

DEEP CREEK LAKE ARROWHEAD COVE DREDGING PROJECT LESSONS LEARNED REPORT

FINAL



Prepared for:

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Executive Summary

Deep Creek Lake, located in Garrett County, Maryland, serves as a crucial resource for public water supply and recreation. Spanning approximately 3,900 acres, the lake was constructed in 1925 and is a significant economic and ecological asset to the region. Despite its importance, Deep Creek Lake has experienced considerable sediment accumulation, primarily in its southern coves, since its creation. In 2017, the Maryland Environmental Service (MES) and Anchor QEA (Anchor) conducted the Deep Creek Lake Dredging Cove Evaluation Report, analyzing ten sediment-impacted coves. This report considered factors such as its popularity for public boating activities and the feasibility of dredging operations in terms of engineering and environmental impact, and ultimately selected Arrowhead Cove for dredging. On December 10, 2018, Garrett County commissioners sought legislative support through a bond bill to fund a pilot project for sediment removal in Arrowhead Cove. In response, the state of Maryland through the Maryland Department of Natural Resources (DNR) allocated \$2.2 million for the Deep Creek Lake Arrowhead Cove Dredging Project. Spearheaded by Garrett County Government in collaboration with MES, and supported by Anchor as the design engineer, the project sought to remove accumulated sediment in Deep Creek Lake's Arrowhead Cove through mechanical removal. A competitive sealed bid process resulted in contracting Byco Enterprises, Inc. for the task. Commencing in November 2023, the dredging operation successfully removed approximately 11,000 cubic yards (cy) of sediment by January 2024.

The Deep Creek Lake Arrowhead Cove Dredging Project served as a pilot dredging project to indicate the feasibility of future dredging projects in Deep Creek Lake. The implementation of this project provided some valuable lessons learned for potential future dredging projects, including, but not limited to, project timing, methodology, and funding. Deep Creek Lake provides significant recreational opportunities during the summer months. To minimize impacts to the recreational activities dredging was limited to the colder months. However, this impacted the limits of both the volume of material that can be successfully removed and dredging methods due to the weather conditions in the colder winter months. For any future dredging projects, especially ones that are larger in scale, the more of these conditions that can be remediated or removed, while still limiting detrimental environmental and recreational impacts, the more robust sediment removal programs can be implemented.

Project Background

Deep Creek Lake, located in Garrett County, Maryland, serves as a crucial resource for public water supply and recreation. Spanning approximately 3,900 acres, the lake was constructed in 1925 and is a significant economic and ecological asset to the region. Despite its importance, Deep Creek Lake has experienced considerable sediment accumulation, primarily in its southern coves, since its creation. Since its establishment,

Deep Creek Lake has not undergone significant sediment removal. Over the years, sedimentation has progressively impacted the lake's southern coves, impairing recreational access and usability without affecting the lake's primary functions or its power systems. The growing concerns over sediment accumulation prompted local government and environmental agencies to seek solutions that would improve public use and ensure the lake's long-term sustainability. This report outlines the steps taken by local and state authorities to address these concerns, focusing on sediment management and the specific dredging of Arrowhead Cove.

Sedimentation Management Efforts

In response to the sedimentation issues, stakeholders convened on December 14, 2018, to develop the Deep Creek Lake Sedimentation Plan. This initiative aimed to prevent further erosion and sediment build-up and was a continuation of the strategies set out in the 2014 Deep Creek Lake Watershed Management Plan. The primary objective for 2019 was to identify the main causes and sources of sediment affecting the lake. Simultaneously, legislative efforts in 2018-2019 led to the introduction of a bill, the State Lakes Protection and Restoration Fund, proposing an annual allocation of \$1 million for three years to Maryland's lakes, including Deep Creek Lake. Although the funding fell short of the requested \$3 million annually, it underscored a state-level commitment to addressing sediment-related issues at Deep Creek Lake and other Maryland lakes.

Ongoing Initiatives and Community Engagement

The Deep Creek Watershed Administrative Council has been pivotal in fostering community engagement and environmental stewardship. Initiatives such as the launch of the "Eyes on Deep Creek Lake" webpage and various educational outreach programs aim to promote sustainable practices and raise awareness about the importance of sediment management. Continued advocacy by local officials and stakeholders aims to secure additional state funding and support for sediment management and other lake preservation activities. These efforts highlight the community's commitment to maintaining the lake's health and recreational value for future generations.

Arrowhead Cove Dredging Initiative

In 2017, MES and Anchor conducted the Deep Creek Lake Dredging Cove Evaluation Report, analyzing ten sediment-impacted coves; Arrowhead Cove, Chadderton School Cove, Deep Creek Cove, Green Glade Cove, Harvey's Cove, Hazelhurst Cove, Pawn Run Cove, Penn Cove, Poland Run Cove, and Turkey Neck Cove. This evaluation was guided by the DNR Waterway Improvement Fund (WIF) Grant criteria, which include environmental benefits, cost, safety, and boating access. Arrowhead Cove was ultimately selected for dredging, ranking highest due to factors such as its popularity for

public boating activities and the feasibility of dredging operations in terms of engineering and environmental impact. On December 10, 2018, Garrett County commissioners sought legislative support through a bond bill to fund a pilot project for sediment removal in Arrowhead Cove. This request was part of broader efforts to enhance funding for the State Lakes Restoration and Protection Fund, emphasizing Deep Creek Lake's value to the local economy and environment.

The sediment management and dredging initiatives at Deep Creek Lake illustrate a comprehensive approach to addressing environmental challenges while balancing recreational needs and economic considerations. Arrowhead Cove's selection for dredging represents a strategic decision based on extensive evaluation and community priorities, setting a precedent for future actions to preserve Maryland's largest freshwater lake.

Arrowhead Cove Dredging Project

Arrowhead Cove, nestled within the expansive waters of Deep Creek Lake and situated northwest of the Glendale Road Bridge, serves as a focal point for environmental restoration, recreational and navigational upkeep (Figure 1). Spanning 23.5 acres of surface water, the cove faced challenges with sediment accumulation. In response, the state of Maryland through the DNR allocated \$2.2 million for the Deep Creek Lake Arrowhead Cove Dredging Project, encompassing final design, permitting, procurement, and construction. Spearheaded by Garrett County Government in collaboration with MES, and supported by Anchor as the design engineer, the project sought to remove accumulated sediment in Deep Creek Lake's Arrowhead Cove through mechanical removal. Through a competitive sealed bid process, Byco Enterprises, Inc. was awarded the contract for the task. Commencing in November 2023, the dredging operation successfully removed approximately 11,000 cubic yards (cy) of sediment by January 2024.

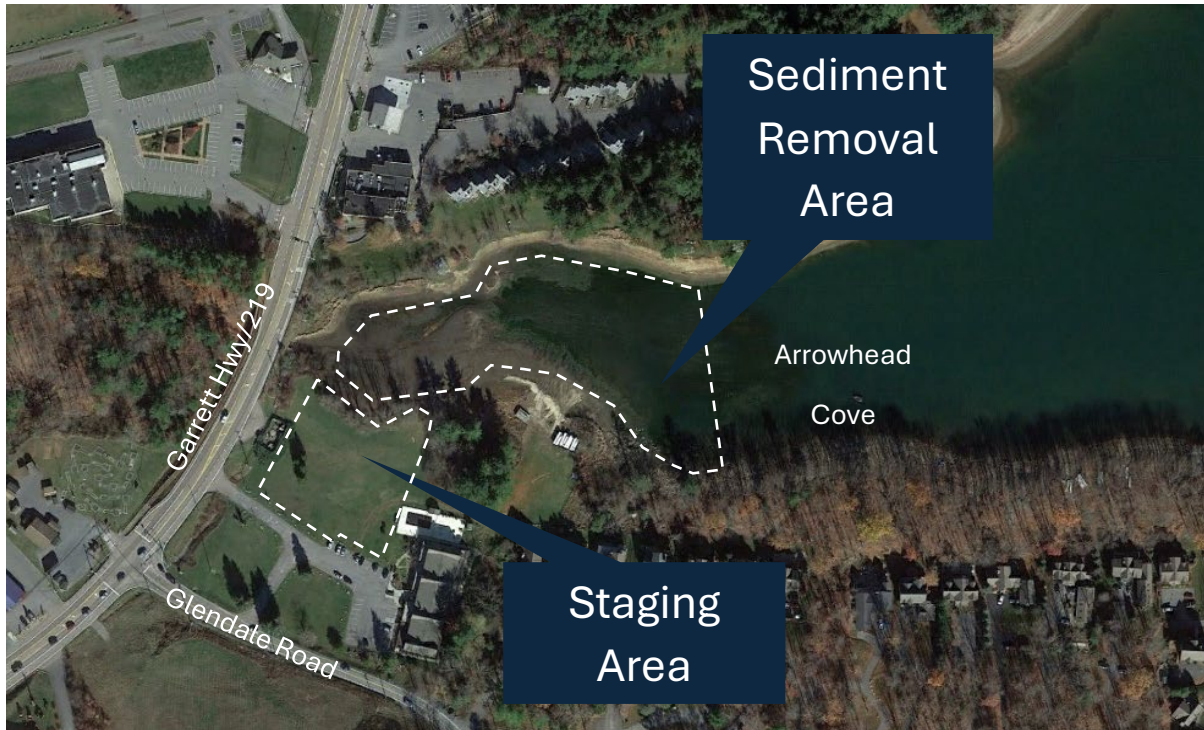


Figure 1. Arrowhead Cove Dredging Area

Permitting

Permitting the Arrowhead Cove Dredging Project began approximately two years prior to construction. Permits were required from federal, state and local agencies including the U.S. Army Corps of Engineers (USACE), Maryland Department of the Environment (MDE), DNR, and Garrett County. The permits obtained prior to the initiation of construction were:

- General Permit for Storm Water Associated w/ Construction Activity Permit # MDRCLS0YG & MDRCLS0YH
- MDE Water Appropriation and Use Permit # GA2023S002(01)
- Permit for Nontidal Wetlands and Waterways # 22-NT-3068/ 202260542
- Garrett County Grading Permit # 2023-0268
- USACE MDSPGP-6 Permit # NAB-2022-60542-M49
- DNR Special Use Permit #4074

Bid

MES managed the procurement of a qualified contractor to complete the Arrowhead Cove Dredging Project through a competitive sealed bid process to mechanically remove 15,000 cy of sediment from Arrowhead Cove, dewater the sediment at an adjacent upland staging area, and haul the material to Garrett County Landfill to be stockpiled for later use as clean landfill cover material. The bid process resulted in one responsive and responsible bidder, Byco Enterprises, Inc., however the bid was significantly above the available project budget. Recognizing the need for flexibility, two alternative bids were also submitted: Alternative 1 for dredging 11,000 cy of sediment, and Alternative 2 to dredge 7,500 cy of sediment. Subsequent negotiations were conducted in pursuit of a solution aiming to remove as much sediment as possible from Arrowhead Cove, while remaining within the project budget. Ultimately, through cost reduction methods including, but not limited to, eliminating the asphalt pad on the upland staging area and instead using crushed stone, as well as reducing trucking costs, the bid resulted in a contract to remove 11,000 cy of material from Arrowhead Cove within the allotted budget.

Means and Methods

The mechanical removal of sediment in Arrowhead Cove was completed “in the dry,” meaning the portion of Arrowhead Cove to be dredged needed to be dewatered prior to the commencement of sediment removal. Mechanical excavation “in the dry” was the preferred dredging method based on efficiency, productivity, and project duration over hydraulic dredging as recommended in the May 2020 Arrowhead Cove Sediment Removal at Deep Creek Lake Alternatives Analysis report prepared by MES and Anchor. Throughout the project duration, an Aqua Dam was installed around the dredging area to ensure operational safety and efficiency in preventing waterflow in the proposed dredging area. Post-dredging, this structure was removed, allowing the natural flow of the lake to continue. Due to permit requirements, mats were placed in the dewatered area to allow for heavy equipment to enter and work in the cove.

Once the accumulated sediment was removed via an excavator, the dredged material was placed in an upland staging area adjacent to Arrowhead Cove. There, the material was dewatered sufficiently so it could be loaded into dump trucks to be hauled to the Garrett County Landfill, where it will be stockpiled and ultimately innovatively reused as clean landfill cover material. The dredging efforts increased water depths in the cove by 1-5 feet, while also incorporating habitat enhancement features such as rock clusters and submerged aquatic vegetation (SAV) plantings, fostering biodiversity and mitigating invasive species.

Pre and post-dredging surveys were completed to provide valuable data for assessing project performance and compliance. The total surveyed removed volume stands at

10,571 cy, inclusive of targeted removal areas and additional depth excavation along designated paths. Following the final survey, an estimated additional 958 cubic yards of material was removed (calculations based on trucked volume due to inclement weather preventing a final drone survey), totaling 11,539 cy for the amount of material removed from Arrowhead Cove (Attachment 1). Dredging concluded on January 3, 2024 and the remainder of the stockpiled sediment was transported to the landfill on January 4, 2024.

Lessons Learned

The Deep Creek Lake Arrowhead Cove Dredging Project represents a crucial initiative aimed at enhancing the environmental and recreational aspects of Arrowhead Cove. There were several noteworthy lessons learned as the project progressed, pertaining to time constraints, scheduling intricacies, consequential dam distance, and funding considerations. This report aims to distill key lessons learned, examining their implications, and offering insights for future dredging endeavors for Deep Creek Lake.

1. Scheduling:

The designated window for dredging was significantly constrained due to the time of year restriction for dredging in the MDE non-tidal wetlands license of March 1 through June 15 and recreational time of year constraints, not being able to start work until after the high tourist season ended in late-October. These constraints resulted in the dredging needing to be done in the winter months, which, in Garrett County, can have some extremely cold temperatures and significant winter storms.

In order to ensure that the work was completed before extreme winter weather set in, the dredging operations were expedited. Under normal circumstances, this would be considered advantageous, however, the compressed schedule resulted in decisions on additional areas to dredge being made without following the proper approval chain, and with only field approval, rather than preferred review and approval by the project engineer. There was also not sufficient time to obtain planned progress surveys and wait for results to fine tune the dredging and ensure that the dredging occurred to the planned elevations prior to equipment being moved to adjacent areas. Once the equipment was moved, it was not cost-effective to go back and remove additional volume, even if the full targeted volume was not removed from those areas.

The mobilization phase commenced later than planned due to several factors, including more time than anticipated negotiating lake water level drawn down with Brookfield Renewable (the dam operator) to assist with the deployment of the coffer dam, and delays incurred by numerous hurdles encountered with dock owners who declined to remove their docks promptly because of the fear of loss of rental income.

Lessons learned regarding scheduling include beginning communication with the residents, managing agencies or operators, and other stakeholders around the lake earlier in the planning phase of the project. By engaging these entities ahead of time to allow for dredging and/or upland work to occur expeditiously, an understanding could be reached to allow work to commence at some time agreed upon within the tourist season. This will result in the reduction of delays that resulted from the dredging occurring in the coldest winter months. Additionally, dock removal should be coordinated through DNR when permits are submitted for the docks in the areas identified for dredging. DNR could be educating the applicants that their dock will have to be removed or not be accessible for a period of time, even during the tourist season and the benefits they will receive in the long term from a dredging project in their area.

2. Weather:

The project was fortunate that there were no prolonged times of severe winter weather during the actual sediment excavation, however, winters in western Maryland are unpredictable, and planning for future projects should take this into consideration. During the dredging operations, the weather remained mostly favorable; however, there were notable instances of precipitation, specifically snowfall, coupled with freezing temperatures. These cold conditions can significantly hinder the performance and efficiency of machinery and equipment used in dredging processes.

In cold weather some of the challenges that exist include, lubricants within the machinery can thicken or freeze, which increases friction and consequently decreases operational efficiency. Frigid temperatures can cause the sediment being dredged to freeze, forming clumps that are more challenging to remove. This not only slows down the dredging process but also demands more power and effort from the equipment, which can lead to increased wear and tear and potential breakdowns. There is a significant cost to the project, even when crews are not working, to maintain water pumps. As mentioned previously, future projects should be considered for a time of year when the weather conditions are more favorable.

3. Time of Year Restrictions:

Dredging operations at Deep Creek Lake would optimally be scheduled during the dry season, spanning the summer months from June to September. This timing aligns with the lake's lowest precipitation levels, facilitating the drying of dredged material before transportation to disposal sites. However, this period also coincides with the peak of recreational activities at the lake of Memorial Day through the annual Autumn Glory Festival in mid-October. As outlined in Lesson 1 "Scheduling," the timeframe that dredging of Arrowhead Cove took place significantly narrowed the window for dredging operations.

Mechanical dredging that occurred during the period when lake water levels are at their lowest between October through February as required by the Deep Creek Lake Operating Rule Band, was advantageous with respect to sediment removal. Dredging mid-summer can mitigate any potential challenges associated with winter weather conditions as mentioned above. However, dredging within the recreational window will necessitate temporary dock closures throughout the lake and the lake water levels will be higher than in the winter months, leading to potential challenges if the selected dredging method is once again mechanical removal in the dry. The resulting higher water levels in the summer months would be favorable for a hydraulic dredging operation but would interfere with recreational activities.

4. MDE Dam Safety Requirements:

The recent dredging project at Arrowhead Cove on Deep Creek Lake was notably expedited due to the absence of a need for a Dam Safety permit from MDE due to the project's distance from the dam. This not only saved considerable time but also avoided various design and cost constraints that typically accompany such permits.

Planning for future dredging initiatives, it is recommended to identify priority projects and their timeline for completion. The proximity of the dam to future Deep Creek Lake dredging projects should be identified early in the planning process and should include additional time in the project timeline for obtaining permits from the MDE Dam Safety Division.

5. Funding:

Despite the original plan to remove 15,000 cubic yards (cy) of sediment from Deep Creek Lake, the project faced budgetary constraints and the bids were above the predicted project cost estimated three years prior to the project construction, leading to a reduction in the targeted removal to 11,000 cy. This decision was primarily influenced by the high costs associated with labor, equipment/materials, and trucking which proved to be beyond the scope of the available funding. To further mitigate the high costs, cost-reduction measures were implemented that uniquely benefited this specific dredging effort. These included negotiated prices and temporary concessions such as not paving the upland staging area, as well as placing the dredged material at the Garrett County Landfill to be innovatively reused as clean landfill cover, which required transportation costs only and no disposal or tipping fees. Given these challenges, it is apparent that increased funding allocations will be essential for future dredging projects. Arrowhead Cove was the smallest and most feasible for dredging operations of the 10 sediment impacted coves evaluated and ranked for potential dredging in the Deep Creek Lake Dredging Cove Evaluation Report (Anchor 2017), meaning that the remaining nine coves would potentially require greater costs to dredge. Funding for any additional cove dredging would need to be identified before work on dredging design and securing required permits. The

state of Maryland is unlikely to cover the entire costs for dredging future Deep Creek Lake Coves. Funding for additional sediment removal projects could be secured from State and/or federal grants, cost share programs, individual donors, and setting up cove specific tax districts.

6. Water Management:

The Deep Creek Lake Arrowhead Cove Dredging Project was completed using mechanical removal in the dry, meaning that the cove had to be dewatered prior to construction using water retention methods. Water retention structures work better and are easier to maintain when the lake water levels are lower.

Therefore, before the project began there were extensive negotiations with Brookfield Renewable, which manages the dam and lake water levels, to lower the water levels throughout the project. After extensive negotiations, the lake water levels were maintained at the middle of the rule band (2456.5 feet) during the end of November through the end of January rule band time period for a brief period during the installation of the water retention structures, but, due to lake level management concerns, the water levels were not maintained at the middle of the rule band for the entire duration of construction. Brookfield Renewable has indicated that they prefer water levels not be lowered in the future for dredging projects, so this should be taken into account when determining if a project will be done in the wet or in the dry, as well as mechanically and/or hydraulically.

7. Accessibility:

Dredging operations require an adjacent or nearby upland area for dredged material management and processing. Many identified sediment impacted coves along the shoreline of Deep Creek Lake are inhabited or inaccessible by roads that would allow for heavy equipment access for mobilization/demobilization and material transport. Future dredging projects should be carefully selected to ensure that there is sufficient upland area to be used for project staging.

8. Recreational Impacts:

As expected, shallow cove dredging improved recreational enjoyment of the cove by increasing boating access to docks, expanding boating areas, temporarily limiting SAV in shallow water habitats, and improving swimming activities. Impacts to fishing are yet to be determined. The initial loss of established SAV habitat in the first-year post dredging might reduce fishing opportunities. The dredging project did provide both rock structures and SAV plantings in the dredging footprint, but it might take a year or two to reestablish good fishing habitat. It will be important to assess any potential short and long-term dredging impacts to fishing. DNR staff planted the SAV in late May post dredging and will be monitoring the success of the plantings and revegetation of native species during the summer and in following years. Recreational improvements must include boating, swimming and fishing and should be designed to complement each other (Attachment 2).

9. Water Quality:

It is critical to conduct pre and post dredging project water quality monitoring to assess potential water quality impacts. DNR conducts Deep Creek Lake long-term monthly (April – October) water monitoring including stations in Arrowhead Cove. They also conduct temporally intensive continuous (readings every 15 minutes) monitoring of physical parameters of turbidity, water temperature, pH, dissolved oxygen, conductivity, and chlorophyll, an indicator of algal biomass, in selected coves. Two continuous monitors were placed in Arrowhead Cove in May 2024, one where Arrowhead Run first enters the cove, and the second one closer to where the cove becomes part of the main body of the lake. Continuous monitors were previously deployed in Arrowhead Cove in 2018. DNR will compare water quality conditions from the continuous monitors to determine any potential water quality impacts. There is the potential that turbidity, an indication of water clarity, could be worse immediately after dredging due to the newly exposed bottom sediment and the loss of SAV. As SAV recolonizes the area, water quality conditions should improve. It will take time to evaluate any potential dredging impacts to cove water quality. Future projects will require a commitment to both pre- and post-water quality and habitat monitoring.

Conclusion

The Deep Creek Lake Arrowhead Cove Dredging Project served as a pilot dredging project to indicate the feasibility of future dredging projects in Deep Creek Lake. As discussed in detail in the previous section, the implementation of this project provided some valuable lessons for potential future dredging projects, including, but not limited to, project timing, methodology, and funding. There were quite a few restrictions placed on the dredging project through permitting, timing, and pressure from property owners to not temporarily impact recreational use. Many of these restrictions led to an increase in project costs, and with a fixed project budget, this results in less sediment removed within the allotted budget. While these restrictions are valid, they increase the cost of dredging projects while decreasing the amount of sediment removal that is possible and should be evaluated for future dredging projects. The more of these conditions that can be remedied or removed, while still limiting detrimental environmental impacts and minimizing recreational impacts, the more robust of a sediment removal program that can be implemented. Mechanical dredging in the dry during late fall and early winter was demonstrated to be an effective tool for removing a relatively large amount of accumulated cove sediment, but at a significant cost and uncertainty due to conditions outside of the project control such as weather. Additionally, for potential future larger-scale dredging projects, hydraulic dredging should be considered and could potentially allow the use of a centralized stockpile area for multiple dredging areas, which could decrease costs and allow for additional sediment removal.

References

Anchor QEA. 2017. Deep Creek Lake Dredging Evaluation Garrett County, Maryland Cove Evaluation Report.

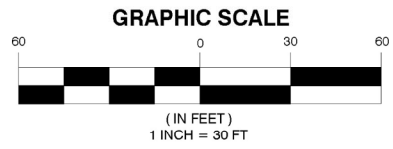
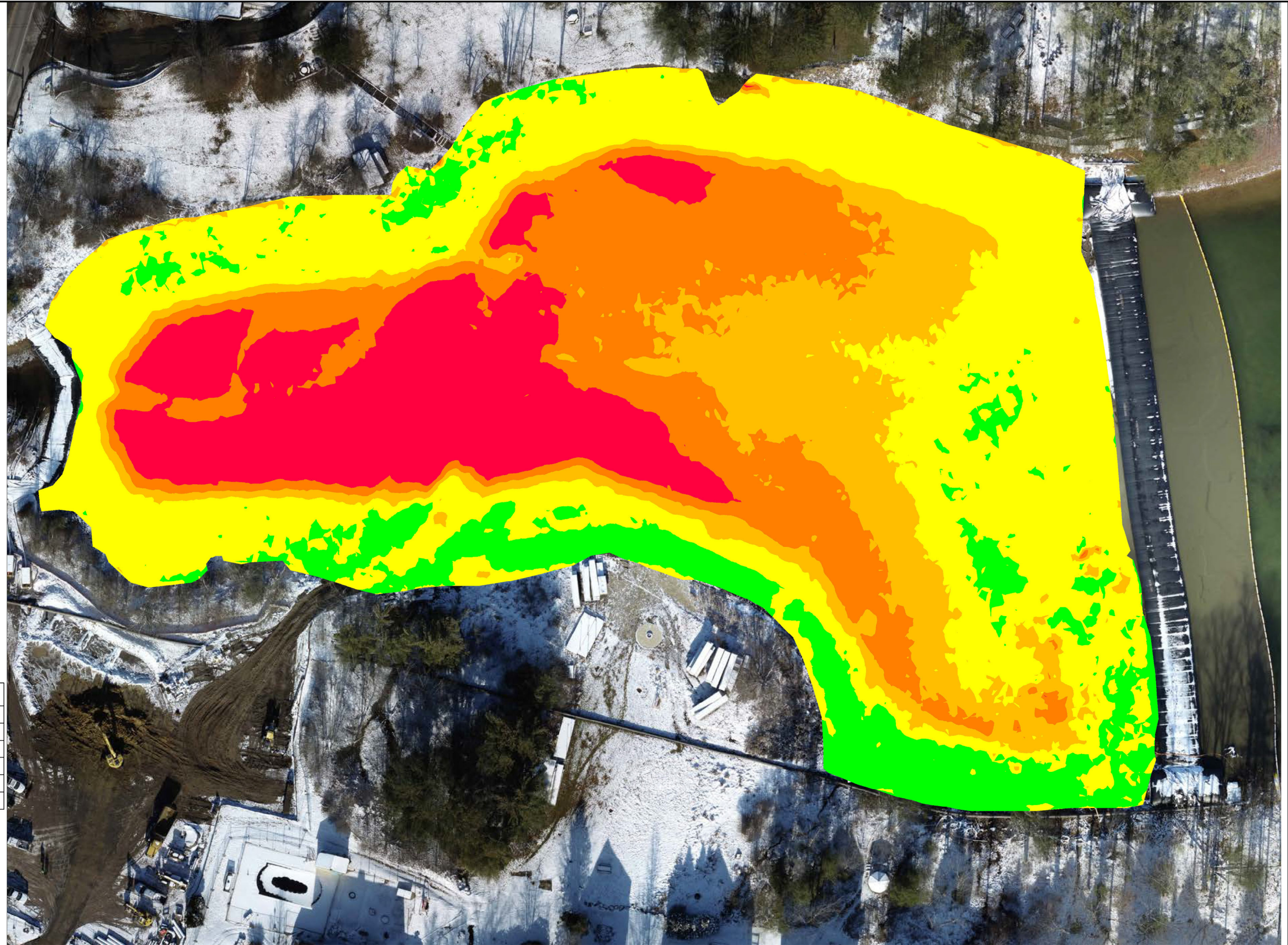
Attachment 1

Cut and fill depths of sediment removal in Arrowhead Cove

MARYLAND COORDINATE SYSTEM
NAD 83 (2011)

- NOTES**
- 1) SURFACE COMPARISONS SHOWN HEREON ARE BASED ON SURVEY DATA COLLECTED BY ANCHOR ENGINEERING (PRE-DREDGE BASE SURFACE) AND MES SURVEY (POST-DREDGE SURFACE) BY THE USE OF SMALL UNMANNED AERIAL VEHICLES (UAV).
 - 2) POST-DREDGE SURFACE FLOWN BY MES SURVEY ON JANUARY 3, 2024. LIGHT DUSTING OF SNOW PRESENT.
 - 3) STANDING WATER PRESENT WITHIN DREDGE AREA DURING POST-DREDGE SURVEY.
 - 4) FILL AREA ON SOUTHERN EXTENT DUE TO ROAD STABILIZATION TIMBERS ON HAUL ROAD.
 - 5) EXISTING GROUND CONTROL POINTS, ESTABLISHED BY ANCHOR, WERE RECOVERED WHEN POSSIBLE AND ADDITIONAL GROUND CONTROL POINTS ESTABLISHED BY MES SURVEY, WERE USED TO GEOREFERENCE THE DATA.
 - 6) HORIZONTAL DATUM: NORTH AMERICAN DATUM OF 1983 MARYLAND STATE PLANE (NAD83/2011).
 - 7) VERTICAL DATUM: NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD 88).
 - 8) THE PROJECT DATUM WAS ESTABLISHED BY EXTENDED GPS SESSIONS.

CUT/FILL DEPTH				
Number	Minimum Elevation	Maximum Elevation	Area	Color
1	-5.81	-3.00	32652.75	Red
2	-3.00	-2.00	37377.15	Orange
3	-2.00	-1.00	33981.85	Yellow
4	-1.00	0.00	81855.21	Light Green
5	0.00	2.41	22060.27	Dark Green



REVISIONS



SURVEYED BY: JBC, CRC, JBB
 DRAWN BY: JBB
 CHECKED BY: DRR
 DATE: JUNE 24, 2024

POST-DREDGE WORKSHEET
 DEEP CREEK LAKE - ARROWHEAD COVE
 GARRETT COUNTY - MARYLAND
 MARYLAND ENVIRONMENTAL SERVICE
 259 Najoles Road - Millersville, Maryland 21108 - Office: 410-729-8200 - www.menv.com

PROJECT NO.
 SCALE: 1" = 30'
 SHEET 1 OF 1
 DRAWING NO.

SAVED: 6/24/2024 10:58:00 AM
 FILE PATH: Z:\METS\PROJECTS\ARROWHEAD COVE\ARROWHEAD COVE - POST-DREDGE - PHOTOLOG.MXD
 PLOTTED: June 24, 2024

Attachment 2
Arrowhead Cove Wild Celery Restoration

Arrowhead Cove Wild Celery Restoration

Mike Naylor, Mark Lewandowski, Stephanie Hall and Kaitlin Scowen, Maryland Department of Natural Resources (DNR), 2023-2024

Introduction

The Arrowhead Cove Wild Celery Restoration project was undertaken as a mitigation measure for the dredging activities in Arrowhead Cove within Deep Creek Lake, Maryland. Wild celery (*Vallisneria americana*) is a native aquatic plant that provides essential habitat for aquatic organisms and serves as a significant food source for waterfowl. Unlike other aquatic plants, wild celery does not form dense surface mats, making it compatible with water-based recreational activities. For this project, Maryland Department of Natural Resources, Resource Assessment Service (RAS) agreed to plant at least 1,000 plants in founder colonies within two restoration sites identified in the restoration plan. Funding for this project was provided by the 2023 State Lakes Protection and Restoration Funds.

Methods

Seed Collection

Wild celery forms seed pods containing 50 to 200 seeds, which can be hand-harvested from the water's surface. On October 17th, 2023, RAS biologists visited three sites at Deep Creek Lake to collect wild celery seed pods. Despite the presence of extensive wild celery beds, seed pods were scarce. Meadow Mountain Cove (Figure 1) was the only location where seed pods were found, resulting in the collection of approximately 20 seed pods. These pods were transported to Annapolis, Maryland for storage.

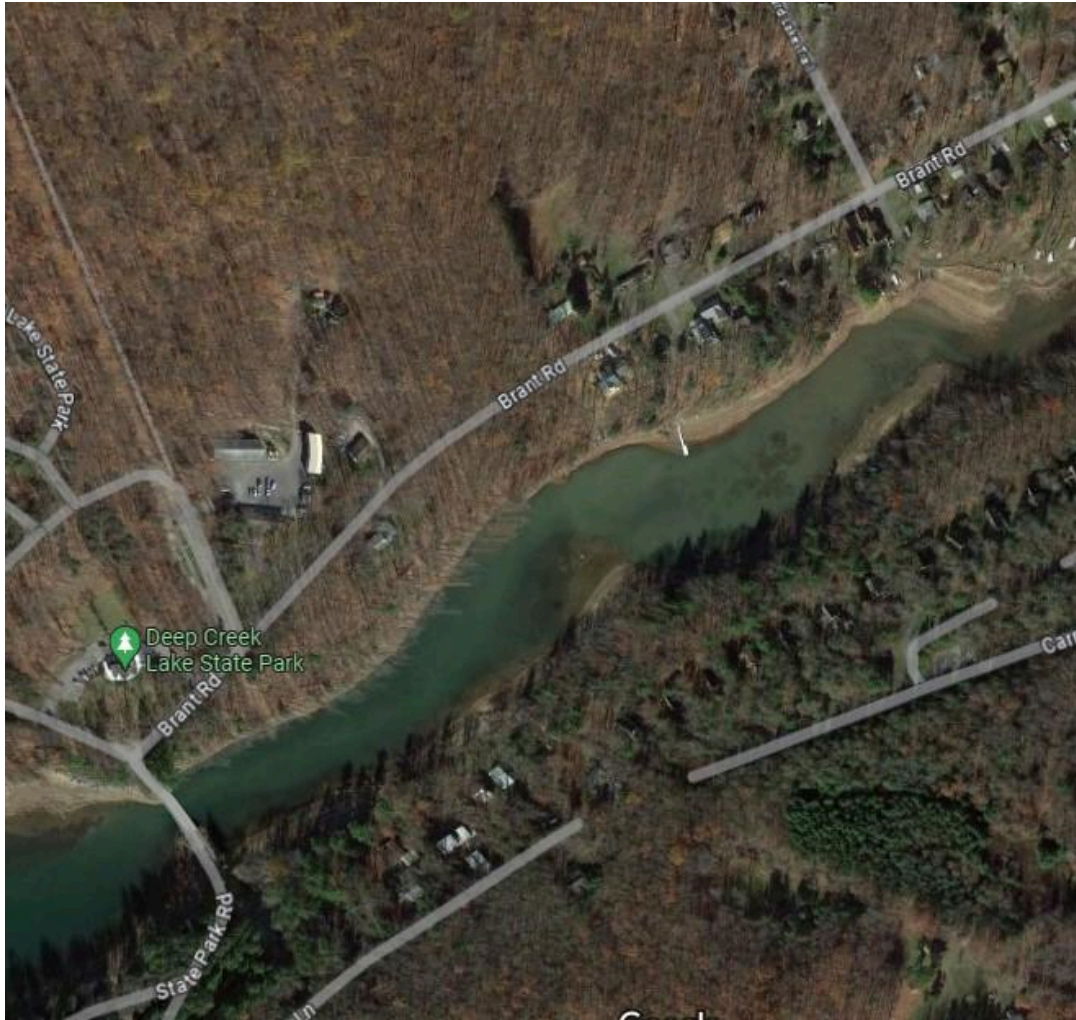


Figure 1 - Seed collection area in Meadow Mountain Cove (Deep Creek Lake)

Seed Germination and Plant Growth

Given the low number of seeds, a decision was made to grow the seeds in a controlled environment instead of doing seed broadcasting. This would maximize the chances of restoration success. Seeds were germinated in trays containing a 50% sand and 50% topsoil mixture. These trays were placed in tubs filled with ten inches of water. Each tub was equipped with powerheads with sponge filters for water circulation and filtration, and heaters were used to maintain optimal temperatures for germination and growth.

Germination Setup

On January 18th, RAS biologists set up ten 2'x3' tubs in a greenhouse at the Providence Center in Arnold, Maryland (Figure 2). Seeds were divided into ten batches

and sprinkled over the substrate in the 1'x1' trays, which were then covered with a thin layer of sand to secure the seeds. The trays were submerged in the tubs. Two sodium halide lights were installed to provide supplemental lighting. A timer was used to extend the photoperiod, simulating spring growth conditions. Germination was observed within 11 days, and 100% tray vegetation was achieved within three weeks.

Figure 2 - Providence Center wild celery grow out greenhouse



From January 17th to May 28th, 2024 twice-weekly maintenance was performed, including water refilling, algae removal, filter pad cleaning, and temperature verification. In early April 2024, five additional tubs were prepared, and trays with abundant growth were thinned and replanted into the new tubs to maximize plant numbers. By May 1st 2024, all trays were fully vegetated (Figure 3).

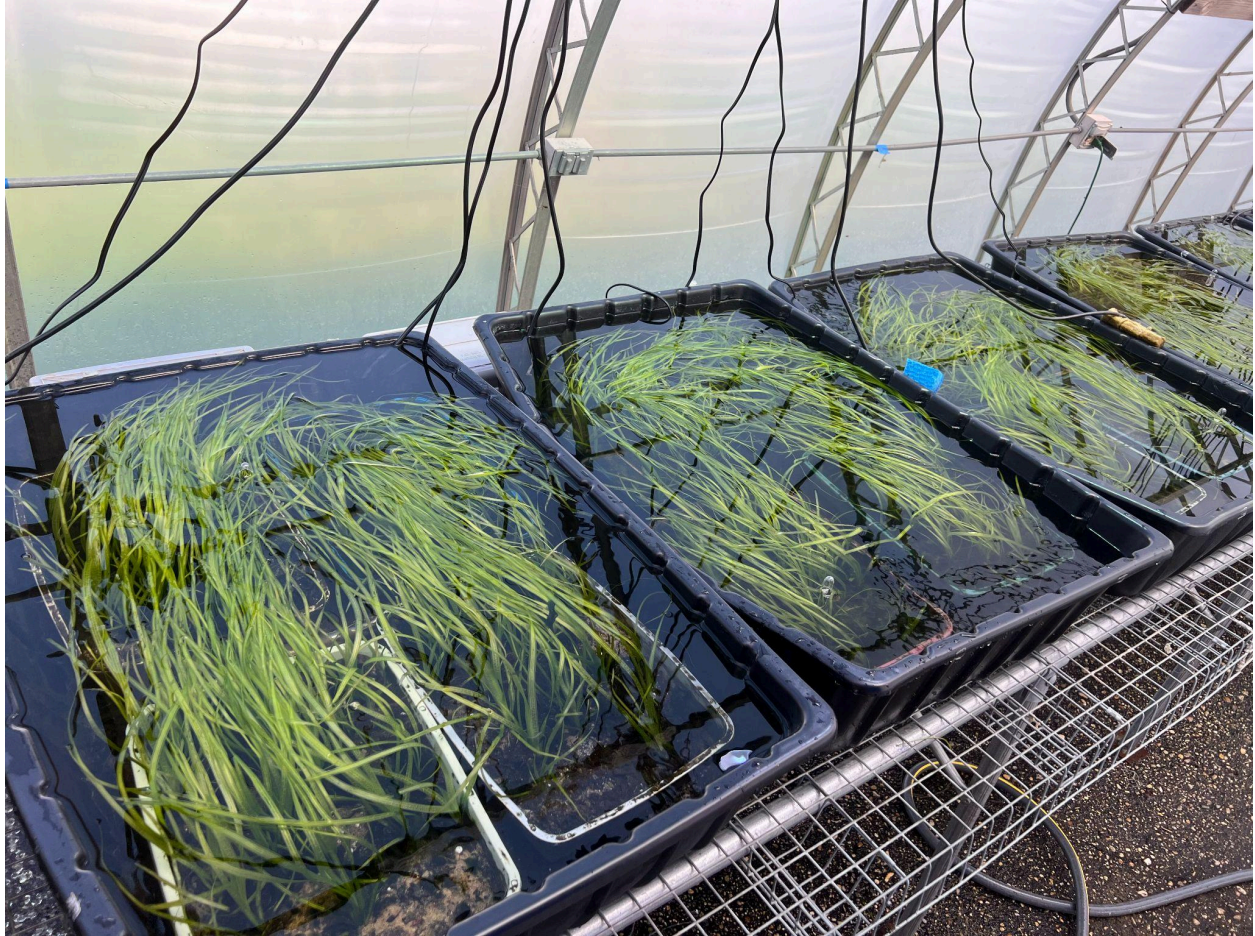


Figure 3 - Full size greenhouse grown wild celery

Transplantation to Arrowhead Cove

On May 28th 2024, RAS staff prepared the wild celery for transport to the planting site. Trays were removed from the water, covered with wet newspaper, and transported by truck to Deep Creek Lake, Maryland. At the lake, the grasses were moved by boat to Arrowhead Cove and placed in staging areas near the planting sites.

Planting Site Preparation

Planting sites were predetermined as per the mitigation plan, with nine sites on each side of the cove (identified as AC3 and SC2 in the September 2022 Arrowhead Cove Restoration Plan, Figure 4). Bamboo poles marked the planting sites.

Coordinates for planting sites were as follows:

- **North Site (Arrowhead Market Side)**
 - N 39.50332, W -79.32448
 - N 39.50320, W -79.32371
- **South Site (Rental Unit Side)**
 - N 39.50265, W -79.32403
 - N 39.50260, W -79.32379

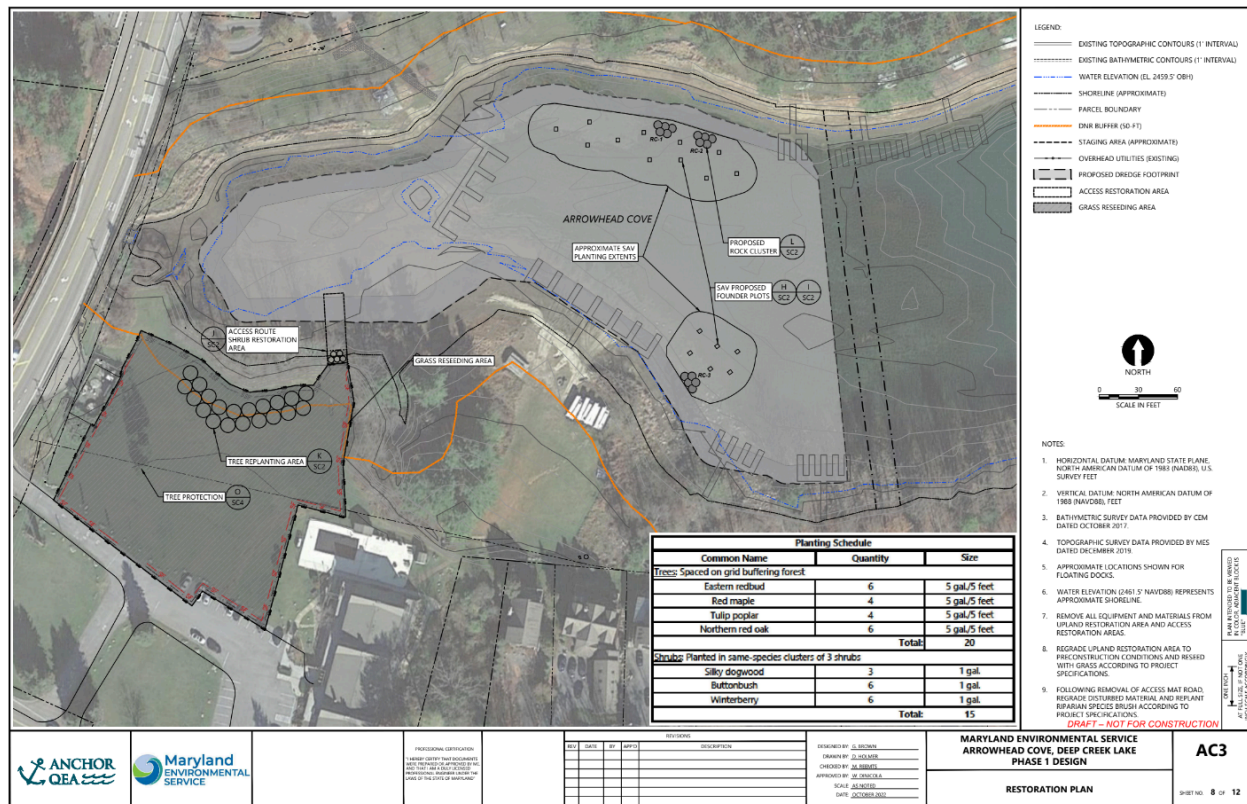


Figure 4 - Arrowhead Cove founder colony planting locations

Three divers worked as a team to establish founder colonies - clusters of adult plants that will expand over time. One diver transported trays of grasses to the sites, while two divers planted three trays of wild celery around each bamboo pole at a depth of 3-4 feet. The divers submerged with a tray, dug holes in the substrate, placed the grasses in the hole and pushed them firmly into the sediment, ensuring firm contact between the plant roots and the sediment. This process was continued until all grasses were planted, resulting in the establishment of approximately 1,000 wild celery plants (Figure 5).

Exclosures were installed around half of the planting sites using storm fencing and bamboo poles to assess the impact of aquatic predation on planting success.



Figure 5 - Planting the wild celery plants at Arrowhead Cove (Deep Creek Lake)

Post-Planting Monitoring

On May 29th 2024, RAS divers revisited the sites to ensure proper rooting of the plants.

Follow-up monitoring on July 21st, 2024 revealed that 16 out of 18 founder colonies contained thriving plants. These plants had already expanded beyond their original footprint and were over two feet tall, visible from the shoreline (Figure 6). Exclosures did not appear to affect planting success, though one exclosure was damaged by a boat, resulting in plant loss. A non-exclosure site also lost its plants.



Figure 6 - Arrowhead Cove (Deep Creek Lake) wild celery, two months after planting

Conclusion

The planting effort was successful, and is expected to result in the tripling of each founder colony's size by the end of summer 2024, along with the production of large numbers of seeds. The project is expected to permanently establish wild celery in Deep Creek Lake's Arrowhead Cove, contributing to ecological restoration and enhancing habitat quality.