PHOSPHORUS CONTROL ACTION PLAN

and Total Maximum Daily (Annual Phosphorus) Load Report

UNITY POND (Lake Winnecook)

Waldo County, Maine

Unity Pond PCAP-TMDL Report

Maine DEPLW 2004 - 0668

Maine Department of Environmental Protection

Maine Association of Conservation Districts and Unity College

Final EPA Submittal Document - September 9, 2004

UNITY POND (Lake Winnecook)

Phosphorus Control Action Plan (PCAP)

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UNITY POND (Lake Winnecook)

Total Maximum Daily (Annual Phosphorus) Load

ACKNOWLEDGMENTS

In addition to Maine DEP and US-EPA New England Region I staff, the following individuals, groups and agencies were instrumental in the preparation of this combined Unity Pond (Winnecook Lake) Phosphorus Control Action Plan-Total Maximum Daily Load report: Unity College (Pam Proulx-Curry, Shawn Biello, Dave Potter, Libby Seigars, and Grant Estell); MACD staff (Jeremy Martin, Jodi Michaud Federle, Forrest Bell, Fred Dillon and Tim Bennett); Towns of Unity, Burnham and Troy (Office staffs); Charles Porter (CEO for Unity, Burnham and Troy); Unity Planning Board and Unity Barn Raisers (John Piotti); University of Maine Cooperative Extension (Rick Kersbergen, Jessie Mae MacDougall, and Kristina Steiff-Henderson); Friends of Lake Winnecook (Mark Huard and Jerry Cinnamon); Kennebec Valley Council of Governments (Bill Naijpauer) Maine Department of Agriculture (David Rocque); Maine Forest Service (Morten Moesswilde); Maine Department of Inland Fisheries & Wildlife, Region B, Sidney (Jim Lucas and Bill Woodward); Maine Department of Marine Resources (Gail Wippelhauser, Hallowell Office); and a very special appreciation to longtime VLMP monitor Max Gillette.

UNITY POND (WINNECOOK LAKE)
PHOSPHORUS CONTROL ACTION PLAN
SUMMARY FACT SHEET

Background

UNITY POND (Lake Winnecook) is a 2,523-acre waterbody located in the towns of Troy, Burnham, and Unity in Waldo County, Maine. Unity Pond has a direct **watershed** (see map) area of 32.7 square miles; a maximum depth of 41 feet, a mean depth of 22 feet; and a **flushing rate** of 1.23 times/yr.

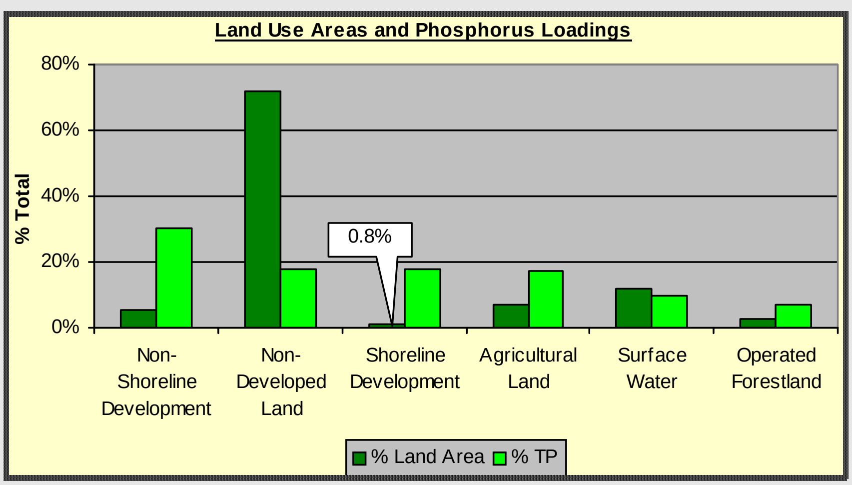
Unity Pond (pictured on right) has a history of supporting excessive amounts of algae in the late summer-early fall, due in large part to the contribution of **phosphorus** that is prevalent in area soils and has accumulated in the pond bottom sediments. Soil erosion in the watershed can have far-reaching consequences, as soil particles effectively transport phosphorus, which serves to "fertilize" the lake and decreases water clarity. Excess phosphorus can also harm fish habitat and lead to nuisance algae blooms—floating mats of green scum—or dead and dying algae. Studies have shown that as lake water clarity decreases, lakeshore property values also decline.

Stakeholder Involvement

Federal, state, county, and local groups have been working together to effectively address this nonpoint source water pollution problem. In 2001, the Maine Department of Environmental Protection funded a project in cooperation with the Maine Association of Conservation Districts and Unity College to identify and quantify the potential sources of phosphorus and identify the **Best Management Practices** needed to be installed in the watershed. A final report, completed in the summer of 2004, is entitled "Unity Pond Phosphorus Control Action Plan" and doubles as a **TMDL** report, to be submitted to the US Environmental Protection Agency, New England Region, for their final review and approval.

What We Learned

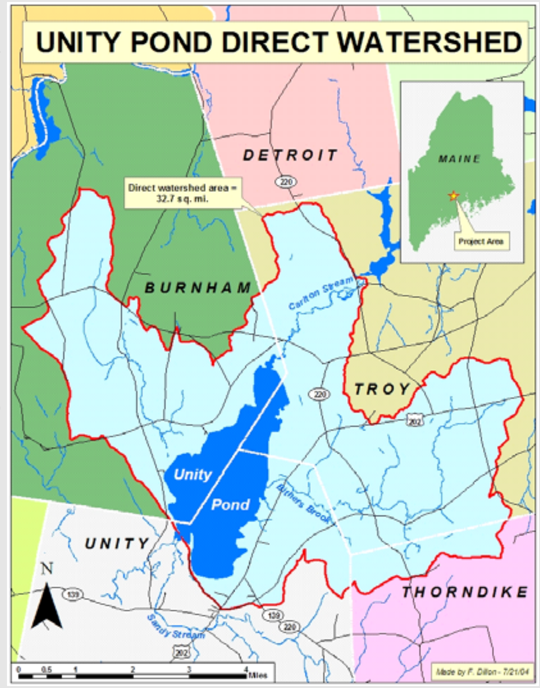
A land use assessment was conducted for the Unity Pond watershed to determine potential sources of phosphorus that may run off from land areas during storm events and springtime snow melting. This assessment utilized many resources, including generating and interpreting maps, inspecting aerial photos, and conducting field surveys.



An estimated 1,728 kilograms (kg) of phosphorus is exported on an annual basis to Unity Pond from the direct watershed. The bar chart (left) illustrates the land area for each representative land use vs. its phosphorus export load.

The total phosphorus contribution from upstream

Carlton Pond was estimated at 542 kg/yr. Over the past two decades the amount of phosphorus being recycled internally (630 kg TP/year) from the bottom sediments of Unity Pond during the summertime is about a third of Unity Pond's natural capacity (2,060 kg TP/yr.) for in-lake phosphorus assimilation.

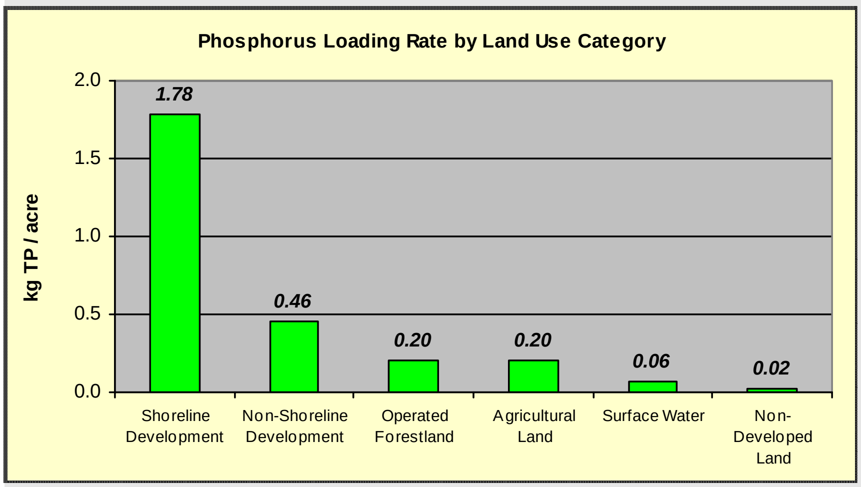


Phosphorus Reduction Needed

The natural capacity of Unity Pond to effectively process 2,060 kg of TP on an annual basis without harming water quality equals an in-lake phosphorus concentration of 15 ppb. Unity Pond's average summertime TP concentration is 20 ppb - equal to an additional 690 kg (5 ppb x 138 kg). Accounting for a 69 kg allocation for future development, the total amount of phosphorus needed to be reduced to attain water quality standards (algal bloom-free conditions) in Unity Pond is 759 kg.

<u>What You Can Do To Help!</u>

As a watershed resident, there are many things you can do to protect the water quality of Unity Pond. Lakeshore owners can use phosphorus-free fertilizers and maintain natural vegetation adjacent to the lake. Agricultural and commercial land users can consult the Waldo County Soil and Water Conservation District or Maine Department of Environmental Protection for information regarding Best Management Practices (BMPs) for reducing phosphorus loads. Watershed residents can always become involved by volunteering to help the Friends of Lake Winnecook (FOLW) and participating in events sponsored by agencies and local organizations. The estimated phosphorus loading to the lake originates from both shoreline and non-shoreline areas (see graph, left) so everyone must take ownership of lake restoration. All stakeholders and watershed residents can learn more about their lake and the many resources available, including review of the Unity Pond Phosphorus Control Action Plan. Following final EPA approval, copies of this detailed report, with recommendations for future NPS/BMP work, will be available online at www.state.me.us/dep/blwq/docmonitoring/tmdl2.htm, or can be viewed and/or copied (at cost) at Maine DEP offices in Augusta (Bureau of Land and Water Quality, Ray Building, AMHI Campus).



Key Terms

- ***<u>Watershed</u>*** *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.*
- ***<u>Flushing rate</u>*** *refers to how often the water in the entire lake is replaced on an annual basis..*
- ***<u>Phosphorus</u>****: 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.*
- ***<u>Best Management Practices</u>*** *are techniques to reduce sources of polluted runoff and their impacts. BMP's are low cost, common sense approaches to reduce storm runoff and velocity to keep soil out of lakes and tributaries.*

Project Premise

This 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 Unity College and the Maine Association of Conservation Districts (MACD), from the summer of 2000 through the summer of 2004.

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 Unity Pond 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 Project Team, will 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*).

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.*

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

Secondly, watershed survey work, including a shoreline and septic survey evaluation, was conducted by the Maine DEP-MACD project team (including Unity College) to help assess **total phosphorus** reduction techniques that would be beneficial for the Unity Pond watershed. Watershed survey work included assessing direct drainage **nonpoint source (NPS) pollution** sites that were not identified during the Watershed Stewards - Unity Pond Watershed Survey conducted in 2000. The results of this current assessment report includes recommendations for future conservation work in the watershed to help citizens, organizations, and agencies restore and protect Unity Pond. **Note:** *To protect the confidentiality of landowners in the Unity Pond watershed, site-specific information has not been provided as part of this PCAP-TMDL report.*

This Phosphorus Control Action Plan (PCAP) report compiles and refines land use data derived from various sources, including the municipalities of Unity, Burnham and Troy, the Friends of Lake Winnecook (FOLW), the Waldo County Soil & Water Conservation District (SWCD), and the Maine Forest Service. Local citizens, watershed organizations, and conservation agencies should benefit from this compilation of data as well as the watershed assessment and the NPS Best Management Practice (BMP) recommendations. Above all, this document is intended to help Unity Pond 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.

Study Methodology

Unity Pond background information was obtained using several methods, including a review of previous studies of the lake and watershed, numerous phone conversations and personal interviews with municipal officials, regional organizations and state agencies, and several field tours of the watershed, including boat reconnaissance of the lake and shoreline area.

Land use data were determined using several methods, including (1) **Geographic Information System (GIS)** map analysis, (2) analysis of topographic maps, (3) analysis of town property tax maps and tax data, (4) analysis of aerial photographs and (5) ground-truthing. Much of the undeveloped land use area (i.e., forest, wetland, grassland) was determined using a GIS layer which is a combination of Maine Gap Analysis (GAP) landcover and USGS Multi Resolution Landcover Characterization (MRLC) landcover layers. It was created at the request of Maine DEP Bureau of Land and Water Quality (BLWQ) staff. It includes those classes in each layer which are best suited to calculating impermeability of watersheds. Both MRLC and GAP (and so Maine COMBO) are based on 1992 Landsat imagery. The developed land use areas were obtained using the best possible information available through analysis of methods 2 through 5 listed above.

> ***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.*

All land use GIS data was compiled under subcontract by ORBIS mapping solutions. Final adjusted phosphorus loading numbers (see Table 3, page 32) were modeled using overlays of soils, slope, and installed Best Management Practices. All of the land use coverage data for developed areas was re-configured using aerial overlays and then ground-truthing the watershed.

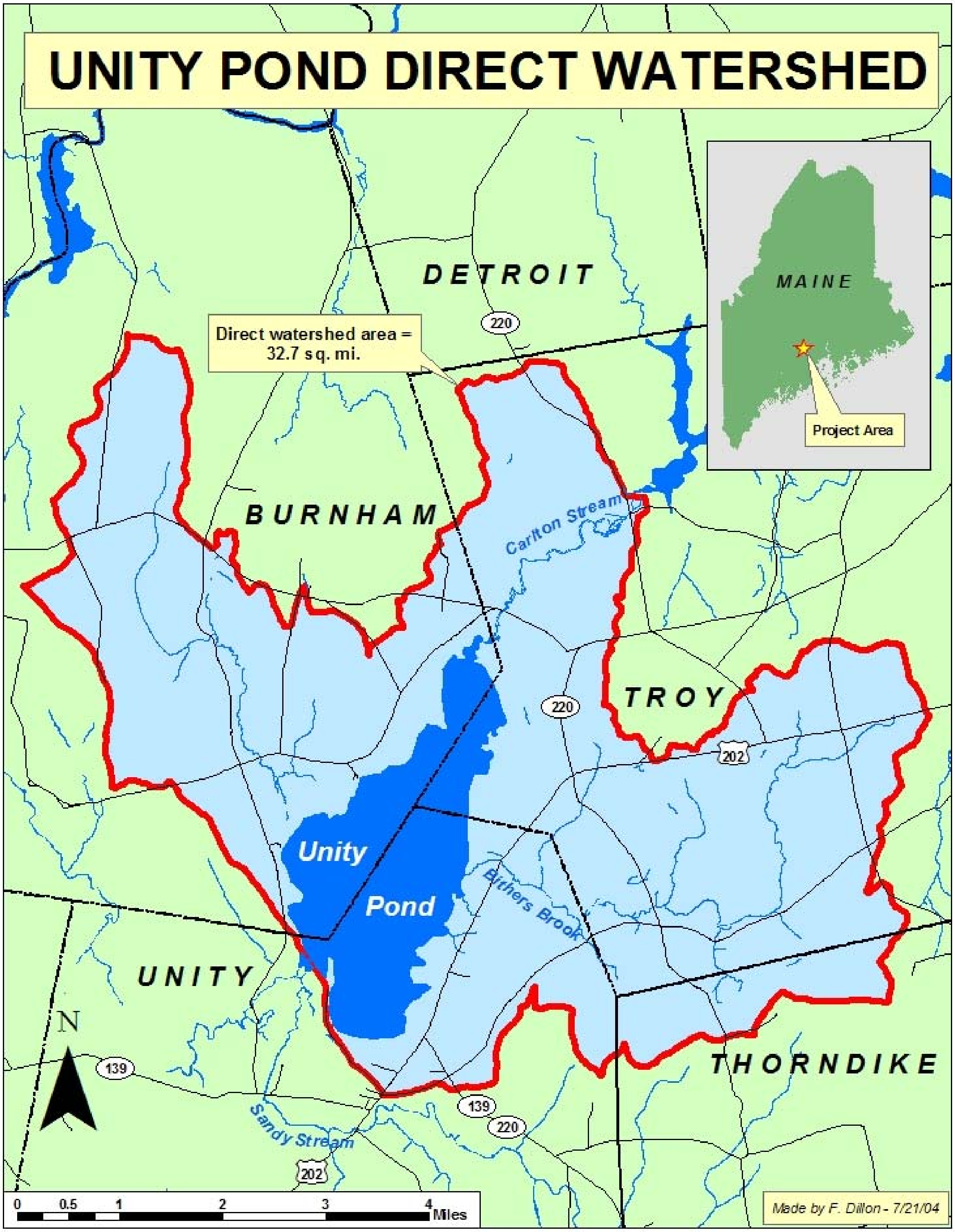
Roadway data were gathered by taking actual road width measurements of the various types of roads (state, town, private/camp) in the watershed. Roads were measured between the two outer edges of the roadside ditches or berms. An average width was used for each of the three road types. Final measurements for all roadways within the watershed were extrapolated using GIS and USGS topographical maps. The roadway area was determined using linear distances and average widths for each of the three main road types.

Agricultural information within the Unity Pond watershed was reviewed by the USDA Natural Resources Conservation Service and Waldo County Soil and Water Conservation District (SWCD). Information regarding forestry harvesting operations was provided by the Maine Forest Service, Department of Conservation.

Study Limitations

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

Figure 1. Map of Unity Pond Direct Watershed



<u>UNITY POND (Lake Winnecook) Phosphorus Control Action Plan</u>

DESCRIPTION of WATERBODY (MIDAS Number <u>5172</u>) and WATERSHED

> *The **direct watershed** refers to the land area that drains to the lake without first passing through another lake or pond.*

UNITY POND (Lake Winnecook) is a 2,523 acre single-basin waterbody (1,021 hectares), located in the towns of Unity, Burnham and Troy (<u>DeLorme Atlas</u>, Maps 21 and 22), within Waldo County in central Maine. Unity Pond has a **<u>direct</u> watershed** area (see Figure 1) of 20,945 acres (32.7 square miles) including lake surface area. Unity Pond watershed is located within the towns of Troy (45%), Burnham (35%), Unity (12%), and Thorndike (8%). Unity Pond has a maximum depth of 41 feet, overall mean depth of 22 feet, and a flushing rate of 1.23 times per year.

Drainage System – Unity Pond has three major tributaries (Figure 1). Meadow Brook, originates in a tamarac bog and flows from the northwest. Bithers (Bog) Brook flows from the east, and Carlton Stream originates in Carlton Bog (a.k.a. Carlton Pond) and flows from the northeast. The Carlton Bog wetlands area is a division of the Sunkhaze Meadows National Wildlife Refuge, managed by the United States Fish and Wildlife Service (USFWS). As the only Waterfowl Production Area east of the Mississippi River, the Refuge provides nesting habitat for endangered black terns. A wooden dam manipulates water levels at the outlet. During significant rain events and low lake water levels, Sandy Stream - originating at Freedom Pond - serves as a sub-drainage, flowing from the south and into Unity Pond at its only outlet. Unity Pond possesses a single outlet, which drains into a wetland area on the southwestern shore at a site locally referred to as the "train trestle" in the town of Unity. Portions of the wetland and abutting grasslands are designated as the Sandy Stream Division of the Sunkhaze National Wildlife Refuge, protecting habitat of the endangered sedge wren. The pond outflow continues into Twenty-Five Mile Stream, flowing into the Sebasticook River in Burnham, eventually draining to the Kennebec River (Martin 2001).

Unique Feature: Outlet Backflushing - The Unity Pond outlet has been a source of concern over the years. Local residents have historically pointed to the outlet problems on the design of the train trestle, which created the wetland area into which the pond now drains. Originally the Sandy Stream watershed, primarily a forested and agricultural area draining 16,736 hectares (65 sq. mi.) including Freedom Pond and Halfmoon Stream, which enters near the Thorndike–Unity town line, served as an indirect drainage flowing from the south directly into Unity Pond at the southwest shore. A number of smaller perennial and intermittent streams also contribute to the Sandy Stream drainage. The construction of the train trestle in 1870 and the development of a wetland area have altered the natural flow of Unity Pond's outlet, Twenty-Five Mile and Sandy streams (Martin 2001).

Typically, Sandy Stream flows from the south and into the wetland area southwest of the Unity Pond outlet and then into Twenty–Five Mile Stream. However, during significant rain events and when lake water levels are low - Sandy Stream may bypass Twenty–Five Mile Stream and flow directly into Unity Pond. When backflushing occurs at the pond's outlet, the Sandy Stream sub-drainage system increases the Unity Pond watershed to 32,825 hectares (127 sq. mi.).

Water Quality Information

Unity Pond is listed on the Maine DEP's 303(d) list of lakes that do not meet State water quality standards as well as the State's Nonpoint Source Priority Watersheds list. Hence, the preparation of an Phosphorus Control Action Plan (and TMDL) was prepared, publicly reviewed, and completed in the summer of 2004.

Based on **Secchi disk transparencies,** measures of both TP and **chlorophyll-a**, the water quality of Unity Pond is considered to be poor and the potential for nuisance summertime algae blooms is high (Maine VLMP 2003). Together, these data document a trend of increasing **trophic state,** in direct violation of the Maine DEP Class GPA water quality criteria requiring a stable or decreasing trophic state.

Secchi Disk Transparency*—a measure of the transparency of water (the ability of light to penetrate water) obtained by lowering a black and white disk into 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 be used to assess trophic state.*

Nonpoint source pollution is the main reason for declining water quality in Unity Pond. 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.

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 algae blooms, which can damage the ecology/aesthetics of a lake, as well as the economic well-being of the entire watershed community.

Principle Uses: The dominant human uses of the Unity Pond shoreline are residential (both seasonal and year-round occupancy) and recreational—boating, fishing, camping and swimming/beach use. There are two public beaches on Unity Pond. Kanokolous Beach on the southwest shore in Unity, and the Burnham Town Beach south of Reynolds Corner. Public access is provided via a number of boat launches, both public and private. There is public access to the lake in the Town of Unity, southeast of the outlet trestle at Kanokolous Beach and in Burnham on the western shore. A private, unimproved launch is located on the east shore of the pond on Windemere Drive in Unity. Private boat launch access is available at numerous private camp roads and residences around Unity Pond (shoreline survey). Three boat launches provide access within the sub-drainage of Sandy Stream on Route 139 approximately 1.5 miles west of Unity center and at the intersection of Routes 202/9 and Quaker Hill Road (Unity College) also in Unity. Access to Halfmoon Stream is located on the Route 220 bridge in Thorndike (Martin, 2001).

Human Development: Unity Pond has a highly developed residential shoreline with about 60% of the shoreline developed mainly on the south, east, and west shores (Martin 2001). There are 286 shoreline housing units (57% seasonal; 43% year-round). It is estimated that the Unity Pond shoreline supports 500 year-round residents. There is one commercial campground and a recreation park located on the south shore in Unity. A cabin rental business and golf course operate on the western shore within the town of Burnham (Martin 2001).

Unity Pond is on the State's **Nonpoint Source Priority Watersheds** list due primarily to algal blooms and other factors. In addition to NPS pollution, high population growth rates are a concern for the watershed. Human population estimated to reside within the towns of Unity (1,893), Burnham (1,179), Troy (961) and Thorndike (705), totals 4,738 – of which the majority live within the Unity Pond watershed. Notably, for the 1980-2000 time frame, all watershed towns experienced at least an 18% population increase (KVCOG 2002). Population growth and increased land use activities during the last two decades have most likely contributed to increased runoff to Unity Pond with a resultant increase of algae growth.

*Waterbodies within designated **NPS priority watersheds** have significant value from a regional or statewide perspective and have water quality that is either impaired or threatened to some degree due to NPS water pollution. This list helps to identify watersheds where state and federal agency resources for NPS water pollution prevention*

Human Development in the Unity Pond Watershed includes this recreation area—"The Field of Dreams" located on the south shore of the lake.

Unity Pond Fish Assemblage - Fisheries Assessment

Based on records provided by the Maine Department of Inland Fisheries and Wildlife (Maine DIFW) and a recent personal conversation with fisheries biologist's Jim Lucas and Bill Woodward (Region B, Sidney DIFW office), **Unity Pond** (Lake Winnecook - Towns of Unity, Burnham and Troy: Twenty-five Mile Stream - Sebasticook and Kennebec River drainages) is currently managed as a mixed warmwater and coldwater fishery and was last surveyed in 1993 (Maine EMAP Project). A total of **20** fish species occur, including: **12** native indigenous fishes (American eel, golden and common shiner, fallfish, white sucker, brown bullhead, chain pickerel, banded killifish, burbot, red-breast sunfish, pumpkinseed, and yellow perch); **4** introduced fishes of uncertain origin (landlocked white perch and rainbow smelt, smallmouth and largemouth bass); **3** annually stocked managed fishes (sea-run alewife - Maine DMR **anadromous** fish restoration program, and catchable-size brook and brown trout - Maine DIFW), and **1** illegally introduced fish species (black crappie). Major warm-water fisheries, in addition to chain pickerel and yellow perch, include largemouth and smallmouth bass and white perch.

***Anadromous** fish are born in fresh water, migrate to the ocean to grow into adults, and then return to fresh water to spawn.*

Anadromous Alewife Stocking - based on a recent conversation with Gail Wippelhauser (Maine DMR, Hallowell Office), the restoration of alewives into Unity Pond began with an initial stockings of 559 to 4,632 fish from 1989 to 1993. Maintenance stocking of 15,000+ fish began in 1994 and has been continued through 2004, when 15,174 fish were stocked. [See Fact Sheet in Appendix p. 44]

History of Alewife Stocking In Unity Pond (Maine DMR)

1989 - 3,301	1994 - 15,343	1999 - 15,240
1990 - 559	1995 - 15,961	2000 - 15,237
1991 - 4,632	1996 - 15,312	2001 - 15,399
1992 - 2,845	1997 - 15,366	2002 - 15,204
1993 - 3,125	1998 - 15,313	2003 - 15,082

Unity Pond has been plagued with annually occurring severe summertime blue green algae blooms and significant depths of **anoxic** waters (50% at deep hole, 6-11 meters, 22-36% by volume/area) for many years. A significant reduction in the total phosphorus load to Unity Pond - concurrent with the gradual depletion of the internal sediment load, in combination with indirect TP reductions from intermittent Sandy Stream contributions - may lead to maintaining in-lake nutrient levels within the assimilative capability of Unity Pond to effectively process total phosphorus, eventually leading to the general absence of nuisance summertime algae blooms. Improved water transparencies and overall acceptable water quality conditions in Unity Pond, including restoration of suitable **dissolved oxygen** conditions (> 5 ppm) will serve to support/maintain existing warmwater and marginally coldwater fisheries.

***Anoxia**—a condition of no oxygen in the water. Often occurs near the bottom of fertile, stratified lakes in the summer and under ice in late winter.*

***Dissolved Oxygen**—refers to the amount of oxygen measured in the water. It is used by aquatic organisms for respiration. The higher the temperature, the less oxygen the water can hold. Oxygen will naturally decline during the summer months as water temperatures rise.*

General Soils Description (Source: USDA SCS 1978):

The Unity Pond Watershed is characterized by several general soil associations:

The southern shoreline and Meadow Brook corridor consist of the **Masardis-Adams-Madawaska** association. These soils are classified as somewhat excessively drained to moderately well drained soils formed in coarse textured and moderately coarse textured material deposited by glacial meltwater. These soils fall within the A and B hydrologic soil group classification and have high rates of permeability and phosphorus transport through groundwater (including septic systems) may occur.

The western shoreline consists of the **Boothbay-Swanville-Lyman** association. These soils are classified as moderately well drained to poorly drained soils formed in marine and lacustrine sediments, and somewhat excessively drained soils formed in moderately coarse textured glacial till. These soils fall within the C and C/D hydrologic soil group classification and have fairly low permeability rates allowing for greater amounts of surface runoff.

The eastern shoreline of Unity Pond and much of the southeast and eastern portions of the watershed consists of **Dixmont-Borosaprists-Monadara** association. These soils are classified as moderately well drained to poorly drained soils formed in medium textured glacial till, and deep, level, very poorly drained soils formed in organic material. These soils fall within the C and D hydrologic soil group and are generally prone to high amounts of surface runoff.

The northern and northeastern portion of the Unity Pond watershed is dominated by the **Peru-Marlow-Brayton** association. These soils are classified as well drained to poorly drained soils formed in dominantly moderately coarse textured, compact glacial till. These soils fall within the C hydrologic soil group allowing for greater amounts of surface runoff than A or B soils.

Land Use Inventory

The results of the Unity Pond watershed land use inventory are depicted in Table 1 (following page). The various land uses are categorized by developed land vs. non-developed land. The developed land area comprises approximately 16% of the watershed and the undeveloped land including the water surface area of Unity Pond, comprise the remaining 84% of the watershed. These numbers may be used to help make future planning and conservation decisions relating to the Unity Pond watershed. The information in Table 1 was also used as a basis for preparing the Total Maximum Daily (Annual Phosphorus) Load report (see Appendices).

Descriptive Land Use and Phosphorus Export Estimates

Agriculture: Historically, agriculture has had a relatively large impact on Unity Pond's water quality (Rabeni 1974). Today, agriculture continues to play an important role in the local economy although the amount of land used for agricultural purposes in the Unity Pond direct watershed is minimal compared to other land uses. The number of farming operations in the direct watershed

Table 1. UNITY Pond Direct Watershed - Land Use Inventory and Phosphorus Loads.

LAND USE CATEGORY	Land Area Acres	Land Area %	TP Export Total %
Operated Forestland			
Operated Forest	541	2.6%	6.4%
Tree Farms / Orchards	63	0.3%	0.7%
Sub-Totals	**604**	**2.9%**	**7.1%**
Agricultural Land			
Row Crops/Tillage/Corn	172	0.8%	6.2%
Hayland - Non-Manured	1,068	5.1%	6.1%
Pasture (grazed Meadows)	155	0.7%	3.6%
Hayland - Manured	63	0.3%	1.2%
Mixed Agriculture	7	0.0%	0.1%
Sub-Totals	**1,465**	**7.0%**	**17.2%**
Shoreline Development			
Residential Septic Systems	-	-	10.5%
Shoreline Medium Density Residential	138	0.7%	3.7%
Shoreline Roads	30	0.1%	3.3%
Shoreline Recreational	3	0.0%	0.2%
Sub-Totals	**171**	**0.8%**	**17.7%**
Non-Shoreline Development			
Roads	421	2.0%	17.6%
Low Density Residential	450	2.2%	6.4%
Commercial-Industrial	110	0.5%	4.4%
Golf Courses	28	0.1%	1.1%
Parks, Cemetaries	34	0.2%	0.7%
Institutional	6	0.0%	0.3%
Gravel Pits / Bare Land	19	0.1%	0.0%
Unknown	80	0.4%	0.0%
Sub-Totals	**1,148**	**5.5%**	**30.5%**
Total: DEVELOPED LAND	**3,388**	**16.2%**	**72.4%**
Non-Developed Land			
Undisturbed/Unmanaged Forest	10,809	51.6%	13.1%
Grassland	812	3.9%	4.6%
Scrub Shrub	95	0.5%	0.3%
Wetland	3,298	15.7%	0.0%
Total: NON-DEVELOPED Land	**15,013**	**71.7%**	**18.0%**
Total: Surface Water (Atmospheric)	**2,543**	**12.1%**	**9.5%**
TOTAL: DIRECT WATERSHED	**20,944**	**100%**	**100%**

has declined since the 1970's, while remaining farms have increased in intensity and production. The majority of farming operations in the Unity Pond indirectly associated watershed (see previous back-flushing discussion on page 9) are located on Halfmoon and Sandy Streams.

A reasonable estimate of "cooperating" farms in the watershed would be 90% (Randy Doak—personal communication). According to the USDA NRCS in Waldo County, more than 15,000 acres of agricultural land (including the indirect watersheds of Carlton Bog and Sandy Stream) are enrolled in conservation programs. Additionally, all of the farms and cropland in the watershed, except for one farm, have had conservation management plans (CMPs) prior to the requirements of the new Nutrient Management rules (Waldo County NRCS).

It is evident that the agricultural community and state and federal agencies involved have worked hard at improving agricultural and land use practices aimed at improving water quality in Unity Pond, both within the direct (Unity Pond) and associated Sandy Stream drainage systems.

Agricultural land in the watershed is estimated to comprise 1,465 acres (7%) of the watershed land area and contribute 297 kg (17%) of the total phosphorus contribution to Unity Pond. These data were mapped using GIS software and verified by aerial photography, ground-truthing, and consultation with the Waldo County NRCS/SWCD office.

Forestry: Generally, poorly managed forestry operations have the potential to negatively impact a waterbody by erosion and sedimentation from logging sites. The estimated "operated forestland" acres for the Unity Pond direct watershed is 541 acres. This estimate is based on the Maine Forest Service's annual average of harvested acres for the period from 1999 through 2003 and represents 2.6% of the total land area and an estimated 6.4% of the total phosphorus load to Unity Pond (personal communication Chris Martin, August 5, 2004). Tree farms and orchards approximate 0.3% of the total land area and an estimated 0.7% of the total phosphorus load. 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 Residential (House and Camp Lots): Shoreline lake residences can have a comparatively large estimated impact, in terms of total phosphorus loading to lakes, in comparison to their relatively small percentage of the total land area in the watershed. This holds true for Unity Pond where the developed shoreline area accounts for less than 1% of the land area and is estimated to contribute almost 18% of the total phosphorus load to Unity Pond.

In order to evaluate the impact of these lake shoreline homes, Unity College and Maine DEP project staff conducted a shoreline residential survey in the summer of 2002. This visual survey was carried out while observing the Unity Pond shoreline from a boat and the results are based on subjective determinations of potential impact ratings using best professional judgment. The visual survey included a residential structure tally along with estimating a potential NPS pollution impact rating based on the following components: presence or lack of vegetated buffers, distance of dwelling from shoreline, shoreline erosion, presence of bare/exposed soil and percent slope of the lot. In addition to the impact rating, project staff estimated the residency status of the dwelling (seasonal vs. year-round) and notable features such as retaining walls or boat launches.

Table 2. Unity Pond Shoreline Buffer Survey Results (2002)	
Buffer Rating	**Number (%) of shoreline sites identified within each category**
1 = Best Buffer	21 (7%)
2 = Good Buffer	69 (24%)
3 = Some Buffer	121 (42%)
4 = Sparse Buffer	64 (23%)
5 = No Buffer	8 (3%)

According to tax property maps, there are 299 shoreline lots on Unity Pond with 286 of those lots containing structures. Much of the undeveloped shoreline is concentrated along the northeastern shore of the lake. The shoreline survey estimated 163 seasonal dwellings and 123 year-round dwellings on the immediate shoreline of Unity Pond (UC & MDEP 2002). An estimated 50% of homes are located within the 100-year flood plain.

Table 2 outlines the findings of the buffer component of the survey. The survey indicated that more than three quarters (categories 3, 4, and 5) of the shoreline dwellings exhibit inadequate or nonexistent shoreline buffers.

- ***To convert kg of total phosphorus to pounds—multiply by 2.2046***
- ***To convert kg/hectare to lbs/acre—multiply by 0.892***

To estimate phosphorus loading from residential land use, the shoreline survey data were classified as medium-density residential. The initial residential area was delineated using GIS mapping software and then corrected using aerial photography and ground-truthing. Phosphorus loading coefficients were developed using information on residential lot stormwater export of algal available phosphorus (Dennis et al. 1992). Seasonal and year-round camp and home lots (excluding septic—see following section) on Unity Pond comprise less than 1% of the land area and an average of 63 kg of total phosphorus annually, which approximates 3.7% of the estimated total phosphorus load.

Shoreline Septic Systems: Total phosphorus export loading from residential septic systems within the 100-foot shoreline zone has been assessed for Unity Pond. The towns have utilized Community Development Block Grant monies from the Maine DEP to address some nuisance septic (waste) situations. Recently, a commercial campground on the south shore in Unity installed an approved system to process sewage from 26 shoreline camp sites (John Carmen, personal communication).

Unity Pond shoreline soils are classified for septic suitability based on the identified soil type's ability to filter and purify effluent in septic tank and drain field systems (Cinnamon 1993). As such, 4% of soils are rated as fair and 96% are rated as inadequate for septic suitability.

In order to estimate total phosphorus loading from shoreline septic systems, a simple model was used based on the following attributes: seasonal or year-round occupancy; estimated age of the system; estimated distance of the system to the lake; and an estimated 3 people per dwelling, while taking into account a groundwater phosphorus loading range based on low, medium and high flow estimates. These attribute values were determined by shoreline survey, town records and personal interviews with municipal officials.

For purposes of these calculations it was assumed that 25% of the dwellings along the shoreline had septic systems installed after 1974. Based on the results of the shoreline survey: 64% of residences (and their septic systems) were estimated to lie less than 50' from the shoreline, 30% between 50' and 150' from the shoreline, and 6% were located greater than 150' from the shoreline; and, 57% of the structures were assumed to be seasonal residences (occupied 90 days/ year) and 43% were assumed to be year-round residences (occupied 365 days/year).

Estimates of the loading from residential septic systems on Unity Pond range from a low of 57 to a high of 177 kg total phosphorus per year. Estimates of the phosphorus loading from the commercial campground septic system and the cottage rental business ranged from a low of 2 to a high of 6 kg total phosphorus per year. Combined residential and commercial shoreline septic system loadings contribute an average total watershed phosphorus export of approximately 10.5% or 182 kg TP annually.

Recreational (Shoreline): Included in this category are the public boat launches and swim areas (approximately 3 acres) and the commercial campground located on the south shore of Unity Pond and the cottage rental business in Burnham. Estimates of loading from recreational (shoreline) development approximate an average TP export of 0.2% or 4 kg of TP annually.

Private/Camp Roadways are analyzed within the shoreline development category and were measured using GIS land use data and field measurements. The average road width for private roads in the Unity Pond watershed is about 20 feet. When multiplied by the average road width, camp and private roads cover 30 acres in the direct watershed. Camp roads contribute an estimated 3% (56 kg/yr) of TP to the total phosphorus load in the direct watershed.

NPS pollution associated with roads can vary widely, depending upon road type, slope and proximity to a resource. Routine maintenance of unimproved roads and associated drainage structures are often inadequate. Friends of Lake Winnecook (FOLW), University of Maine

Cooperative Extension (UMCE) and Unity College watershed surveys identify numerous NPS problems associated with roads (Martin 2001).

Overall, shoreline development comprises less than 1% of the total watershed area, yet contributes an average of 305 kg of total phosphorus annually, which approximates 17.7% of the estimated phosphorus load.

Other Development and Land Uses

Non-Shoreline Development consists of all lands outside the immediate shoreline of Unity Pond - including residential areas, commercial areas, state and town roads, and other land uses such as commercial, cemeteries, institutional (public) areas, and recreational areas. These land use areas were calculated using GIS land use coverage, aerial photos and ground-truthing.

Public Roadways were measured using GIS land use data and field measurements. The average road width for state roads in the Unity Pond watershed is 72 feet and town road width average 53 feet. When multiplied by the average road width, public roads cover 421 acres in the direct watershed. Roads contribute an estimated 305 kg of TP to the direct watershed, which approximates 17.6% of the total phosphorus load.

Low-Density Residential Homes: GIS land use maps, aerial photos and ground-truthing were used to determine the extent of residential dwellings within the Unity Pond watershed. This land use is characterized by dispersed, low-density, single-family homes. Non-shoreline residential areas account for an estimated 450 acres and 6.4% of the total phosphorus load to Unity Pond.

Recreational – There are two non-shoreline (primarily) recreational land uses in the Unity Pond watershed. The Field of Dreams recreational facility in Unity comprises 10 hectares (24 acres), including a park and ball fields, and has approximately 500 feet of accessible shore frontage (Martin 2001). The facility has an underground sprinkler system and the fields and lawn area are fertilized each season. There is one golf course located on the western shore in Burnham, encompassing 208 acres, however the fairways are not fertilized (Dave Potter, personal communication). Recreational areas including the golf course comprise 62 acres of land in the watershed and an estimated 1.8% of the phosphorus load to Unity Pond.

Institutional— These areas include municipal buildings and churches which comprise only 6 acres of land and less than 1% of the total phosphorus load to Unity Pond.

Commercial development includes professional, service and retail stores. There is a total of 110 acres of commercial lands in the Unity Pond watershed. An estimated 4% (75 kg/yr.) of the total phosphorous load to Unity Pond derived from commercial sources.

Gravel Pits / Bare Land – GIS data indicates there are approximately 19 acres of bare land, most likely representing abandoned and/or working gravel pits. Water quality concerns associated with gravel pit operations include sedimentation of streams and potential ground water contamination (Martin 2001).

Overall, non-shoreline development accounts for 5.5% of the total land area and contributes about 30.5% of the total phosphorus load to Unity Pond.

Phosphorus Loading from Non-Developed Lands

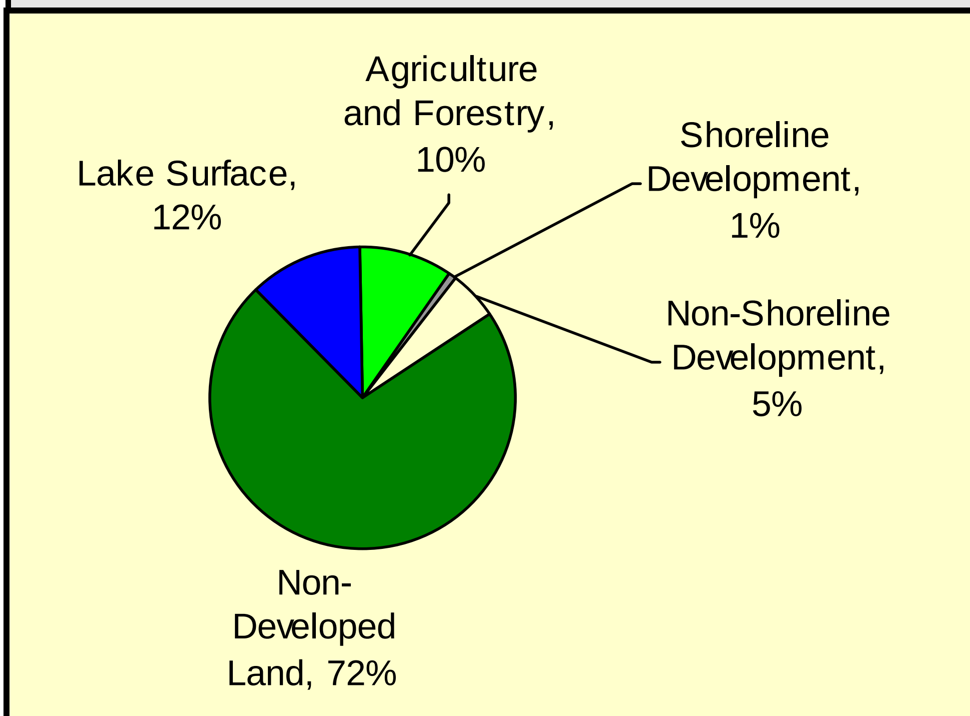
Forests: Of the total land area within the Unity Pond watershed, 10,809 acres are forested, characterized by privately-owned non-managed deciduous and mixed forest plots. Approximately 13.1% of the phosphorus load is estimated to be derived from non-commercial forested areas within Unity Pond's direct drainage area.

Other Non-Developed Land Areas: Combined wetlands, grassland/reverting fields and old field scrub shrub account for the remaining 20% of the land area and 4.9% of the total phosphorus export load.

Atmospheric Deposition (Open Water): Unity Pond surface waters (2,543 acres) comprise 12% of the total watershed area and account for an estimated 165 kg of total phosphorus, representing 9.5% of the total direct watershed load entering Unity Pond.

The lower total phosphorus loading coefficient chosen (0.16 kg/P/ha) is similar to that used for nearby central Maine lakes in Kennebec County, while the upper range (0.21 kg/P/ha) generally reflects a watershed that is 50 percent forested, combined with agricultural areas interspersed with urban/suburban land uses (Reckhow et al. 1980). **Figure 2** (below) depicts the percentage of total land area covered by each land use.

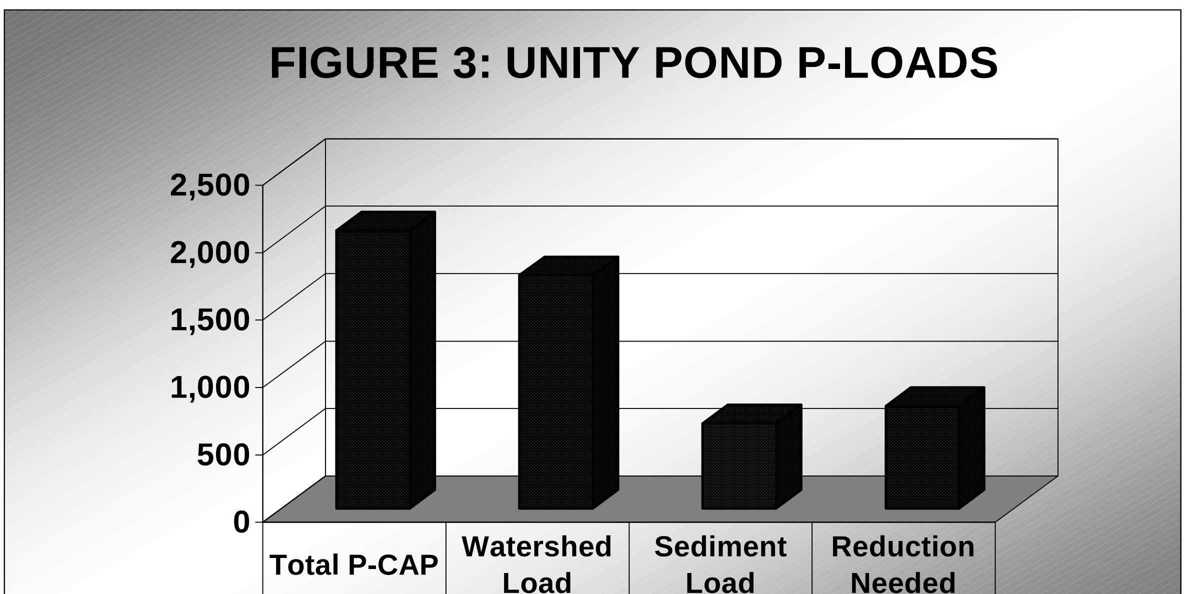
Figure 2: Unity Pond Direct Watershed - Total Land Area



PHOSPHORUS LOADS – Watershed, Sediment and In-Lake Capacity

Supporting documentation for the phosphorus loading analysis includes the following: 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).

- Total phosphorus loadings to Unity Pond originate from a combination of direct external (watershed) and internal (pond sediment) sources. External (direct) watershed TP sources, totalling 1,728 kg annually have been identified and accounted for by land use.
- Total phosphorus loading from the associated upstream Carlton Bog (Pond) accounts for external loading from the indirect watershed of 542 kg annually, determined on the basis of (*flushing rate = 19) x (volume = 1.5) x (TP concentration = 19),* and typical area gauged stream flow calculations.
- The contribution of bottom sediment sources of total phosphorus within Unity Pond range from 293 kg (1991) to 829 kg (2000), with an average annual value of 630 kg.
- The annual contribution to account for future development for Unity Pond is 69 kg.
- The load allocation (lake assimilative capacity) for all existing and future non-point pollution sources for Unity Pond is 2,060 kg of total phosphorus per year, based on a non-algal bloom target goal of 15 ppb.
- A change of 1 ppb in phosphorus concentration in Unity Pond is equivalent to 138 kg. The difference between the target goal of 15 ppb and the average summertime total phosphorus concentration (20 ppb) is 5 x 138 or 690 kg.
- Given a 69 kg allocation for future development (0.5 x 138), the total amount of phosphorus needed to be reduced to maintain water quality standards in Unity Pond is estimated to be 759 kg (690 + 69).



	Total P-CAP	Watershed Load	Sediment Load	Reduction Needed
Series1	2,060	1,728	630	759

UNITY POND (Lake Winnecook)

<u>PHOSPHORUS CONTROL ACTION PLAN</u>

Recent and Current NPS/BMP Efforts

Responding to water quality concerns, the USDA Natural Resources Conservation Service (NRCS), University of Maine Cooperative Extension (UMCE), Unity College, and watershed landowners contributed considerable time, resources, and funds to mitigate agricultural and other nonpoint pollution sources which have impacted water quality in Unity Pond and its tributaries. In 1991, the Waldo County Soil & Water Conservation District (SWCD) and the University of Maine Cooperative Extension received a US EPA 319 grant to fund the implementation of agricultural BMPs and camp road improvement projects to curb the nutrient load to Unity Pond. The project was quite successful in that nearly all of the farms cooperated and the water quality data that was collected to gage effectiveness showed positive indications for improvement (WC NRCS, personal communication).

University of Maine's Cooperative Extension Service expanded its Watershed Stewards program to include Lake Winnecook. This service provided training to members of FOLW, college students and members of the community. The new "watershed stewards" then conducted a watershed survey in 2001. The watershed survey culminated in a Day of Service—completing 16 erosion control projects by more than 200 members of the community and Unity College.

Unity College Lake Winnecook Service-Learning projects for the years of 2000-2002 included implementation of BMPs addressing identified impact sites in the Unity Pond and Sandy Stream drainages. Projects completed include upgrading/maintaining selected public boat launches, rip-rapping of selected road sites and construction of water bars on camp roads.

The Maine Forest Service (MFS) maintains an ongoing partnership with the Sustainable Forestry Initiative, Certified Logger Program and Master Logger Program in providing certification and recertification training specifically geared towards water quality BMPs for forest harvest operations. The MFS also recently established "WoodsWISE," a forest stewardship cost share program to provide funds for forest land erosion control system design and layout; mitigation of pre-existing erosion problems; stream crossing structure installation / stabilization; and riparian forest buffer planting. Finally, the MFS's Project Canopy Program offers grant opportunities for community plantings within riparian areas.

In January of 2004, the Waldo County Soil and Water Conservation District hired a project coordinator for a two-year Unity Pond Watershed Restoration Project. This project seeks to implement Best Management Practices at priority NPS pollution sites and educate landowners about NPS pollution, among other things. Recently, an EPA 319 Grant was awarded to fund the completion of a watershed survey in the lower section of Sandy Stream, which includes downtown Unity, and a grant from the MBNA Corporation will fund a water quality monitoring program and shoreline buffer installations. In August 2004, a manure storage facility will be installed in the northern section of the watershed. Given these recent accomplishments, the desired outcome of the Unity Pond Restoration Project to build momentum for long-term stewardship in the region is well underway.

Unity Pond Watershed History

Unity Pond has an extensive and documented history of human impact dating back to the late 1700's. European settlers, arriving in 1785, cleared much of the vast virgin white pine forests that characterized the area. One Unity historian claimed some white pine stumps were large enough to serve as a turn-around for a team of oxen. By the early 1800's Carlton Stream, Bithers Brook and Sandy Stream all supported numerous sawmills. These tributaries also served to transport the industry's logs, which were driven through Unity Pond to the Twenty-Five Mile Stream outlet to the Sebasticook River and into the Kennebec River Drainage in Winslow. Deforestation soon led to the forced closure of most sawmills supported in the Unity Pond drainage. Only a few mills remained in operation by 1830, on both Bithers Brook and Sandy Stream (Huard 2001).

Permanent settlers arrived and burned remaining less valued forests in preparation for agricultural use. Farming was extensive on the lakeshore and occurred throughout the Unity Pond, Carlton and Sandy Stream watersheds, with the exception of boggy areas. These practices continued in the area for approximately 150 years. Subsistence agriculture declined after World War II while commercial dairies and poultry production increased until about 20 years ago (Huard 2001).

Along with the demand for agricultural products, the Maine Railroad posted monies to secure rights to laying tracks from Burnham to Belfast. Starting in Burnham in the spring of 1870 the Maine Railroad erected the train trestle on the southwest shore near the Twenty-Five Mile Stream outlet (Pat Clark, personal communication). The construction of the train trestle in 1870 and the development of a wetland area have altered the natural flow of Unity Pond's outlet, Twenty-Five Mile and Sandy streams (Martin 2001).

In the early 1920's agricultural advances increasing local crop productivity brought industry to the area through the establishment of several canneries and a creamery. In Unity a cannery was constructed less than one mile from the south shore of Unity Pond. The seasonal plant processed and packed peas, beans and carrots during the months of July and August and disposed of effluent through an underground conduit pipe directly into the lake at the south shore. The Unity pea cannery began operations in 1923 and it is estimated that 2500m^3 per day of effluent was discharged until its closing in 1954 (Huard 2001).

A former cannery site was leased to Thorndike Press in the 1980's. In the mid 1990's employees complained of a continuous foul odor rising through the floor. Investigation exposed raw sewage under the building and it was determined that the septic system had inadvertently been connected to the cannery discharge conduit pipe, rather than the town utilities sewage system. In 2000, a FOLW member setting buoys on Unity Pond, located and identified the discharge conduit pipe by observing a plume entering the lake near the Field of Dreams Recreational Center in downtown Unity (Dave Potter, personal conversation).

A blueberry canning factory was established in Freedom on Sandy Stream in the 1920's and remained in operation until 1967. Sandy Stream continued to support a sawmill producing broomstick handles and toothpicks, which closed in the early 1940's and one tannery was in operation until the late 1940's. These industries discharged waste directly into Sandy Stream. Life long residents of Freedom and former employees of the tannery, mill and cannery describe sweeping and/or rinsing industry wastes directly into Sandy Stream. In order to handle the volume of discharge, wooden sluice dams were constructed along the stream and at the Freedom Pond outlet to regulate pond and stream water levels to assist in flushing the accumulated industry effluents and organic wastes from plant sites (Louise Mailloux, personal communication).

In 1932 the Constable Egg Hatchery of Waldo County was established on Quaker Hill Road in Unity. The poultry hatchery produced 30,000 chicks/week in 1948 and by 1953 production had increased to 700,000 hatched/week. The hatchery relocated to Belfast Maine in the early 1960's when production rates were 500,000 hatched/week. The Unity College campus now occupies the former Constable Egg Hatchery site (Pat Clark, personal conversation).

The 1940's are marked by the decline and abandonment of small shoreline farms, which encouraged camp development. Prior to 1940 approximately 70 residences, mostly seasonal camps, were located on the Unity Pond shore, compared to the estimated 500 year round and seasonal dwellings that are located within a ring of roads that encircle the lake today (Huard 2001).

In 1946 the towns of Unity, Troy and Thorndike established a site for the cooperative disposal of household waste for the three towns. The open style landfill was situated on the Dump Road in proximity to the north fork and floodplain of Halfmoon Stream in the Sandy Stream drainage. The Unity Waste Disposal Site underwent official closure procedures with the Maine Department of Environmental protection in the 1990's (Cinnamon 1994).

According to historical records water quality in Unity Pond has deteriorated due to cultural eutrophication (domestic and industrial wastes). Dating back to the 1930's, an oxygen deficiency in the bottom waters had prevented a cold-water fishery from being established. The blame was largely held on the discharge from the pea factory and after its closing water quality was noted as to have improved and a cold water fishery was introduced. However, due to a continued lack of oxygen in the bottom waters and the annual algal blooms, a salmon and trout fishery has never been established (Rabeni 1974). Although point source pollution contributors have since been removed, non-point source pollution continues to affect the water quality of Unity Pond.

The Friends of Lake Winnecook (FOLW) was formed in 1987 by a group of concerned citizens to "preserve, enhance and protect the beauty of Lake Winnecook and its adjacent area". The FOLW have approximately 60 to 100 members at any one time. Unity College began to work collaboratively with the FOLW in 1997 to incorporate a service-learning curricula for several classes that could enhance the FOLW's lake restoration efforts. The service-learning project focuses on improving local watershed health by offering services to various watershed entities, including the lake association, state resource management agencies and other community education entities. The service-learning project includes environmental monitoring, environmental research projects, educational outreach, development of outreach tools, research and interpretation of land use changes in the watershed, and studies of impacts that poor water quality has on the local economy and tax base.

Recommendations for Future Work

Unity Pond is a waterbody that has impaired water quality due mostly to nonpoint source (NPS) pollution and resultant internal sediment recycling of phosphorus. Specific recommendations regarding recent and current efforts in the watershed, Best Management Practices (BMPs), and actions to reduce external watershed total phosphorus loadings in order to improve water quality conditions in Unity Pond are as follows:

Watershed Management: Many different organizations (i.e., Unity College, FOLW, Maine DEP, UMCE, USDA-NRCS, WC-SWCD) have been involved in the restoration of Unity Pond's water quality . In January of 2004, the Waldo County SWCD hired a two-year Project Coordinator for the Unity Pond Watershed Restoration Project. It will be important to coordinate existing information about the past and present restoration projects that have been undertaken in order for the Coordinator and other interested organizations to adequately assess future NPS BMP needs in the watershed.

Action Item # 1: Coordinate Existing Watershed Management Efforts		
Activity	**Participants**	**Schedule & Cost**
Develop a Unity Pond Leadership Team	FOLW, WC-SWCD, Unity College, Maine DEP, UMCE, municipalities, and interested watershed citizens	Annual Roundtable Meetings beginning in 2004—**minimal cost**

Shoreline Residential areas have the potential to negatively impact the lake's water quality. According to a Unity College/Maine DEP shoreline survey conducted in 2002, there are 286 shoreline dwellings. The survey identified 193 dwellings (or 68%) as having inadequate or nonexistent vegetated buffers. The survey also noted that 63% of shoreline dwellings are situated less than 50' from the lake. With so many homes in close proximity to the water's edge, it is critical that adequate, effective buffers are in place in order to decrease and slow run-off from shore land sites. Also noteworthy was the presence of bare and/or eroding soil, observed on about half of all shoreline lots. The cumulative impact of these problematic residential sites can significantly add to existing phosphorus levels in Unity Pond.

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 Waldo County SWCD (338-1964 ext 2).

Action Item # 2: Educate Watershed Citizens About Shoreline Buffers		
Activity	**Participants**	**Schedule & Cost**
Develop a Buffer Awareness Campaign for Watershed Citizens	FOLW, WC-SWCD, Unity College, Maine DEP, UMCE, municipalities, watershed citizens	Begin immediately—$1,500/year

Roadways: Many are not designed and maintained properly and can be a major source of erosion and sedimentation to the lake. Unity Pond stakeholders should consider utilizing existing watershed survey results to target roads for BMP installation. The 2000 Unity Pond Watershed Stewards Survey Summary Information, conducted by University of Maine Cooperative Extension, identified 4 problem sites on state roads and 24 problem sites on town roads in the Unity Pond watershed. There were 20 miles of camp and private road surveyed which identified 46 problem sites. The 2001 Unity Pond Watershed Survey (Unity College) identified 4 sites on state roads, 9 sites on town roads and 2 sites on private roads along the perimeter of the direct Unity Pond drainage and includes sites in the Sandy Stream sub- drainage (Martin 2001).

Action Item # 3: Implement Roadway Best Management Practices		
Activity	**Participants**	**Schedule & Cost**
Continue to Implement Roadside BMPs watershed-wide	WC-SWCD, FOLW, Maine DEP, watershed road associations	Annually beginning in 2004 **$20,000/yr**

Agricultural and Forestry: A limited number of sites have been identified through the FOLW/ UMCE survey conducted in 2000. BMP recommendations for agricultural and forestry land uses include providing education on conservation practices and planning, as available, from the Waldo County Soil and Water Conservation District and Natural Resources Conservation Service offices located in Waldo County. For free technical assistance, potential cost-share funds or for more information about proper agricultural BMPs, contact the WCSWCD or NRCS offices in Waldo County.

Landowners, loggers and foresters working within the watershed should contact the Maine Forest Service (1-800-367-0223) for a copy of Forestry BMP guidelines (*Best Management Practices for Forestry: Protecting Maine's Water Quality*) and other forest management assistance. Special attention should be given to forest access roads and proper erosion control measures should be utilized. The MFS also provides water quality BMP training for forest harvest operations along with a cost share program for a variety of forestry management activities specifically related to water quality.

Action Item # 4: Conduct Workshops for Agriculture and Forestry Operators		
Activity	**Participants**	**Schedule & Cost**
Conduct workshops encouraging the use of phosphorus control measures	WC-SWCD, NRCS, MFS, forestry and agriculture community	Annually beginning in 2004 **$1,000/yr**

Non-Shoreline Residential and Commercial properties should also be considered as potential problem areas, especially areas adjacent to Unity Pond watershed brooks and streams. It was noted during field observations by UC staff that residences that are not located on the immediate shoreline are likely to be significant contributors of phosphorus to the lake. This is partly due to the clustering of many house lots located on private roads 100 – 1000 feet away from Unity Pond.

Action Item # 5: Develop Stewardship Initiatives for Unity Pond Tributaries		
Activity	**Participants**	**Schedule & Cost**
"Adopt" local streams to promote stewardship efforts including education and water quality monitoring	FOLW, WC-SWCD, Maine DEP Stream Team, local schools, golf course, and watershed citizens	Annually beginning in 2004 **$2,500/yr**

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 Unity Pond. While Unity Pond 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 Unity Pond which are sited in coarse, sandy 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.

Recommendations for reducing existing phosphorus inputs to lakes include seeking replacement of pre-Plumbing Code septic systems and other poorly functioning systems within the shoreland zone of Unity Pond. Identification of potential problem systems can be accomplished through town records and sanitary surveys. 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. In some cases, a revolving loan fund could be established to assist in the replacement of malfunctioning septic systems. Above all, educational efforts should make residents aware of impending problems and possible cost-effective solutions.

Action Item # 6: Expand Homeowner Education & Technical Assistance Programs		
Activity	**Participants**	**Schedule & Cost**
Increase outreach and education efforts to watershed citizens including technical assistance to landowners	FOLW, WC-SWCD, WPA	Annually beginning in 2004 **$7,500/yr includes printing of educational materials**

Individual Action: All watershed residents should be encouraged through continued education and outreach efforts, including: retention or planting of natural vegetation of buffer strips, use of non-phosphate cleaning detergents, elimination of phosphorus-containing fertilizers, adequate maintenance of septic systems.

Municipal Action: Should include ensuring public compliance with local and state water quality laws and ordinances (Shoreland Zoning, Erosion and Sedimentation Control Law, plumbing code) through education and enforcement action, when necessary.

WATER QUALITY MONITORING PLAN

Historically, the water quality of Unity Pond has been monitored via measures of Secchi disk transparencies during the open water months since 1977 (Maine DEP and VLMP). Continued long-term water quality monitoring of Unity Pond will be conducted monthly, from May to October, through the continued efforts of Maine DEP and VLMP. 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 Unity Pond. A post-TMDL adaptive management status report will be prepared five to ten years following EPA approval.

PCAP CLOSING STATEMENT

The Waldo County Soil and Water Conservation District (WC-SWCD), in cooperation with lake stakeholders, have worked diligently since the early to mid-1990's addressing nonpoint source pollution in the watershed of Unity Pond. Technical assistance by WC-SWCD is available to all watershed towns to mitigate phosphorus export from existing NPS pollution sources and to prevent excess loading from future sources through stakeholders' technical advice to local planning boards. It is critical that Unity Pond watershed towns recognize the value of their water resources and its link to the local way of life in the respective communities as well as the local economies by providing strong support to lake restoration and protection efforts. These towns should be asked for their continued support of and cooperation with WC-SWCD and the FOLW in the pursuit of regional lake protection and improvement. This teamwork approach by regional and local groups, in conjunction with the continued water quality protection efforts of WC-SWCD, FOLW, Unity College, University of Maine Cooperative Extension, and other partners lends a high probability that NPS awareness and NPS-BMP implementation within the watershed will increase in future years.

APPENDICES

UNITY POND (Lake Winnecook)

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.' 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.

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 (Kennebec County).

The first Maine lake TMDL was developed (1995) for Cobbossee Lake by the Cobbossee Watershed District (CWD) - under contract with Maine DEP and US-EPA. TMDLs have been approved by US-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 and Pleasant Pond (under contract with CWD), Sabattus and Toothaker ponds. 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 (SWCDs) - for Upper Narrows Pond and Little Cobbossee Lake (under contract with CWD), Togus, Lovejoy, and Duckpuddle ponds, and Long Lake (Bridgton - with assistance from Lakes Environmental Association). PCAP-TMDL studies have also been initiated for Lilly, Hermon-Hammond, and Sewall ponds, as well as two of the remaining seven 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 (287-7649).

Water Quality Monitoring: (Source: Maine DEP and VLMP 2002) Water quality monitoring data for Unity Pond (station 1, deep hole) has been collected annually since 1986, and for the years 1977-78, 1981, and 1983. Hence, this present water quality assessment is based on 22 years of Secchi disk transparency (SDT) measures, combined with 13 years of epilimnion core total phosphorus (TP) data, 11 years of water chemistry and 14 years of chlorophyll-a monitoring data. In addition, the internal sediment load calculation was based on two years of intensive water column bi-meter profile sampling (2000-2002). Water quality data from a second station was collected only in 1978 (SDT 4.4 - 4.5 meters) and 2000-2002 (SDT 0.9-3.3 meters).

Water Quality Measures: (Source: Maine DEP and VLMP 2003) Historically, Unity Pond has a range of SDT measures from 0.9 to 6.1 meters, with an average of 2.5 m; an epilimnion core TP range of 12 to 30 with an average of 21 parts per billion (ppb), and chlorophyll-a measures ranging from 3 to 41, with an average of 14.8 ppb. Recent dissolved oxygen (DO) profiles indicate moderately low levels of DO in deep areas of the lake. Late summer dissolved oxygen levels in 2001 and 2002 remained fairly low (0-4 ppm) with 50% of the water column (lower 6 meters) unsuitable for salmonid species (e.g., brown trout). The potential for total phosphorus to leave the bottom sediments and become available to algae in the water column (internal loading) is moderate (Maine DEP 2001).

Priority Ranking, Pollutant of Concern and Algae Bloom History: Unity Pond is listed on the State's 1998 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 stakeholder interest and need to complete an accelerated approach to lakes TMDL development. The Unity Pond TMDL has been developed for total phosphorus, the major limiting nutrient to algae growth in freshwater lakes in Maine.

The water quality of Unity Pond during the summers of 2001-02 appear to be unimproved in contrast to 2000 and the preceding 18 years of record. Minimum transparencies dropped to 1.0 meters (1.8 average) and total phosphorus (30 ppb) and chlorophyll-a (mean 31.3 ppb) levels remained fairly high. On the basis of measured water transparencies below 2 meters in the summertime, nuisance algae blooms were prevalent during 15 of the last 16 years, with only a suitable low measure of 2.2 meters observed in the summer of 1988. Prior to this (1977-1986), the SDT was much more acceptable, ranging from 2.5 to 4.3 meters (average 3-4 meters). Estimates of total phosphorus export from different land uses found in the Unity Pond direct watershed are presented in Table 2 and 4.

Total phosphorus loading from the associated upstream Carlton Pond (542 kg/TP/yr) and the Sandy Stream drainage system (during high flows) accounts for loading from the indirect watershed), determined on the basis of flushing rate x volume x TP concentration, and typical area gauged streamflow calculations (Jeff Dennis, personal communication).

Natural Environmental Background levels for Unity Pond 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 non-point source loading, it is very difficult to separate natural background from the total non-point source load (US-EPA 1999). There are no known point sources of pollutants to Unity Pond.

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. Unity Pond is a lightly colored lake (average color 33 SPUs), with relatively high late summer minimal SDT readings (annual average of 2.5 meters), in association with moderate/high chlorophyll a levels (15.1 ppb annual average). Currently, Unity Pond does not meet water quality standards due to a significant decline in water transparency trends over time, combined with monitored annual summertime hypolimnetic dissolved oxygen deficiencies. This water quality assessment uses historic documented conditions as the primary basis for comparison.

Designated Uses and Antidegradation Policy: Unity Pond 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 Unity Pond is set at 15 ppb total phosphorus (2,060 kg TP/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 April - early May) total phosphorus levels in Unity Pond historically approximated 15 - 17 ppb during the time period 1977-1989, and generally maintained these levels in the earlier years (1977-1986). In contrast, during 1987-1989, in-lake (epilimnion core) total phosphorus summer-time (June through August) measures averaged 26 ppb (algal bloom conditions). Since then, springtime (pre-stratification) total phosphorus measures range from 18-22 ppb, while late summer measures range from 22-34 ppb.

In summary, the numeric water quality target goal of 15 ppb for total phosphorus in Unity Pond was based on available late spring - early summer pre water column stratification data, 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 Unity Pond watershed. The key below explains the columns and the narrative that follows the table (pages 33-34) relative to each of the representative land use classes.

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, aerial photography, Delorme Topo USA software, and field reconnaissance.

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

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

TP Coeff. Value kg TP/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 (BMP's) installed.

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

TP Export Load kg P: Total hectares x applicable total phosphorus coefficient

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

Table 3. UNITY Pond Direct Watershed - Estimated Phosphorus Export by Land Use Class

LAND USE CATEGORY	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	GIS Adjusted* kg TP	TP Export Total %
Operated Forestland								
Operated Forest	541	2.6%	0.3-0.7	0.40	219	87	111	6.4%
Tree Farms / Orchards	63	0.3%	0.4-0.7	0.40	25	10	12	0.7%
Sub-Totals	**604**	**2.9%**			**244**	**98**	**123**	**7.1%**
Agricultural Land								
Row Crops/Tillage/Corn	172	0.8%	0.8-3.8	1.50	70	104	107	6.2%
Hayland - Non-Manured	1,068	5.1%	0.2-1.1	0.20	432	86	106	6.1%
Pasture (grazed Meadows)	155	0.7%	0.6-1.4	0.81	63	51	62	3.6%
Hayland - Manured	63	0.3%	0.5-2.6	0.65	25	16	20	1.2%
Mixed Agriculture	7	0.0%	0.9-1.4	0.91	3	3	3	0.1%
Sub-Totals	**1,465**	**7.0%**			**592**	**261**	**297**	**17.2%**
Shoreline Development								
Residential Septic Systems	**UNITY POND SEPTIC SYSTEM MODEL**						182	10.5%
Shoreline Medium Density Residential	138	0.7%	0.7-1.7	1.00	56	56	63	3.7%
Shoreline Roads	30	0.1%	2.8-6.8	4.00	12	49	56	3.3%
Shoreline Recreational	3	0.01%	0.4-0.8	0.50	1	1	4	0.2%
Sub-Totals	**171**	**0.8%**			**69**	**106**	**305**	**17.7%**
Non-Shoreline Development								
Roads	421	2.0%	1.1-2.5	1.50	170	255	305	17.6%
Low Density Residential	450	2.2%	0.4-0.8	0.50	182	91	110	6.4%
Commercial-Industrial	110	0.5%	1.1-2.5	1.50	44	66	75	4.4%
Golf Courses	28	0.1%	1.1-2.1	1.50	11	17	19	1.1%
Parks, Cemetaries	34	0.2%	0.6-1.2	0.80	14	11	12	0.7%
Institutional	6	0.0%	1.4-2.3	1.50	3	4	5	0.3%
Gravel Pits / Bare Land	19	0.1%	-	0.00	8	0	0	0.0%
Unknown	80	0.4%	-	-	32	-	0	0.0%
Sub-Totals	**1,148**	**5.5%**			**464**	**444**	**526**	**30.5%**
Total: DEVELOPED LAND	**3,388**	**16.2%**			**1,369**	**908**	**1,251**	**72.4%**
Non-Developed Land								
Undisturbed/Unmanaged Forest	10,809	51.6%	0-0.1	0.04	4,367	175	227	13.1%
Grassland	812	3.9%	0.1-0.3	0.20	328	66	80	4.6%
Scrub Shrub	95	0.5%	0.1-0.2	0.10	38	4	4	0.3%
Wetland	3,298	15.7%	-	0.00	1,332	0	0	0.0%
Total: NON-DEVELOPED Land	**15,013**	**71.7%**			**6,065**	**244**	**311**	**18.0%**
Total: Surface Water (Atmospheric)	**2,543**	**12.1%**	0.11 - 0.21	0.16	**1,029**	**165**	**165**	**9.5%**
TOTAL: DIRECT WATERSHED	**20,944**	**100%**			**8,463**	**1,317**	**1,728**	**100%**

Estimates of total phosphorus exported from different land uses found in the Unity Pond watershed are presented in Table 3 and represent the current extent of external phosphorus loading to the lake basin. TP loads from associated waterbodies (e.g. Carlton Bog drainage and Sandy Stream sub-drainage) are accounted for on the basis of flushing rate volume x TP concentration. TP-loading measures are expressed as a range of values to reflect the degree of uncertainty generally associated with such relative estimates (Walker 2001). The watershed total phosphorus loadings were primarily determined using literature-derived export coefficients as found in Schroeder (1979), Reckhow et al. (1980), Maine DEP (1981 and 1989), Dennis (1986), Dennis et al. (1992), and Bouchard et al. (1995) for low and high density residential properties, roadways, and other types of developments (recreational, commercial, agricultural and timber harvesting) - taking into account the overall prevalence of sandy, well-drained soils, which generally have low phosphorus retention capabilities.

Total Phosphorus Land Use Loads

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 loadings 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 (e.g., recreational, commercial).

In some cases (primarily roads and shoreline residential) selected phosphorus loading coefficients were reduced to account for the estimated bioavailability of the soil runoff sources according to available literature (Lee et al. 1980 and Sonzogni et al. 1982) and to better account for algal available-P export values as reflected in Dennis et al. (1992). These adjustments accounted not only for the readily available SRP (soluble-reactive-phosphorus) in the runoff, but also a substantial portion of the particulate inorganic component, particularly the P which is weakly adsorbed on the surface of soil particles (relative to discussion in Chapra 1997, pg. 524). **Note:** *These adjustments in P-load coefficients did not effectively alter the overall conclusions and final recommendations of the Unity Pond PCAP-TMDL report regarding identified needs and NPS/BMP implementation plans for the Unity Pond watershed.*

Agricultural and Forest Operational Lands: Phosphorus loading coefficients as applied to agricultural land uses were adopted, in part, from Reckhow et. al. 1980: manured hayland 0.65 kg TP/ha, pasture 0.81 kg TP/ha; and Dennis and Sage 1981: low-intensity hayland 0.20 kg TP/ha; and from past Maine DEP 1982 studies and discussions with Kennebec County SWCD/NRCS offices: row crops 1.50 kg TP/ha. The phosphorus loading coefficient applied to operated forestlands (0.40 kg TP/ha) was derived (best estimate) from the original Cobbossee Lake TMDL report (Monagle 1995).

Shoreline Residential Lots (House and Camp): To determine phosphorus loading estimates, each developed shoreline lot was mapped using GIS software, and verified by ground-truthing and aerial photography analysis. The range of phosphorus loading coefficients used (0.25 – 2.70 kg ha/yr) were developed using information on residential lot stormwater export of algal available phosphorus as derived from Dennis et al (1992).

Private Camp Roads: The total phosphorus loading coefficient for private camp roads (4.00 kg/ha) was chosen, in part, from previous studies of rural Maine highways (Dudley et al. 1997), as well as best professional judgment (Jeff Dennis, Maine DEP).

Non-Shoreline Development

Residential: Non-shoreline residential areas in the watershed are best characterized as low density residential - reflected in the 0.50 TP loading coefficient.

Golf Courses: The total phosphorus loading coefficient (1.50 kg TP/ha) applied to the golf course area takes into account the limited use of fertilizer used as well as proximity to the resource and the area drained with direct flow to the lake.

Public Roadways: Town and state roadways (170 ha) were assigned a total phosphorus loading rate of 1.50 kg per hectare per year. This coefficient was chosen, in part, from previous studies of rural Maine highways (Dudley et al. 1997).

Total Developed Lands Phosphorus Loading: A total of 75% (1,390 kg) of the total phosphorus loading to Unity Pond is estimated to have been derived from the cumulative effect of the preceding cultural land use classes: agriculture (297 kg) and forestry (261 kg); non-shoreline development (526 kg) and shoreline development (305 kg), including septic systems (182 kg) and camp/private roads (56 kg) – as depicted in Table 4.

Non-Developed Lands Phosphorus Loading: The phosphorus export coefficient for forested land (0.04) is based on a New England regional study (Likens et al 1977). The lower total phosphorus loading coefficient chosen for atmospheric deposition (0.16 kg TP/ha) is similar to that used for the China Lake TMDL (Kennebec County), while the upper range (0.21 kg TP/ha) generally reflects a watershed that is 50 percent forested, combined with agricultural areas interspersed with urban/suburban land uses (Reckhow et al. 1980). Other Non-Cultural Land Uses: Forested areas, combined wetlands, reverting fields, old field scrub shrub and open land account for 16% (298 kg) of the total phosphorus load entering Unity Pond.

Atmospheric Deposition (Open Water): Unity Pond surface waters (1,029 ha) comprise 12% of the total watershed area (9,505 ha) and account for an estimated 165 kg of total phosphorus, representing 9% of the total phosphorus load entering Unity Pond.

Phosphorus Load Summary

It is our professional opinion that the selected export coefficients are appropriate for the Unity Pond watershed. Results of the land use analysis indicate that a best estimate of the present total phosphorus loading from external (watershed generated) nonpoint source pollution approximates 1,728 kg TP/yr. This annual external watershed generated loading to Unity Pond equates to a total phosphorus loading modeled at 12.5 ppb (1,728 kg TP/year) - approximately 332 kg below the TMDL target goal of 15 ppb (2,060 kg TP/year). Obviously, both indirect (Carlton Pond = 542 kg) and internal (pond bottom sediments = 630 kg) sources of phosphorus are significant additional contributors to the existing nonpoint pollution related water quality problem in Unity Pond.

LINKING WATER QUALITY and POLLUTANT SOURCES

Assimilative Loading Capacity: The Unity Pond TMDL is expressed as an annual load as opposed to a daily load. As specified in 40 C.F.R. 130.2(i), TMDLs may be expressed in terms of either mass per unit time, toxicity, or other appropriate measures. It is thought appropriate and justifiable to express the Unity Pond TMDL as an annual load in part because the backflushing at the pond outlet, contributing factors associated with the Sandy Stream sub-drainage, and the lake basin has a relatively long hydraulic residence time (1.23 flushes per year), slightly less than the average flushing rate for Maine lakes of 1.50.

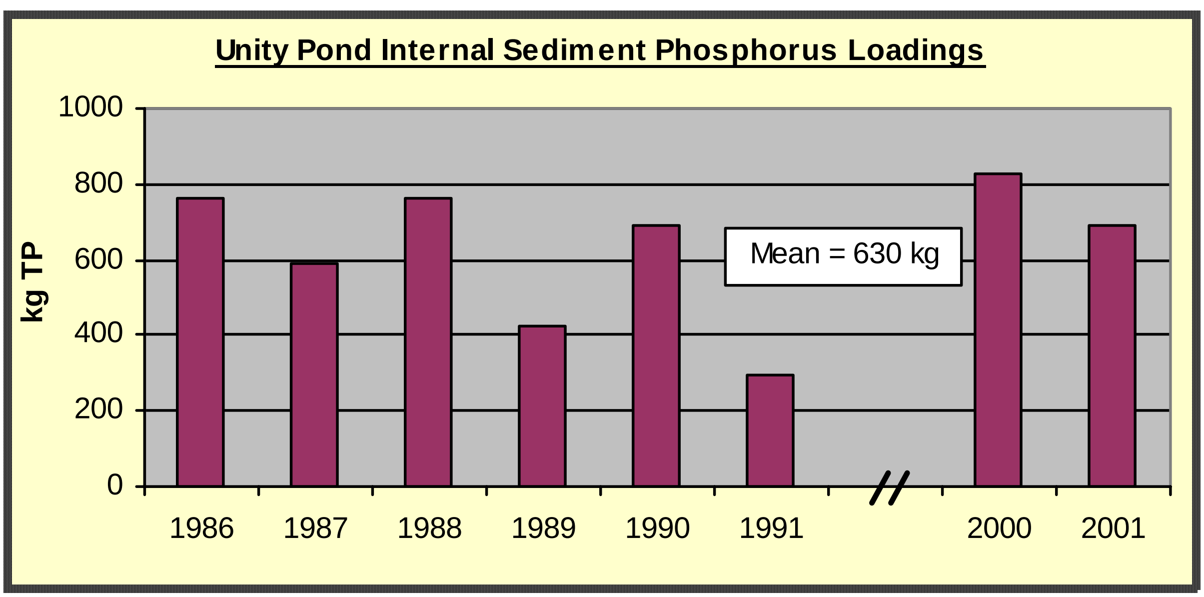
The Unity Pond basin lake assimilative capacity is capped at 2,060 kg TP/yr, as derived from the empirical phosphorus retention model based on a target goal of 15 ppb. This value reflects the modeled annual phosphorus loading responsible for current trophic state conditions, based on a long term goal of maintaining average phosphorus concentrations at or below 15 ppb.

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 Unity Pond watershed approximates 69 kg annually (0.5 x 1 ppb change in trophic state = 138 kg).

Undoubtedly, human growth will continue to occur in the Unity Pond watershed, contributing new sources of phosphorus to the lake. Hence, existing phosphorus source loads must be reduced by at least 69 kg to allow for anticipated new sources of phosphorus to Unity Pond.

Overall, the presence of nuisance algae blooms in Unity Pond may be reduced, along with halting the trend of increasing trophic state, if the existing combined phosphorus loading is reduced by approximately 759+ kg TP/yr. Reductions already underway in nonpoint source total phosphorus loadings are expected from the continued implementation of best management practices - primarily from improvements to roadways and residential shoreline vegetative buffer plantings (see NPS/BMP Implementation Plan and PCAP Summary).

Internal Lake Sediment Phosphorus Mass: The relative contribution of internal sources of total phosphorus within Unity Pond - 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 from 1986-1991 and 2000-2001, the only years for which adequate lake profile TP concentration measures were available to derive reliable estimates of internal lake mass. Given the relatively high levels of phosphorus in the water column and the presence of nuisance algae blooms, it was expected that internal sediment derived phosphorus mass would be a significant problem in Unity Pond.



Linking Pollutant Loading to a Numeric Target: The basin loading assimilative capacity for Unity Pond was set at 2,060 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 Unity Pond TMDL Analysis includes the following: Maine DEP and VLMP water quality monitoring data, and specification of a phosphorus retention model – including both empirical models and retention coefficients.

Total Phosphorus Retention Model (after Dillon and Rigler 1974 and others)

L = P (A z p) / (1-R) where,

2,060 = **L** = external total phosphorus load capacity (kg TP/year)
15.0 = **P** = spring overturn total phosphorus concentration (ppb)
10.21 = **A** = lake basin surface area (km^2)
5.80 = **z** = mean depth of lake basin (m) **A z p = 72.8**
1.23 = **p** = annual flushing rate (flushes/year)
0.53 = **1- R** = phosphorus retention coefficient, where:
0.47 = **R = 1 / (1+ sq.rt. p)** (Larsen and Mercier 1976)

Previous use of the Vollenwieder (Dillon and Rigler 1974) type empirical model for Maine lakes, e.g., Cobbossee, Madawaska, Sebasticook, East, China, Mousam, Highland, Webber, Threemile, Threecornered, Annabessacook, Pleasant, and Sabattus TMDLs (Maine DEP 2000-2004) 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 Unity Pond 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 (Vollenwieder 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 Unity Pond 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 Unity Pond equals 2,060 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 (averaging 1,728 kg annually) have been identified and accounted for in the land-use breakdown portrayed in Table 3. Further reductions in non-point source phosphorus loadings are expected from the continued implementation of NPS best management practices (see summary, pages 24 - 26). 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, and China Lake TMDLs), in-lake nutrient loadings in Unity Pond originate from a combination of direct and indirect external (watershed + Carlton Pond) and internal (lake sediment) sources of total phosphorus.

WASTE LOAD ALLOCATIONS (WLA's): There are no known existing point sources of pollution (including regulated storm-water sources) in the Unity Pond watershed, hence, the waste load allocation for all existing and future point sources is set at 0 (zero) kg/year of total phosphorus.

MARGIN OF SAFETY (MOS): An implicit margin of safety was incorporated into the Unity Pond TMDL through the conservative selection of the numeric water quality target, as well as the selection of relatively conservative phosphorus export loading coefficients for cultural pollution sources (Table 3). Based on both the Unity Pond historical records and a summary of statewide Maine lakes water quality data for non-colored (< 30 SPU) lakes - the target of 15 ppb (2,060 kg TP/yr in Unity Pond) represents a highly conservative goal to assure 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 statewide data base for uncolored Maine lakes indicate that summer nuisance algae blooms (growth of algae which causes Secchi disk transparency to be less than 2 meters) are more likely to occur at 18 ppb or above. The difference between the in-lake target of 15 ppb (2,060 kg) and 17 ppb (2,335 kg), or 275 kg, represents a 11.8 (12)% implicit margin of safety for Unity Pond. A non-quantified margin of safety for attainment of state water quality goals is additionally provided by the inherently conservative methods used by Maine DEP to estimate future growth in the Unity Pond watershed.

SEASONAL VARIATION: The Unity Pond 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 1.23 flushes/year, the average annual phosphorus loading is most critical to the water quality in Unity Pond. 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. Nonpoint source best management practices (BMPs) proposed for the Unity Pond watershed have been designed to address total phosphorus loading during all seasons.

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

1. Maine DEP and Unity Pond TMDL Project Leader, Dave Halliwell, and MACD resource specialist, Jeremy Martin, attended the FOLW annual meeting in the summer of 2000.
2. Maine DEP TMDL Project Leader, Dave Halliwell attended the FOLW annual 2001 meeting to discuss and distribute information explaining the TMDL process, and to address concerns and questions about the status of the Unity Pond TMDL.
3. Unity College TMDL Project Manager, Pamela Proulx-Curry attended the 2002 annual FOLW meeting to present the current status of the Unity Pond TMDL report and answered related questions.
4. On October 1, 2002, UC Project Manager Pamela Proulx-Curry and Unity Pond TMDL Specialist, Shawn Biello, attended FOLW Water and Habitat Quality Forum Organizational Meeting to present information regarding the Unity Pond TMDL.
5. Maine Association of Conservation District (MACD) staff compiled existing information provided in this report and ground-truthed the watershed to verify GIS mapping and met with Waldo County SWCD/NRCS to review agricultural data and incorporate their conservation projects into the model.
6. MACD staff (Fred Dillon) gave a presentation on the PCAP / TMDL process and the draft Unity Pond PCAP report at the Friends of Lake Winnecook annual meeting on August 4, 2004.

STAKEHOLDER AND PUBLIC REVIEW PROCESS and COMMENTS

A stakeholder review document (see below) was distributed electronically on July 22, 2004 (through August 5th, 2-week review period) to the following individuals that participated in the field work or development of the draft Unity Pond PCAP-TMDL report: Waldo County SWCD/NRCS staff (Randy Doak and Kym Sanderson); Rick Kersbergen (University of Maine Cooperative Extension), Roy Bouchard, Jeff Dennis, Barry Mower and Jessie Mae MacDougall (Maine DEP), Morten Moesswilde (Maine Forest Service), David Roque (Maine Department of Agriculture), Dave Potter, Pam Proulx-Curry and Shawn Biello (Unity College), Maine DIFW (Jim Lucas and Bill Woodward) and Maine DMR (Gail Wippelhauser).

Dear Unity Pond Stakeholders:

Attached is the **PRELIMINARY STAKEHOLDER** review draft of the Unity Pond Phosphorus Control Action Plan (PCAP) - Total Maximum Daily Load (TMDL) report prepared by Unity College, the Maine Association of Conservation Districts, and Maine Department of Environmental Protection. Please review the draft and, if necessary, respond by Wednesday, August 4. All comments will be reviewed and considered by the Maine DEP and the Maine Association of Conservation Districts. Individual responses to the preliminary draft review will not generally be provided; however, acceptable changes will be incorporated into the final public review document.
The final public review document of the Unity Pond PCAP-TMDL will be made available to the general public for the formal public review process during the week of August 4 for a four-week review period. Any public comments received during this time will be reviewed and appended to the final Unity Pond PCAP-TMDL report to be submitted to the EPA for their final review and approval. Please send all comments, in writing only, to Dave Halliwell at david.halliwell@maine.gov. or Maine Department of Environmental Protection, 17 State House Station, Augusta, ME 04330.

There were no responses/comments received during the stakeholder review period.

PUBLIC REVIEW PROCESS: The following statement was advertised in the *Kennebec Journal, Morning Sentinel, and Bangor Daily News* over a 2-weekend period (August 14-15 & 21-22, 2004):

> 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 for the **Unity Pond** (DEPLW 2004-0668) watershed, located within the towns of Unity, Burnham, Troy, and Thorndike . This **PCAP-TMDL** report identifies and provides best estimates of non-point source phosphorus loads for all representative land use classes in the **Unity Pond** 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 Central Offices in Augusta (Ray Building, Hospital Street - Route 9, Land & Water Bureau) or on-line: http://www.state.me.us/dep/blwq/comment.htm. Please send all comments, in writing - by September 6, 2004, to Dave Halliwell, Lakes TMDL Program Manager, Maine DEP, State House Station #17, Augusta, ME 04333. or e-mail: david.halliwell@maine.gov

There were no responses/comments received during the public review period.

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Alewife (*Alosa pseudoharengus*) Fact Sheet

Prepared by Dr. David Halliwell* Maine DEP, Aquatic Biologist, 15 May 2004

Fact 1 - Alewife can occur in fresh waters as either historically present/restored anadromous or stocked landlocked forms. The same can be said for several other 'freshwater' fish species (Atlantic salmon, rainbow smelt, and white perch).

Fact 2 - Generally speaking, landlocked and anadromous forms of fish are very different in terms of their behavior and ability to adapt to various aquatic habitats. Although landlocked alewives may move between waterbodies, the population no longer has an inherent ability to migrate to the sea. Conversely, an anadromous alewife does not have the inherent ability to survive and prosper in inland lakes and ponds. Some Individual fish may survive for a time, but are not capable of over-wintering, or completing their life cycle wholly in freshwater environments.

Fact 3 - The historical (pre-industrial or pre-dam) natural distribution of alewife in freshwaters is well documented by the Maine Department of Marine Resources and includes all waterways and waterbodies included in the current anadromous fish restoration program - representing all three Maine-New England native and indigenous *Alosine*- type fishes (alewife, blueback herring, and American shad).

Fact 4 - Anadromous fish populations, including alewife, are indigenous species which were historically an integral part of the freshwater ecosystem to which they are currently being restored. The trophic status of many of these waterbodies have become increasingly eutrophic over the past century. Given the inherent capacity of anadromous alewives for entrance and departure from natal lakes and ponds are not interfered with (beaver dams, inadequate flow levels), then the lake water quality impact of their temporary presence should not be a problem.

Fact 5 - If for any reason (e.g., beaver dams, extended drought, dam regulation, inadequate fish passage) adult post-spawning anadromous alewives are not able to effectively exit from a given waterbody - then they will not survive, but will fall prey to avian and mammalian predators and/or scavengers and ultimately could be an additional source of nutrients to the aquatic ecosystem in which they occur.

***Critically reviewed by Jim Stahlnecker, Barry Mower, and Dana Murch (Maine DEP).**