PHOSPHORUS CONTROL ACTION PLAN

and Total Maximum Daily (Annual Phosphorus) Load Report

Arnold Brook Lake- Presque Isle

Aroostook County, Maine

Arnold Brook Lake PCAP - TMDL Report

Maine DEPLW - 0813

DEPARTMENT OF ENVIRONMENTAL PROTECTION
STATE OF MAINE

Maine Department of Environmental Protection

and Maine Association of Conservation Districts

EPA Final Review Document – February 5, 2007

ARNOLD BROOK LAKE - Presque Isle

Phosphorus Control Action Plan (PCAP)

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ARNOLD BROOK LAKE (Presque Isle)

Total Maximum Daily (Annual Phosphorus) Load

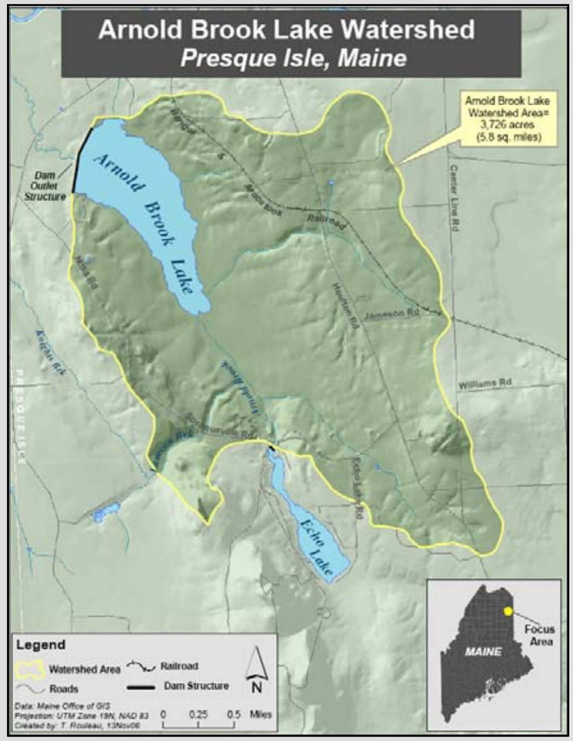
ACKNOWLEDGMENTS

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 Arnold Brook 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); City of Presque Isle (George Howe); and Maine Volunteer Lake Monitor, Malcolm Brown (1999-2002).

Arnold Brook Lake - Presque Isle Phosphorus Control Action Plan Summary Fact Sheet

Background

ARNOLD BROOK LAKE (Midas No. 409) is a shallow, 395 acre, **colored** lake located in the City of Presque Isle in Aroostook County, Maine. Arnold Brook Lake has a direct drainage area of approximately 5.8 square miles (see map at right); a maximum depth of 15 feet (5 meters), a mean depth of 8 feet (2 meters); and a **flushing rate** of ~2.4 times per year. The total Arnold Brook Lake watershed drainage area, inclusive of associated sub-watersheds (Echo Lake) is approximately 7 square miles (see map on p.8).



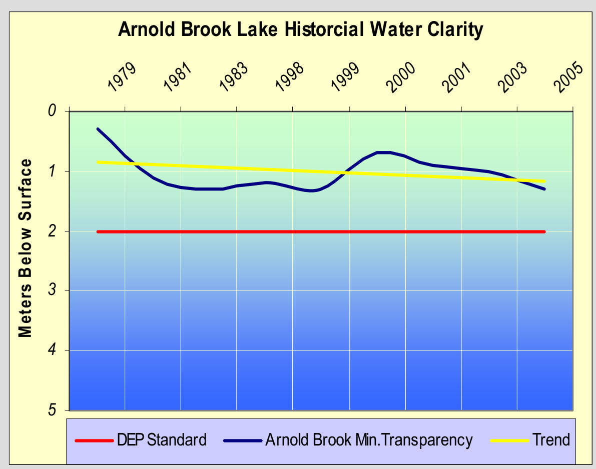
Historical Information

Arnold Brook Lake is a man-made flood-control and recreational impoundment created in 1971 by the Soil Conservation Service to reduce flooding hazard to the City of Presque Isle. Like other areas in and around Presque Isle and Aroostook County, agriculture and forestry have had a major presence in the watershed since settlement began.

Arnold Brook Lake has a history of supporting persistent nuisance algal blooms. Documentation of nutrient contamination in Arnold Brook Lake began in 1979 at the onset of water quality monitoring. Since this time, lake baseline chemical information and water transparency data have been collected. Arnold Brook Lake's largest freshwater input is via Arnold Brook which flows out of upstream Echo Lake, another 303 (d) listed lake with a history of algal blooms.

Overall, the water quality of Arnold Brook Lake is considered to be poor based on measures of water transparency (see graph to right), total **phosphorus**, and chlorophyll-a. Phosphorus input is of particular concern since it effectively "fertilizes" the pond to promote algal growth. Consequently, the potential for nuisance summertime algal blooms in Arnold Brook Lake is high.

Nutrient contamination is due in large part to the contribution of phosphorus that is prevalent in Maine 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



Arnold Brook Lake has not met water clarity standards since sampling began in the late 1970's.

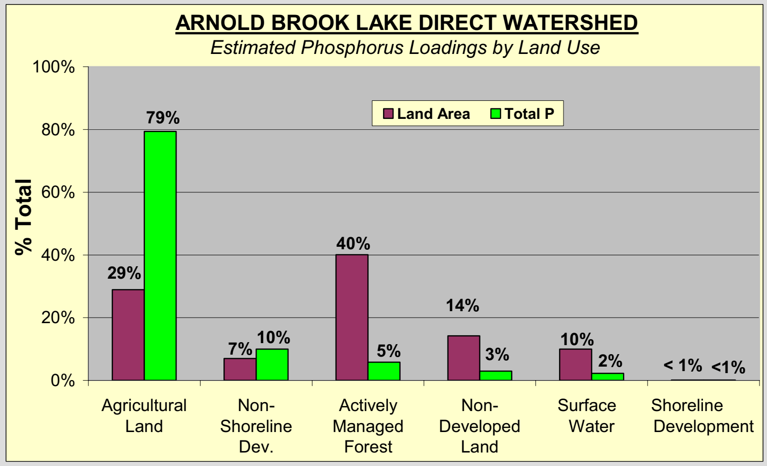
Key Terms

- ***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.*

particles effectively transport phosphorus, which serves to "fertilize" the lake and decreases water clarity. Since Arnold Brook Lake is an impounded stream, it collects a substantial amount of sediments over time. These nutrient rich bottom sediments can be a source of high phosphorus as a result of internal loading especially during the warm summer months. 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 efforts to reduce erosion and phosphorus loading in the watershed, phosphorus levels are still high enough to affect water quality and promote algal growth. Arnold Brook 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.

What We Learned

The land use assessment conducted for the Arnold Brook 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 Arnold Brook Lake.

An estimated 1,133 kg (2,498 lbs) of phosphorus is exported annually to Arnold Brook 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 (81 kg/year) from Arnold Brook Lake bottom sediments during the summer-time (1981, 2001) is approximately 36% of the lake's natural capacity (199 kg/year) for in-lake phosphorus assimilation (assuming a target goal of 16 ppb for a colored lake).

Phosphorus Reduction Needed

Arnold Brook Lake's average summertime TP concentration approximates 34 ppb (408 kg) - equal to an additional 209 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 16 ppb or less) in Arnold Brook Lake approximates 222 kg.

What You Can Do To Help!

As a watershed resident, there are many things you can do to protect the water quality of Arnold Brook 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 Arnold Brook Lake originates primarily from 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 Arnold Brook 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 Arnold Brook 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 Arnold Brook 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 Arnold Brook Lake. **Note:** *To protect the confidentiality of landowners in the Arnold Brook 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 Arnold Brook 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

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

> ***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.*

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 verified in the field by the Central Aroostook Soil and Water Conservation District (CA-SWCD) using ground-truthing.

Final adjusted phosphorus loading numbers (see Table 2, page 24) 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 the CA-SWCD.

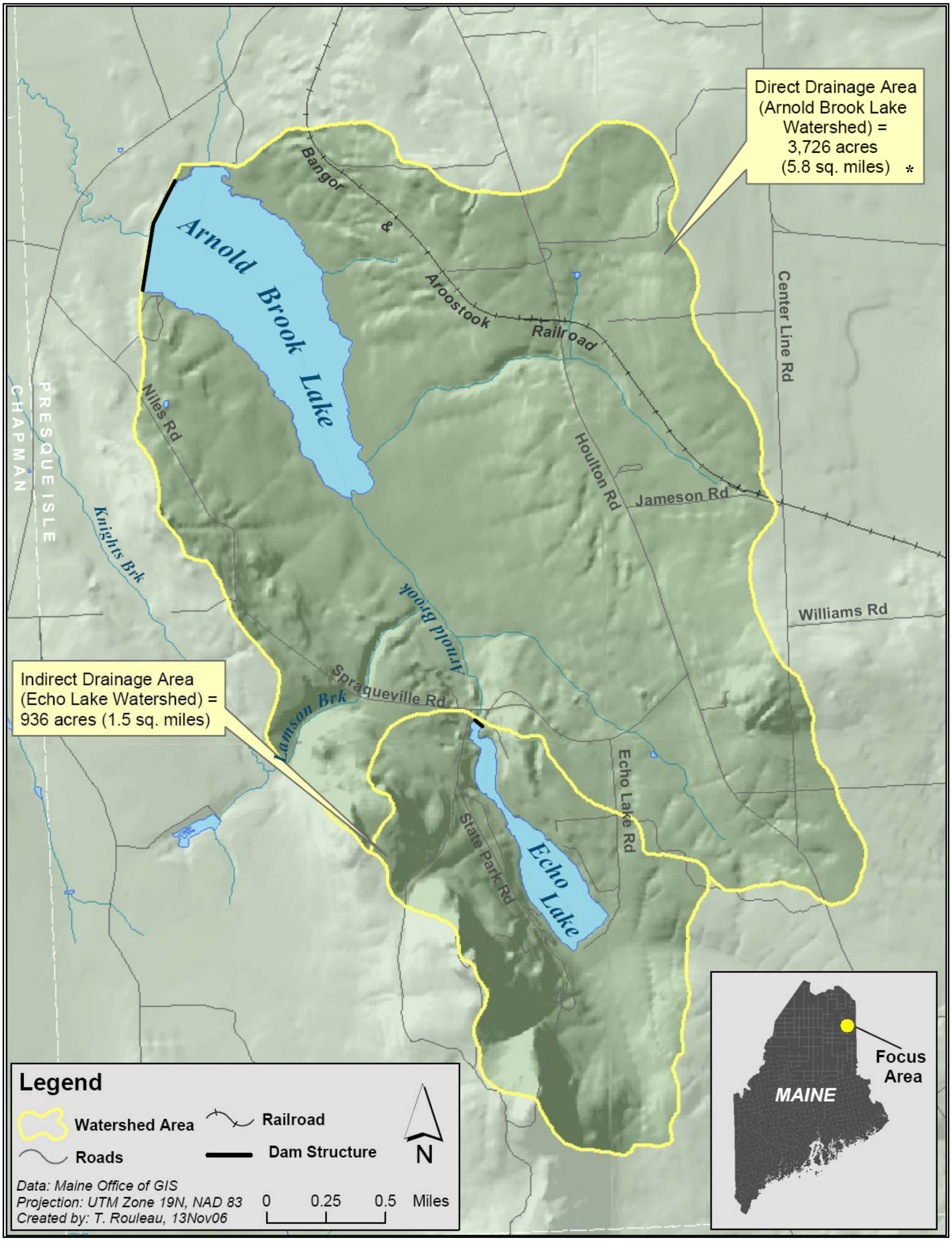
Roadway widths were estimated from previous PCAP reports where actual measurements were made for the various road types. In general, state-owned roads were found to be 22 meters wide; city-owned roads were found to be 16 meters wide; and privately-owned roads were found to be 6 meters wide. GIS was used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

Agricultural information within the Arnold Brook 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 Arnold Brook 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 Arnold Brook Lake Direct and Indirect Watersheds



** 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 (395 acres).*

ARNOLD BROOK LAKE Phosphorus Control Action Plan

DESCRIPTION of WATERBODY (MIDAS Number 409) and WATERSHED

> ***Direct Watershed-*** *the land area that drains to a waterbody without first passing through an associated lake or pond.*

ARNOLD BROOK LAKE is a 395-acre (160 hectare) colored waterbody situated in the city of Presque Isle (DeLorme Atlas, Map 65), within Aroostook County, Maine. Arnold Brook Lake has a **direct watershed** area (see Figure 1) of approximately 3,726 acres (5.8 square miles) exclusive of lake surface area. The Arnold Brook Lake direct watershed is located 100% within the city of Presque Isle. Arnold Brook Lake has a maximum depth of 15 feet (5 meters), overall mean depth of 8 feet (2 meters), and a flushing rate of 2.4 times/year. Note: Direct watershed area was updated for this report based on the watershed area from the Maine Office of GIS. The average flushing rate and volume for Arnold Brook Lake are approximate (Linda Bacon, personal communication).

Drainage System: Arnold Brook Lake is a man-made flood-control and recreational impoundment created in 1971 by the Soil Conservation Service to reduce flooding hazard to the City of Presque Isle. There are two major tributaries that flow into Arnold Brook Lake from the south. The largest volume of water to the lake is Arnold Brook Stream, which flows out of Echo Lake (another 303(d) listed lake to the south). The second source of freshwater is an unnamed stream that flows in from wetlands on the southeast side of the lake. Water exits the lake at the dam on the north end via Arnold Brook. The outlet stream flows through wetlands before joining Presque Isle Stream. Presque Isle Stream flows through the City of Presque Isle to the Aroostook River, which flows north and east to the St. John River in New Brunswick, Canada. A City-owned public boat launch and picnic area is located within the Arnold Brook Lake Recreation Area on the northwestern end of the Lake. The large earthen dam on the northern end is maintained by the City of Presque Isle.

Arnold Brook Lake Water Quality Information

> ***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.*

Arnold Brook 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 Arnold Brook Lake during the fall/winter of 2006.

Based on **Secchi disk transparencies (SDT),** measures of total phosphorus (TP), and **chlorophyll-a**, (Chl-a), the water quality of Arnold Brook Lake is considered to be poor and the potential for nuisance summertime algae blooms is high (Maine VLMP 2005). 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 combination of internal phosphorus recycling from bottom sediments and variety of nonpoint sources of pollution may be contributing to the poor water quality in Arnold Brook Lake. Like many lakes, the water quality of Arnold Brook Lake is influenced by runoff events from the watershed. During storm events, nutrients, such as phosphorus—naturally found in Maine soils– drain into the lake from the surrounding watershed by way of streams and overland flow and are may be deposited and stored in the lake bottom sediments (81 kg based on two 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 likely resulted in a buildup of sediment in Arnold Brook Lake. The potential for TP to leave bottom sediments and become available to algae in the water column is high (Maine VLMP 2005). In additional to naturally occurring phosphorus in bottom sediments, nonpoint sources of pollution such as erosion from land uses such as residential development, forestry, agriculture, and roads in the watershed all contribute to the declining water quality in Arnold Brook Lake.

Principle Uses & Human Development:

Developed and managed land in the Arnold Brook Lake watershed includes agricultural land, actively managed forest, roads, residential areas, railroad, and parks. The most prevalent of these human uses in the watershed are actively managed forest (40%) and agriculture (29%). With 76% (3,140 acres) of the land area consisting of developed and managed land, NPS pollution is a significant concern for the watershed. Consequently, Arnold Brook 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 Arnold Brook Lake watershed is characterized by the Caribou-Conant soil association (SCS, 1964) 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 make up the majority of the soils in the eastern portion of the watershed, and are located on slopes ranging from 0-25%, while Conant soils are intermixed with Caribou soils on slopes ranging from 0-15%. Depth to bedrock is generally greater than sixty inches in both soils. Caribou/Conant soils are located in the eastern portion of the watershed, while more poorly drained soils such as Easton and Washburn silt loams, formed in fine textured glacial till, and peat and muck, make up a majority of the soils adjacent to, and west of the lake where the land has less relief and the water table remains a foot below the surface for 9 months of the year.

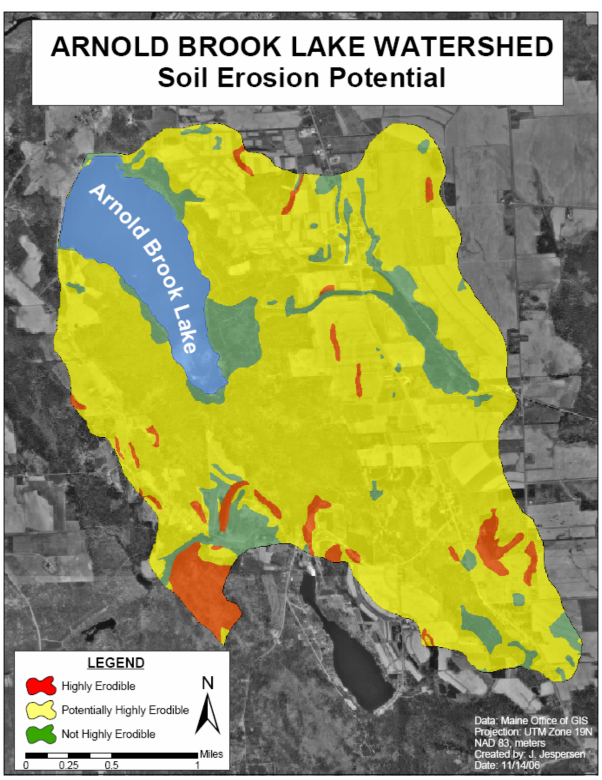


Figure 2. *Soils in the Arnold Brook Watershed have a potential to be highly erodible if not managed properly. Land under intensive uses, and on steep slopes, including agricultural land without a winter cover crop may be particularly vulnerable to erosion.*

The greatest land area in the Arnold Brook Lake watershed is comprised of soils in hydrologic groups B (38%) and D (30%) which are soils with moderate and very slow infiltration capacity.

Land Use Inventory

The results of the Arnold Brook 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 (operated) 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 76% of the watershed and the un-managed/un-developed land, including the water surface area of Arnold Brook Lake, comprises the remaining 24% of the watershed. These numbers may be used to help make future planning and conservation decisions relating to the Arnold Brook 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).

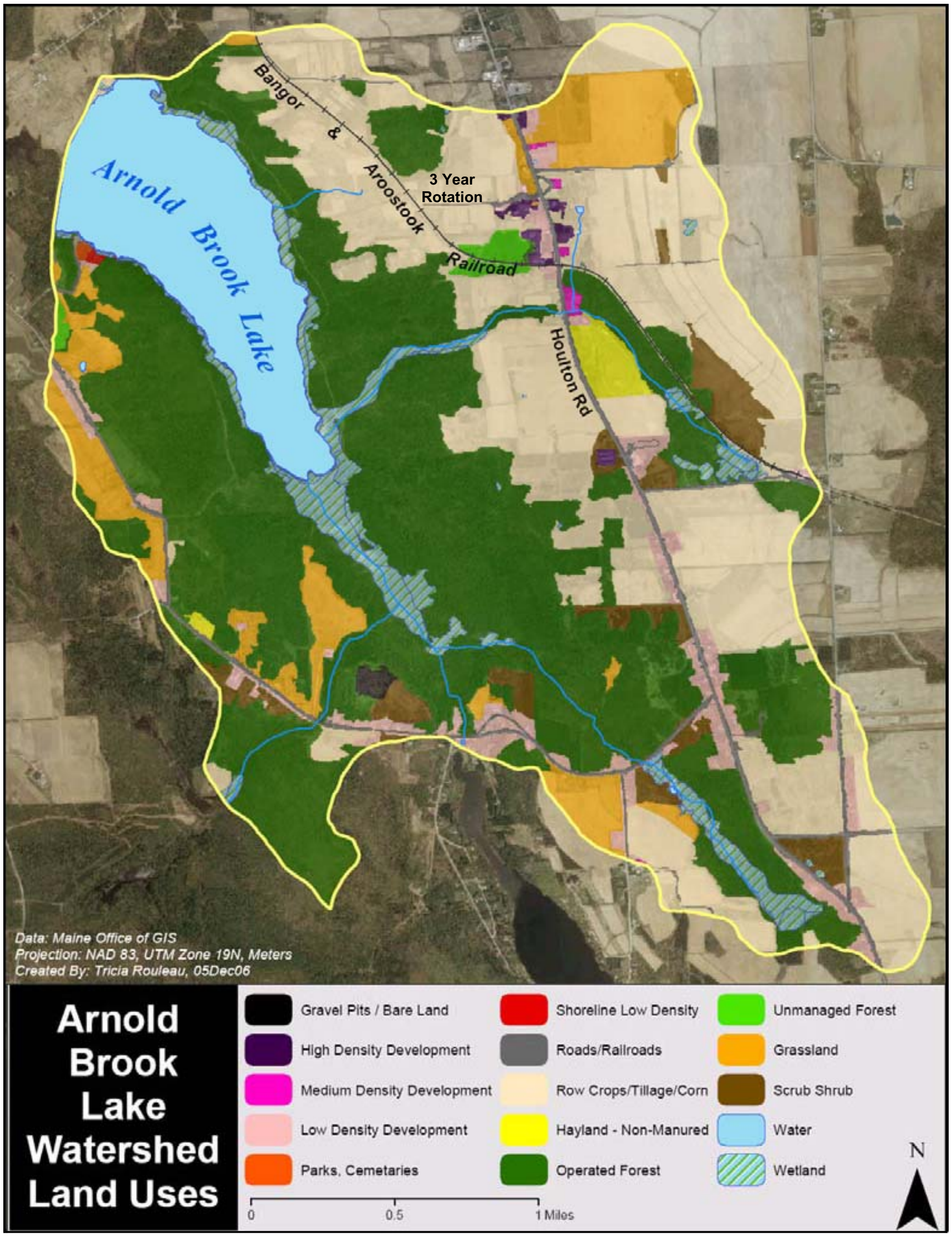
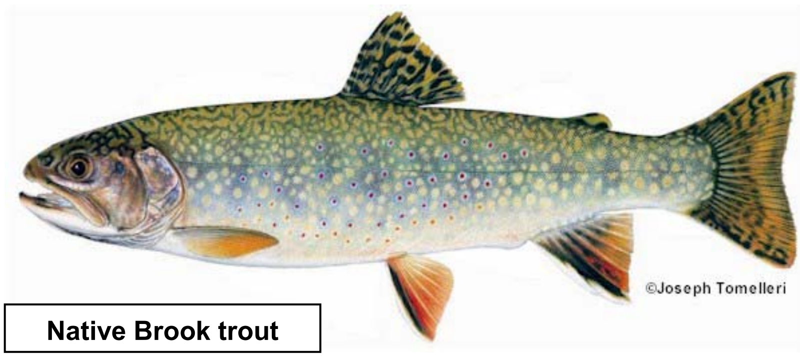


Figure 3. Developed and managed land uses in the Arnold Brook Lake watershed are primarily operated forest land and agricultural land including row crops.

Arnold Brook 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), 395-acre (maximum depth 15 feet) Arnold Brook Lake (Presque Isle - Stream and Aroostook River drainage system) is currently managed as a coldwater (brook trout) fishery. Arnold Brook Lake was originally surveyed by Maine DIF&W in 1972, while their lake fisheries report was previously revised in 1989. A total of **10** native indigenous fish species (brook trout, longnose and white sucker, threespine stickleback, banded killifish and five minnow species - northern redbelly and blacknose dace, common shiner, creek chub, and fathead minnow) are found to occur, in association with **1** non-indigenous baitfish species (golden shiner). Arnold Brook Lake is a man-made flood-control/ recreational impoundment created in 1971 (Soil Conservation Service = NRCS and city of Presque Isle) which provides a mixed wild and hatchery supported brook trout fishery in close proximity to an urban area.



Native Brook trout

Future improvements in water quality, reducing the prevalence of nuisance summertime algal blooms, may serve to enhance fisheries conditions in Arnold Brook Lake. Given that the trophic state of Arnold Brook Lake has been disturbed by cumulative human impacts over the past several decades - then a significant reduction in the total phosphorus loading from the Arnold Brook 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.

Arnold Brook Lake also provides habitat for a variety of migrating ducks and geese, and resident waterfowl. 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 Arnold Brook 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 phophorus loading from external (watershed) sources (JWEL, 2000).

Table 1. Arnold Brook 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)	34	<1%	0.35-1.35	0.64	13	8	<1%
Row Crops	735	18%	0.26 - 18.6	2.24	297	670	59%
Row Crops - 3 year rotation	425	10%	-	1.17	172	221	20%
Actively Managed Forest	1653	40%	0.04 - 0.6	0.08	669	66	6%
Sub-Totals	**2,847**	**69%**			**1,151**	**965**	**85%**
Shoreline Development							
Shoreline Low Density	2	<1%	0.14 - 4.90	1.0	1	<1	<1%
Parks/Cemetaries	2	<1%	0.14 - 4.90	0.8	1	1	<1%
Sub-Totals	**4**	**<1%**			**2**	**1**	**<1%**
Non-Shoreline Development							
Roads	108	3%	0.60 - 10.0	1.5	44	68	6%
Low Density Residential	145	4%	0.25 - 1.75	0.5	59	30	3%
Medium Density Residential	6	<1%	0.40 - 2.20	1.0	2	3	<1%
High Density Residential	15	<1%	0.56 - 2.70	1.4	6	8	<1%
Commercial-Industrial-Railroads	7	<1%	0.77 - 4.18	1.5	3	5	<1%
Gravel Pits	8	<1%	0.00-0.00	0	3	<1	<1%
Sub-Totals	**289**	**7%**			**117**	**114**	**10%**
Total: MANAGED/DEVELOPED LAND	**3,140**	**76%**			**1,270**	**1,080**	**95%**
Non-Developed Land							
Inactive/Passively Managed Forest	23	<1%	0.01 - 0.08	0.04	9	<1	<1%
Grassland/Reverting Fields	274	7%	0.1 - 0.2	0.15	111	17	2%
Scrub-Shrub	132	3%	0.1 - 0.2	0.15	53	8	<1%
Wetlands	157	4%	0 - 0.05	0.01	64	<1	<1%
Total: NON-DEVELOPED LAND	**586**	**14%**			**237**	**27**	**3%**
Total: Surface Water (Atmospheric)	**395**	**10%**	**0.11 - 0.21**	**0.16**	**160**	**26**	**2%**
TOTAL: DIRECT WATERSHED	**4,121**	**100%**			**1,667**	**1,133**	**100%**

Descriptive Land Use and Phosphorus Export Estimates

Agriculture: Agricultural land is estimated to comprise 1,194 acres (29%) of the watershed area including: non-manured hayland (1%), row crops (18%), row crops - 3 year rotation (10%). These agricultural land uses are estimated to contribute 899 kg, or just over 79% of the total phosphorus loading to Arnold Brook Lake. Row crops are the largest agricultural contributor, accounting for approximately 59% of the total phosphorus load to Arnold Brook Lake. Row crops in 3 - year rotations account for 20% of the total phosphorus load. These data were mapped using GIS software, 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 Arnold Brook Lake direct watershed consists of 1,653 acres. This is the largest land use class among the managed land. This estimate is based on a GIS analysis of land uses and represents 40% of the total land area, contributing about 6% of the total phosphorus load to Arnold Brook 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.

Shoreline Development consists of all lands within the immediate shoreland area (250 feet) of Arnold Brook Lake. This type of development can have a large total phosphorus loading impact in comparison to their relatively small percentage of the total land area in the watershed. However, the lack of shoreline development around Arnold Brook Lake limits the amount of total phosphorus from this land use. Consisting primarily of city park land, shoreline land uses makes up the smallest land area among developed land uses in the watershed (4 acres), and contribute the least amount of phosphorus to Arnold Brook Lake (~ 1%).

The MACD/Maine-DEP Project Team met at the City's public boat launch on the north west end of Arnold Brook Lake to discuss current water quality conditions.

Non-Shoreline Development and Land Uses

Non-Shoreline Development consists of all lands outside the immediate shoreline of Arnold Brook Lake - including public and private roads, a gravel pit, business and residential development, and railroad. 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 were estimated to be 6 meters-average width) to determine the amount of total phosphorus loading from this land use category. Based on these factors, non-shoreline roads contribute an estimated 68 kg/year, or 6% of the total phosphorus load to Arnold Brook Lake's direct watershed. This is the third greatest contributor behind row crops and actively managed forests.

Residential: Residential development in the Arnold Brook Lake watershed can be divided into three categories: low, medium and high density. Low density development consists of approximately 145 acres and contributes an estimated 30 kg/year of the total phosphorus loading to the Arnold Brook Lake direct watershed. Medium density development consists of 6 acres and contributes 3 kg/year of total phosphorus. High density development accounts for 15 acres of land in the Arnold Brook Lake watershed, and 8 kg/year of the total phosphorus to Arnold Brook Lake. Combined, these residential land use classes account for just over 4% of the land area and approximately 4% of the total phosphorus load to Arnold Brook Lake.

Commercial-Industrial-Railroads: The Bangor and Aroostook Railroad makes up a small fraction of the Arnold Brook Lake watershed (<1%). This land use consists of approximately 7 acres, and contributes an estimated 5 kg/year (1%) of total phosphorus to the Arnold Brook Lake direct watershed.

Gravel Pits: A gravel pit located south of Arnold Brook Lake makes up <1% of the Arnold Brook Lake watershed area. This land use contributes <1% of the total phosphorus load to the lake.

Phosphorus Loading from Non-Developed/Non-Managed Lands and Water

Inactive/Passively Managed Forests: Of the total non-developed land area within the Arnold Brook Lake watershed, 23 acres are forested, characterized by privately-owned non-managed deciduous and mixed forest plots. Less than 1% of the phosphorus load (<1 kg/year) is estimated to be derived from non-commercial forested areas within Arnold Brook Lake's direct drainage area.

Other Non-Developed Land Areas: Combined grasslands/reverting fields, scrub-shrub, and wetlands account for 14% of the land area and just over 2% of the total phosphorus export load.

Atmospheric Deposition (Open Water): Surface waters for Arnold Brook Lake's direct watershed comprise 10% of the total land area (395 acres) and account for an estimated 26 kg of total phosphorus per year, representing 2% of the total <u>direct</u> watershed load entering Arnold Brook 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 Arnold Brook 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 Arnold Brook Lake originate from a combination of external watershed and internal lake sediment sources. Watershed total phosphorus sources, totaling approximately 1,133 kg (2,498 lbs) annually (corrected using GIS) have been identified and accounted for by land use (See Table 2 - page 24). In contrast, average annual internal lake sediment P-loading of 81 kg was estimated from two years of data (1981, 2001).

Loading from the Indirect Watershed: Total phosphorus loading from upstream Echo Lake accounts for an estimated indirect watershed average load of 37 kg annually, determined on the basis of *flushing rate x volume x TP concentration* (see page 25 for more information). The sum of these two potential sources indicates that an estimated 1,170 kg/yr may be contributing to the current in-lake phosphorus levels of Arnold Brook Lake. However, these models do not take into account many of the complex factors that affect lake water quality. Instead, these figures provide stakeholders with estimates that should assist with targeting implementation measures in the watershed.

2. In-Lake Concentration Method (TMDL)

Lake Capacity: The assimilative capacity for all existing and future non-point pollution sources for Arnold Brook Lake is 199 kg of total phosphorus per year, based on a target goal of 16 ppb (See Phosphorus Retention Model - page 28).

Target Goal: A change in 1 ppb in phosphorus concentration in Arnold Brook Lake is equivalent to 12 kg. The difference between the target goal of 16 ppb and the measured average summertime total phosphorus concentration (34 ppb) is 18 ppb or 216 kg (18 ppb x 12 kg).

Future Development: The annual total phosphorus contribution to account for future development for Arnold Brook Lake is 6 kg (0.50 x 12) (see page 27 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 Arnold Brook Lake approximates 222 kg (216 + 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 Arnold Brook Lake watershed and have helped them establish voluntary conservation management plans to reduce nutrient export from agricultural operations. Continued efforts for installing BMPs and reducing NPS pollution in the Arnold Brook Lake watershed are imperative given the current water quality conditions.

The University of Maine experimental farm, which consists of 425 acres on the north side of Arnold Brook Lake, and along Houlton Road is the largest of the 5 University of Maine Research Farms. Aroostook Farm is a tremendous resource for local farmers. Researchers at the farm are examining the effects of soil amendments (manure and yard wastes) and crop rotation on soil properties and potato productivity. The USDA-ARS is conducting research on potatoes grown in three-year rotations using soybeans, canola, sweet corn, green beans and barley clover (UMaine 2006). This research is critical in reducing not only soil erosion on agricultural land, but also the amount of chemicals and fertilizers that are being applied to these types of crops.

Recommendations for Future NPS/BMP Work

Arnold Brook 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 Arnold Brook Lake are described below.

Watershed Management: Several agencies (i.e., Maine DEP, CA-SWCD, USDA/NRCS) have been involved in attempting to restore the water quality of Arnold Brook 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.

Action Item #1 : Coordinate existing watershed management efforts		
Activity	**Participants**	**Schedule & Cost**
Initiate efforts to develop an Arnold Brook Lake Advisory Team	CA-SWCD, USDA/NRCS, Maine DEP, City of Presque Isle, UMaine Cooperative Extension, interested watershed citizens—stakeholders.	Annual roundtable meetings—beginning in Spring 2007—minimal cost

Agriculture: Agricultural land covers over 28% of the watershed land area and contributes the greatest phosphorus load. BMP recommendations for agricultural land uses include providing education on conservation practices and planning assistance to local farmers. Recommendations are aimed at reducing soil erosion and phosphorus inputs, and increasing soil organic matter. Both the Natural Resources Conservation Service and the University of Maine Cooperative Extension provide technical assistance for using proper agricultural BMPs. For more information contact the NRCS office in Aroostook County (207-764-4153 ext. 3), or the UMCE (207-764-1462).

Action Item # 2: Educate and assist agricultural landowners		
Activity	**Participants**	**Schedule & Cost**
• Conduct workshops encouraging the use of phosphorus control measures within the watershed. • Educate farmers about conservation tillage where appropriate or practical. • Update, inspect, and maintain installed BMPs in the watershed. • Provide education and incentives for maintenance and upkeep of existing BMPs. • Test soil before fertilizing. • Establish and maintain protective vegetated buffers between cropland and Arnold Brook Lake. • Build waterways in fields with gully erosion. • Plant crops and till cross-slope. • Use strip cropping on steep slopes. • Plant a winter cover crop to reduce soil erosion during the off season . • Maintain accurate field records. • Establish crop rotations.	CA-SWCD, NRCS, agricultural landowners, the City of Presque Isle, UMCE.	Annually beginning in 2007 Variable cost depending on type of activities

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 contribute approximately 6% of the total phosphorus load per year to Arnold Brook 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.

Action Item # 3: Monitor and maintain roadway best management practices		
Activity	**Participants**	**Schedule & Cost**
• Create or update list of problem areas along roadways. • Repair eroding roads, failing and improperly sized culverts by establishing/implementing roadway	Maine DEP, CA-SWCD, City of Presque Isle, Maine DOT, interested watershed citizens.	Immediately & ongoing- Variable cost depending on extent of repair needed.

Individual Action: Medium and high density residential development in the watershed is estimated to contribute more 4% of the total phosphorus to Arnold Brook Lake. Therefore, all watershed residents should be encouraged to reduce phosphorus loading 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 # 4: 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, UMCE.	Begin immediately- $2,000

Municipal Action: Municipal officials should be trained in current erosion and sediment control methods in order to 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 # 5: BMP training for municipal officials		
Activity	**Participants**	**Schedule & Cost**
• Municipal officials should 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 Arnold Brook Lake has been monitored via measures of Secchi disk transparencies during the open water months since 1979 (Maine DEP and Maine VLMP). Continued long-term water quality monitoring (water transparencies) for Arnold Brook Lake will be conducted monthly, from May to October, through the 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 proposed, 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 Arnold Brook Lake. A post-TMDL adaptive management status report will be prepared 5 to 10 years following EPA approval.

PCAP CLOSING STATEMENT

The Maine Association of Conservation Districts and the Central Aroostook Soil and Water Conservation District, in cooperation with lake stakeholders, have initiated the process of addressing nonpoint source pollution in the Arnold Brook 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. The City of Presque Isle has initiated efforts to address NPS pollution in the Arnold Brook Lake watershed, and recognizes the inherent value of the lake and its vital link to the community by providing strong support to restoration efforts. The city should continue with efforts to cooperate with the NRCS, ME-DEP, and the CA-SWCD in the pursuit of local and regional lake protection and improvement strategies. This teamwork approach will result in an eventual and overall improvement in Arnold Brook Lake through NPS-BMP implementation and increased public involvement and awareness.

APPENDICES

ARNOLD BROOK 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 Monson Pond and Trafton Lake. 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 Echo 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.

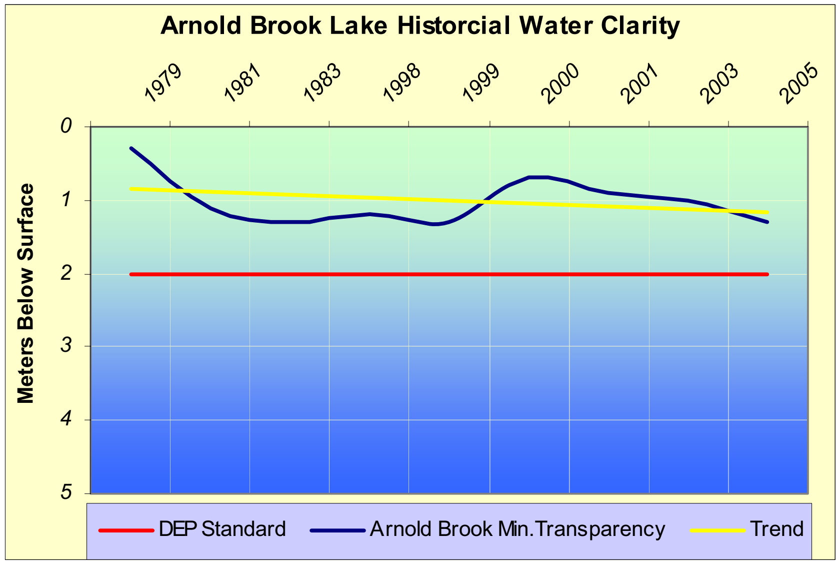
PCAP-TMDLs are important tools for maintaining and protecting acceptable lake water quality and are designed to 'get a handle' on the magnitude of the NPS pollution problem and to develop plans for implementing Best Management Practices (BMPs) to effectively address the lake's water pollution problem. 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 2005) Water quality monitoring data for Arnold Brook Lake (station 1, deep hole) has been collected since 1979 (1979, 1981, 1983, 1998-2003, 2005), as well as at the outlet from 2002-2004 (station 98). Hence, this present water quality assessment is based on eleven years of water quality data including 9 years of Secchi disk transparency (SDT) measures, combined with 5 years of epilimnion core total phosphorus (TP) data, 6 years of water chemistry and 9 years of chlorophyll-a measures.

Water Quality Measures: (Source: Maine DEP and Maine VLMP 2005) Historically, Arnold Brook Lake has had a range of SDT measures from 0.3 to 2.4 m, with an average of 1.2 m; an epilimnion core TP range of 25 to 50 with an average of 38 parts per billion (ppb); and chlorophyll-a measures ranging from 4.9 to 39 ppb, with an average of 21.1 ppb.



Since sampling began in 1979, Arnold Brook Lake has never met State water clarity standards. .

The potential for total phosphorus to leave the bottom sediments and become available to algae in the water column (internal loading) is moderate based on recent dissolved oxygen profiles. However, due to the shallow depth of Arnold Brook Lake, bottom sediments may be a source of high phosphorus, even when dissolved oxygen measures show non-depletion. This is particularly true during warm water months.

Priority Ranking, Pollutant of Concern and Algae Bloom History: Arnold Brook 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 Arnold Brook 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 Arnold Brook Lake has been poor during the entire monitoring period, never meeting the state's water quality limit of two meters. Consequently, summertime nuisance algal blooms have been a regular occurrence.

As evidenced from the chart above, there appears to be a slight improvement in the water quality of Arnold Brook Lake since 2000. Improvements may be attributed, in part, to a reduction in inputs from the Echo Lake. However, it is unclear whether the water quality trends shown in the graph above are truly an improvement, or simply natural variation that occurs in lakes. Total phosphorus (34 ppb-based recent summertime data, 2001-2005) 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 Arnold Brook 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 Arnold Brook 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). Arnold Brook Lake is a colored lake (average color 56 SPUs), with low late summer SDT readings (annual average of 1.2 meters), in association with high chlorophyll-a levels (21 ppb late summer average). Currently, Arnold Brook 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: Arnold Brook 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 Arnold Brook Lake is set at 16 ppb total phosphorus (199 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 Arnold Brook Lake historically approximated 47 ppb (1981), while summertime levels historically averaged 54 ppb (1981, 1983). Current total phosphorus (34 ppb-based on recent summertime data 2001-2005) reflect a 37% improvement from historical levels, but still do not meet water quality standards.

In summary, the numeric water quality target goal of 16 ppb for total phosphorus in Arnold Brook 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 2 details the numerical data used to determine external phosphorus loading for the Arnold Brook Lake watershed. The key below Table 2 on the next page explains the columns and the narrative that follows (pages 24-26) relative to each of the representative land use classes.

Table 2. Arnold Brook 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)	34	0.8%	0.35-1.35	0.64	13	8	0.7%
Row Crops	735	18%	0.26 - 18.6	2.24	297	670	59%
Row Crops - 3 year rotation	425	10%	-	1.17	172	221	20%
Actively Managed Forest	1653	40%	0.04 - 0.6	0.08	669	66	6%
Sub-Totals	**2,847**	**69%**			**1,151**	**965**	**85%**
Shoreline Development							
Shoreline Low Density	2	0.04%	0.14 - 4.90	1.0	1	0.3	0.03%
Parks/Cemetaries	2	0.04%	0.14 - 4.90	0.8	1	1	0.05%
Sub-Totals	**4**	**0.1%**			**2**	**1**	**0.1%**
Non-Shoreline Development							
Roads	108	3%	0.60 - 10.0	1.5	44	68	6%
Low Density Residential	145	4%	0.25 - 1.75	0.5	59	30	3%
Medium Density Residential	6	0.1%	0.40 - 2.20	1.0	2	3	0.2%
High Density Residential	15	0.4%	0.56 - 2.70	1.4	6	8	0.7%
Commercial-Industrial-Railroads	7	0.2%	0.77 - 4.18	1.5	3	5	0.4%
Gravel Pits	8	0.2%	0.00-0.00	0	3	0.03	0.003%
Sub-Totals	**289**	**7%**			**117**	**114**	**10%**
Total: MANAGED/DEVELOPED LAND	**3,140**	**76%**			**1,270**	**1,080**	**95%**
Non-Developed Land							
Inactive/Passively Managed Forest	23	0.5%	0.01 - 0.08	0.04	9	0.4	0.04%
Grassland/Reverting Fields	274	7%	0.1 - 0.2	0.15	111	17	2%
Scrub-Shrub	132	3%	0.1 - 0.2	0.15	53	8	0.7%
Wetlands	157	4%	0 - 0.05	0.01	64	0.8	0.07%
Total: NON-DEVELOPED LAND	**586**	**14%**			**237**	**27**	**3%**
Total: Surface Water (Atmospheric)	**395**	**10%**	**0.11 - 0.21**	**0.16**	**160**	**26**	**2%**
TOTAL: DIRECT WATERSHED	**4,121**	**100%**			**1,667**	**1,133**	**100%**

Key for Columns in Table 2

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 25 and 26 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.

Total Phosphorus Land Use Loads

Estimates of total phosphorus export from different land uses found in the Arnold Brook Lake watershed as presented on the previous page in Table 2 represent the extent of the current direct watershed phosphorus loading to the lake (1,133 kg/yr). Total phosphorus loading from *Arnold Brook Lake's* indirect watersheds (Echo Lake– 37 kg/yr) was determined on the basis of *flushing rate x volume x TP concentration (4.5 flushes/yr x 0.456 x 18 ppb),* representing typical area gauged stream flow calculations.

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.

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 land use coefficient used for row crops under 3-year rotation (1.17 kg TP/ha/yr) is based on the mean for one year of row crops and two years of grain or grass (0.64 kg TP/ha/yr). 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 business and residential land uses, including; low density development (0.5 kg/ha/yr), medium density development (1.0 kg TP/ha/ yr), and high density development (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 public roads) was chosen, in part, from previous studies of rural Maine highways (Dudley et al. 1997) and phosphorus research by Jeff Dennis (Maine DEP).

Commercial-Industrial-Railroads: The total phosphorus coefficient for Commercial/Industrial (1.50 kg TP/ha/yr) is based on recommendations by Jeff Dennis (Maine DEP), and was first used for the Cobbossee Lake TMDL (1995).

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 Managed and Developed Lands Phosphorus Loading: A total of 96% (1,205 kg) of the phosphorus loading to Arnold Brook Lake is estimated to have been derived from the cumulative effect of the preceding cultural land use classes: agriculture (>79% - 899 kg); forestry (6% - 66 kg); shoreline development <1% - 1 kg); and non-shoreline development (10% - 114 kg) as depicted in Table 2.

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 Arnold Brook Lake watershed. Results of the land use analysis indicate that a best estimate of the present total phosphorus loading from external (direct and indirect drainages) nonpoint source nutrient pollution approximates 1,170 (1,133 + 37) 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 Arnold Brook Lake TMDL as an annual load because the lake basin has an annual flushing rate of 2.36 (see discussion of seasonal variation on page 29). 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 31 (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)

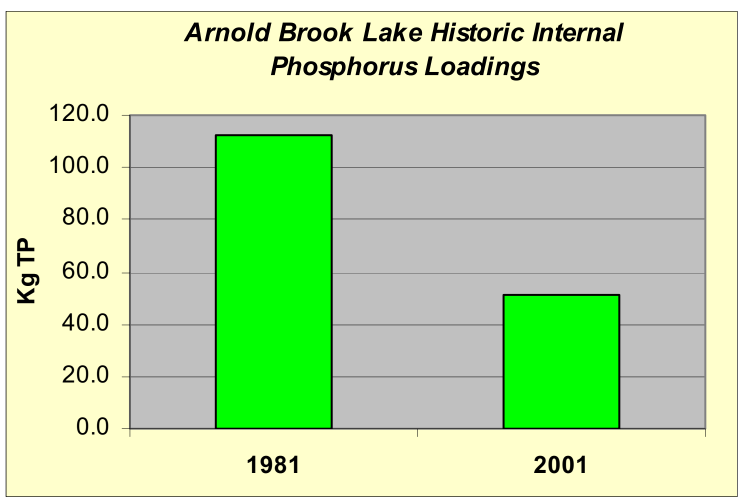
The daily loads for Arnold Brook Lake are presented on page 30.

Assimilative Loading Capacity: The Arnold Brook Lake basin lake assimilative capacity is capped at 199 kg TP/yr, as derived from the empirical phosphorus retention model based on a target goal of 16 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 16 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 Arnold Brook 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 Arnold Brook 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 Arnold Brook Lake.

Overall, the presence of nuisance algae blooms in Arnold Brook Lake may be reduced, along with halting the trend of increasing trophic state, if the existing phosphorus loading is reduced by approximately 222 kg TP/yr.



Recent measurements of Internal Phosphorus loading are 54% lower than measurements in the early 1980's.

Internal Lake Sediment Phosphorus Mass: The relative contribution of internal sources of total phosphorus within Arnold Brook 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 1981 and 2001, for an average annual value of 81 kg.

Linking Pollutant Loading to a Numeric Target: The basin loading assimilative capacity for colored Arnold Brook Lake was set at 199 kg/yr of total phosphorus to meet the numeric water quality target of 16 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 Arnold Brook 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.

Arnold Brook 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**

199 = **L** = external total phosphorus load capacity (kg TP/year)
16 = **P** = total phosphorus concentration (ppb) = Target Goal = **16 ppb**
1.60 = **A** = lake basin surface area (km^2) = 160 ha or 395 acres
2.0 = **z** = mean depth of lake basin (m) **A z p = 7.6**
2.36 = **p** = annual flushing rate (flushes/year)
0.61 = **1- R** = phosphorus retention coefficient, where:
0.39 = **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 Arnold Brook 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 Arnold Brook Lake during the summertime, when the potential (both occurrence and frequency) of nuisance algae blooms are greatest. The loading capacity of 16 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 Arnold Brook Lake equals 199 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 2). Direct external TP sources (totaling 1,133 kg annually) have been identified and accounted for in the land-use breakdown portrayed in Table 2 (corrected GIS). Further reductions in non-point source phosphorus loadings are expected from the continued implementation of NPS best management practices (see summary, pages 17-19). 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 Arnold Brook Lake originate from a combination of direct and indirect (watershed + Echo Lake) 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 Arnold Brook 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 Arnold Brook Lake historical records and a summary of statewide Maine lakes water quality data for colored (> 30 SPU) lakes - the target of 16 ppb (199 kg/yr in Arnold Brook 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. The state-wide database for colored Maine lakes indicates that summer nuisance algae blooms (growth of algae which causes water transparency to be less than 2 meters) are more likely to occur at 18 ppb or above.

SEASONAL VARIATION: The Arnold Brook 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 2.36 flushes/year, the average annual phosphorus loading is most critical to the water quality in Arnold Brook 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 Arnold Brook Lake watershed have been designed to address total phosphorus loading during all seasons.

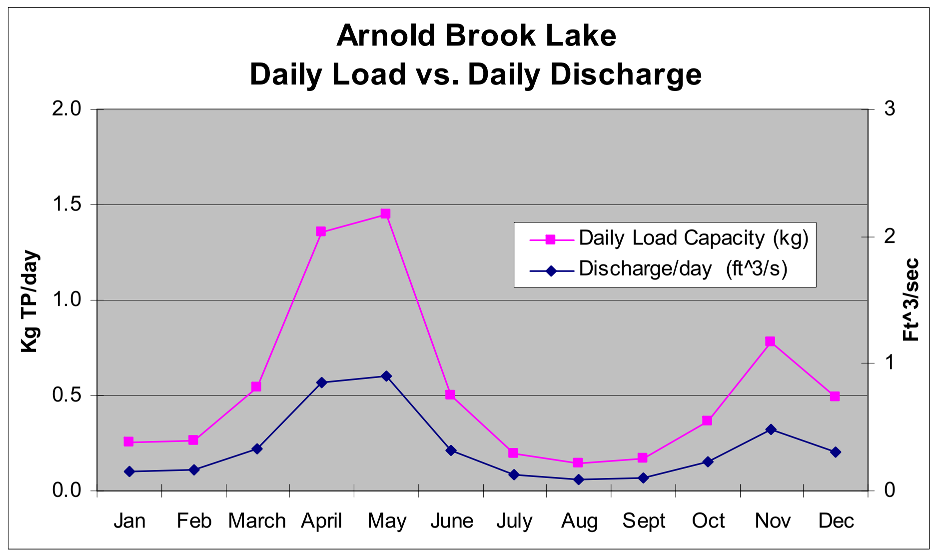
This variation is further accounted for in calculations of seasonal (May-October, November– April), monthly, and daily TP load calculations (p. 30). These numbers are derived from formulas developed by Dudley (2004) for ungaged rivers in Maine, and are based on several physical and geographic parameters 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. 31) for calculating the external total phosphorus load capacity (pp. 24-26) for the lake.

Daily TP Pollutant Loads for Arnold Brook 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	4.86	4%	0.09	7.80	0.16	0.157	0.25
Feb	4.53	4%	0.09	7.27	0.16	0.162	0.26
March	10.41	8%	0.20	16.72	0.34	0.336	0.54
April	25.38	21%	0.49	40.77	0.85	0.846	1.36
May	27.92	23%	0.53	44.84	0.90	0.901	1.45
June	9.34	8%	0.18	15.01	0.31	0.311	0.50
July	3.76	3%	0.07	6.05	0.12	0.121	0.20
August	2.76	2%	0.05	4.43	0.09	0.089	0.14
September	3.24	3%	0.06	5.20	0.11	0.108	0.17
October	7.03	6%	0.13	11.30	0.23	0.227	0.36
November	14.60	12%	0.28	23.44	0.49	0.487	0.78
December	9.50	8%	0.18	15.26	0.31	0.306	0.49

Season	% of Total	# Flushes
May -October	44%	1.0
November-April	56%	1.3

Vollenweider: L = P (Azp) / (1-R)	
L = external P load capacity (kg TP/yr)	**199**
P = total P concentration (ppb)	16
A = lake basin surface area (km2)	1.60
z = mean depth of lake basin (m)	2
p = annual flushing rate	2.36
1-R = P retention coefficient	0.61
R = 1 / (1 + sq. rt. p)	0.39



Regression Equations Used for Calculating Daily Loads for Arnold Brook Lake (Dudley, 2004)

16 Estimating Monthly, Annual, and Low 7-Day, 10-Year Streamflows for Ungaged Rivers in Maine

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)	$(PRESS/n)^{1/2}$ (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
$Q_{aug\ mean} = 0.353\ (A)^{1.075}\ 10^{0.922(SG)}$	-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 Arnold Brook 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 Arnold Brook 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 Arnold Brook Lake watershed.

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

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

8) **October 11, 2006:** MACD contacted Nancy Walker, President of the Arnold Brook Lake Improvement Society, to discuss potential BMP needs for Arnold Brook 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 Arnold Brook Lake watershed.

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

11) **November 14, 2006:** MACD staff Jennifer Jespersen contacted the University of Maine Cooperative Extension to discuss current educational opportunities for watershed landowners, and future interest in being a member of the Watershed Advisory Team.

12) **November 14, 2006:** MACD staff Jennifer Jespersen contacted Randy Smith, Farm Manager for the University of Maine Aroostook Farm for possible stakeholder input.

13) **December 11, 20006:** MACD, Maine-DEP, and CA-SWCD sponsored a public meeting at the CA-SWCD office in Presque Isle to discuss the Arnold Brook 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 Arnold Brook Lake PCAP-TMDL report: Maine DEP (Kathy Hoppe); CA-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/Aroostook Farm (Randy Smith); University of Maine Cooperative Extension (Peter Sexton); and Maine Potato Board (Tim Hobbs). 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 in the *Presque Isle Star Herald* during the week of December 27, 2006:

ARNOLD BROOK 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 0813) for the **ARNOLD BROOK 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 **ARNOLD BROOK 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

Dr. Steve Sutter (Associate Supervisor, CA-SWCD) reviewed the document and recommended a minor revision to the public participation information (p. 32). Additionally, Dr. Sutter 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 Arnold Brook 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. 25). 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). Furthermore, much of the actively managed forest land in the watershed has had management plans prepared by a professional forester, and is properly managed (L. Alverson, personal communication). Therefore, we believe the current coefficient of 0.08 kg/ha/yr is appropriate.

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

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