Design of a Sediment Mitigation System for Conowingo Dam

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***Abstract*— The water quality of the Susquehanna River, the major freshwater tributary of the Chesapeake Bay, significantly diminishes during major scouring events. Major scouring events are defined as enhanced erosion of sediment due to significantly increased flow rates and constant interaction of water with the Dam. During these events, the sediment build up at Conowingo Dam in the Lower Susquehanna River has an adverse direct impact on the ecosystem of the Chesapeake Bay. The goal of this paper is to determine the best mitigation technique to address the scouring of sediment at Conowingo Dam.**

Design alternatives were evaluated for ecosystem impact and sediment mitigation; (i) No Mitigation (ii) Hydraulic Dredging (quarry, rotary kiln product, low-temperature washing product, plasma gas arc vitrification product), and (iii) Hydraulic Dredging and Artificial Island. Three models were used to evaluate these design alternatives; (1) a sediment mitigation model to simulate sediment flow from upstream and sediment outflow at Conowingo Dam, (2) an ecological impact model to simulate ecological impact of the scoured sediment on the Chesapeake Bay ecosystem, and (3) a business model to simulate sediment production revenue and the offset of alternative costs.

An analysis is …TBD

I. Introduction

The Lower Susquehanna flows from Pennsylvania into Maryland and empties into the Chesapeake Bay, providing approximately 60% of its freshwater. It has been used as a source of water and power since the 1730's. By the 20th century people had begun to use the waterway for waste disposal of metals, coal tar, railroad refuse, and other pollutants. During the 20th century, the U.S. Army Corps of Engineers was brought in to protect the local communities from the pollutants that were being disseminated during major flooding. The US Army Corps of Engineers mitigated this problem by designing and implementing artificial channels and levies, which actually further degraded the water quality. Dams, power plants, and incinerators were also built during the 20th century along the Lower Susquehanna. They contributed to the alteration of fish migration, the heating of the river, and the reduction in the quality of the river's water.

During the 20th century, four dams were built on the lower Susquehanna; the York Haven, Safe Harbor, Holtwood, and Conowingo Dams. Despite the dams' positive impact of providing clean energy to the power grid, they have contributed to the alteration of fish migration, the heating of the river, and the reduction in the quality of the river's water[1]. The Conowingo Dam was constructed in 1928 as a hydroelectric power source. The Conowingo Dam is the southernmost dam on the Susquehanna River. While the Conowingo Dam traps sediment and nutrients from reaching the Chesapeake Bay, a study conducted by the United States Geological Survey (USGS) suggests that the reservoir will reach capacity around the year 2030. To be at maximum capacity means the dam will be completely silted up and will no longer be able to retain sediment. At that point in time sediment will begin to reach the bay at a an increased steady-state. Once this happens, it is estimated that sediment delivery to the Bay will increase by about 150%[2].

The biggest concern regarding the Conowingo Dam stems from the adverse effects of scouring events that occur during major storms. Scouring events have been defined as storms that cause the flow rate of the Lower Susquehanna River to exceed 300,000 cubic feet per second (cfs).

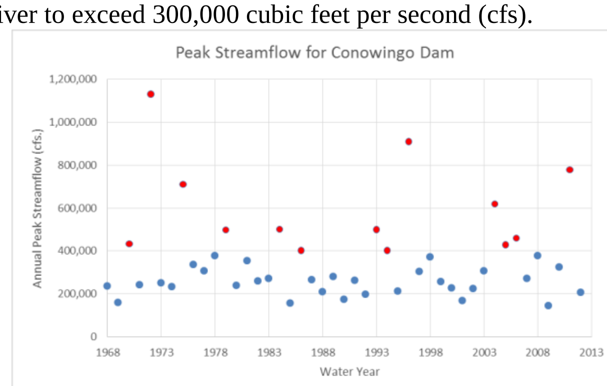

Fig. 1: Annual Peak Water Flow at Conowingo Dam (1968-2012) [3]

Figure 1 shows the annual peak stream flow at Conowingo Dam by water year. A water year is defined as a period of 12 months from October 1st through September 30th, where the water year is designated by the year in which September 30th falls. The water years in which a scouring event occurs are denoted in red on the graph. Although there is a slight increase in the number of scouring events from 2003 to 2013 in comparison to the 10-yr periods prior, this incidence does not conclude that these events are occurring more frequently. From the data, a scouring event occurs, on average, a little over every three years. Extremely devastating storms such as Tropical Storm Agnes and Tropical Storm Lee occur much less frequently. During these storms water flow reached over 7000,000 cfs.

II. Stakeholder Analysis

A. Lower Susquehanna Riverkeeper and Stewards of the Lower Susquehanna

The Lower Susquehanna Riverkeepe founded the Stewards of the Lower Susquehanna, Inc. (SOLS), a non-profit environmental advocacy organization that supports the licensed Riverkeeper. The association works with citizens and scientists to find solutions to environmental problems along the Lower Susquehanna River and the Chesapeake Bay Watersheds[4]. The objectives of SOLS and the Lower Susquehanna Riverkeeper are to find alternative uses for the sediment stored behind Conowingo Dam, highlight vulnerabilities in environmental law and legislation at present, as well as to make sure future catastrophic weather events do not displace sediment and further harm the Chesapeake Bay's ecosystem[5].

B. Waterkeepers Chesapeake

Waterkeepers Chesapeake is a coalition comprised of 18 independent Waterkeeper programs that operate within the Chesapeake and Delmarva Coastal Bays Watersheds. The programs within Waterkeepers Chesapeake are also members of the Waterkeeper Alliance[6]. Waterkeeper Alliance is an environmental advocacy organization that aims to unite Waterkeeper organizations, locally and internationally, to cover issues related and affecting the quality of rivers, lakes, and other various bodies of water [7]. Accordingly, the objective of the Waterkeepers Chesapeake is to protect and improve the health of the Chesapeake Bay and the waterways in the region [8].

C. Pennsylvania and Maryland Residents

Some of the residents of Maryland and Pennsylvania make up the population known as the Lower Susquehanna Watershed residents. The residents of the watershed, primarily those that use the river's water for agricultural purposes, contribute to the river's pollution through the deposition of phosphorus and nitrogen. Some of the residents of the two states also benefit from the recreational uses of the water, including fishing and various water sport activities, and use the river to access drinking water. The objective of these residents is to maintain healthy waters in the river for recreational purposes and overall water quality.

Other residents of Maryland and Pennsylvania make up the population that does not necessarily reside in the Lower Susquehanna Watershed. These residents benefit from the electricity harvested at Conowingo Hydroelectric Plant. The objective of these residents is to receive power from the hydroelectric plant at Conowingo Dam.

D. Exelon Generation

Exelon Generation is the owner of the Conowingo Dam. The Conowingo Dam provides 55% of Maryland's clean, renewable energy [9]. Exelon Generation also provides energy to major constituents in Philadelphia, PA [10]. The objective of Exelon Generation is to extend their licensing for ownership and usage of Conowingo Dam prior to the license expiration set to occur September 1, 2014. The relicensing, if granted by the Federal Energy Regulatory Commission (FERC), will allow Exelon Generation the ability to continue to provide power to some of the Lower Susquehanna Watershed residents until 2060.

E. Federal Energy Regulatory Commission

The Federal Energy Regulatory Commission (FERC) regulates and oversees interstate transmission of natural gas, oil, electricity and hydropower projects. In relation to hydroelectric projects, FERC is responsible for licensing and inspecting private, municipal and state hydroelectric projects. The objective of FERC is to "assist consumers in obtaining reliable, efficient and sustainable energy services at a reasonable cost through appropriate regulatory and market means" [11].

F. Stakeholder Tensions

The Lower Susquehanna Riverkeeper, SOLS, Waterkeepers Chesapeake and the residents of the Lower Susquehanna Watershed all want Exelon Generation to take some, if not most, responsibility for the sediment build up behind Conowingo Dam. In taking responsibility for the sediment, Exelon would be tasked with providing a substantial amount of funding for sediment mitigation. To make a change these groups, alongside other environmental organizations, are urging FERC to implement greater regulations on Exelon Generation. The Lower Susquehanna Riverkeeper, SOLS and Waterkeepers Chesapeake have gone so far as to take legal action against Exelon Generating Company, LLC in the form of a motion to intervene. The motion was filed July 17, 2013. It sites that the groups are seeking to protect the watershed resources from adverse conditions. The group is hoping that by filing the motion during this relicensing period, long-term ecological consequences and impacts will be avoided[8].

Exelon Generation is seeking a new license from FERC that will allow them to operate until 2060[8] but currently Exelon has no plan to deal with the sediment build-up behind the dam. To help mitigate the problem in some fashion, Exelon has been studying possible solutions as part of their process for relicensing[12]. At present Exelon claims no responsibility for the sediment build-up behind Conowingo Dam. To Exelon, the sediment build-up is river problem, not strictly an Exelon problem. In accordance, with the environmental organizations and Exelon, a problem to the river is a problem to all. That is why the Lower Susquehanna Riverkeeper, SOLS and Waterkeepers Chesapeake would also like to see the residents of the watershed that are contributing to pollution, clean up their agricultural methods as well. As of March 2012, Exelon merged with Constellation, which seems to be an important factor in why Exelon is not willing to let Conowingo Dam go despite all the problems it is causing [13]. Conowingo Dam supplies power to one of their biggest consumers, Philadelphia, and with the merge, Exelon already relinquished some of their power production ventures to remain within FERC limits for energy production [13][14].

III. Statement of Need

There is a need to reduce the environmental impact of scouring events by reducing the sediment and nutrients currently trapped behind Conowingo Dam. This is to be done while maintaining energy production in order to help satisfy FERC standards, and eventual TMDL regulations.

IV. Design Alternatives

Sediment mitigation is paramount to the system's success. Three major alternatives have been identified to meet the needs of our stakeholders through meeting at least one of our mission requirements.

A. No Mitigation Techniques

In terms of immediate, short-term cost benefit, taking no action at Conowingo Dam would be the most cost-efficient decision. Enforcing no sediment mitigation techniques imposes no direct financial costs on stakeholders in the form of equipment or labor expenses. Doing nothing with the sediment build up within the reservoir would allow for an asymptotic buildup at Conowingo Dam for the next 10-15 years, before capacity is met. Once the remaining 30,000,000 tons of capacity behind the dam fill, all suspended sediment from upriver would simply flow from the reservoir, through the Conowingo Dam, and down the Lower Susquehanna into the Chesapeake Bay[15].

B. Hydraulic Dredging

Hydraulic dredging is a method in which a device on the dredge moves over a particular area of water, and removes the material below by stirring and sucking up the sediment through a pipeline. The sediment is then transported onto land, where it can be moved into mechanical dewatering systems, dewatering tubes, open discharge, dredge material placement site, or geotextile bags. The process of hydraulic dredging can be best seen in Figure 5. Given optimal conditions, this alternative could remove up to 525 tons of sediment per hour[16].

To help offset costs for dredging, dredged sediment can be decontaminated, processed and manufactured into various products. The ultimate goal remains to produce the largest amount of product to help minimize our costs associated with the mitigation alternatives and maximize the reusability of the dredged sediment. Alongside product alternatives is the use of a quarry for storing the sediment. The quarry alternative implies no sediment is turned into product.

Products Section To Be Added Later.

C. Hydraulic Dredging and Artificial Island

As mentioned with the second alternative, hydraulic dredging is a high-cost process that requires not only a cost of processing, but a cost for transportation as well. Instead of transporting the sediment to a processing center, it may be beneficial to actually reuse it in the reservoir. If enough sediment was processed and dumped into one location, an artificial island could be built. With this, flow velocity around the island would increase, which would decrease the Rouse number in these locations. More sediment would get through the dam and into the Chesapeake Bay. This would not only reduce the cost of transportation of sediment to the reservoir instead of a processing center, but would also reduce the cost of continual maintenance dredging with total less sediment in the reservoir. A sample location of the reservoir is shown in Figure 2.

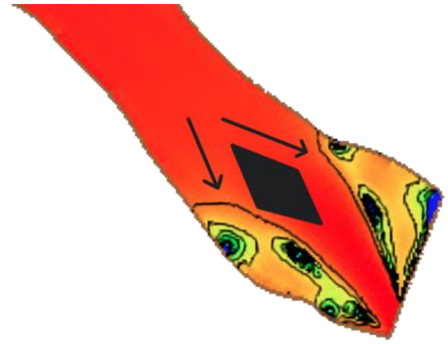

Fig. 2: Example Artificial Island Location in Conowingo Reservoir

This artificial island would be in a diamond shape with varying size and distance from the dam. A diamond was chosen because it is efficient enough to minimize the drag coefficient while maintaining feasibility with a simple shape for construction. While this technique may remove a substantial amount of suspended sediment, not all of the sediment may be removed this way. Any unaffected sediment would still need regular dredging in combination with the artificial island.

V. Method of Analysis

To Be Added Later.

VI. Results

A. Sediment Mitigation Model Results

To Be Determined.

B. Ecological Impact Model Results

To Be Determined.

C. Business Model Results

To Be Determined

VII. Recommendations

To Be Determined.

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