Lake Accotink Discovery Report

Interim Deliverables November 3, 2023

prepared for:

Fairfax County, VA

Final

November 6, 2023

LimnoTech

Water Environment | Scientists Engineers

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prepared by:
LimnoTech

under contract to:
Fairfax County, VA

ACKNOWLEDGEMENTS

We would like to acknowledge the Lake Accotink Task Force who assembled the discovery questions, and Charles Smith, who served as our liaison throughout this project.

Note:

All materials in this report are based on high-level, rapid assessments and should be considered preliminary.

Introduction

The sections of this report are formatted to reflect the eight primary questions posed in the Task Force's discovery scope document. This deliverables report documents responses to several questions and sub-questions, primarily focusing on sediment transport and dam issues. The questions addressed in the deliverables include sub-questions 2.7, 3.3 – 3.5, 4.5, 6.1-6.3, and 7.1 – 7.7.

1 WHAT WILL HAPPEN TO THE LAKE IF NOTHING IS DONE?

1.1 Will mud flat form?

Previously discussed in the 9/19/23 deliverable.

1.2 b. Will there be quicksand that poses a risk to park users?

Previously discussed in the 9/19/23 deliverable.

1.3 Will there be nuisances such as mosquitos, odors, etc.?

Previously discussed in the 9/19/23 deliverable.

1.4 Will it become overrun with invasive species?

Previously discussed in the 9/19/23 deliverable.

1.5 Will flood risk increase?

Previously discussed in the 9/19/23 deliverable.

2 IS MANAGING THE LAKE AS A WETLAND A VIABLE OR POTENTIALLY DESIRABLE OPTION?

2.1 What is a stream/wetland complex? How is it different than what we typically think of as wetlands?

Previously discussed in the 9/19/23 deliverable.

2.2 What is required to develop a plan to manage the lake footprint as a wetland?

Previously discussed in the 10/5/23 deliverable.

2.3 What might it look like?

Previously discussed in the 10/5/23 deliverable.

2.4 How long will it take to create a managed wetland that is a community asset providing environmental and recreational benefits?

Previously discussed in the 10/5/23 deliverable.

2.5 Will a managed wetland be "overcome" by storm pulses and sediment loading with emphasis on extreme events?

Previously discussed in the 9/19/23 deliverable.

2.6 Will a wetland have a less cooling effect on the environment than an eight-foot or more depth lake? Will a wetland create a heat island?

Previously discussed in the 9/19/23 deliverable.

2.7 Would managed wetlands have different regulatory requirements than a lake, and if so, summarize them?

Please note: This section focuses on regulations pertaining to lake/wetland and construction regulations. Please see Section 4.5 for a discussion of the Accotink Dam regulations.

Both lakes and wetlands within Accotink Park are considered Waters of the US. As such, they both are subject to local, state, and federal regulations. While both are viewed slightly differently in the regulations, the protection goals are similar. A permit is required to modify either a lake or a wetland.

The easiest permits to obtain are for restoration activities that do not change the overall character of the waterbody, such as a permit for invasive species management. Permits for smaller restoration activities, such as shoreline habitat and short stretches of shoreline restoration (typically less than 500 ft), are also relatively easy to obtain.

Larger and more invasive restoration projects that change the morphology/shape of the waterbody require more to work to obtain. Placing fill in lakes and wetlands can be particularly challenging to get permitted. The intervention scenarios that include partially dredging the downstream end of the lake and placing the dredge spoils at the upstream end of the lake will require an extensive permitting process. Beneficial reuse of dredge sediments is feasible, but it is a relatively new regulatory process that few regulators have worked through in the past. Using the dredged sediment for wetland restoration will likely make onsite beneficial reuse of sediment a more straightforward permit application.

The most challenging permits to obtain are for projects that would effectively remove land from the Waters of the US. For example, filling the lake or wetland to the point where it is outside of the floodplain (or even the ordinary high-water mark) may actually require that you provide compensatory wetland mitigation in another location. In the extreme, filling in the lake to build a parking lot may not be permissible at all.

Of the scenarios presented under this study, the do-nothing scenario is the only one that would not require new permits. Of the remaining scenarios, the full dam removal and fish passage permits would likely be easiest to obtain, and the partial dredge and reuse permits would likely be the most difficult to obtain.

2.8 What is the cost to design, permit, and construct and maintain a managed wetland?

To be discussed under a future deliverable.

3 COULD A MANAGED WETLAND OPTION INCLUDE OPEN WATER AREAS?

All potential scenarios regarding the future configuration of Lake Accotink include open water areas. Since Accotink Creek flows through the site, at a minimum there will always need to be enough open water area to convey Accotink Creek flows through the site.

3.1 Where might open water be located?

Previously discussed in the 10/5/23 deliverable.

3.2 What type of open water could be maintained?

Previously discussed in the 10/5/23 deliverable.

3.3 How large and deep could an open water feature be?

If the goal is to avoid hauling dredge material offsite, the size of an open water feature is essentially a function of the proportions of deposited sediment and stored water within the lake. The desired lake depth is also a factor. For example, the average depth in Zones 2 and 3 are between 3.0 and 3.5 feet (Figure 3-1). If the goal is to dredge 3.0 – 3.5 feet from the downstream end of the lake, the total remaining open water area would be approximately half of what it is today. The open water area may be able to be increased slightly by raising portions of the wetland area 1-2 feet above the normal water surface elevation. That is an optimization exercise that could be included in a master planning study, if the community chooses to pursue a dredge reuse project.

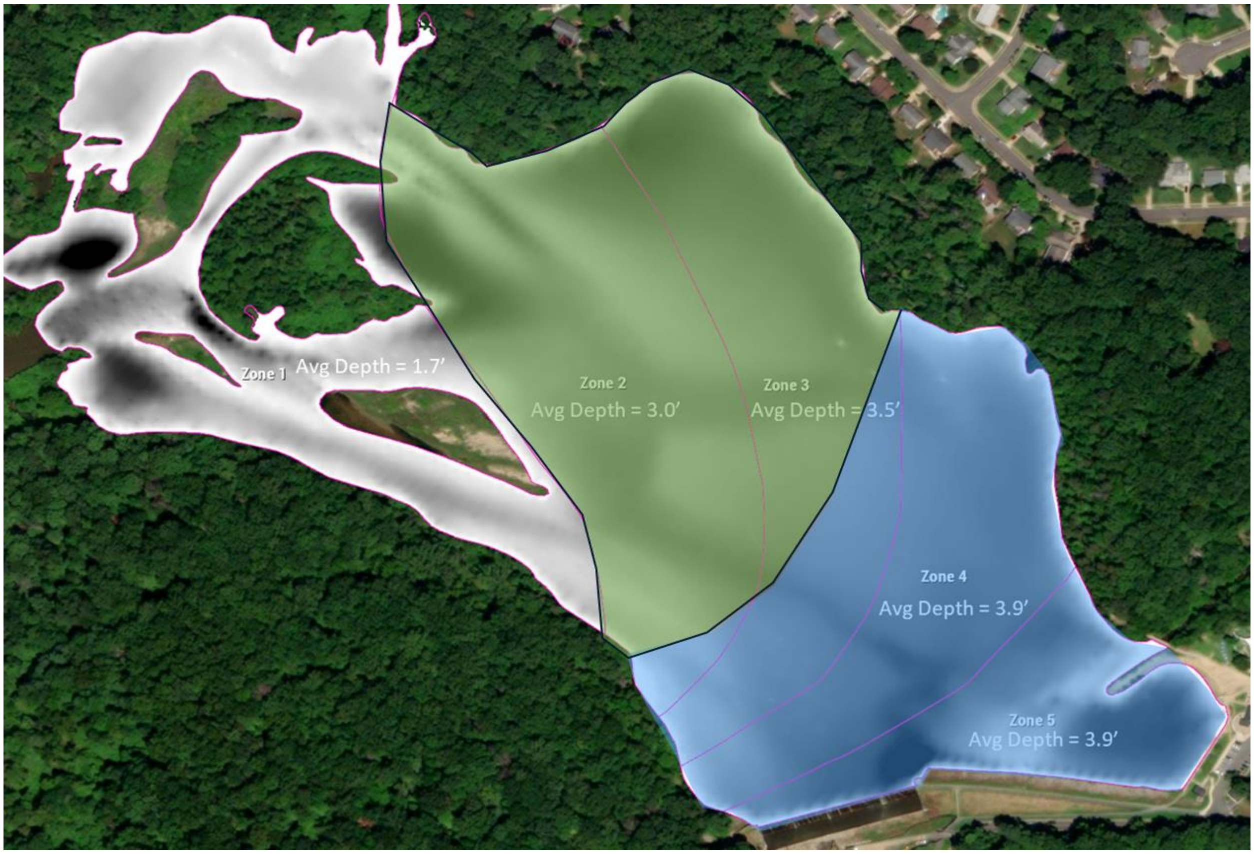

Figure 3-1 Example open water area and new wetland area for a target dredge depth of 3.0 - 3.5 feet

3.4 Would an open water feature need to be dredged periodically?

Yes. If the goal is to maintain an open water lake indefinitely, periodic dredging will almost certainly be necessary. It may be possible to maintain a deep pool in a riverine system, but a precedence has not been identified for this in Accotink Creek, and a deep riverine pool is likely not in the spirit of this question.

It should be noted that beneficial reuse of sediment should be considered a temporary strategy for reducing the cost of dredging in the lake. As the reuse sites are filled, the cost and challenges of beneficial reuse will increase. Eventually, dredging and offsite transport will be necessary to maintain a lake area.

There are research teams working on efficient sediment bypass systems which could, in theory, capture sediment from upper Accotink Creek and bypass it around the lake to downstream of the dam. This technology is quite young (i.e., still in the development stages) and Lake Accotink likely would not be a good candidate for this. Challenges to implementing sediment bypass include:

- Limited site space
- High suspended sediment concentrations
- The TMDL

3.5 How could an open water ("lake") area be sized to maximize the open water but minimize impacts from any necessary maintenance dredging operations to include:

i. Eliminate or reduce the need for pipelines and offsite processing areas,

ii. Utilize existing open spaces in Lake Accotink Park for operations,

iii. Maximizing the extent to which dredged sediment can be kept and used onsite, and

iv. Minimize impacts from trucking materials out?

The intervention strategy most conducive to optimizing open water space and dredge materials handling is the partial dredge anastomosing scenario (Figure 3-2). This scenario maximizes the reuse of dredge material in the smallest space manageable. There could be multiple rounds of utilizing this scenario for future maintenance dredging activities. The exact balance of wetland and open water would need to be optimized during a master planning effort or feasibility study. A long-term adaptive management strategy will likely be required as the wetland grows and the lake shrinks. If a large open water lake is desired, eventually hauling dredge spoils offsite will be necessary.

Figure 3-2 Partial dredge anastomosing scenario

4 HOW WOULD LAKE ACCOTINK DAM BE INCORPORATED INTO A MANAGED WETLAND OPTION?

4.1 Could the dam remain as is?

Previously discussed in the 10/5/23 deliverable.

4.2 Could the dam be modified to improve wetland function and maintenance?

Previously discussed in the 10/5/23 deliverable.

4.3 Would management options be improved by removal of any portion of the dam?

Previously discussed in the 10/5/23 deliverable.

4.4 How could fish passage be incorporated into dam/lake management options?

Previously discussed in the 10/5/23 deliverable.

4.5 Describe the regulatory requirements for Lake Accotink Dam and potential impacts on sediment fate and transport downstream in Accotink Creek for the following scenarios:

i. No action is taken and the dam is left as is.

ii. A managed wetland is created and the dam is left as is.

iii. A managed wetland is created and the dam is modified.

iv. The dam is partially or wholly removed and Accotink Creek returned to a flowing stream.

Dam Regulation:

Please note: This section focuses on regulations pertaining to the Accotink Dam. Please see Section 2.7 for a discussion of Lake/Wetland regulations, as well as construction regulations.

The Lake Accotink dam is a composite structure, consisting of an earthen embankment section and concrete spillway section. The dam is approximately 100 years old and is classified as a high hazard dam. Currently, the Accotink Dam has a conditional Virginia Dam Safety Operation and Maintenance (O&M) Certificate since the spillway can only pass 0.6 times the Probable Maximum Flood (PMF), well below the 0.9 PMF spillway design flood (SDF) requirement for a high hazard dam.

Virginia DCR considers any sediment captured within the lake to be liquifiable material. Essentially, when calculating the volume of material stored upstream of the dam, captured sediment volume is counted the same as impounded water volume. Consequently, allowing the lake to fill in with sediment or dredging and reusing sediment to build wetland/island will not allow us to declassify the Accotink dam as a regulated dam. In short, regulation of the dam will not change due to Lake Accotink sediment management scenarios/ management of sediment within the lake.

Based on this assessment:

- There will be no changes or impacts on the regulation of the dam if no action is taken and the dam is left as it is because there will be no change to the effective capacity of the reservoir upstream of the dam.

- There will be no changes or impacts on the regulation of the dam if a managed wetland is created and the dam is left as is for the same reasons noted in the bullet above.

- There are unlikely to be changes or impacts on the regulation of the dam if a managed wetland is created and the dam is modified because it is unlikely that dam modification would be significant enough to delist the dam structure as a regulated dam. Doing so would require lowering the crest of the dam such that the impounding capacity no longer exceeds 50 acre-feet of combined volume of water and sediment (which would yield a dam height of only 1-2 feet). To delist the dam, the height of the dam would also need to be less than 25 feet.

- If the dam is removed and the river is restored, there will no longer be a dam to regulate. However, dam removal must satisfy its own set of conditions and requirements. Note that according to Virginia Department of Wildlife Resources, the dam is a high priority for removal to improve fish passage. This could make a dam removal permit easier to obtain.

Maintaining the Accotink dam as-is or in a modified condition would continue to subject the dam structure to ongoing inspection, maintenance, and tabletop analysis requirements. In addition, the dam would still require application for conditional certification from VA DCR. Through this process, an analysis by a certified Professional Engineer would determine the actions necessary to maintain the dam.

Sediment Transport in Lower Accotink Creek:

Rivers transport both water and sediment. Lanes Diagram (Figure 4-1) describes the general relationship between sediment and water flow. Most healthy streams that maintain a quasi-equilibrium have balanced sediment transport energy and water transport energy. When these two energies are out of balance, the stream will tend to degrade/erode or aggrade/deposit sediment.

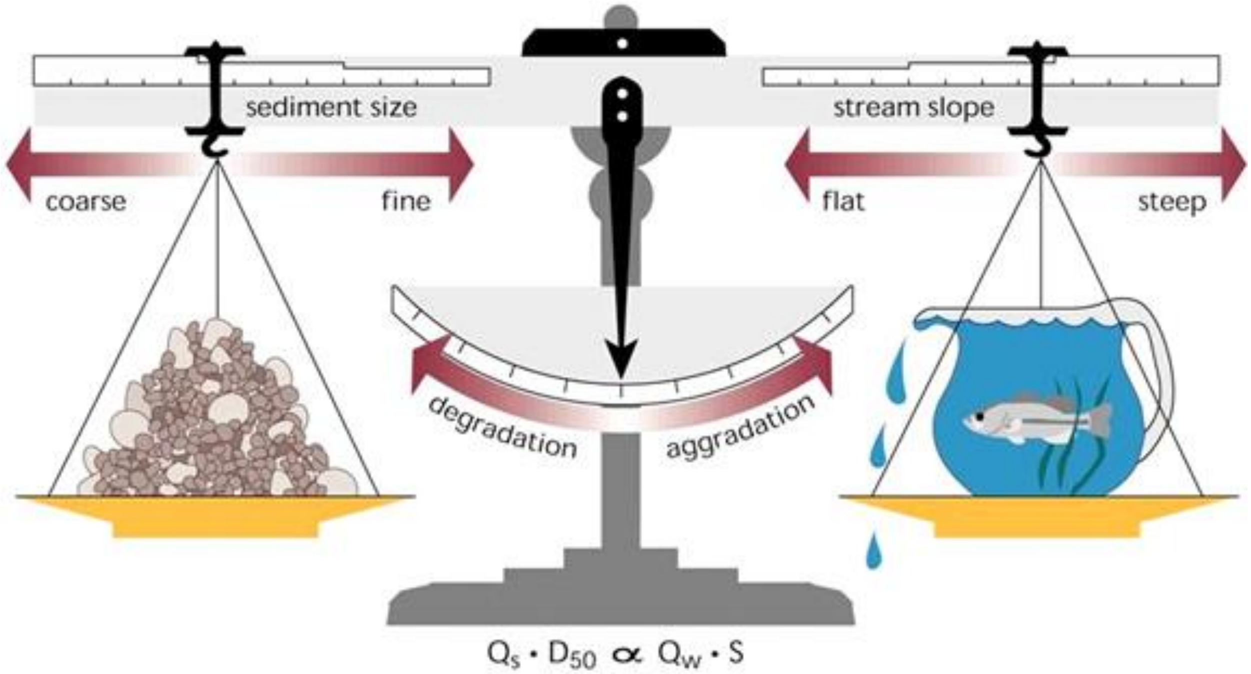

Figure 4-1 Lanes Diagram (Lane, 1955)

Urban development often disproportionately increases the water flow to a stream but not the flow of properly sized sediment. Consequently, the stream is sediment starved and degradation, incision, and erosion occur. This is a contributing factor to the historic degradation of upper Accotink Creek.

When upper Accotink Creek enters Lake Accotink, the opposite is true. The relatively flat water surface has less energy to transport sediment and some sediment accumulates within the lake.

Downstream of the dam, the balance flips yet again. The stream slope returns to its natural grade, but the sediment load has not returned, leading to stream degradation in lower Accotink Creek. This explains why there is larger creek substrate immediately below the dam – all of the fine material has washed through.

Given that the creek appears to be sediment starved downstream of the dam, leading to bed erosion, it is unclear if Lake Accotink is actually reducing the total load of sediment to the downstream waters. Unfortunately, there is not enough available data to assess this potential condition.

5 WHAT FEATURES/AMENITIES/BENEFITS/IMPACTS WILL A MANAGED WETLAND PROVIDE/HAVE?

Previously discussed in the 10/5/23 deliverable.

6 WHAT MAINTENANCE WOULD BE NECESSARY FOR A MANAGED WETLAND?

6.1 What would be required to manage a wetland complex?

The main management effort will likely be invasive species management. Beyond that, a wetland complex can be managed similarly to a lake.

If a partial dredging and reuse strategy is utilized, then wetland restoration activities will be needed with each round of dredging.

6.2 What would maintenance cycles look like?

Invasive species management is typically an ongoing challenge with annual maintenance cycles. These may include chemical treatment, water level manipulations, and selective harvesting.

If a partial dredging and reuse strategy is utilized, the required dredging frequency will likely be anywhere from annual to decadal depending on the intervention strategy.

6.3 How much would maintenance cost?

Cost cannot be assessed with any degree of accuracy without a comprehensive operations and maintenance plan. The cost is largely a question of priorities, which direct the operations and maintenance plan.

For wetland establishment/restoration strategies, there will be higher levels of maintenance required during the establishment period. After that, it is reasonable to assume that the annual invasives maintenance costs will be similar in all scenarios.

Longer-term dredging operations can be expected to be the most expensive management option.

7 WHAT ARE THE SEDIMENT LOADS WITHIN ACCOTINK CREEK AND HOW WILL THEY CHANGE?

When considering sediment load into and out of Lake Accotink, the following must be considered:

- Estimating sediment transport rates is a very challenging undertaking,
- The physics of sediment transport is still not fully understood, and
- The available data for the Accotink watershed can only tell us part of the story.

"IF YOU CAN ESTIMATE SEDIMENT TRANSPORT WITHIN A FACTOR OF FOUR, YOU ARE DOING PRETTY GOOD."
Dr. Chris Paola, Professor of Geology & Geomorphology, U. of Minnesota

7.1 What are the current sediment loads in Accotink Creek and what are the likely trends for sediment generation in the future?

The local USGS field office has been collecting flow and suspended sediment samples from Accotink Creek and Long Branch for many years. The USGS has processed their sample data to estimate annual suspended sediment data for each creek (Table 7-1). These annual summaries are modeled estimates based on the best available data for Accotink Creek and Long Branch, but there is no way to determine the exact "true" loads.

Water Year	Accotink Creek (WRTDS-K)	Long Branch (Surrogate)	Total load to Lake Acc
2014	27,700,000	2,945,876	30,645,876
2015	6,010,000	1,537,426	7,547,426
2016	8,960,000	1,351,470	10,311,470
2017	14,000,000	7,423,491	21,423,491
2018	31,300,000	11,027,030	42,327,030
2019	14,700,000	10,294,552	24,994,552
2020	11,900,000	7,233,527	19,133,527

Units are in pounds

Table 7-1 Estimated annual suspended sediment load for Accotink Creek and Long Branch (Provided by the USGS)

The suspended sediment loads estimated by the USGS were averaged to estimate the typical annual suspended sediment loads delivered to Lake Accotink (Table 7-2). The suspended sediment load was then adjusted to approximate the total load by assuming 13% of the total load is bedload and 87% of the total load is suspended load.

Average Annual Loads Based on USGS Gage Data 2014-2020*	Suspended Sediment Load in lbs	SS Load in Tons	Cubic Yards @ 45 lbs/cf	Cubic Yards @ 94 lbs/cf
Average SS Load	22,340,482	11,170	18387	8802
Average Total Load	25,678,714	12,839	21,135	10,118

Table 7-2 Annual suspended sediment and total load estimates

The 13% bedload assumption is consistent with the 2002 HDR report that reviewed several literature values; however, there is no available data to support this assumption and it could be highly inaccurate.

The sediment delivery volume has been estimated using unit weights of 45 lbs/cf and 94 lbs/cf. For lake infilling analysis we utilized 45 lbs/cf because the sediment has high concentrations of silt and clay. The mass balance calculations in Section 7.2 do not support the use of a unit weight of 94 lbs/cf.

Load Trends for the Future

The County is actively restoring reaches of upper Accotink Creek with the goal of reducing the overall suspended sediment loads delivered downstream. These efforts should lead to a declining trend in suspended sediment loads.

There are several observations of erosion and degradation in Long Branch. If left unchecked, continued degradation could lead to increasing trends in sediment loads, particularly courser bedloads.

7.2 What loads are leaving the lake in its current condition?

To estimate the loads leaving the lake, we first estimate the loads captured within the lake, and then utilize the inflow loads and the capture loads to estimate the exiting loads.

The loads captured within the lake were estimated by comparing two bathymetric surveys – one collected in May 2015, and one in November 2020. A map of the bathymetric changes is provided in Figure 7-1. During the 5.5 years between surveys, the lake infilled by as much as 7.2 feet, with a total infill volume estimate of 45.9 acre-ft (1,999,404 ft^3).

Based on these results, the average annual capture is:

- Weight = 16,358,825 Pounds
    - Assuming a unit weight of 45 lbs/ft^3.
- Volume = 363,529 ft^3 (13,464 CY)

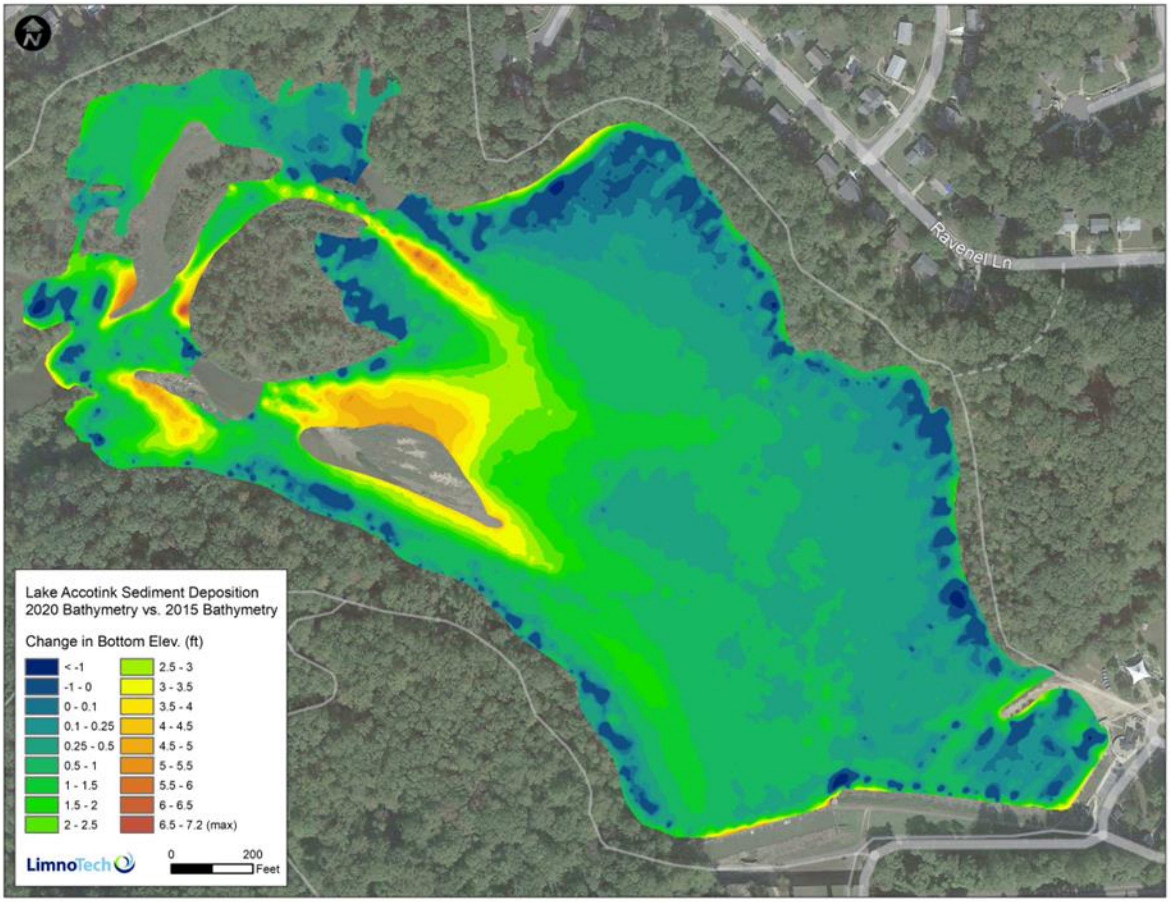

Figure 7-1 Bathymetric changes from May 2015 to November 2020

A comparison of the sediment capture rates and the sediment inflow rates yield an estimated load of approximately 4,700 tons of sediment transported to lower Accotink Creek and a capture efficiency of ~64% within the lake.

It should be noted that this analysis is entirely dependent on the percent bedload assumption, in which we have minimal confidence. The high deposition rates in the delta area that have higher shear stress and the lower deposition rates in the lower shear stress areas may indicate that that the percentage of bedload entering the lake is much higher than the assumed 13%. The observations of high erosion rates in Long Branch would further support a hypothesis that the bedload rates may be higher than assumed.

In summary, the bedload estimates/percentage is a critical assumption. This analysis should be considered our best guess at the loads leaving Lake Accotink. These values are only being reported because they are explicitly requested by the task force, and we would urge caution if using them to inform decisions about the future of the lake and dam.

7.3 How will these loads change if no action were taken?

If no action is taken, the lake will capture less and less sediment as it infills until it is completely full. Once full, the loads delivered downstream of the lake will be equal to the load entering the lake from upstream.

7.4 What would the loads leaving the lake be like if the lake were managed as a wetland?

As a partial wetland/partial lake system, the loads delivered downstream of the dam will likely be slightly higher than the current loads. The smaller lake volume will likely be slightly less efficient at capturing sediment than the current lake is; however, some of this loss in efficiency could be made up by maintaining a deeper lake.

As a full wetland complex, the loads delivered downstream will be similar to, but possibly slightly less, than the loads currently delivered to the lake from upstream. Wetlands do have the ability to capture some sediment, but most of that occurs during floodplain overtopping events. Consequently, most sediment entering the wetland complex will pass through via the creek portion of the system.

7.5 What would the sediment loads be in Accotink Creek if the dam were removed?

If the dam were completely removed, the loads delivered downstream of the site will be equal to the load entering the site from upstream.

7.6 How will these loads affect downstream resources:

How will they impact instream fauna? (Mussels)

Most healthy streams need bedload sediment; consequently, restoring the bedload sediment to lower Accotink Creek should have a generally positive impact on the instream fauna.

Suspended sediment is often considered a pollutant and can have negative impacts on instream fauna; however, the suspended sediment loads in Accotink Creek are sufficiently high that the creek may already be dominated by suspended sediment-tolerant species.

Mussel beds are common downstream of a dam, but habitat is often transient. Dams remove the fine sediment which can foul a mussel bed and allows mussel beds to thrive after a dam is installed. Dams also remove the bedload sand which is necessary to sustain mussel beds. The fact that sands take longer to wash out of the downstream reaches than the fine sediments is what creates the transient mussel habitat.

How much sediment could be expected to be captured by the floodplains?

Floodplains can capture large volumes of sediment during flood events; however, at the annual scale, floodplain capture of sediment is usually relatively small due to the fact that capture only occurs during flood events. A well-connected floodplain can be expected to flood almost annually.

How might these loads affect Gunston Cove?

The total sediment load delivered to Gunston Cove may or may not be influenced by Lake Accotink. That cannot be determined with the available data (see the example in Section 4.5).

How could these effects be mitigated?

Suspended sediment leaving Lake Accotink could be mitigated by:

- Continually dredge the lake to remove collected sediment and prevent washout, or
- Target sediment management strategies elsewhere in the watershed

7.7 What regulatory implications are there for Fairfax County due to increased sediment loads downstream of Lake Accotink and how much could mitigating these increased loads cost?

The County does receive sediment reduction credits for Lake Accotink in the Chesapeake Bay TMDL. If management activities within the lake increase suspended sediment discharge to lower Accotink Creek, then those TMDL credits may be lost.

The County is actively pursuing additional TMDL credits through other restoration activities and believes the additional cost to offset the Lake Accotink credits via other restoration activities is manageable.

Green infrastructure practices and stream restoration projects are often the most cost-effective strategies for mitigating suspended sediment loads at the community scale. This is because these practices are physically closer to the sediment sources and, once implemented, the maintenance of those practices is more manageable. Dredging is traditionally one of the most expensive sediment load reduction strategies because it needs to be done repeatedly.