5. DREDGED MATERIAL

Dredged material has a variety of possible uses in the context of sea level rise adaptation and, unlike in the recent past, is now viewed as a valuable resource. The decisions surrounding the disposition of dredged material or sediment in an area are termed sediment management strategies. Sediment management strategies can involve a number of items including removal of deposited sediment, by dredging or BMP use, and also disposal, by placement in a dredged material containment facility (DMCF) or other location or through beneficial use. Sediment management strategies at the present time and in the future will be critical elements to effective resiliency planning. These sediment management strategies should necessarily focus on the long-term disposition as well as possible deployment of sediment to maximize resiliency potential from this material in the Northern Chesapeake Bay Project Area.

The first step in being able to set an effective sediment management strategy is to understand the general sedimentation dynamics of the Northern Chesapeake Bay Project Area. It is also important to gain a historical perspective of how sedimentation dynamics have evolved in recent history so that educated decisions can be made regarding future trends. The review of sedimentation dynamics should include the accretion rates, or amount of sedimentation, found within the Project Area. It is also important to have a general understanding of what sediment management policies are in effect at present or which are planned, including current dredging locations, cycles, and trends in the region. Lastly, the sediment management decisions related to the Conowingo Reservoir, the final major impoundment on the Susquehanna River, could have substantial impacts on the Project Area. Each of these items is described in the sections below.

5.1 DREDGING OVERVIEW

The process of dredging is accomplished using water-based floating dredges and barges and/or land-based equipment operated from the channel bank. This equipment removes material from the channel bottom to keep waterways at a depth of water in which vessels can safely navigate. Dredging can be accomplished using mechanical or hydraulic methods. Mechanical dredging involves the use of clamshell buckets, which are deployed to the waterway bottom with crane systems to physically remove sediment. Hydraulic dredging uses a system of hoses and a cutting head to entrain and remove the sediment. The material removed during the dredging operations is then placed in an approved permitted location.

Dredging can also be an adaptation measure for sea level rise or can provide material to be used for a variety of mitigation or adaptation measures. Dredging as an adaptation measure can be used to clear or otherwise open-up waterways to provide the ability for stormwater runoff to progress to open water without elevating flood levels during storm events. As discussed within the previous section the dredged material could also, depending on the specific material properties, be used for raising of wetlands through thin layer placement or construction of hardscape engineering solutions as a fill material or a component of concrete mixtures or other similar uses. The use of dredged material for such applications is referred to as innovative reuse or beneficial use.

In Maryland, MDE has provided guidance on the innovative reuse or beneficial use of dredged material. This document, *Innovative Reuse and Beneficial Use of Dredged Material Guidance Document*, was complete in 2017 in recognition of the fact that most dredged material from Chesapeake Bay, including the navigation channels in the Project Area, are comprised of clean sediments that can be used on the land as soil amendments or engineered fill or in the water to create aquatic habitat and help improve water quality. It is the intent of the document to encourage further innovation in the use of dredged material in environmentally beneficial ways or as useful products such as fill for raising of infrastructure in response to sea level rise (MDE Website). The State of Maryland has set a goal to utilize annually 500,000 cubic yards of dredged sediment through this program. This guidance stands to be an important component for sediment management in the Project Area if and when resiliency measures begin to be deployed that incorporate the use of dredged sediment.

5.2 SEDIMENTATION IN THE NORTHERN CHESAPEAKE BAY

Dredging in the Project Area is ongoing due to the amount of sedimentation, or accretion, which occurs in the northern portion of the Chesapeake Bay. The majority of the sediments are transported to the Chesapeake Bay by the Susquehanna River. The Susquehanna River provides approximately half of the total incoming flow to Chesapeake Bay. Much of this flow carries suspended sediments that, for the last 90 years, since completion of the Conowingo Dam, have to a large extent been prevented from entering the Bay by the dam as well as two immediate upstream dams—Holtwood Dam and Safe Harbor Dam, which form the impoundments Lake Aldred and Lake Clarke, respectively. Over this time period, the dams have acted as de-facto stormwater BMPs removing portions of the total sediments and nutrients in the Susquehanna River before they could enter the Bay. Over the years, the impoundments behind the dams have slowly filled with sediment. Presently, and since about 2011, the reservoirs have reached an end-state with the sediment behind the dams known as dynamic equilibrium (USACE et al. 2015). The condition of dynamic equilibrium indicates that the amount of sediment presently conveyed by the Susquehanna River is over time in total entering Chesapeake Bay. Although sediment transport during typical conditions will still lead to settlement behind the dam, during storm events with larger flow velocities, sediment in the impoundment area is scoured and mobilized to flow through the dam spillway or penstocks to the Bay. Dynamic equilibrium indicates that there is no absolute capacity at which the reservoir is full and will no longer trap sediment, a cycle of periodic settlement followed by scour events can be expected to occur indefinitely (USACE et al. 2015).

Currently, the Bay receives approximately 1.2 million tons (Chesapeake Bay Program 2019) of sediment from the Susquehanna River annually. Although this is an annual average, during single large storm events, that total can be greatly surpassed. As an example, during Hurricane Agnes in 1972, the largest sediment loading event ever observed in the Project Area, it was estimated that 30 million tons of sediment were discharged to the Bay (USGS 2003). Of the annual total from the Susquehanna River, it is estimated that 70% of the sediment is included in the Project Area as it settles out of the water column before it could be transported further south in the Bay. The heavier (sand-sized material) fraction of the suspended sediment from the Susquehanna River is generally found in the Susquehanna Flats as this larger-grained material settles out prior to the estuarine turbidity maximum. This turbidity maximum for the Northern Bay is usually located between Tolchester and Turkey Point and is the location where the Bay waters are most turbid, or clouded by suspended particles, due to the flow, tidal conditions and associated sediments from the Susquehanna River (USACE et al. 2015).

Historically, the Chesapeake Bay received significant amounts of sedimentation starting in the colonization period and peaking in the late 1800s and early 1900s due to increased land clearing for agriculture and development (USACE et al. 2015). Of note, Joppatowne, located in the Project Area, was used in colonial times was a deep-water port receiving shipping similar to Baltimore until significant sedimentation made such use impossible. In the Northern Bay and onto the Susquehanna Flats, large quantities of sediment have been deposited from the Susquehanna River basin. The average water depth in a 32-square-mile area of the Northern Bay was reduced by 2.5 ft from the 1840s to 1930s. Even more significantly, sediment accumulation measured through core sampling indicates that about 7 ft of sediment was deposited on the Susquehanna Flats area from the 1890s to 1990s (USGS 2003). In the context of sediment management, this deposited material provides a potential opportunity for future use in scenarios where existing sediment sources may be a limiting factor for execution of resiliency projects.

The Susquehanna Flats portion of the Project Area is a subaqueous delta of the Susquehanna River, which encompasses over 10,000 acres. This formation is shallow, with depth as low as ½ to 1 ft at mean lower low water (MLLW) due to sediment buildup from the Susquehanna River over long periods of time. Another dynamic of the Susquehanna Flats area is the increase in SAV (submerged aquatic vegetation) in recent years. SAV beds are important to ecological systems, providing shelter for marine organisms and other benefits, and are an indicator of a healthy ecosystem. The SAV beds in the area along with the shallow water depth also help reduce the velocity and flow capacity of suspended sediments during discharge events. Because of this, deposition of material from the Susquehanna River during storm events is conveyed in large part to the dredged channel which traverses from Havre de Grace to the south. Also, as sea levels rise, natural reworking of sediments in the Susquehanna Flats by waves and currents are expected to continue to maintain shallow water habitat where the SAV thrives. Conowingo sediment management strategies that release substantial quantities of sediment may be detrimental to SAV beds in the Susquehanna Flats area in the short term, but could be beneficial over time by maintaining shallow water in this area as sea levels rise. Essentially, this process is a naturally occurring process that is similar to the resiliency method of thin layer placement. For sediment management purposes it is important to note that the timing of sediment releases with respect to growing season from April to October will also impact the overall health of the SAV beds in the Susquehanna Flats (USACE et al. 2015).

Besides the Susquehanna River, to a lesser extent flow from other rivers and stormwater conveyance to the northern portion of the Bay also provides sediment which accretes in the Project Area. Additionally, shoreline erosion contributes to the accretion as well. Shoreline erosion is an ongoing process in Chesapeake Bay, being caused by wave action during storms and high-tide events. Over time, wave action has caused the erosion of significant portions of land within the Project Area. For example, sections of the shoreline have receded more than 700 ft along the APG shore near Taylor Point since the 1840s (EA Engineering, Science, and

Technology, Inc. 2007). Sandy sediments derived from shoreline erosion are generally found near shore in depths less than 10 ft within the Project Area. In the Northern Bay approximately 15% of total fine-grained sediment load, smaller than sand-sized material, is derived from shoreline erosion (USGS 2003).

Throughout most of Chesapeake Bay the rate of sediment accretion is less than about 1.5 millimeters per year (mm/year). The deeper channel areas have higher rates of accumulation which are about 5 mm/year in the middle and lower portions of the Bay. In the Northern Bay Project Area, the rates are much higher, which reflects the large sediment loads from the Susquehanna River and the location of the turbidity maximum. Fine-grained sediments generally accumulate away from shorelines at an average accretion rate of 6 to 8 mm/year with the rate in the deeper maintained shipping channels significantly higher at up to 170 mm/year (USGS 2003). The actual sediment accretion rate at a specific location in the Project Area will vary due to the factors described above including the annual amount of precipitation and storm events.

5.3 DREDGING CYCLES

Dredging cycles, the frequency of which a waterway needs to be dredged, is a reflection on the amount of sedimentation, or accretion of sediment, occurring in an area as well as the use of the waterway. Every year, the Maryland Department of Transportation (MDOT) Maryland Port Administration (MPA) and USACE dredge approximately 4.5 million cubic yards of sediment from the Chesapeake Bay (MDOT 2017a). Of that total, 1.2 million cubic yards come from the channels adjacent to or in the vicinity of the Project Area. The federally maintained channels in the Northern Bay provide deep water access for vessels entering and leaving the Chesapeake Bay through the Chesapeake and Delaware Canal and also provide access to Havre de Grace for smaller draft vessels including barge traffic. Dredging in the Susquehanna Flats area is ongoing by USACE to provide access to Havre de Grace and points on the lower Susquehanna River to the navigational channels in the Bay located south. The Havre de Grace channel through the Susquehanna Flats is maintained at a depth of 15 ft at MLLW and width of 200 ft. Additional dredging is provided to maintain access to the Havre de Grace marina as well (USACE et al. 2015).

In the last decade, accretion rates have increased at Havre de Grace, which typically required dredging once every 5 years to maintain the channel. It is now planned to start dredging every 4 years (Anderson 2018). The dredging in 2012 to maintain the navigational channel at Havre de Grace included the removal of 200,000 cubic yards of sand that was placed to expand Battery Island located in the southern portion of the Susquehanna Flats (USACE et al. 2015). The project at Battery Island provides an important example of the beneficial use of dredged material. This type of project, as noted previously, could be executed in other locations within the Project Area to accomplish several objectives. These objectives include stabilization of lands from coastal erosion, restoration of historical shoreline, and/or providing elevation increase for sea level rise resiliency. In the case of Battery Island, the objective was also to find a location for the beneficial use of dredged material, instead of depositing the material in an upland DMCF.

Currently, all material from the USACE Federal Navigation channels in the Project Area, defined as the channels north of Pooles Island, (**Figure 6-1**) are deposited in the DMCF at Pearce Creek in Cecil County, Maryland USACE 2015b. This facility, after undergoing a recent modification, is projected to be able to accept the full 1.2 million cubic yards of sediment from the Project Area navigation channels up to the year 2037. The State of Maryland Dredged Material Management Program, which includes both USACE and MDOT MPA, reviews current capacity needs annually and will plan to establish the future sediment management containment locations once capacity is reached at the Pearce Creek facility (MDOT MPA 2017a). The costs and time associated with siting, design and construction of new dredged containment facilities is significant. Therefore, if innovative reuse or beneficial use of dredged material could be established in the Project Area for resiliency or other uses it would extend the useful life of Pearce Creek DMCF by removing some of the material currently slated for deposit at the facility. This, in turn would, also be a cost and time saving prospect for the DMMP (MDOT MPA 2017b). The confluence of objectives for dredged material may provide the prospect for collaborative approaches to future resiliency projects within the northern Chesapeake Bay. As noted above, one such example project recently completed was the work at Battery Island within the Susquehanna Flats. This project, then, could be looked at as a model for future resiliency-based projects.

Besides the USACE channel dredging projects, smaller non-federal maintenance dredging projects occur regularly within the Project Area with the primary purpose of maintaining recreational boating access as well. For example, during 2018, Harford County received Maryland State grants totaling $492,000 for completion of several dredging projects, including dredging of the existing channel in the Gunpowder River, dredging of the channel upstream of the Taylor Creek public boat launch at Mariner Point Park, and dredging to restore boating access at Foster Beach in Joppatowne. At APG, sediment deposition has been occurring along Spesutie Island, which has impacted the use of the boat ramp which currently cannot be used during low tides; therefore, dredging will be needed to restore boating access at that facility in the near future (Anderson 2018; Deel 2018).

For the smaller dredging projects in the Project Area, there are a variety of placement sites that accept dredged material including landfills; however, none of these sites provide a large-capacity option for the placement of dredged material.

5.4 DREDGED MATERIAL USE DISCUSSION

Since the sediment loading and accretion rates from the Susquehanna River are expected to remain stable over time, planning for dredging in the Project Area is projected to continue at the rate of 1.2 million cubic yards per year for the USACE Navigational Channels. Smaller maintenance projects can also be expected to occur at regular intervals as well. Sediment management decisions related to the Conowingo Reservoir are not included.

With the possibility of utilizing the annual dredged material from within the Project Area (or material outside of the area, if needed) and the possibility of utilizing deposited material within the Susquehanna Flats, there are many planning challenges that would need to be addressed.

Even with the MDE Innovative Re-use and Beneficial Use document, the discussions for resiliency projects to utilize dredged material would have to be formally vetted through regulatory channels before steps could be taken to utilize this material. Specific material properties, material volumes, and dredging schedules would need to be matched to resiliency measures for a certain area. Inorganic and organic chemicals and nutrient constituents in the material must also be considered.

Despite the challenges involved at the present time, dredged material does provide a viable resource both now and in the future for climate resiliency projects. The possible uses and material volume requirements should be considered when establishing or planning for future sediment management within both the Project Area and the Chesapeake region.

5.5 IMPACTS OF CONOWINGO SEDIMENT MANAGEMENT

Management of the sediments within the Conowingo Reservoir could have significant impacts to sedimentation and water quality within the Project Area. In discussing sediment management, it is also important to realize the sediment load itself is not the major threat to Bay water quality. Once sediment is deposited on the bottom, the effect on water quality essentially ceases unless it is resuspended. The nutrients associated with the sediments are more damaging to the Chesapeake Bay ecosystem. After deposition, biogeochemical processes transform particulate organic nutrients and inorganic nutrients adsorbed to sediment into dissolved forms, which diffuse into the water column and become bioavailable. These dissolved nutrients stimulate algal growth; the algal organic matter then decays and consumes oxygen in the eutrophication cycle. This leads to the ‘dead zones’ that occur in the summer months in the deeper waters of the Chesapeake Bay (USACE et al. 2015).

Sediment and nutrient impacts to the Bay are presently regulated by EPA through total maximum daily load (TMDL), and the expected impacts of sediment from the Susquehanna River to the Chesapeake Bay have been extensively studied. These studies have included review of several sediment management strategies to address and restore or partially restore impoundment sediment capacity in Conowingo Reservoir. These strategies stand to have a significant impact on the sedimentation in the Project Area if implemented. In general, the proposed sediment management strategies fall into three categories:

- Reducing sediment yield from upstream watershed
- Minimizing sediment deposition
- Increasing or recovering volume of the reservoir.

A detailed comparison of these possible strategies was completed as part of the Lower Susquehanna River Watershed Assessment (USACE et al.) in 2015. These are summarized in the following paragraphs.

Dredging to restore capacity in the impoundment was reviewed as part of the Lower Susquehanna River Watershed Assessment (LSRWA) study. Dredging was contemplated on different scales referred to as strategic or extreme dredging. Strategic dredging was defined as dredging targeted at removing material in areas of the Conowingo Reservoir where higher scour is expected in the impoundment during storm events. During the LSRWA, a volume of strategic dredging of 3 million cubic yards was identified and modeled to ascertain the effects on the reservoir and Chesapeake Bay. This volume was found to have little effect on the ability of Conowingo Reservoir to retain sediment. The overall cost of this strategic dredging option was estimated to range from approximately $48 to $267 million. In addition, strategic dredging would have minimal impact on the total sediment load delivered to the Bay when large flood events occur.

Extreme dredging in the LSRWA report was the term used to define a large-scale dredging project to restore the Conowingo Reservoir to the same bathymetry as existed in 1996. This would require the one-time dredging of approximately 31 million cubic yards of sediment. This scenario was modeled to compare 1996 bathymetric data (as the reservoir would exhibit post-extreme dredging) to 2011 data within the Conowingo Reservoir by running of flow conditions for a 4-year period from 2008 to 2011. The comparison indicated over this time frame a 10% increase in total sediment load to the Bay, a 67% increase in bed scour, and a 33% increase in reservoir sedimentation (USACE et al. 2015). The net reduction in sediment discharge in this scenario, however, represents a small fraction of the sediment load resulting from a large storm event. Cost of this scenario was estimated to range from approximately $496 million to $2.8 billion. This extreme dredging would need to be completed approximately every 15 years to keep pace with sedimentation. This scenario would require a location for placement of the dredged material and would remove that portion of sediment from deposition to Chesapeake Bay.

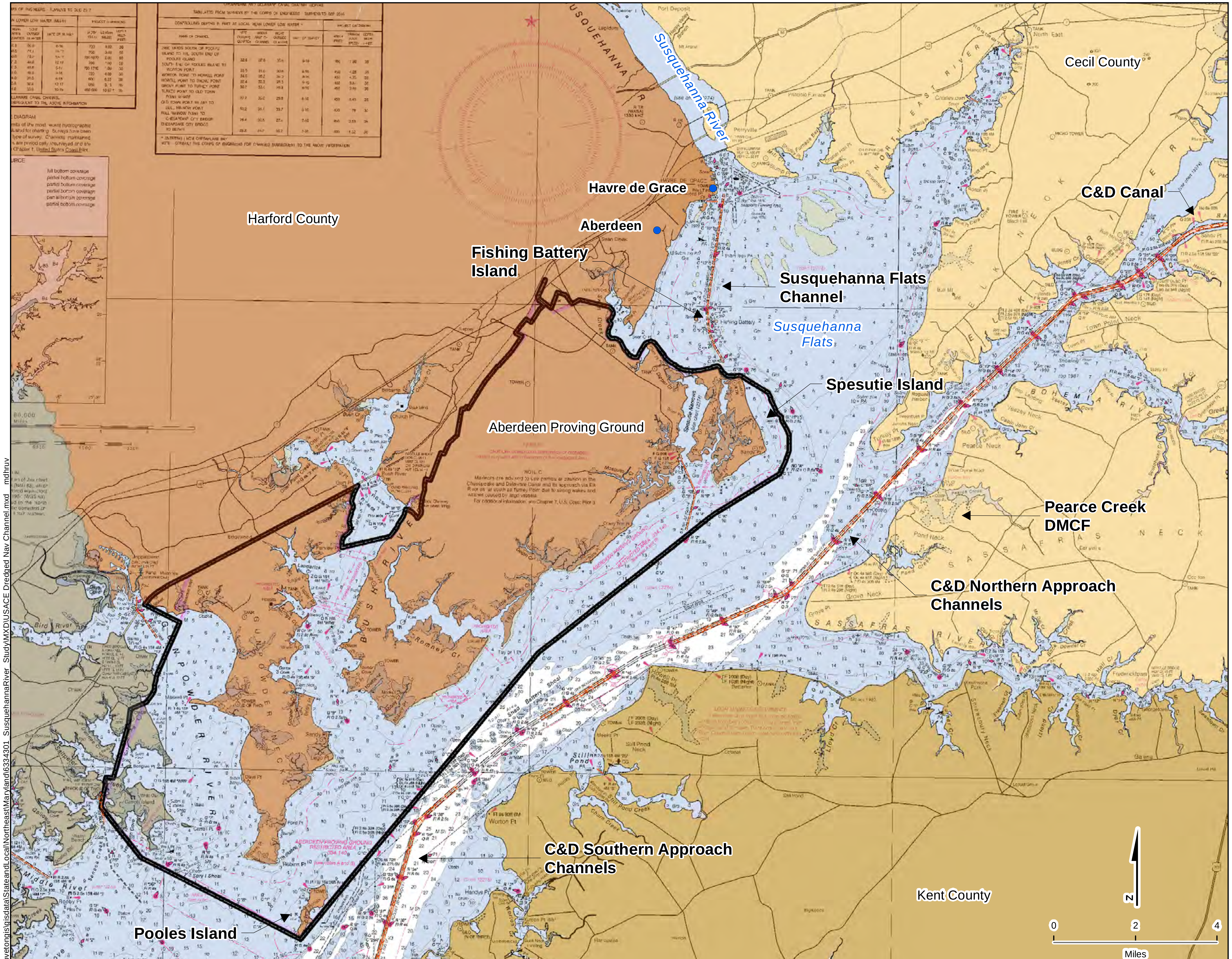
Bypassing of sediment through the Conowingo Dam through agitation dredging or piping was the third alternative reviewed. This management method would not remove sediment from deposition to Chesapeake Bay but would recover volume in the reservoir. The strategy for bypassing sediment would focus on allowing bypass to occur during times when it is ecologically less harmful than to have the material scoured by a storm event at an unplanned time. In some bypass scenarios, piping would be constructed to allow for transport of sediment from behind the dam to below the dam. In other scenarios, agitation dredging would be used to mechanically or hydraulically re-suspend bed sediments which are then entrained in the water column and transported out of the impoundment with the currents. For the agitation dredging removal strategy to be successful, adequate flow velocities in the reservoir are required to transport the re-suspended sediments. The bypass scenario was reviewed for a defined amount of sediment per time period to determine the impact of suspended sediment concentrations below the dam. For a 90-day discharge of 3 million cubic yards of sediment, the expected impact to the lower channel and Susquehanna Flats would increase by a factor of 15, from 12 to 174 milligrams per liter total suspended solids. In a 270-day bypass of 2.4 million tons it would increase suspended sediment concentrations by a factor of 5; from 12 to 65 milligrams per liter total suspended solids. The overall cost of the program could range from approximately $15 to $480 million. During modeling, it was found that the bypass of sediment environmental costs (diminished dissolved oxygen, increased chlorophyll) is roughly 10 times greater than the benefits gained from reducing bed sediment scour in the reservoir (USACE et al. 2015).

Reducing the sediment yield from the upstream watershed, such as implementation of stormwater BMPs, is ongoing as part of the Watershed Implementation Plans of the EPA TMDL. These are a critical item to reduce sediment and nutrient loading required to meet the TMDL by 2025. During the LSRWA study, additional opportunities to reduce sediment in the watershed with additional BMPs beyond the level established by the Watershed Implementation Plans were reviewed. It was found that these would be of high cost and would cause only small sediment load reductions in comparison to other strategies (USACE et al. 2015).

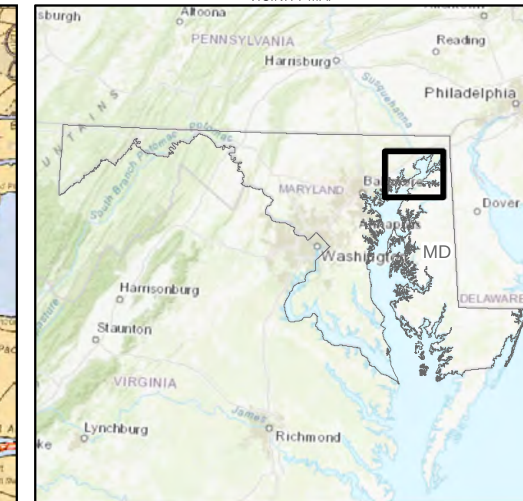
Currently, decisions regarding how to move forward on the Conowingo Dam sediment issue are being reviewed as part of the Federal Energy Regulatory Commission relicensing process for the Conowingo Dam for an additional 50-year period. The relicensing process requires the facility to obtain a Water Quality Certification through MDE. This certification was issued by MDE for the dam in April 2018, but has been challenged by dam owner, Exelon. The Water Quality Certification requires Exelon to improve conditions for aquatic life and fish migration and to improve debris management. It is undetermined how sediment management may change based on these requirements and ongoing discussions.

In addition, Maryland Environmental Service issued a request for proposal in August 2018 for a pilot dredging, sediment characterization, and innovative reuse of dredged material project for a small area within the Conowingo Reservoir. The results of this procurement are currently pending.

Whatever decisions are made regarding the sediment within the Conowingo Reservoir, it is likely it will continue to have a major effect in the Project Area. Based on the current status of the discussions, it is likely that no major changes to the sediment loading within the Project Area from the Susquehanna River should be expected in the near future.



VICINITY MAP



Legend

- City/Town
- USACE Navigation Channel
- APG Boundary
- Cecil County
- Harford County
- Kent County

Map Date: 1/30/2019
Source: USACE 2007, APG 2018
NOAA Chart: 12273 January 2014
Projection: WGS 1984 UTM Zone 18N Meter

FIGURE 5-1
USACE Dredged Navigation Channels
Planning for Coastal Resiliency in the Northern Chesapeake Bay