogeneous with respect to various attributes considered by the model. Additionally, the model does not spatially distribute the source areas, but aggregates the loads from each area into a watershed total. In other words, there is no spatial routing. For subsurface loading, the model acts as a lumped parameter model using a water balance approach. No distinctly separate areas are considered for subsurface flow contributions. Daily water balances are computed for an unsaturated zone as well as for a saturated subsurface zone, where infiltration is computed as the difference between precipitation and snowmelt minus surface runoff and evapotranspiration.

GWLF models surface runoff using the Soil Conservation Service Curve Number (SCS-CN) approach with local daily weather (temperature and precipitation) inputs. Erosion and sediment yield are estimated using monthly erosion calculations based on the USLE algorithm (with monthly rainfall-runoff coefficients) and a monthly composite of KLSCP values for each source area (e.g., land cover/soil type combination). The KLSCP factors are variables used in the calculations to depict changes in soil loss/erosion (K), the length/slope factor (LS), the vegetation cover factor (C), and the conservation practices factor (P). The USLE approach is commonly used to predict erosion, particularly in agricultural areas, and is a component of other watershed models such as the Agricultural Non Point Source Loading model (AGNPS) and the Soil and Water Assessment Tool (SWAT). A sediment delivery ratio (SDR), based on watershed size, and a transport capacity, based on average daily runoff are applied to the calculated erosion to determine sediment yield for each source area.

Surface nutrient losses are determined by applying dissolved nitrogen and phosphorus coefficients to surface runoff and a sediment coefficient to the yield portion for each agricultural source area. Point source discharges, which are not of concern in this study area, can also contribute to dissolved loads to the stream and are specified in terms of kilograms per month. Manured areas, as well as septic systems, can also be considered. Urban nutrient inputs are all assumed to be solid-phase, and the model uses an exponential accumulation and washoff function for these loadings. Subsurface losses are calculated using dissolved nitrogen and phosphorus coefficients for shallow groundwater contributions to stream nutrient loads, and the subsurface submodel considers only a single, lumped-parameter contributing area.

Evapotranspiration is determined using daily weather data and a cover factor dependent on land use/cover type. A water balance is performed daily using supplied or computed precipitation, snowmelt, initial unsaturated zone storage, maximum available zone storage, and evapotranspiration values. All of the equations used by the model can be found in the original GWLF paper (Haith and Shoemaker, 1987) and GWLF User's Manual (Haith et al. 1992).

3.2 Model Configuration

Watershed data needed to run the GWLF model with the BasinSim 1.0 interface were generated using geographic information systems (GIS) spatial coverages, local weather data, literature values, and other information. For execution, the model requires three separate input files containing transport parameters, nutrient parameters, and weather related data.

More detailed information about these parameters and other secondary parameters can be obtained from the GWLF User's Manual (Haith et al. 1992). Pages 15 through 41 of the manual provide specific details that describe equations and typical parameter values used in the model.

3.2.1 Transport Parameters

The transport file (TRANSPRT.DAT) defines parameters that are a function of hydrology, erosion, and sedimentation. These parameters include global transport parameters, seasonal transport parameters, and source area transport parameters.

3.2.1.1 Global Transport Parameters

Model inputs for the global parameters are shown in Table 5. Critical global parameters include the unsaturated water capacity, 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. SDR specifies the percentage of eroded sediment delivered to surface water and is empirically based on watershed size. These parameters were set within reasonable ranges to match basin characteristics.

Table 3.1 Global Transport Parameters

Parameter	Fish Brook	Allen Stream	Footman Brook
Number of Rural Land Use Types	7	8	7
Number of Urban Land Use Types	4	4	2
Recession Coefficient	0.02	0.02	0.02
Seepage Coefficient	0	0	0
Initial Unsaturated Storage	0	0	0
Initial Saturated Storage	0	0	0
Sediment Delivery Ratio (SDR)	0	0	0
Initial Snow Cover	0.177	0.176	0.192
Unsaturated Water Capacity	10	10	10

3.2.1.2 Source Area Transport Parameters

Source area transport parameters describe the spatial variation in hydrology, erosion, and nutrient loading in the watershed. These parameters include land use / land cover areas, curve number, and the Universal Soil Loss (USLE) parameters K, LS, C, and P. The land use / land cover areas were derived directly using the digital land use / land cover GIS layers. The curve number parameter determines the amount of precipitation that infiltrates into the ground or enters surface water as runoff. It is based on specified combinations of land use / land cover and hydrologic soil type. It is calculated directly using the digital land use and soil GIS layers. The USLE equation determines soil erodibility based on the K factor, LS factor, C factor, and P factor. Unless otherwise specified, these parameters are derived from the NRCS Natural Resources Inventory (NRI) database (1992). The individual parameters are described in Table 3.2. The source area transport parameters for the Fish Brook watershed, the Allen Stream watershed, and the Footman Brook watershed are shown in Tables 3.3, 3.4, and 3.5 respectively.

Table 3.2 USLE Parameter Descriptions

Factor	Description
K factor	This relates to inherent soil erodibility, and affects the amount of soil erosion taking place on a given unit of land. K-factor values were derived from STATSGO for each soil type and assigned to land use areas based on the distribution of soils within that land use area.
LS factor	This is a function of the length and grade of the slope from a source area to the waterbody. An average grade was derived from the 30-meter DEM coverage. The slope length was derived from regional crop specific literature values from the NRCS NRI database (1992).
C factor	This is related to the amount of vegetative cover in an area and is largely controlled by the crops grown and the cultivation practices used. Values range from 0 to 1.0, with larger values indicating a lower potential for erosion. The C factor was derived from crop-specific literature values from the NRCS Natural Resources Inventory (NRI) database (1992) based on moderate tillage practices.
P factor	This is directly related to the conservation practices used in agricultural areas. Values range from 0 to 1.0, with larger values indicating a lower potential for erosion.

Table 3.3 Source Area Transport Parameters for Fish Brook

Land Use / Land Cover	Area (ha)	CN	K*LS*C*P
Crops*	100.9	88.0	0.001
Abandoned Field	30.1	86.0	0.014
Grasslands**	850.8	74.0	0.035
Clear Cut	92.6	77.0	0.003
Early Regeneration	1,575.2	70.0	0.000
Deciduous Scrub-shrub	19.8	70.0	0.016
Fresh Emergent	13.2	78.0	0.000
Sparse Residential (Pervious)	56.7	74.0	0.001
Sparse Residential (Impervious)	14.2	98.0	0.000
Dense Residential (Pervious)	1.0	74.0	0.001
Dense Residential (Impervious)	0.4	98.0	0.000

* Includes plowed ground and bare ground
** Includes hayfield, pastures, lawns, golf courses)

Table 3.4 Source Area Transport Parameters for Allen Stream

Land Use / Land Cover	Area (ha)	CN	K*LS*C*P
Crops*	177.9	88.7	0.0010
Abandoned Field	21.9	87.5	0.0130
Grasslands**	360.0	75.8	0.0316
Clear Cut	114.2	80.5	0.0029
Early Regeneration	1961.6	73.7	0.0003
Deciduous Scrub-shrub	85.8	74.7	0.0147
Fresh Emergent	10.5	78.0	0.0000
Sparse Residential (Pervious)	29.9	75.6	0.0010
Sparse Residential (Impervious)	7.5	98.0	0.0000
Dense Residential (Pervious)	0.6	74.0	0.0010
Dense Residential (Impervious)	0.3	98.0	0.0000

* Includes plowed ground and bare ground
** Includes hayfield, pastures, lawns, golf courses)

Table 3.5 Source Area Transport Parameters for Footman Brook

Land Use / Land Cover	Area (ha)	CN	K*LS*C*P
Crops/Ground	139.5	88.0	0.0010
Abandoned Field	9.45	86.0	0.0132
Grasslands	276.75	74.1	0.0319
Clearcut	179.64	78.4	0.0029
Early Regeneration	1250.28	70.2	0.0003
Deciduous Scrub-shrub	28.26	70.1	0.0151
Fresh Emergent	27.27	78.0	0.0000
Sparse Residential-Pervious	8.208	74.0	0.0010
Sparse Residential- Impervious	2.052	98.0	0.0000

* Includes plowed ground and bare ground
** Includes hayfield, pastures, lawns, golf courses)

3.2.1.3 Seasonal Transport Parameters

Model inputs for the seasonal transport parameters are shown in Table 3.6. These parameters account for seasonal variability in hydrology, erosion, and sedimentation. The monthly evapotranspiration cover coefficient, day length, and erosivity coefficient are based on regional literature values. (Haith et al. 1992).

Table 3.6 Seasonal Transport Parameters

Month	ET Cover Coefficient (0 to 1)	Day Length (hrs)	Growing Season (1) Non Growing Season (2)	Erosivity Coefficient
Apr	0.490	13.2	0	0.13
May	1.000	14.5	1	0.13
Jun	1.000	15.2	1	0.13
Jul	1.000	14.8	1	0.13
Aug	1.000	13.7	1	0.13
Sep	1.000	12.3	1	0.13
Oct	1.000	10.8	1	0.07
Nov	0.490	9.5	0	0.07
Dec	0.490	8.8	0	0.07
Jan	0.490	9.2	0	0.07
Feb	0.490	10.3	0	0.07
Mar	0.490	11.7	0	0.07

3.2.2. Nutrient Parameters

The nutrient file (NUTRIENT.DAT) specifies the loading parameters for the different sources. The dissolved nutrient concentrations for each rural land use and nutrient loading rates for each urban land use are derived from literature values and are shown in Tables 3.7 and 3.8 (Haith et al. 1992). Soil nitrogen and phosphorus concentrations of 3000 mg/kg and 1300 mg/kg, respectively, and groundwater nitrogen and phosphorus concentrations of 0.34 mg/l and 0.013 mg/l, respectively, were also determined using regional literature values (Haith et al. 1992).

Table 3.7 Nutrient Concentrations for Rural Land Uses

Land Use / Land Cover	N mg/l	P mg/l
Crops*	2.90	0.26
Abandoned Field	1.60	0.13
Grasslands**	3.00	0.25
Clear Cut	0.34	0.01
Early Regeneration	0.19	0.01
Deciduous Scrub-shrub	1.00	0.13
Fresh Emergent	1.00	0.13

* Includes plowed ground and bare ground
** Includes hayfield, pastures, lawns, golf courses)

Table 3.8 Nutrient Loading Rates for Urban Land Uses

Land Use / Land Cover	N kg/ha/day	P kg/ha/day
Sparse Residential	0.012	0.0016
Dense Residential	0.045	0.0045

Estimates of the septic systems in the watershed were generated based on 1990 Census data and regional failure rates. Septic system numbers are shown in table 3.9

Table 3.9 Septic System Status

Septic Systems	Fish Brook	Allen Stream	Footman Brook
Normal (89%)	443	127	34
Ponded (10%)	50	14	4
Short-Circuited (1%)	5	2	1
Total (100%)	498	144	39

3.2.3. Weather Parameters

The weather file (WEATHER .DAT) contains daily average temperature and total precipitation values for each year simulated. Daily precipitation and temperature data were obtained from local National Climatic Data Center (NCDC) weather stations and are shown in Table 3.10 and Figure 3.1. The period of record selected for model runs, April 1, 1990 through March 31, 2002, was based on the availability of daily precipitation and temperature data.

Table 3.10 Weather Stations

Watershed	Weather Station	Station Code	Data Type	Period
Fish Brook	Skowhegan	ME7827	Daily Precipitation	1948-2002
Allen Stream, and Footman Brook	Milo	ME5347	Daily Precipitation	1975-2002
Fish Brook, Allen Stream, and Footman Brook	Brunswic NAS	ME14611	Daily Max/Min Temp	1945-2002

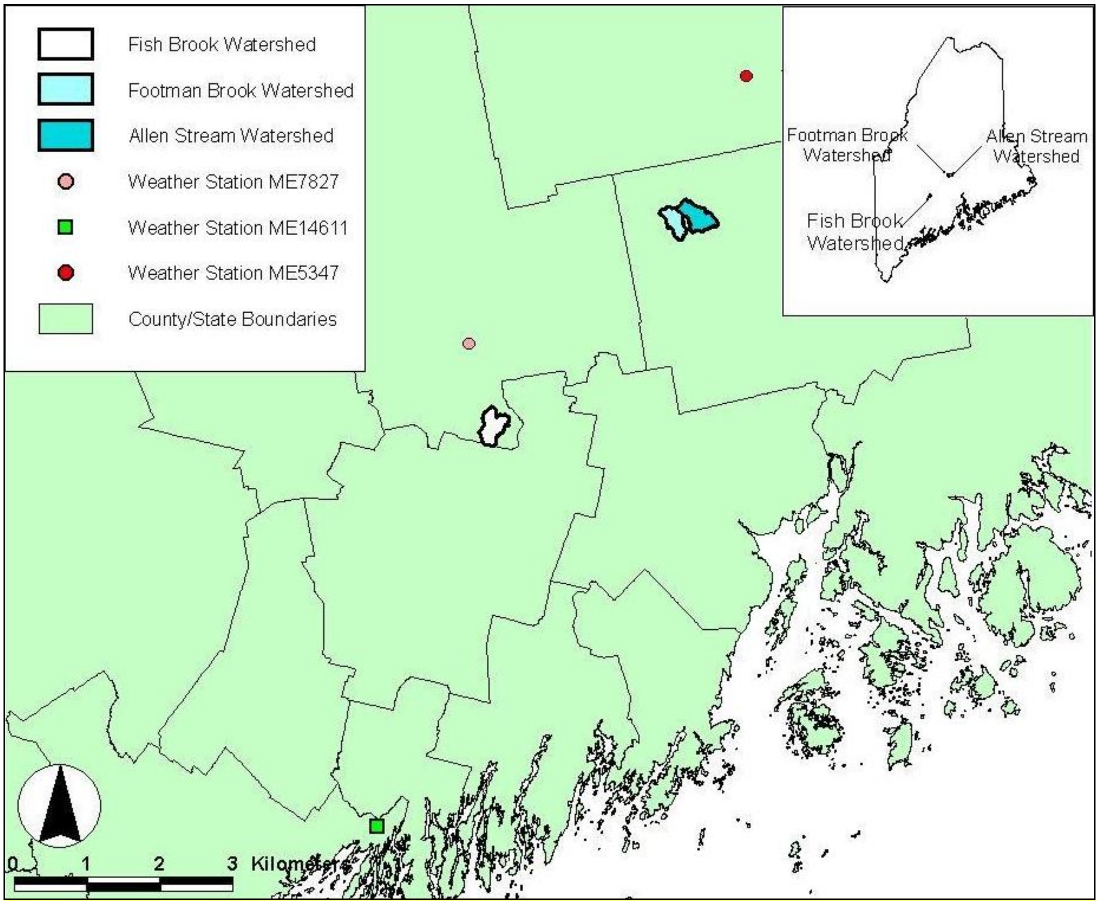

Figure 3.1 Weather Station Locations

3.3 Limitations and Assumptions

Time-variable GWLF results were not calibrated to monitoring data, because insufficient data were available. GWLF results were consistent with the water quality monitoring data available. Local land use, soil, and meteorological data were, however, used to define model parameters and ensure accuracy in load estimation. Critical assumptions include:

- Total Phosphorus and Total Nitrogen were assumed to be an appropriate surrogate for the DO impairment
- Nutrient loading parameters for grasslands were assumed to be representative of nutrient loading from dairy farm operations.
- Meteorological data were assumed to be representative of the watersheds, although the stations are located outside of the watershed.
- Septic system failure rates were assumed to be consistent with percentages from rural communities in upstate New York.

Figures 3.2 and 3.3 show the average monthly, observed total phosphorus and total suspended solids (TSS) concentrations at the mouth of Fish Brook from August to November 2002 and the average monthly, predicted total phosphorus and TSS concentrations from April 2001 to March 2002 for total phosphorus and total suspended sediment, respectively. Total nitrogen was not shown because observation data was not available. The value in the parenthesis represents the number of observations and the bars represent the minimum and maximum observed values. The average monthly total phosphorus results ranged from 0.02 mg/l (May) to 0.63 mg/l (December) and the observation data ranged from 0.02 mg/l (September) to 0.19 mg/l (September). The average monthly total suspended solids results ranged from 0 mg/l (May, August, October) to 418 mg/l (December) and the observation data ranged from 8 mg/l (November) to 343 mg/l (September).

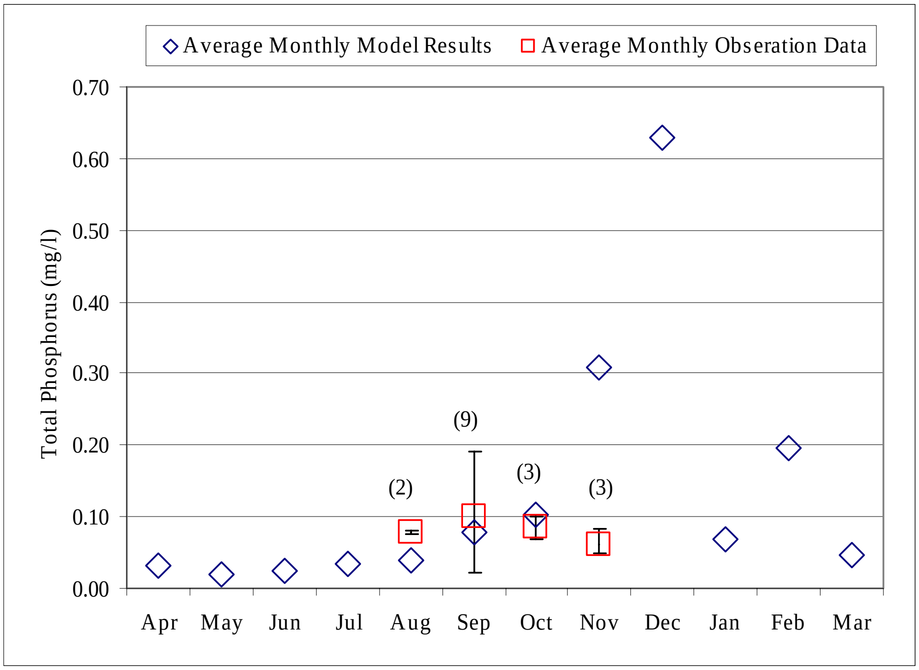

Figure 3.2 Total Phosphorus Observation Data and Model Results for 2002

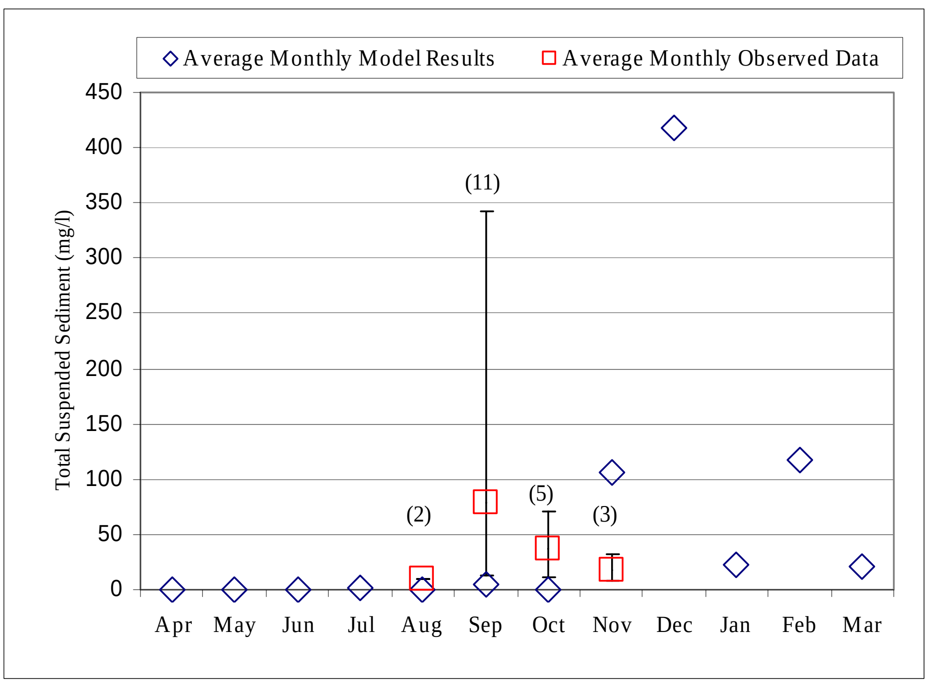

Figure 3.3 Total Suspended Sediment Observation Data and Model Results for 2002

4. Results

The impaired watershed (Fish Brook) and reference watershed (Allen Stream and Footman Brook) models were run for a 12-year period (4/1990 to 4/2002). The first year of each model run was excluded from the analysis to allow the model to stabilize. It is assumed that this period will capture sufficient hydrologic and weather conditions to account for typical variations in nutrient loading conditions. The 12-year means for sediment, total nitrogen, and total phosphorus loads were determined for each land use / land cover. (Tables 4.1, 4.2 and 4.3)

Table 4.1 Predicted Sediment Load and Percentages by Land Use

	Fish Brook		Allen Stream		Footman Brook	
Source Category	Sediment Load (t/year)	Sediment Load (%)	Sediment Load (t/year)	Sediment Load (%)	Sediment Load (t/year)	Sediment Load (%)
Forest	15.61	2.00	15.01	4.20	10.44	3.60
Grassland / Field	737.63	94.34	290.35	81.14	245.86	84.76
Cropland	2.75	0.35	4.54	1.27	3.88	1.34
Clear/Partial Cuts	7.34	0.94	8.45	2.36	14.50	5.00
Residential	0.00	0.00	0.00	0.00	0.00	0.00
Abandoned Field	10.59	1.35	7.27	2.03	3.49	1.20
Scrub-shrub	7.99	1.02	32.19	9.00	11.90	4.10
Wetland	0.00	0.00	0.00	0.00	0.00	0.00
Total	781.91		357.82		290.08	

Table 4.2 Predicted Nitrogen Load and Percentages by Land Use

	Fish Brook		Allen Stream		Footman Brook	
Source Category	Total Nitrogen Load (lbs/yr)	Total Nitrogen Load (%)	Total Nitrogen Load (lbs/yr)	Total Nitrogen Load (%)	Total Nitrogen Load (lbs/yr)	Total Nitrogen Load (%)
Forest	0.25	1.98	0.35	3.84	0.19	3.05
Grassland / Field	4.45	35.67	1.91	20.67	1.44	23.68
Cropland	0.70	5.64	1.30	14.07	0.96	15.77
Clear/Partial Cuts	0.06	0.45	0.08	0.83	0.11	1.86
Residential	0.06	0.49	0.08	0.82	0.01	0.24
Abandoned Field	0.13	1.04	0.10	1.09	0.04	0.67
Scrub-shrub	0.04	0.30	0.17	1.87	0.05	0.88
Wetland	0.02	0.12	0.01	0.13	0.00	0.00
Ground Water	4.34	34.80	4.57	49.51	3.26	53.43
Septic Systems	2.44	19.53	0.66	7.16	0.02	0.40
Total	12.48		9.22		6.10	

Table 4.3 Predicted Phosphorus Load and Percentages by Land Use

Source Category	Fish Brook Total Phosphorus Load (lbs/yr)	Fish Brook Total Phosphorus Load (%)	Allen Stream Total Phosphorus Load (lbs/yr)	Allen Stream Total Phosphorus Load (%)	Footman Brook Total Phosphorus Load (lbs/yr)	Footman Brook Total Phosphorus Load (%)
Forest	0.03	2.00	0.04	3.97	0.02	2.98
Grassland / Field	1.14	74.20	0.46	51.54	0.38	53.88
Cropland	0.07	4.28	0.12	13.43	0.09	12.86
Clear/Partial Cuts	0.01	0.68	0.01	1.39	0.02	2.98
Residential	0.01	0.51	0.01	0.89	0.00	0.21
Abandoned Field	0.02	1.41	0.02	1.77	0.01	1.00
Scrub-shrub	0.01	0.79	0.05	5.75	0.02	2.54
Wetland	0.00	0.00	0.00	0.00	0.00	0.00
Ground Water	0.17	10.77	0.17	19.38	0.12	17.75
Septic Systems	0.08	5.24	0.02	1.69	0.01	0.84
Total	1.54		0.90		0.70	

The unit area loading for sediment, nitrogen, and phosphorus is shown in Tables 4.4, 4.5, and 4.6. The average reference unit area sediment load (0.057 t/acre/year) is 49 percent of the estimated unit area load in Fish Brook (0.115 t/acre/year). The average reference unit area nitrogen load (2.90 lb/acre/year) is 72 percent of the unit area load in Fish Brook (4.40 lb/acre/year). The average reference unit area phosphorus load (0.31 lb/acre/year) is 62 percent of the unit area load in Fish Brook (0.51 lb/acre/year).

Table 4.4 Unit Area Sediment Loads

Watershed	Sediment Load (t/acre/year)	Sediment Load (t/acre/year)
Fish Brook (Impaired)	0.115	0.115
Allen Stream (Reference)	0.052	0.057*
Footman Brook (Reference)	0.061	

* Average Unit Area Load for Both Reference Waterbodies

Table 4.5 Unit Area Nitrogen Loads

Watershed	Nitrogen Load (lb/acre/year)	Nitrogen Load (lb/acre/year)
Fish Brook (Impaired)	4.04	4.04
Allen Stream (Reference)	2.97	2.90*
Footman Brook (Reference)	2.83	

* Average Unit Area Load for Both Reference Waterbodies

Table 4.6 Unit Area Phosphorus Loads

Watershed	Phosphorus Load (lb/acre/year)	Phosphorus Load (lb/acre/year)
Fish Brook (Impaired)	0.50	0.50
Allen Stream (Reference)	0.29	0.31*
Footman Brook (Reference)	0.33	

* Average Unit Area Load for Both Reference Waterbodies