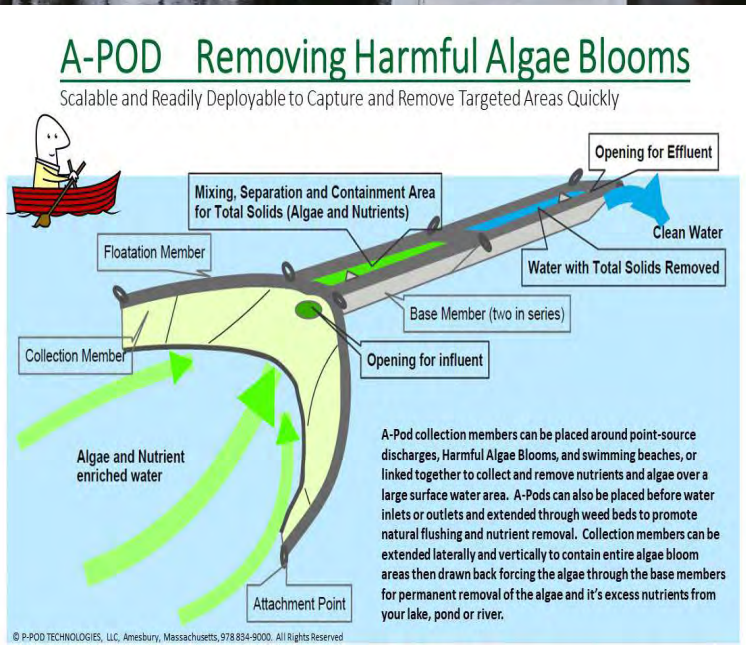
HIGGINS ENVIRONMENTAL ASSOCIATES, INC.
AND
P-POD TECHNOLOGIES, LLC

Innovative New Tools and Processes for Permanent Removal of Harmful Cyanobacteria and Algae Blooms, Excess Nutrients, Contaminants and Soft Sediments from Water Bodies

A-POD*
2018-2019 PROOF OF CONCEPT RESULTS
UPPER GREEN POND, NEWBURY, MASSACHUSETTS

November 2019 Upper Green Pond, Newbury, Massachusetts



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* The A-Pod is covered by U.S. Patent No. 10,745,879

INTRODUCTION

From September 2018 to September 2, 2019, the Upper Green Pond in Newbury, Massachusetts has served as a proof of concept demonstration location for one of P-Pod Technologies, LLC's (P-Pod Tech's) innovative new tools called the "A-Pod" for permanently removing harmful algae and cyanobacteria blooms ("cyanoHABs") and the excess nutrients they contain from water bodies. The A-Pod is covered by U.S. Patent No. 10,745,879 issued originally on April 9, 2019 then again as a continuation in part filing in August 2020. The Upper Green Pond was suitable as a proof of concept location for the A-Pod because of its past history of dense cyanoHABs and related surface scum layer despite biannual chemical treatments with aluminum sulfate, copper sulfate and herbicides by others for years. The small size of the pond also allowed us to have a more robust assessment of performance metrics for the A-Pod's fully scalable permanent removal process. When you look at the Upper Green Pond and the A-Pod, it could just as easily have been a much larger water body with one or more larger A-Pod units in use. The same primarily physical and chemical principals apply to the A-Pod's collection, concentration and permanent removal process for cyanoHABs and their excess nutrients regardless of water body size. The A-Pod is fully scalable and readily deployable.

The objective of this proof of concept demonstration was to document the effectiveness of the A-Pod's permanent removal process for cyanoHABs and their excess nutrients. The primary performance metrics were: 1) The dry-weight pounds of cyanoHABs recovered and their nutrient concentration; and, 2) The reduction of total phosphorus concentration in sediment following use of the A-Pod and permanent removal of cyanoHABs.

SUMMARY OF SIGNIFICANT PERFORMANCE METRICS

From September 2018 to September 2, 2019, we documented an overall 85 percent decrease (58% in 2018 and an additional 27 % in 2019) in total phosphorus nutrient content of sediment by efficiently and permanently removing cyanoHABs and their excess nutrients from the pond.
The A-Pod was successfully deployed in less than one day and on several different occasions to rapidly capture and permanently remove active cyanoHAB blooms.
Summer water clarity improved from inches (pre-2015) to 3.5 feet in 2019.
Dissolved oxygen remained near saturation (8 mg/l) in the summer of 2019.
Aquatic habitat improvement supported numerous frogs, tadpoles, fish, herons and a fish-eating duck (female merganser) in 2019.

GENERAL SUMMARY OF THE A-POD PROCESS

The A-Pod (the "A" in A-Pod stands for Algae) technology is essentially a physical trap for suspended cyanoHABs and the A-Pod can be used either passively or actively. Both active and passive operations of the A-Pod were used in this proof of concept demonstration. In passive mode, cyanoHABs would be driven into the

"base member or trap" portion of the A-Pod by wind-induced water currents. In active mode, an extendable and detachable "collection member" of the A-Pod was extended around concentrated cyanoHAB areas (yes, cyanoHABs concentrate in different areas even in this small pond and they can be either as benthic or planktonic forms) then drawn back forcing water with suspended cyanoHABs into the A-Pod's base member trap. In active or passive modes, cyanoHABs are concentrated in the trap area until such time that the trap is closed and the concentrated cyanoHABs in the trap are permanently removed by the user. We use a proprietary removal process in the contained area of the A-Pod trap to float and sink out cyanoHABs which can then be removed using hand tools or by pumping if desired. This cyanoHAB collection and removal process can be automated with pumping and monitoring systems for larger water body and cyanoHAB area applications. Importantly, we documented that the A-Pod can be rapidly deployed to capture, contain and then permanently remove cyanoHABs without having to use large capacity water pumping systems, electricity or land-based staging areas. The A-Pod's ease of deployment combined with its rapid containment and efficient removal process also serves to limit the potential for harm posed by otherwise uncontrolled cyanoHABs to people, wildlife and the environment. The A-Pod can also be used as a preventative tool or sentry to: (1) limit the extent of new impacts to water bodies from external sources of cyanoHABs and their excess nutrients such as from areas of nutrient-laden storm water runoff, pipe discharges, or polluted ground water; and (2) to remove suspended cyanoHABs before they can develop dense (high cell count) blooms.

BACKGROUND AND SETTING

The Upper Green Pond is a small, approximately 30,000 square foot, four foot deep (to soft sediments) ground water fed water body with a limited watershed area and only one, overflow, outlet. The pond has been impacted by dense, cyanoHAB blooms and scums for years. The pond is located within the Town of Newbury's Upper Green, a grass surface, public park with historic memorials and a ball field. The land area surrounding the pond is landscaped grass surfaces with little topographic relief. Coarse, white sand and gravel were historically placed around the entire water edge of the pond extending into the pond by about 15 to 20 feet on all sides. The central portion of the pond has approximately one and a half feet of soft, light brown to grey sediment above a peat layer. Soft sediments are also present within shallower, eastern and western limits of the pond, apparently driven and deposited by predominant wind directions over time. There are no surface water inlets or contributing surface water flows to the pond other than limited runoff from the immediate landscaped area. A paved roadway, High Street, is located off and separated from the northern edge of the pond by an earthen and grass area approximately 20 feet wide. There are small fish, frogs, insects, tadpoles, and turtles in the pond. The pond is used at times by birds including Canada geese, ducks, herons, cormorants, kingfishers and mergansers.

2015 and earlier, the Upper Green Pond is covered by dense scums of cyanoHABs despite biannual chemical treatments by others. Water clarity is several inches.

For many years before our involvement, the pond was treated biannually by others with aluminum sulfate (alum), an algaecide (copper sulfate) and a herbicide (as needed) in an ongoing effort to control cyanoHABs and nuisance aquatic vegetation. When we first considered the pond as a proof of concept location in August of 2015, the entire surface was covered by a dense, cyanoHAB scum layer. At that time we were told, "it would be worse without the chemical treatments". In August 2015, the water clarity of the pond was limited to at most several inches. This was the type of cyanoHAB-impacted water body that we were actually looking for as a demonstration, proof of concept location for the A-Pod cyanoHAB removal technology. By early 2016, we obtained approval from the Town of Newbury's Board of Selectmen and Conservation Commission to utilize our new technology, what is now called the "A-Pod", to remove cyanoHABs and the excess nutrients they contain from the Upper Green Pond. At our request, chemical treatments by others were discontinued and have not been used since 2015. In Year 2016, this area of New England experienced a severe drought and by July 2016 the pond only had several inches of water above its soft sediment layer. There were no cyanoHABs (floatable benthic mats or planktonic) in Years 2016 or 2017. It was not until September and October 2018, that the pond had a late season and sustained cyanoHAB bloom. Our proof of concept demonstration for the A-Pod officially began in September 2018.

SUMMARY OF YEAR 2015-2017 BASELINE FIELD CONDITIONS AND SAMPLING RESULTS

From late-June to mid-October 2015, the entire surface of the pond was covered by a thick cyanoHAB scum layer. Water clarity was at most several inches when the algae scum was pushed away. We understand that this was a "typical" condition for many years despite biannual chemical treatments with alum and algaecides by others. We did not observe shoreline- or emergent- rooted plants in 2015 as these were apparently controlled by herbicide treatments by others.

In 2016, this part of Massachusetts experienced a severe drought. The worst on record since the 1960s. By July, there was only several inches of water in the pond. CyanoHABs were not observed in Year 2016 or in 2017.

In March of 2017, an initial "baseline" composite sediment sample was collected from the top 0.5 feet of soft sediment on three transects through the central portion of the pond for laboratory analysis for total phosphorus, sulfate/sulfide, and the metals arsenic, chromium, nickel and mercury. The phosphorus sample was ashed for one hour at 550 degrees Celsius prior to laboratory analysis by US EPA Method 6010 following an ashing method developed by Andersen (1976). Ashing of the sample: 1) makes more of the phosphorus otherwise strongly-bound to organic material available for analytical extraction; and, 2) reduces the variance (lower or higher than actual concentration) bias when testing for phosphorus content in organic–rich, low percent solid, soft sediments. All other (non phosphorus) tests were from non-ashed samples. Results in March 2017 were 1,420 mg/kg for total phosphorus in sediment. This result is consistent with organic-rich, soft sediment from other mesotrophic to eutrophic water bodies with a history of active cyanoHABs. Laboratory results are summarized on **Table 1 - Sediment and CyanoHAB Analytical Results**. This summary table also includes

laboratory results for sediment, algae and cyanobacteria from 2018 and 2019.

SUMMARY OF YEAR 2018 RESULTS

Year 2018 was characterized by heavy and frequent rain events from mid-July until January 2019. There were very few Canada geese at the pond in 2018. Unusual for the New England region, it was not until September and October 2018 that sustained cyanoHAB blooms occurred as noted in the following photograph. An earlier bloom occurred just prior to heavy rains in July but the heavy rains appeared to have knocked-down the active bloom.

Photograph: September 13, 2018, Proof of Concept A-Pod prototype with cyanoHAB bloom, Upper Green Pond, Newbury, Massachusetts.

In the interest of quickly recovering the September and October 2018 cyanoHAB blooms, as shown in the above photograph, before other heavy rain events, the A-Pod's detachable collection member (0-4 foot depth interval) was used to draw back the bloom into the base member "trap" of the A-Pod for final processing and removal. The dense, green-colored, active bloom (water clarity of several inches below bloom) can be seen in the foreground of the photograph with a relatively clear section of pond (water clarity of 2.5 feet in bloom cleared area) processed by the A-Pod in the background. The A-Pod shown is an early prototype.

The majority of the cyanoHAB removal process using the early A-Pod prototype was completed in two separate

days. A total of 17.8 dry-weight pounds of cyanoHABs were removed from the pond with the A-Pod. As confirmed by composite sampling and laboratory analysis, the recovered cyanoHABs contained an elevated total phosphorus concentration of 12,400 mg/kg on an ashed, dry-weight basis (same method as 2017 baseline sediment sample); this equates to 0.22 pounds of total phosphorus in cyanoHAB removed in 2018. A composite sample of soft sediment collected in April 2019, after the 2018 bloom removal, had a total phosphorus concentration of 822 mg/kg. This represents a 58 percent reduction in total phosphorus in sediment when compared to the pre-removal baseline, 2017 sediment sample result of 1,420 mg/kg.

> 2018 A-Pod cyanoHAB removal process resulted in a 58 percent reduction in "legacy" or internal nutrient load for total phosphorus in sediment compared to 2017 baseline.

SUMMARY OF YEAR 2019 RESULTS

Year 2019 was a fairly typical year with normal amounts of precipitation and temperature changes. CyanoHAB bloom season started in late May with the frequent lifting of benthic cyanoHAB mats from the bottom. Water clarity from May to August was varied between 2.5 to 3.5 feet depending primarily upon cyanoHAB conditions. Lifting of benthic cyanoHAB mats often occurred on sunny days as the cyanoHABs

Photograph: August 18, 2019, Proof of Concept A-Pod prototype with captured cyanoHABs, Upper Green Pond, Newbury, Massachusetts. A detachable A-Pod collection member can be seen in the background awaiting use in active mode as needed. The A-Pod is also keeping areas "behind and in the foreground" of the A-Pod relatively free of cyanoHABs from the remainder of the pond. This is part of the preventative or sentry use capability of the A-Pod to control and limit harm posed by new cyanoHAB events to non-impacted areas of a water body.

photosynthesized, generated oxygen, and air bubbles trapped in the mats raised the mats off the soft bottom portion of the pond. The A-Pod was set up in passive collection mode on the western side of the pond to take advantage of the predominant east to west seabreeze in this area. CyanoHAB mats could be observed to raise up frequently, move across the pond surface, and collect within the A-Pod base member trap area on a daily basis. Small blooms of planktonic cyanobacteria also occurred and were similarly captured in the A-Pods base member trap. When full or conveniently full enough, the A-Pod base member was closed off and trapped cyanoHABs were removed using a proprietary separation process and hand tools. Conveniently, the planktonic cyanobacteria would often adhere and bind to the benthic more filamentous algae mats making removal fairly easy and without having to use polymers or surfactants to float out the cyanoHABs.

> Water clarity improved from inches to 3.5 feet.
>
> Dissolved oxygen documented near saturation at 8 mg/l in August 2019

A total of 300 dry-weight pounds of cyanoHABs were removed in 2019. Of note was that laboratory analytical results for total phosphorus from recovered cyanoHAB composite samples actually decreased significantly from June 26, 2019 (13,100 mg/kg) to September 2, 2019 (283 mg/kg) as cyanoHABs and their nutrients continued to be permanently removed. We surmise that this is a new performance metric, as the overall nutrient pool available to cyanoHABs is reduced, the concentration of these nutrients decrease in future cyanoHAB cells when compared to pre-removal "luxury" cyanoHAB nutrient concentrations. Similarly, a composite sample of soft sediment from the pond, collected on September 2, 2019 was also significantly reduced in total phosphorus content (219 mg/kg) when compared to both the 2017 baseline of 1,420 mg/kg and to the sample collected after the prior Year 2018 A-Pod removal operation of 822 mg/kg. The 2019 versus 2017 baseline result for total phosphorus in sediment documented a significant reduction (85 percent) in total phosphorus concentration. A total of 3.93 pounds of total phosphorus were removed in 2019. By the end of August, cyanoHAB occurrence had diminished markedly, water clarity approached 3.5 feet in the central area of the pond and dissolved oxygen was near saturation at 8 mg/l. The A-Pod was removed on September 2, 2019 ending the demonstration and proof of concept trial.

> 2019 A-Pod cyanoHAB removal process resulted in an additional 27 percent reduction in "legacy" or internal nutrient load for total phosphorus in sediment compared to 2018 or in total by 85 percent since the 2017 baseline.

PERFORMANCE METRICS

This proof of concept trial was initiated to document the A-Pod's ability to capture, concentrate and remove cyanoHABs and their excess nutrients (phosphorus in particular) from water bodies. Accordingly, by removing cyanoHABs which utilize nutrients available to them in the pond, we also surmised that the concentration of total phosphorus (our primary metric nutrient) in sediment would also decrease.

For the first performance metric, cyanoHAB mass removal, from 2018 to 2019 the A-Pod removed a total of approximately 320 dry-weight pounds of cyanoHABs with an average total phosphorus concentration of 8,594 mg/kg. Note, by September 2, 2019 the concentration of phosphorus in recovered cyanoHABs was substantially reduced when compared to a June 26, 2019 cyanoHAB sample result of 13,100 mg/kg. As such, the average concentration of total phosphorus in cyanoHABs removed from the pond decreased after June 26, 2019. There was also a marked decrease in the mass and frequency of cyanoHAB in the pond and recovered by the A-Pod as the summer of 2019 progressed.

1st Metric: A-Pod removed 320 dry-weight pounds of cyanoHABs. CyanoHAB occurrence diminished over time.

For the second performance metric, reduction in total phosphorus content in sediment during use of the A-Pod, for cyanoHAB removal actions in year 2018 there was a 58 percent reduction when compared to the baseline 2017 result. In year 2019, there was an additional 27 percent reduction when compared to year 2018 post-removal results using the A-Pod. This equates to an 85 percent reduction (1,420 mg/kg in 2017 reduced to 219 mg/kg in 2019) pre- and post- use of the A-Pod. Essentially, the total phosphorus concentration reduction in sediment correspond to an improvement in pond trophic status from eutrophic (nutrient-rich) to oligotrophic (low nutrient).

2nd Metric: A-Pod reduces total phosphorus content of sediment by 85% a change from Eutrophic to Oligotrophic for this pond!

Importantly, a third performance metric became apparent during use of the A-Pod - a reduction in cyanoHAB cell nutrient concentration over time as cyanoHABs were recovered and removed from the pond by the A-Pod. Between June 26th and September 2, 2019, the concentration of total phosphorus in recovered cyanoHABs decreased from 13,100 mg/kg to 283 mg/kg on an ashed, dry-weight basis. This decrease could be interpreted to indicate a decrease in cyanoHAB nutrient content as the season progresses and sunlight radiance and cyanoHAB growth decreases. However, the nutrient content of cyanoHABs recovered in October 2018 at the start of this A-Pod proof of concept were elevated for total phosphorus at 12,400 mg/kg on an ashed, dry-weight basis. This evidence tends to support a finding that the nutrient content of cyanoHAB cells decrease (from being indicative of luxury uptake to growth limited) as available nutrients in the pond sediment decreases. Makes sense, as it is well known that cyanoHAB's are luxury feeders and their density (cell count) and occurrence increases as nutrient availability increases.

3rd Metric: A-Pod use results in reduction of phosphorus content of cyanoHABs by 98%. (e.g., from luxury uptake to growth limited)

PROOF OF CONCEPT FINDINGS

By actively and passively removing cyanoHABs, the A-Pod technology documented (by composite sampling and laboratory analysis using EPA method 6010) the efficient and rapid removal of cyanoHABs and 85 percent of the total phosphorus in sediment (referred to as "legacy or internal load") from this historically cyanoHAB-impacted public park pond. The A-Pod was shown to keep cyanoHABs separated from other non-impacted areas of the pond (behind the A-Pod), documenting its ability to limit as a preventative measure the impact of otherwise uncontrolled cyanoHABs on other water body areas, people or wildlife. We demonstrated that the A-Pod technology could be set up and used to capture and remove cyanoHABs in less than one day. The A-Pod is readily deployable and fully scalable. Though this was a small pond with a documented history of cyanoHABs, it could just as well have been a very large water body with one or more larger A-Pods as the physical and chemical properties of cyanoHABs and their occurrence and movement in water are not scale dependent. With ongoing A-Pod use, by late summer of 2019, the occurrence and nutrient concentration of cyanoHABs in the pond decreased. Summertime water clarity and dissolved oxygen content was improved by use of the A-Pod to remove cyanoHABs and their excess nutrients. We also saw an apparent increase in the number of frogs, tadpoles and fish than in years past. We removed our larger A-Pod and ended this 2019 demonstration on September 2, 2019.

Proprietary CyanoHAB separation and removal process

TABLE 1 - Sediment and CyanoHAB Analytical Results - Upper Green Pond
HEA Project No. 03124, Newbury, Massachusetts

SAMPLE LOCATION	Central Portion of Pond	Central Portion of Pond	Central Portion of Pond
DEPTH (in Feet)	Sediment 0-0.5 foot	Sediment 0-0.5 foot	Sediment 0-0.5 foot
Date Collected	3/30/2017	4/17/2019	9/2/2019
ANALYSIS in milligrams per kilogram			
Total Phosphorus	1420	822	219
Sulfate	ND(2)	NA	ND(377)
Sulfide	667	NA	2.2
Total Sulfur	NA	NA	1550
Kjeldahl Nitrogen	NA	NA	NA
Nitrate and Nitrite as Nitrogen	NA	NA	NA
Total Nitrogen	NA	NA	NA
Arsenic	17.6	NA	NA
Chromium	50.4	NA	NA
Nickel	55.8	NA	NA
Mercury	ND(0.482)	NA	NA

SAMPLE LOCATION	CyanoHABs Recovered	CyanoHABs Recovered	CyanoHABs Recovered	CyanoHABs Recovered
DEPTH (in Feet)				detritus in trap
Date Collected	10/26/2018	6/26/2019	9/2/2019	9/2/2019
ANALYSIS in milligrams per kilogram				
Total Phosphorus	12400	13100	283	295
Sulfate	NA	NA	NA	NA
Sulfide	NA	NA	NA	NA
Total Sulfur	NA	NA	9880	3300
Kjeldahl Nitrogen	NA	NA	NA	NA
Nitrate and Nitrite as Nitrogen	NA	NA	NA	NA
Total Nitrogen	NA	NA	NA	NA

Notes for Table 1:

1. Results reported in milligrams per kilogram (parts per million). All laboratory analysis completed using EPA Method 6010C and Standard Methods SM4500-S04-E and SM4500-S-D
2. ND(#) = Not detected at laboratory detection limit noted. NT = Not Tested; NS = No Standard; NA = Not Applicable or Available.
3. For Total Phosphorus analysis, samples were ashed at 550 degrees Celcius for one hour prior to extraction in accordance with Andersen (1976). All other analytes are from non-ashed sample aliquots.
4. All sample results represent composite samples for each sample type.
5. Sediment 0-0.5 foot samples represent composited sediment samples that serve to assess changes in total phosphorus content of sediment prior to, during, and following this A-Pod demonstration for removal of excess nutrients from the Upper Green Pond.