

# LILY POND WATER QUALITY (1979-2021)

*Rockport Conservation Commission Report*

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## Introduction

In the early 1900s, Lily Pond was widely known for the clarity of its water and the quality of ice cut in winter and stored for shipment south in the summer. Marked deterioration in water quality by the 1970's, however, raised concerns locally and at the Maine Department of Environmental Protection (MDEP). This eventually resulted in the issuance of the Phosphorus Control Plan and Total Maximum Daily (Annual Phosphorus) Load Report<sup>1</sup>. The report (1) identified elevated phosphorus concentrations as the cause of observed declines in water quality, which included excessive chlorophyll concentrations and reduced water clarity; (2) set a target total phosphorus concentration of 15 ugP/L; and (3) recommended a number of management actions for reaching that target. The latter included reducing the inputs of phosphorus from two sources – riparian landuse activities at Aldermere Farm and runoff of nutrient-rich landfill leachate from the former Jacob's Quarry.

## Data Sources

MDEP conducted water quality monitoring efforts from 1979 to 2008 as a means to better describe water quality conditions and identify potential trends. These efforts included measurements of water clarity (i.e., Secchi disk depth), water temperature and dissolved oxygen concentration, as well as the collection of water samples for laboratory analyses for total phosphorus and chlorophyll. Water samples were collected either from the surface, at selected depths throughout the water column or using a tube to collect an integrated or core sample from the upper mixed layer (referred to as the epilimnion).

The Rockport Conservation Commission (RCC) has conducted monitoring efforts since 2013, collecting much of the same type of information that was collected earlier by the MDEP<sup>2</sup>. Most recently (2018 to present), Lake Stewards of Maine (LSM) local volunteer George Haselton has been measuring water clarity weekly or biweekly during June through September. He also collects 3-4 water samples from the surface during this period for determining total phosphorus concentration<sup>3</sup>.

## Implementation of Best Management Practices (BMPs) at Aldermere Farm

Aldermere Farm (AF), a working farm operated by the Maine Coastal Heritage Trust (MCHT), is located on 136 acres in northeast Rockport. The property includes wood lots, hay grounds and grazing pastures

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<sup>1</sup> Phosphorus Control Plan and Total Maximum Daily (Annual Phosphorus) Load Report; Lilly Pond - Rockport and Camden, Knox County, Maine. Maine Department of Environmental Protection and Maine Association of Conservation Districts. Corrected - Final EPA Document (26 March 2008). Available online at [https://www1.maine.gov/dyep/water/monitoring/tmdl/2008/lillypond\\_rep.pdf](https://www1.maine.gov/dyep/water/monitoring/tmdl/2008/lillypond_rep.pdf)

<sup>2</sup> Chemical analyses performed by the Nutrient Analytical Services Laboratory, University of Maryland.

<sup>3</sup> Analyses performed by the Maine Health and Environmental Testing Laboratory.

for the farm’s Belted Galloway herd, which ranges from 75 to 100 head depending on season. Only 14.8 acres of the land dedicated to grazing are within the Lily Pond watershed; of these, 8.7 acres are riparian to Lily Pond. The remaining areas drain either to Rockport Harbor or directly to Penobscot Bay. Recognizing the potential for impacts to Lily Pond from AF operations, the MCHT staff consulted State agencies for assistance in establishing Best Management Practices designed to reduce impacts to Lily Pond.

**Table 1. Timeline of relevant activities and the implementation of Best Management Practices at Aldermere Farm<sup>4</sup>.**

Year	Event	Comments
2000	MCHT staff consult with Maine Department of Inland Fisheries and Wildlife	Gathered/reviewed existing water quality data for Lily Pond as related to AF operations and practices.
	MCHT staff meet with the NPS Program Coordinator, Watershed Management Division, Bureau of Land & Water Quality, Maine Department of Environmental Protection (MDEP) and Maine Department of Agriculture, Conservation and Forestry (DACF)	Existing management practices at AF were reviewed and a general management plan for AF was developed
		Based on MDEP and DACF input, a variety of projects were completed, including: <ul style="list-style-type: none"> <li>Fencing around a pasture abutting Lily Pond was rebuilt to eliminate a 1-acre area popular with the cattle and having high potential for runoff.</li> <li>Selected areas that were previously hay ground and not in the Lily Pond watershed were converted to grazing pasture as a means to reduce grazing impacts and associated runoff from more vulnerable areas in the pond’s watershed.</li> </ul>
2001	Nutrient Management Plan specifically for managing agricultural lands cared for by AF staff developed and implemented in coordination with the Nutrient Management Coordinator of Maine Department of Agriculture, Conservation and Forestry	The plan was designed to utilize best practices in the management of soils, amendments and grazing. The protection of Lily Pond's water quality is a key component. Following the State's guidelines, the plan outlines practices that include the comprehensive sampling and testing of field soils and identifying what amendments are necessary for proper management of the forages while working to minimize impact to Lily Pond.
2006	AF receives grant from MDEP to reduce phosphorus loading to Lily Pond	Expansion of 11 acres of new pasture land out of the Lily Pond watershed accomplished through the grant as a means to reduce phosphorus loading to Lily Pond.
2007	Lily Pond Watershed Pasture Hydrology and Nutrient Reduction Report <sup>5</sup> submitted to MDEP and AF	Report describes runoff-contributing areas (RCAs), and recommends BMPs, including exploration of reducing of fertilizer applications, reducing or eliminating fertilizer application in RCAs, restricting access to

<sup>4</sup> Joelle Albury, Outreach & Office Manager, Aldermere Farm provided information presented in this table.

<sup>5</sup> [Lily Pond Watershed Pasture Hydrology and Nutrient Reduction Report](#). Undated report prepared by Hillier and Associates, Inc., Augusta, ME for the Maine Department of Environmental Protection and the Aldermere Farm.

Year	Event	Comments
		selected RCAs (accomplished in 2000), and use of frost-seeding or other no-till methods to maximize water retention and nutrient uptake.
2014	AF Nutrient Management Plan updated and approved	This is the current and operative version of the AF's Nutrient Management Plan

## Structural and Operational Changes at Jacob's Quarry

Runoff and leachate from the waste management facility now operated by the Mid-coast Solid Waste Corporation (MCSWC) on the site of the former Jacob's Quarry (JQ) were identified in the combined Phosphorus Control Action Plan and Total Maximum Daily Load Report as principal sources of nutrient enrichment and the resultant deteriorated water quality in Lily Pond. A 1993 Administrative Consent Agreement and Enforcement Order dictated cessation of leachate export from the site, which was to be accomplished by lowering the local groundwater table by pumping. Routine pumping continues and groundwater levels indicate that JQ may now act as a groundwater sink preventing or reducing the transport of leachate and associated contaminants toward Lily Pond. The fate of materials leached from the site prior the initiation of pumping in 1994 is unknown.

**Table 2. Timeline of relevant events, and structural and operational changes at Jacob's Quarry**

Date	Event	Comments
1855 until 1930	Ongoing quarrying operations occur at Jacob's Quarry (JQ)	Quarrying resulted in two deeper sections connected over a shallower wall of unsuitable material. The quarry was pumped dry while in operation.
1907-1930	Limited quarrying activity and eventual cessation of quarrying operations	Some report that it took years for JQ to fill with water. Water then flowed through JQ to Lily Pond
1940s	Use of Jacob's Quarry as a dump for the Town of Rockport initiated	Dumping occurred in both deeper sections (JQ North and JQ South)
1972	Ownership of JQ transferred to the Town of Rockport	Dumping of municipal solid waste and industrial waste continued.
1979	JQ becomes a four-town facility under a Joint Municipal Agreement	The CRLH Recycling Center now accepts waste from Camden, Rockport, Lincolnton and Hope
1983	Cessation of dumping of municipal solid waste ordered by MDEP	After this date, JQ is used solely for dumping of construction and demolition waste; solid waste is now transported off-site.
April 1993	Administrative Consent Agreement and Enforcement Order between MDEP and CRLH signed.	Order dictated the cessation of the natural flow of leachate out of the JQ. Until that time, leachate flowed continuously southwards to Lily Pond over the lip of the JQS quarry at an approximate elevation of 107 feet.

Date	Event	Comments
May 1994	Pumping of leachate from JQ South initiated	Leachate from both wells is pumped to the Camden Wastewater Treatment Facility to depress the groundwater table as a means to greatly reduce or eliminate the outward flow of leachate from the JQ site.
July 1994	Pumping of leachate from JQ North initiated	
2003-2004	Negotiations between MDEP and MCSWC, and monitoring efforts focus on attaining acceptable groundwater levels	With continued pumping, leachate levels are drawn down over 15 ft. MDEP accepts that “hydraulic control of leachate levels” has been attained.
1994-present	Leachate continues to be pumped out of JQ South (JQS) via the leachate production well located in JQ South	The 2016 groundwater monitoring report <sup>6</sup> concludes that “...elevations outside of the Quarry remain higher than the leachate elevation in the Quarry indicating that the Quarry continues to be a local groundwater sink. The occurrence of this hydraulic condition over the last thirteen consecutive years has prevented the migration of contamination out of the Quarry into surrounding groundwater.”

## Water Quality

Marked improvement in water quality has been observed based on water samples collected during the period 1979-2021. Notably, there has been a clear trend of decrease in epilimnetic and surface total phosphorus concentrations to levels near or below the 15 ugP/L target for Class GPA Waters<sup>7</sup> (Figure 1). This decreasing trend spans the period when ground water pumping in Jacob’s Quarry was initiated to depress the local water table and prevent leachate movement toward Lily Pond (1994 to present) and when Best Management Practices designed to reduce nutrient loading to Lily Pond were implemented at Aldermere Farm (2000 to present). These two watershed management efforts likely resulted in a substantial reduction in the loads of total phosphorus entering Lily Pond.

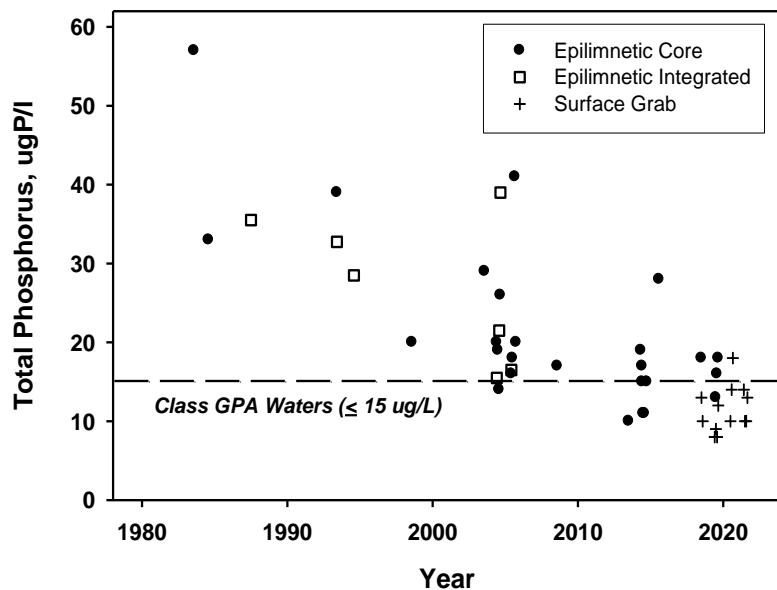
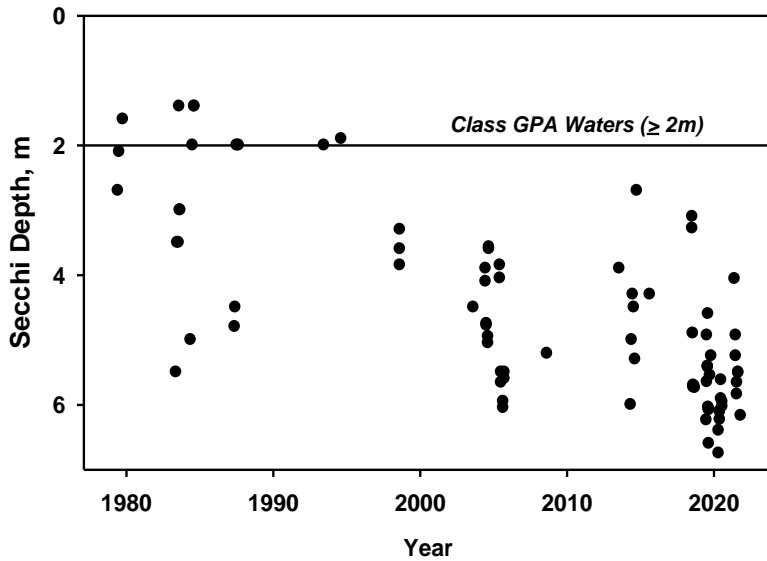


Figure 1. Change in total phosphorus concentrations in Lily

<sup>6</sup> Hydrogeological Investigation of Jacob’s Quarry Landfill, Rockport, Maine - Annual Report for 2015 Data. Report submitted to MCSWC by Emery & Garrett Groundwater Investigations, LLC, Meredith, New Hampshire (May 2016)

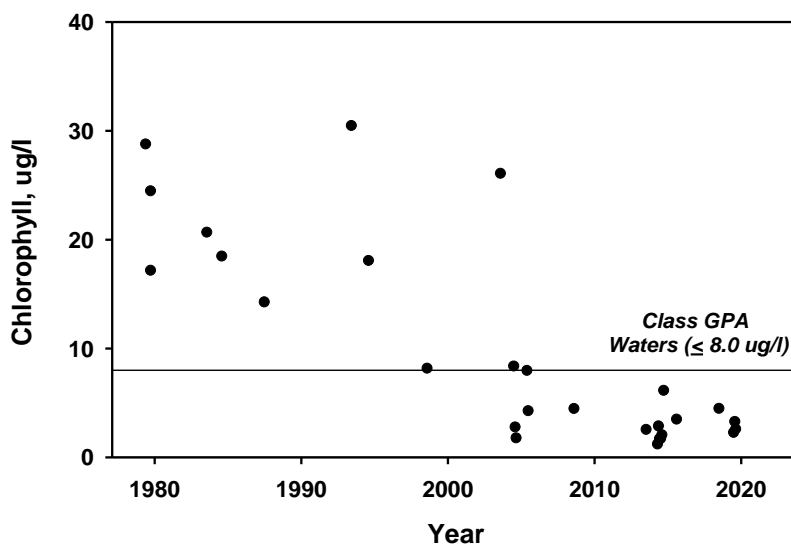
<sup>7</sup> The designation “Class GPA Waters” includes all Maine lakes and ponds. For additional classification information, see <https://legislature.maine.gov/statutes/38/title38sec465-A.html>



**Figure 2. Changes in Lily Pond Secchi Depth**

The influence of nutrient supplies, particularly of nitrogen and phosphorus, on algal growth is well established. Assessment of nutrient data collected since 2013 supports the conclusion that phosphorus availability is a primary limiting factor in algal growth in Lily Pond and that decreases in phosphorus concentrations would be expected to result in decreases in algal abundance.

Given these dependencies, it would be anticipated that the observed declines in total phosphorus in Lily Pond (Figure 1) would lead to commensurate changes in water clarity and chlorophyll concentration. This, in fact, was observed. Secchi depths (Figure 2), while frequently shallow prior to about 1995, have increased steadily since then and now exceed MDEP’s recommended level for Class GPA Waters of



**Figure 3. Changes in Lily Pond chlorophyll concentration.**

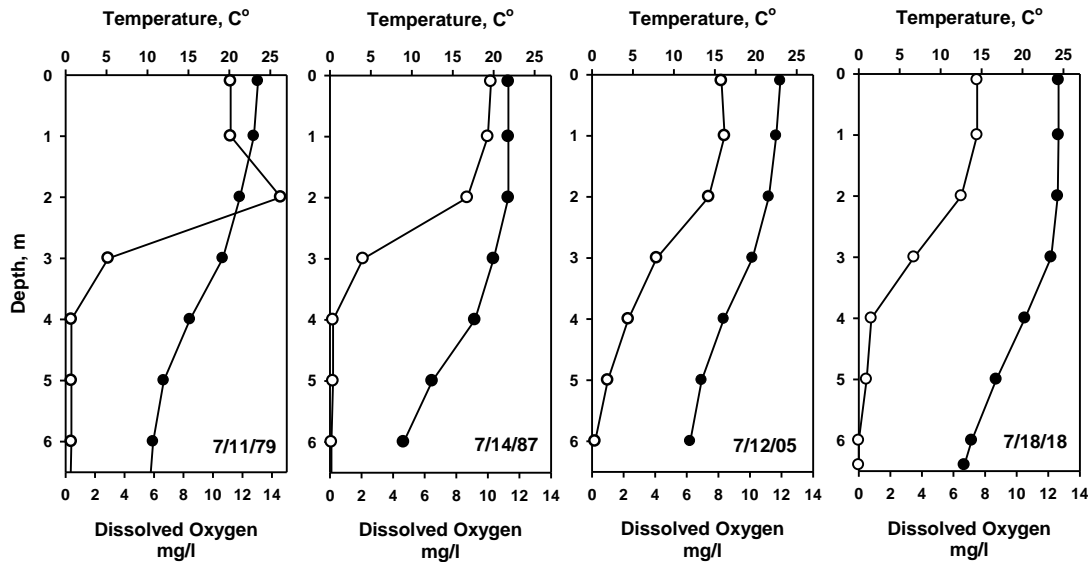
Lily Pond has exhibited other positive changes in water quality that are linked to the observed reductions in total phosphorus. Water clarity is negatively influenced by the substances that impart color to water, and the presence of suspended particles, including algae. Assessment of data collected to date indicates that reduced water clarity in Lily Pond was primarily a function of increased amounts of algae (as inferred from chlorophyll concentration).

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Similar changes were observed for chlorophyll concentration (Figure 3). Concentrations prior to 2005 were decidedly excessive, with values as high as 30 ug/l observed, and far in excess of the MDEP’s recommended level of equal to or less than 8 ug/l for Class GPA Waters. Concentrations have

been dramatically lower and below the MDEP recommended concentration since 2005.

Despite these dramatic changes in these key water quality characteristics, dissolved oxygen concentrations in Lily Pond's bottom waters continue to be impacted during summer when the lake is thermally stratified. Under stratified conditions, there is limited upward mixing of cooler, denser bottom waters and therefore limited opportunity for replacing oxygen consumed due to decomposition of organic matter. This is especially problematic in lakes that are moderately to highly productive or



**Figure 4. Vertical changes in temperature (closed circles) and dissolved oxygen (open circles) observed in Lily Pond during July in selected years.**

receive excessive amounts of organic matter from the watershed.

A comparison of four temperature and dissolved oxygen profiles recorded during the month of July suggest little change during the period 1979 to 2018 (Figure 4) despite apparent reductions in algae (based on observed changes in chlorophyll concentration). Clearly there are other sources of decomposable organic matter that exert an oxygen demand in summer in Lily Pond. Given its small size relative to the size of the pond, implementation of BMPs by AF and structural and operational changes at Jacob's Quarry, it's unlikely that the watershed is still a significant source of excessive loads of organic material to the pond.

More likely are contributions from the pond's extensive and densely-vegetated littoral area. High rates of plant productivity in these shallow waters likely lead to elevated dissolved oxygen concentrations during the day due to photosynthesis and low levels at night due to respiration. Important for the deeper, open-water areas of the pond, the growth and subsequent senescence of littoral plants would lead to the deposition organic detritus, a portion of which is likely transported to deeper water and

accumulated in bottom sediments thus potentially contributing to the observed oxygen declines in bottom waters. Available data are insufficient to address this issue directly.

## Summary

Deterioration in Lily Pond water quality resulted in the issuance of the Phosphorus Control Plan and Total Maximum Daily Load Report by the Maine Department of Environmental Protection. The report recommended application of Best Management Practices at Aldermere Farm to reduce phosphorus inputs to the pond from riparian areas, and structural and operational changes designed to reduce inputs of nutrient-rich landfill leachate from the former Jacob's Quarry to the pond. Data for the period 1979-2021 suggest that these management activities markedly improved Lily Pond water quality. Water clarity and total phosphorus and chlorophyll concentrations now meet or surpass levels recommended by Maine Department of Environmental Protection. Questions concerning persistent low dissolved oxygen concentrations in bottom waters during summer remain.