PHOSPHORUS CONTROL ACTION PLAN

and Total Maximum Daily (Annual Phosphorus) Load Report

Echo Lake- Presque Isle

Aroostook County, Maine

Echo Lake PCAP - TMDL Report

Maine DEPLW - 0812

Maine Department of Environmental Protection

and Maine Association of Conservation Districts

EPA Final Review Document – February 5, 2007

ECHO LAKE - Presque Isle

Phosphorus Control Action Plan (PCAP)

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ACKNOWLEDGMENTS

In addition to Maine DEP (Division of Environmental Assessment - Lakes Assessment Section and Watershed Management Division-Augusta and Presque Isle) and U.S. EPA New England Region I staff, the following individuals, groups and agencies were instrumental in the preparation of this Echo Lake combined Phosphorus Control Action Plan and Total Maximum Daily Load report: MACD staff (Forrest Bell, Jennifer Jespersen, Tricia Rouleau, and Fred Dillon); Maine Department of Agriculture (David Rocque); Maine Forest Service (Chris Martin); Maine Department of Inland Fisheries and Wildlife (Dave Basley); Central Aroostook Soil and Water Conservation District (Linda Alverson); Echo Lake Improvement Society (Nancy Walker); City of Presque Isle (George Howe); and Maine Volunteer Lake Monitor, Patty Hutchings (1998-present).

Echo Lake - Presque Isle
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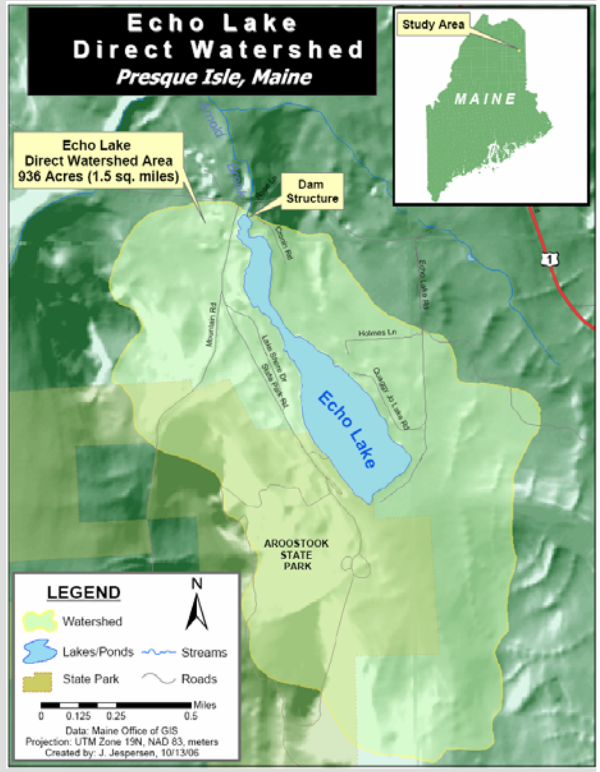
Background

ECHO LAKE (Midas No. 1776) is a shallow, 90 acre, non-**colored** lake located in the City of Presque Isle in Aroostook County, Maine. Echo Lake has a direct drainage area (see map at right and on p. 8) of approximately 1.5 square miles; a maximum depth of 9 feet (3 meters), a mean depth of 5 feet (2 meters); and a **flushing rate** of ~4.5 times per year.

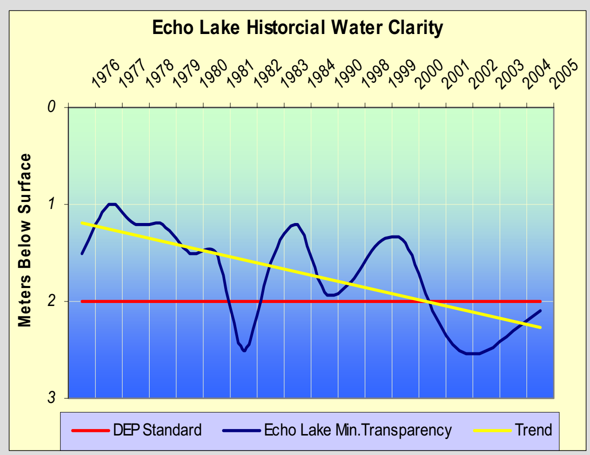


Historical Information

Echo Lake is a man-made lake created in 1864 by the damming of Arnold Brook for the creation of a mill on the northern end of the lake (Welch 1985). The land area around the lake has undergone many changes since the land was first settled in the 1850's. Initially, land was cleared for agriculture, and roads and houses were built. Around 1923, the first camps appeared on the east shore of the lake, followed by the west shore in the 1940's. Wetlands on the south end of the lake were buried in six feet of fill and sold as house lots in the 1960's. In 1938 Maine's first state park was created on the west side of the lake. The park has remained a popular camping and boating area, accounting for as many as 16,000 to 19,000 visitors every year (F. Appleby, personal communication).

Between 1965 and 1975 local residents noticed changes in the water quality of Echo Lake: noxious smells, turbid water, rich aquatic plant life and occasional fish kills (Welch 1985). Long-term sampling efforts to assess water quality and to determine potential sources of nutrient contamination began soon after (see graph to right). Nutrient contamination is due in large part to the contribution of **phosphorus** that is prevalent in area soils. Considered a non-point source (NPS) of pollution, phosphorus stems primarily from soil erosion in the surrounding **watershed** and stormwater runoff from area roads.

Soil erosion can have far reaching impacts, as soil particles effectively transport phosphorus, which serves to "fertilize" the lake and decreases water clarity. Since Echo Lake is an impounded stream, it collects a substantial amount of sediments over time. These nutrient rich bottom



Minimum water clarity measurements have only met standards in 6 of 18 years. Yet, the trend shows improvement since sampling began in the 1970's.

Key Terms

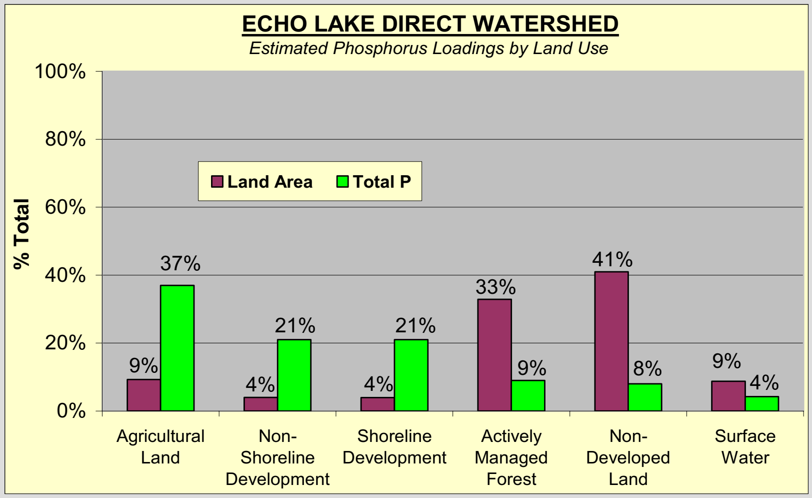
- ***Colored*** *lakes or ponds occur when dissolved organic acids, such as tannins or lignins, impart a tea color to the water, reflected in reduced water transparencies and increased phosphorus values.*
- ***Flushing rate*** *refers to how often the water in the entire lake is replaced on an annual basis.*
- ***Phosphorus****: is one of the major nutrients needed for plant growth. It is naturally present in small amounts and limits the plant growth in lakes. Generally, as phosphorus increases, the amount of algae also increases.*
- ***Watershed*** *is a drainage area or basin in which all land and water areas drain or flow toward a central collector such as a stream, river, or lake at a lower elevation.*

sediments can be a source of high phosphorus as a result of internal loading especially during the warm summer months (Maine VLMP 2006). Excess phosphorus can also harm fish habitat and lead to nuisance algae blooms—floating mats of green scum—or dead and dying algae.

Although there have been substantial efforts to reduce erosion and phosphorus loading in the watershed, phosphorus levels are still high enough to affect water quality and promote algal growth. Echo Lake is listed by DEP as "water quality limited" which means that it is well below the minimum standard. It is also listed on Maine's 303(d) list of impaired waterbodies as well as the state's Non-point Source Priority Watershed List.

What We Learned

The land use assessment conducted for the Echo Lake watershed helped to determine the potential sources of phosphorus that may run off from land areas during storm events and springtime snow melting. This assessment utilized many resources, including generating and interpreting maps, inspecting and verifying aerial photos, consulting with local citizens, and visiting the watershed.



Agricultural land uses make up the greatest proportion of total phosphorus exported to Echo Lake. Residential development and roads on the shoreline and throughout the watershed are the next greatest contributors.

An estimated 136 kg (300 lbs) of phosphorus is exported annually to Echo Lake from the direct watershed. The bar chart (right) illustrates the land area representative land uses as compared to the phosphorus export load for each land use. According to sampling data, the amount of total phosphorus being recycled internally (3.1 kg/year) from Echo Lake bottom sediments during the summer-time (1977, 1985, 2001, 2003) is approximately 2% of the lake's natural capacity (179 kg/year) for in-lake phosphorus assimilation (assuming a target goal of 15 ppb for a non-colored lake).

Phosphorus Reduction Needed

Echo Lake's average summertime TP concentration approximates 18 ppb (216 kg) - equal to an additional 36 kg more than the lake's natural capacity. Including a 6 kg allocation for future development, the total annual amount of phosphorus needed to be reduced to support Maine water quality standards (algal bloom-free total phosphorus concentrations of 15 ppb or less) in Echo Lake approximates 42 kg.

What You Can Do To Help!

As a watershed resident, there are many things you can do to protect the water quality of Echo Lake, including maintaining areas of natural vegetation, using phosphorus-free fertilizer, and getting septic systems pumped regularly. Agricultural land users can consult the USDA/Natural Resources Conservation Service, the Maine Department of Environmental Protection, or the Maine Department of Agriculture, Food, and Rural Resources for information regarding **Best Management Practices** (BMPs) for reducing phosphorus loads. Watershed residents can always become involved by participating in events sponsored by State agencies and local organizations. The estimated phosphorus loading to Echo Lake originates from both shoreline and non-shoreline areas, so all watershed residents must take ownership of maintaining suitable water quality.

Lake stakeholders and watershed residents in Presque Isle can learn more about their lake and the many resources available, including review of the Echo Lake Phosphorus Control Action Plan and **TMDL** report. Following final EPA approval, copies of this detailed report, with recommendations for future NPS/BMP work, will be available online at www.maine.gov/dep/blwq/docmonitoring/tmdl2.htm, or can be viewed and/or copied (at cost) at Maine DEP offices in Presque Isle and Augusta (Bureau of Land and Water Quality, Ray Building, AMHI Campus).

- ***Best Management Practices*** *are techniques to reduce sources of polluted runoff and their impacts. BMPs are low cost, common sense approaches to reduce storm runoff and velocity to keep soil out of lakes and tributaries.*
- ***TMDL****, an acronym for Total Maximum Daily Load, represents the total amount of a pollutant (e.g., phosphorus) that a waterbody can receive on an annual basis and still meet water quality standards.*

Project Premise

This lakes PCAP-TMDL project, funded through a Clean Water Act Section 319-grant from the United States Environmental Protection Agency (EPA), was directed and administered by the Maine Department of Environmental Protection (Maine DEP) under contract with the Maine Association of Conservation Districts (MACD), from 2005 to 2006.

The objectives of this project were twofold: First, a comprehensive land use inventory was undertaken to assist Maine DEP in developing a Phosphorus Control Action Plan (PCAP) and a Total Maximum Daily Load (TMDL) report for the Echo Lake watershed. Simply stated, a TMDL is the total amount of phosphorus that a lake can receive without harming water quality. Maine DEP, with assistance from the MACD, will fully address and incorporate public comments before final submission to the US EPA. *(For more specific information on the TMDL process and results, refer to the Appendices or contact Dave Halliwell at the Maine DEP Augusta Office at 287-7649 or at david.halliwell@maine.gov*).

Secondly, watershed assessment work was conducted by the Maine DEP-MACD project team to help assess **total phosphorus** reduction techniques that would be beneficial for the Echo Lake watershed. The results of this assessment include recommendations for future conservation work in the watershed to help citizens, organizations, and agencies restore and protect Echo Lake. **Note:** *To protect the confidentiality of landowners in the Echo Lake watershed, site-specific information has not generally been provided as part of this PCAP-TMDL report.*

Total Phosphorus (TP) - *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.*

This Phosphorus Control Action Plan (PCAP) report compiles and refines land use data derived from various sources, including the Maine Office of Geographic Information Systems, the Central Aroostook Soil & Water Conservation District (CA-SWCD), and the Maine Forest Service (MFS). Local citizens, active and/or developing watershed organizations, and conservation agencies will benefit from this compilation of both historical and recently collected data as well as the watershed assessment and the NPS Best Management Practice (BMP) recommendations. Above all, this document is intended to help Echo Lake stakeholder groups to effectively prioritize future BMP work in order to obtain the funding resources necessary for further **NPS pollution** mitigation work in their watershed.

Nonpoint Source (NPS) Pollution *- is polluted runoff that cannot be traced to a specific origin or starting point, but accumulates from overland flow from many different watershed sources*

Study Methodology

Echo Lake background information was obtained using several methods, including a review of previous surveys of the lake and watershed, numerous phone conversations and personal interviews with municipal officials, regional organizations and state agencies, input from local stakeholders, and a field visit to the lake.

Land use data were determined using several methods, including (1) **Geographic Information System (GIS)** map analysis, (2) analysis of topographic maps and (3) analysis of aerial photographs. Watershed boundaries, as well as developed and non-developed land use area (i.e., forest, wetland, grassland) were initially determined using a combination of steps 1 and 2. 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). It includes those classes in each layer which are best suited to calculating impermeability of watersheds. Though released in 2006, the Maine Land Cover Data (MELCD) used for this analysis is a land cover map for Maine primarily derived from Landsat Thematic Mapping imagery from the years 1999-2001, which was further refined using panchromatic imagery from the spring and summer months of 2004. Land uses within these maps were further refined by MACD based on aerial photos and then field verified by the Central Aroostook Soil and Water Conservation District (CA-SWCD) using ground-truthing.

> ***GIS****—or* ***geographic information system*** *combines layers of information about a place to give you a better understanding of that place. The information is often represented as computer generated maps.*

> ***Ground-truthing*** *involves conducting field reconnaissance in a watershed to confirm the relative accuracy of computer generated maps.*

Final adjusted phosphorus loading numbers (see Table 3, page 27) were modeled using overlays of soils, and slope. All of the land use coverage data for agricultural areas was re-configured using aerial overlays in conjunction with ground-truthing by local stakeholders throughout the watershed.

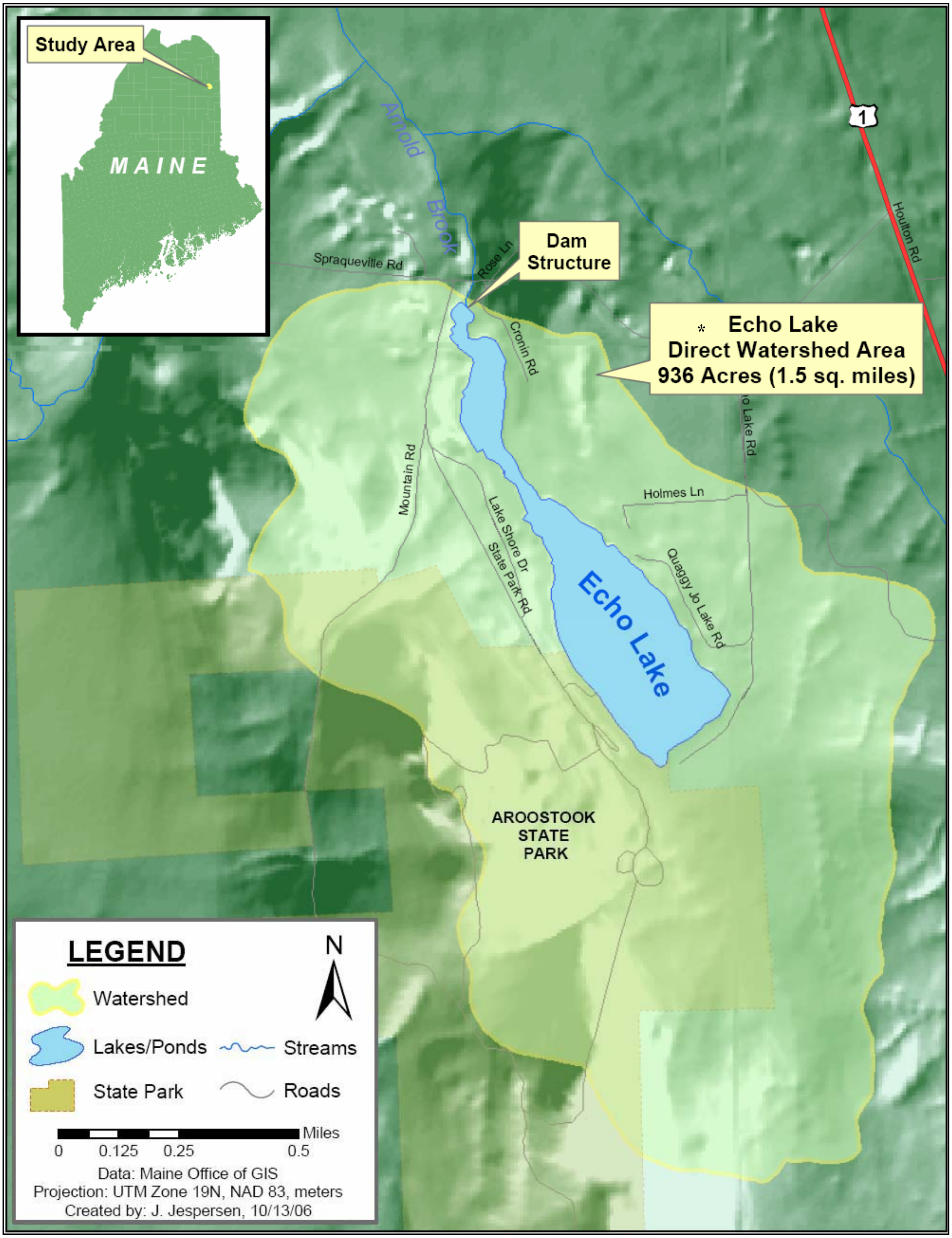
Roadway widths were estimated from previous PCAP reports where actual measurements were made for the various road types. In general, state-owned roads were found to be 22 meters wide; city-owned roads were found to be 16 meters wide; and privately-owned roads/trails were found to be 6 meters wide. GIS was used to calculate total road surface area.

Agricultural information within the Echo Lake watershed was reviewed by the CA-SWCD. Information regarding forest harvest operations were reviewed by the Maine Forest Service, Department of Conservation.

Study Limitations

Land use data gathered for the Echo Lake watershed is as accurate as possible given all of the available information and resources utilized. However, final numbers for the land use analysis and phosphorus loading numbers are approximate, and should be viewed only as carefully researched estimations.

Figure 1. Map of Echo Lake Direct Watershed



** The direct drainage area was recalculated for this report to reflect lake surface area calculations (MDIF&W) and watershed delineations from the Maine Office of GIS using 7.5 minute maps. The direct drainage area does not include the surface area of the lake (90 acres).*

ECHO LAKE Phosphorus Control Action Plan

DESCRIPTION of WATERBODY (MIDAS Number 1776) and WATERSHED

ECHO LAKE is a 90-acre (36 hectare) non-colored waterbody situated in the city of Presque Isle (DeLorme Atlas, Map 65), within Aroostook County, Maine. Echo Lake has a **direct watershed** area (see Figure 1) of approximately 936 acres (1.5 square miles) exclusive of lake surface area. The Echo Lake direct watershed is located 100% within the city of Presque Isle. Echo Lake has a maximum depth of 9 feet (3 meters), overall mean depth of 5 feet (2 meters), and a flushing rate of 4.5 times/year. Note: Direct watershed area was updated for this report based on the watershed area from the Maine Office of GIS.

> ***Direct Watershed:*** *The direct watershed refers to the land area that drains to a waterbody without first passing through an associated lake or pond.*

Drainage System: Echo Lake is a man-made lake created in 1864 by the damming of Arnold Brook for the creation of a mill on the northern end of the lake (Welch 1985). Before it was dammed, the southern half of the lake was a wide eddy in Arnold Brook (Bordner 2001). A study of Echo Lake in 1983 (Welch 1985) revealed that there are as many as 21 perennial and intermittent streams that flow into Echo Lake. However, the largest volume of water to the lake comes from three unnamed tributaries draining the wetland on the south end of the lake. As many as nine perennial and intermittent streams flow into the lake as a result of the runoff from steep Quaggy Jo Mountain within Aroostook State Park to the west. Another nine tributaries drain the agricultural land on the east side of the lake. The only outflow is on the north end of the lake, through the earthen dam, and under Spraqueville Road to downstream Arnold Brook Lake; another 303 (d) listed waterbody. Improvements in water quality for Echo Lake should help improve the water quality of downstream Arnold Brook Lake. A picnic area, 30 site camping facility, and public boat launch is located within Aroostook State Park on the southwestern end of the Lake.

Echo Lake Water Quality Information

Echo Lake is listed on the Maine DEP's 2004 303(d) list of lakes that do not meet State water quality standards. Therefore, a combined Phosphorus Control Action Plan and TMDL report was prepared for Echo Lake during the fall/ winter of 2006.

Based on **Secchi disk transparencies (SDT),** measures of total phosphorus (TP), and **chlorophyll-a**, (Chla), the water quality of Echo Lake is considered to be poor and the potential for nuisance summertime algae blooms is high (Maine VLMP 2006). Together, these water quality data document a trend of increasing **trophic state,** in direct violation of the Maine DEP Class GPA lakes water quality criteria requiring a stable or decreasing trophic state.

A variety of nonpoint sources of pollution may be contributing to the poor water quality in Echo Lake. The water quality of Echo Lake is heavily influenced by runoff events from the watershed. During storm events, nutrients, such as

> ***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.*

> ***Chlorophyll-a*** *is a measurement of the green pigment found in all plants including microscopic plants such as algae. It is used as an estimate of algal biomass; the higher the Chl-a number, the higher the amount of algae in the lake.*

> ***Trophic state -*** *the degree of eutrophication of a lake. Transparency, chlorophyll-a levels, phosphorus concentrations, amount of macrophytes, and quantity of dissolved oxygen in the hypolimnion can all be used to assess trophic state.*

phosphorus—naturally found in Maine soils– drain into the lake from the surrounding watershed by way of streams and overland flow and are deposited and stored in the lake bottom sediments (3.1 kg based on four years of measurements). Phosphorus is naturally limited in lakes and can be thought of as a fertilizer, a primary food for plants, including algae. When lakes receive excess phosphorus from NPS pollution, it "fertilizes" the lake by feeding the algae. Too much phosphorus can result in nuisance algae blooms, which can damage the ecology and aesthetics of a lake, as well as the economic well-being of the entire lake watershed.

Years of soil erosion have resulted in a buildup of sediment in Echo Lake. The potential for TP to leave bottom sediments and become available to algae in the water column is low based on recent dissolved oxygen measurements but there may be rich bottom sediments which contribute to the high phosphorus, especially during warmer summer months (Maine VLMP 2006).

Nonpoint sources of pollution such as erosion from land uses such as development, agriculture, and roads in the watershed all contribute to the declining water quality in Echo Lake. As part of a preliminary Watershed Survey for Echo Lake, volunteers identified 315 separate NPS problem sites (Bordner 2001). The survey found that water quality is affected largely by residential lots and their driveways (61% of problems), and eroding trails and roads at Aroostook State Park (24%). City roads, access points, agriculture, and the snowmobile clubhouse made up the remainder of the problems (15%). A lack of vegetative buffers was noted especially for residential lots and the State Park.

Principle Uses & Human Development:

Developed and managed land in the Echo Lake watershed includes agricultural land, actively managed forest, residential areas, roads, and parks. The most prevalent of these human uses in the watershed are actively managed forest (33%) and agriculture (9%). With 50% (522 acres) of the land area consisting of developed land managed land, NPS pollution is a significant concern for the watershed. Consequently, Echo Lake is on the State's 303(d) list due primarily to excessive phosphorus (sediments), lake enrichment and the historical prevalence of nuisance algal blooms.

General Soils Description

The Echo Lake watershed is characterized by the Caribou-Conant soil association (SCS, 1958) which consists of very deep, well drained soils of the Caribou series, and very deep, moderately well drained and somewhat poorly drained Conant soils. Both soils formed in loamy till consisting of weathered limy shale (decayed limestone and calcareous shale – NRCS 2006). Caribou soils are located on slopes ranging from 0-25%, while Conant soils are located on slopes ranging from 0-15%. Depth to bedrock is generally greater than sixty inches in both soils. Caribou/Conant soils are primarily located east and south of the lake, while steeper, rockier soils such as the Thorndike shaly loam, Plaisted very stony loam, and the Steep Rockland-

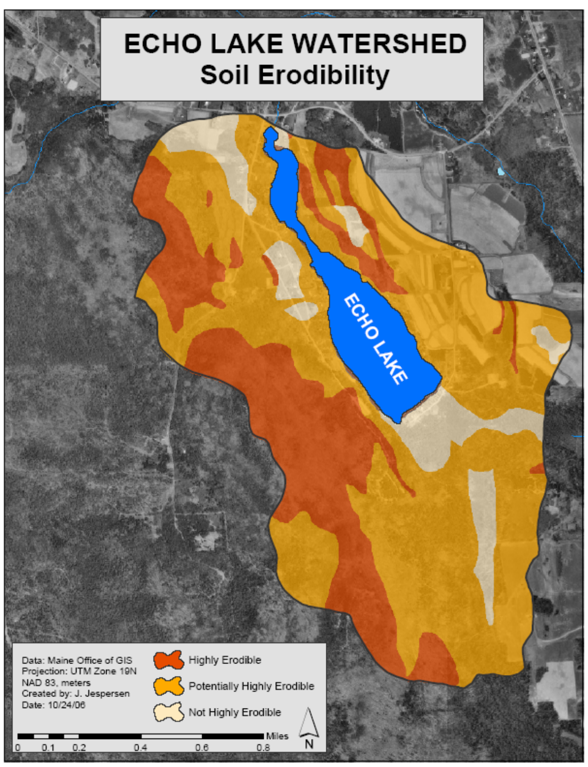


Figure 2. *If not properly managed, soils in the Echo Lake Watershed have the potential to be highly erodible. Soils west of the Lake, in the undeveloped Stake Park are Highly Erodible.*

Thorndike soil (primarily composed of bare shale bedrock), are located to the west of the lake within the State Park boundaries. Since much of this land is forested, highly erodable soils within the Sate Forest are less likely to cause concern.

The greatest land area in the Echo Lake watershed is comprised of soils in hydrologic groups C (42%) and D (33%) which are soils with slow and very slow infiltration capacity and rapid runoff if not vegetated. Land under intensive uses, and on steep slopes, including agricultural crops without a winter cover crop may be particularly vulnerable to erosion.

Land Use Inventory

The results of the Echo Lake watershed land use inventory are depicted in Figure 3 (below) and Table 1 (p. 13). The dominant land uses in the watershed are actively managed forest land and agricultural land. In Table 1, watershed land uses are categorized by developed land vs. non-developed land. The developed and managed land area comprises approximately 50% of the watershed and the undeveloped land, including the water surface area of Echo Lake, comprises the remaining 50% of the watershed. These numbers may be used to help make future planning and conservation decisions relating to the Echo Lake watershed. The information in Table 1 was also used as a basis for preparing the Total Maximum Daily (Annual Phosphorus) Load report (see Appendices).

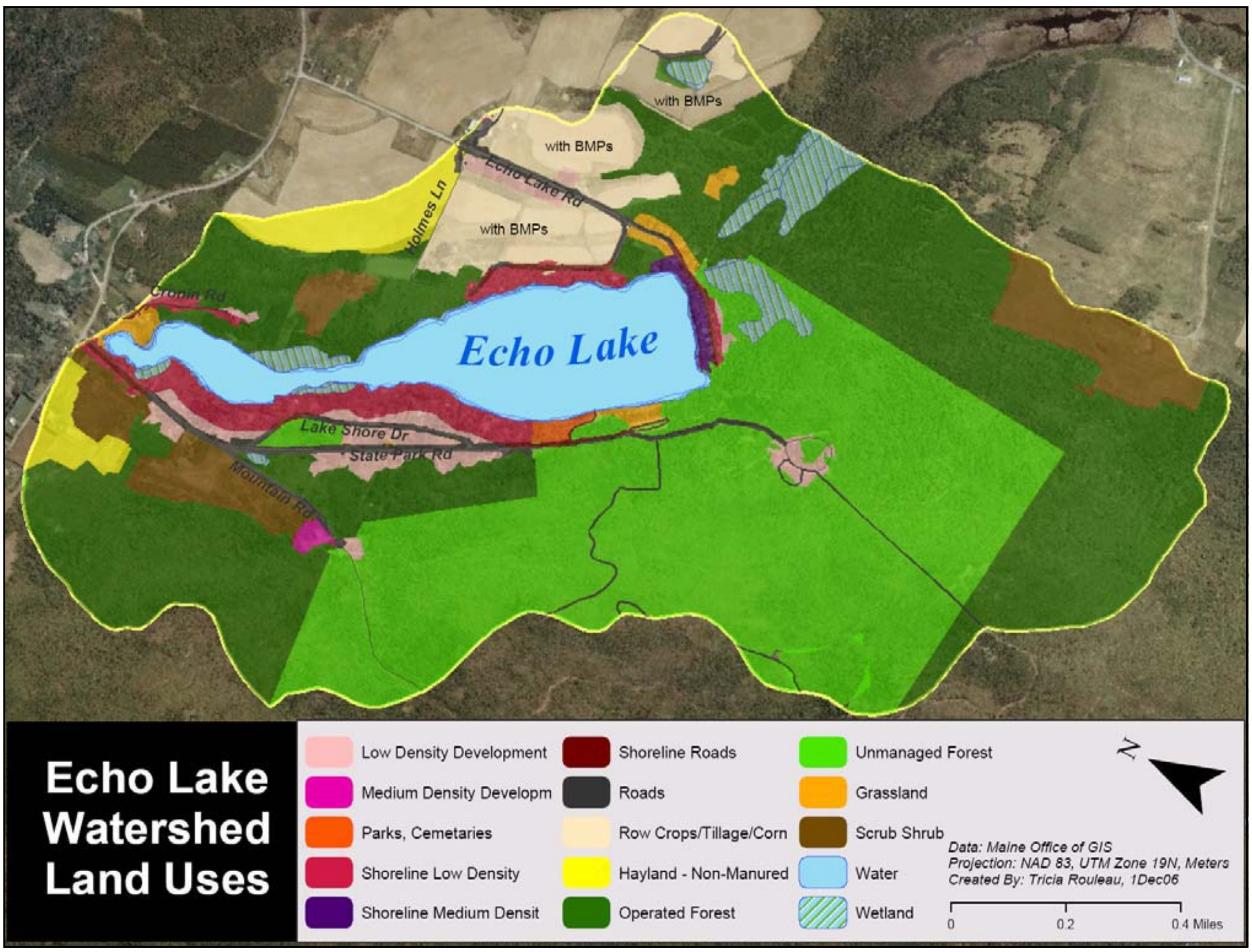
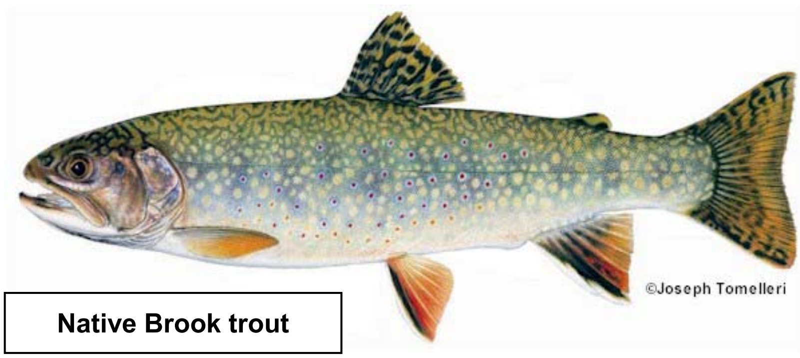


Figure 3. Developed land uses in the Echo Lake watershed are primarily actively managed forest land and agricultural land including hayland and row crops. Note that 32% of he watershed land area is permanently protected State Park land.

Echo Lake Fish & Wildlife Status

Based on records provided by the Maine Department of Inland Fisheries and Wildlife (Maine DIF&W) and recent conversations with fisheries biologist Dave Basley (Region G, Ashland DIF&W office), 90-acre (maximum depth 9 feet) **Echo Lake** (Presque Isle - Stream, Aroostook River drainage system) is currently managed as a coldwater (brook trout) fishery. Echo Lake was originally surveyed by Maine DIF&W in 1954, while their lake fisheries report was previously revised in 1963 and 1990. Following three chemical reclamations (rotenone treatments in 1959, 1983 and 1987) to reduce competing fish species in favor of brook trout fisheries, only **2** fish species are now found to occur (brook trout and banded killifish). According to Maine DIF&W records, the lack of adequate spawning habitat mandates the need for a regular/annual trout stocking program, given its location within the city limits of Presque Isle and the associated heavy recreational use.



Native Brook trout

Future improvements in water quality, reducing the prevalence of nuisance summertime algal blooms, may serve to enhance fisheries conditions in Echo Lake. Given that the trophic state of Echo Lake has been disturbed by cumulative human impacts over the past several decades - then a significant reduction in the total phosphorus loading from the Echo Lake watershed may lead to maintaining in-lake nutrient levels within the natural assimilative capacity of this lake to effectively process total phosphorus - and enhance existing brook trout fisheries.

Echo Lake also provides habitat for a variety of migrating ducks and geese, and resident seagulls. Concerns have been expressed (Aroostook Park Manager, Maine DEP - NMRO, and Maine DIF&W) regarding the possible total phosphorus loading from the excrement of large numbers of resident waterfowl which utilize Echo Lake and its shoreline habitats. A study conducted on nearby Christina Reservoir, a very productive waterfowl management area, showed that "while as many as 1,000 birds may visit the lake on any day, the estimated TP loading (0.6 kg TP/day) is minimal" compared to the magnitude of total phosphorus loading from external (watershed) sources (JWEL 2000).

**Table 1. Echo Lake Direct Watershed—
Land Use Inventory and External Phosphorus Loads**

LAND USE CLASS	Land Area Acres	Land Area %	TP Coeff. Range kg TP/ha	TP Coeff. Value kg TP/ha	Land Area Hectares	TP Export Load kg TP	TP Export Total %
Managed Land							
Hayland (non-manured)	30	3%	0.35 - 1.34	0.64	12	8	6%
Row Crops	66	6%	0.26 - 18.6	2.24/1.66	27	46	34%
Actively Managed Forest	338	33%	0.04 - 0.6	0.08	137	15	11%
Sub-Totals	**434**	**42%**	**0.04-0.6**		**176**	**69**	**51%**
Shoreline Development							
Shoreline Septic Systems						13	9%
Shoreline Roads	7	<1%	0.60 - 10.0	2.0	3	6	5%
Shoreline Low Density	28	3%	0.25-1.75	0.5	11	6	5%
Shoreline Medium Density	3	<1%	0.14 - 4.90	1.0	1	2	1%
Parks/Cemetaries	2	<1%	0.14 - 4.90	0.8	<1	<1	<1%
Sub-Totals	**40**	**4%**			**16**	**28**	**21%**
Non-Shoreline Development							
Roads	22	2%	0.60 - 10.0	1.5	9	15	11%
Low Density Development	24	2%	0.25 - 1.75	0.5	10	5	4%
Medium Density Development	2	<1%	0.40 - 2.20	1.0	<1	<1	<1%
Sub-Totals	**48**	**4%**			**20**	**20**	**15%**
Total: MANAGED / DEVELOPED LAND	**522**	**50%**			**212**	**118**	**87%**
Non-Developed Land							
Inactive/Passively Managed Forest	327	32%	0.01 - 0.08	0.04	132	7	5%
Grassland/Reverting Fields	8	<1%	0.1 - 0.2	0.15	3	<1	<1%
Scrub-Shrub	57	6%	0.1 - 0.2	0.15	23	4	3%
Wetlands	23	2%	0 - 0.05	0.01	9	<1	<1%
Total: NON-DEVELOPED LAND	**415**	**41%**			**167**	**12**	**9%**
Total: Surface Water (Atmospheric)	**90**	**9%**	**0.11 - 0.21**	**0.16**	**36**	**6**	**4%**
TOTAL: DIRECT WATERSHED	**1,027**	**100%**			**415**	**136**	**100%**

Descriptive Land Use and Phosphorus Export Estimates

Agriculture: The amount of agricultural land in the Echo Lake watershed diminished significantly in the period from 1940 to 1968 (Welch 1985). Farmland is no longer active along the shoreline of Echo Lake, and is limited to just one landowner (Linda Alverson, personal communication). Multiple surveys of the watershed (Welch 1985, Bordner 2001) revealed that agricultural landowners have done their best in conserving soil using Best Management Practices (BMPs), and that many of the erosion problems in the past have been fixed. Agricultural land is estimated to comprise 96 acres (9%) of the watershed area including: non-manured hayland (3%), row crops (6%). These agricultural land uses are estimated to contribute 54 kg, or 40% of the total phosphorus loading to Echo Lake. Row crops are the largest agricultural contributor, accounting for approximately 34% of the total phosphorus load to Echo Lake. These data were mapped using GIS software and verified by aerial photography and ground-truthed by staff at the Central Aroostook Soil and Water Conservation District.

- *To convert kilograms (kg) of total phosphorus to pounds - multiply by 2.2046*

Actively Managed Forest Land: The estimated operated forest land for the Echo Lake direct watershed consists of 338 acres. This is the largest land use class among the developed land. This estimate is based on a GIS analysis of land uses and represents 33% of the total land area, contributing about 11% of the total phosphorus load to Echo Lake. Properly managed forestry operations prevent erosion and sedimentation from logging sites by using well thought out skidding systems, proper placing of log landings, and seeding and stabilizing bare soils following harvest operations. Sustainable forest management can enhance water quality through sequestering excess nutrients, particularly in forested riparian areas. Harvested forest acres in Maine typically regenerate as forest, whether or not they are under any type of planned forest management or under the supervision of a Licensed Forester. Much of the actively managed forestland in the Echo Lake watershed has had management plans prepared by a professional forester (see page 19 for more information).

Shoreline Development consists of all developed lands within the immediate shoreland area (250 feet) of Echo Lake. A complete shoreline survey was conducted in November of 2006 by the CA-SWCD. The survey was conducted from a boat, approximately 50 feet from the shoreline. The survey results provide a shoreline structure tally and quantitatively evaluates the nonpoint source pollution impact of each lot in regard to phosphorus loading. A total of 54 developed lots were evaluated during the shoreline survey. Between residential development and beach/boat access, only 3,000 ft. of shoreline remains undeveloped. This type of development can have a large total phosphorus load-

Between 50 and 60 seasonal and year-round residential dwellings dot the shoreline of Echo Lake. Without adequate buffers and regular septic inspections, this type of development can contribute to the algal growth occurring in Echo Lake (photo by F. Bell).

ing impact in comparison to their relatively small percentage of the total land area in the watershed. Low density residential land makes up the largest area (28 acres) within the shoreland area, and contributes the most phosphorus of all developed land use classes in the shore zone. The small grassy picnic area designated as park contributes < 1 kg TP/yr.

A shoreline survey was conducted by boat in the fall of 2006 to assess impacts from both seasonal and year-round residential lots (photo by L. Alverson).

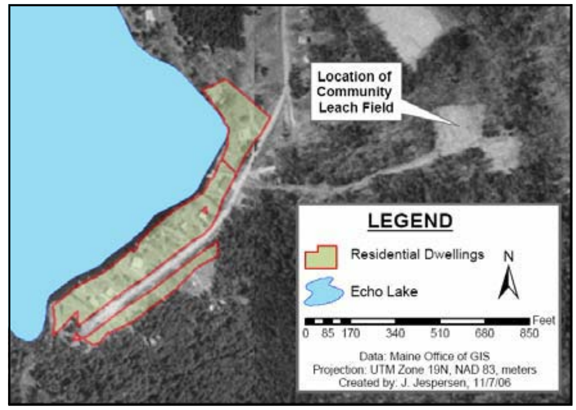
To help characterize shoreline development and to assist stakeholders to target and implement future shoreline BMPs, each house lot was evaluated and assigned an NPS pollution impact rating from a boat. Best professional judgment was utilized to establish subjective determinations of potential impact ratings. The visual survey included a residential dwelling tally along with rating estimates for potential NPS pollution impacts based on the presence or lack of vegetated buffers, distance of dwelling from shoreline, shoreline erosion, presence of bare-exposed soil and percent slope of the lot (See Table 2). In addition to the impact rating, project staff estimated the residency status of the dwelling (seasonal vs. year-round) and other notable features such as retaining walls or private boat launches.

Table 2. Results of Echo Lake Shoreline Survey (2006)

NPS Pollution Potential Severity Score	Impact rating based on a combination of the following from each category:	# of sites within each category	% of sites within each category
1 = Low Impact	Good natural vegetation, very little erosion, no bare soil, minimal slope, set back more than 150' from shore	1	2%
2 = Moderate Impact	Some natural vegetation, visible erosion, evidence of exposed soil, sloped, within shore zone	25	40%
3 = High Impact	Little to no natural vegetation, extensive erosion and bare soil, steeply sloped, close to shoreline	37	59%

Overall, 59% of the lots surveyed on Echo Lake have a high impact due to lack of any vegetation or visual erosion on banks and access ways. In addition, 40% of all shoreline lots that were surveyed on Echo Lake have a moderate impact due to inadequate vegetative buffers and/or close proximity to the pond. Many shoreline areas lack vegetative plantings, while others have only mowed lawns. Vegetative buffers help to decrease the amount and flow of run-off from the sites. Only one (1) property met the criteria for low impact. This lot retained a healthy buffer of natural vegetation between the pond and any substantial development. Only 21% of shoreline properties on Echo Lake have buffer ratings of "Good" or "Best", while more than 50% have little to no buffer. Besides residential dwellings, the State Park features one of the largest stretches of unbuffered shoreline. Including septic systems and roads, shoreline development is second among all other developed land uses with a total contribution of 21% of the total phosphorus to Echo Lake.

Shoreline Septic Systems: A study of lake bacteria in the 1980's did not show that septic systems were contributing to poor water quality, though it did suspect at least 9 properties that had the potential for leaky systems (Welch, 1985). Today, at least three of these suspected properties on the south end of the lake have been switched over to a community septic system that collects waste from the residential dwellings on the south end of the lake. The septic is regularly inspected and maintained by the City of Presque Isle, and was made possible by a small community grant program sponsored by the Maine-DEP and the City of Presque Isle.



A community leach field treats 13 residential properties on the south end of Echo Lake.

Total phosphorus export loading from residential septic systems within the 100-foot shoreline zone was estimated for Echo Lake in 2006. This was accomplished using a simple model based on the results from the shoreline survey. The following attributes were included in the model: seasonal or year-round occupancy status; estimated age of the system; estimated distance of the system to the lake; and an estimate of 3 people per dwelling. A range of low, medium and high groundwater flow values were also factored into the model.

For purposes of these calculations it was assumed that 50% of the dwellings along the shoreline had septic systems installed after 1974. Based on the results of the shoreline survey, 41% of residences (and their septic systems) were estimated to lie less than 50 feet from the shoreline, while only 59% were estimated to lie beyond 50 feet from the shoreline. Approximately 48% of the shoreline dwelling units were assumed to be occupied on only a seasonal basis while the remainder were assumed to be year-round residences.

Estimates of the loading from residential septic systems to Echo Lake range from a low of 7 kg to a high of 22 kg of total phosphorus per year. Assuming a mid-range value of 13 kg of total phosphorus per year, shoreline septic systems represent a relatively substantial contribution (at approximately 9%) of the total phosphorus loading to Echo Lake. The south shore properties on the community septic system were not factored into the model since the community septic is located at least 800 feet from the lake.

Shoreline Roads: NPS pollution associated with shoreline roads (roads within 250 feet of the shoreline) can vary widely, depending upon road type, slope and proximity to a surface water resource. For the Echo Lake TMDL, total phosphorus loading from shoreline roads was estimated using GIS land use data to determine the overall area occupied by this category. The average width for shoreline roads in the Echo Lake watershed was estimated to be about 22 meters for state-owned roads and 16 meters for city-owned roads (based on the findings from previous Maine lake PCAP reports). Based on these factors, shoreline roads were determined to cover about 7 acres and contribute approximately 5% of the total phosphorus load to the direct watershed.

Poorly maintained roads and ditches provide direct conduits for phosphorus laden sediment to Echo Lake (Bordner 2001).

Overall, shoreline development comprises just 4% of the total watershed area and contributes approximately 28 kg of total phosphorus annually, accounting for 21% of the estimated phosphorus load.

Non-Shoreline Development and Land Uses

Non-Shoreline Development consists of all lands outside the immediate shoreline of Echo Lake - including public and private roads and medium density residential areas. The total land area covered by these land-uses was calculated with GIS land use data and corrected using ground-truthing by the CA-SWCD.

Roads: Road widths were estimated from previous PCAP reports and from on-screen viewing of aerial photography. Private roads and trails were estimated to be 6 meters (average width) to determine the amount of total phosphorus loading from this land use category. Trails within the State Park were categorized as private roads Based on these factors, non-shoreline roads contribute an estimated 15 kg/year, or 11% of the total phosphorus load to Echo Lake's direct watershed. This is the second greatest contributor behind row crops.

Residential: Low density development consists of approximately 24 acres and contributes an estimated 5 kg/year of the total phosphorus loading to the Echo Lake direct watershed. Medium density development consists of approximately 2 acres. Combined, these land use classes account for about 2% of the land area and approximately 5% of the total phosphorus load to Echo Lake.

Phosphorus Loading from Non-Developed Lands and Water

Inactive/Passively Managed Forests: Of the total non-developed land area within the Echo Lake watershed, 327 acres are forested, characterized by privately-owned non-managed deciduous and mixed forest plots. Notably, 32% of the watershed land area is permanently protected forest within the State Park. Approximately 5% of the phosphorus load (7 kg/year) is estimated to be derived from non-commercial forested areas within Echo Lake's direct drainage area.

Other Non-Developed Land Areas: Combined grasslands/reverting fields, scrub-shrub, and wetlands account for the remaining 9% of the land area and 4% of the total phosphorus export load.

Atmospheric Deposition (Open Water): Surface waters for Echo Lake's direct watershed comprise 9% of the total land area (90 acres) and account for an estimated 6 kg of total phosphorus per year, representing 4% of the total direct watershed load entering Echo Lake. The total phosphorus loading coefficient chosen (0.16 kg/ha) is similar to that used for central Maine lakes in Kennebec County. This value represents the median of a range of values from Reckhow (1980) of 0.11 kg/ha to 0.21 kg/ha. The upper range generally reflects a watershed that is 50 percent forested, combined with agricultural areas interspersed with urban/suburban land uses.

PHOSPHORUS LOADS – Watershed, Sediment and In-Lake Capacity

Supporting documentation for the phosphorus loading analysis includes water quality monitoring data from Maine DEP and the Volunteer Lake Monitoring Program, and the development of a phosphorus retention model (see Appendices for detailed information). Please note that two methods were used in our total phosphorus loading analysis to assist with the preparation of this report: 1) a GIS-based model to provide a relative estimation of impacts from watershed land uses for the development of phosphorus reduction strategies by stakeholders; and 2) an in-lake phosphorus concentration model to determine the phosphorus reduction needed for the Echo Lake TMDL. These two methods may yield different overall phosphorus loading results depending on the available water quality data and particular characteristics of the watersheds and water bodies being modeled.

1. GIS-Based Land Use and Indirect Load Method

Watershed Land Uses: Total phosphorus loadings to Echo Lake originate from a combination of external watershed and internal lake sediment sources. Watershed total phosphorus sources, totaling approximately 136 kg (300 lbs) annually (corrected using GIS) have been identified and accounted for by land use (See Table 3 - page 27). In contrast, average annual internal lake sediment P-loading of 3.1 kg was estimated from four years of data (1977, 1985, 2001, 2003).

2. In-Lake Concentration Method (TMDL)

Lake Capacity: The assimilative capacity for all existing and future non-point pollution sources for Echo Lake is 179 kg of total phosphorus per year, based on a target goal of 15 ppb (See Phosphorus Retention Model - page 32).

Target Goal: A change in 1 ppb in phosphorus concentration in Echo Lake is equivalent to 12 kg. The difference between the target goal of 15 ppb and the measured average summertime total phosphorus concentration (18 ppb) is 3 ppb or 36 kg (3 ppb x 12 kg).

Future Development: The annual total phosphorus contribution to account for future development for Echo Lake is 6 kg (0.50 x 12) (see page 30 for more information).

Reduction Needed: Given the target goal and a 6 kg allocation for future development, the total amount of phosphorus needed to be reduced, on an annual basis, to restore water quality standards in Echo Lake approximates 42 kg (36 + 6).

PHOSPHORUS CONTROL ACTION PLAN

Recent and Current NPS/BMP Efforts

The Aroostook County– Central Aroostook USDA/Natural Resources Conservation Service (USDA/ NRCS) and the Central Aroostook Soil and Water Conservation District (CA-SWCD) have an ongoing relationship with land owners in the Echo Lake watershed. This cooperation has helped them establish voluntary conservation management plans to reduce nutrient export from residential and agricultural operations.

A 2001 preliminary Watershed Survey conducted by local volunteers, and led by an AmeriCorps volunteer, identified and prioritized Nonpoint Source (NPS) pollution sites in terms of runoff, erosion, nutrient loading and sedimentation (Bordner 2001). This survey pinpointed more than 300 individual problem sites across many different land uses. The results of this survey were used to acquire 319 funding that would target many of the "chronic" problems in the watershed. Many of these chronic problems were associated with runoff from residential driveways and roofs, and erosion along State and City roads, shoulders and roadside ditches. Erosion of trails, unstable culverts, lack of buffers, and surface erosion was noted in the State Park.

In an effort to address some of these issues, Aroostook State Park received grants totaling approximately $14,000 from the Land for Maine's Future Program to work on the problems noted in the Echo Lake Watershed Survey. When the matching funds were added, the work accomplished under these grants totaled over $20,000. (F. Appleby, personal communication)

Additionally, a federal 319 grant was awarded to the CA-SWCD in 2004 for $107,106 to reduce NPS pollution in the Echo Lake Watershed. As a result of this grant, cooperative efforts between the SWCD, residents, the City of Presque Isle and Aroostook State Park has led to soil loss reduction estimates of approximately 10,165 pounds, or approximately 2.3 kg of phosphorus/year (Roble 2005). More than $30,000 worth of erosion control BMPs were installed at the State Park including improvements to the main parking area using non-erodible permeable material, resurfacing and installing drainage at the boat landing, and installing water diverters on the campground roads (see photo below).

As much as $24,500 of the grant went toward improving City roads and ditches along Lower Mountain Road, Quaggy Jo Lake Road and the end of Echo Lake Road. These improvements included a large in-kind match from the City of Presque Isle.

The first diversion ditches on agricultural land were established on the east side of the lake in the 1950's (Welch 1985). Today, the only active farmer in the watershed and is an active conservationist and maintains a high conservation standard. BMPs such as strip cropping, grassed waterways and diversion ditches are used to prevent NPS pollution from entering Echo Lake.

According to the CA-SWCD the only remaining 319 projects are two short private, multi-residence gravel camp roads that need shaping, including improvements to ditches and addition of diversions (Linda Alverson, personal communication).

Much of the actively managed forestland in the Echo Lake watershed has had management plans prepared by a licensed forester. Recent harvests in the watershed have utilized "light on the land" forestry equipment. Landowners are well educated and informed concerning forest management practices and are using these sustainable practices on their land. (Linda Alverson, personal communication)

Other discussions in the past to reduce phosphorus in Echo Lake have involved draw down and

Example of a rubber water diverter used to prevent erosion on State Park roads.

Example of road and ditch improvements along city roads surrounding the lake.

dredging. Drawdown attempts to limit sediment resuspension by consolidating the sediment on the bottom of the lake. This procedure was not deemed feasible because of the high costs associated with completely draining the south basin and either blasting the ledge in the narrows of the pond, or using high capacity pumps to empty the basin (Welch 1985).

Dredging the lake to remove phosphorus laden bottom sediments is not a recommended activity. DEP permits are strictly limited to highly polluted sites such as superfund sites. It was estimated that dredging the top meter of sediment from the south basin of Echo Lake would cost between 2.3 and 3.9 million dollars (1985 estimate). Therefore, it was deemed more effective to install lower cost, traditional BMPs throughout the watershed, thereby limiting the amount of sediment being delivered to the lake.

Recommendations for Future NPS/BMP Work

Echo Lake has impaired water quality primarily due to historical high phosphorus inputs from nonpoint source (NPS) pollution and resultant internal lake sediment recycling of phosphorus. Specific recommendations regarding recent and current efforts in the watershed, Best Management Practices (BMPs), and actions to reduce (1) external watershed and (2) accumulated bottom sediment phosphorus total phosphorus loadings in order to improve water quality conditions in Echo Lake are described below. Additional recommendations are outlined in the draft Echo Lake Watershed Survey (Bordner 2001).

Watershed Management: Several agencies/groups (e.g., Maine DEP, CA-SWCD, USDA/NRCS, City of Presque Isle, Aroostook State Park, Echo Lake Improvement Society) have been involved in restoring the water quality of Echo Lake. This PCAP-TMDL report will serve as a compilation of existing information about the past and present restoration projects that have been undertaken in order to adequately assess future NPS BMP needs in the watershed. The development of an Advisory Team for Echo Lake would help monitor the effectiveness of recently installed BMPs, and provide a forum for discuss regarding additional measures needed to control NPS pollution in the watershed.

Action Item #1 : Support existing watershed management efforts		
Activity	**Participants**	**Schedule & Cost**
Resource agencies should continue to support the Echo Lake Improvement Society.	CA-SWCD, USDA/NRCS, Maine DEP, Echo Lake Improvement Society, City of Presque Isle, Aroostook State Park, interested watershed citizens—stakeholders.	Annual roundtable meetings—beginning in Spring 2007—minimal cost

Agriculture: Behind forest land, agricultural land covers the greatest land area in the watershed, and contributes the greatest phosphorus load. While greater than 90% of the agricultural land in the watershed contains BMPs, this land use still has a potential for delivering NPS pollution, especially during the spring and fall when precipitation is greatest, and fields are bare and vulnerable to erosion. The only active farmer in the watershed has taken many necessary measures to implement BMPs. Recommendations for future agricultural BMPs include monitoring and maintenance of existing BMPs, and use of winter cover crops. The Natural Resources Conservation Service provides technical assistance for using proper agricultural BMPs. For more information contact the NRCS office in Aroostook County (207-764-4153 ext. 3).

Action Item # 2: Monitor and maintain agricultural BMPs		
Activity	**Participants**	**Schedule & Cost**
• Update, inspect, and maintain installed BMPs on cropland. • Plant a winter cover crop to reduce soil erosion during the off season.	CA-SWCD, USDA/NRCS, agricultural landowners.	Annually beginning in 2007 Variable cost depending on type of activities

Shoreline Residential: Pockets of densely developed residential dwellings have the potential to negatively impact water quality. According to the 2006 shoreline survey conducted for this PCAP report, there are 54 shoreline dwellings, over 50% of which were identified as having inadequate or nonexistent vegetated buffers. The survey also estimated that 41% of shoreline dwellings are situated less than 75-feet from the lake. With homes in close proximity to the water's edge, it is critical that adequate and effective vegetative buffers are in place to decrease and slow down run-off from shoreland sites.

An effort should be undertaken to encourage landowners to establish adequate and effective vegetated buffers along the shoreline. For a copy of The Buffer Handbook, contact the Maine DEP's Bureau of Land & Water Quality in Augusta (287-2112) or for technical assistance regarding buffers, contact the CA-SWCD (207) 764-4153.

Action Item # 3: Educate watershed citizens about shoreline buffers		
Activity	**Participants**	**Schedule & Cost**
Develop a Buffer Awareness Campaign	Maine DEP, CA-SWCD, City of Presque Isle, Echo Lake Improvement Society, interested watershed citizens, Aroostook State Park.	Begin immediately - $1,500/yr

Other Shoreline Development: Aroostook State Park has the longest continuous length of shoreline with no vegetated buffers. While time and money have gone towards making improvement s in Aroostook State Park, there have been no concerted efforts to plant vegetated buffers along the shore.

Action Item # 4: Aroostook State Park shoreline buffer plantings		
Activity	**Participants**	**Schedule & Cost**
• Vegetate unbuffered shoreline areas within Aroostook State Park. • Provide demonstration buffer plant-ings.	Aroostook State Park, Maine DEP, CA-SWCD, City of Presque Isle, Echo Lake Improvement Society, interested shoreline residents.	Begin immediately- Cost is variable, depending on length of shoreline

Stabilizing culverts and maintaining roadside ditches can help reduce erosion and sedimentation.

Roadways: A common cause of NPS pollution in lake watersheds is often related to roads and roadside ditches, which if not properly designed and maintained can be a major source of erosion and sedimentation into lakes and streams. This PCAP report estimates that public and private roads combined contribute slightly more than 26% of the total phosphorus load per year to Echo Lake. If not properly designed and maintained, roadside ditches may be acting as conduits, effectively transporting sediments from bare agricultural fields in the spring and late fall. Recently installed roadway BMPs should be monitored and maintained to ensure the effectiveness of these practices.

Action Item # 5: Monitor and maintain roadway Best Management Practices		
Activity	**Participants**	**Schedule & Cost**
• Monitor and maintain BMPs on recently improved culverts, ditches and roads throughout the watershed.	Maine DEP, CA-SWCD, City of Presque Isle, Maine DOT, Aroostook State Park, interested watershed citizens.	Immediately & ongoing- Variable cost depending on extent of repair needed.

Septic Systems: Older, poorly designed and installed septic systems within the shoreland zone may contribute significantly to water quality problems, adding to the cumulative phosphorus load to Echo Lake. While Echo Lake septic systems – when properly sited, constructed, maintained, and set back from the water – should not affect water quality, many septic systems do not meet all of these criteria and thus have the potential to contribute phosphorus and other contaminants to lake water. Septic systems around Echo Lake which are sited in poorly drained soils with minimal filtering capacity are especially likely to contribute nutrients to lake waters, as are older septic systems which pre-date Maine's 1974 Plumbing Code.

Lakeshore residents who believe they may have problems with their septic systems are encouraged to contact their town office for possible technical and/or financial assistance.

Action Item # 6: Develop a septic system inspection program		
Activity	**Participants**	**Schedule & Cost**
Conduct septic system inspections to identify any potential malfunctions and promote regular pumping to ensure proper septic system operation	Maine DEP, CA-SWCD, City of Presque Isle and watershed citizens.	Annually beginning in 2007 $1,500/yr

Individual Action - Non-shoreline Residents: Non-shoreline development is estimated to contribute more total phosphorus to Echo Lake than shoreline land uses. Therefore, watershed residents outside of the immediately shoreline should be encouraged through continued education and outreach efforts. Particular attention should be given to properties adjacent to watershed brooks and streams. Use of natural vegetation, buffer strips, non-phosphate cleaning detergents, elimination of phosphorus-containing fertilizers, and adequate maintenance of septic systems should be encouraged.

Action Item # 7: Expand homeowner education & technical assistance programs		
Activity	**Participants**	**Schedule & Cost**
Provide stormwater management education to small business owners and residents in the Watershed.	Maine DEP, CA-SWCD, City of Presque Isle.	Begin immediately- $2,000

Municipal Action: Presque Isle officials have been trained in current erosion control methods as evidenced in the recent 319 projects the city has completed. However, Municipal officials ongoing training in current erosion and sediment control methods will ensure public compliance with local and state water quality laws and ordinances (Shoreland Zoning, Erosion and Sedimentation Control Law, plumbing code). This can be achieved through education and enforcement action, when necessary.

Action Item # 8: Ongoing BMP training for municipal officials		
Activity	**Participants**	**Schedule & Cost**
• Municipal officials should continue to ensure compliance with local and State water quality laws and ordinances.	Maine DEP, Maine DOT, CA-SWCD, City of Presque Isle, interested watershed citizens.	Annually beginning 2007 Variable cost depending on extent of repair needed.

WATER QUALITY MONITORING PLAN

Historically, the water quality of Echo Lake has been monitored via measures of Secchi disk transparencies during the open water months since 1976 (Maine DEP and Maine VLMP). Continued long-term water quality monitoring (water transparencies) for Echo Lake will be conducted monthly, from May to October, through the continued efforts of Maine DEP and Maine VLMP. Additional monitoring and assessment during storm events would help further gauge the impact of inputs from the surrounding watershed. Under this planned, post-TMDL water quality-monitoring plan, sufficient data will be acquired to adequately track seasonal and inter-annual variation and long-term trends in water quality in Echo Lake. A post-TMDL adaptive management status report will be prepared 5 to 10 years following EPA approval.

PCAP CLOSING STATEMENT

The Central Aroostook Soil and Water Conservation District, in cooperation with the city of Presque Isle, the Echo Lake Improvement Society, and watershed residents have taken significant action to address nonpoint source pollution in the Echo Lake watershed. Technical assistance by the USDA/ NRCS, the ME-DEP, and the CA-SWCD is available to watershed residents to mitigate phosphorus export from existing NPS pollution sources and to prevent excess loading from future sources. These groups recognize the inherent value of the lake and its vital link to the community by providing strong support to restoration efforts. Watershed stakeholders have made a significant contribution to stemming water pollution in Echo Lake. It is important to maintain these existing improvements while continuing to make further progress, particularly in the form of vegetated buffers and stormwater control measures. This teamwork approach will result in an eventual and overall improvement in Echo Lake through NPS-BMP implementation and increased public involvement and awareness.

APPENDICES

ECHO LAKE (Presque Isle)

Total Maximum Daily (Annual Phosphorus) Load

Maine Lake TMDLs and Phosphorus Control Action Plans (PCAPs)

You may be wondering what the acronym 'TMDL' represents and what it is all about. TMDL is actually short for 'Total Maximum Daily Load' as historically applied to point-source pollutants. This information, no doubt, does little to clarify TMDLs in most people's minds. However, when we think of this as an annual phosphorus load (*Annual Total Phosphorus Load),* it begins to make more sense, for nonpoint source pollution. Following EPA guidance (Spring 2006), we now report daily and annual phosphorus loads.

Simply stated, excess nutrients or phosphorus in lakes promote nuisance algae growth/blooms - resulting in the violation of water quality standards as measured by water clarity depths of less than 2 meters. A lake TMDL is prepared to estimate the total amount of total phosphorus that a lake can accept on an annual basis without harming water quality. Historically, development of TMDLs was first mandated by the Clean Water Act in 1972, and was applied primarily to *point sources* of water pollution. As a result of public pressure to further clean up water bodies, lake and stream TMDLs are now being prepared for watershed-generated *Non-Point Sources* (NPS) of pollution.

Nutrient enrichment of lakes through excess total phosphorus originating from watershed soil erosion has been generally recognized as the primary source of NPS pollution. Major land use activities contributing to the external phosphorus load in lakes include residential-commercial developments, roadways, agriculture, and commercial forestry. Statewide, there are 32 lakes in Maine which do not meet water quality standards due to excessive amounts of in-lake total phosphorus - the great majority of which are located in south-central Maine.

The first Maine lake TMDL was developed (1995) for Cobbossee Lake by the Cobbossee Watershed District (CWD) - under contract with Maine DEP and U.S. EPA. Recently (June 2006), Cobbossee Lake was officially removed from the TMDL listing of "impaired" waterbodies, in light of 8 years of above standard water clarity measures. TMDLs have been approved by U.S. EPA for Madawaska Lake (Aroostook County), Sebasticook Lake, East Pond (Belgrade Lakes), China Lake, Webber, Threemile and Threecornered ponds (Kennebec County), Mousam Lake, the Highland lakes in Falmouth and Bridgton, Annabessacook Lake, Pleasant Pond, Upper Narrows Pond and Little Cobbossee Lake (under contract with CWD), Sabattus, Toothaker, and Unity ponds and Long Lake (with assistance from Lakes Environmental Association), Togus Pond, Duckpuddle Pond, Lovejoy Pond, Lilly Pond, Sewall Pond, Cross Lake, Daigle Pond, Trafton Lake, and Monson Pond. PCAP-TMDLs are presently being prepared by Maine DEP, with assistance from the Maine Association of Conservation Districts (MACD) and County Soil and Water Conservation Districts (SWCD's) - for Hermon and Hammond Ponds and Arnold Brook Lake. PCAP-TMDL studies have also been initiated for Christina Reservoir, the last of the remaining 2004 303(d) listed PCAP-TMDL waterbodies in Aroostook County.

Lake PCAP-TMDL reports are based in part on available water quality data, including seasonal measures of total phosphorus, chlorophyll-a, Secchi disk transparencies, and dissolved oxygen-water temperature profiles. Actual reports include: a lake description; watershed GIS assessment and estimation of NPS pollutant sources; selection of a total phosphorus target goal (acceptable amount); allocation of watershed/land-use phosphorus loadings, and a public participation component to allow for stakeholder review.

PCAP-TMDLs are important tools for maintaining and protecting acceptable lake water quality and are designed to 'get a handle' on the magnitude of the NPS pollution problem and to develop plans for implementing Best Management Practices (BMPs) to effectively address the lake's water pollution problem. Landowners and watershed groups are eligible to receive technical and financial assistance from state and federal natural resource agencies to reduce watershed total phosphorus loadings to the lake. **Note:** for non-stormwater regulated lake watersheds, the *development of phosphorus-based lake PCAP-TMDLs are not generally intended by Maine DEP to be used for regulatory purposes*.

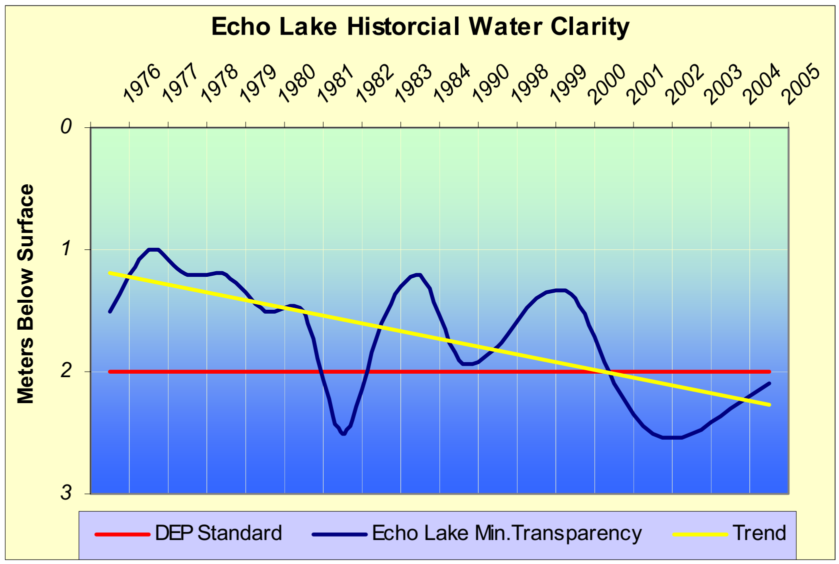
For further information, contact Dave Halliwell, Maine Department of Environmental Protection, Lakes PCAP-TMDL Program Manager, SHS #17, Augusta, ME 04333 (207-287-7649).
E-mail: david.halliwell@maine.gov

Water Quality, Priority Ranking, and Algae Bloom History

Water Quality Monitoring: (Source: Maine DEP and Maine VLMP 2006) Water quality monitoring data for Echo Lake (station 1, deep hole) has been collected since 1976 (77-85, 90, 98-05). Hence, this present water quality assessment is based on nineteen years of water quality data including 19 years of Secchi disk transparency (SDT) measures, combined with 9 years of epilimnion core total phosphorus (TP) data, 11 years of water chemistry and 12 years of chlorophyll-a measures.

Water Quality Measures: (Source: Maine DEP and Maine VLMP 2006) Historically, Echo Lake has had a range of SDT measures from 1.0 to 3.1 m, with an average of 2.2 m; an epilimnion core TP range of 13 to 41 with an average of 20 parts per billion (ppb), and chlorophyll-a measures ranging from 2.9 to 42.1 ppb, with an average of 7.7 ppb.

Recent dissolved oxygen (DO) profiles show very little DO depletion in deep areas of the lake since the lake is too shallow to thermally stratify in the summer. The potential for total phosphorus to leave the bottom sediments and become available to algae in the water column (internal recycling) is low based on recent oxygen measurements, but there may be rich bottom sediments which contribute to the high phosphorus, especially during warmer summer months (Maine DEP 2006).



The water clarity readings for Echo Lake have gradually improved since sampling began in 1976 and have been consistently above minimum standards in the last 5 years of sampling (2001-2005).

Priority Ranking, Pollutant of Concern and Algae Bloom History: Echo Lake is listed on the State's 2004 303(d) list of waters in non-attainment of Maine State water quality standards and was moved up in the priority development order due to the need to complete an accelerated approach to lakes TMDL development. This Echo Lake TMDL has been developed for total phosphorus, the major limiting nutrient to algae growth in freshwater lakes in Maine.

As indicated by the chart above, the water quality of Echo Lake has generally been poor during the entire historical monitoring period. Since 2001 minimum transparencies have been at or below the state's water quality limit of two meters. Consequently, summertime nuisance algal blooms have been a regular occurrence.

As indicated by water clarity, the water quality of *Echo Lake* appears to be improving over the period of record. Improvements may be due to the substantial efforts of watershed stakeholders to reduce watershed runoff. However, since 1976 minimum transparencies have averaged at or below 2 meters in 12 of the 18 sampling years. Total phosphorus (18 ppb-based historical summertime data) does not meet State minimum standards for acceptable water quality, and summertime nuisance algal blooms have been a regular occurrence.

Natural Environmental Background levels for Echo Lake were not separated from the total non-point 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 (US-EPA 1999). There are no known point sources of pollutants to Echo Lake.

WATER QUALITY STANDARDS & TARGET GOALS

Maine State Water Quality Standard for nutrients which are narrative, are as follows *(July 1994 Maine Revised Statutes Title 38, Article 4-A*): "Great Ponds Class A (GPA) waters shall 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, and 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). Echo Lake is a non-colored lake (average color 24 SPUs), with low late summer SDT readings (annual average of 2.2 meters 76-85, 90, 98-05). Currently, Echo Lake does not meet water quality standards primarily due to non-attainment of water transparency measures over time. This water quality assessment uses historic documented conditions as the primary basis for comparison.

Designated Uses and Antidegradation Policy: Echo Lake 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."

Numeric Water Quality Target: The numeric (in-lake) water quality target for Echo Lake is set at 15 ppb total phosphorus (179 kg/yr). Since numeric criteria for phosphorus do not exist in Maine's state water quality regulations - and would be less accurate targets than those derived from this study - we employed best professional judgment to select a target in-lake total phosphorus concentration that would attain the narrative water quality standard. Spring-time (late May - June) total phosphorus levels in Echo Lake historically approximated 18 ppb, similar to summertime levels, which also averaged 18 ppb. Current data show that summertime levels (1998, 2001-2005) are much lower than their historical average, at 15 ppb.

In summary, the numeric water quality target goal of 15 ppb for total phosphorus in Echo Lake was based on observed late spring - early summer pre-water column stratification measures, generally corresponding to non-bloom conditions, as reflected in suitable (water quality attainment) measures of both Secchi disk transparency (> 2.0 meters) and chlorophyll-a (< 8.0 ppb).

ESTIMATED PHOSPHORUS EXPORT BY LAND USE CLASS

Table 3 details the numerical data used to determine external phosphorus loading for the Echo Lake watershed. The key below Table 3 on the next page explains the columns and the narrative that follows (pages 29-30) relative to each of the representative land use classes.

Table 3. Echo Lake Direct Watershed - Estimated Phosphorus Export by Land Use Class

LAND USE CLASS	Land Area Acres	Land Area %	TP Coeff. Range kg TP/ha	* TP Coeff. Value kg TP/ha	Land Area Hectares	TP Export Load kg TP	TP Export Total %
Managed Land							
Hayland (non-manured)	30	3%	0.35 - 1.34	0.64	12	8	6%
Row Crops	66	6%	0.26 - 18.6	2.24/1.66	27	46	34%
Actively Managed Forest	338	33%	0.04 - 0.6	0.08	137	15	11%
Sub-Totals	**434**	**42%**	**0.04-0.6**		**176**	**69**	**51%**
Shoreline Development							
Shoreline Septic Systems						13	9%
Shoreline Roads	7	0.7%	0.60 - 10.0	2.0	3	6	5%
Shoreline Low Density	28	3%	0.25-1.75	0.5	11	6	5%
Shoreline Medium Density	3	0.3%	0.14 - 4.90	1.0	1	2	1%
Parks/Cemetaries	2	0.2%	0.14 - 4.90	0.8	0.8	0.8	0.6%
Sub-Totals	**40**	**4%**			**16**	**28**	**21%**
Non-Shoreline Development							
Roads	22	2%	0.60 - 10.0	1.5	9	15	11%
Low Density Development	24	2%	0.25 - 1.75	0.5	10	5	4%
Medium Density Development	2	0.2%	0.40 - 2.20	1.0	0.7	0.8	0.6%
Sub-Totals	**48**	**4%**			**20**	**21**	**15%**
Total: MANAGED / DEVELOPED LAND	**522**	**50%**			**212**	**118**	**87%**
Non-Developed Land							
Inactive/Passively Managed Forest	327	32%	0.01 - 0.08	0.04	132	7	5%
Grassland/Reverting Fields	8	0.8%	0.1 - 0.2	0.15	3	0.5	0.4%
Scrub-Shrub	57	6%	0.1 - 0.2	0.15	23	4	3%
Wetlands	23	2%	0 - 0.05	0.01	9	0.1	0.1%
Total: NON-DEVELOPED LAND	**415**	**41%**			**167**	**12**	**9%**
Total: Surface Water (Atmospheric)	**90**	**9%**	**0.11 - 0.21**	**0.16**	**36**	**6**	**4%**
TOTAL: DIRECT WATERSHED	**1,027**	**100%**			**415**	**136**	**100%**

Key for Columns in Table 3

Land Use Class: The land use category that was analyzed for this report.

Land Area in Acres: The area of each land use as determined by GIS mapping, and aerial photography.

Land Area %: The percentage of the watershed covered by the land use.

TP Coeff. Range kg/ha: The range of the total phosphorus coefficient values listed in the literature associated with the corresponding land use.

***TP Coeff. Value kg/ha**: The selected coefficient for each land use category. The total phosphorus coefficient is determined from previous research – usually the median value, if listed by the author. The coefficient is often adjusted using best professional judgment based on conditions including soil type, slope, and best management practices (BMPs) (see pages 29 and 30 for more information).

Land Area in Hectares: Conversion, 1.0 acre = 0.404 hectares.

TP Export Load kg TP : Uses GIS to incorporate soils and slopes into the final phosphorus loading number using total hectares.

TP Export Total %: The percentage of estimated phosphorus exported by the land use.

* Agricultural land with BMPs was assigned a lower TP coefficient (see p. 29 for more information).

Total Phosphorus Land Use Loads

Estimates of total phosphorus export from different land uses found in the Echo Lake watershed as presented on the previous page in Table 3 represent the extent of the current direct watershed phosphorus loading to the lake (136 kg/yr).

Total phosphorus loading measures are provided as a range of values to reflect the degree of uncertainty generally associated with such relative estimates (Walker 2000). The watershed total phosphorus loading values were primarily determined using literature and locally-derived export coefficients as found in Schroeder (1979), Reckhow et al. (1980), Dennis (1986), Dennis et al. (1992), and Bouchard et al. (1995) for residential properties, roadways, agriculture and other types of land uses. Export coefficients for agricultural land with BMPs were adjusted using carefully researched reduction methods including the EPA STEPL model.

Agriculture: Phosphorus loading coefficients as applied to agricultural land uses were adopted from: Dennis and Sage (1981): non-manured hayland (0.64 kg/ha/yr), and Reckhow et al. (1980): row crops/ tillage/cultivation (2.24 kg TP/ha/yr). The coefficient used for agricultural land in which other types of BMPs (e.g. grassed waterways and diversion ditches) were implemented (1.66 kg TP/ha/yr) was adjusted using the EPA STEPL model which incorporates annual rainfall, soil P concentration, hydrological soil group, and the percent of area the BMP covers. The coefficient used for all non-manured hayland in the watershed may actually underestimate its impact since some hayland may receive commercial fertilizer.

Actively Managed Forest Land: The phosphorus loading coefficient applied to actively managed forest land (0.08 kg/ha/yr) was changed beginning with the Long Lake PCAP-TMDL report following consultation with Lakes Environment Association and Maine Forest Service staff. The rationale for this change was based on the fact that properly managed harvest areas will generally act as phosphorus sinks during periods of regeneration. According to the Maine Forest Service, of the nearly 3,500 water quality inspections conducted throughout the state in 2003, approximately 7% of the harvested sites posed “unacceptable” risks to water quality.

PCAP-TMDL reports prior to the Long Lake report identified a “worst case” upper limit phosphorus loading coefficient of 0.6 kg/ha/yr for operated forestland. Therefore, for any given watershed in Maine we determined that applying this “worst case” coefficient to 7% of operated forest land while applying the “best case” coefficient (0.04 kg/ha/yr) to the remaining operated forest land would provide a relatively accurate estimate of total phosphorus loading from operated forest land. Combining worst case and best case coefficients yields the new phosphorus loading coefficient for operated forest land of 0.08 kg/ha/yr [(0.07 x 0.6) + (0.93 x 0.04)].

Residential Development: The phosphorus loading coefficients for residential land uses, including; low density residential (0.5 kg/ha/yr), medium density residential (1.0 kg TP/ha/yr), and high density residential (1.4 kg TP/ha/yr) were developed from information on residential lot stormwater export of phosphorus as derived from Dennis et al (1992), and first implemented in the 1995 Cobbossee Lake TMDL.

Private and Public Roads: The total phosphorus loading coefficient for private and public roads (2.0 kg/ha/yr for shoreline roads and 1.5 kg/ha/yr for non-shoreline roads) was chosen, in part, from previous studies of rural Maine highways (Dudley et al. 1997) and phosphorus research by Jeff Dennis (Maine DEP).

Parks/Cemeteries: The phosphorus loading coefficient for parks and cemeteries (0.80 kg TP/ha/yr) is based on unpublished research from Wagner-Mitchell-Monagle (ENSR 1989).

Total Developed Lands Phosphorus Loading: A total of 50% (128 kg) of the phosphorus loading to Echo Lake is estimated to have been derived from the cumulative effect of the preceding cultural land use classes: agriculture (37% - 54 kg); forestry (9%-13 kg); shoreline development 21% - 31 kg); and non-shoreline development (21% - 30 kg) as depicted in Table 3.

Non-Developed Lands Phosphorus Loading: The phosphorus export coefficient for inactive/ passively managed forest land (0.04 kg/ha/yr) is based on a New England regional study (Likens et al 1977) and phosphorus availability recommendation by Jeff Dennis (Maine DEP). The phosphorus export coefficient for grassland/reverting fields and scrub/shrub (0.15 kg/ha/yr) is based on research for the Annabessacook Lake TMDL in 1990, and by Bouchard in 1995. The export coefficient for wetlands is based on research by Bouchard 1995 and Monagle 1995 (0.01 kg/ha/yr). The phosphorus loading coefficient chosen for surface waters (atmospheric deposition - 0.16 kg/ha/yr), was originally used in the China Lake TMDL (Kennebec County), and subsequent PCAP-TMDL lake studies in Maine.

Shoreline Erosion: Undeveloped areas of the lake shoreline that may be eroding due to natural causes (i.e., wind, wave and ice action) are not included as a source of phosphorus due to the difficulty in quantifying impact area and assigning suitable phosphorus loading coefficients.

Phosphorus Load Summary

It is our professional opinion that the selected export coefficients are appropriate for the Echo Lake watershed. Results of the land use analysis indicate that a best estimate of the present total phosphorus loading from external nonpoint source nutrient pollution approximates 136 kg/yr.

LINKING WATER QUALITY and POLLUTANT SOURCES

Annual/Daily Load Capacity: Total Phosphorus (TP) serves as a surrogate measure of Maine's narrative water quality standards for lake trophic status. The TP TMDL is originally calculated as an annual load (kg TP/yr), which is based on an in-lake numeric water quality target (ppb or ug/l TP) and the annual flushing rate of the lake, using generally accepted response models for lakes. It is appropriate and justifiable to express the Echo Lake TMDL as an annual load because the lake basin has an annual flushing rate of 4.5 (see discussion of seasonal variation on page 33). The annual flushing rate, or the theoretical rate at which water in a lake is replaced on an annual basis, is calculated as:

 # Flushes/year = (Watershed area * Runoff/year) / Lake volume

This TMDL also presents daily pollutant loads of TP in addition to the annual load. Daily flushing rates were determined by first calculating the monthly discharge 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 (ArcMap 8.3).

Once the monthly discharge was determined, this information was used to ascertain the following:

% Total Monthly Discharge = (Total monthly discharge/ Total annual discharge) *100

 # Flushes/month = (Total # of flushes/year * % of total monthly discharge)

 # Flushes/day = (Flushes/month)/(Days/month)

The majority of the parameters used for calculating the annual loading capacity (kg TP/yr) on page 34 (Dillon and Rigler 1974, where L= (Azp)/(1-R)), remain unchanged for use in calculating the daily loading capacity. The exception is p, where p now equals flushes/month. Thus, the monthly loading capacity is expressed as a proportion of the annual loading capacity, based on the discharge expected for that month.

The daily loading capacity was then calculated as follows:

Daily Load Capacity (kg/day) = (Monthly Load Capacity)/(Days/month)

The daily loads for Echo Lake are presented on page 34.

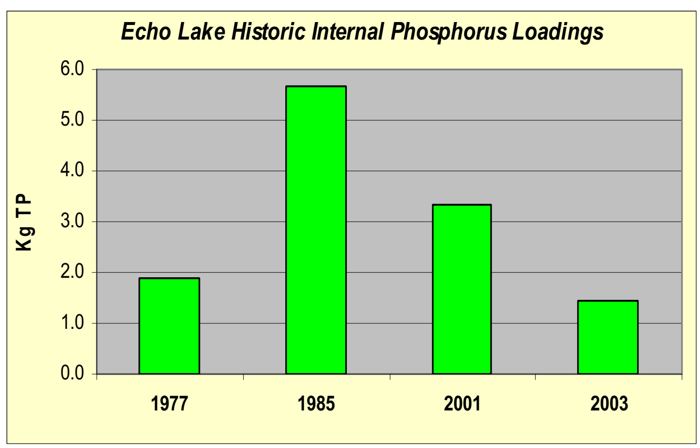
Assimilative Loading Capacity: The Echo Lake basin lake assimilative capacity is capped at 179 kg TP/yr, as derived from the empirical phosphorus retention model based on a target goal of 15 ppb. This value reflects the modeled annual phosphorus loading responsible for current trophic state conditions, based on a long term goal of maintaining average phosphorus concentrations at or below 15 ppb. This TMDL target concentration is expected to be met at all times (daily, monthly, seasonally, and annually). 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.

Future Development: The Maine DEP water quality goal of maintaining a stable trophic state includes a reduction of current P-loading which accounts for both recent P-loading as well as potential future development in the watershed. The methods used by Maine DEP to estimate future growth (Dennis et al. 1992) are inherently conservative, as they provide for relatively high-end regional growth estimates and largely non-mitigated P-export from new development. This provides an additional non-quantified margin of safety to ensure the attainment of state water quality goals. Previously unaccounted P-loading from anticipated future development on Echo Lake watershed approximates 6.0 kg annually (0.5 x 1 ppb change in trophic state or 12 kg).

Human population growth will continue to occur in the Echo Lake watershed, contributing new sources of phosphorus to the lake. Hence, existing phosphorus source loads must be reduced by at least 12 kg to allow for anticipated new sources of phosphorus to Echo Lake.

Overall, the presence of nuisance algae blooms in Echo Lake may be reduced, along with halting the trend of increasing trophic state, if the existing phosphorus loading is reduced by approximately 42 kg TP/yr.

Internal Lake Sediment Phosphorus Mass: The relative contribution of internal sources of total phosphorus within Echo Lake - in terms of sediment TP recycling - were analyzed (using lake volume-weighted mass differences between early and late summer) and estimated on the basis of water column TP data. Years in which adequate lake profile TP concentration was available to derive reliable estimates of internal lake mass were 1977, 1985, 2001 and 2003, for an average annual value of 3.1 kg.



Internal phosphorus loading in Echo Lake was at its peak in the mid 1980's. Recent measurements are at a historical low.

Linking Pollutant Loading to a Numeric Target: The basin loading assimilative capacity for non-colored Echo Lake was set at 179 kg/yr of total phosphorus to meet the numeric water quality target of 15 ppb of total phosphorus. A phosphorus retention model, calibrated to in-lake phosphorus data, was used to link phosphorus loading to numeric target.

Supporting Documentation for the Echo Lake TMDL Analysis includes the following: Maine DEP and Maine VLMP water quality monitoring data, and specification of a phosphorus retention model – including both empirical models and retention coefficients.

Echo Lake Total Phosphorus Retention Model

(after Dillon and Rigler 1974 and others)

L = P (A z p) / (1-R) where, **1 ppb change = 12 kg**

179 = **L** = external total phosphorus load capacity (kg TP/year)
15 = **P** = total phosphorus concentration (ppb) = Target Goal = **15 ppb**
0.36 = **A** = lake basin surface area (km^2) = 36 ha or 90 acres
5.0 = **z** = mean depth of lake basin (m) **A z p = 8.10**
4.5 = **p** = annual flushing rate (flushes/year)
0.68 = **1- R** = phosphorus retention coefficient, where:
0.32 = **R = 1 / (1+ sq. rt. p)** (Larsen and Mercier 1976)

Previous use of the Vollenweider (Dillon and Rigler 1974) type empirical model for Maine lakes, e.g., Cobbossee, Madawaska, Sebasticook, East, China, Mousam, Highland (Falmouth), Webber, Threemile, Threecornered, Annabessacook, Pleasant, Sabattus, Toothaker, Unity, Upper Narrows, Highland (Bridgton), Little Cobbossee, Long (Bridgton), Togus, Duckpuddle, Lovejoy, Lilly, Sewall, Cross, Daigle and Trafton Lake PCAP-TMDL reports (Maine DEP 2000-2006) have all shown this approach to be effective in linking watershed total phosphorus (external) loadings to existing in-lake total phosphorus concentrations.

Strengths and Weaknesses in the Overall TMDL Analytical Process: The Echo Lake TMDL was developed using existing lake water quality monitoring data, derived watershed export coefficients (Reckhow et al. 1980, Maine DEP 1981 and 1989, Dennis 1986, Dennis et al. 1992, Bouchard et al. 1995, Soranno et al. 1996, and Mattson and Isaac 1999) and a phosphorus retention model which incorporates both empirically derived and observed retention coefficients (Vollenweider 1969, Dillon 1974, Dillon and Rigler 1974 a and b, and 1975, Kirchner and Dillon 1975). Use of the Larsen and Mercier (1976) total phosphorus retention term, based on localized data (northeast and north-central U.S.) from 20 lakes in the US-EPA National Eutrophication Survey (US-EPA-New England) provides a more accurate model for northeastern regional lakes.

Strengths:

- ❖ Approach is commonly accepted practice in lake management
- ❖ Makes best use of available water quality monitoring data
- ❖ Based upon experience with other lakes in the northeastern U.S. region, the empirical phosphorus retention model was determined to be appropriate for the application lake.

Weaknesses:

- ❖ Inherent uncertainty of TP load estimates (Reckhow 1979, Walker 2000) and associated variability and generality of TP loading coefficients.

Critical Conditions occur in Echo Lake during the summertime, when the potential (both occurrence and frequency) of nuisance algae blooms are greatest. The loading capacity of 15 ppb 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).

LOAD ALLOCATIONS (LA's) - The load allocation for Echo Lake equals 179 kg TP on an annual basis and represents, in part, that portion of the lake's assimilative capacity allocated to non-point (overland) sources of phosphorus (from Table 3). Direct external TP sources (totaling 136 kg annually) have been identified and accounted for in the land-use breakdown portrayed in Table 3 (corrected GIS). Further reductions in non-point source phosphorus loadings are expected from the continued implementation of NPS best management practices (see summary, pages 20-22). As previously mentioned, it was not possible to separate natural background from non-point pollution sources in this watershed because of the limited and general nature of the available information. As in other Maine TMDL lakes (see Sebasticook Lake, East Pond, China Lake, and subsequent TMDLs), in-lake nutrient loadings in Echo Lake originate from a combination of direct external and internal (lake sediment) sources of total phosphorus.

WASTE LOAD ALLOCATIONS (WLA's): Since there are no existing point source discharges subject to NPDES permit requirements in the Echo Lake watershed, the WLA is set at 0 (zero), and all of the loading capacity is allocated as a gross allotment to the "load allocation".

MARGIN OF SAFETY (MOS): The TMDL expressed in terms of annual and daily loads includes an implicit MOS through the relatively conservative selection of the numeric water quality target (based on a state-wide database for lakes, supported by in-lake data). Based on both the Echo Lake historical records and a summary of statewide Maine lakes water quality data for non-colored (< 30 SPU) lakes - the target of 15 ppb (179 kg/yr in Echo Lake) represents a highly conservative goal to assure future attainment of Maine DEP water quality goals of non-sustained and non-repeated blue-green summer-time algae blooms due to NPS pollution or cultural eutrophication and stable or decreasing trophic state.

SEASONAL VARIATION: The Echo Lake 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 4.5 flushes/year, the average annual phosphorus loading is most critical to the water quality in Echo Lake. 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. Furthermore, non-point source best management practices (BMPs) proposed for the Echo Lake watershed have been designed to address total phosphorus loading during all seasons.

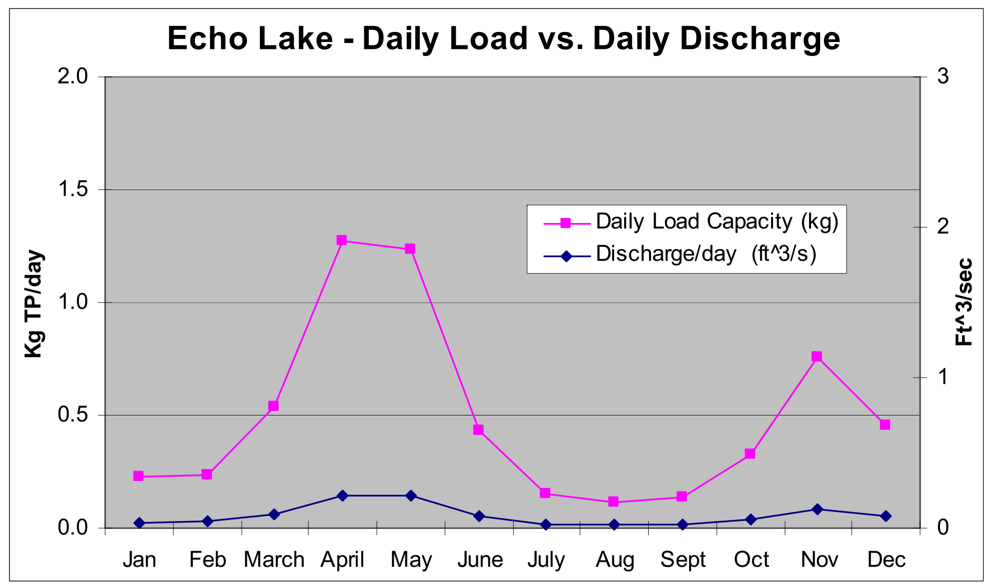
This variation is further accounted for in calculations of seasonal (May-October, November– April), monthly, and daily TP load calculations (p. 34). These numbers are derived from formulas developed by Dudley (2004) for ungaged rivers in Maine, and are based on several physical and geographic parameters including: 1) drainage area of the waterbody, 2) percent of sand and gravel aquifers in the drainage area, 3) distance from a stationary line along the Maine coast, and 4) mean annual precipitation. Daily loading rates are then determined using variables from Dillon and Rigler (1974 - p. 35) for calculating the external total phosphorus load capacity (pp. 28-30) for the lake.

Daily TP Pollutant Loads for Echo Lake

Month	Discharge/Month (ft^3/s)	% of Total	Flushes/month	Monthly Load Capacity (kg)	Discharge/day (ft^3/s)	Flushes/Day	Daily Load Capacity (kg)
Jan	1.20	4%	0.18	6.96	0.04	0.006	0.22
Feb	1.14	4%	0.17	6.63	0.04	0.006	0.24
March	2.88	9%	0.42	16.75	0.09	0.014	0.54
April	6.59	21%	0.96	38.25	0.22	0.032	1.27
May	6.59	21%	0.96	38.28	0.21	0.031	1.23
June	2.23	7%	0.33	12.93	0.07	0.011	0.43
July	0.79	3%	0.12	4.62	0.03	0.004	0.15
August	0.59	2%	0.09	3.41	0.02	0.003	0.11
September	0.71	2%	0.10	4.14	0.02	0.003	0.14
October	1.73	6%	0.25	10.04	0.06	0.008	0.32
November	3.90	13%	0.57	22.64	0.13	0.019	0.75
December	2.43	8%	0.36	14.13	0.08	0.011	0.46

Season	% of Total	# Flushes
May -October	41%	1.8
November-April	59%	2.7

Vollenweider: L = P (Azp) / (1-R)	
L = external P load capacity (kg TP/yr)	**179**
P = total P concentration (ppb)	15
A = lake basin surface area (km2)	0.36
z = mean depth of lake basin (m)	5
p = annual flushing rate	4.5
1-R = P retention coefficient	0.68
R = 1 / (1 + sq. rt. p)	0.32



Regression Equations Used for Calculating Daily Loads for Echo Lake (from Dudley, 2004)

Table 7. Regression equations and their accuracy for estimating mean monthly streamflows for ungaged, unregulated streams in rural drainage basins in Maine

[ASEP, average standard error of prediction; PRESS, prediction error sum of squares; EYR, equivalent years of record; n, number of data points used in regression]

Regression equation	ASEP (in percent)	$(PRESS/n)^{½}$ (in percent)	Average EYR
$Q_{jan\ mean} = 36.36\ (A)^{1.007}\ (DIST)^{-0.771}$	-10.2 to 11.4	-11.1 to 12.5	29.9
$Q_{feb\ mean} = 46.79\ (A)^{0.991}\ (DIST)^{-0.929}$	-9.79 to 10.8	-12.0 to 13.7	41.2
$Q_{mar\ mean} = 109.10\ (A)^{0.924}\ (DIST)^{-0.807}$	-21.0 to 26.6	-22.4 to 28.8	7.27
$Q_{apr\ mean} = 1.362\ (A)^{1.006}\ 10^{0.013(pptA)}$	-15.6 to 18.4	-16.7 to 20.0	4.94
$Q_{may\ mean} = 0.350\ (A)^{1.035}\ (DIST)^{0.486}$	-15.8 to 18.8	-16.8 to 20.2	6.96
$Q_{jun\ mean} = 1.372\ (A)^{1.030}$	-14.6 to 17.1	-15.2 to 17.9	13.1
$Q_{jul\ mean} = 0.475\ (A)^{1.089}\ 10^{0.631(SG)}$	-19.3 to 24.0	-21.4 to 27.2	8.38
$Q_{aug\ mean} = 0.353\ (A)^{1.075}\ 10^{0.822(SG)}$	-22.0 to 28.2	-22.9 to 29.6	8.60
$Q_{sep\ mean} = 0.434\ (A)^{1.049}\ 10^{0.834(SG)}$	-19.9 to 24.9	-23.2 to 30.2	13.9
$Q_{oct\ mean} = 1.084\ (A)^{0.989}\ 10^{0.399(SG)}$	-19.3 to 24.0	-22.5 to 29.1	17.0
$Q_{nov\ mean} = 2.497\ (A)^{0.949}$	-18.6 to 22.9	-20.7 to 26.0	11.9
$Q_{dec\ mean} = 16.92\ (A)^{0.979}\ (DIST)^{-0.476}$	-12.4 to 14.1	-13.6 to 15.7	28.9

where,

Q — streamflow statistic of interest.

A — contributing drainage area, in square miles.

SG — fraction of the drainage basin that is underlain by significant sand and gravel aquifers, on a planar area basis, expressed as a decimal. For example, if 15 percent of the drainage area of a basin has significant sand and gravel aquifers, then *SG* = 0.15. Based on the significant sand and gravel aquifer maps produced by the Maine Geological Survey and maintained as GIS data sets by the Maine Office of GIS.

pptA — mean annual precipitation, in inches, computed as the spatially averaged precipitation in the contributing basin drainage area. Based on non-proprietary PRISM precipitation data spanning the 30-year period 1961-1990. Data maintained as GIS data sets by the Natural Resources Conservation Service (1998).

DIST —distance from the coast, in miles, measured as the shortest distance from a line in the Gulf of Maine to the contributing drainage basin centroid. The line in the Gulf of Maine is defined by end points 71.0W, 42.75N and 65.5W, 45.0N, referenced to North American Datum of 1983.

See the Regression Analyses section of this report for more details.

PUBLIC PARTICIPATION: Adequate ('full and meaningful') public participation in the Echo Lake PCAP-TMDL development process was ensured - during which land use and phosphorus load reductions were discussed - through the following avenues:

1) **September 26, 2005:** MACD staff traveled to Aroostook County to meet with staff from Maine DEP and the CA-SWCD to gather information and discuss the water quality of Echo Lake.

2) **September 27, 2005:** MACD staff met with Maine DEP and CA-SWCD staff in the field and were given a tour of the Echo Lake watershed.

3) **July 24, 2006:** MACD staff met with Maine-DEP staff to collect historical information for the Echo Lake Watershed.

4) **July 20, 2006:** MACD staff contacted the Jim Roby at the VLMP to determine current and historical volunteer water quality monitors for Echo Lake.

5) **August 1, 2006:** MACD staff contacted Linda Bacon at Maine-DEP to discuss the flushing rate and watershed area for Echo Lake.

6) **September 5, 2006:** MACD staff sent GIS corrected land use maps to CA-SWCD for review and ground-truthing.

7) **October 10, 2006:** MACD staff contacted Linda Alverson at the CA-SWCD to discuss current BMP activities within the Echo Lake Watershed.

8) **October 11, 2006:** MACD contacted Nancy Walker, President of the Echo Lake Improvement Society, to discuss potential BMP needs for Echo Lake from a citizens perspective and to gather other relevant information such as state of the lake and current projects.

9) **October 17, 2006:** MACD staff contacted George Howe, City of Presque Isle Economic & Community Development Division, to discuss current road projects in the Echo Lake watershed.

10) **November 3, 2006:** CA-SWCD staff Linda Alverson (with boating assistance from a shoreline resident) conducted a shoreline survey for Echo Lake.

11) December 11, 20006: MACD, Maine-DEP, and CA-SWCD sponsored a public meeting at the CA-SWCD office in Presque Isle to discuss the Echo Lake TMDL and to receive stakeholder feedback.

STAKEHOLDER AND PUBLIC REVIEW PROCESS

A two-week stakeholder review was distributed electronically on November 22, 2006 to the following individuals who expressed a specific interest, participated in the field work or helped develop the draft Echo Lake PCAP-TMDL report: Maine DEP (Kathy Hoppe and Bill Sheehan); Central Aroostook SWCD (Linda Alverson and Steve Sutter); Maine Forest Service (Chris Martin); Maine Department of Agriculture (David Rocque); Maine Department of Inland Fisheries and Wildlife (Dave Basley), St. John Valley-Aroostook RC&D (Skip Babineau), USDA/Natural Resources Conservation Service (Ken Hill); City of Presque Isle (George Howe); University of Maine Cooperative Extension (Peter Sexton); Aroostook State Park (Fritz Appleby); Echo Lake Improvement Society (Nancy Walker); and land owner/ producer (Laurence Park). The stakeholder review draft was revised according to comments received by Central Aroostook SWCD (Linda Alverson and Steve Sutter); Maine DEP (Kathy Hoppe and Bill Sheehan); University of Maine Cooperative Extension (Peter Sexton); and Aroostook State Park (Fritz Appleby). The revised draft was re-distributed and the stakeholder review period was extended to the public meeting date of December 11, 2006. Public meeting attendees included representatives from MACD, CA-SWCD, Maine-DEP, USDA/NRCS, University of Maine Cooperative Extension, Aroostook State Park, Echo Lake Improvement Society, University of Maine-Presque Isle, Maine DIF&W, McCain Foods, and interested watershed residents.

The following statement will be advertised in the *Bangor Daily News* over the weekend of December 23-24, 2006, and the *Presque Isle Star Herald* during the week of December 27, 2006.

ECHO LAKE - Presque Isle, Maine

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 combined Phosphorus Control Action Plan (PCAP) and Total Maximum Daily Load (TMDL) nutrient report (DEPLW–0812) for the **ECHO LAKE WATERSHED**, located within the City of Presque Isle. This PCAP-TMDL report identifies and provides best estimates of non-point source phosphorus loads for all representative land use classes in the **ECHO LAKE** direct watershed and the total phosphorus reductions required to restore and maintain acceptable water quality conditions. A Public Review draft of this report may be viewed at Maine DEP Northern Maine Regional offices in Presque Isle (1235 Central Drive, Skyway Park) or at the Central Maine DEP offices in Augusta (Ray Building, Hospital Street - Route 9, Land & Water Bureau) or on-line: http://www.maine.gov/dep/blwq/comment.htm. Please send all comments, in writing by January 11, 2007 to Dave Halliwell, Lakes TMDL Program Manager, Maine DEP, State House Station #17, Augusta, ME 04333 or e-mail: david.halliwell@maine.gov

PUBLIC REVIEW Comments Received

All received public review comments were incorporated into this final EPA draft submittal.

Fritz Appleby (Aroostook State Park) reviewed the Public Review document and provided a revised estimate regarding the number of yearly visitors to Aroostook State Park (p. 4) and recommended a minor edit to the recent and current NPS/BMP information (p. 19).

Dr. Steve Sutter (Associate Supervisor, CA-SWCD) provided comments regarding the phosphorus export coefficient for actively-managed forest, and suggested a higher loading coefficient of .3 kg/ha/year for this land use.

RESPONSE - from Tricia Rouleau, MACD
Thank you for your comments regarding the Echo Lake TMDL. The phosphorus loading coefficient applied to actively managed forest land (0.08 kg/ha/yr) was changed beginning with the Long Lake PCAP-TMDL report following consultation with Lakes Environment Association and Maine Forest Service staff. This coefficient falls within the range published in Reckhow et al (.019 - .83 kg/ha/yr) and reflects the idea that properly managed harvest areas will generally act as phosphorus sinks during periods of regeneration. The rationale behind the phosphorus loading coefficient for actively managed

forest land is discussed in the report under ‘Total Phosphorus Land Use Loads’ (p. 29). According to the Maine Forest Service, “the high end of the coefficient range (published by Reckhow et al.) may be attributed to actual soil loss into adjacent waterbodies resulting from actively managed forests. However statewide BMP monitoring data continues to indicate that this is an uncommon occurrence” (C. Martin, personal communication). Therefore, we believe the current coefficient of 0.08 kg/ha/yr is appropriate.

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