# Active Phosphate Sequestration for Reduced Nutrient Loading in Seneca Lake

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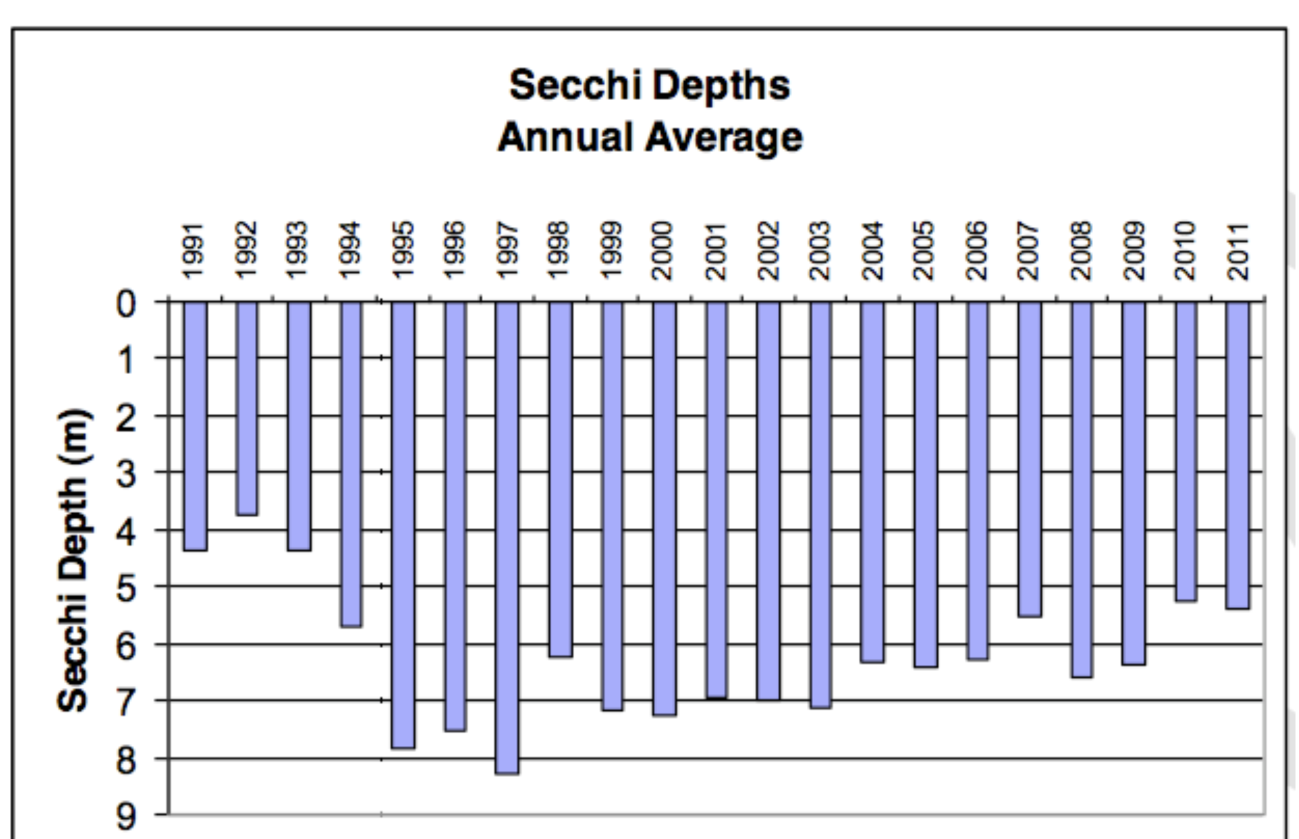
## Abstract:

This research project has focused on nutrient management schemes that employ artificial nutrient sequestration processes. Successful management of artificial phosphates in lake tributaries can improve water quality while also helping to reduce algal, and macrophyte growth for a given body of water. The proposed nutrient management scheme would involve the construction of apparatuses called photo-bioreactors, or algae-bioreactors. These reactors would actively sequester nutrients from tributaries such as Catherine Creek, Wilson Creek, and the Keuka Outlet. The nutrients would be removed through the natural growth processes of algae within the reactor. The algae could then be used for multiple purposes, such as livestock feed or for the generation of bio-fuels.

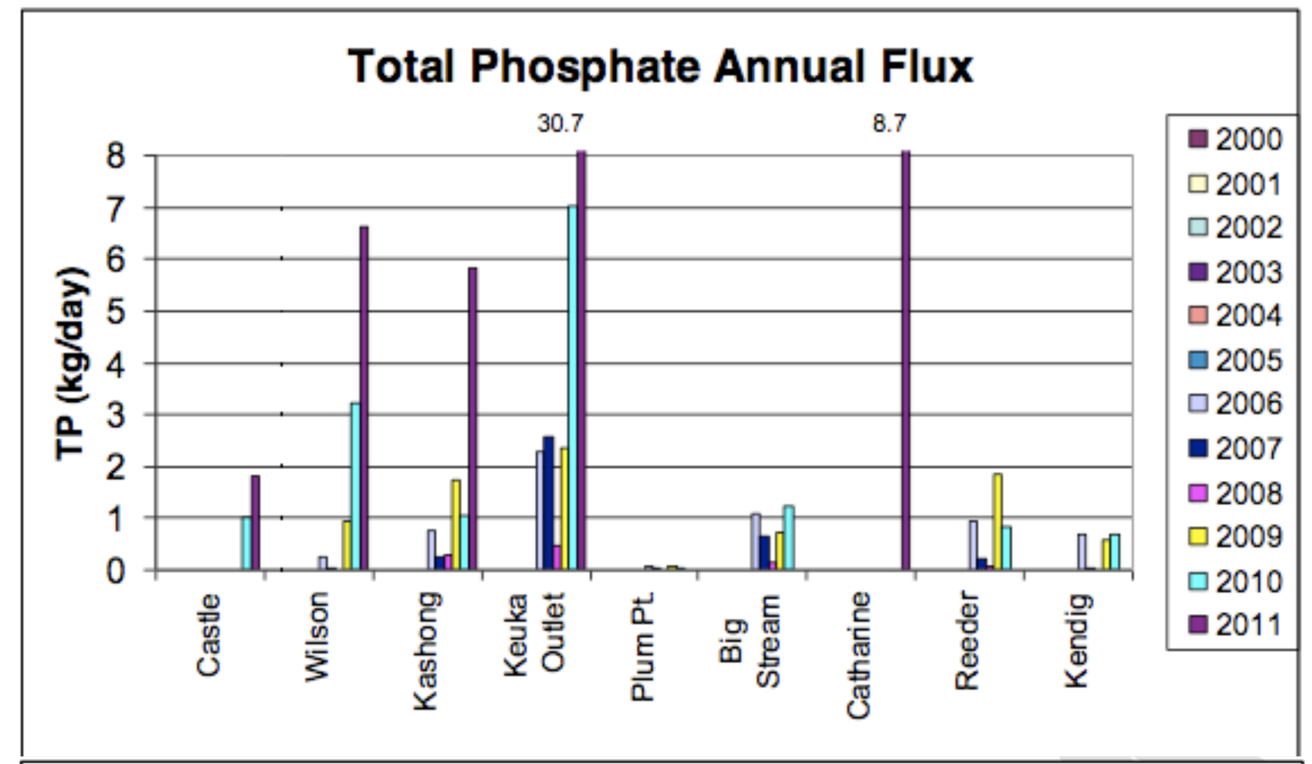
## Nutrient Loading:

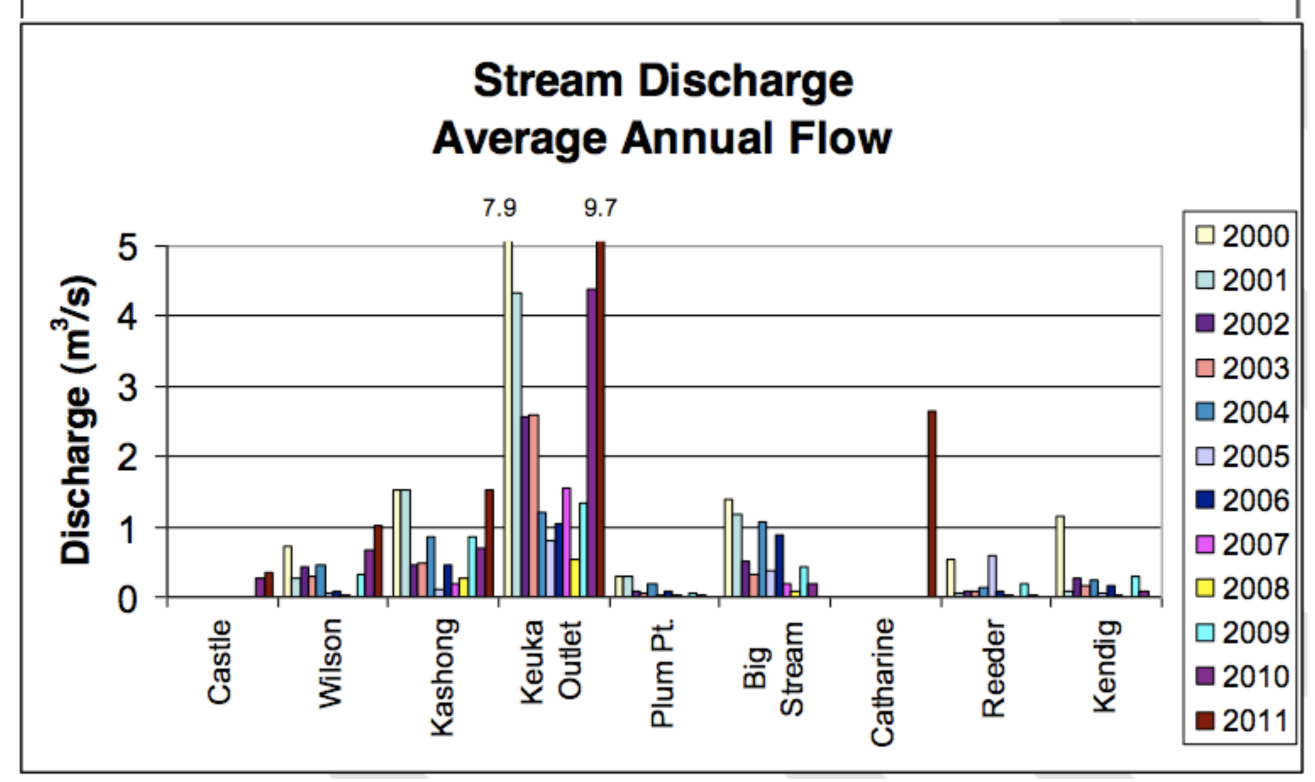
Turbidity or clarity is the most important indicator of water quality and nutrient loading. Generally low turbidity (high clarity) is the criteria for good water quality. Seneca Lake is a Phosphate limited system, so addressing phosphate loading alone will be sufficient in improving overall water quality and reducing growth of macrophytes such as eurasion milfoil.

Seneca Lake is currently in an oligotrophic state, however increased phosphate loading into the lake, and regular cyclic changes in the lake's nutrient profile can, and have historically pushed Seneca to a more productive state, high productivity increases water turbidity or conversely decreased water clarity. There exists data for the past 20 years reflecting water clarity in Seneca, in the form of measured secchi disk depths, where low values indicate increasing turbidity over the last 14 years.




Secchi Disk Depths are the standard measure of water clarity and reflect the water quality of the lake.




Given the steam flow, and phosphate fluxes above, as well as the algae C:N:P ratio of 47:7.2:1, total algae growth/m³ of processed stream water can be determined for any Seneca Tributary.

Keuka Outlet: $4.3 \times 10^{-3}$ kg Algae/m³
Wilson Creek: $6.8 \times 10^{-3}$ kg Algae/m³

## Phosphate Sources:

The top graph to the left shows the total annual phosphate flux from the tributaries into Seneca Lake. The largest phosphate source in the Seneca Lake watershed is agricultural runoff. The implementation of Agricultural Best Management Practices (BMPs) have been shown to reduce phosphate loading in nearby Conesus Lake and resulted in improved water quality. The practices were intended to prevent erosion of surface soil, retain nitrate, organic nitrogen, and phosphorus. This was accomplished through BMPs such as constructing terraces, vegetation buffer strips, and sediment control basins. In comparison nonstructural (cultural) BMPs involved modification to practices intended to minimize site disturbance through planning and design, activities such as mandated regular soil testing, limited fertilizer application, and new tillage and crop sequencing practices.

The proposed construction of algae bio-reactors in conjunction with proven agricultural BMPs can help address Phosphate loading at problematic tributaries into Seneca Lake. Streams known to have high phosphate concentrations such as Wilson, Kashong, Keuka Outlet, and Catherine Creek are all possible cites for the implementation of bio-reactor technology.

## Algae Photo Bio-Reactors:

Shown to the left are the two primary bio-reactor configurations. The top is a closed, tubular reactor design used for the capture of $CO_2$ from a fossil fuel power plant. Tubular reactors are commercially available and have capacities ranging from 3.8m³ to 140m³. Tubular reactor designs have several benefits including low energy consumption and high automation of pump and cleaning systems.

Below is an open "pond" style reactor which can be designed for any capacity and is capable of handling higher water volume than closed tubular systems.

Algae grown in a bio reactor can be used for animal feed, compost for fertilizer, to make bio diesel, for methane production, or can be dried and burned for heat.

Algae consume nutrients in an approximate C:N:P mass ratio of 47:7.2:1 resulting in an approximate 55kg of algae growth for every kg of phosphate consumed. Assuming such a system could be implemented along the Keuka Outlet, the bioreactor could effectively produce 1600kg of dry algae biomass per day of operation.