Analysis and Recommendations for Maryland's State-owned Lakes

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Executive Summary

The funds made available for state-owned lakes have provided an important, long overdue opportunity to protect and restore these lakes. This report provides information on expenditures of state lakes funds and summarizes some of the work performed to date using State Lakes Protection and Restoration funds. The State Lakes program has enabled many beneficial projects to be completed that improved the health and recreational value of our state-owned lakes for citizens to enjoy. Many more projects remain that would further address the restoration goals of this fund, including dredging most of the lakes. Despite these projects, costs to perform the dredging needed to restore these lakes to their original depths are estimated to be approximately $20 million to $185 million. This is far beyond the scope of the funds available.

Maryland State Lakes Background

Maryland is home to more than 100 lakes, 16 of which are owned and maintained by the state (Figure 1). In 2018, the State Lakes Protection and Restoration Fund was approved and the Maryland Department of Natural Resources (DNR) was tasked with preserving and improving the health of these lakes for wildlife and human recreational use.

The lakes span the state geographically from western Maryland to the Eastern Shore to southern Maryland (Figure 1). They range in size from the 13-acre New Germany Lake to 3,900-acre Deep Creek Lake. The lakes are managed by three different units within DNR, with ten managed by the Maryland Park Service, four by the Fishing and Boating Service, and two by the Wildlife and Heritage Service. These lakes are very diverse in age, structure, biodiversity, presence and abundance of native and/or non-native species, and their potential health concerns.

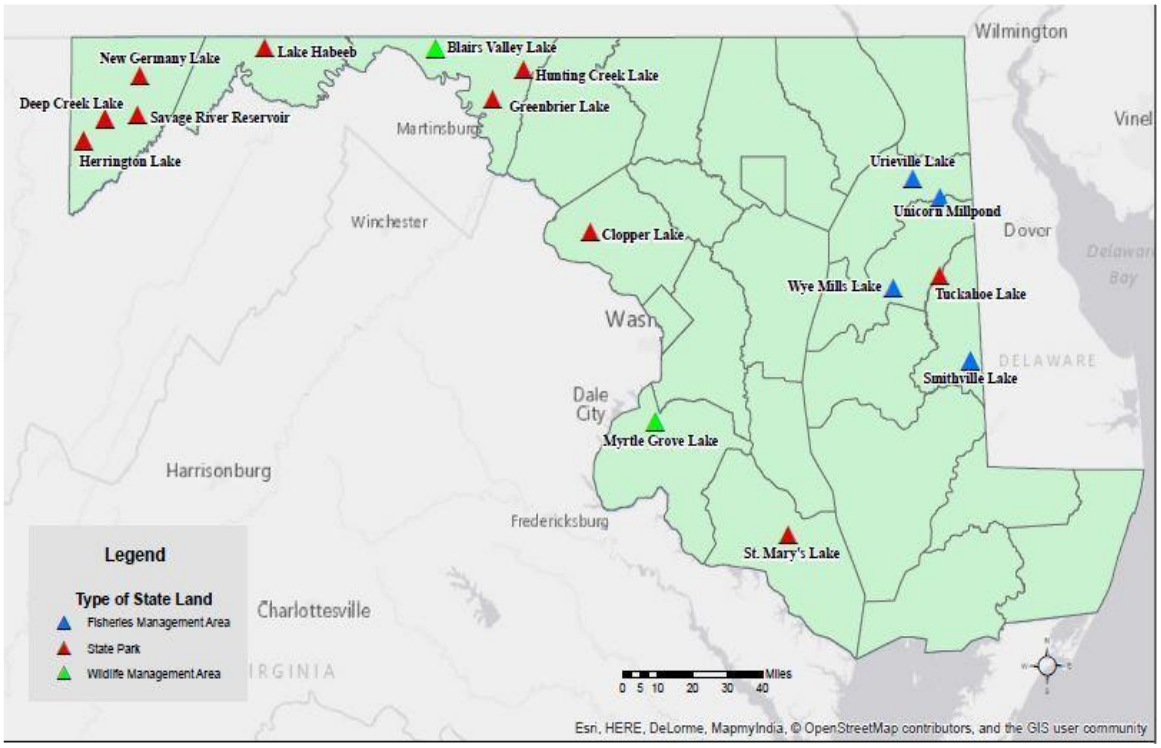


Figure 1. Map of State-Owned and Managed Lakes

While there are no naturally formed lakes in Maryland, there are hundreds of man-made water bodies. Referred to as lakes, ponds, or reservoirs, they are popular destinations for fishing, swimming, boating, and many other types of outdoor recreation. Maryland's state-owned lakes are almost all 50 years old or older. As they age, lakes typically become more and more filled with sediment. As the lakes become more shallow, more and more areas become colonized by both native and non-native SAVs. SAV is ecologically beneficial, but can become an impediment to water-based recreation. As state-owned lakes aren't used for drinking water and are not a focus for nutrient sampling, historically there has been little water quality monitoring in most of Maryland's lakes. Harmful algae blooms now occur regularly in some lakes.

Over the last several decades, the Chesapeake Bay and its tributaries have received significant attention and funding to monitor and preserve its health. While the Bay provides significant historical, cultural, recreational, and economic value to Maryland and deserves funding for restoration, the state lakes also provide great recreational, environmental, and economic value to the state and have not previously received a similar level of funding for restoration and preservation. This program seeks to bridge that gap.

When the State Lakes Protection and Restoration Fund was enacted, five actionable steps were outlined as a means of achieving the Senate Bill's goals. Appropriations may only be used for the following actions in state-owned or managed lakes:

1. Removing sediment
2. Treating contaminated sediment
3. Preventing the spread of invasive species
4. Improving ecological and recreational value
5. Taking any other action the department determines is necessary

This initiative has served as a catalyst for learning more about each of the state-owned lakes. Previously, there was very little information known about some of our lakes. Focused efforts are now being made to assess multiple lake health parameters, including water quality, submerged aquatic vegetation (SAV) surveys, harmful algae bloom (HAB) monitoring, aquatic invasive species (AIS) identification and eradication as well as educating lake managers and the public about what they can do to improve our lakes. While much has been accomplished, there are challenges to achieving the full scope of goals mandated by the fund. Thorough assessments of some parameters have been possible, as described above, while other lake health indices continue to have large data gaps.

In addition, while the $1,000,000 annual funding has facilitated many important projects, this level of funding is inadequate to perform the main objective of the initiative- dredging. Costs for dredging projects at the scale necessary to fully restore lake function are estimated in this report.

Structure, History, and Characteristics of Each State Lake

Following is a basic description of each lake, including its morphology, historical origination, biodiversity of SAV and fish, and anthropogenic uses. Lake descriptions are in ascending order from the smallest, New Germany Lake, to the largest, Deep Creek Lake. A comprehensive survey of SAV, including both native and non-native species, was performed in 2016 in all 16 state-owned lakes. Those results will be referenced below. The complete findings of that study can be found in the "Survey of Aquatic Invasive Species in Maryland Lakes." (https://dnr.maryland.gov/Invasives/Documents/Aquatic-Invasive-Reservoir-Summary.pdf)

New Germany Lake is a 13-acre reservoir inside New Germany State Park in Garrett County and is within the North Branch Potomac River watershed. Created by a dam on Poplar Lick, the lake is used today primarily for fishing and swimming. Historically, the original earthen dam was constructed during the colonial era in 1837-1847 by German immigrants to power the first saw mill and grist mill in the area. Today's current dam was built from this original dam and a concrete spillway was constructed in 1933-1935. This small impoundment is shallow with a mud bottom that is only seven feet at its deepest location and four feet deep on average. When the dam was repaired in 2008, a sediment study was also performed by the DNR. This study discovered that New Germany Lake has accumulated a maximum of 1.8 to 3.8 feet of sediment thickness throughout the majority of the lake over its almost 180 year history. In the 2016 SAV survey, six native species of macrophytes were observed as well as two non-native species (Table 1). Cold spring water temperatures allow the lake to be stocked seasonally with several thousand rainbow trout to provide anglers with a put and take fishery in addition to the abundant large mouth bass, bluegill, pumpkinseed, and yellow perch present. Seven species of fish were identified by the DNR Fishing and Boating Service (Table 2). One potentially toxic cyanobacteria species was detected during 2016 (*Woronichinia sp*) and three non-toxic cyanobacteria were observed in the lake (*Aphanocapsa*, *Chroococcus*, *Cuspidothrix*).

Tuckahoe Lake is a 19-acre reservoir in Tuckahoe State Park in Queen Anne's County within the Choptank River watershed. It was created by the damming of Tuckahoe Creek near Crouse Mill Road and historically powered a mill. The lake is now used for recreation, mainly fishing and boating. The average lake depth is five to six feet with a maximum depth of seven feet near the dam. Although no macrophytes were observed during the 2016 SAV survey (Table 1), 13 species of fish were observed by the Fishing and Boating Service (Table 2). The lake offers a robust largemouth bass population for anglers to enjoy. This lake has not had any cyanobacteria

detections. The phytoplankton community was dominated by chlorophytes and diatoms. Low abundance of some benthic mats of *Rhizoclonium* were present.

Myrtle Grove Lake is a 23-acre reservoir within the Myrtle Grove Wildlife Management Area in Charles County and is in the Lower Potomac River watershed. Formed by impounding a small tributary to Mattawoman Creek in 1965, the lake is used primarily by residents for recreational fishing. No native SAV species were found during the 2016 survey while two invasive SAV species were identified, including hydrilla, a prolific and commonly invasive macrophyte (Table 1). Five different species of fish were observed by DNR Fishing and Boating Service (Table 2), including put and take rainbow trout and golden trout that are stocked during the spring and fall seasons. Two potentially toxic species of cyanobacteria were identified at Myrtle Grove Lake, including *Dolichiospermum* and *Cylindrospermopsis sp*. and six non-toxic species (*Aphanocapsa, Chroococcus, Coelospaherium, Cuspidothrix, Merismopedia, Oocystis*), all at low concentrations.

Blairs Valley Lake is a 32-acre reservoir in Washington County constructed in 1967 by damming Little Conococheague Creek. It lies within the Upper Potomac River watershed. It was constructed by the Department of Game and Inland Fish for recreational purposes and is primarily used for fishing. A maximum depth of 18 feet can be found near the dam riser while the upper half of the lake is generally less than ten feet. To permit a five-foot winter drawdown for fish and wildlife management activities, the dam was designed and built with valves and the lake draws down to 22 acres. Due to the fertile watershed and the lake's phytoplankton blooms, oxygen becomes depleted below the depth of eight feet during the summer months. Therefore, the majority of the lake's deeper water cannot be utilized by gamefish during the summer season. Only one native species of SAV was identified during the 2016 SAV survey, while two invasive species were observed, including hydrilla (Table 1). The Fishing and Boating Service observed 8 different species of fish (Table 2) and also stock rainbow trout for a put and take fishery. A baseline phytoplankton community has not been conducted for presence of cyanobacteria.

Urieville Lake is a 35-acre reservoir in Kent County formed by damming an unnamed tributary to Morgan Creek in the Chester River watershed. Common duckweed (*Lemna minor*), a floating aquatic invasive, covers large areas of the lake surface. The lake was initially built in colonial times when two tributaries to Morgan Creek were impounded. When first created, Urieville Lake had fairly steep bottom bathymetry, with two distinct, flooded creek channels that were two to three meters deep in some places. Over time, intense agricultural practices, deforestation, and development in the watershed have caused excess sediment and nutrient loading into the lake. This has resulted in the stream channels and main body of the lake to fill with silt, leading to very shallow overall lake depth. Abundant nitrogen and phosphorus inputs into the shallow lake have created excellent conditions for aquatic plant growth. By the month of June, aquatic vegetation becomes so abundant that total surface coverage with plant material is not atypical.

Heavy vegetative coverage has made angling and subsequent management activities very difficult and undesirable. In 2016, three species of native macrophytes were identified and two invasive species were identified (Table 1). Nine different species of fish were observed by the Fishing and Boating Service (Table 2). The aquatic plants in this lake are covered with potentially toxic filamentous cyanobacteria, *Microseira wollei* and *Lyngbya sp.* and *Rhizoclonium sp.* (a green filamentous algae).

Greenbrier Lake is a 42-acre reservoir in Greenbrier State Park in Washington County formed by a dam on Little Beaver Creek. The lake is part of the Upper Potomac River watershed and is used for recreational purposes, including fishing, swimming, canoeing, and boating. The 2016 SAV survey found three different species of native macrophytes and no sign of any invasive species (Table 1). Fishing and Boating Service found four different species of fish present and stocks the lake with rainbow trout, largemouth bass, and bluegill (Table 2). A baseline phytoplankton community has not been conducted for the presence of cyanobacteria, but the potentially toxic cyanobacteria, *Woronichinia*, was found at bloom levels in 2019.

Hunting Creek Lake is a 43-acre reservoir in Cunningham Falls State Park in Frederick County formed by damming Big Hunting Creek. It lies within the Middle Potomac River watershed. The lake was created in the early 1970s to increase visitors to the park and is primarily used for swimming, boating, and fishing. A paved boat ramp is heavily used by fishermen and recreational boaters. Hunting Creek Lake has a heavily used and enjoyed beach area for recreational swimming that has had to close several times due to elevated concentrations of toxic Harmful Algal Blooms (HABs). No contact advisories are issued when HABs concentrations exceed the EPA recreational contact threshold. Four native SAV species were observed in the 2016 survey along with one invasive species (Table 1). Five different species of fish have been identified by the Fishing and Boating Service (Table 2). Anglers can enjoy an abundance of largemouth bass, including trophy sized fish, as well as trout that are stocked for a put and take fishery. Toxic algae blooms have been recurring at Hunting Creek Lake in some capacity for years. The first major HAB was recorded in 2011 and resulted in a no contact advisory being issued by Frederick County (maximum microcystin was 680 ppb). No routine monitoring occurred after this until another significant bloom was recorded in 2019. Key cyanobacteria species include *Microcystis*, *Woronichinia*, *Dolichospermum*, and *Aphanizonomenon*. Several filamentous benthic cyanobacteria species have also been detected, *Lyngbya, Oscillatoria* and *Leibleinia.* There has been no detection of anatoxin in the lake.

Smithville Lake is a 43-acre reservoir in Caroline County in the Nanticoke watershed. It was created when a dam was constructed across a tributary to Marshyhope Creek and is managed to provide a public angling resource. The upper third of Smithville Lake is very shallow with gradual drop-offs, while the lower two-thirds of the lake have steeper banks with sharp drop-offs. The lower two-thirds of Smithville Lake contains the best fish habitat. The lake's fishery is

managed primarily for largemouth bass and bluegill, but supports good fisheries for black crappie and chain pickerel as well. In recent years, water quality in the lake has been poor, particularly in times of drought. These fluctuations in water quality have likely impacted the quality of the fishery resources, as largemouth bass abundance and quality has decreased in recent years. Nine different species of fish have been observed by the Fishing and Boating Service (Table 2) while only one species of native SAV was identified in 2016 and no invasive species were observed (Table 1). Recurring cyanobacteria blooms (*Microcystis sp*) have occurred with generally low toxin but in 2013 microcystin reached 125 ppb (EPA thresholds is 8 ppb) resulting in a no-contact water advisory being issued by Caroline County Health Dept. Potentially toxic, benthic, filamentous cyanobacteria have been noted in abundance (*Microseira wollei, Lyngbya* and *Oscillatoria*) with microcystin up to 5.0 ug/g.

Unicorn Lake is a 43-acre reservoir in Queen Anne's County formed by damming Unicorn Branch. It lies within the Chester River watershed and receives cool water year round from Unicorn Branch. Unicorn Lake has a maximum depth of eight feet, with a mean depth of roughly four feet. The upper third of the lake is extremely shallow, with the mean depth being less than one foot. In addition to natural woody debris found along the shoreline, fish attractors made with discarded Christmas trees have been placed in the lower half of the lake near the dam breast to augment existing habitat. A fish ladder was installed at the dam to allow the passage of anadromous fish species to 14.5 miles of habitat upstream of the lake. While the lake's fishery is primarily managed for largemouth bass and bluegill, many anglers come to Unicorn Lake to fish for chain pickerel. Unicorn Lake has great native macrophyte biodiversity, with seven native species identified in the 2016 survey and only one invasive macrophyte species observed (Table 1). Ten different species of fish have been observed by the Fishing and Boating Service (Table 2). No cyanobacteria have been identified in water samples. Benthic mats are a mix of the green algae, *Hydrodictyon reticulata*, and various potentially toxic, filamentous cyanobacteria species (*Microseria wollei, Lyngbya, Phormidium, Oscillatoria* with the pelagic *Microcystis panniformis* mixed in).

Wye Mills Lake is a 50-acre reservoir in Queen Anne's County within the Chester River watershed. Created to hold back the Wye East River, water from the reservoir powered a grain mill during colonial times. Established in 1682, Old Wye Mill is the oldest working mill in Maryland. The reservoir is now managed primarily to provide recreational fishing opportunities. Maximum depth is 8 feet, with a mean depth of 4 feet. The upper third of the lake is very shallow with gradual drop-offs, while the lower two-thirds of the lake has steeper banks with sharp drop-offs.

The lower two-thirds of Wye Mills Lake contains outstanding fish habitat, including downed trees and undercut roots scattered along the shoreline. Fish habitat is augmented by sinking Christmas tree "fish attractors" along the concrete dam breast to provide fishing opportunities

from shore. The lake outflow constitutes the uppermost tidal portion of the Wye River. Proximal tidal influence to the base of the lake has promoted the introduction of undesirable fish species such as gizzard shad (*Dorosoma cepedianum*) and common carp (*Cyprinus carpio*) by anglers fishing the tidal river. These undesired fish species have since become abundant in the lake and their presence has become detrimental to maintaining a balanced bluegill-largemouth bass (*Lepomis macrochirus-Micropterus salmoides)* fishery. However, this is not the only issue, which is currently hampering effective management. Excessive siltation is occurring in the upstream areas of the lake. Some areas that were sampled in the past have become too shallow for motorized boat operation. These impacts, in combination with a rapidly expanding resident waterfowl flock, have increased nutrient inputs. Results of surveys have shown greatly reduced populations of largemouth bass and bluegill. Intense stocking of bass has been completed annually since 2008 to boost the population. The Fishing and Boating Service has identified ten different fish species in the lake (Table 2). No SAV were observed in the 2016 survey (Table 1). Potentially toxic cyanobacteria have been identified, with *Microcystis* and *Mesimopedia* common, *Aphanizomenon* and *Planktothrix* abundant, and *Dolichospermum* present. Benthic mats have also contained filamentous cyanobacteria, including *Microseira wollei and Oscillatoria*. The lake manager has posted signs warning that animal health could be affected by lake water.

Herrington Lake is a 53-acre reservoir located within Garrett State Forest in Garrett County. It was formed in the 1930s by damming Herrington Creek and is in the Youghiogheny River watershed, which flows into the Ohio River drainage basin, and is used primarily by visitors for boating, swimming, and recreational fishing. The lake is a shallow body of water with a muddy bottom and a maximum depth of 14 feet. Roughly half of the lake is three feet deep or less. Lake drawdowns are performed annually to expose the lake bottom and keep aquatic vegetation from establishing around the lake perimeter. While drawdowns prevent the growth of some aquatic vegetation, mitigation is in place to provide new habitat.
Fishing and Boating Service personnel have completed habitat enhancement projects in the lake by sinking Christmas trees and providing channel catfish nesting boxes throughout the lake. Largemouth bass are a prime target of many anglers, but panfish make up the majority of species pursued. Each year in early spring, rainbow trout are stocked in the lake for a recreational put-and-take fishery along with bonus trout stockings for youth fishing rodeos. Herrington Lake was drawn down during the winter/spring of 2016 for a dam rehabilitation project that resulted in the loss of the majority of the fish population. Fish populations have been recovering since the drawdown. A total of eight fish species have been identified (Table 2) while four native SAV species were recorded during the 2016 survey and no invasive SAV species were observed (Table 1). Limited samples have shown one potentially toxic cyanobacteria has been observed at low concentration (*Woronichinia*) and five non-toxic cyanobacteria genera were observed (*Chroococcus*, *Coelosphaerium*, *Oocystis*, and *Pseudanabaena*).

Clopper Lake is a 90-acre impoundment on Long Draught Branch within Seneca Creek State Park in Montgomery County. Within the Seneca Creek watershed, the dam was built in 1975 for recreation and flood control. Clopper Lake averages 18 feet in depth with several shallow coves. Tree downfalls and beaver huts provide habitat in some areas of the lake for recreational fish species. Clopper Lake is one of only two lakes surveyed that doesn't have a poured concrete boat ramp.

Two native SAV species as well as two invasive SAV species were noted during the 2016 survey (Table 1). One of the native macrophytes observed, wild celery (*Vallisneria americana*), was planted in 2010 by DNR's Bay Grasses in Classes program and has been successfully growing in Clopper Lake ever since. The invasive SAV hydrilla dominates the macrophyte community, leading to targeted herbicide treatments in 2021 to control and hopefully eradicate its growth. Nine different fish species have been identified by the Fishing and Boating Service (Table 2). Several potentially harmful and toxic species of cyanobacteria (blue-green algae) have been identified (*Dolichiospermum planktonica, Aphanizomenon sp, Microcystis. incerta, Microcystis weissenbergii, Woronchinia*) as well as five non-toxic cyanobacteria species (*Aphanocapsa incerta, Chroococcus, Coelosphaerium, Oocystis, Pseudanabaena*). Benthic algae mats were composed of two potentially toxic cyanobacteria (*Nostoc, Microseria)* and other algae such as *Fragilaria* (diatom) and *Spirogyra* (green filamentous algae).

Lake Habeeb is a 243-acre drinking water supply reservoir in Allegany County within Rocky Gap State Park. The reservoir was formed in 1969 by damming Rocky Gap Run and is in the North Branch portion of the Potomac River watershed. Citizens enjoy boating, fishing, and swimming in the lake. The lower reaches of the lake provide a deep, rock bottom with cold water while the upper end is composed of a more shallow, muddy bottom.

A variety of habitat types can be found throughout the lake consisting of abundant aquatic vegetation, woody debris, and boulders, along with some fabricated habitat. This includes fifty-three reef balls that were installed in the summer of 2020, funded by the State Lakes Protection and Restoration Fund, to provide habitat enhancement. Lake Habeeb supports a very healthy fish population that provides anglers with a wide variety of warmwater, coolwater, and coldwater fish species. With a maximum depth of 74 feet, the lake waters stratify during the summer months and the deeper zone maintains cold, oxygenated water suitable for a "two-story" fishery. Rainbow trout and brown trout are stocked in the lake annually, providing anglers with a year-round recreational put-and-take trout fishery. Preferring temperatures below 68° F, trout retreat to the deep water during the summer. Lake Habeeb is also popular with bass anglers due to its healthy and abundant largemouth bass population. The cold, clean water from the lake supports a native brook trout population located just below the dam in Rocky Gap Run. Brook trout is Maryland's only native trout species. The lake has great biodiversity in fish, with 17 different species identified by the Fishing and Boating Service (Table 2).

Five different species of native macrophytes were identified in the 2016 SAV survey as well as two invasive species (Table 1). The entire shoreline, except for the swimming beach, is covered with macrophytes out to a depth of 15-20 feet. Of the invasive SAV species, an overabundance of hydrilla (*Hydrilla verticillata*) has caused concern in recent years. Monitoring and control efforts have been implemented to control this invasive species. While a baseline phytoplankton community has not been conducted for presence of cyanobacteria, the presence of microcystin (a cyanobacteria) has been noted during the National Lakes Assessment Surveys conducted by EPA in 2007, 2012, and 2017. Microcystin was detected in the sample from 2012 at a very low concentration (.08 ppb). Cyanobacteria species present included *Dolichiospermum sp*, *Aphanizomenon spp*, *Aphanocapsa spp* (dominant), *Microcystis sp* and *Synechococcus sp*.

St. Mary's Lake is a 250-acre impoundment situated in St. Mary's River State Park in St. Mary's County. It was formed by damming the Western Branch of the St. Mary's River in the Lower Potomac River watershed. The area is a popular fishing spot. The lake has been designated a trophy bass lake and, as such, special fishing regulations may be in effect.

Golden shiners have annually been stocked in the lake for several years to supplement the forage that is absent from the fish community. The Fishing and Boating Service has deployed fish attractors in the form of pickle barrel structures (sunken locust and Osage orange tree branches cemented into buckets) in select locations around the lake. Reef balls and anchored drainage pipe have also been installed along drop-offs around the lake. The highly invasive Northern snakehead (*Channa argus*) have migrated their way upstream in the St. Mary's River from the Potomac River and pursued by anglers in the lake spillway.

Two different species of native macrophytes were identified as well as one invasive species of SAV, hydrilla (Table 1). Seven different species of fish have been observed by the Fishing and Boating Service (Table 2). Three potentially toxic cyanobacteria species (*Dolchiospermum planktonic*, *Cylindrospermopsis* and *Aphanizomenon sp.*) were identified in 2016 samples and four non-toxic genera (*Aphanocapsa*, *Chroococcus*, *Aphanizomenon* and *Pseudanabaena*). In 2022, a potentially toxic cyanobacteria bloom of *Oscillatoria* occurred. Park staff posted animal health alert signs.

Savage River Reservoir is a 360-acre impoundment in Garrett County that was created by damming the Savage River in the North Branch Potomac River watershed within the Savage River State Forest. It is a shared resource, operated jointly by the Army Corp of Engineers and DNR. This reservoir is owned and operated by the Upper Potomac River Commission, for the primary uses of flood control and drinking water supply. It is the second of two state owned lakes that does not have a paved launch, so larger vessels are unlikely to be launched. There are, however, three locations on the reservoir where a canoe, kayak, or boat can be launched. The

lower reaches of the lake are deep, with widespread rock substrate. The upper end of the reservoir is more shallow with extensive areas of mud and silt bottom.

A variety of habitat types can be found throughout the lake consisting of woody debris, boulders, steep ledges, along with some fabricated habitat. Fishing and Boating Service staff have completed habitat enhancement projects by placing Christmas tree habitat structures and vertical post clusters throughout the lake. With a maximum depth of 184 feet, the lake stratifies during the summer months and the deeper zone maintains cold, oxygenated water suitable for a "two-story" fishery. Rainbow trout are stocked in the lake annually, providing anglers with a year-round recreational put and take trout fishery. Preferring temperatures below 68° F, trout retreat to the deep water during the summer. The tailwater fishery downstream of the dam, known as the Lower Savage River, supports a "Trophy Trout" area. This special management area was listed in the top 100 rivers in the U.S by Trout Unlimited. In 2010, the reservoir was drained to repair gate valves inside the dam that had suffered severe corrosion since its construction in 1952. Since then, both the lake and tailwater fishery have recovered and provide excellent fishing opportunities.

Due to the drawdown required to maintain a trout fishery in the Savage River, the lake level fluctuates greatly, limiting the ability of SAV to colonize and spread. While twenty two different species of fish have been identified by the Fishing and Boating Service (Table 2), only two species of native SAV have been observed (Table 1). No invasive species of SAV have been observed. Multiple species of cyanobacteria have been identified, with high densities of potentially toxic species. In 2007 the EPA National Lakes Assessment detected potentially toxic cyanobacteria and microcystin in Savage River Reservoir. In 2016, a visible bloom was noted throughout the lake. Two potentially toxic cyanobacteria were recorded (*Dolichospermum planktonica* and *Aphanizomenon*). Both are potential anatoxin (neurotoxin) producers. In 2021, a bloom of *Aphanizomenon flos-aquae* was observed and microcystins were 0.550 ppb (0.3 is the EPA drinking water threshold for children under age 5) and anatoxin (neurological cyanotoxin) was below detection limits. In addition, *Didymo* (aka Rock Snot) was identified for the first time in the reservoir in 2016.

Deep Creek Lake is a 3,900-acre reservoir in Garrett County formed by a dam on Deep Creek and lies within the Youghiogheny River watershed. Deep Creek Lake is one of only two state-owned reservoirs that is in the Ohio River drainage basin. Currently, there are nine primary access points to the reservoir; one public and eight private or community launches as well as over 1,900 permitted access points for non-motorized vessels. Impounded in the 1920s and filled by 1929, Deep Creek Lake is Maryland's largest freshwater impoundment, with a maximum depth of seventy-five feet and a mean depth of twenty-nine feet. Originally constructed for a hydroelectric dam, the lake now additionally serves many recreational purposes for its citizens,

including boating, fishing, swimming, and kayaking both on the Lake and on the downstream river

Deep Creek Lake supports at least 18 fish species (Table 2), including a variety of game species. The lake holds claim to the current state records for northern pike and bluegill and a previous record for yellow perch. Walleye, smallmouth bass, and largemouth bass are probably the most sought after gamefish in the lake and tournaments for these species are common throughout the year. The lake stratifies during the summer months leaving cold, deep, oxygenated zones, perfect for year-round trout survival. Annual stockings of brown and rainbow trout add to an already fantastic fishery. During winter months, after the lake freezes, the lake becomes a popular ice fishing destination. The ice allows fishermen access to the entire lake, otherwise only reached by boat. Deep Creek Lake provides many habitat types, including rocky shorelines, submerged woody debris, and aquatic vegetation flats that offer a variety of habitats for its diverse fish community. Through funding provided by the State Lakes Protection and Restoration Fund, materials were purchased to construct and deploy concrete reef balls at locations throughout the lake to enhance habitat.

Deep Creek Lake is home to 15 different SAV species as well as four invasive SAV species (Table 1). The invasive species hydrilla was first observed in 2013, prompting quick action to slow and eliminate its growth and spread. Beginning in 2014, an intensive targeted herbicidal treatment program was started and has been reduced to maintenance level treatment that is ongoing. Full details of the treatment program can be found in the "2020 Deep Creek Lake Hydrilla Management Plan and Report of Control Activity." (https://dnr.maryland.gov/fisheries/Documents/Hydrilla_Mgt_Plan.pdf). These hydrilla control activities are the largest single expense of State Lakes funds at this time.

Deep Creek has a history of euglena blooms. Cyanobacteria were first noted in 2009 and typically remain below bloom levels. Three potentially toxic species have been documented (*Microcystis* (*M. aeruginosa, M. wesenbergii, Woronichinia*) and two non-toxic species (*Aphanocapsa sp and Pseudanabaena)*. Microcystin levels are typically low (non detect - 2 ppb) but reached 8 ppb in a small cove in the summer of 2018 (prior to EPA establishing an 8 ppb threshold).

Table 1. Native and Invasive Submerged Aquatic Vegetation, SAV, species found in State Lakes (2016 survey results).

		New Germany Lake	Tuckahoe Lake	Myrtle Grove Lake	Blairs Valley Lake	Urieville Lake	Greenbrier Lake	Hunting Creek Lake	Smithville Lake	Unicorn Lake	Wye Mills Lake	Herrington Lake	Clopper Lake	Lake Habeeb	St. Mary's Lake	Savage River Reservoir	Deep Creek Lake
Native Sumbersed Macrophytes																	
Callatriche spp.	Water starwort									X		X					
Ceratophyllum demersum	Coontail					X				X							X
Chara spp.	Muskgrass	X			X			X				X				X	
Elodea canadensis	Common waterweed							X		X							X
Elodea nuttallii	Slender waterweed									X							X
Heteranthera dubia	Water stargrass							X									
Isoetes spp.	Quillwort																X
Lemna minor	Common duckweed					X			X	X							
Najas flexilis	Slender water nymph	X															X
Najas guadalupensis	Common water nymph	X					X						X	X			X
Potamogeton amplifolius	Largeleaf pondweed													X			X
Potamogeton diversifolius	Waterthread pondweed									X							X
Potamogeton nodosus	Longleaf pondweed													X			X
Potamogeton pusillus	Slender pondweed	X				X							X	X		X	X
Potamogeton robinsii	Robbins' pondweed	X								X							X
Potamogeton spirillus	Spiral pondweed						X	X							X		
Potamogeton vaseyii	Vasey's pondweed	X															X
Sagittaria cristata	Crested arrowhead											X					X
Utricularia spp.	Bladderwort						X					X			X		X
Vallisneria americana	Wild celery													X			X
Invasive Submersed Macrophytes																	
Eurasian Watermilfoil	Milfoil	X												X			X
Hydrilla verticillata	Hydrilla			X	X								X	X	X		X
Najas minor	Spiny Naiad	X			X			X		X			X				X
Potamogeton crispus	Curly pondweed					X											X
Egeria densa	Brazilian waterweed					X											
Pistia stratoites	Water lettuce			X													

Table 2. Fish species observed in State Lakes through 2020, MD DNR Fishing and Boating Service

		New Germany Lake	Tuckahoe Lake	Myrtle Grove Lake	Blairs Valley Lake	Urieville Lake	Greenbrier Lake	Hunting Creek Lake	Smithville Lake	Unicorn Lake	Wye Mills Lake	Herrington Lake	Clopper Lake	Lake Habeeb	St. Mary's Lake	Savage River Reservoir	Deep Creek Lake
Micropterus salmoides	Largemouth bass	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Micropterus dolomieu	Smallmouth bass													X		X	X
Lepomis macrochirus	Bluegill	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Lepomis microlophus	Redear sunfish		X	X	X	X	X	X	X	X	X		X	X	X	X	
Pomoxis nigromaculatus	Black crappie		X	X	X		X	X	X	X	X	X	X	X	X	X	X
Ictalurus punctatus	Channel catfish				X			X				X		X			
Perca flavescens	Yellow perch	X			X					X			X	X	X	X	X
Ameiurus nebulosus	Brown bullhead		X		X	X				X	X		X		X	X	X
Ameiurus natalis	Yellow bullhead													X		X	X
Cyprinus carpio	Common carp				X						X		X				X
Lepomis cyanellus	Green sunfish												X	X		X	
Notemigonus crysoleucas	Golden shiner	X	X			X			X		X	X	X	X		X	X
Catostomus commersoni	White sucker		X													X	X
Esox lucius	Northern pike																X
Esox niger	Chain pickerel		X			X			X	X		X			X		X
Salmo trutta	Brown trout													X			X
Oncorhynchus mykiss	Rainbow trout											X		X		X	X
Ambloplites rupestris	Rock bass															X	X
Lepomis gibbosus	Pumpkinseed	X				X				X	X	X		X		X	X
Etheostoma nigrum	Johnny darter																X
Sander vitreus	Walleye															X	X
Lepomis auritus	Redbreast sunfish													X		X	
Cyprinella spiloptera	Spotfin shiner													X			
Pimephales notatus	Bluntnose minnow													X		X	
Notropis atherinoides	Emerald shiner													X			
Lepomis gulosus	Warmouth			X													
Notropis hudsonius	Spottail shiner	X															
Esox lucius x masquinongy	Tiger muskie	X															
Campostoma anomalum	Central stoneroller															X	
Notropis procne	Swallowtail shiner															X	
Pimephales notatus	Blacknose dace															X	
Semotilus atromaculatus	Creek chub															X	
Salvelinus fontinalis	Brook trout															X	
Dorosoma cepedianum	Gizzard shad		X						X		X						
Erimyzon oblongus	Creek chubsucker		X						X	X							
Anguilla rostrata	American eel		X			X			X	X	X						
Gambusia affinis	Mosquitofish		X														
Esox americanus americanus	Redfin pickerel		X														
Enneacanthus gloriosus	Bluespotted sunfish					X											

State Lakes Expenditures

There were no expenditures in FY 18 or FY 19 as no funding was allocated to the State Lakes Program.. Expenditures for FY 20 were significantly delayed by Covid-19, with many projects getting a late start. Expenditures for FY20 totaled just $57,537. Despite continued delays with contractors and a protracted procurement problem, FY 21 saw a significant increase in spending, totaling $640,275. Many of the projects listed below had a significant portion of the work delayed a year or longer. Administrative costs for 2020 were $37,606.14, for 2021 administrative costs were $131,511.85. Administrative costs include all personnel costs associated with the grant including public outreach and field work.

2019-2020

Lake	**Project**
Deep Creek Lake	Hydrilla Control
Deep Creek Lake	Shoreline stabilization cost-share
Deep Creek Lake	Create and improve fish habitat
New Germany Lake	Invasive SAV population analysis
Herrington Lake	Invasive species assessment
Lake Habeeb	Invasive SAV assessment and control
Lake Habeeb	Hydrilla control within lake
Clopper Lake	Invasive SAV assessment and control
Greenbriar Lake	Invasive SAV assessment
Blairs Valley Lake	Hydrilla control
Hunting Creek Lake	Invasive SAV assessment and control
St. Mary's Lake	Fish habitat enhancement
St. Mary's Lake	Invasive SAV assessment and control
Tuckahoe Lake	Invasive SAV assessment and control
Tuckahoe Lake	Harmful algae bloom assessment
Smithville Lake	Harmful algae bloom assessment
Wye Mills Lake	Harmful algae bloom assessment
Myrtle Grove Lake	Invasive SAV assessment and control
Urieville Lake	Harmful algae bloom assessment
Urieville Lake	Sediment evaluation for potential dredging
Unicorn Lake	Harmful algae bloom assessment

2020-2021

Lake	**Project**
Deep Creek Lake	Hydrilla Control
Deep Creek Lake	Shoreline stabilization cost share
Deep Creek Lake	Create fish structures
Herrington Lake	Sediment evaluation for potential dredging
Herrington Lake	Purchase and deliver limestone to mitigate low pH

Lake Habeeb	SAV monitoring
Lake Habeeb	Fish habitat enhancement
Lake Habeeb	Hydrilla control (ramps only)
Clopper Lake	Invasive SAV monitoring and control
Clopper Lake	HAB monitoring
Blairs Valley Lake	Hydrilla control
Blairs Valley Lake	Sediment evaluation for potential dredging
Blairs Valley Lake	HAB monitoring
Blairs Valley Lake	Fish habitat enhancement
Hunting Creek Lake	Shoreline stabilization (day use area)
Hunting Creek Lake	HAB monitoring
Hunting Creek Lake	SAV monitoring
Hunting Creek Lake	Fish habitat enhancement
Hunting Creek Lake	SAV control
St. Mary's Lake	Sediment evaluation for potential dredging
St. Mary's Lake	SAV restoration
Tuckahoe Lake	Vegetation control around perimeter
Tuckahoe Lake	HAB monitoring
Smithville Lake	HAB monitoring
Wye Mills Lake	HAB monitoring
Unicorn Lake	HAB monitoring

Dredging Maintenance

Most of the lakes owned by Maryland are more than fifty years old. Some, including Herrington Lake and Deep Creek Lake, are almost one hundred years old. All lakes experience some degree of natural sediment and nutrient loading as a result of storm events, erosion, and natural inputs from the streams and rivers that were impounded to create them. While the sedimentation and eutrophication of lakes is a naturally occurring process, this phenomenon is greatly accelerated by anthropogenic factors including excessive runoff from urban development, agricultural practices and in some cases shoreline erosion. Maryland's lakes serve as a sink for any inputs coming into them. The sediment and nutrients build up over the years with no natural outlet. In an undisturbed watershed, this process would take place slowly over hundreds or thousands of years. In Maryland, anthropogenic impacts accelerate this process such that significant shifts in lake ecological processes, fish, and wildlife can be observed within decades.

Increased sedimentation eventually restricts recreational access for boaters as lakes continually lose depth. This starts in the headwaters of the lakes and gradually moves towards the dams. All the state-owned lakes are already experiencing this to some degree. The upper reaches of many

of our lakes are already completely inaccessible to boaters (e.g. Unicorn Lake, Herrington Lake). Urieville Lake is so filled with sediments resulting in the majority of the lake being less than two feet deep. Even in Deep Creek Lake many of the coves are becoming less and less accessible to boating due to sediment input from feeder streams. This reduction in lake volume can significantly impact fish populations as water becomes shallower and warmer.

As the structure and chemistry of a lake changes, it may become uninhabitable to species for which it was once well suited. Trout may no longer be able to survive in rising water temperatures as cool, deeper waters and substrate are gradually filled in and lost. Eutrophication of lakes greatly impacts ecosystem dynamics as well. Increases in nutrients lead to increases in SAV growth and algae blooms. While SAV is part of a healthy ecosystem, an excess of nutrients can lead to an overabundance of SAV growth as well as a change in the biodiversity of SAV. An overabundance of macrophytes can make recreational boating frustrating or even impossible (e.g. Urieville Lake). Algae blooms can occur more frequently and may consist of toxic species, or HABs. The proliferation of algae blooms can cause waters to become unsightly and may even pose health concerns via contact or ingestion to humans and wildlife. There are several cases of otherwise healthy canines dying quickly after swimming in or drinking from lakes with active HAB blooms.

Periodic maintenance dredging can remove excess sediments as well as nutrients bound to those sediments to help restore the original morphology of lakes. Very little dredging has been performed on the 16 state-owned lakes. In fact, none of our state-owned lakes have had any maintenance dredging to date. Several factors can be inhibitive to dredging, with cost being the primary inhibitor. Before dredging begins, soil samples throughout the area to be dredged are usually obtained and analyzed for soil composition and elemental analysis. The dredge material must be dewatered and transported off-site.

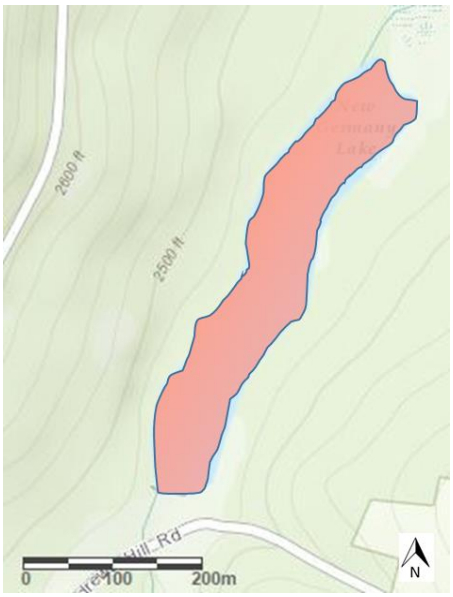
While dredging impaired waterbodies can be hugely beneficial for many reasons, it can also be costly due to the various stages required throughout the process. The first step is to test the sediment to be removed for composition and possible contaminants to determine the best end use of the material. Engineers must be contracted to devise a comprehensive plan that includes the volume of sediment that should be removed, how it should be removed, and where it should be relocated. Additionally, the dewatering of the sediment typically involves water that needs to be treated for nutrient discharges. There are a multitude of state and federal regulations to adhere to, requiring interagency involvement and approvals. Heavy machinery is most often used to remove sediment and can be costly. Relocating the sediment can also be costly, depending on the distance it is transported and the volume. Costs at the different stages can vary greatly depending upon many factors specific to each project, with a very general estimate in the range of cost being $50-$150 per cubic yard of sediment dredged. The cost of dredged material transport and disposal is often a significant barrier to dredging projects.

Because so little dredging maintenance has been conducted or initiated in the state-owned lakes to date, the first step in the process is simply gathering information about which lakes would benefit from dredging and where and to what extent they need to be dredged. To this effort, the park manager for each state-owned lake was contacted and asked for their input. Based on their feedback in conjunction with the applicable knowledge of other stakeholders, maps of each lake were created with proposed areas that could benefit from being dredged. Several of the lakes would benefit from lake-wide dredging. Without performing sediment analyses and contracting engineers to begin assessing the lakes and devising an expert plan, only hypothetical recommendations and cost estimates can be made. The following are back of the envelope calculations intended to give a very rough idea of the costs that might be associated with these projects. These estimates do not include all potential costs and in most cases are likely to be underestimates.

Tuckahoe Lake is a great example of a state-owned resource that would benefit from lake-wide dredging. The assistant park manager has maintained the property for almost 2 decades and knows the lake and its history well. She has observed a significant loss of overall depth throughout the lake over the years due primarily to local agricultural runoff. Tuckahoe State Park recently installed an ADA compliant kayak launch adjacent to the boat ramp. Both the boat ramp and kayak launch are very desirable and valuable resources for citizens to enjoy, but are unfortunately almost unusable due to excessively shallow water resulting from sedimentation. Compounding the loss of depth is the growth of the invasive smartweed along the shoreline, further increasing the impassibility of these launches. An herbicidal treatment program is currently underway to address the removal of smartweed, but there is no current plan to address the sedimentation and loss of depth. Many of the state-owned lakes have similar conditions that are leading to an unfortunate loss in recreational access and value as well as loss of habitat. Should these conditions persist or perhaps worsen, the Use Class designation of these lakes could be changed during MDE’s triennial review.

To get a gross estimate of possible dredging costs, we created a series of maps (below) of each state-owned lake with area(s) that have significant sediment accumulation in pink. "Acres with significant sediment accumulation" is a rough approximation of areas that could potentially have sediment removed. Depth of dredging required is also generally unknown without further analysis and is approximated based on historical knowledge of lake depth versus current depth measurements. Proposed cost estimates range from $50 per cubic yard to $150 per cubic yard and may also vary greatly depending upon the many factors previously mentioned. Most lakes would likely need more than one foot of sediment removed. The one foot of removed dredge material estimate is provided as a baseline estimate, while the three feet of removed sediment estimate shows the impact of the amount of material removed on overall project cost.

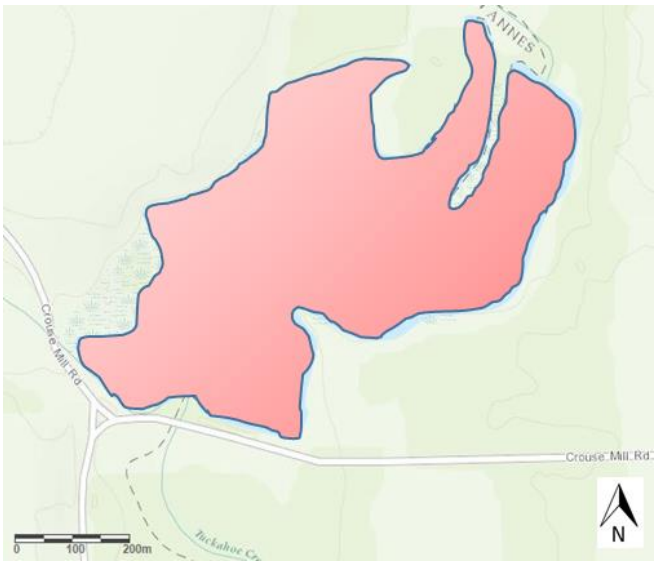
New Germany Lake



Approximate acres with significant sediment accumulation: 13

Approximate Cost Range:	One Foot Deep	$1,048,650 - $3,145,950
	Three Feet Deep	$3,145,950 - $9,437,850

Tuckahoe Lake



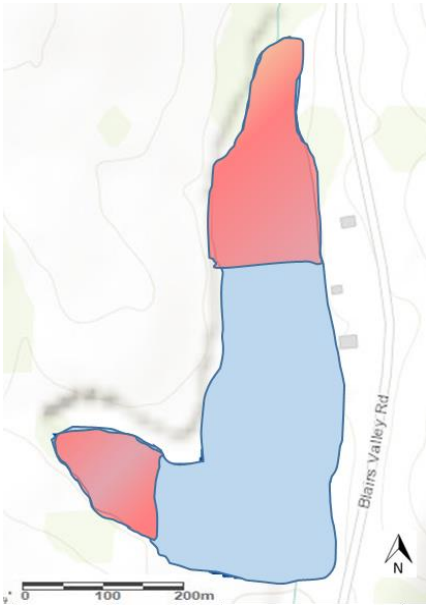
Approximate acres with significant sediment accumulation: 19

Approximate Cost Range:	One Foot Deep	$1,532,650 - $4,597,950
	Three Feet Deep	$4,597,950 - $13,793,850

Myrtle Grove Lake

No dredging required
Approximate acres with significant sediment accumulation: 0
Approximate Cost Range: $0

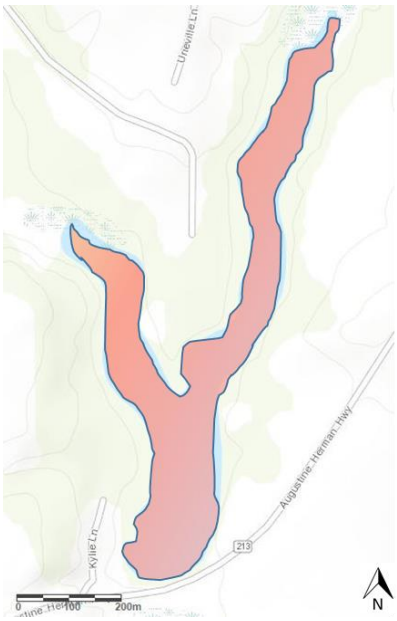
Blairs Valley Lake



Approximate acres with significant sediment accumulation: 32

Approximate Cost Range:	One Foot Deep	$2,581,350 - $7,744,050
	Three Feet Deep	$7,744,050 - $23,232,150

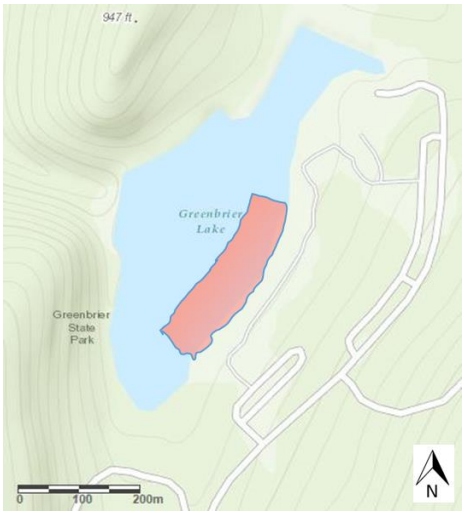
Urieville Lake



Approximate acres with significant sediment accumulation: 35

Approximate Cost Range:	One Foot Deep	$2,823,350 - $8,470,050
	Three Feet Deep	$8,470,050 - $25,410,150

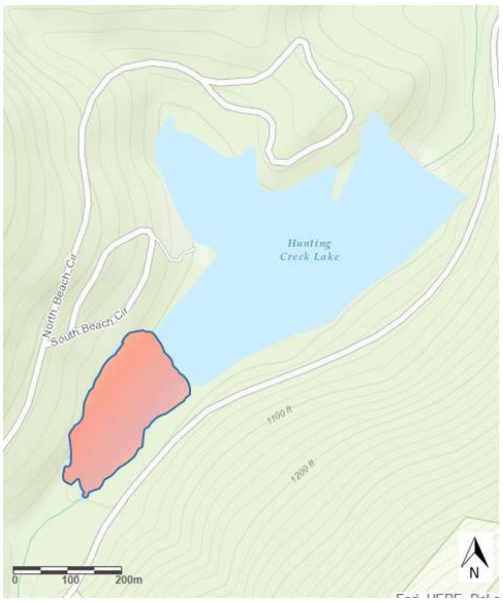
Greenbrier Lake



Approximate acres with significant sediment accumulation: 8.5

Approximate Cost Range:	One Foot Deep	$685,650 - $2,056,950
	Three Feet Deep	$2,056,950 - $6,170,850

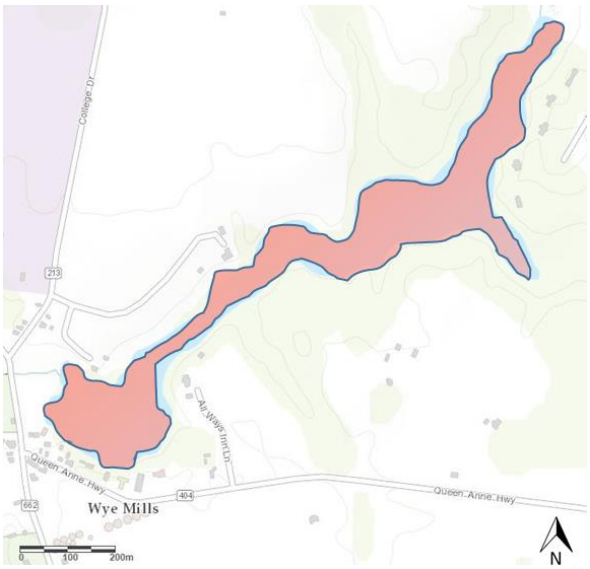
Hunting Creek Lake



Approximate acres with significant sediment accumulation: 8.6

Approximate Cost Range:	One Foot Deep	$693,750 - $2,081,250
	Three Feet Deep	$2,081,250 - $6,243,750

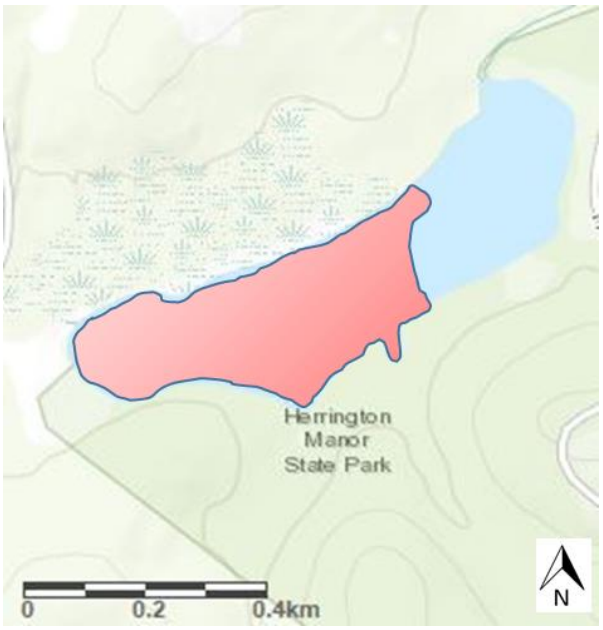
Wye Mills Lake



Approximate acres with significant sediment accumulation: 50

Approximate Cost Range:	One Foot Deep	$4,033,350 - $12,100,050
	Three Feet Deep	$12,100,050 - $36,300,150

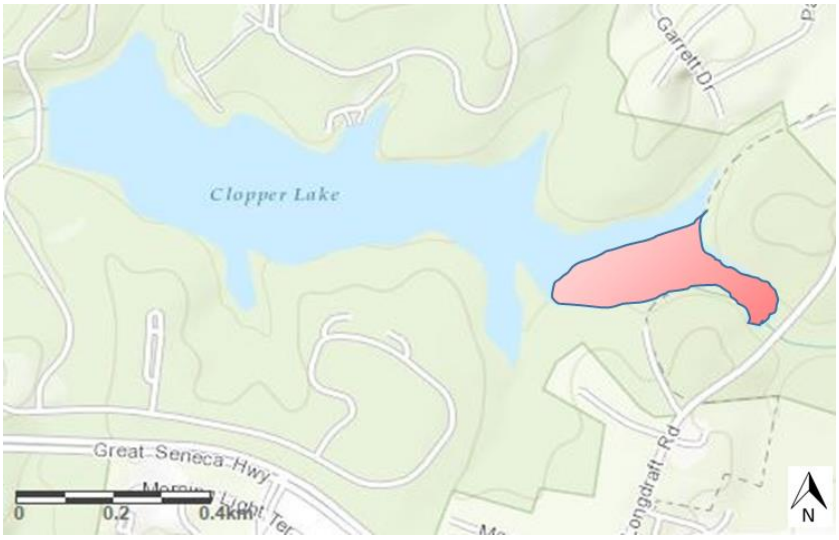
Herrington Lake



Approximate acres with significant sediment accumulation: 35

Approximate Cost Range:	One Foot Deep	$2,823,350 - $8,470,050
	Three Feet Deep	$8,470,050 - $25,410,150

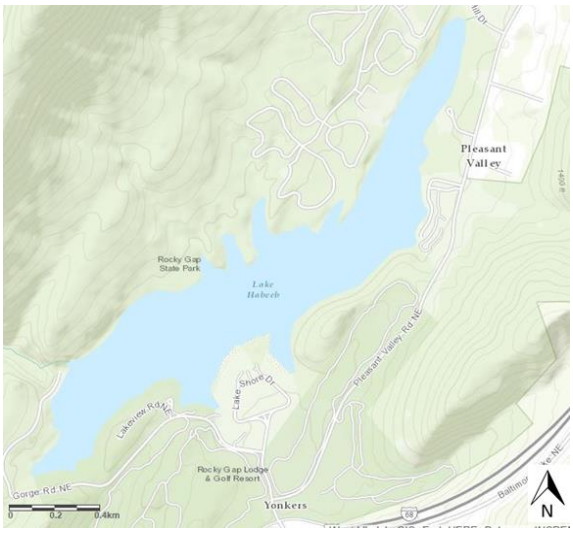
Clopper Lake



Approximate acres with significant sediment accumulation: 11.25

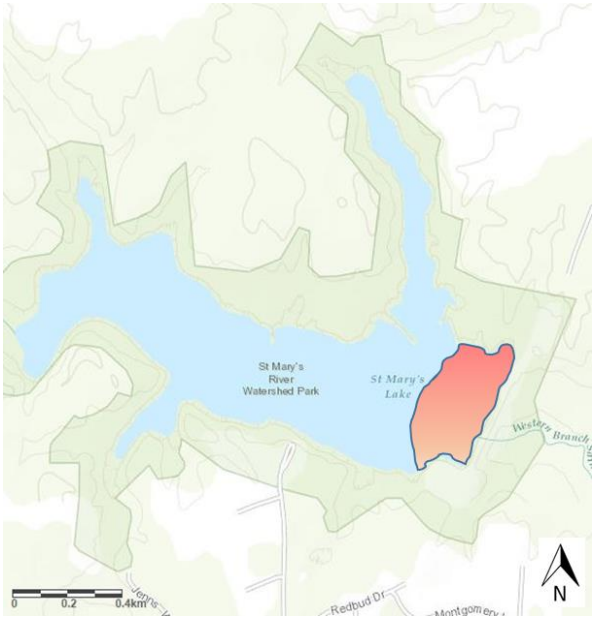
Approximate Cost Range:	One Foot Deep	$907,500 - $2,722,500
	Three Feet Deep	$2,722,500 - $8,167,500

Lake Habeeb



No dredging required
Approximate acres with significant sediment accumulation: 0
Approximate Cost Range: $0

St. Mary's Lake



Approximate acres with significant sediment accumulation: 42

Approximate Cost Range:	One Foot Deep	$3,388,000 - $10,164,000
	Three Feet Deep	$10,164,000 - $30,492,000

Currently, a project to dredge Arrowhead Cove in Deep Creek Lake is being designed. It is in the early stages of design, so many details of the project are subject to change. It has been estimated that 15,000 cubic yards of material will be removed at $147 per cubic yard for a project cost of $2.2 million. This is not the total cost of the project, however, as about $400,000 was spent on pre-design work and other costs have not yet been factored in, such as repaving roads and repairing bridges.

A small dredging project is also in process for Urieville Lake. The project is fully permitted and approved to remove a minimum of 500 cubic yards of sediment from around the boat ramp for $300,000. Funding includes transportation of the removed material to a disposal area at Cypress Branch NRMA, necessary improvements to a gravel road needed to access the disposal site, and protective fencing around the site after the work is completed.

Invasive SAV Management and Eradication

Lake managers of some lakes reported that SAV populations interfered with public use. While SAV is generally a healthy part of an aquatic ecosystem, non-native species can adversely impact the biodiversity of grass beds as well as negatively impact fish populations and other aquatic fauna by becoming so dense that they interfere with boating. An overabundance of SAV, most often by non-native species, can lead to the species becoming a nuisance for boating and fishing by making waters less navigable and fish less accessible. Chemical treatments with herbicides are an effective way to control SAV populations and ensure invasive species are not impacting the lake ecosystem or the recreational use of the lake.

Treatment was requested at four lakes in 2020; Herrington Lake, Hunting Creek Lake, Clopper Lake and Lake Habeeb. Tuckahoe State Park requested help for Tuckahoe Lake to control the non-native smartweed (*Polygonum hydropiperoides*) which grew along much of the shoreline, preventing fishing. After follow-up surveys were conducted, it was determined that the SAV at Herrington Lake creating a nuisance was native, so the treatment for that park was canceled for 2020.

At Hunting Creek Lake, spiny naiad (*Najas minor*) was present in the swimming area and was limiting water access. Control was requested in the cove with the swimming beach, but not the rest of the lake. Blairs Valley NRMA had hydrilla control throughout the entire lake, so a whole lake treatment was requested. Clopper Lake and Lake Habeeb had hydrilla in certain coves with higher recreational use, so only those coves and ramps were treated. At Lake Habeeb, a separate chemical was used to treat the area adjacent to the drinking water intake, as there were concerns over possible effects to the filtration system.

2020
Tuckahoe Lake did not get positive control on the smartweed as needed. Smartweed came back very quickly to the treated areas. Hunting Creek saw positive control of the spiny naiad in the treatment area, and none was detected post treatment. Lake Habeeb saw positive control of hydrilla; it was still present with ground level plants but the canopy was reduced. Clopper Lake had positive control, but hydrilla persisted in some coves.

2021
Treatment was requested in five lakes in 2021: Tuckahoe Lake, Clopper Lake, Lake Habeeb, Hunting Creek Lake and Blairs Valley Lake. Tuckahoe Lake requested that a licensed herbicide applicator treat there given the poor results of 2020, with the treatment being broken into smaller blocks. The Clopper Lake and Hunting Creek Lake treatments remained the same in 2021. Blairs Valley Lake continued the whole lake treatment for 2021.

2022
Treatment was requested in five lakes in 2022: Tuckahoe Lake, Clopper Lake, Lake Habeeb, Hunting Creek Lake and Blairs Valley Lake. The Clopper Lake and Hunting Creek Lake treatments remained the same as in 2021. Blairs Valley Lake continued the whole lake treatment for 2022.

Improving Ecological and Recreational Value of State-owned Lakes

Improving the ecological and recreational value of state-owned lakes will require sediment removal and invasive species controls. Additionally, many lakes need nutrient loads to be reduced. Nine of the priority state-owned lakes have been listed as impaired due to phosphorus impairment (Clopper Lake, Deep Creek Lake, Hunting Creek Lake, Greenbrier Lake, Lake Habeeb, Myrtle Grove Lake, St. Mary’s Lake, Unicorn Lake, Urieville Lake and Wye Mills Lake). Out of the seven that are not listed as impaired, two have been shown to have toxic cyanobacteria (Smithville Lake, Unicorn Lake).

Table 5: Cyanobacteria species found at each lake and if toxins were present (pink box) or greater than EPA recreational contact threshold (red box). Green columns indicate potentially toxic species.

Lake	No contact advisory	approved TMDL	*Anabeana sp.*	*Dolichospermum flosaqua*	*planktonic*	*Anabaenopsis*	*Aphanizomenon*	*Aphanocapsa*	*Chroococcus*	*Coelospaherium*	*Cuspidothrix*	*Cylindrospermopsis*	*Merismopedia*	*Microcystis*	*Oocystis*	*Planktothrix*	*Pseudanabaena*	*Synechococcus*	*Woronichinia*	*Lyngbya- benthic*	*Microseria wollei- benthic*	*Nostoc- benthic*	*Oscillatoria- benthic*	*Phormidium- benthic*
Blairs Valley																								
Clopper Lake		P, S	X		X		X	X	X	X		X		X	X		X		X		X	X		X
Deep Creek Lake		P																						
Greenbriar																			X					
Herrington									X	x					X		X		X					
Hunting lake					X		X							X					X	X			X	X
Lake Habeeb		N/P			X		X	X						X				x						
Myrtle Grove					X			X	X	X	X	X	X		X									
New Germany								X	X		X								X					
Savage Reservoir		Hg			X		X																	
Smithville Lake														X						X	X		X	
St Mary's lake					X		X	X	X			X					X						X	
Tuckahoe lake																								
Unicorn Lake								X	X					x			X			X	X		X	X
Urieville									X											X	X			
Wye Mills					x		X						X	X		X			X		X		X	

Nutrient rich sediments that accumulate in lakes help fuel algae blooms. In addition to nutrients, decreased depths of the lakes, along with increasing air temperatures and increased drought periods make ideal conditions for toxic cyanobacteria to bloom.

Cyanobacteria blooms are increasing globally. Additional methods may need to be implemented to help alleviate blooms and maintain recreational use. Other lakes in Maryland have used barley straw additions, winter drawdown, aerators/sonicators, and chemical methods (e.g. green clean, hydrogen peroxide). Innovative methods such as wood chip bioreactors and small stream/ditch weirs to intercept nutrient pathways may help to reduce nutrient loading.

Recommendations for State Lakes

To maintain and restore the aesthetic and recreational value of Maryland's owned lakes, most lakes need to be dredged due to their sedimentation which restricts recreational access for boaters and leads to water quality issues including harmful algae blooms. Efforts need to be made to deter invasive species and assess water quality in a standardized manner. Assessments should include measuring the abundance and diversity of fish and SAV populations, regular water quality monitoring and sampling for potential HABs. Continued and regular monitoring of these

parameters will greatly increase DNR's knowledge of current lake health and allow these data to drive decision-making toward what's best for lake wildlife and recreation. Regular and cohesive communication among park managers, DNR staff, and other involved partners will also contribute to effective management strategies.

DNR recently contracted the University of Maryland, Chesapeake Biological Laboratory (CBL) to conduct baseline water quality monitoring and analysis at every state-owned lake except Deep Creek Lake, which already has a monitoring program. Creating a comprehensive dataset for water quality at every lake over a short period of time will allow DNR staff to compare lake chemistry between lakes. This will help us offer educated suggestions for future management.

Many of the recommendations will be similar among many of the lakes, such as requiring some level of dredging to restore their full health and functionality, while other recommendations are specific to a lake's particular ecosystem or recreational uses, such as restoring public swimming areas and removing excess nutrients through licensed treatments. Dredging improves habitat as well as removes built up nutrients (which can help reduce harmful algae blooms). Following are recommendations to improve habitat and ecosystem health for each lake:

New Germany Lake
A DNR study found that the lake has accumulated roughly two to four feet of sediment lake-wide over its long history. During the almost two centuries of its existence, no maintenance dredging has been carried out on this lake. It is suggested that the entire lake be dredged to return its bathymetry to its historical depths to preserve this lake's rich history and recreational value.

Tuckahoe Lake
Tuckahoe Lake would benefit greatly from lake-wide dredging. This would allow the newly installed ADA kayak launch and boat ramp to be further enjoyed by citizens so they can launch their vessels without quickly getting stuck in the mud. It would also provide more habitat for wildlife. A sediment survey and analysis should be conducted by MGS to acquire baseline sediment data of the lake as well as provide necessary information for potential dredging. Further treatment of the invasive smartweed is also necessary to make these launch sites more navigable as well as to curtail the negative impacts of this non-native species on the lake ecosystem. It is important to address the sources of agricultural runoff to prevent the lake from becoming filled in with sediment and other debris yet again.

Myrtle Grove Lake
Myrtle Grove Lake is a shallow, unusual lake with a very small watershed and no known need for dredging at this time. Ideally, a sediment survey and analysis should be carried out to learn more about the lake's current status and historical morphology. After this information is obtained, it can be better determined if any portion of the lake would benefit from dredging. The manager did report, however, a nuisance emergent plant that is proliferating and becoming an

impediment to recreational fishing. Based on their description, it is likely American lotus that is growing abundantly and becoming invasive. Work remains to analyze the extent to which recreational activities and quality of wildlife habitat are being affected. Based on this analysis, biologists can determine with lake management staff if an eradication plan is needed and the best course of treatment.

As a potential drinking water source, routine cyanobacteria monitoring should be established to ensure water is clean enough to be used for public water supply.

Blairs Valley Lake

Dredging in two locations at Blairs Valley Lake would help restore both habitat to aquatic life, and access to anglers and boaters. The upper end of the lake near its input from Little Conococheague Creek as well as its westernmost reach have both heavily silted in over the years and become shallow and would benefit from having excess sediment removed. This would restore more areas within the lake for boating and fishing. Blairs Valley Lake has also experienced the adverse effects of the invasive macrophyte hydrilla. While two herbicidal treatments have been performed to establish control and eradication of hydrilla, it has persisted within the shallow areas of the lake. Further treatments are necessary to continue to combat its growth and establish control over the non-native species. Dredging these shallow areas could have the added benefit of making these areas less habitable to hydrilla.

As a potential drinking water source, routine cyanobacteria monitoring should be established to ensure water is clean enough to be used for public water supply.

Urieville Lake

Due to the overall and extreme shallow conditions at Urieville Lake, lake-wide dredging is necessary to restore the lake to its fullest health and recreational use. In most areas, the lake is currently only 1-2 feet deep, restricting anglers from boating and providing very little habitat for wildlife. A very localized dredge project is planned for Fall 2022 that will remove sediment from the boat ramp and the area immediately surrounding it. While it is positive to have a dredging project planned, this project will only address a very small portion of the lake's need for sediment removal and much of the lake will remain unnavigable.

Two non-native macrophytes, curly pondweed (*Potamogeton crispus*) and brazilian waterweed (*Egeria densa*), are present in the lake. If they remain an issue after reclamation work is complete a management plan can be created.

To help prevent the infilling of Urieville Lake again, the point and nonpoint sources of runoff should be addressed. The lake manager will be very helpful with this measure, as they are already aware of the local activities that are negatively impacting their lakes. Possible solutions

to curtail the excessive input of sediment into the lake include implementing best management practices for local agricultural land and ensuring there are sufficient riparian buffers to help absorb runoff and capture some of the nutrients and sediments that otherwise would run straight into the lake.

A benthic algae survey should be conducted to more fully understand the extent of eutrophication of the lake.

Greenbrier Lake

Overall, Greenbrier Lake is one of the healthiest of the state-owned lakes. While it may not require intensive actions for lake health restoration, it would still benefit from some maintenance and improvement projects to maintain its pristine status. As a result of lowering the lake to make necessary repairs to the dam, significant erosion of the sand in the swimming area occurred. Dredging this area to restore a desirable depth in which to swim as well as restoring lost sand to the beach would be very beneficial. The lake may need to be lowered again in the near future as part of ongoing repairs to the dam, which could be an ideal and cost saving time to dredge the swim area. A sediment survey and analysis should also be performed to learn more about the lake's current and historical sediment profile.

The lake has begun plans for a waterfront restoration project. While there is already a boat ramp, there is currently no ADA compliant kayak launch. Adding this feature to the waterfront project would greatly add recreational value to the lake. In addition, there are multiple areas around the shoreline of the lake that require vegetative restoration and stabilization as a means to prevent erosion and further filling in of the lake. There are also bulkheads near the dam that need to be replaced.

Additional cyanobacteria monitoring should be conducted to determine the extent of potentially toxic cyanobacteria blooms.

Hunting Creek Lake

Hunting Creek Lake would benefit from having its headwaters near Big Hunting Creek dredged as this area has filled in over the years. A sediment survey and analysis should also be performed so the state has baseline information about the lake's sediment structure and further understanding of dredging needs.

The lake has suffered from chronic algal blooms, including some that have been harmful and have forced the state park to close the otherwise heavily used public beach due to water contact health concerns. Regular water quality monitoring would be beneficial to learn more about the cause and seasonality of these algal blooms. To help reduce the concentration of nutrients in the lake that fuel algal blooms, the park manager and DNR are investigating the application of Alum

treatments that would help permanently bind phosphorus out of the water column and help inhibit algal blooms. This method is used in many systems across the U.S.

The lake has also experienced impediments to its recreational areas, mainly the swimming beach, due to an abundant growth of the non-native macrophyte spiny naiad. Herbicidal treatments have achieved positive control of the invasive but continued monitoring and management is necessary as these species can sometimes return if not closely observed early in the treatment stages.

Smithville Lake

A noticeable decrease in water quality has been observed in Smithville Lake in recent years and is thought to be a contributing factor to the decline in fish quality and abundance, most notably within the largemouth bass (*Micropterus salmoides*) population. The lake manager has been able to determine that the primary nonpoint source of nutrients and sediments is agricultural runoff. These effects are compounded by the removal of water from the watershed for agricultural irrigation which reduces the natural flushing that would occur. Best management plans can be created and implemented, such as restoring riparian buffers, improving agricultural fertilizer application and reducing nutrient runoff, and creating or improving stormwater management systems, to ultimately reduce the negative impacts of local agriculture on Smithville Lake. A sediment survey and analysis should also be conducted to gather baseline data for the lake's sediments and further understand its dredging needs.

A benthic algae survey should be conducted to more fully understand the extent of eutrophication of the lake.

Unicorn Lake

A sediment analysis should be performed to obtain baseline information about the lake's sediment structure and potential dredging needs. A benthic algae survey should be conducted to more fully understand the extent of eutrophication of the lake.

Wye Mills Lake

Lake-wide dredging is necessary to restore Wye Mills Lake to its healthiest state. Siltation throughout the entire lake is the result of runoff from agriculture in the watershed. This has resulted in the lake becoming more shallow and areas that were once navigable by boat are no longer accessible. Increased nutrient inputs have also resulted from this runoff and have negatively impacted the lake. Further investigation into the sources of sediment and nutrient runoff should be conducted to determine the best management strategies to curb their entry into the lake. A sediment survey and analysis should also be conducted to gain historical and current knowledge of its sediment structure and further determine dredging needs.

Herrington Lake

Herrington Lake is yet another state-owned lake whose health would improve greatly in multiple ways by being dredged. Herrington Manor State Park, in which Herrington Lake resides, has received multiple requests from a concerned citizen who has enjoyed an annual camping and fishing trip with family over the last 45 years. He has witnessed the significant loss of lake volume due to sediment inputs and the resulting decrease in fish abundance and boating accessibility. He loves the lake and enjoys all it has to offer with his family but is understandably disappointed that it is slowly able to offer less and less recreational value. While only a sediment analysis of the lake can inform managers about the full extent of sedimentation, anecdotal observations are very helpful in providing information about the lake's use by citizens and changes in morphology and character over time.

As a potential drinking water source, routine cyanobacteria monitoring should be established to ensure water is clean enough to be used for public water supply.

Clopper Lake

Clopper Lake has much to offer its visitors and would benefit from having the upper portion of the lake near its headwaters dredged. This area has become very muddy and shallow and traps a lot of debris. The lake is more stagnant where it has filled in and has resulted in loss of habitat as well as impeded recreational boating. A sediment survey and analysis should be carried out to obtain a baseline understanding of the lake's sediment structure and as a first step in determining its dredging needs.

Lake Habeeb

One of the few state-owned lakes without sedimentation concerns, Lake Habeeb does not have any need for any dredging projects at this time. It would still be beneficial to perform a sediment survey and analysis to have a baseline knowledge of the lake's current and historical sediment background.

Lake Habeeb does, however, have concerns with invasive SAV. Both hydrilla (*Hydrilla verticillata*) and American Lotus (*Nelumbo lutea*) are present in the lake and chemical treatments have already been applied to help manage and eradicate these species. While some control has been achieved, the invasives still persist in their presence and continued treatments are recommended to achieve complete positive control. It can require multiple treatments each growing season for several years to fully achieve the desired results. Continued monitoring and herbicidal treatments as needed is imperative to eradicate these undesirable and harmful species. In addition to these two species, Lake Habeeb also has spiny naiad (*Najas marina*) and Eurasian milfoil (*Myriophyllum spicatum*) present, which are also non-native. Currently, these species are not being treated and there is no management plan in place yet to eradicate them. Further assessments should be performed to determine the extent of their growth and possible

impairment to recreational activities and the ecosystem. Based on this information, it can then be determined how best to manage these invasive species.

Lake Habeeb has an ADA accessible dock with a path that is currently in disrepair. The path should be restored to its fullest safety and functionality so that this resource may be safely enjoyed by citizens.

The lake also suffers from consistent water advisories due to elevated bacterial levels caused by *E. coli*. Further analysis should be carried out to determine the cause of these elevated levels and a management plan should be created to help prevent unsafe levels from persisting. If it is determined that high levels of phosphorus are fueling the harmful levels, licensed Phoslock treatments may be necessary to remove excess phosphorus from the ecosystem. A possible reason for the elevated E. coli levels is an abundant waterfowl population If this is determined to be true, measures can be taken to prevent the waterfowl from inhabiting the area around the swimming beach.

St. Mary's Lake

Dredging the lower end of St. Mary's River Lake by the dam would be very beneficial as there is a gate near the bottom that can be used to help control the water level that can get blocked by debris and sediment. During the summer of 2022, a neon green benthic algae was consistently found in the lake and raised suspicion due to its unnatural bright green color. Initial identification cautioned that it could be a toxic cyanobacteria. Samples were sent to the Maryland Department of the Environment for further identification and results have yet to be determined. Regular water quality monitoring as well as HABs testing should continue to better track the conditions enabling these blooms to occur. If harmful blooms continue to occur, further assessments should be done to create a management plan to ensure the water is safe for human recreational use and wildlife.

Park managers and DNR staff are currently working on removing invasive species along the shoreline and replacing the removed vegetation with native species. Efforts to remove the invasives should continue and these sites should also continue to be monitored to ensure the invasives do not return, as it can take several attempts initially to fully eradicate them.

Savage River Reservoir

A sediment survey and analysis should be conducted to obtain baseline data of the lake's sediment structure. As a drinking water source, routine cyanobacteria monitoring should be established to ensure water is clean enough to be used for public water supply.

Deep Creek Lake

Deep Creek Lake provides Maryland the greatest amount of tourism and revenue among the state owned lakes. Its preservation and restoration are vital to the state's economy and year round recreational value to citizens. As with many other desirable locations in the state to live and vacation, development within the watershed has greatly increased. Increased development results in increased impervious surface and urban runoff, delivering increased sediment and nutrient loads directly into the lake. To help mitigate these effects, attention needs to be paid during developmental planning to stormwater control, smart growth, and reestablishing riparian buffers along the lakes shoreline and surrounding area.

As referenced above, a small dredging project is currently being designed in Arrowhead Cove. This could help with restoring the accessibility and available habitat within the lake. There are other coves and portions of the lake that would also benefit from sediment removal. Further analysis and planning is necessary to determine these locations.

Outlook for the Work of the Fund After the Funding Mandate Sunsets

Were the fund to sunset, costs for these projects would be incurred by the DNR units responsible for each lake. As much of this work began thanks to this new funding source, some or all of this work is likely to stop.

Conclusion

The funds made available for state-owned lakes have provided an important opportunity to protect and restore these lakes. SAV and HAB monitoring and management, water quality monitoring, shoreline restoration and habitat enrichments of state-owned lakes have all been funded by this program. Current funding levels for the program are insufficient to perform the dredging needed to restore these lakes to their original depths.