ABSTRACT

Title of Thesis: DESIGNING WITH DEBRIS: ECOLOGICAL INFRASTRUCTURE FOR URBAN TIDAL RIVERS

Spencer Craig, Master of Landscape Architecture, 2026

Dissertation directed by: Dr. Deni Ruggeri, Associate Professor, PSLA

Urban tidal rivers, such as the Anacostia River in Southeast Washington D.C., continue to experience persistent accumulation of floating debris and nutrient pollution from both legacy contamination and ongoing urban runoff. This thesis examines how in-water ecological infrastructure can address these intertwined challenges by integrating debris management, water quality improvement, and public engagement strategies in a single framework. Through a review of debris monitoring methods, hybrid capture systems, and ecological precedents, this project explores how modular floating and shoreline-based interventions can function as debris sorting systems that highlight natural riverine processes. Located in Southeast Washington D.C., the design reinterprets floating litter and woody debris accumulation along shoreline edges not as a sign of neglect, but as an opportunity for nutrient interception, habitat formation, and increased public stewardship. In doing so, the project proposes a model for urban waterfront resilience in which debris-responsive infrastructure contributes to both ecological restoration and civic engagement.

DESIGNING WITH DEBRIS: ECOLOGICAL INFRASTRUCTURE FOR URBAN TIDAL RIVERS

by

Spencer Craig

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Advisory Committee:
Deni Ruggeri, Chair
Christopher D. Ellis
David R. Tilley
Naomi A. Sachs

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List of Abbreviations

AWS: Anacostia Watershed Society

BID: Business Improvement District

BOD: Biochemical Oxygen Demand

CFU: Colony Forming Units

DC Water: District of Columbia Water and Sewer Authority

DDOT: District Department of Transportation

DO: Dissolved Oxygen

DOEE: District Department of Energy and Environment

DPR: Department of Parks and Recreation

EPA: U.S. Environmental Protection Agency

FNU: Formazin Nephelometric Units

HDPE: High-Density Polyethylene

IBI: Index of Biotic Integrity

NOAA: National Oceanic and Atmospheric Administration

PAHs: Polycyclic Aromatic Hydrocarbons

PCBs: Polychlorinated Biphenyls

SAV: Submerged Aquatic Vegetation

TMDL: Total Maximum Daily Load

TSS: Total Suspended Solids

USACE: U.S. Army Corps of Engineers

USGS: U.S. Geological Survey

Chapter 1: Introduction

1.1 The Anacostia River

This research reframes debris accumulation along urban tidal rivers as a design opportunity, exploring how landscape interventions can work with river processes to support ecological function and shape public perception of river health.

The Anacostia River is an 8.4-mile tidal tributary starting in the Northwest Branch of Maryland and flows through Washington, D.C., into the Potomac River (Anacostia River, 2024). Over time, extensive changes in land use, including agriculture, urbanization, and industrial development, continue to shape the river's physical conditions and current use (Anacostia River: A Legacy of Pollution, 2017). The mix of land uses has contributed to long-term environmental challenges, including increased stormwater runoff, sediment pollution, and the contamination and transport of heavy metals and litter (USGS, 2023). Although Washington, D.C. has invested in both sewer infrastructure and water quality initiatives, the Anacostia River consistently ranks poorly in water quality assessment (Anacostia Watershed Society, 2024).

In addition to chemical impairments, visible debris such as floating trash and mixed-sized woody material reinforces public perceptions of neglect. In tidal systems, hydrologic forces, watershed inputs, and overall tidal movement not only sustain floating debris settlement but also visually degrade experiences along key recreational destinations along the river (Do et al., 2026). While waterfront maintenance strategies in the Anacostia often prioritize rapid removal of accumulated debris, these approaches separate ecological processes from the public. These practices may address short-term aesthetic concerns, but they fail to recognize the underlying natural dynamics of debris transport and nutrient loading (Collaboratively Addressing Derelict Vessels and Large Debris in the Anacostia River, 2025).

Rather than attempting to eliminate all visible forms of woody material and floating plastic debris, this project positions debris accumulation as an inevitable condition of urban tidal rivers. The design introduces a system of floating and shoreline interventions that selectively retain, sort, and display accumulated debris. Framed around ecological modular systems that improve water quality, the strategy enhances public experiences and perceptions of the river by placing this natural process at the forefront of the design. By operating as a hybrid system, the design supports existing routine maintenance while coexisting with the river's natural tidal dynamics. The design reframes debris accumulation as a precedent-setting approach for how urban waterfronts can function as ecological and aesthetic opportunities to enhance ecological performance, improve public perceptions of river processes, and promote active participants in river stewardship.

1.2 Relevance to Landscape Architecture

Urban river systems are often managed through engineering and maintenance-driven approaches that prioritize efficiency, containment, and removal of debris. While these strategies address functional concerns, they overlook the spatial, ecological, and experiential dimensions of waterfront environments. As a result, debris is treated as a condition to be hidden or eliminated, reinforcing perceptions of neglect and disconnecting the public from the dynamic natural processes that shape urban rivers.

Landscape architecture offers a critical framework to rethink these conditions by engaging with water systems as designed environments rather than purely infrastructure problems. Within this discipline, the river edge is understood not only as a boundary, but as a performative space where ecological processes, human activity, and material flows intersect.

Floating debris, including plastics and woody material, reveals underlying hydrologic patterns and spatial constraints within urban river systems.

Designing with these processes shifts debris management from reactive removal toward systems that guide, organize, and make debris movement visible within the landscape. By integrating ecological infrastructure, public access, and maintenance operations, landscape architecture can transform debris from a sign of environmental failure into a legible, managed component of the waterfront.

Chapter 2: Literature Review

2.1 Legacy of Pollution in the Anacostia River

The integrity of the Anacostia River has undergone drastic changes. The river was home to the Nacotchank people in the early 1600s and served as a vital waterway for food, transport, and trade (Anacostia Riverkeeper, n.d.). However, during European settlement and conflict periods in the 17th century, deforestation, land clearing, and agricultural practices greatly altered the land (Anacostia Riverkeeper, n.d.). These were some of the first land-altering interventions that increased sediment erosion in the river, contributing to habitat loss and flooding (Smithsonian Environmental Research Center [SERC], n.d.). These events set in motion long-term patterns of sediment and pollutant accumulation and resuspension are still evident today.

In the seventeenth century, Washington, D.C. experienced significant urban growth, particularly following the Civil War. As a result, the Anacostia River became an outlet for much of the city's untreated human and animal waste, industrial byproducts, and urban runoff (Anacostia Riverkeeper, n.d.). Increased pollutants and dredging soon followed, taking place throughout much of the 1900s. The U.S. Army Corps of Engineers conducted various dredging projects to combat flooding, fill wetlands associated with malaria, promote navigable water, and make room for more development. These practices disturbed existing contaminated soils while introducing heavy metals, such as lead and mercury, and later industrial compounds, into the waterway (Goldman, 2010). Industrial compounds like heavy metals, oil, and toxins continued to be discharged throughout the twentieth century (U.S. Environmental Protection Agency, n.d.). Among the most concerning pollutants were polychlorinated biphenyls (PCBs). Organic chemicals were widely used in electrical equipment and lacked the ability to break down naturally. PCBs bind closely to soil particles, making them difficult to dissolve in water. These properties make them susceptible to easy transport into river, particularly during storm events when multiple water sources discharge into the river simultaneously. Runoff, leakage, improper disposal, and wastewater transport create further challenges in both monitoring and containing dispersion. This historic accumulation of anthropogenic and environmental contaminants persists as significant concerns for the river today. Despite the historic physical and chemical damage to the river, ongoing efforts, built on water quality regulations, are improving, with hopes of mitigating impacts and restoring the Anacostia to a condition that better supports both human use and wildlife.

2.2 Clean River Initiatives

Formal acts to address water quality in the Anacostia River gained momentum in the late twentieth century. Through a combination of federal regulations, regional coordination, and local policy, the Anacostia experienced considerable efforts to combat its water quality pollutant stressors. Among the most comprehensive acts passed was the Clean Water Act in 1972. This act established an enforceable national standard regulating the discharge of pollutants into U.S. waters including rivers, wetlands, and coastal systems (U.S. Army Corps of Engineers, n.d.).

Although not specific to the Anacostia River, the act provided a regulatory framework for water quality standards and pollutant load and discharge limits.

Building on the Clean Water Act, in 1987 the Anacostia Watershed Restoration Agreement coordinated efforts among Washington D.C., Maryland, and regional agencies toward improving water quality, restoring habitats, and promoting watershed stewardship (Metropolitan Washington Council of Governments, n.d.). Additional local parties assisted these efforts to target pollutant sources. In 2009, the District of Columbia introduced a five-cent fee on plastic bags through the Anacostia River Clean Up and Protection Act. This policy significantly reduced the amount of plastic litter entering the river and has since been adopted by local Virginia jurisdictions within the past five years (District Department of Energy and Environment, 2023). Accompanying these efforts, in 2010 D.C. and Maryland adopted the Total Maximum Daily Load (TMDL) requirement, which establishes pollutant load thresholds necessary to meet water quality standards.

More recent investments have focused on reducing combined sewer overflows (CSOs) through large-scale infrastructure to reduce untreated sewage and pollution from entering the waterway. Projects constructed under DC Water's Clean River Projects include the Anacostia River Tunnel (2018) and the Northwest Boundary Tunnel (2023). In conjunction with these projects, other collaborative efforts, such as the Anacostia Waterfront Initiative (AWI) have led efforts since 2000 to guide ecological restoration, waterfront access, economic development, and parks development along the Anacostia corridor. This framework positions environmental cleanup and habitat restoration as its foundational components linking water quality improvements with public access, recreation, and community investment (District of Columbia Office of Planning, n.d.). Supporting these multi-agency efforts, programs like the Anacostia

Watershed Society have also implemented strategies to address stormwater runoff, trash accumulation, and flooding by applying green infrastructure, river cleanup efforts, and public education initiatives (Anacostia Watershed Society, n.d.).

Despite such measurable progress, legacy pollutants and debris remain embedded in the river system, demonstrating the need for continued and complementary approaches to restoration. The following section examines specific contaminants affecting the Anacostia River and implications for advancing a cleaner and more resilient river.

2.3 Sources and Pathways of Plastics

One of the most visually prominent and persistent contaminants in the Anacostia River is plastic. The most common and identifiable type of plastics are macroplastics. Macroplastics are typically medium size, ranging from 5mm to 50 cm and include items like bottles, bags, and food wrappers with plastic bottles accounting for roughly sixty percent of trash by weight (Anacostia Riverkeeper, 2023). The other category concerning plastics is microplastics. These fragmented byproducts of macroplastics are largely invisible to the human eye, smaller than 5mm, but still pose equally pervasive risks. They stem from various everyday items and activities, such as personal care cleansers and scrubs, clothes and synthetic fabrics, tire wear rubber, cleaning products, toothbrushes, and dental floss (Boucher et al., 2017). Because these types of plastics originate from various sources and fragment easily, they remain difficult to trace while runoff and sewer systems continuously transport them through waterways. Their widespread distribution and accumulation pose risks to both wildlife and human health as they move through aquatic systems.

2.4 Ecological and Human Impacts

Research documents the ecological consequences of plastics in aquatic ecosystems. Fish, birds, and benthic organisms ingest macroplastics and microplastics, which inflict internal injury and cause transferable toxins up the food chain (Rochman et al., 2013). Microplastics pose significant risks because their surfaces absorb and concentrate pollutants already in the water. These plastics absorb pollutants like heavy metals, PCBs, and pesticides, amplifying their negative effects on wildlife and the people and animals that ingest them (Teuten et al., 2009). Not only do pollutants cause toxic chemical transfer, but exposure has been shown to cause behavioral changes and reproductive issues affecting microbial communities, impacting overall dynamics of river ecosystems (Sunny et al., 2025).

Humans are also at risk. Microplastics, susceptible to accumulating multiple contaminants, affect the greater ecological system and pose a threat to humans through the consumption of seafood and drinking water (Leslie et al., 2022). Because plastics do not biodegrade but instead fragment into smaller pieces, they remain trapped in ecosystems, causing long-term impacts. Although humans ingest macroplastics less frequently, their physical presence in river systems reinforce negative perceptions of pollution in waterways. This pollutant type causes environmental and human impacts, and researches have implemented various monitoring efforts to better understand its persistence and distribution. Although researchers have implemented efforts to monitor and reduce plastic accumulation in water systems, significant limitations remain.

2.5 Monitoring Framework

Microplastics cause numerous human and environmental impacts and researching them is akin to “finding a needle in a haystack,” according to the research group at Aalborg University, Denmark (Schmidt Ocean Institute, 2022, para. 3). Their widespread dispersion across oceans, rivers, soil, and air makes tracing their origins challenging. Because of this complexity, researchers have primarily focused on macroplastics, which are larger, more visible, and more readily identified and collected by both human observers and automated technologies.

A 2019 review article investigated methods used to monitor macroplastics, including visual counting, net trawls, floating booms, and camera-based monitoring systems. Across monitoring methods, the synthesis found a lack of standardized measurement protocols and weak quality assurance/quality control (QA/QC) (GESAMP, 2019). For example, although visual counting methods remain inexpensive and widely used, studies fail to specify observer training nor detailed how counts were extrapolated to represent a total flux. Similarly, net trawl sampling provides physical debris for identification and weighing, but mesh size, deployment time, and submersion depth varied between cases, making cross-comparison difficult. The synthesis found that floating booms are the most effective at capturing floating debris. However, studies report inconsistencies in how operators sort debris, the efficiency of debris sorting, and the frequency in which debris was removed from them. Finally, camera and image-based monitoring shows promise, but researchers train algorithms on different datasets and rarely validate these systems with on-ground identification.

Public participation serves as a valuable tool to support infrastructure and data collection practices (Conrad & Hilchey, 2011). Researchers increasingly use citizen science approaches to collect large, wide-reaching dataset samples that would otherwise be cost-prohibitive. For example, a 2018 study in the Gallatin River Watershed (Montana, USA) evaluated whether citizen scientists could effectively collect samples for quantifying microplastic pollution at a watershed scale (Barrows et al., 2018). The goal of this study was to examine the spatial and temporal patterns of contaminants within a river system across 72 sites. Volunteers helped collect over 700 samples.

Although the research did not conclusively identify specific contamination sources of microplastic contamination, the study demonstrated how volunteer-driven monitoring can be successful in gathering datasets, even in less-developed watersheds. The researchers concluded that complementary monitoring approaches are needed to support human observation and address limitations in source identification. Together, these monitoring and data collection practices establish a foundation for the future of debris and pollutant management within water systems. The following section examines existing monitoring approaches that rely more heavily on infrastructural and technological systems that directly target litter in river systems.

2.6 Technological Monitoring Approaches

2.6.1 Image Monitoring: Klang River

Researchers face both opportunities and constraints when measuring microplastic datasets, but a growing body of research uses camera-based monitoring under both controlled and real-world conditions to leverage their ability to track visible floating plastics (macroplastics) beyond human observation. A study conducted in the Klang River in Malaysia, utilized a stationary bridge-mounted camera to count floating plastics in the river. A fixed camera positioned above the river continuously captures imagery of floating debris and track debris transport. A deep learning object detection algorithm analyses the captured images to identify floating debris to identify and label plastics versus non-plastics against the river background. The model accurately detects and counts floating macroplastics like those trained by human observers (Van Emmerik et al., 2020).

Though the practice was effective in gathering imagery, the system presents several limitations. One of the biggest constraints was that the systems only functions effectively when objects are sufficiently illuminated and identifiable, making the tool's efficiency limited to daytime hours (van Emmerik et al., 2020). The camera was also only capable of capturing surface debris, leading to data collection gaps for submerged items. This study highlights the potential of automated monitoring techniques for debris detection yet highlights ongoing basic operating limitations technology still faces.

2.6.2 Video-Based Monitoring

Building on technological capabilities of debris monitoring, studies have expanded beyond stationary binary classification of plastics versus non-plastics and have utilized Unmanned Aerial Vehicles (UAVs) to collect imagery and address the transport of debris across larger riverine areas. In a river environment artificially created on the Arno River in Italy, the study anchors plastic samples to the riverbed and flies a drone overhead to test detection accuracy to assess whether the air-borne system could effectively identify submerged materials. Within this controlled river environment, the drone achieves recall rates above 98% when detecting plastics (Cortesi et al., 2022). These high recall rates demonstrate the systems' ability to accurately identify floating debris, otherwise absent from surface capturing camera practices or human observers. This study also demonstrates the potential high-performing technologies have toward pollutant monitoring across a dynamic study area.

The Arno River study does not assess system performance under variable river conditions. While recall was high in their controlled settings, the study notes it significantly declined when using UAVs at higher altitudes and when assessed against more complex riverine backgrounds. These two factors caused resolution fluctuations resulting in mixed and unidentifiable identification of submerged plastics. Although recall identifications yielded promise in controlled settings, the study highlights the persistent variables that impact consistent identification even when using more advanced monitoring methods (Cortesi et al., 2022).

The stationary image-based tracking and the UAV monitoring system underscore high capabilities for the future of debris tracking but also reveal critical operation limitations. These technology-based system shortcomings should be considered, particularly if applied to uncontrolled river conditions present at the Anacostia River where it experiences tidal fluctuation and includes a range of both floating and submerged debris. In response, Section 4 turns to hybrid strategies where monitoring and tracking are closely verified across one another.

2.7 Debris Capture Devices and Hybrid Strategies

2.7.1 Containment Booms

Containment booms are common infrastructure elements deployed in water systems for their general surface collecting capabilities and are used to reduce the spread of oil and other pollutants from shorelines (U.S. Environmental Protection Agency [EPA], n.d.). This floating barrier is installed along waterways and uses flexible surface anchoring to contain, guide, and collect debris within a defined area without restricting natural flow. Because they are installed across a waterway or a portion of a waterway, they collect all surface debris, not differentiating between material types. At larger scales, established boom networks have provided significant long-term benefits in reducing debris loads in major rivers (Ultratech International, n.d.).

In a study along the Seine River in Paris, France, an annual estimate of 27 tons of floating plastics have been intercepted through a system of floating retention booms (Gasperi et al., 2014). Debris captured from these booms is collected and manually sorted and weighed where plastics are isolated and identified to generate percentages against the various other materials. The study concluded that while the booms were effective in diverting debris downstream, gaps remained in the booms ability to intercept deeper subsurface material, and that the systems required consistent service to maintain efficiency. Nevertheless, this case illustrates the effectiveness of regional deployment strategies and signals how hybrid monitoring measures can work in tandem to reduce plastic flux within aquatic environments.

2.7.2 Drones & Manual Counting

In addition to containment booms, other camera-based systems have been deployed for hybrid debris monitoring cases. In the Low Segura River Basin (Spain) researchers deployed drones to conduct surveys of the river's surface to track floating debris (Rocamora et al. 2021). Rather than solely reporting identification, surveys collected from the drone were validated with manual counts. The study found that manual counts of debris were consistent with those identified in the drone survey. Though manual counts and surveys were consistent, the study noted that drone imagery tended to overestimate debris volume. This suggests that while these systems can be a great asset in monitoring, they do not guarantee perfect accuracy. It also emphasizes the significance human observers still have in conjunction with technology to ensure validity and accuracy.

2.7.3 Seabins

Hybrid systems such as seabins can be deployed in smaller scale environments that do not require frequent monitoring. While varied in size, seabins are constructed as fixed or floating collection units that passively skim the surface water to capture floating trash, plastics, and oils into collection bags or nets (Ocean Plastic Cleanup, n.d.). Typically deployed in marinas and calm waterways, they allow water to pass through but capture debris for later removal. Deployed as pilot studies in locations like Laucala Bay, Yards Park, and James Creek Marina, seabins have proved effective in capturing floating plastics and filter them from additional floating organic matter. Due to their small scale and finer capturing capabilities, seabins have recorded consistent and manageable monitoring and debris identification (Schuyleret al. 2019). These systems highlight how smaller scale hybrid monitoring approaches can still be effective and even more applicable in more controlled marina settings that allow for passive collection and less frequent monitoring.

Taken together, there are a range of ongoing monitoring practices and hybrid strategies that track debris accumulation based on site needs and river characteristics. From traditional river infrastructure elements like containment booms and net trawls to technological imagery and small hybrid installation, three consistent lessons have emerged: device performance is highly dependent on hydrological fit; maintenance strategies must be considered based on debris typology; and though technology-based methods have shown promise, operational constraints limit their universal applicability. These findings reinforce existing gaps in research and underscore the need for approaches that extend beyond just technical performance. Design and management of such systems must take into account how debris capture systems are experienced, maintained, and interpreted within urban waterfronts like those along the Anacostia River.

2.8 Stressors in the Anacostia River

The previous sections examined the broad historical conditions of the Anacostia River and introduced a range of existing pollutant monitoring practices. These discussions provided a foundation for understanding origins of contamination and various monitoring practices that overlap with some of the pollutants present in the Anacostia River. Within this section, specific stressors will be investigated to gain a detailed, site-based understanding of how contaminants persist and behave within a tidal system. This analysis informs targeted, site-specific approaches that align with existing river maintenance practices. Rather than removing all debris types, the project focuses on redirecting floating litter and woody debris away from the shoreline so that it supports routine maintenance and operations, while making river processes visible to the public.

2.8.1 Sediment Pollutants in the Anacostia River

A 2011 study in the Anacostia River traced the accumulation of different classes of contaminants and how their concentrations shifted over time (Velinsky et al., 2011). It examined the depth of pollutants from collected sediment cores, which the researchers measured and analyzed for PAHs (polycyclic aromatic hydrocarbons), PCBs (polychlorinated biphenyls), organochlorine pesticides, and trace metals such as cadmium (Cd), copper (Cu), mercury (Hg), lead (Pb), and zinc (Zn) (Velinsky et al., 2011).These contaminants were examined for their persistence, toxicity, and strong association with sediments, linking them to agricultural, industrial, and urban land-uses within the Anacostia Watershed.

Collected sediment cores revealed that several contaminants remain present throughout their profile, indicating long-term storage and continued environmental relevance. PCBs and certain metals revealed higher concentration in older sediments corresponding to periods of high industrial activity while also appearing in newer cored samples as well. Importantly, the study noted that contaminated sediments remain susceptible to being resuspended and transported during storm events, supporting why pollutant types were observed in both older and newer cored sediments. From these findings, sediments reveal a historic record of pollution in the Anacostia but also reflect sediments as active sources capable of being reintroduced into the water regardless of being decades from their initial deposition (Velinsky et al., 2011).

2.8.2 Dissolved Oxygen

Sediment contaminants represent long term chemical stressors in the Anacostia River and closely relate to the biogeochemical process that impacts overall water quality. One of the most critical components of this process is dissolved oxygen (DO). DO refers to the amount of oxygen present in the water column that is available for aquatic organisms to breathe and for aerobic processes to occur. Adequate DO supports fish respiration, invertebrate survival, and healthy nutrient cycling (U.S. EPA, 2021). On the other hand, low DO conditions reduce habitat stability and can lead to hypoxia, which directly affects suitability of habitat, ecological function, and the persistence of chemical stress.

Within the Anacostia, chronically low DO is reported as a persistent challenge (Anacostia Watershed Society, 2025). While DO is influenced by multiple processes, sediment-bound contaminants, such as PAHs, contribute to the broader stress by remaining in the water column. This persistence, supported by Velinsky et al. (2011) reinforces that contaminants can compound ecological stress.

Storm-driven inputs and urban runoff further contribute to low DO conditions. Despite infrastructure reducing combined discharge, the Anacostia River continues to experience low DO conditions associated with storm events and sediment loading (Jones et al., 2014). Long-term water quality assessment monitoring has demonstrated that shallow tidal reaches are particularly vulnerable when runoff increases biological oxygen demand. Runoff from streets and discharged directly into rivers often accumulate in shallow reaches. In these shallow reaches, conditions prevent old water from being flushed and replaced with newer water. This lack of exchange means sediments are resuspended during storm events yet are unable to flush out and thus remain in place, causing a cycle of chronic ecological stress. Channel geometry and water-column stratification are also factors that reduce a waterbody's ability to replenish oxygen following depletion events (Cerco et al., 2010).

This process, paired with river physical characteristics, reflects how DO functions as a compounding stressor that links sediment contamination, stormwater inputs, and tidal hydrodynamics. Its persistence emphasizes the need for management and design strategies that address not only pollutant sources, but also the physical and ecological processes that regulate oxygen availability within the river.

2.8.3 Secondary Water Quality Indicators

Beyond dissolved oxygen, several additional nutrient and chemical indicators play a significant role in shaping ecological conditions and visible signs of healthy river systems. Nitrogen and phosphorus are the most prominent nutrients that affect river health and are linked to eutrophication, algal growth, and oxygen depletion (U.S. Geological Survey, n.d.). These nutrients are largely in excess within the Anacostia River, elevated in part due to stormwater runoff from pet waste, fertilizer, and organic contamination accumulating from streets (DOEE, n.d.). These elevated levels of nitrogen and phosphorus increase oxygen demand during decomposition and indicate shifts in flora and fauna that will be discussed the next sections.

Biological oxygen demand (BOD) and turbidity further reflect the interaction between nutrients, sediments, and pollutants that shape water quality within the Anacostia. Historic records of elevated BOD signal increased microbial consumption of oxygen associated with high nutrient loading (MacAvoy et al., 2009). In parallel, turbidity indicates concentration of suspended sediments. This has also been reported as being historically high with elevated levels reflected in reduced water clarity, signally high correspondence to nutrient transport of metals, PAHs, and PCBs (Anacostia Riverkeeper, 2020). Both elevated BOD and turbidity function as biological and physical indicators of poor water quality and are often visual signs of declining water health.

2.8.4 Hardened Shoreline and Habitat Fragmentation

In addition to the chemical and biochemical stressors, the physical structure of the Anacostia River, including the project site, presents significant indicators of poor ecological health. Substantial portions of the river have been hardened through the installation of bulkheads, seawalls, and riprap as a result historical flood controlling efforts, navigational improvements, and urban waterfront development. Although these interventions stabilize the shoreline and support adjacent land use, their alterations impact river-land connection that reduces the availability of shallow, transitional habitats to develop that are associated with a healthy and diverse river environment.

These hardened shorelines contribute to habitat fragmentation by eliminating gently sloped zones that support spawning, foraging, and refuge for fish and benthic organisms (NOAA, n.d.). Vertical armored edges accelerate flow velocities, limit sediment deposition, and reduce the establishment of submerged and emergent vegetation, further complicating the ability for habitats to form. These structural constraints, along with existing sediment, chemical, and DO stressors, significantly reduce the river's capacity to support resilient aquatic communities. Biological assessments of the Anacostia River have found fish communities score "poor" to "very poor" on the Index of Biotic Integrity metrics (Maryland Department of the Environment, 2022). This composite score is based on the structure and function of biological communities, designed to show how far a system has deviated from a "natural" or reference condition. Moreover, the score is characterized by reduced species richness, loss of sensitive native species, and dominance of pollution-tolerant and generalist species linked to the combined effects of urban land use, degraded water quality, and altered physical habitat structures, including hardened shorelines (Boward et al., 2007).

2.8.5 Invasive and Stress-Tolerant Species Dominance

The high prominence of invasive and stress-tolerant species also reveals evidence of stressful conditions in the river. Invasive or opportunistic vegetation such as *Phragmites australis* (common reed), hybridized *Typha spp*. (cattails), *Reynoutria japonica* (Japanese knotweed), and *Ailanthus altissima* (tree-of-heaven) have been observed along edges of the Anacostia River and disturbed shorelines (McMahon et al., 2014). These species are well-adapted to the compacted sediments, nutrient-enriched soils, and fluctuating water levels, allowing them to outcompete native vegetation. Similarly, stress-tolerant species like *Ictalurus furcatus* (blue catfish) and *Cyprinus carpio* (common carp), thrive under low dissolved oxygen, high turbidity, and contaminant sediments (Schmitt et al., 2019, Jones et al., 2014).

Equally important is the reduced presence of sensitive native species typical within healthier tidal river systems. Studies in the Anacostia have documented the decline of native fish diversity and benthic macroinvertebrates, particularly species that require well-oxygenated water and stable near-shore conditions. Among these, anadromous fish such as the river herring (alewife and blueback herring) and American shad, once abundant in the Anacostia River, have experienced exponential decline during the twentieth century (Jones et al., 2014). While resident species, such as the yellow perch remain present, the Index of Biotic Integrity (IBI), consistently classify the Anacostia as biologically impaired with low species richness and lackluster representation of sensitive native taxa (Boward, et al., 2007). As such, species dynamics in the Anacostia provide insight into the poorer ecological conditions of the river linked with water quality.

These chemical stressors and species patterns underscore the need for interventions that do more than mitigate individual stressors in isolation. In response, the following chapter examines strategies to address some of these stressors with natural and manmade interventions that promote the reintroduction of habitats.

2.9 Ecological Services of Wetlands

2.9.1 Nutrient Transformation and Water Quality Improvement of Natural Wetlands

Tidal wetlands are widely recognized as critical ecosystems that filter pollutants and cycle nutrients (NOAA Fisheries, 2024). Research examining tidal wetlands reports both the ecological benefits and constraints associated with their role in providing ecosystem services. Wetlands have collectively been shown to reduce excess nitrogen and phosphorus through a combination of plant uptake, sediment trapping, and microbial denitrification (Audet et al., 2019).

Other empirical studies have demonstrated that nutrient transformation in tidal wetlands can be substantial, yet highly variable. This variation is largely due to site-specific hydrologic conditions. Nitrogen removal in wetlands has been reported to range from approximately 40% to as high as 90% under favorable conditions. This removal is primarily driven by microbial denitrification among sediments in favorable hydrological conditions, resulting in this wide percentage range. Phosphorous retention has also been documented, with reported efficiencies ranging from approximately 30% to 70%. This range is also dependent on sediment composition, residence time, and watershed nutrient inputs. Collectively, these findings highlight the capacity of tidal wetlands to function as effective nutrient sinks, while underscoring the importance of site-specific dynamics that determine overall performance (Mitsch et al., 2014).

In addition to nutrient processing, wetlands play a critical role in trapping suspended sediments associated with elevated turbidity. Wetland systems have been shown to retain approximately 50% to 80% of incoming suspended sediments under low-flow conditions (Braskerud et al., 2005). This characteristic is important in urban tidal rivers where contaminants such as heavy metals and PAHs, are often bound to sediments. However, sediment retention does not equate to permanent contaminant removal. Research in the Anacostia demonstrates that while wetlands and other systems can capture contaminated sediments, these materials remain active within the system rather than being fully remediated (Velinsky et al., 2011). Events such as storms, tidal change, and other physical disturbances can resuspend stored contaminants and prolong treatment. Wetlands should not be understood as systems that directly remediate pollutants like PCBs, PAHs, or heavy metals in isolation. Instead, wetlands function by managing the nutrient, sediment, and oxygen-related processes that influence pollutant transfer and ecological stress. This process-based role supports the importance of recovery timeliness, maintenance requirements, and long-term performance, as addressed in the following section.

2.9.2 Recovery Timelines, Maintenance, and System Longevity

Understanding the temporal characteristics of wetland recovery is essential for evaluating their ecosystem services, particularly in the context of restored natural tidal wetlands. In a comparative analysis, wetlands were analyzed for how quickly ecosystem services were re-established following interventions such as dredging, dike breaching, and the reopening of blocked channels (Rowland et al., 2004). Results indicated that nitrogen and phosphorus removal tend to recover relatively faster after restoration, often within five to ten years. Sediment retention and hydrological regulation were also shown to have shorter recovery times once tidal exchange was reestablished. In contrast, habitat diversity required longer periods to recover, often exceeding ten years and were strongly dependent on reconnection to natural tidal hydrology (Rowland et al., 2004).

2.9.3 Artificial Wetlands

Artificial wetlands have been used for their flexible installation capabilities and adaptable deployment among varying water and environmental conditions. In a pilot study, The Wild Mile project located in the Chicago River installed nearly one thousand square meters of modular floating treatment wetlands (FTWs), described within the project as "floating gardens" (Urban Rivers, n.d.). These modular wetland systems were planted with native species and evaluated to see whether artificial floating wetlands could improve water quality by reducing key nutrients commonly found in urban waterways (Peterson et al., 2021). Researchers collected upstream and downstream samples at the surface and at a 0.3m depth relative to the modules. During the growing season, the wetlands demonstrated significant downstream water nitrate-nitrogen reduction by approximately 6.9% and phosphate reductions by approximately 6.0% relative to the upstream baseline values. When normalized to wetlands surface area, these reductions correspond to average nitrogen removal rates of approximately 0.29-0.52 g/ m^2/day and phosphorus removal rates of approximately 0.06–0.24 g/m^2/day ((Peterson et al., 2021). This pilot-scale model positions artificial floating wetlands as a viable form of scalable nutrient treatment infrastructure, rather than a purely experimental or aesthetic installation.

Taking the ecological services and pilot study findings, tidal and artificial wetlands can play a dynamic, service-providing role toward improving water quality and ecological availability. The literature indicates that while both natural and artificial wetlands have the ability to serve as natural filters, they can still be limited in capacity due to hydrological changes, site conditions, and restoration goals. In urban and highly visible waterfront contexts, like that of the Chicago River and the Anacostia, these constraints shape how ecological services are expressed over time, highlighting the importance of aligning wetland function to surrounding physical conditions and patterns of human interaction.

Building from this foundation, the following sections turn to precedent projects to explore how debris capture projects can function not only as an environmental intervention, but as visible and culturally legible components of urban river stewardship.

2.10 Theoretical Framework

2.10.1 Cues to Care

The waterfront design in this thesis incorporates the concept of *Cues to Care* to signal maintenance, stewardship, and its ecological intent. As described by landscape architect and environmental design theorist, Joan Iverson Nassauer, c*ues to care* refer to visible design elements that signal human intention and ongoing maintenance within a landscape (Nassauer, 1995, pp. 161-165). These cues may include elements like mown or trimmed lawns, defined paths and boardwalks, clear access points, regularly maintained infrastructure, or subtle fencing that reinforce that the landscape is cared for rather than neglected (Nassauer, 2011). This concept is particularly important not only to the visual legibility of the proposed design but also how the long-term maintenance is perceived. The proposed debris sorting system in this thesis seeks to promote river stewardship by integrating aesthetic infrastructure that respond to natural debris accumulation along the shoreline at Diamond Teague Park.

2.11 Ecological Self-Organization

While cues to care establish visual legibility and communicate human intention within the landscape, they primarily address how users perceive and interpret designed environments. However, these visual strategies do not fully account for how ecological systems evolve over time in response to environmental conditions and material flow. To better understand how designed systems may adapt and reorganize beyond spatial implementation, it is necessary to consider the role of ecological self-organization.

2.11.1 Ecological Self-Organization and Design Adaptation

Ecological self-organization, often referred to as self-design in ecological engineering, describes how patterns and structures naturally form within an ecosystem. These patterns emerge through local interactions and are not fully predetermined or controlled. In nature-based systems, this occurs as continuous inputs of biological material such as seeds, organisms, and nutrients, which gradually reshape the system over time. These inputs interact with conditions like water movement, soil, and disturbance, producing shifting patterns like clustering, patchiness, and gradients (Kangas, 2025). These patterns are not random but show how the system responds to its environment.

In ecological engineering, this process is also tied to how systems organize around available energy and resources. Odum describes this as "self-organization for maximum power," where ecosystems shift toward conditions that make the most efficient use of energy under given environmental inputs (Odum, 1995, p. 311). This connects to ideas of ecological succession, where species establish, compete, and shift over time as conditions change (Mitsch, 2003). Disturbance plays a key role in this process. Changes in water levels, sediment, or flow continually reshape the system rather than allowing it to stabilize into a fixed state.

While structures or altered conditions may be introduced, self-organization systems are not intended to produce a fixed or static end state. Instead, they are understood as dynamic systems that respond to ongoing inputs such as hydrologic change, sediment movement, species interactions, and disturbances. System performance is therefore typically understood through its capacity to adapt over time, reflected in the shifting spatial patterns, changing species composition, and ability to recover after a disturbance like a flood or storm surge. Conversely, reduced diversity, increased uniformity, or breakdowns in system function may indicate limitations in the system.

This perspective is significant because it shifts emphasis from controlled outcomes to work with dynamic system processes. Within this framework, material flows including organic material and debris, are understood as ongoing inputs that influence system structure and function. It also highlights the importance of recognizing how systems respond to intervention, supporting approaches that account for change over time rather than assuming fixed, static conditions. Together, these concepts inform the methodological approach that follow, which examine how ecological processes, debris management strategies, and public-facing design elements operate within the Anacostia River.

Chapter 3: Methods

3.1 Site Overview

This MLA thesis project uses a mixed-methods approach integrating spatial analysis, field observations, and informal conversations with practitioners and researchers in watershed science and ecological engineering. Design interventions examine floating litter and woody material accumulation along a mixed-use waterfront located in Southeast Washington, DC along the shoreline at Diamond Teague Park. The site is adjacent to the Anacostia Riverwalk Trail Pedestrian Bridge, with permanent infrastructure elements that link upland areas of Diamond Teague Park to the water. These elements include a 100 ft x 20 ft kayak launch dock, three gangways from the Anacostia Riverwalk Trail to kayak dock, and two containment booms. The proposed design aims to enhance existing site features without removing any existing infrastructure or in-water elements.

The project site was selected for its prominence as a recreational waterfront in Washington, D.C. and its location within a high priority area identified by the District Department of Energy and Environment (DOEE) for elevated PCB contamination within the Anacostia River watershed. As shown in Figure 3.1, the Anacostia River Sediment Project Boundary identifies priority environmental cleanup zones along the river corridor. Figure 3.2 further illustrates PCB hotspots, highlighting the spatial distributions of contamination. In addition, Figure 3.3 presents the distribution of trash across the Anacostia watershed, reinforcing the site's location within a high-priority zone for both pollutions and debris accumulation (District of Columbia Office of the Attorney General, 2023). The priority areas, overlapping with visible signs of litter and pollution, highlight the site's significance as a strategic location for design intervention that address visible accumulation of litter and nutrient concerns.

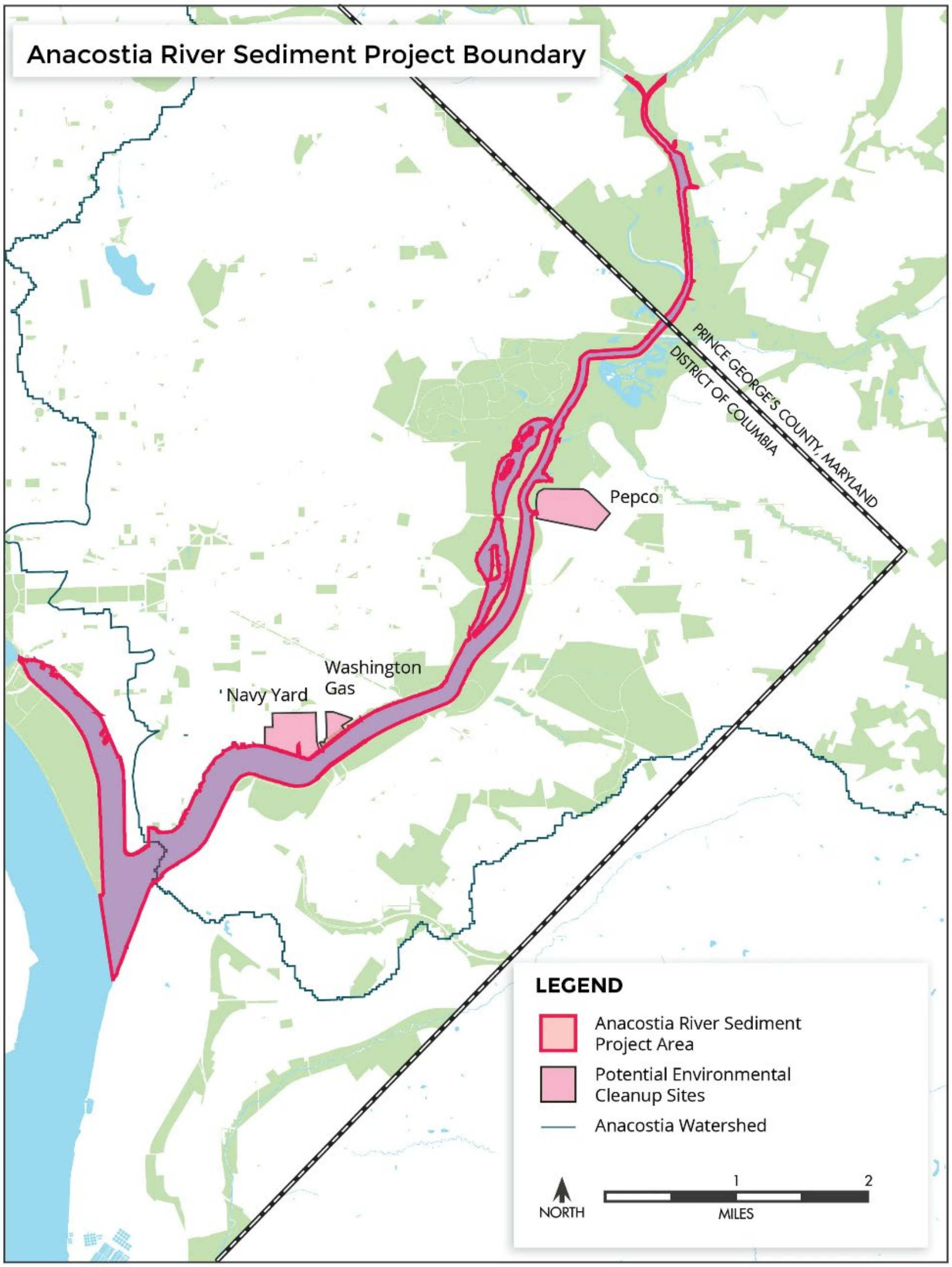


Figure 3.1

Boundary map showing potential environmental cleanup sites along the Anacostia River.

Note. Source: Anacostia Park Community Collaborative (2019)

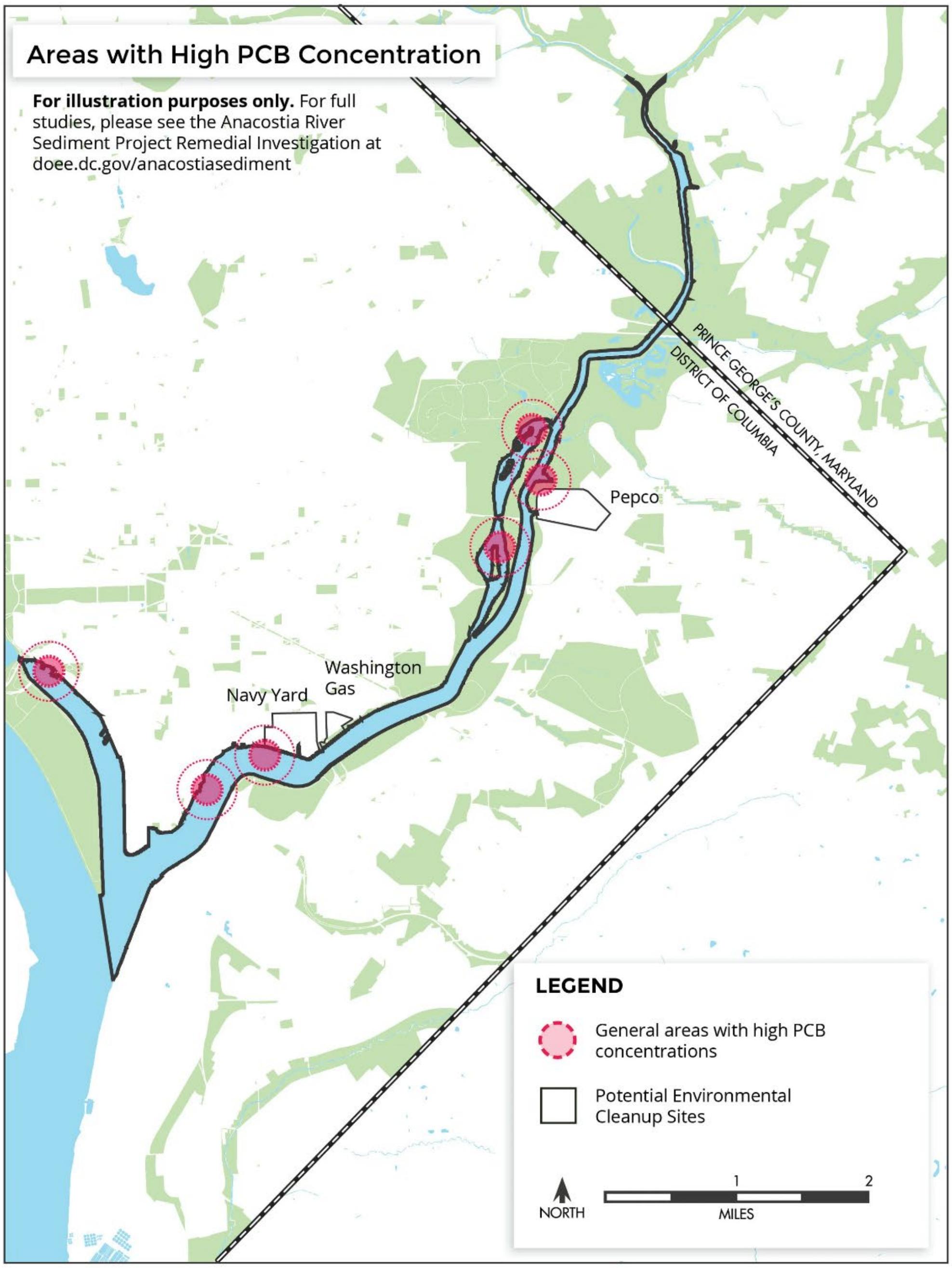


Figure 3.2

Boundary Map Showing Elevated PCB Concentration Along the Anacostia River

Note. Source: Anacostia Park Community Collaborative (2019)

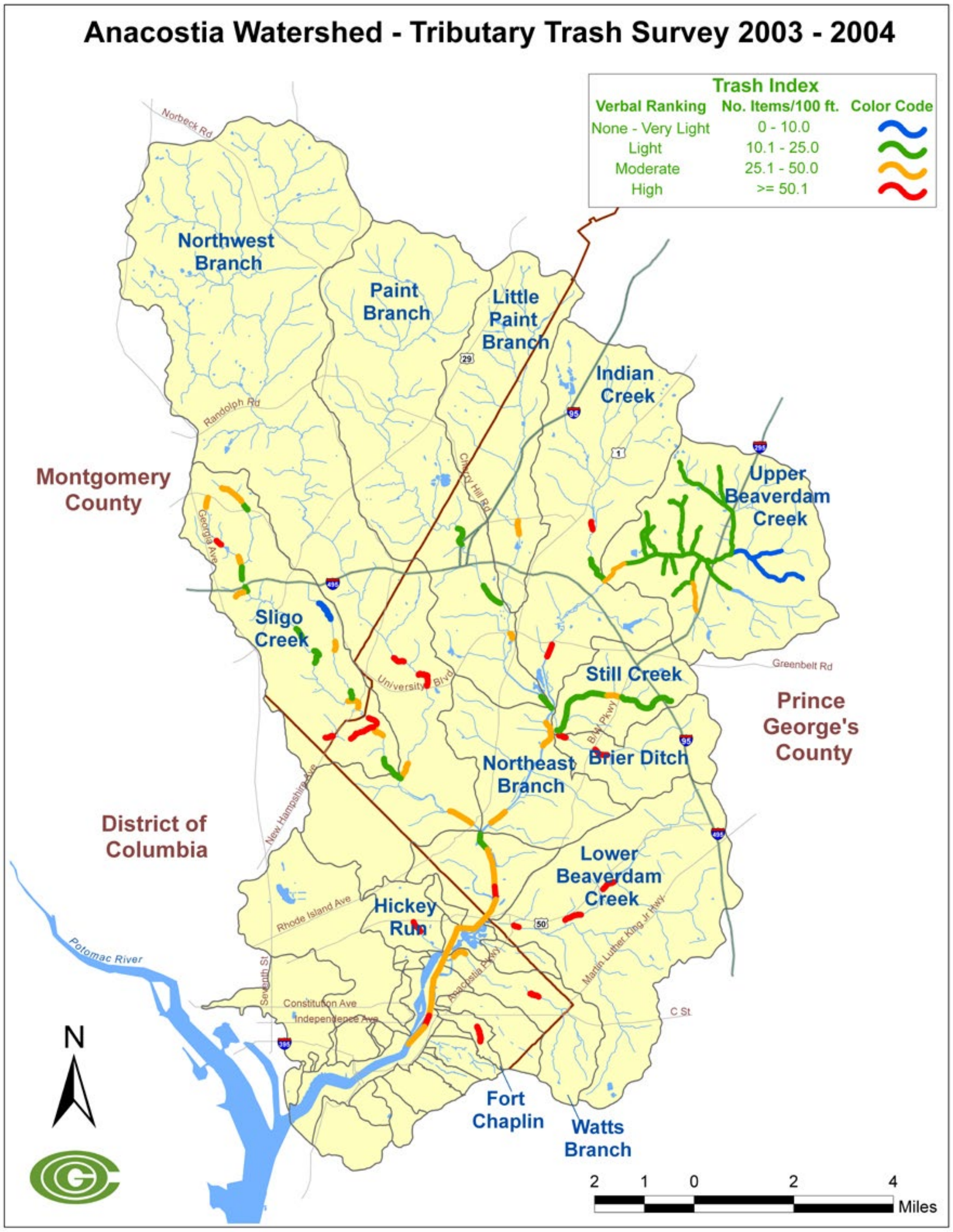


Figure 3.3

Distribution of Trash Levels Across the Anacostia River Watershed (2003-2004)

Note: Source: Anacostia Watershed Society (n.d.).

This project synthesizes water monitoring data, spatial analysis, and regulatory documentation from federal and District sources to establish baseline conditions. GIS-based mapping and spatial analysis were used to support site inventory and evaluate environmental conditions within the study area. Additional information on regulatory boundaries, tidal fluctuation patterns, navigational constraints, nutrient properties, and debris accumulation was compiled from water quality monitoring datasets, agency reports, and published studies. Agency reports and formal documents related to debris removal and river maintenance were also reviewed to understand how existing systems function seasonally.

3.2.1 Spatial and Environmental Analysis

The researcher evaluated datasets to examine relationships between hydrology, nutrient concentrations, debris movement, and infrastructure limitations. The analysis focused particularly on tidal currents and their interactions with shoreline geometry, bridge structures, existing booms, and the movement of debris typologies. The researcher analyzed distance from navigation channels, water depths, and adjacency to circulation routes to determine feasible locations for debris interception and habitat strategies. These analyses identified locations where the design could operate effectively without conflicting with existing structures, creating additional safety hazards, or conflicting with regulatory buffers.

3.2.2 Field Observations

Repeated site visits were conducted during 2025 and 2026 to document live conditions not evident in mapping data. Observations focused on debris type, location, size, and accumulation patterns. Tidal variation, recreational use, and existing maintenance activity were also documented. Representative shoreline conditions, debris accumulation patterns, and vegetation structure are documented in Figure 3.4. These observations were critical in validating mapping assumptions and refining the placement and orientations of proposed elements.

Figure 3.4

Field Observation Photos of Shoreline Conditions During Fall 2025

Note. Photographs by author (2025)

3.2.3 Design Development and Translation

Insight from site inventory, field observations, and site analysis were translated into a system of permanent and seasonal module shoreline and in-water elements that organize debris into predictable zones that align with existing servicing duties and frequency. Interventions were positioned to align with where currents naturally deliver material, allowing infrastructure to work alongside existing and predicted river dynamics. Decisions regarding form, spacing, orientation, and installation were guided by adaptability to seasonality and in-water regulations. The resulting design operates as a hybrid framework that accommodates maintenance while expanding habitat and educational opportunities.

3.2.4 Evaluation Framework

Because the project operates at a conceptual scale, the researcher assesses performance through anticipated functional outcomes and approximate quantified engineering metrics. The evaluation considers the system's ability to intercept debris along known transport paths while maintaining compatibility with existing navigation and safety requirements and creating visible relationships between ecological processes and public experience. The framework therefore prioritizes spatial logic, adaptability, and stewardship potential as the primary indicator of success.

Chapter 4: Site Inventory

4.1 Field Observations

Between Fall 2025 and the Early Spring of 2026, I visited and engaged in field observations at Diamond Teague Park and areas outside the project boundary. Observations focus on shoreline conditions, debris accumulation patterns, water quality indicators, and hydrologic dynamics. The site reflected a highly managed urban waterfront where hardened edges, tidal fluctuations, and existing infrastructure influence the movement and accumulation of floating litter and woody debris. Observations also noted existing vegetation and species present within and around Diamond Teague Park. Together, these observed conditions inform opportunities for targeted ecological and infrastructural interventions.

4.1.1 Site Location and Boundaries

The project site is located along the Capitol Riverfront in Southeast Washington, D.C., within the lower reach of the Anacostia River. This waterfront district is a highly active mixed-use area that supports residential communities, offices, restaurants, and recreational spaces for residents, workers, and visitors throughout the year. Public amenities like the Anacostia Riverwalk Trail, Nationals Ballpark, kayak launches, marinas, and parks make the riverfront a popular destination for walking, boating, and waterfront gatherings. The regional context of the project site is illustrated in Figure 4.1, while Figure 4.2 shows a detailed view of the project boundary and existing debris management infrastructure.

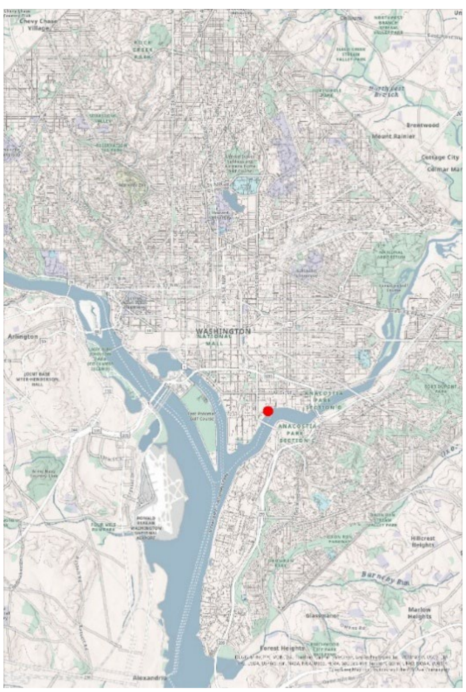


Figure 4.1

Project Site Within the Greater Washington, D.C., Area

Note. Map by author (2026)

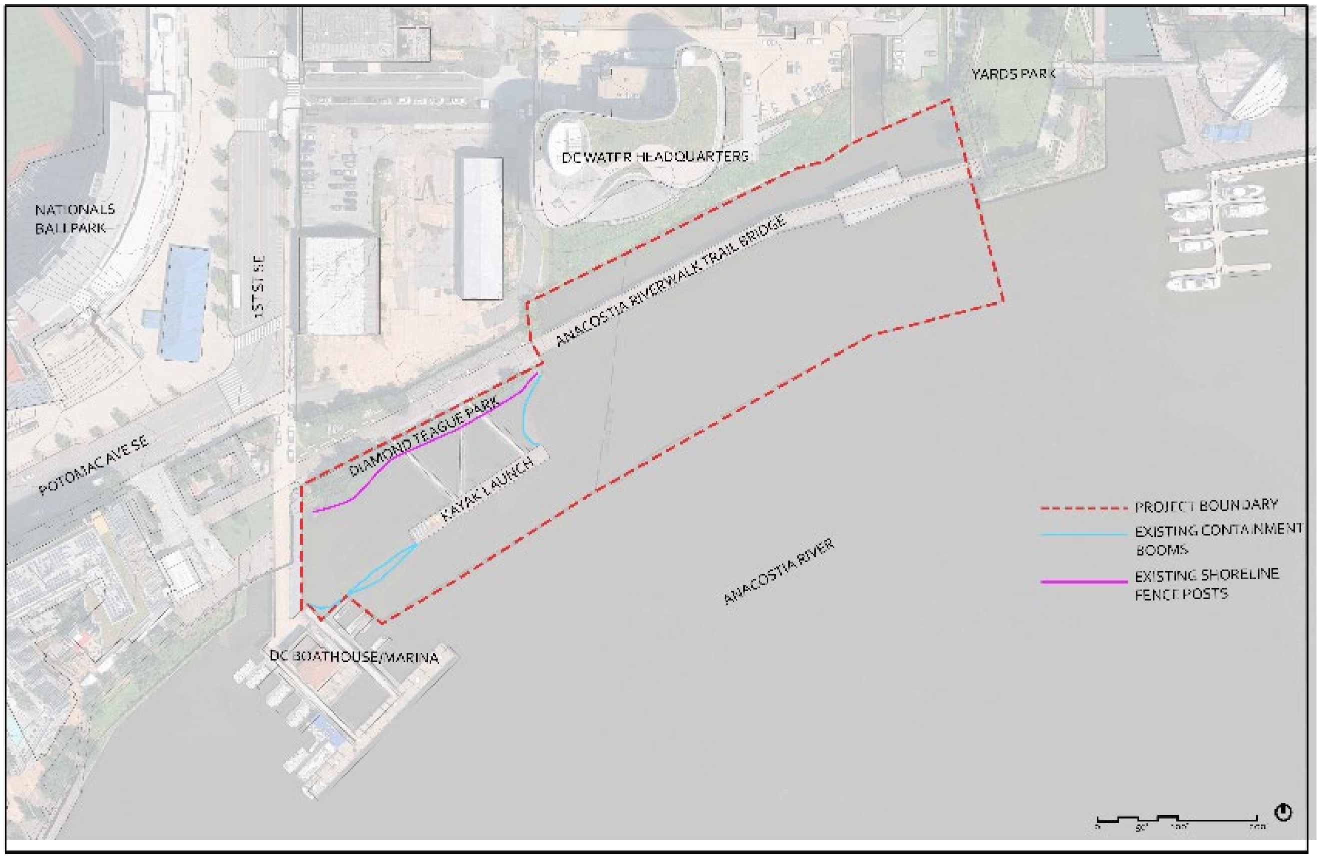


Figure 4.2

Aerial Image Showing Project Boundary and Existing Debris Management Features at Diamond Teague Park

Note. Imagery from Google Earth Pro; annotations by author (2026).

Within the broader context, the project occupies segments of the shoreline between Diamond Teague Park and Yards Park and is located less than a mile and a half upstream from the Potomac River confluence point. The project boundary encompasses approximately 5.2 acres, with inland boundaries following the hardened shoreline edge along Diamond Teague Park and extending east upstream along the seawall, adjacent to the Anacostia Riverwalk Trail Bridge, before reaching Yards Park. The site boundary extends approximately 170 feet outward from the seawall.

Outside of the project boundary, land uses are composed of mixed use, residential, and commercial properties. Within the site boundary, it includes areas of Diamond Teague Park. This 0.9-acre public park is adjacent to the DC Boathouse and marina and includes a kayak launch dock, vegetated shoreline, and inland boardwalk and bench seating options that connect to the Anacostia Riverwalk Trail and bridge. At Diamond Teague Park and within the site boundary, DC Water, with coordination with the District Department of Energy and Environment (DOEE), use booms to collect and and capture floating litter. The first collection boom spans between the kayak launch dock and the foot of the Riverwalk Bridge. This system serves as the first area of interception for debris flowing downstream and within the project site. The second boom is at the western edge of the kayak launch and connects to the downstream DC Boathouse marina finger dock. Beneath the elevated concrete boardwalk leading to the DC Boathouse, and outside the project site, is an additional debris containment boom that is attached to the seawall and is the farthest downstream boom structure relative to the site. In addition to these structures, individual metal fence posts are spaced intermittently along the shoreline to prevent larger material from washing on shore.

During each site visit, the orientation and connection points of each of the containment booms were constant and consistently filled with floating plastic litter and woody material. The boom attached to the kayak launch consistently retained higher amounts of mixed plastic litter and small woody debris compared to the downstream booms. Additionally, shoreline fence posts were less effective at preventing larger logs, woody material, and floating plastic litter from reaching the shorelines, as material not captured by the booms consistently accumulated along edges and bypassed the posts.

4.1.2 Usage

Site observations indicate that Diamond Teague Park and the Riverwalk Bridge, function primarily as a high-throughput urban waterfront rather than a long-duration recreational destination. The user population reflects mixed demographic, including young adults, service workers from nearby restaurants and commercial establishments, daily commuters, and a high proportion of dog owners. Children and family-oriented use were observed less frequently. Pedestrian movement is largely linear and time-bound, with most users traveling the park and adjacent bridge as part of daily routines rather than lingering along the shoreline or along the Riverwalk Bridge. Seating and shoreline edges adjacent to the vegetated shoreline are used intermittently, and while benches and other seating options are available, time spent near the river is generally short with observed dwelling times of approximately ten minutes. These patterns suggest that the site operates as a transitional and circulatory public space with underutilized potential for sustained waterfront interaction. Figure 4.3 shows surrounding land use patterns, while circulation routes are shown in Figure 4.4.

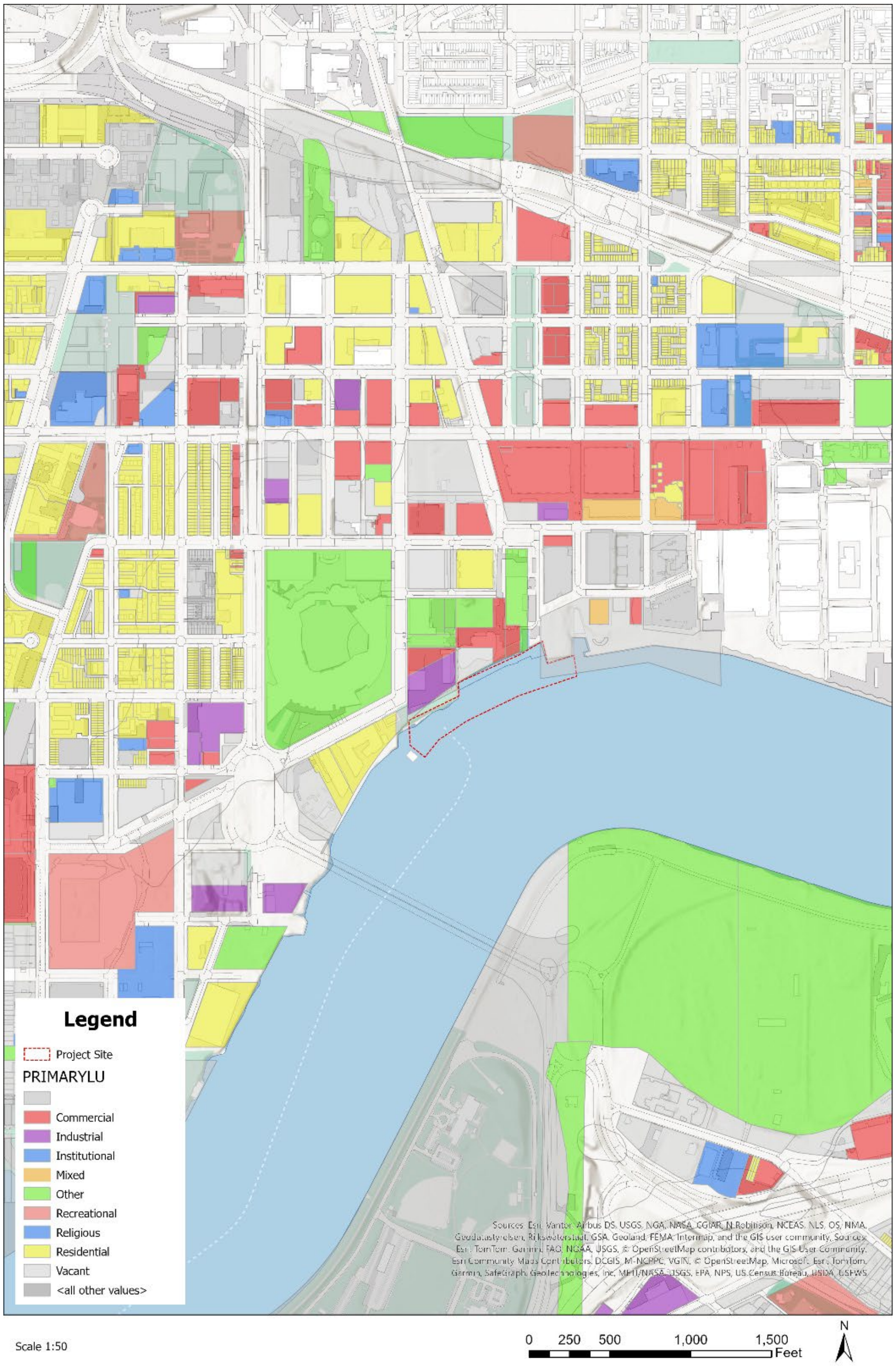


Figure 4.3

Navy Yard and Waterfront Land Use Map Surrounding the Project Site

Note. Map by author (2026)

People can access the project site from the boardwalk at Diamond Teague Park and from three gangways that connect to the kayak launch dock. Numerous public sidewalks, roads, and public transit options within ample walking distances of the stie support additional access to the waterfront. Along with these circulation paths, various viewsheds provide expansive views of the river and surrounding parks.

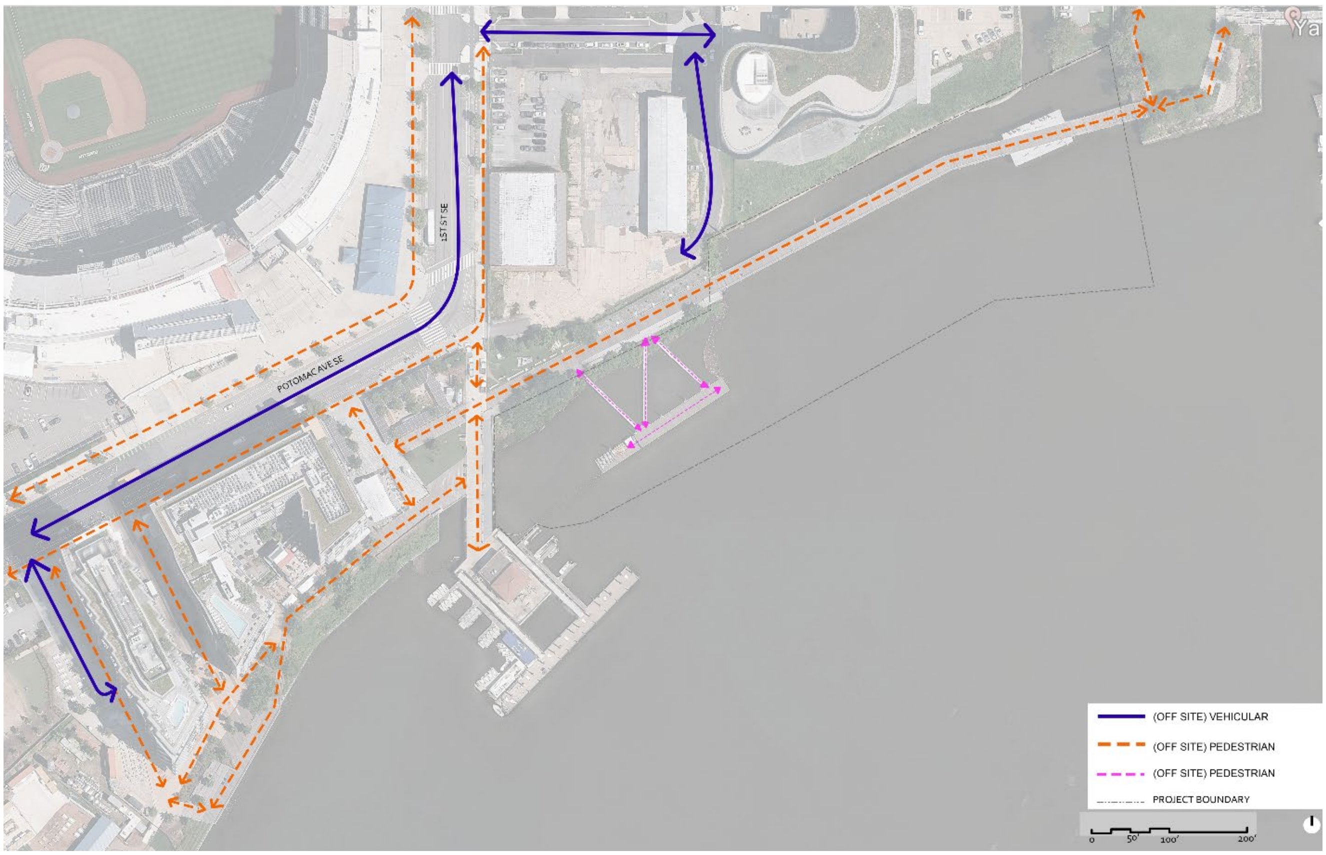


Figure 4.4

Pedestrian and Vehicular Circulation Diagram

Note: Imagery from Google Earth; annotations by author (2026).

4.1.3 Bathymetry and Channel Morphology

The bathymetry of the Anacostia River reflects extensive modification associated with dredging and shoreline urbanization. Within the project area, hardened seawalls are the primary edge condition with traces of rip rap around edges of the shoreline and where the bridge meets the vegetated shoreline at Diamond Teague Park. These overall hard-edge conditions have primarily stayed the same over the past decades except for additional infrastructure like the kayak launch dock and Pedestrian Riverwalk Bridge constructed in 2010 and 2011. Changes in shoreline condition and river morphology are illustrated in Figures 4.5, 4.6, and 4.7.

Figure 4.5

Aerial Imagery of the Anacostia River (2000)

Note. Imagery from Google Earth; annotations by author (2026).

Figure 4.6

Aerial Imagery of the Anacostia River (2010)

Note. Imagery from Google Earth; annotations by author (2026).

Figure 4.7

Aerial Imagery of the Anacostia River (2025)

Note. Imagery from Google Earth; annotations by author (2026).

4.1.4 River Width and Depths

Starting at the project site, the Anacostia River spans approximately 1,177 feet wide from the shoreline at Diamond Teague Park to Poplar Point across the river. Within this width, water depth is organized into shore-to-channel gradients shaped by the engineered banks and central navigation channel. Nearshore fringe zones typically extend 30 feet from each end of the shoreline and are approximately 0-8 feet in water depth. Extending beyond, depths also follow a gradient of about 4 to 10 feet deep and extend approximately 100-150 feet from the shoreline. Water depths increase rapidly nearer to the navigation channel. Depths toward the central navigation channel approach 12 to 20 feet or greater. This deeper portion of the river occupies a substantial portion of the total river width and is often between 400 to 800 feet wide. This approximate metric corresponds to the historically maintained navigation channel with assumptions being applied to the project site (U.S. Army Corps of Engineers, n.d.; NOAA, n.d.). Figure 4.8 shows the relationship between shoreline zones, depths gradients, and navigations channel.

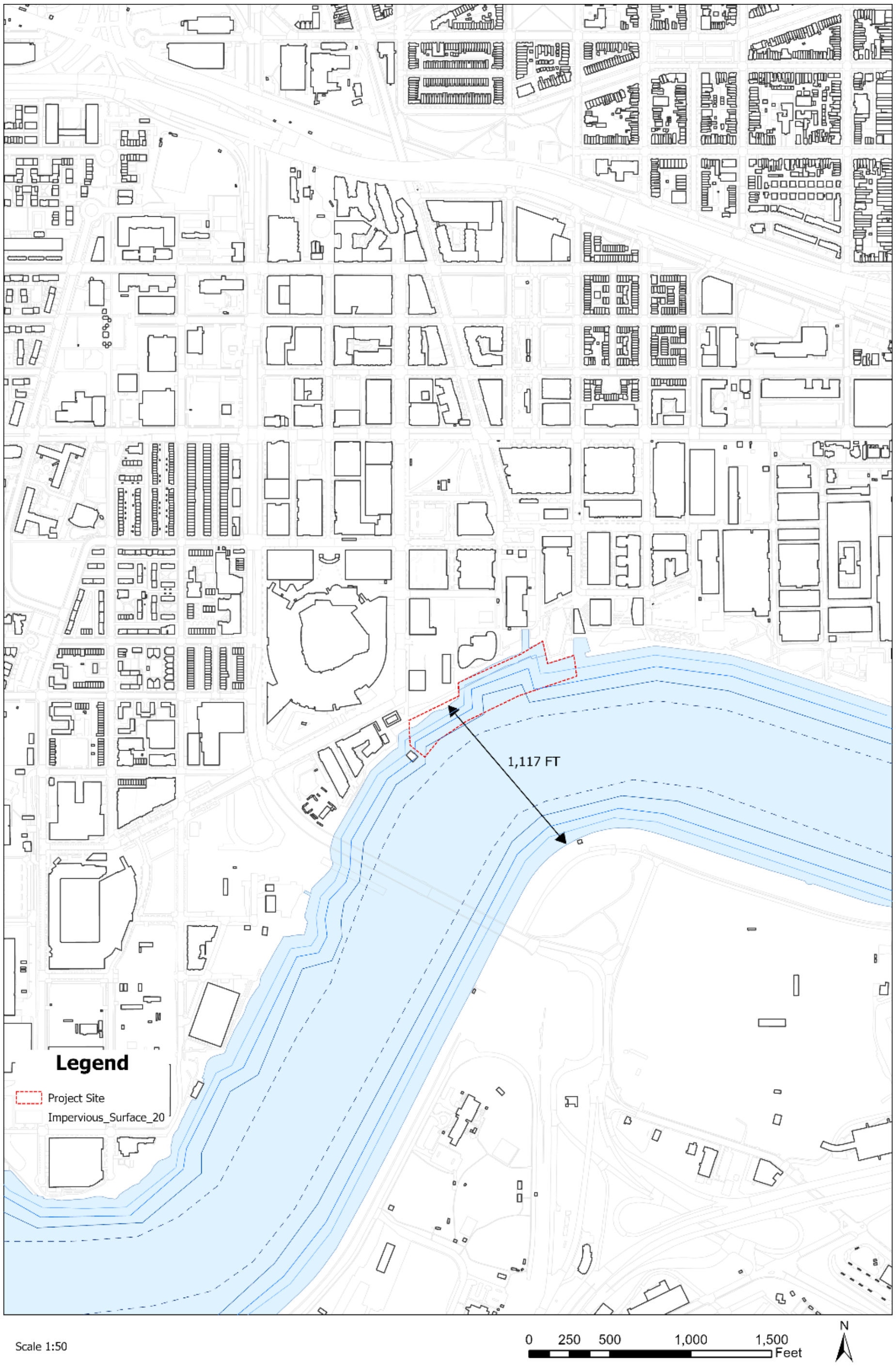


Figure 4.8

Approximate River Width and Water Depth Zones from Diamond Teague Park to Poplar Point

Note. Map by author (2026)

4.1.5 Ecological Conditions

Vegetation within the project site and surrounding area reflects a highly urbanized waterfront with clear distinctions between upland, shoreline, and in-water zones. Upland areas within Yards Park and Diamond Teague Park consist primarily of sod or synthetic turf, ornamental shade trees, landscaped planting beds, and raised planters to support recreational programming and public gathering spaces. Because the project site boundary primarily consists of hard-edge seawalls, vegetation along the shoreline is minimal where seawalls meet the water surface. The only exception is the approximate 350-foot-long vegetated transition between the boardwalk and river located at Diamond Teague Park. While not fully inclusive of all vegetation species, I mapped the species according the District Department of Transportation (DDOT) – Urban Forestry Division (UFD) shown in Figure 4.9.

COMMON_NAM	SCIENTIFIC	GENUS_NAME	NLCD_LAND_	ICODE	DBH (in)	HEIGHT (ft)
Mockernut hickory	Carya alba	Carya	Dev-Med	CATO	0.5	6
Amur maple	Acer tataricum ssp. ginnala	Acer	Dev-Med	ACGI	2	10
Amur maple	Acer tataricum ssp. ginnala	Acer	Dev-Med	ACGI	4	14
River birch	Betula nigra	Betula	Dev-High/Barren	BENI	5	18
Tulip tree	Liriodendron tulipifera	Liriodendron	Water	LITU	9	28
Japanese flowering cherry	Prunus serrulata	Prunus	Dev-Med	PRSE2	2	10
Amur maple	Acer tataricum ssp. ginnala	Acer	Dev-Med	ACGI	3	11
American elm	Ulmus americana	Ulmus	Water	ULAM	9	28
Honeylocust	Gleditsia triacanthos	Gleditsia	Dev-Med	GLTR	9	28
Amur maple	Acer tataricum ssp. ginnala	Acer	Dev-Med	ACGI	3	12
Sweetgum	Liquidambar styraciflua	Liquidambar	Dev-Med	LIST	2	11
Sugar maple	Acer saccharum	Acer	Dev-Med	ACSA2	6	20
Eastern white pine	Pinus strobus	Pinus	Dev-Med	PIST	5	19
Red maple	Acer rubrum	Acer	Dev-Med	ACRU	12	36
Slippery elm	Ulmus rubra	Ulmus	Dev-Med	ULRU	2	10
Scarlet oak	Quercus coccinea	Quercus	Dev-Med	QUCO	2	10
Mockernut hickory	Carya alba	Carya	Dev-Med	CATO	2	10
Silver maple	Acer saccharinum	Acer	Dev-Med	ACSA1	2	10
Sweetgum	Liquidambar styraciflua	Liquidambar	Dev-Med	LIST	2	10
Slippery elm	Ulmus rubra	Ulmus	Dev-Med	ULRU	1	7
Sawtooth oak	Quercus acutissima	Quercus	Dev-Med	QUAC	3	12
Sweetgum	Liquidambar styraciflua	Liquidambar	Dev-Med	LIST	6	19
Silver maple	Acer saccharinum	Acer	Dev-Med	ACSA1	2	10
Willow oak	Quercus phellos	Quercus	Dev-Med	QUPH	2	10
Eastern redbud	Cercis canadensis	Cercis	Dev-Med	CECA	0.5	6
Amur maple	Acer tataricum ssp. ginnala	Acer	Dev-Med	ACGI	0.5	6
American elm	Ulmus americana	Ulmus	Dev-Med	ULAM	2	10
Eastern redbud	Cercis canadensis	Cercis	Dev-Med	CECA	6	19
Ginkgo	Ginkgo biloba	Ginkgo	Dev-Med	GIBI	2	10
Callery pear	Pyrus calleryana	Pyrus	Dev-High/Barren	PYCA	2	10
				AVERGAE	3.616666667	

Figure 4.9

Tree Inventory Within the Diamond Teague Park Shoreline (DDOT, UDF)

Note. Source: District Department of Transportation, Urban Forestry Division (n.d.)

Within this vegetated zone, a mixture of shrubs, trees, grasses, and invasive vines populate the vegetation band. Through field observations and publicly recorded species from iNaturalist reports, species like Silver Maple (*Acer saccharinum*), Common Milkweed (*Asclepias syrica*), Pickerelweed (*Pontederia cordata*), and Black Locust (*Robinia pseudoacacia*) among many others grow along this shoreline edge. During field observations, this transition area showed evidence of newly planted whips, or young tree saplings, with protective fencing. While this is the only vegetated transition zone between inland and the water's edge, growth habitats were dense within the entire transition area presenting healthy, green, and full canopy coverage from the boardwalk all the way down to the water's edge. Images below of the transition zone reflect its dense growth form during the fall months of 2025. Existing shoreline vegetation conditions are illustrated in Figure 4.10 and 4.11.

Figure 4.10

Shoreline Whip Tree Planting at Diamond Teague Park

Note. Photograph by author (2026).

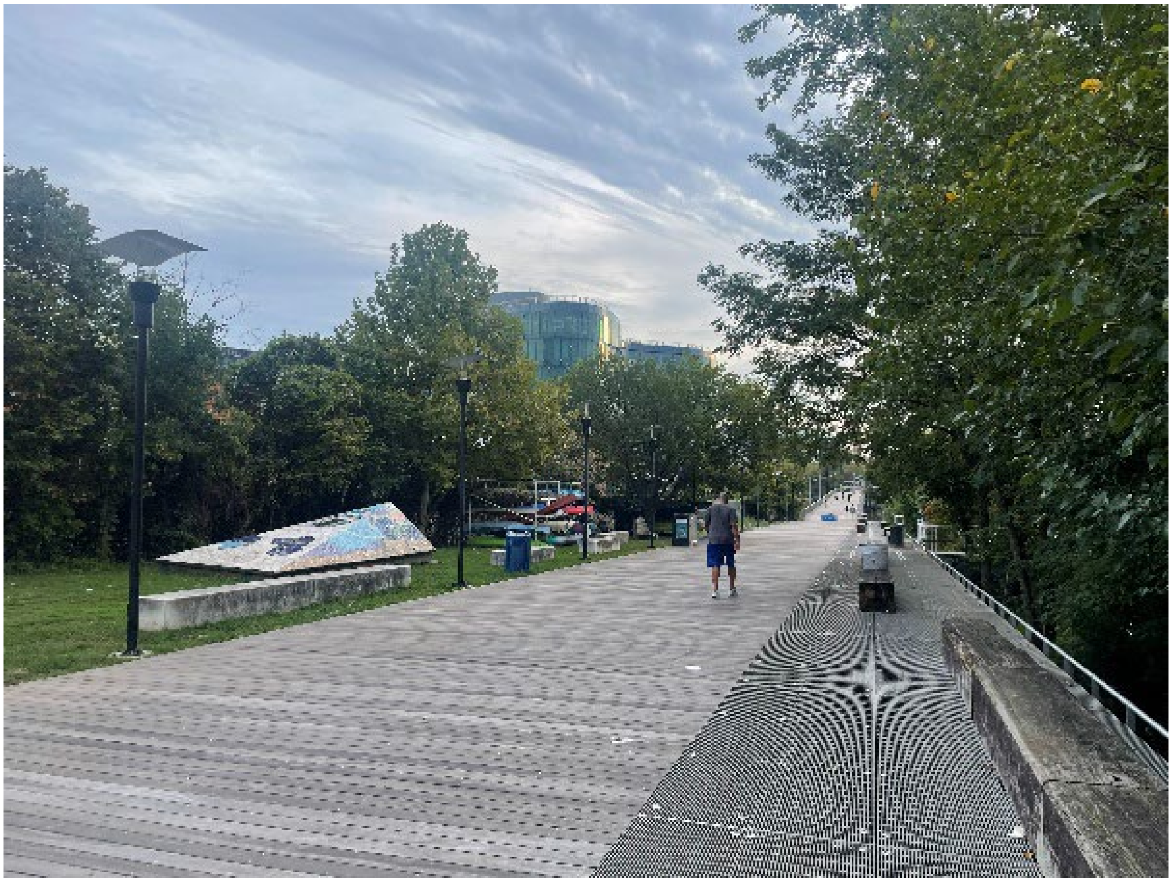


Figure 4.11

View Along Anacostia Riverwalk Trail

Note: Photograph by author (2026).

In the following months, the same vegetated area presented significantly less vegetation density. As a result, sightlines were less obstructed towards the river from the boardwalk. Though winter observation showed less vegetation density, its decline was assumed to be related to the typical growing habits of seasonal dormancy and thinner canopy and not a result from any abnormal external conditions affecting its growth habitats.

4.1.6 Vegetation

In-water vegetation was limited or absent during all field observation and site visits. Submerged aquatic vegetation (SAV), which depends on shallow water depths, adequate sun exposure, and stable sediments, was largely absent along the hardened edges and seawalls of the site as well as off the shoreline at Diamond Teague Park. As a comparison, a few examples of SAV in the greater Anacostia include native species like Wild Celery (*Vallisneria americana*), Redhead grass (*Potamogeton perfoliatus*), and Saga pondweed (*Stuckenia pectinata*). Such species were not visibly apparent during field observations, but unobserved SAV does not exclude them from existing. Additionally, while historic imagery of the site indicates the presence of constructed wetlands in 2010 at Diamond Teague Park, no evidence of these wetlands, nor any like them, were observed during field observations.

4.1.7 Wildlife

Wildlife activity was limited, with the only sighting being of common urban bird species utilizing the river and adjacent structures. To supplement these field observations, I reviewed publicly available records from iNaturalst within the project boundary. These records included Mallard ducks (*Anas platyrhnchos*), pond sliders (*Trachemys scripta*), blue catfish (*Ictalurus furcatus*), and groundhogs (*Marmota monax*), which were among the most documented species publicly observed over time. While these species were not observed during site visits, their repeated documentation suggest episodic and opportunistic use of the river corridor and the shoreline rather than continuous habitat occupancy. This contrast between limited direct field observation sightings and broader community-reported records highlights the variability of wildlife at the site.

4.1.8 Debris Patterns

Visible indicators of water quality stressors were consistently present at the project site, with floating litter and woody debris primarily along seawalls, collecting in tighter corners and along the vegetated shoreline at Diamond Teague Park. Observed floating litter primarily consisted of plastic bottles and smaller pieces of plastic mixed among larger floating wooden logs that rested within nearshore zones. Although existing posts lined the shoreline, which was assumed to be an effort to prevent large woody debris from washing on shore, both woody debris and plastics were still entangled along the shoreline at Diamond Teague Park, indicating some degree of past or ongoing failure of the collection method. The farthest upstream boom attached to the kayak launch dock and foot of the Riverwalk bridge was also observed. Its orientation and capture efficiency was successful in capturing all types of floating debris throughout each site visit and field observation. While debris types within the capture area were primarily the same each visit (floating plastics and smaller floating woody debris), load amounts varied based on site visit date and time, indicating routine maintenance was servicing the area between visits. While debris removal from these booms was not observed during site visits, nor are skimmer boat removal schedules publicly available, the assumed baseline frequency is at least once a week with more frequent removal coordinating with seasons and following heavy storm events.

While trash accumulations values are reported from various sources, including the MS4 Annual Report in the following section, specific debris accumulation is not specified by season. However, research on urban tidal rivers indicates that floating debris inputs are strongly correlated with storm events, recreation activity, and hydrodynamics (Schreyers et al., 2024). In tidal systems, debris is often redistributed during flood tide and accumulates during ebb and slack tide conditions where water is more stagnant. Seasonal variability also reflects these seasonal storm-driven dynamics, often occurring in spring and elevated plastic persistence in low-flow summer months.

4.1.9 Water Clarity

Water clarity was limited with water being primarily murky. Suspended sediments were observed to be persistent reinforcing reduced water clarity even during dry weather conditions which significantly reduced visibility of any SAVs (if present) and the riverbed. Although no turbidity measurements were collected during field visits, the visual appearance of water was consistent with sediment suspension and water quality reports commonly documented from Anacostia Monitoring data outlined in the following section.

4.2 Water Quality

4.2.1 Data Sources and Approach

On-site water quality sampling was not conducted as part of this study. Instead, this inventory on water quality synthesizes publicly available monitoring datasets collected by regulatory agencies and watershed organizations to characterize baseline conditions that influence the project site. These sources were selected due to their methodological rigor, spatial relevance, and consistency over time. This allows field observations to be evaluated within a broader, river-wide context.

4.2.2 Regulatory Water Quality Assessment: Department of Energy and Environment's 2024 Integrated Report

This report aligns with sections of the Clean Water Act and represents a comprehensive assessment of water quality based on collected field data, laboratory analyses, and established impairment thresholds (DOEE, 2024). The report noted that none of the monitored water bodies fully supported their designated uses (e.g., recreation, aquatic life, fish consumption), with indications of widespread impairment within the district. Bacteria, specifically E. Coli, was highlighted as a primary concern, with most water bodies including rivers and tributaries, exceeding recreational water standards (DOEE, 2024). Turbidity frequently reported elevated levels within the watershed while pH and temperatures generally fell within acceptable ranges. DOEE identified urban stormwater runoff and discharge from Municipal Separate Storm Sewer Systems (MS4) as the dominant source of impairment, exacerbated by dated infrastructure and improper connections. These structures were noted to contribute to the elevated bacteria counts, suspended sediments, and overall pollutant loads.

The report concludes that while measurable improvements in water quality are progressing through policy, infrastructure, and restoration investment, significant impairments persist, particularly impacting standards needed for recreational use and aquatic habitat support. Future initiatives, continued data collection, and regulatory compliance, are among the stated factors in advancing the district toward both fishable and swimmable waters stipulated under the Clean Water Act.

4.2.3 DOEE 2025 MS4 Report

Supplementing this 2024 Report, the DOEE 2025 MS4 Annual report was reviewed. This report documents substantial pollutants loads entering the Anacostia River. Estimated annual cumulative loads include approximately 211,504 pounds of Total Nitrogen (TN), 22,189 pounds of Total Phosphorus (TP), and 1,605 tons of Total Suspended Solids (TSS). Additionally, there were considerable measures of copper, zinc, lead, cadmium, and E. Coli (DOEE, 2025). Among the three major basins (Rock Creek, Potomac River, and Anacostia River), the Anacostia received the highest nitrogen, phosphorus, sediment, and bacterial loads and is highlighted in the table below. These pollutant loads are summarized in Figure 4.12.

18. Per Section 4.7.2.1, list Estimated Annual Cumulative Pollutant Loads in this Reporting Year:					
	Rock Creek	Anacostia River	Potomac River	Total	
Total Suspended Solids	255.97	1,605.05	682.65	2,543.67	tons
Total Nitrogen	42,131.31	211,504.52	81,913.00	551,073.00	pounds
Total Phosphorus	6,891.74	22,189.38	8,979.42	59,140.00	pounds
Copper	416.67	548.98	497.78	3,267.00	pounds
Lead	79.64	184.26	108.59	717.00	pounds
Zinc	1,467.38	3,427.30	2,281.12	9,832.00	pounds
Cadmium	5.97	18.14	10.32	49.84	pounds
E. coli	8.05E+13	1.82E+15	3.08E+14	1.04E+15	MPN

19. Estimated Annual Cumulative Pollutant Load Reductions in this Reporting Year:					
	Rock Creek	Anacostia River	Potomac River	Total	
Total Suspended Solids	4.45	14.58	3.12	22.14	tons

15

19. Estimated Annual Cumulative Pollutant Load Reductions in this Reporting Year:					
	Rock Creek	Anacostia River	Potomac River	Total	
Total Suspended Solids	4.45	14.58	3.12	22.14	tons

15

Total Nitrogen	539	1,291	464	2,294	pounds
Total Phosphorus	64	148	53	265	pounds
Copper	8.54	20.42	7.29	36.25	pounds
Lead	2.72	6.27	2.26	11.25	pounds
Zinc	16.77	47.17	14.09	78.02	pounds
Cadmium	2.98	6.86	2.47	12.32	pounds
E. coli	4,121	9,710	3,474	17,305	billion MPN

Figure 4.12

DOEE 2025 MS4 Report of Nutrient Loads and Pollutants

Note: Source: District Department of Energy and Environment (2025).

4.2.4 Anacostia Watershed Society Report 2025

Unlike regulatory assessments, the 2025 Anacostia Watershed Society (AWS) State of the River Report emphasizes system performance over time, allowing for comparison across years of river segments. The report further characterizes water quality conditions contributing to conditions at the project site. This annual report synthesizes long term field observation throughout the Anacostia River and its tidal reaches. It provides an assessment of chemical, biological, and ecological indicators.

Within the report, the Anacostia River received an overall grade of 'D,' corresponding to poor conditions within the 'A-F' water quality grading score. Within the report, nutrient indicators were one of the most impeding factors causing poor water quality. Specifically, Total Nitrogen and phosphorus concentrations consistently exceed thresholds. AWS attributes these nutrient levels to a combination of stormwater runoff, diffuse nonpoint sources, and internal recycling within the river rather than identifying a singular point-source discharge (Anacostia Watershed Society, 2025).

Dissolved oxygen values further illustrate the influence nutrients have on the ecological function of the river. Dissolved oxygen in tidal freshwater segments of the river frequently falls below 5 mg/L (the minimum level generally considered supportive of aquatic life). Moreover, average dissolved oxygen values often declined to 3-4 mg/L, indicating a higher demand associated with nutrient availability (Anacostia Watershed Society, 2025).

The report documents elevated chlorophyll-a concentrations as another contributing factor to water quality. This elevated value indicates sustained algal production driven by nutrient enrichment. These levels commonly exceed 20-30 µg/L, with the highest values occurring during the summer and surpassing thresholds associated with eutrophic conditions. E. coli levels also were reported to exceed recreational contact standards, particularly following rainfall events with mean concentrations exceeding 410 CFU/100 mL, which is the threshold used to assess safe recreational use.

The AWS report supports statements within the 2024 DOEE Integrated Report and further elaborates on nutrient enrichment significance, contributing to dissolved oxygen levels, elevated algal biomass, and episodic bacterial contamination that persist in the river. In the following section, water quality values are extracted directly from monitoring stations, providing additional evidence to support these reports.

4.2.5 USGS Continuous Monitoring: Hydrology and Turbidity

Supplementing the 2024 DOEE Integrated Report by and the 2025 AWS Report, continuous hydrologic and water quality data collected from the U.S. Geological Survey. This data provides additional continuous temporal insight into water quality within the Anacostia with published records associated with specific hydrologic monitoring stations throughout the Anacostia watershed. From publicly available data, two stations were chosen based on direct flow paths upstream and downstream of the project site. These two fixed stations bracket the project site, providing water quality trends that will assist in interpreting assumed water quality conditions at the project site. Figure 4.13 shows the spatial relationship of these monitoring stations along the Anacostia River.

The Kenilworth Aquatic Gardens station (USGS 01651760), located upstream of the project site, was chosen as the input monitoring location. This station provides tidal freshwater conditions prior to reaching the central river channel and the project site. Buzzard Point Station (USGS 01651827) is the downstream station where data is collected at the confluence point at the Potomac River.

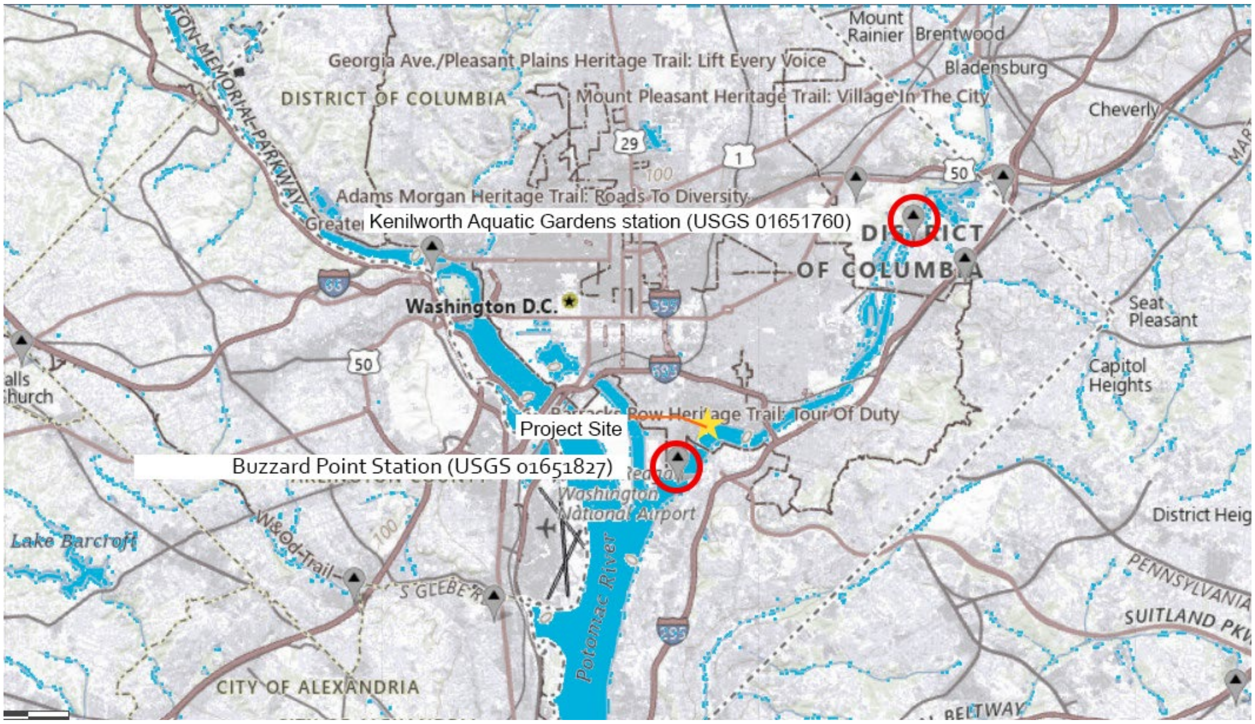


Figure 4.13

USGS Monitoring Station Locations Map

Note. Source: U.S. Geological Survey. (2025).

From these two stations, turbidity measurements were extracted from each station during the full 2025 calendar year. For both stations, a monthly mean turbidity value was calculated to consolidate the continuous values collected throughout the year. Turbidity is reported in Formazin Nephelometric Units (FNU), infrared-based metrics commonly used for continuous monitoring that quantifies scattering of suspended particles in water. FNU reflects cloudiness from suspended particles that harm aquatic life and signal pollutants within the water. Turbidity trends at the upstream Kenilworth station (Figure 4.14) and downstream Buzzard Point station (Figure 4.15) reveal differences in suspended sediment conditions across the project site.

USGS 01651760 ANACOSTIA RIVER AT KENILWORTH AT WASHINGTON, DC

Available data for this site | Time-series: Monthly statistics | GO

District Of Columbia, Dist. of Columbia
Hydrologic Unit Code 02070010
Latitude 38°54'33", Longitude 76°57'19" NAD83

Output formats: HTML table of all data | Tab-separated data | Reselect output format

63680, Turbidity, water, unfiltered, monochrome near infra-red LED light, 780-900 nm, detection angle 90 +-2.5 degrees, formazin nephelometric units (FNU),

Monthly mean in FNU (Calculation Period: 2024-08-01 -> 2025-10-31)

YEAR	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2024								19.5	14.8			
2025	14.1	24.1	23		18.3	22.4	32.1	17.5	16.6	15.6		
Mean of monthly Turbidity, Form Neph	14	24	23		18	22	32	18	16	16		

** No Incomplete data have been used for statistical calculation

Figure 4.14

USGS Kenilworth Station Mean Monthly Turbidity Values (2025)

Note. Source: U.S. Geological Survey. (2025).

USGS 01651827 Anacostia River nr Buzzard Point at Washington, DC

Available data for this site | Time-series: Monthly statistics | GO

District Of Columbia, Dist. of Columbia
Hydrologic Unit Code 02070010
Latitude 38°51'54.6", Longitude 77°00'37.2" NAD83
Gage datum -0.14 feet above NAVD88

Output formats: HTML table of all data | Tab-separated data | Reselect output format

63680, Turbidity, water, unfiltered, monochrome near infra-red LED light, 780-900 nm, detection angle 90 +-2.5 degrees, formazin nephelometric units (FNU),

Monthly mean in FNU (Calculation Period: 2019-05-01 -> 2025-03-31)

YEAR	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2019					5.19		8.81			9.27		5.9
2020		16.1		12.1		7.06		10.4		12.7	17.6	33.5
2021	15.1	12.2	20.9	9.93	6.75			11	14.6			5.77
2022	9.1	16.5	10.1	13.2	9.08	6.04				8.06	6.72	20.5
2023	11.7	11.9	10.4	6.7	5.62	4.61	4.03	6.24	6.08	5.88	7.27	25.1
2024	29.3	16.6	15.1	14.4	4.92	5.31		5.75	4.57	6.19	5.98	5.92
2025	3.86	12.6	8.39									
Mean of monthly Turbidity, Form Neph	14	14	13	11	6.3	5.8	6.4	8.3	8.4	8.4	9.4	16

** No Incomplete data have been used for statistical calculation

Figure 4.15

USGS Buzard Point Station Mean Monthly Turbidity Values (2025)

Note. Source: U.S. Geological Survey. (2025).

From the two reports, lower turbidity values at Buzzard Point may indicate reduced suspended sediment concentration due to increased channel depth and tidal flushing. However, these values should not be interpreted as evidence of clear or healthy water conditions. Rather, the contrast between stations reflects a longitudinal gradient of sediment transport and dilution across the tidal Anacostia River. This is congruent with field observation where the project site lacked vegetation complexity, habit diversity, and significantly low water quality visibility.

4.2.6 DOEE Monitoring Data: Ambient Water Quality Data Collection

Ambient water quality data was obtained from the District Department of Energy and Environment's (DOEE) publicly accessible Water Quality Portal (WQP). This database aggregates regulatory monitoring data by the DOEE and partnering agencies. Primary data reflects grab samples collected under MS4 compliance and watershed monitoring programs. While data systems gathered from USGS provide continuous flow and hydrologic measurements at fixed locations, DOEE data accessed through the WQP include a broader network of fixed ambient chemistry monitoring stations, offering greater spatial coverage across the watershed. The WQP, ANA19, and ANA24 stations were reviewed for their spatial proximity to the project site.

Nutrient data from these stations span 2021 to 2025, with values either representing averages from the most recent sampling year (2025) or, where more recent data are unavailable, the most recent year of record (2021). Although Total Nitrogen (TN) and Total Phosphorus (TP) values were not available for all monitoring stations, specific dissolved nutrients species were analyzed. These nutrients include Nitrate, Orthophosphate, and average Dissolved Oxygen because they represent the most bioavailable and ecologically active forms of nitrogen and phosphorus in aquatic systems. These dissolved nutrients are directly taken up by algae and aquatic plants and are the primary drivers of eutrophication in tidal rivers. Therefore, measuring these forms provides insight into immediate nutrient availability and short-term biological response within the river. Nutrient indicator values are summarized in Figure 4.16, while Figure 4.17 locates the corresponding monitoring stations relative to the project site.

Indicator	ANA19	ANA24
Avg. Dissolved Oxygen (2024–2025)	7.3 mg/L	8.6 mg/L
Observed DO Range (2024–2025)	3.1–12.1 mg/L	5.4–12.5 mg/L
Nitrate (NO_3) Range (2021)	0.007–0.265 mg/L	0.005–0.115 mg
Orthophosphate (PO_4) Range (2021)	0.01–0.08 mg/L	0.01–0.06 mg/l

Figure 4.16

WQP Average Nutrient Indicator Values for Stations ANA14 and ANA24 (2021, 2024-2025)

Note. Source: District Department of Energy and Environment's (DOEE) Water Quality Portal (WQP) (2025).

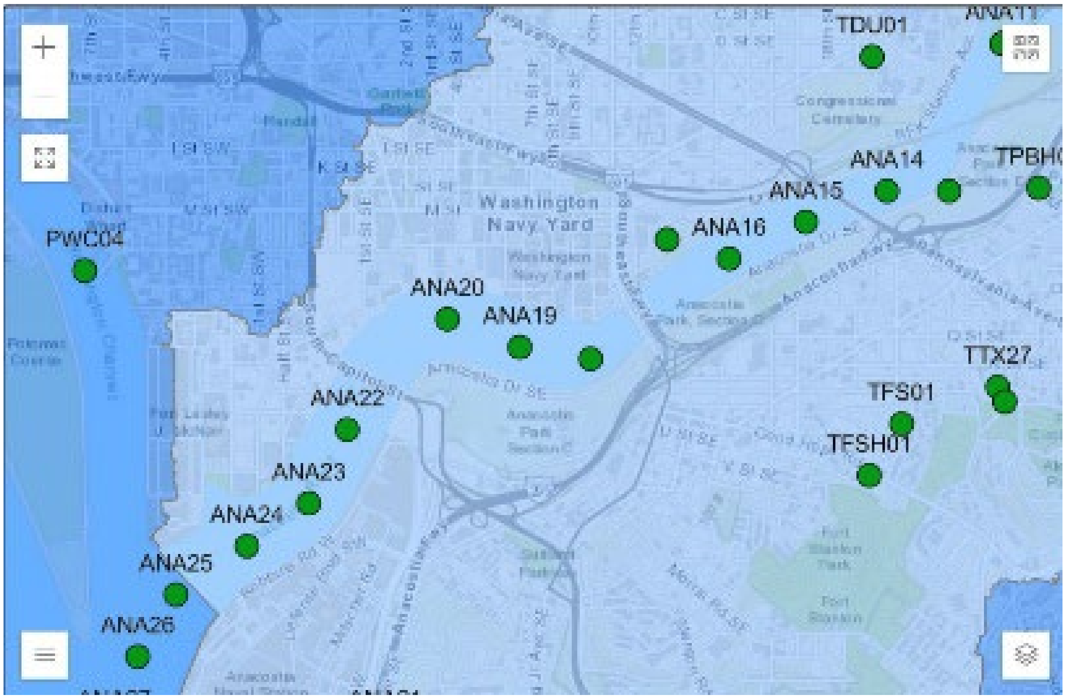


Figure 4.17

WQP ANA Station Locations Map Along the Anacostia River

Note. Source: District Department of Energy and Environment's (DOEE) Water Quality Portal (WQP), (2025).

4.3 Regional, Tidal, and Hydrologic Context

4.3.1 Watershed and Tidal Dynamics

The Anacostia Watershed conditions are not only influenced by the immediate surrounding area and land uses, but also by elements upstream from its tributaries and surrounding urbanized areas. This upstream and downstream relationship plays a significant role in shaping water quality, sediment transport, and the accumulation of debris observed at the project site.

The Anacostia River experiences a semi-diurnal tide, meaning two high tides and two low tides occur roughly every 24 hours. The difference between the highest and lowest tidal range in the river is about 2.5 to 3 feet near Diamond Teague Park area and is continuously active, cycling approximately every 6 hours and 12 minutes between high and low tides (NOAA, 2024).

4.3.2 NOAA Tidal Range

NOAA-predicted tidal water surfaced elevations were used to characterize tidal variability for the project site. NOAA Station 8594900 (Washington, DC) provides the tidal data used in this study and while not within the project site, it was selected as the tidal reference because it provides the nearest long term, datum-controlled tidal predictions representative of the lower Anacostia River. The reference station's location within the river system is shown in Figure 4.18. From available data for this NOAA station, parameters were set to analyze monthly tidal surface elevations during the year 2025. This parameter was chosen for its most recent and available tidal data. (NOAA, 2024).

Figure 4.18

NOAA Station 8594900 Location Map

Note. Source: National Oceanic and Atmospheric Administration (NOAA), (2025).

NOAA tidal water surface elevations are reported in vertical datums. These vertical datums are a defined reference surface from which water elevations are measured and reported. In tidal systems, these datums derive from long term observations and represent statistically averaged water levels rather than instantaneous conditions. These tidal datums are gathered and analyzed from NOAA and are calculated over a fixed 19-year averaging period, known as the National Tidal Datum Epoch (NTDE). This duration is intentionally selected to encompass the full 18.6-year lunar nodal cycle, which influences the tidal variability. The current NTDE used by NOAA Center for Operational Oceanographic Products and Services is 1983-2001. Although this period precedes the present day, it remains the nationally standardized time frame for tidal datums (National Oceanic and Atmospheric Administration, 2000)

Tidal elevations in this study are referenced to Mean Lower Low Water (MLLW), defined as the average height of the lower of the two daily tides over the NTDE. At NOAA Station 8594900, 0.0ft MLLW corresponds to an elevation of +1.40 ft NAV88, meaning that predicted tidal heights represent variation above this tidal baseline rather than absolute topographic elevations. In the graph below, it illustrates just one period from this station during the month of November 2025. Short-term tidal fluctuations are captured in Figure 4.19, while seasonal variation is presented in Figure 4.20.

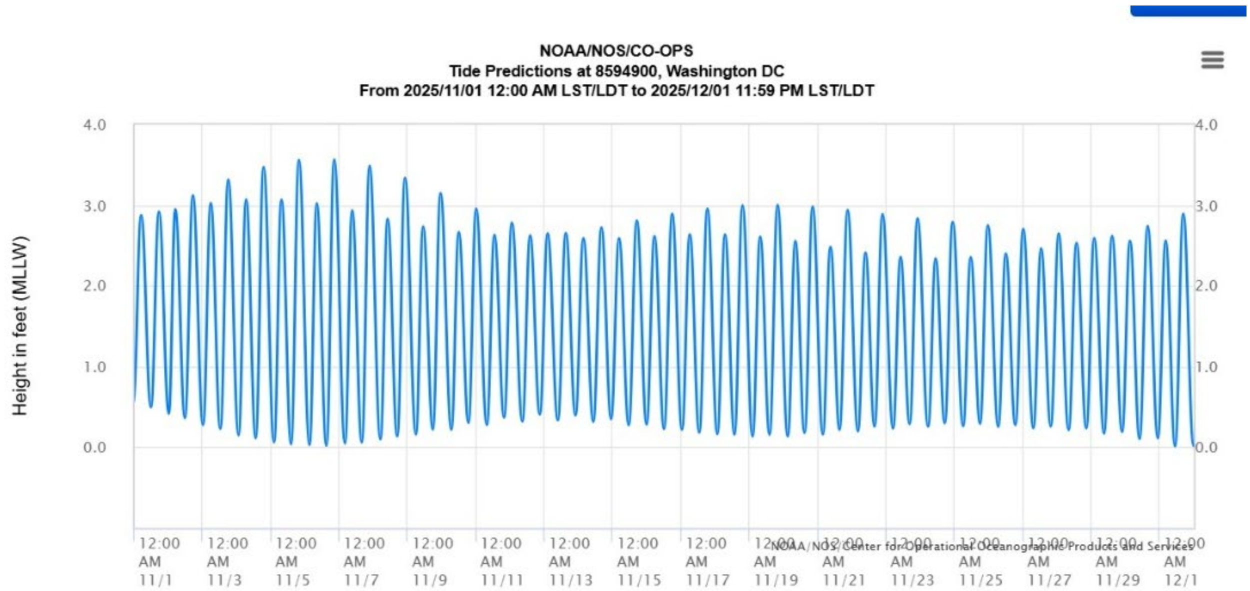


Figure 4.19

November 2025 Tidal Levels from NOAA Station 8594900

Note. Source: National Oceanic and Atmospheric Administration (NOAA) (2025).

At this station, Mean High Water (MHW) is 2.94ft and Mean Lower (MLW) is 0.16 ft relative to MLLW, producing a Mean tidal range of 2.79 ft. Mean High Water (MHHW) averages 3.17 feet. These values reflect long-term average conditions across all seasons; in other words, a typical day fluctuates about 3 feet between low and high tide at this tidal reference station. As shown in the table above, short-term fluctuations occur day-to-day showing two high tides and two low tides. However, the heights of these high and low tides vary around the datum averages due to spring and neap cycles and seasons.

A comparison of monthly recorded NOAA predicted tidal elevations were taken for January, March, August, and November 2025 to demonstrate the measurable seasonal fluctuations of water levels based on seasonality and time of the year. Winter months (January) exhibited lower baseline conditions, with low tides falling below 0 ft relative to MLLW and high tides generally ranged between 2.0 and 2.6 ft. During late summer conditions (August) high tides commonly exceeded 3.0 ft and low tides remained above 0. These seasonal differences between winter and late summer approach approximately 0.5-0.9 ft. While mean tidal ranges remain approximately 2.8 ft, the vertical positions shift based on seasons.

Overall, water levels in the lower Anacostia change not only twice a day with tides, but also slightly shift depending on the season. Winter months experience lower low tides and slightly lower high tides, while late summer months consistently show higher baseline water levels. While the daily tidal range remains about three feet throughout the year, the entire waterbody can shift upward and downward by several inches to nearly a foot depending on season.

Seasonal Tidal Elevation Comparison (NOAA Station 8594900, 2025 Predictions)

Month (2025)	Typical High Tide Range (ft)	Typical Low Tide Range (ft)	Approx. Total Daily Range (ft)
January	2.0 – 2.6	-0.55 – -0.30	~3.0 – 3.1
March	2.4 – 3.4	-0.35 – -0.05	~3.3 – 3.5
August	3.0 – 3.4	0.30 – 0.90	~2.4 – 3.1
November	2.8 – 3.2	0.00 – 0.50	~2.6 – 3.2

Figure 4.20

Seasonal Tidal Change at NOAA Station 8594900 (2025)

Note.Table by author using data from National Oceanic and Atmospheric Administration (NOAA) (2025).

4.3.3 Hydrology and Flow Patterns

Direct, publicly available flow velocity data are not available for the project site nor adjacent nearshore zones. Therefore, reported velocity ranges reflect values documented in published hydrodynamic modeling and monitoring studies of the lower Anacostia River and

Washington Channel. Reports from these studies are used to characterize representative flow conditions rather than site-specific measurements.

Hydrodynamic studies were conducted using observational data and model calibration from the late 1990's through 2014. From these findings, under typical, non-storm tidal conditions, the highest velocities of the Anacostia River occur within the central navigation channel, where peak ebb and flood velocities range from approximately 0.2 to 0.6 meters per second (approximately 0.7 to 2.0 feet per second) (Cerco et al., 2010; Jones et al., 2014).

In contrast, closer to the shoreline, zones experience significantly lower flow velocities. Along bulkhead edges, velocities are commonly below 0.2 meters per second (approximately less than 0.7 feet per second) with periods of near stagnation occurring during slack tide. The presence of bulkheads, floating docks, and limited shoreline complexity further dampen circulation in these near-shore bulkhead locations.

Storm events are a significant factor that introduce short term changes to flow behavior. During moderate to large rainfall events (approximately 1 to 3 inches of precipitation over one to several days) velocities within the main channel increase and often exceed 0.6 meters per second and in some cases exceed 1.0 meters per second (approximately 3.3 feet per second) in contrast, nearshore velocities during storm events are more variable. While some zones along the edge experience more modest increases in velocities, typically between 0.2 to 0.4 meters per second, other areas remain slow due to shoreline geometry and obstructions. As a result, storm events do not consistently flush nearshore zones and are often followed by periods of reduced circulation (Jones et al., 2014)

4.3.4 Discharge

River flow magnitude was characterized from discharge data collected form the U.S. Geological Survey National Water Information System (NWIS). Discharge represents the total volumetric flow of water passing a river cross-section per unit of time. It differs from velocity, which describes speeds of water at a specific location.

Two USGS monitoring stations were selected following the same temporal and spatial parameters as prior monitoring stations. From these parameters, two stations were selected; the Anacostia River at Kenilworth (USGS 01651760), representing upstream inflow, and Anacostia River near Buzzard Point (USGS 01651827), capturing tidally influenced discharge near the project site. The charts below provide a more expansive report of turbidity with the primary focus being during the year 2025 for consistent analysis. Figures 4.21 and 4.22 show discharge patterns for upstream and downstream stations, highlighting variation in flow conditions along the river.

Annual statistics
Anacostia River at Kenilworth at Washington, DC - USGS-01651760

Annual mean (average) of daily mean values
for each calendar year (January 1 December 31) when data was recorded

	Discharge, tidally filtered, cubic feet per second		Dissolved oxygen, water, unfiltered, milligrams per liter		Specific conductance, water, unfiltered, microsiemens per centimeter at 25 degrees Celsius		Temperature, water, degrees Celsius		Turbidity, water, unfiltered, monochrome near infra-red LED light, 780-900 nm, detection angle 90 +-2.5 degrees, formazin nephelometric units (FNU)	
Year ↑↓	mean ↑↓	count of records	mean ↑↓	count of records	mean ↑↓	count of records	mean ↑↓	count of records	mean ↑↓	count of records
2024	47.687	180	6.302	179	370.061	179	19.238	179	15.449	165
2025	136.427	189	6.659	321	697.48	321	17.333	321	19.739	321

Figure 4.21

Mean Discharge for the Anacostia River at Kenilworth (2024–2025) (USGS 01651760)

Note. Source: U.S. Geological Survey National Water Information System (NWIS) (2025).

Annual statistics
Anacostia River nr Buzzard Point at Washington, DC - USGS-01651827

Annual mean (average) of daily mean values
for each calendar year (January 1 - December 31) when data was recorded

	Discharge, tidally filtered, cubic feet per second		Specific conductance, water, unfiltered, microsiemens per centimeter at 25 degrees Celsius		Temperature, water, degrees Celsius		Turbidity, water, unfiltered, monochrome near infra-red LED light, 780-900 nm, detection angle 90 +-2.5 degrees, formazin nephelometric units (FNU)	
Year ↑↓	mean ↑↓	count of records	mean ↑↓	count of records	mean ↑↓	count of records	mean ↑↓	count of records
2019	NA		342.176	289	19.339	289	9.1	279
2020	NA		292.112	357	16.844	358	14.175	357
2021	229.797	35	364.929	338	16.72	361	11.208	353
2022	249.181	336	371.289	360	16.242	365	10.942	354
2023	229.783	334	308.433	365	17.065	365	8.804	365
2024	216.484	366	340.26	366	17.228	366	10.063	357
2025	-214.937	30	504.973	113	7.244	113	7.716	113

Figure 4.22

Mean Discharge for the Anacostia River at Buzzard Point (2021–2025) (USGS 01651827)

Note. Source: U.S. Geological Survey National Water Information System (NWIS) (2025).

4.3.5 Flooding

According to the FEMA Flood Insurance Rate Map (FIRM) for the District of Columbia, the Anacostia River edge, including the project site, are within Zone AE. Zone AE is equivalent to a 100-year floodplain with Base Flood Elevations (BFEs) between 8 and 11 feet. These two maps are significant in understanding the potential future impacts flooding may have on the site and its adjacent land. Flood risk conditions and FEMA-designated flood zones are mapped in Figure 4.23 and 4.24.

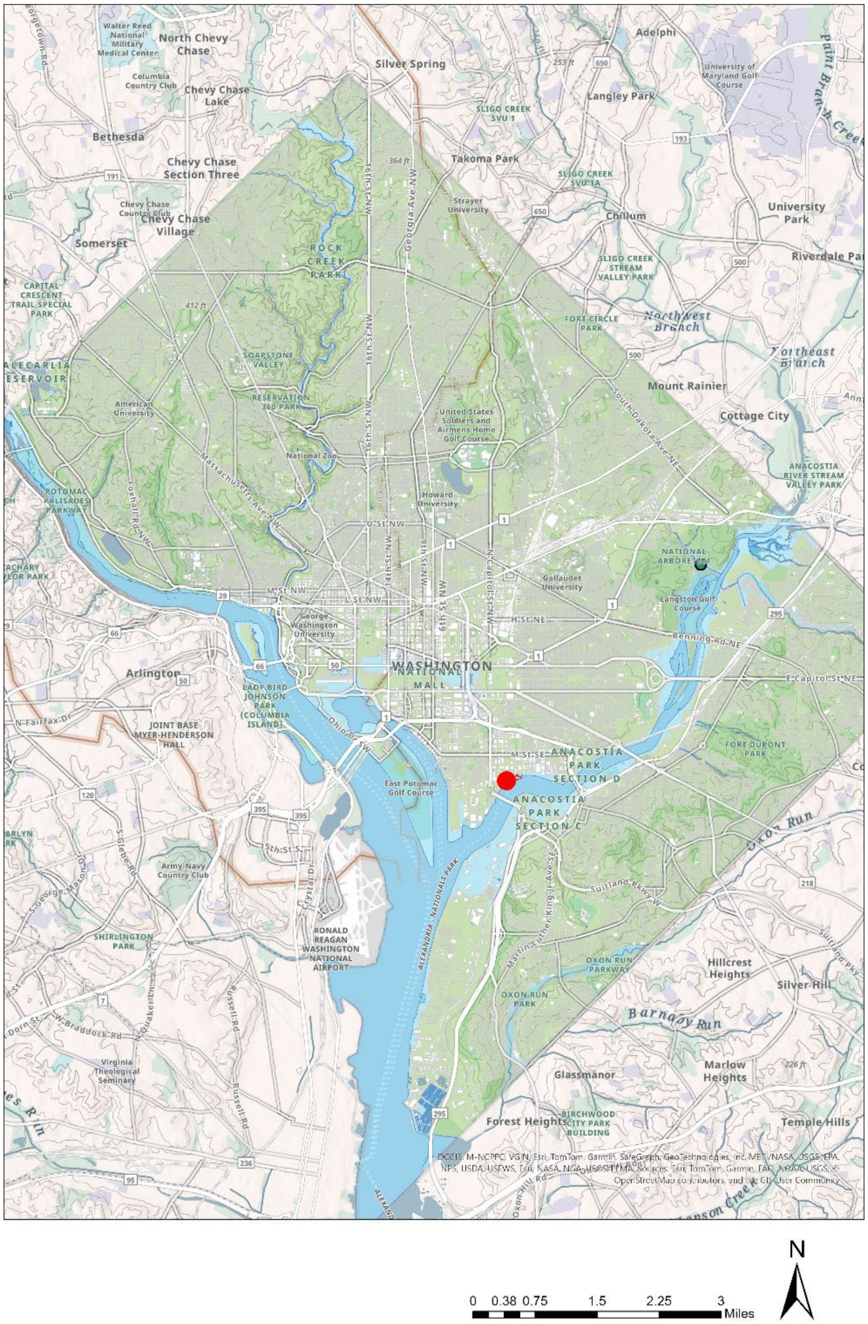


Figure 4.23

Washington, D.C., FEMA FIRM Context Map

Note. Map by author (2026).

Figure 4.24

Project Boundary FEMA FIRM Enlargement Map

Note. Map by author (2026).

4.3.6 Stormwater and Sewer Infrastructure

In addition to the natural accumulation of debris and its tidal patterns, the Anacostia River is closely linked to the region's sewer outfalls and stormwater infrastructure. Municipal Separate Storm Sewer Systems (MS4), also discharge into the river. These systems collect runoff and discharge them directly to the surface waters. There is one MS4 system located Southwest of Diamond Teague Park just outside the project boundary and a total of ten MS4 systems within a mile radius of the site that distribute into the river. These inputs distribute nutrients, sediments, and debris into the river, reinforcing the connection between urbanization and water quality. Regional stormwater infrastructure and MS4 outfall locations are identified in Figure 4.25 and 4.26.

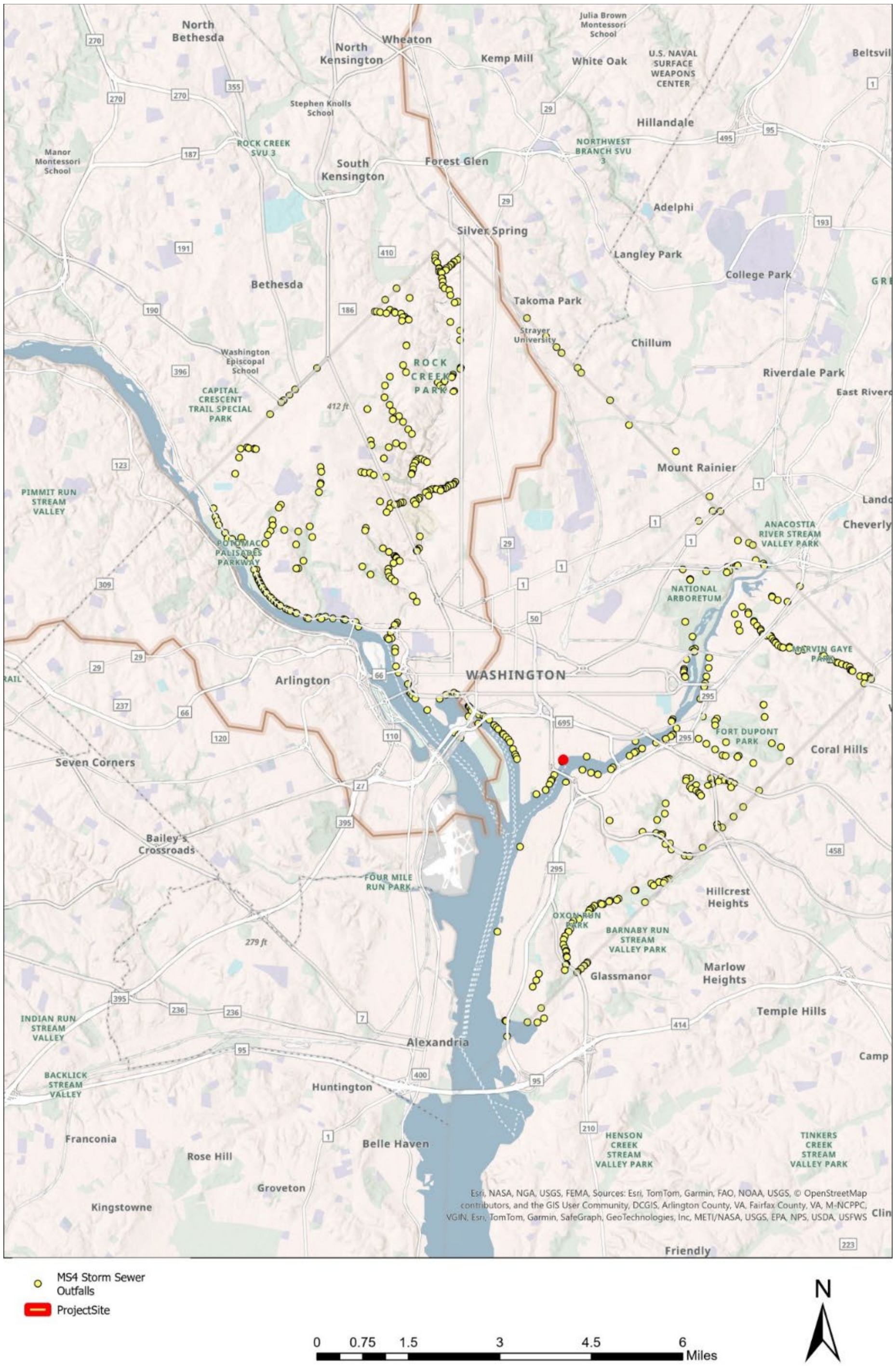


Figure 4.25

Washington, D.C., MS4 Sewer Outfall Locations Map

Note. Map by author (2026).

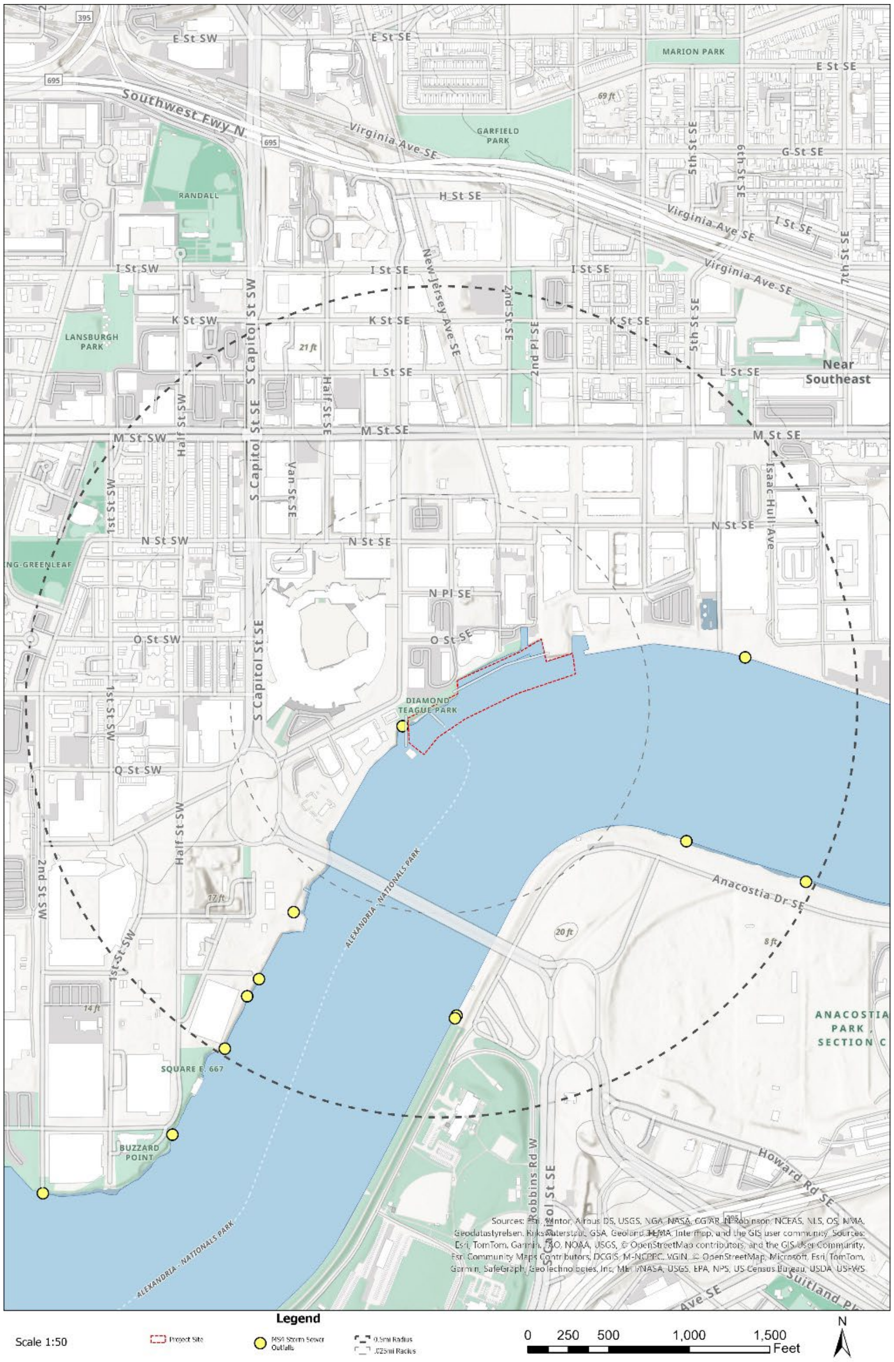


Figure 4.26

MS4 Sewer Outfall Locations Within 0.25- and 0.5-Mile Radius of the Project Site

Note. Map by author (2026).

4.3.7 Floating Pollutants and Debris

Floating debris represents one of the most visible and persistent forms of pollution within the Anacostia River and within the site. This inventory draws on regional trash interception records and watershed scale assessments that support field observations.

According to the Anacostia Watershed Society (AWS), plastics are consistently the dominant category of floating debris by item count throughout the Anacostia River. Within the 2025 State of the Anacostia River Report, it records plastic material such as bags, bottles, caps, food packaging, and foam containers accounting for approximately 70-80% of identifiable floating litter items despite leaves and other woody debris comprising a larger share by weight (Anacostia Watershed Society, 2025).

DOEE reports trash interception and cleanup efforts remove hundreds of tons of floating litter annually, from infrastructure like booms, skimmer operations, and shoreline cleanups (DOEE, 2024). Additionally, trash traps installed throughout the watershed by the DOEE and partnering organizations have record capturing over 70,000 pounds of trash since 2009 based on cumulative cleanup removal records from stormwater outfalls and tributaries (District of Department of Energy and Environment, 2024). Supplementing these records, *Figure 4.27* documents cumulative trash removal types and values for the year 2025. Annual debris removal quantities and material composition are summarized in Figure 4.27.

31. Per Section 3.7.1.1 of the permit, provide annual trash reductions in the Anacostia River basin for this reporting year. Totals should be reported under Question #4 in Part 1.		
Annual Trash Reductions in the Anacostia River Basin		
	Trash Removed (pounds)	Annual Load Reduction (pounds)
Trash Traps	7,461	7,461
Environmental Hot Spots	3,018	3,018
Clean-up Events	15,395	10,579
Skimmer Boats	90,000	44,177
Clean Teams Program	3,592,175	1,760,201
Bag Law	242	242
Other:		
Other:		
Totals	3,708,291	1,825,678

32. How are these trash reduction technologies and activities being applied in other parts of the MS4 Permit Area?
DOEE tackles trash pollution holistically, combining pollution prevention, pollution mitigation, and litter capture or removal. This strategy relies on District policy, programming, environmental monitoring, and research applied throughout the MS4 Permit Area. DOEE programs that promote education, regional collaboration, and community engagement, reduce the amount of pollution entering the environment. Policies addressing foam and plastic pollution prevent pollution at the source and are applied throughout the entire District. Trash traps and other intervention technologies tackle capture and removal at fixed locations within the MS4 Permit Area. Cleanups take place throughout the MS4 Permit Area at high litter volume locations.

Figure 4.27

2025 MS4 Annual Trash Reductions Report

Note. Source: District Department of Energy and Environment (DOEE) (2025).

DC Water also operates their own skimmer boats and report removing more than 400 tons of floating debris annually (DC Water, 2024). Among these records, community cleanup events by Anacostia Riverkeeper and affiliated volunteer organizations, record removing approximately 156,000 pounds of debris between 2014 and 2025 (Anacostia Riverkeeper, 2025). While reported debris and plastic removal is not explicitly associated with one location, these trends reinforce existing debris accumulation patterns observed within the site.

4.4 Maintenance and Regulations

4.4.1 Maintenance

Diamond Teague Park is owned and maintained by the District of Columbia Department of Parks and Recreation (DPR). As primary owner and manager, typical maintenance responsibilities include the landscape maintenance of lawns, trees, planting beds, parks amenities like seating, signage, and lighting, as well as general routine cleanup of trash and safety inspections (District Department of Parks and Recreation [DPR], n.d.). Although DPR is the primary steward of the space, the Capitol Riverfront BID plays a supporting role in the surrounding public areas through additional cleaning, programing of events, and general maintenance. These primary maintenance duties are for inland areas that predominantly cover the boardwalk and adjacent amenity spaces.

The shoreline at Diamond Teague Park is maintained through a shared responsibility structure. Primary shoreline maintenance is conducted by District Department of Energy and Environment (DOEE) who own and maintain bulkheads and seawalls. Tasks include inspections, repairs, and long-term structural integrity. Day-to-day maintenance is also conducted by BID, DOEE who regulate shoreline work and shoreline interventions which coordinate additional volunteer maintenance tasks from volunteers from the Earth Conservation Corps.

The Anacostia River is maintained by several parties. DC Water operates skimmer boats that remove floating trash, but the primary removal of debris removed from infrastructure elements like the containments booms and trash cages, including the existing boom within the site, is managed by the DOEE and contracts full-time crews that operate skimmer boats for debris removal. Frequency of removal is not publicly stated, but based on field observations, frequency is assumed at least once a week with increased frequency corresponding to season and storm events. Additional in-water debris removal includes nonprofits like Anacostia Riverkeeper, who lead volunteer shoreline cleanups and in river cleanups through kayaks and canoes. Anacostia Watershed Society (AWS) also provides similar water cleanup programs and includes the installation and maintenance of trash traps.

4.4.2 Policy and River Regulations

The Anacostia River itself is governed through a layered regulatory framework with parties including federal, district, and local agencies. The river is classified as a navigable water of the United States, placing it under federal jurisdiction. Submerged lands within portions of the river are generally held in public trusts by the District of Columbia, though regulatory authority over navigation and in-water structures fall under the U.S. Army Corps of Engineers (USACE). This designation means that any infrastructure placed within the river must avoid obstructing navigation, altering flow that will impact channel stability, or increase flood risks.

At the district level, environmental oversight and water quality regulations are administered by DOEE, where they enforce the Clean Water Act and manage TMDLs. They oversee permitting for the shoreline and any in-water interventions that cross over with these regulations. Additionally, any proposed infrastructure, whether ecological, recreational, or debris management related, is subject to multiple permitting requirements. The primary authorization is needed at that federal level under Section 10 of the Rivers and Harbors Act, administered by the USACE. Projects that also include dredging or modification of wetlands must comply with Section 404 of the Clean Water Act that is also overseen by the USACE and DOEE. Collectively, these regulations and ownerships conditions require that any in-water interventions be reversible, adaptive, and non-obstructive. The regulatory framework influencing these constraints is outlined in Figure 4.28.

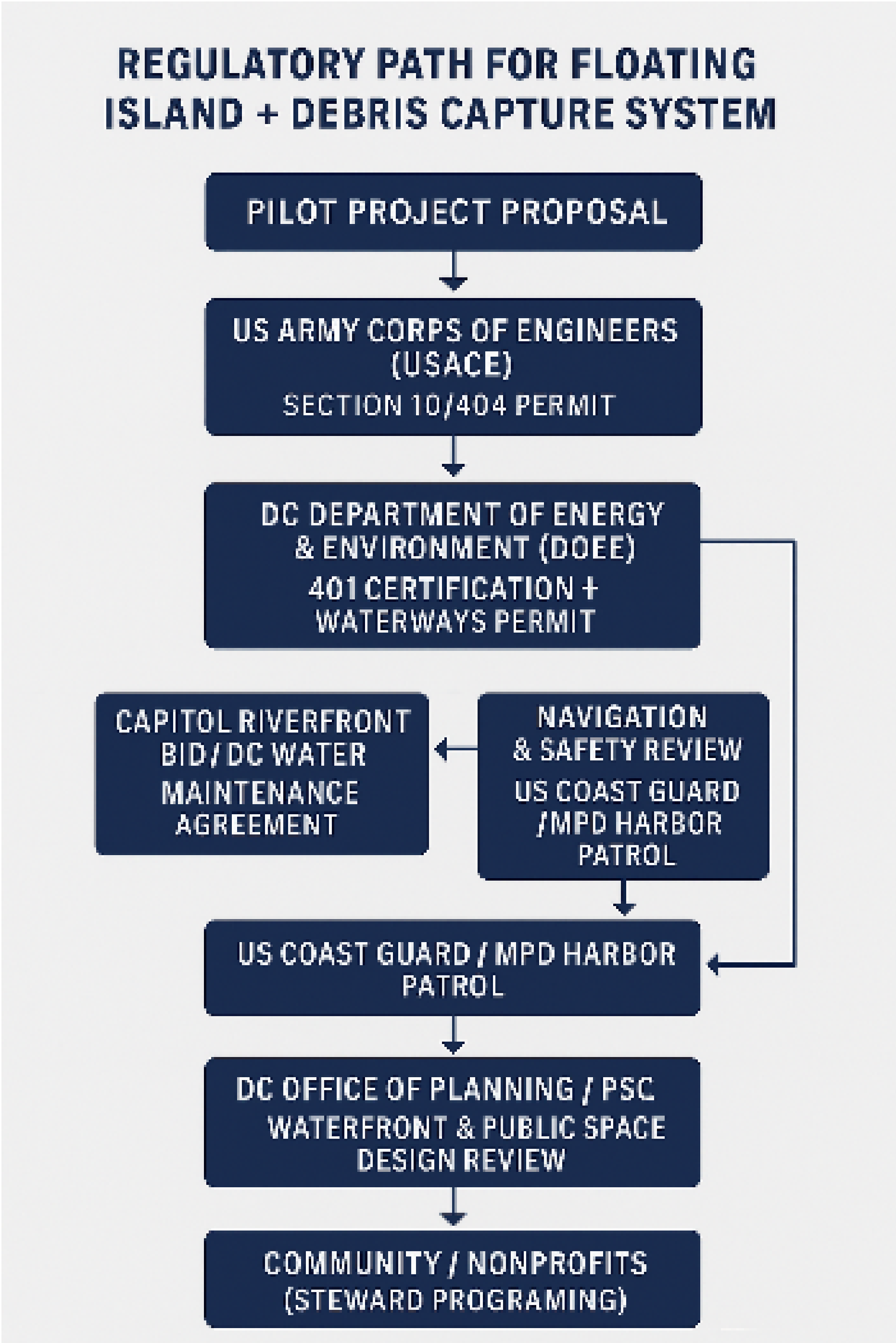


Figure 4.28

Regulatory Flowchart of Project Site Governance and Permitting

Note. Diagram by author (2026).

Chapter 5: Analysis & Design Framework

This chapter synthesizes site inventory findings and literature review research to establish the design logic and framework for the design proposal. Specific construction details and performance criteria are documented in the subsequent Design Proposal Sections.

5.1 Case Studies

5.1.1 Mr. Trash Wheel

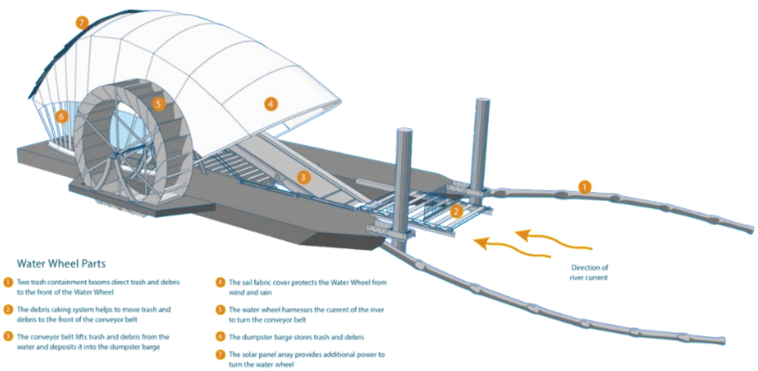


Figure 5.1

Mr. Trash Wheel Debris Collection Diagram

Note. Source: EcoWatch (2017).

Located in Baltimore, Maryland, Mr. Trash Wheel is a semi-autonomous trash interception and collection device, managed in Baltimore's Inner Harbor, to capture floating debris before it enters the Chesapeake Bay. The system uses a floating containment boom to guide floating debris toward a conveyor belt that lifts trash into collection cages for off-site removal. Since its deployment in 2014, Mr. Trash wheel has intercepted over 2 million pounds of debris including plastics, foam, organic material and requires low operational input (Viviano, 2020). Beyond its functional performance, Mr. Trash Wheel is a highly visible piece of infrastructure that intentionally uses design elements like signage and real-time reporting data to communicate river pollution and stewardship to the public. Although it effectively serves as an iconic figure of the Inner Harbor and Baltimore, the system is limited to specific hydrologic conditions that require it to be regularly maintained, manned, and serviced. Regardless, Mr. Trash Wheel exemplifies how debris interception and servicing can be effective at a large-scale level while operating as a public-forward monitoring and educational system. The system components and debris capture process are shown in Figure 5.1, illustrating how conveyor-driven collection integrates with passive debris collection.

5.1.2 The Wild Mile

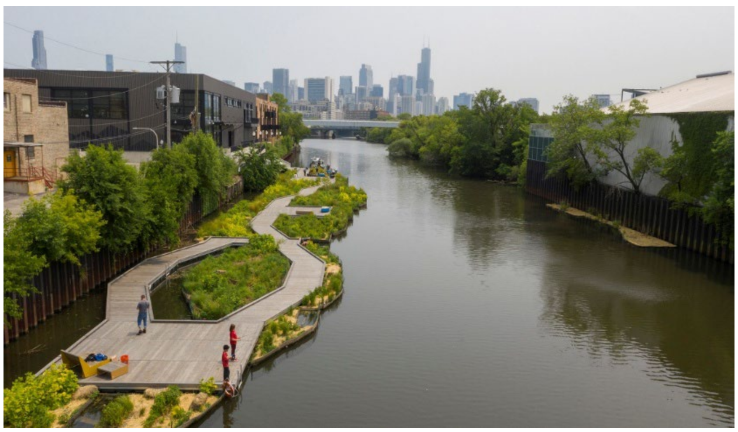


Figure 5.2

The Wild Mile Floating Gardens

Note. Source: American Society of Landscape Architects (ASLA) (2024).

The Wild Mile is a floating ecological corridor installed along the Chicago River. It integrates floating wetland module structures and a public walkway that transforms an urban waterway into a public amenity. The system and gathering space were developed under collaboration between non-profits, designers, and ecologists, who utilize planted modular floating systems to support habitat creation, improve water quality, and increase public interaction with the river (Urban Rivers, 2023).

Although it was not explicitly designed to be a debris intercepting system, The Wild Mile demonstrates the capabilities of modular wetland systems in achieving ecological, aesthetic, and design goals. Moreover, expanding on these modular capabilities and structural geometry can be applied to address the interaction of floating debris and monitoring for this project. The spatial configuration and public interface of the Wild Mile are presented in Figure 5.2, highlighting the integration of ecological systems with public access.

5.1.3 The Wharf Floating Wetlands

A series of floating wetlands at the Wharf in Washington, D.C. represents a hybrid approach to shoreline restoration. The wetlands are located at a highly programmed and active urban waterfront where their visibility actively plays a role in river stewardship. Developed using modular planted systems, these wetlands are designed to improve nearshore habitat, enhance water quality, and soften the hardened edges along the channel. These installations are maintained through partnerships between developers, local agencies, and environmental organizations, emphasizing a managed ecological approach within a highly urban context (DOEE, n.d.).

The floating wetlands at the Wharf are not primarily designed to intercept floating debris or trash. However, they do interact with floating litter and organic matter by slowing surface flows and trapping smaller debris within the island root systems. Similar to the Wild Mile in Chicago, the wetlands primarily serve as a public-facing system with their performance being measured by vegetation, maintenance, and habitat use. The wetlands demonstrate how isolated systems can be integrated into highly visible waterfronts where ongoing stewardship and maintenance can be promoted to support their aesthetic and ecological function. Existing floating wetland installation at the Wharf are shown in Figure 5.3, demonstration how modular systems function within an urban waterfront context.

Figure 5.3

The Wharf Floating Wetlands

Note. Source: Lightman, A. (2017), via East of the River DC News.

5.2 Hydrodynamics

Based on approximate daily, monthly, and annual flow patterns, nearshore areas at the project site present low velocities. While velocities increase toward the center of the river. The project site will not extend to those widths and therefore the design primarily considers tidal movement within these slower zones and the interaction of floating and subsurface debris within these zones. Both configuration and geometry must consider these patterns to avoid obstructing or restricting existing flow patterns to ensure adequate flushing. Additionally, because the river experiences tidal reversals twice a day with two high and two low tides, the design considers adaptability to both direction and water level. This relationship between depth, velocity, and shoreline proximity is illustrated in Figure 5.4, showing how flow conditions vary across the river section.

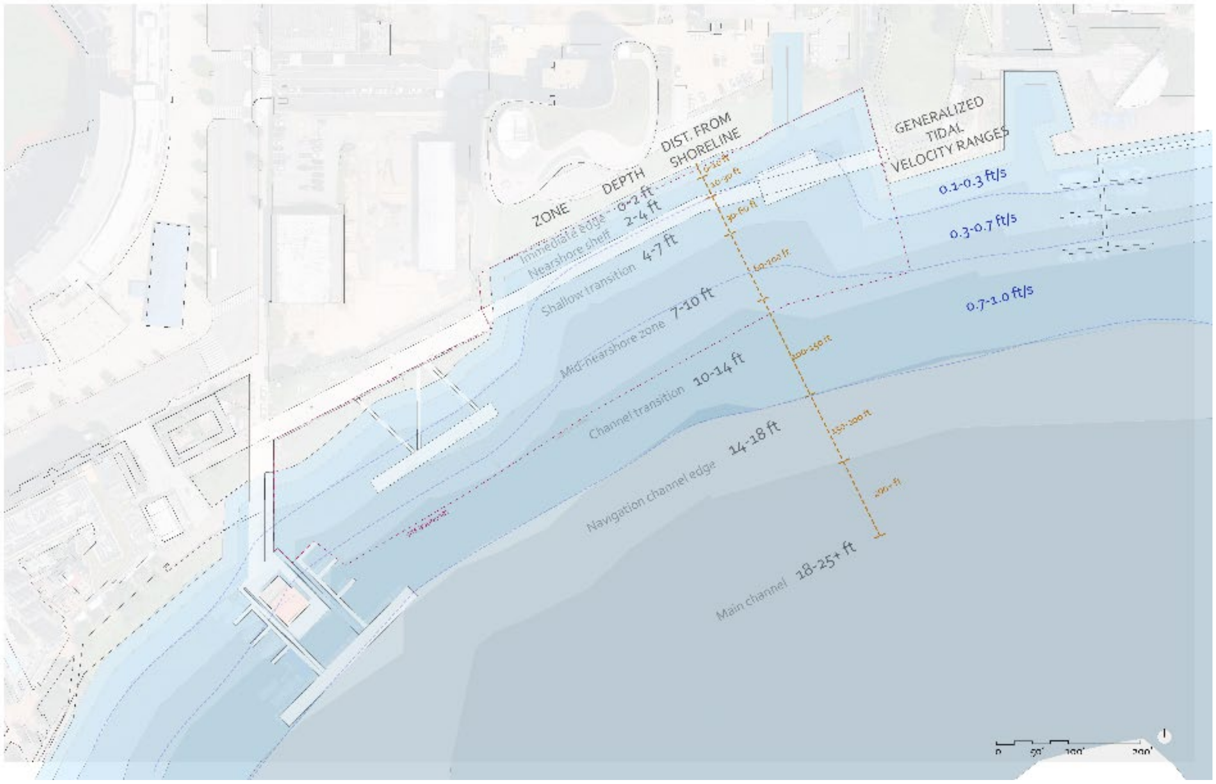


Figure 5.4

Depth, Distance, and Velocity Gradient from the Shoreline at the Project Site

Note. Map by author (2026).

In parallel, elements must be well-adapted to anticipated changing water levels associated with projected sea level rise and the location of existing MS4 locations. While MS4 locations fall outside the project boundary, existing upstream outlets should be considered as additional sources of discharge. The design must respond by not obstructing any existing outlets. Additionally, environmental concerns, such as sea level rise pose a significant threat for the longevity and function for any proposed in-water element. While existing edge conditions are elevated and armored suggesting greater resilience to elevated water levels, in-water features must be accommodated for increased water levels and dynamic storm flushes. As a result, elements must be able to withstand both vertical and horizontal change and be flexible to not create any additional wakes, blockages, or navigational hazards.

5.3 Nutrients and Debris Capture

Documented water quality reports and monitoring station data present persistent levels of legacy and ongoing chemical pollutants, excessive amounts of observed and collected litter, poor species diversity, and insufficient beneficial nutrients associated with biological processes. From these deficiencies, nitrogen and phosphorus are identified because they are the primary drivers of eutrophication, directly affecting algal blooms, dissolved oxygen depletion, and are closely tied to urban stormwater and wastewater systems. These nutrients relate to a need for a multifaceted design approach to adequately promote both local and watershed-scale impacts.

These existing limitations pose opportunities to promote native vegetation and enhanced areas of water quality treatment. The high persistence of visible debris poses both opportunities and constraints. Observed existing boom structures are effective in their orientation and effectively capture floating debris transporting downstream. The relocation of any existing boom or the proposal of any additional or altered boom collection methods may pose unanticipated risks toward collection efficiency and may also potentially inadvertently alter river flow dynamics. The design should consider these factors to ensure continuous capture of both floating litter and woody debris while maintaining accessibility for existing maintenance operations.

5.4 Debris Typologies and Sorting Strategy

Site inventory and field observations indicate that debris arriving at the project site varies in size, type, and buoyancy. From field observations, three debris typologies were identified: large woody debris, medium woody debris, and floating plastics. Large woody debris, including logs and sizeable branches, is often partially submerged and influenced by surface flow and subsurface drag, causing it to move more slowly and collect along broader convergence zones. Medium woody debris, including smaller branches, tend to remain closer to the surface but respond more to changes in current velocities and direction. Floating plastics and other lightweight trash are predominately surface-driven, experiencing rapid movement which causes them to be frequently redistributed during ebb and flood currents. These debris types and their transport behaviors are diagrammed in Figure 5.5, distinguishing between surface plastics and partially submerged woody material.

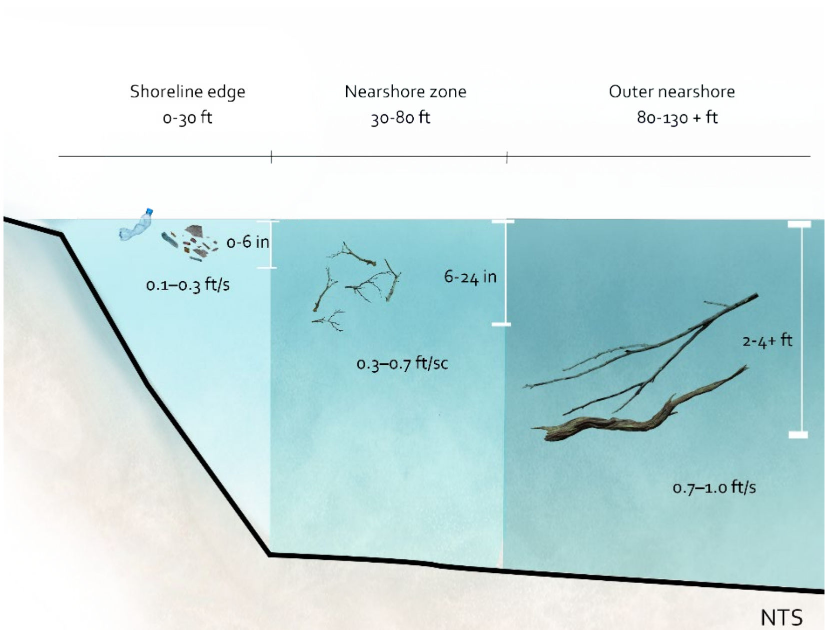


Figure 5.5

Debris Typology, Depth, and Transport Diagram

Note. Map by author (2026).

These conditions pose opportunities for selective debris assortment, but because of the mixture of debris typologies interacting with the site simultaneously, the project faces constraints in arrangement, materiality, and geometry to avoid restricting flow, impeding navigable waters, or posing risk to existing infrastructure elements.

5.5 Buffer Zones

Based on approximate navigable areas, water depths, and flow velocities established by the USACE, DOEE, and supplemental literature, various spatial constraints limit areas permitted to deploy in-water design elements. Limit of work boundaries must respond to existing parameters set around navigation zones, existing maintenance operations, and must minimize impact to existing infrastructure. These zones assist in defining the project's workable area but limit complete design capabilities within the project boundary. Working within these limitations, the design proposal responds by positioning in-water interventions that align with existing river processes and operational requirements.

Chapter 6: Design Proposal

6.1 Design Overview

The proposed design is as a publicly accessible landscape that highlights the natural river processes of debris management along a recreational along the Anacostia River. The design deploys a series of in-water debris guidance components, enhanced shoreline plantings, and extended recreational dock nodes to support ecological function, public engagement, and maintenance access. In-water components build upon existing boom infrastructure configurations and existing maintenance operations to effectively sort, collect, and display floating and partially submerged material away from the shoreline. This interception strategy streamlines maintenance tasks by effectively separating floating plastics litter and larger woody material, like logs and branches, in accessible concentrated areas for removal while making the process legible. The proposal operates within a researcher-defined Limit of Work informed by existing structural and navigation regulation buffers established by the DOEE, USACE, and other regulatory organizations and maintenance agencies.

6.2 Design Goals and Framework

Site-specific design goals draw from existing regional watershed goals established in the DOEE Anacostia Watershed Restoration Plan and the district-scale objectives outlines in the Anacostia Watershed Society's Anacostia River Renewed (2024-2025) initiative. These efforts emphasize nutrient reduction, habitat restoration, litter reduction, recreational usage, and long-term visions for improving visual and chemical conditions of the Anacostia River. While these frameworks operate at the watershed and policy scale, this project translates their objectives into specific design strategies, prioritizing low-impact, adaptable, and tidal-responsive elements that integrate with current conditions and maintenance operations.

6.2.1 Site-Specific Design Goals

1. Reduce floating litter and large woody debris from washing along the shoreline at Diamond Teague Park.
2. Maintain navigable paths that promote maintenance capabilities for inland and in-water servicing crews.
3. Promote in-water and shoreline habitats that support native fauna.
4. Promote stewardship through artful elements that educate and highlight the process of trash accumulation and river pollutants.

6.3 Limit of Work

The Limit of Work is 1.1 acres in size within the greater 5.4-acre site boundary. This workable area responds to existing buffer zones around infrastructure like piers, marinas, navigation, and marina access zones. Within these identified zones, any proposed elements, whether temporary or permanent, are subject for district review, approval, and permitting. In response, the limit of work boundary works within feasible areas outside these buffer constraints while supporting existing maintenance operations and debris collection infrastructure. Within the boundary, areas include the entire vegetated shoreline at Diamond Teague Park, a segment of the nearshore water between the shoreline and existing kayak launch dock, areas extending no more than 30 feet from the kayak dock, and upstream areas leading to the existing containment boom.

6.4 Interception Framework

Within the researcher-defined Limit of Work, a sorting strategy follows a coarse-to-fine framework where incoming downstream debris is diverted away from shoreline and hardened edge areas toward defined containment areas. This strategy responds to both floating plastic litter and larger woody debris that reduces its accumulation within nearshore areas and along the shoreline where removal and access become more difficult. The overall coarse-to-fine interception strategy is outlined in Figure 6.1, showing how debris is progressively sorted across the system.

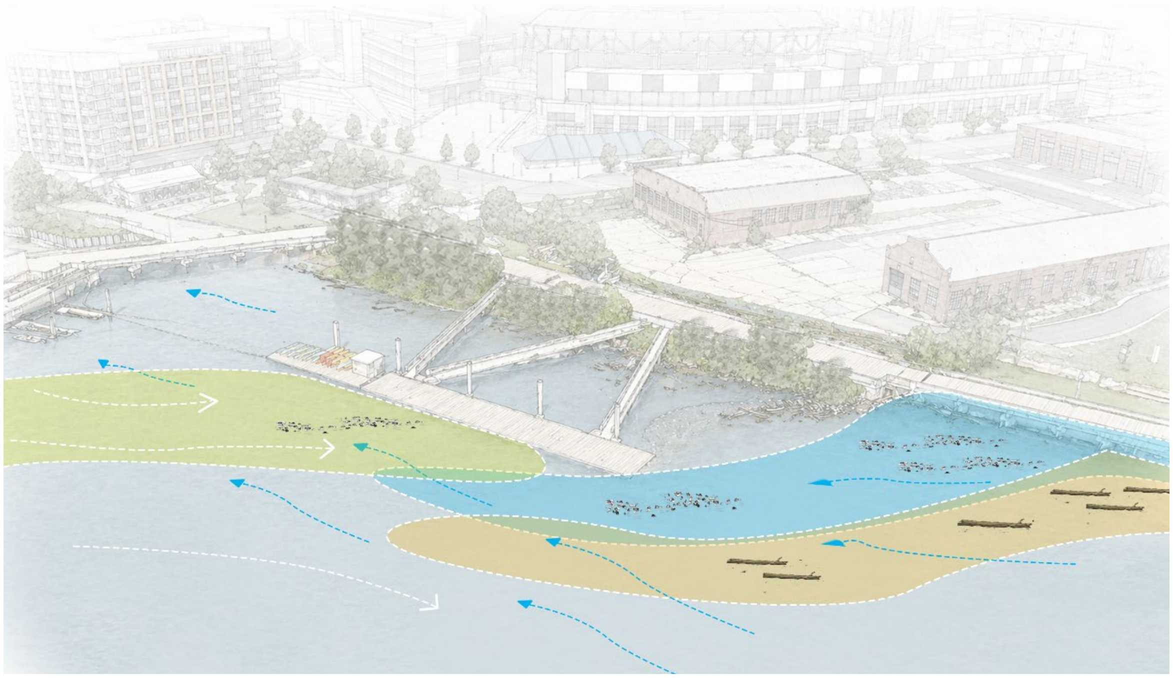


Figure 6.1

Coarse-to-Fine Debris Interception Zoning Diagram

Note. Rendering by author (2026).

6.5 Large Woody Debris Deflectors

The Large Woody Debris Deflectors are designed as the primary interception and redirection system for larger floating and partially submerged woody material moving downstream. Their design targets sizable branches and logs before they accumulate along shoreline edges. Positioned within nearshore zones and as the first point of contact for all debris types, these elements operate by passively guiding debris towards designated collection and sorting areas while maintaining existing hydrodynamic conditions. Rather than acting as rigid barriers, the deflectors are configured to redirect material through downstream angled alignment and controlled spacing, allowing water to pass through while selectively redirecting larger material.

These elements are constructed using a combination of natural and standard marine materials to support durability, low-impact, and adaptability to tidal dynamics and water elevation changes. The primary components include rot-resistant hardwood logs (approximately 12-18 inches in diameter) as the guiding element and are installed on the upstream edge of typical Biomatrix modular wetlands (7.5 ft x 3.5 ft). Attached to the underside of these logs are High-Density Polyethylene (HDPE) subsurface curtains extending approximately two to four feet below surface levels to intercept and redirect partially submerged materials. These components are constructed in approximately 10-foot and 20-foot segments. By constructing these elements as segments, as opposed to a continuous structure that acts as a harsh barrier, gaps between the segments allow water to continuously travel downstream, minimizing interference with existing bridge piers while providing adaptability to stronger currents in the event of a storm. As such, segments are spaced approximately 5 feet apart and staggered 15 feet downstream. Supplemental marine components, including galvanized or stainless-steel hardware, rub rails, and optional HDPE sleeves or collars, are integrated to reduce abrasion, extend material lifespan, and improve effective guidance of oncoming structural elements. Together, these elements are anchored to the riverbed using flexible mooring and helical anchor systems attached to the underside of the modular wetlands. This anchoring system supports existing and anticipated tidal fluctuations, permitting controlled lateral movement while adapting to vertical changes in water level. The configuration and material system of the deflectors are detailed in Figure 6.2, illustrating how angled elements redirect large debris without obstructing flow.

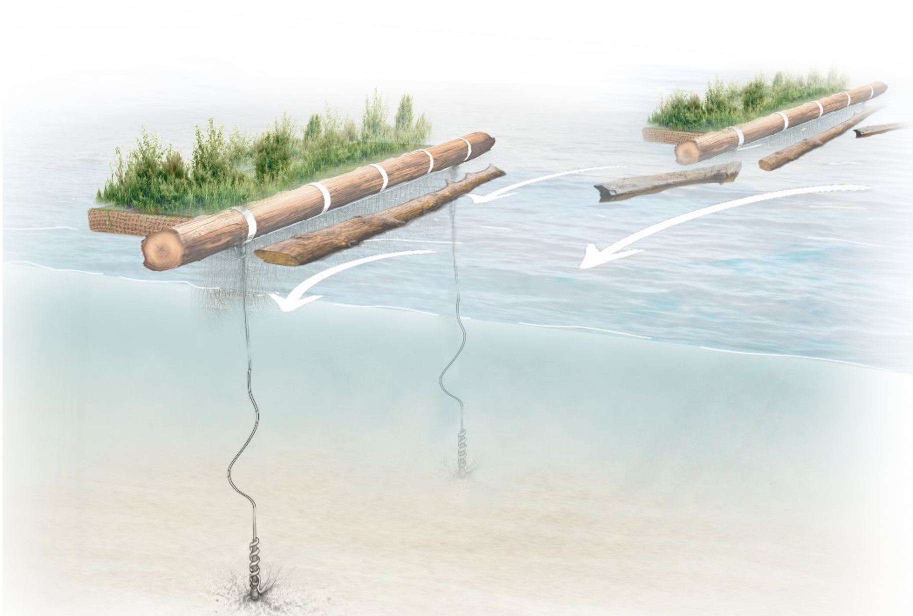


Figure 6.2

Large Debris Deflectors

Note. Rendering by author (2026).

6.6 Large Woody Debris Collection Crescent

The Large Woody Debris Collection Crescent is positioned downstream of the Large Debris Deflector segments and serves as the primary zone for retaining large woody debris and partially submerged material. The 55-foot mouth opening of the crescent collection area is oriented upstream to allow for debris to deflect off the guides, reorient, then concentrate within the pocket and away from the shoreline during typical downstream tidal conditions. The collection structure is composed of structured Biomatrix wetland modules and deploys the same HDPE subsurface curtain strategy, seaflex mooring, and helical anchoring system as the debris guides. Additionally, a HDPE rub rail is installed along the interior edge of the wetland modules for shock absorption while providing additional stability to retain larger woody material. The crescent shape optimizes a larger capture area for logs with the edge closest to the inner channel of the river being slightly shorter which serves as a relief gap for debris to escape if debris amounts exceed the retainable pocket area or flow exceeds typical downstream velocities. Nevertheless, removal of larger material is supported by a generous 80-foot approach channel for skimmer boat or adjacent in-water maintenance vessels. This log retention area is intended to retain logs with less frequent removal to support aquatic habitats and serve as a visual landscape element while minimizing downstream accumulation along shorelines. The spatial organization of the log retention system is shown in Figure 6.3, highlighting how debris is staged for periodic removal.

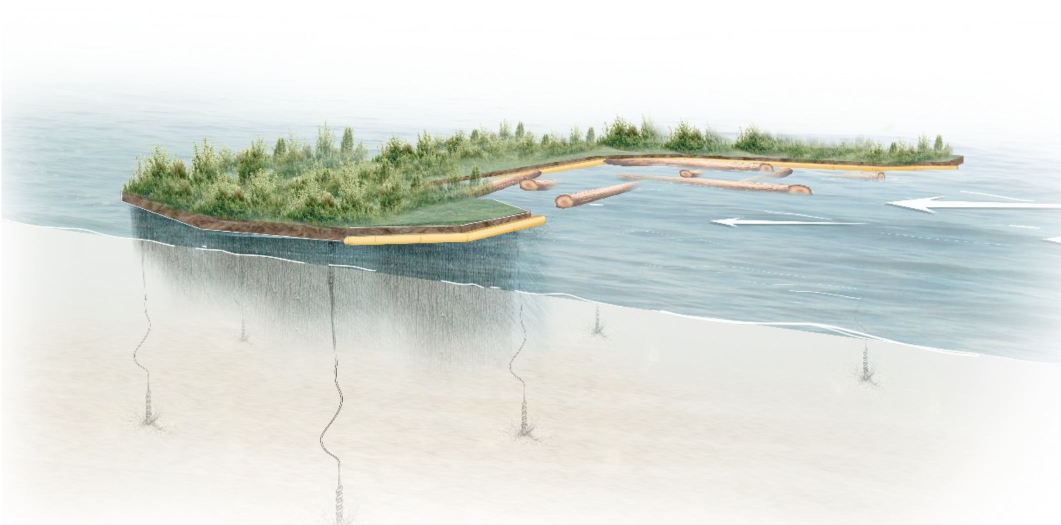


Figure 6.3

Log Retention Crescent

Note. Rendering by author (2026).

6.7 Fine Debris Deflection and Collection

Located approximately 45 feet downstream and parallel to the Large Debris Deflector Guides and Log Retention Crescent is the Fine-Debris Deflector. This porous wall intercepts and guides finer, smaller floating plastic litter and smaller woody material and is the second downstream element within the sorting system. This design components guides material towards the existing containment boom and redirects any material that may have bypassed the upstream guides away from the shoreline and toward and concentrated area for more frequent removal based on existing maintenance schedules conducted by the DOEE.

This debris guiding element is composed of vertically driven rot-resistant (6–10-inch diameter) logs with clear 12-to-24-inch spacing. The logs extend 6-12inches above the MLLW to account for changing water levels and are pile-driven into the riverbed to ensure stability and consistent guidance over time. Attached on the upstream face of the logs is a HDPE guidance tube and partially submerged highly porous (approximately 70-80%) HDPE curtain. The curtain is intentionally more porous than the upstream deflectors to allow for continued waterflow and tidal exchange within the nearshore zone and extends 1.5 to 3 feet below the water surface. This system does not employ any seaflex mooring or helical anchoring but attaches directly to the existing containment boom in which debris is deflected toward. The fine debris deflection system is illustrated in Figure 6.4, demonstrating how smaller materials are guided toward collection zones.

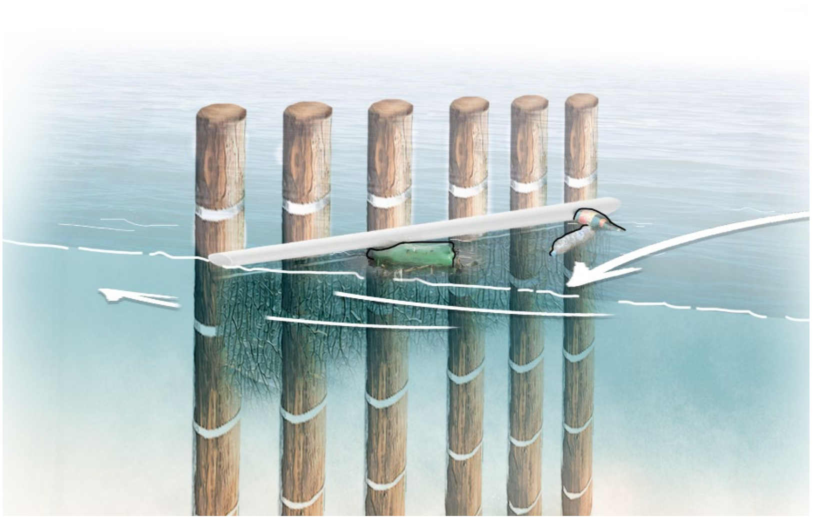


Figure 6.4

Fine Debris Deflector

Note. Rendering by author (2026).

6.8 Wetland Treatment System

The wetland treatment system its constructed within a 30-foot area around the outer edge of the existing 200 ft x 20 ft kayak launch dock and includes floating aluminum modular dock segments (AccuDock) and a custom configuration of Biomatrix floating wetlands modules. This 30-foot extension around the existing kayak launch dock maintains consistency with the scale and function of the existing dock as an accessory waterfront element, minimizing additional regulatory complexity while supporting continued public access and maintenance operations. This system serves as both public and ecologic infrastructure by extending access to the river and making river processes of debris capture visible while improving water quality.

This Wetland system deploys custom dock segment dimensions and includes three main accessible dock areas for servicing floating debris and viewing. These dock segments are divided into a service dock (6.5 ft x 10 ft), a central circulation node (26 ft x 15 ft), and two overlook nodes (11 ftx 10 ft and 10 ft x 10 ft) with connectors. Surrounding these proposed docks and the kayak launch dock are a total of 78 floating wetland modules. These wetland modules attach at the corners to one another and are installed in segments which attach and detach directly to the proposed and existing dock using flexible connector brackets and tether lines. Within this configuration, an additional small debris capture pocket is configured to capture floating debris that floats back upstream when tides reverse. This small collection area is positioned to support collection from the service dock with additional water access for kayak removal that supports existing river cleanup programs. This collection pocket is designed as part of the custom proposed wetland modular configuration, but all modular segments can be detached or reconfigured based on seasonal needs or aesthetics. This custom configuration and attachment strategy allows proposed floating dock modules and wetland modules to move with water levels while remaining secured to the kayak dock edge but also adaptable based on seasonal needs or maintenance requirements. The modular wetland and dock connection system is shown in Figure 6.5, emphasizing flexibility, habitat creation, and integration with public access.

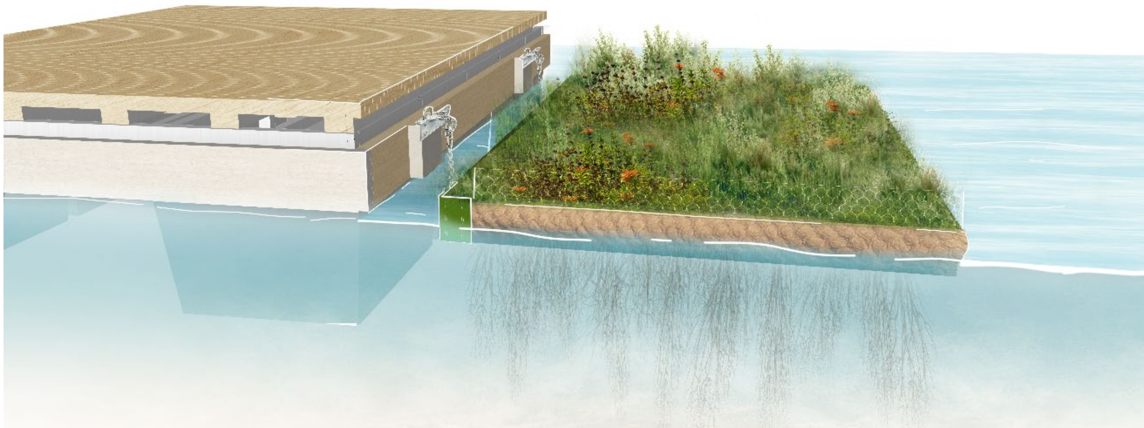


Figure 6.5

Floating Modular Wetland (Biomatrix) and Modular Dock Connection (Accudock)

Note. Rendering by author (2026).

6.9 Shoreline Enhancement

The proposed shoreline complements the in-water wetland system and existing inland boardwalks at Diamond Teague Park by reinforcing the river's edge as an ecological and visual transition between land and water. The proposed intervention plan includes enhancing the emergent fringe zone located between the existing shoreline and the shallow bench. The existing vegetation along the shoreline is not replaced but selectively reinforced through increased plant density and species to improve shoreline stability, habitat diversity, and nutrient uptake.

The proposed shoreline planting includes a mixture of emergent native sedges, submerged aquatic vegetation, shrubs. Along steeper eroded edges of the shoreline, proposed coir rolls stabilize the bank and reinforce the shoreline shelf and plantings. Additionally, powder-coated marine-grade aluminum or stainless-steel ring sculptures and a linear LED strip lighting are integrated along the shoreline to enhance the aesthetic textural plant character of the shoreline while improving nighttime visibility and safety. The overall site plan and shoreline interventions are presented in Figure 6.6, illustrating the integration of ecological, infrastructural, and public elements.

Figure 6.6

Proposed Site Plan Enlargement

Note. Rendering by author (2026).

Chapter 7: Discussion

7.1 Site Location and Scope

Defining the site boundary, limit of work, and broader waterfront context within Washington, D.C. was a critical step in the design process. Informed by observed visual debris accumulation patterns, DOEE mapping of PCBs and trash hotspots, the selected site falls within a priority area well-suited for a targeted design intervention.

Given the scale and complexity of watershed processes, it is not feasible for a single site-based intervention to fully treat all inputs or water quality impairments entering the project site. Instead, the project operates within a defined nearshore zone, focusing on areas of highest accumulation and visibility within an existing active waterfront where targeted interventions can have the greatest visual and experiential impact. This approach allows the design to function as a localized and site-specific system within a broader upstream and regional management effort.

7.2 Design Components

Based on existing regulatory constraints around permitting, navigation, and limitations for in-water elements, the design proposes modular elements and low-impact anchoring methods. These strategies reduce riverbed impact and minimize alterations to existing navigation, access, and maintenance operations. The proposal utilizes existing, customizable, and field-tested products for wetland modules and dock systems, supporting constructability, feasibility, and long-term performance. In alignment with existing regional and district scale goals, design components support watershed-scale goals by directly addressing litter and debris accumulation persistent in the Anacostia while using common low-impact materials.

7.3 Public Access and Programming

Proposed dock extensions and overlook nodes enhance the waterfront experience by supporting circulation and increased dwell times. By expanding accessible areas and preserving the function of the existing kayak launch dock, the proposed configuration supports ongoing deployment, storage, and maintenance to the kayak the dock and its nearshore areas. Additionally, the proposed docks enhance public interaction with the river providing spaces for learning and engagement with river cleanup activities that support existing volunteer programs and initiatives. These activities, supported through docks and modular wetlands, are supplemented with educational signage and interactive elements that highlight water quality conditions and the Anacostia River's ecosystem. Collectively, through modular wetlands and docks, serviceable areas, and additional spaces that support existing volunteer programs, the system supports existing regional and district goals of river stewardship and recreational usage.

7.4 Operations and Maintenance

Prior removal of both floating plastic litter and larger woody material was observed to be absent along the shoreline at Diamond Teague Park. As a result, observed shoreline tactics were deployed (shoreline fence posts) to minimize its accumulation. The large Debris Collection Crescent, in conjunction with debris guiding elements, responds to this existing limitation by creating areas that allow material to passively accumulate. Retaining this material in offshore locations is designed to follow existing maintenance operations, schedules, and capabilities. Larger woody debris allowing for less frequent, yet vessel-accessible, removal, while fine floating plastics are retained in the existing location with maintained skimmer boat access. Additionally, within the Wetland Treatment System, docks and attached wetland modules consider seasonal maintenance tasks. Both floating systems are configured to support manual maintenance and removal by docks or by vessel, utilizing standard marine-grade connections that enable efficient detachment when necessary.

Maintenance of wetland modules, docks and debris removal from designated collection areas are designed to support existing maintenance operations and capabilities carried out by the DOEE, BID, and other contracted parties. Removal of debris from the Large Debris Crescent is to be less frequent and dependent on accumulation amounts, whereas fine debris collection from the existing containment boom is follow the existing removal schedule (approximately on a weekly basis). The additional return pocket, formed by the wetland modules and attached to the

Wetland Treatment System, is designed as a secondary passive collection area to capture floating debris floating back upstream. This area supports accessible maintenance from the proposed service dock and small kayak access to be maintained on a seasonal basis or dependent on wetland module configuration.

7.5 Conceptual cost estimate

At the conceptual design stage, a cost estimate presents values intended to establish feasibility and relative investment across project components rather than precise construction budgets. Unit costs are derived from typical ranges for urban waterfront and ecological infrastructure projects and are applies consistently across systems to allow for comparison. All major elements, such as shoreline plantings, floating wetland modules and plantings, coir logs, and dock infrastructure are priced and account for installation. These estimates exclude permitting, contractor overhead, contingency, and specialized hardware, and should be understood as a planning-level calculation subject to refinement.

Each system is priced using unit rates that align with its material and construction complexity. Shoreline planting is calculated per square foot, reflecting plant material, labor, and additional moderate site preparation typical of shoreline enhancement projects. Floating wetland module costs are derived from per square foot rates that include its construction, planting, and anchoring/connection brackets scaled across the total system area. AccuDock systems are priced per square foot and account for fabrication, delivery, and installation. Coir logs are estimated using per-unit costs and adjusted to include installation labor.

Chapter 8: Evaluation

The design frames debris management as an ecological and civic opportunity rather than solely a maintenance challenge. By integrating floating wetlands and shoreline enhancements with existing debris sorting infrastructure, the project promotes environmental function with public visibility that reinforces the river as both a living system and a shared urban resource.

Ecologically, the wetlands are intended to enhance habitat complexity within the river while supporting pollutant treatment with vegetated aquatic systems. Floating wetland modules increase surface roughness and assist in water quality improvement. Along the shoreline, restoration plantings reinforce the river edge as a transitional habitat zone, buffering wave interaction and reducing direct debris accumulation along the shore while strengthening ecological connectivity.

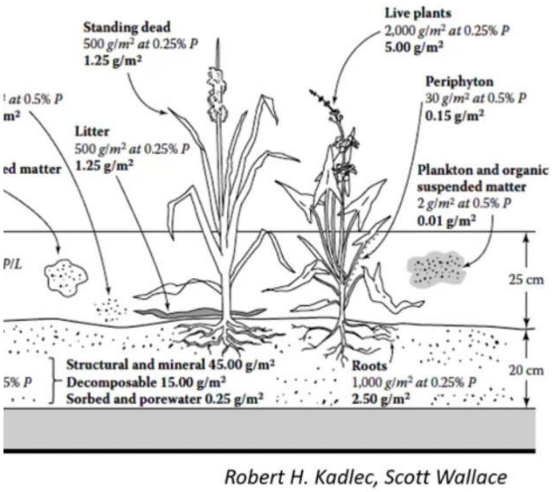
This design includes opportunities for shared stewardship through education, interactive elements, and coordination with existing volunteer cleanup programs. Public dock nodes, circulation routes, and collection pockets, support visitors to observe debris movement, sorting, and the collection process supporting both regional, district, and site-specific design goals of river stewardship and recreation. Evaluating the success of designed elements and programming is discussed in the following section.

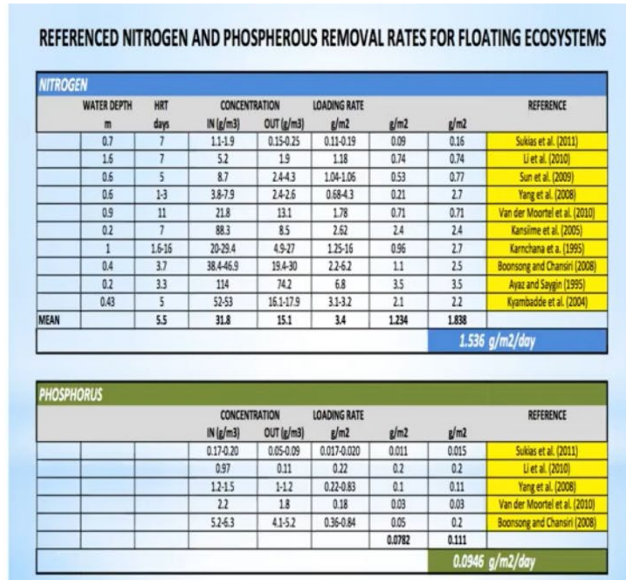
8.1 Maintenance and Operational Efficiency

Design success can be evaluated by assessing future efficiency and predictability of maintenance activities relative to existing conditions. Indicators may first include the visible reduction and consolidation of debris away from shoreline. Secondly, operational efficiency can be measured against operational compatibility with existing skimmer boat operations and whether proposed orientation and retainment of debris collection and guiding elements support vessel access, navigation, and removal. In parallel, proposed elements support existing manual upland maintenance tasks and capabilities carried out by maintenance teams from BID and volunteer groups that maintain shoreline and upland areas. Seasonal performance, particularly during winter months, provides an additional measure of structural performance and debris removal efficiency. During winter months, seasonal kayak debris removal programs and activities may be reduced coinciding with vegetative dormancy. Measuring both the structural performance through varied seasons and ongoing debris removal should also be considered as a measure of effective maintenance and operational efficiency.

8.2 Wetland Treatment

The proposed system is supports existing maintenance tasks while also offering additional volunteers programs and initiatives. In addition to these anticipated services, the wetland modules themselves can be evaluated for water quality treatment, not just social value, and debris collection. Biomatrix suggests that floating wetlands have the capacity of processing nitrogen at 1.536 g/ m^2/ day and phosphorus treatment of 0.0946 g/ m^2/ day (Biomatrix Water Solutions, n.d.). While these values vary depending on site conditions, they provide a general range of expected treatment performance and support the use of floating wetlands as a viable water quality intervention. Reported nutrient removal rates for modular wetland systems are summarized in Figure 8.1, providing a basis for estimating system performance.





REFERENCED NITROGEN AND PHOSPHEROUS REMOVAL RATES FOR FLOATING ECOSYSTEMS

NITROGEN

	WATER DEPTH	HRT	CONCENTRATION		LOADING RATE			REFERENCE
	m	days	IN (g/m3)	OUT (g/m3)	g/m2	g/m2	g/m2	
	0.7	7	1.1-1.9	0.15-0.25	0.11-0.19	0.09	0.16	Sukias et al. (2011)
	1.6	7	5.2	1.9	1.18	0.74	0.74	Li et al. (2010)
	0.6	5	8.7	2.4-4.3	1.04-1.06	0.53	0.77	Sun et al. (2009)
	0.6	1-3	3.8-7.9	2.4-2.6	0.68-4.3	0.21	2.7	Yang et al. (2008)
	0.9	11	21.8	13.1	1.78	0.71	0.71	Van der Moortel et al. (2010)
	0.2	7	88.3	8.5	2.62	2.4	2.4	Kansiime et al. (2005)
	1	1.6-16	20-29.4	4.9-27	1.25-16	0.96	2.7	Karnchana et a. (1995)
	0.4	3.7	38.4-46.9	19.4-30	2.2-6.2	1.1	2.5	Boonsong and Chansiri (2008)
	0.2	3.3	114	74.2	6.8	3.5	3.5	Ayaz and Saygin (1995)
	0.43	5	52-53	16.1-17.9	3.1-3.2	2.1	2.2	Kyambadde et al. (2004)
MEAN		**5.5**	**31.8**	**15.1**	**3.4**	**1.234**	**1.838**	
							1.536 g/m2/day	

PHOSPHORUS

			CONCENTRATION		LOADING RATE			REFERENCE
			IN (g/m3)	OUT (g/m3)	g/m2	g/m2	g/m2	
			0.17-0.20	0.05-0.09	0.017-0.020	0.011	0.015	Sukias et al. (2011)
			0.97	0.11	0.22	0.2	0.2	Li et al. (2010)
			1.2-1.5	1-1.2	0.22-0.83	0.1	0.11	Yang et al. (2008)
			2.2	1.8	0.18	0.03	0.03	Van der Moortel et al. (2010)
			5.2-6.3	4.1-5.2	0.36-0.84	0.05	0.2	Boonsong and Chansiri (2008)
						0.0782	**0.111**	
							0.0946 g/m2/day	

Figure 8.1

Biomatrix Referenced Nitrogen and Phosphorus Removal Rates

Note. Source: Biomatrix (2026).

At the system scale, the proposed design includes 122 total wetland modules with the typical dimension being approximately 7.5 ft x 3.75 ft and a grand total area of 3,337 square feet (310 m²/) of modular wetland area. From the supporting literature from Biomatrix, the proposed system supports nutrient removal of about 0.48 kg/day/ of nitrogen and 0.03 kg/day of phosphorus equating to approximately 174 kg/year and 10.6 kg/year, respectively. These values represent generalized estimates and may vary based on site conditions.

8.3 Social and Educational Engagement

Social performance can be evaluated through the site's ability to support visible stewardship activities and public interaction. Inventory findings identified the site as a high pedestrian throughput, transitional public space with limited dwelling time. The design responds by introducing opportunities for observation, interpretation, and participation. Success in this dimension is measured not by attendance alone, but by the frequency and diversity of stewardship activities supported over time, including volunteer cleanups, educational programming, and informal public engagement with river processes.

8.4 Site Integration and Land Use Effectiveness

The effectiveness of the design as a use of space can be evaluated by how well it integrates with existing site features documented in the inventory, including the Anacostia Riverwalk Trail Bridge, kayak launch, marina, and adjacent parks. Multifunctional elements that support debris interception, habitat creation, and public access indicate efficient land use. Equally important is the project's ability to enhance the broader riverfront system without obstructing circulation, viewsheds, or navigation, ensuring that the intervention functions as an extension of the existing landscape rather than an isolated installation.

Chapter 9: Gaps and Limitations

9.1 Monitoring Gaps and the Role of Public Visibility

Site inventory revealed consistent gaps between upstream nutrient monitoring and downstream, river conditions. While tributary inputs are well-documented through station reports, in-channel nutrient concentrations within the lower Anacostia are largely interpreted with specific nutrient reports not being publicly accessible. This disconnect underscores the challenge of linking watershed-scale inputs to site-specific impacts.

While the proposed design addresses this gap by positioning ecological infrastructure within a highly visible and accessible reach of the river, additional nutrient specific monitoring is recommended to best assess project performance and water quality treatment within the project area and across broader watershed context.

9.2 Limitations

This thesis is a design-research investigation with the debris collection and guidance strategy designed at the conceptual scale. Therefore, this project is subject to several limitations related to data availability, methodological scope, and professional boundaries. Direct field sampling and laboratory analysis of nutrient concentrations was not conducted as part of this thesis project. Instead, nutrient dynamics were inferred from publicly available regulatory and monitoring datasets. Although this approach provides a credible baseline for understanding broader Anacostia River dynamics and chemical properties, it limits the ability to quantify site-specific nutrient conditions and potential treatment performance. Publicly reported and documented data on volume, type, and temporal variability of floating debris at the site are also limited. While broader watershed debris values are reported from a range of community scale and district scale programs, debris amounts for woody material and floating plastics are assumed based on field observations which were limited to time day field observations were conducted and time of year, thus restricting greater quantitative assessment of debris accumulation specific to the site.

Lastly, the project does not include detailed structural or hydraulic engineering analysis. Engineering feasibility, constructability, and regulatory compliance are addressed at a conceptual level and would require further evaluation by licensed professionals. Future evaluation of design performance and feasibility should consider greater site-specific data collection and analysis, with additional consideration to various environmental factors such as wind, sea level rise, wave movement from vessels, and debris transport following storm events. Despite these limitations, the study presents a robust design framework grounded in documented site conditions, scientific literature, and precedent research. The work is intended to inform future interdisciplinary collaboration, site-specific monitoring, and adaptive refinement rather than to serve as a predictive or performance-guaranteed model.

Chapter 10: Conclusion

The Anacostia River is a complex tidal river system that acts simultaneously as an ecological system, infrastructural corridor, and public landscape. However, legacy pollutants, visible forms of debris, and consistent poor ranking watershed water quality reports reinforce negative perceptions. This thesis argues that these stressors, particularly floating plastic litter, and woody material, should not be treated solely as maintenance failures, but rather as opportunities to design infrastructure that make natural river process legible, productive, and meaningful with hopes to promote river stewardship.

Through a synthesis of literature on debris monitoring, floating treatment wetlands, and hybrid infrastructure practices, this project demonstrates that debris interception can be reimagined as a multifunctional landscape. The design at Diamond Teague Park illustrates how ecological infrastructure can operate simultaneously with river process and existing district initiatives while remaining culturally relevant and engaging. At the river scale, debris deflectors organize and collect debris into predictable zones. At the site scale, floating wetlands, docks, and shoreline planting introduce habitat diversity and educational elements compatible with existing navigation, maintenance, and regulatory framework. This hybrid system reinforces stewardship through proximity, interpretation, and participation.

Importantly, the design does not propose a singular solution to the Anacostia's water quality challenges, nor does it aim to completely remove visible accumulation of debris associated with natural river processes. Instead, the project positions ecological infrastructure as a complimentary element with its values lying in its educational and site-scale landscape performance role. By aestheticizing debris capture rather than concealing it, this project challenges conventional distinctions of infrastructure, landscape, maintenance, and public space. It suggests that future urban waterfronts can move beyond purely restorative or recreational models and pivot toward hybrid systems that acknowledge environmental stress. In doing so, debris-responsive ecological infrastructure offers a framework for urban river resilience that is not only functional, but culturally legible and supportive of long-term resilience.

Appendices

Appendix A: Wetland Design Documentation

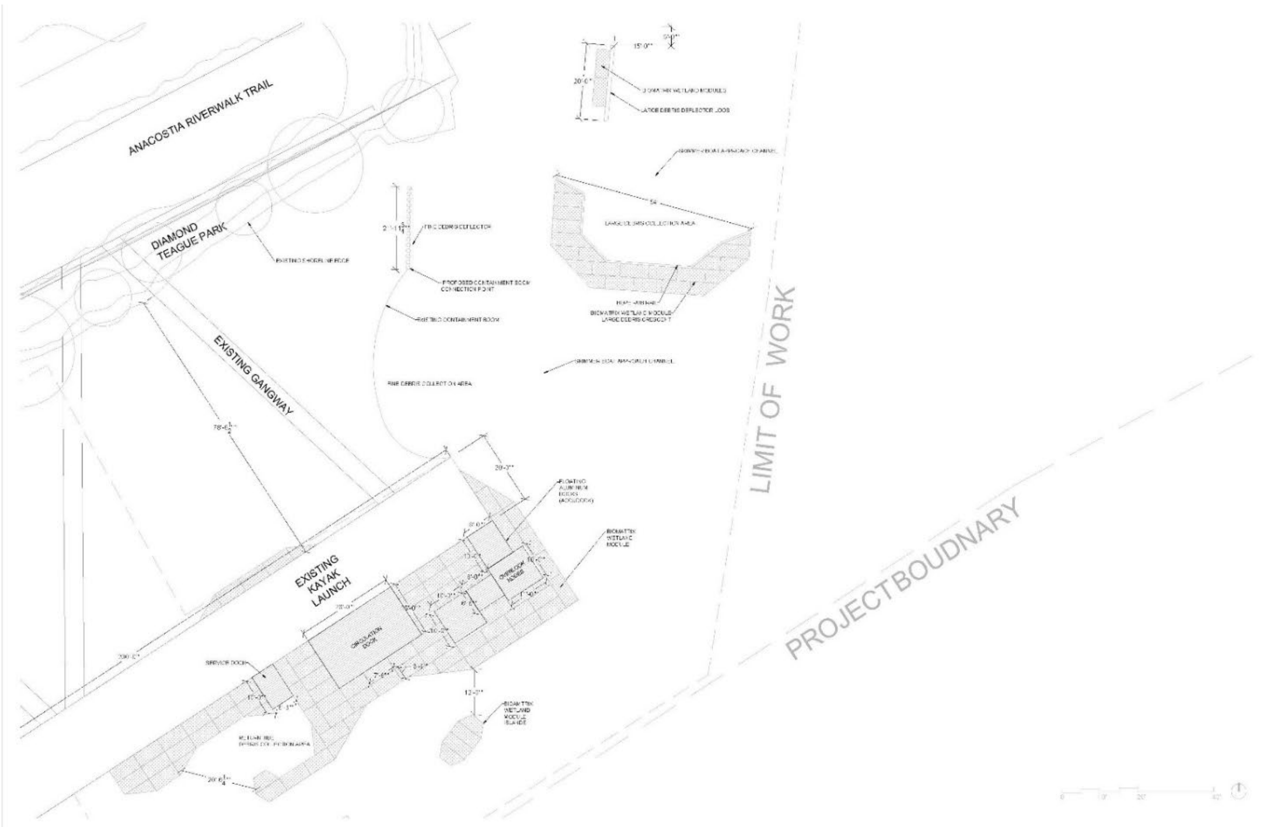


Figure A.1

Enlarged Site and Dimensioned Plan

Note. Image by author (2026)

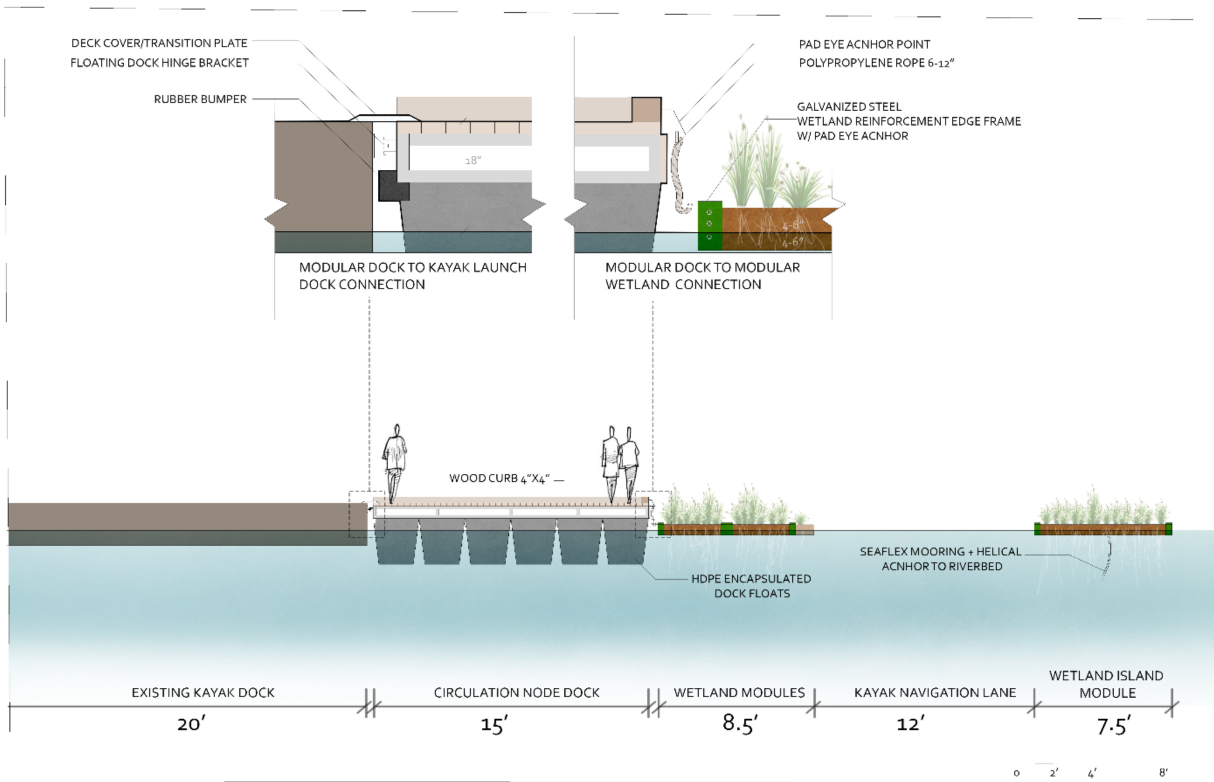


Figure A.2

Floating Wetland and Dock Connection Section

Note. Image by author (2026)

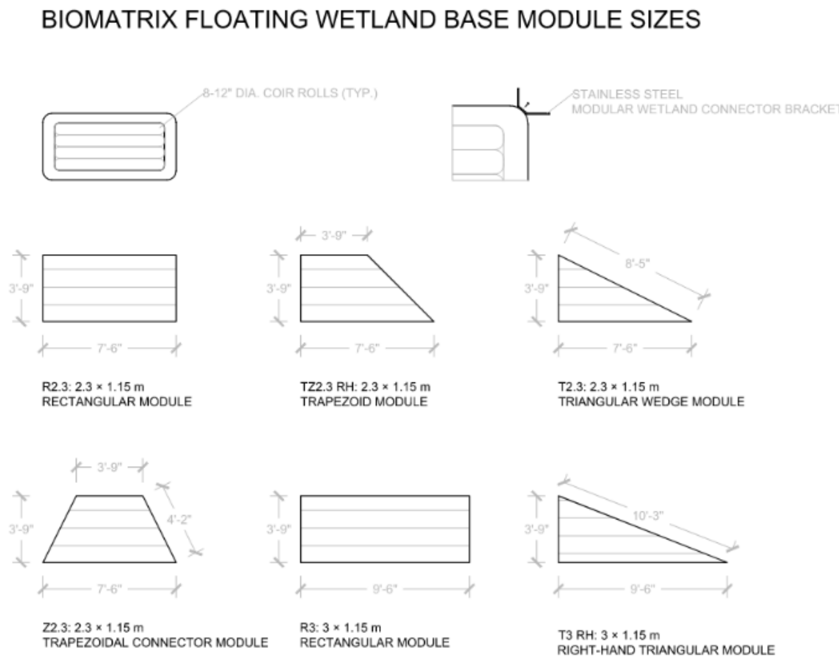


Figure A.3

Typical Module Dimensions Sheet of Biomatrix Wetlands

Note. Image by author (2026)

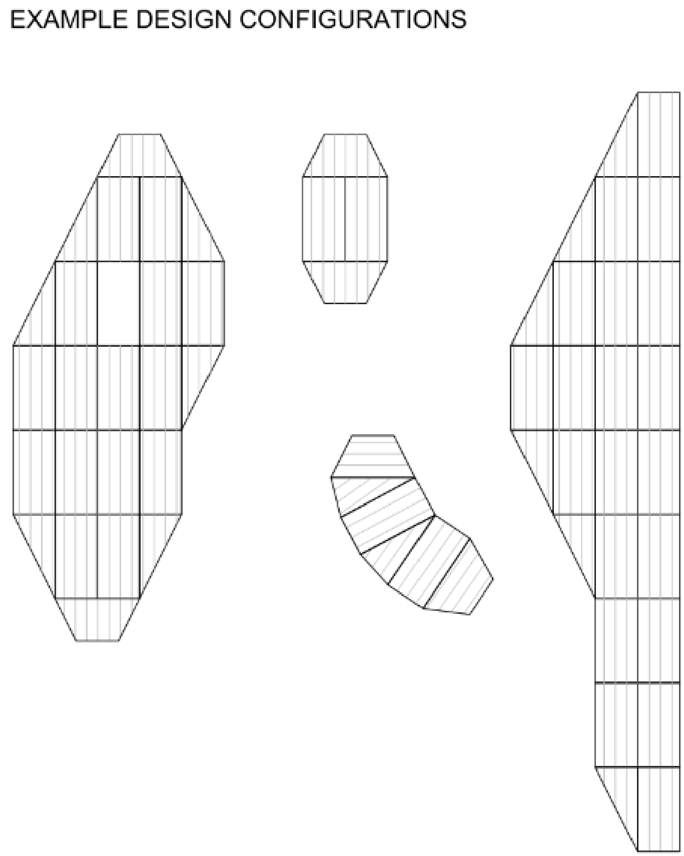


Figure A.4

Example Modular Configuration of Biomatrix Wetland Typical Modules

Note. Image by author (2026)

Appendix B: Additional Perspectives

Figure B.1

System Organization

Note. Render by author (2026)

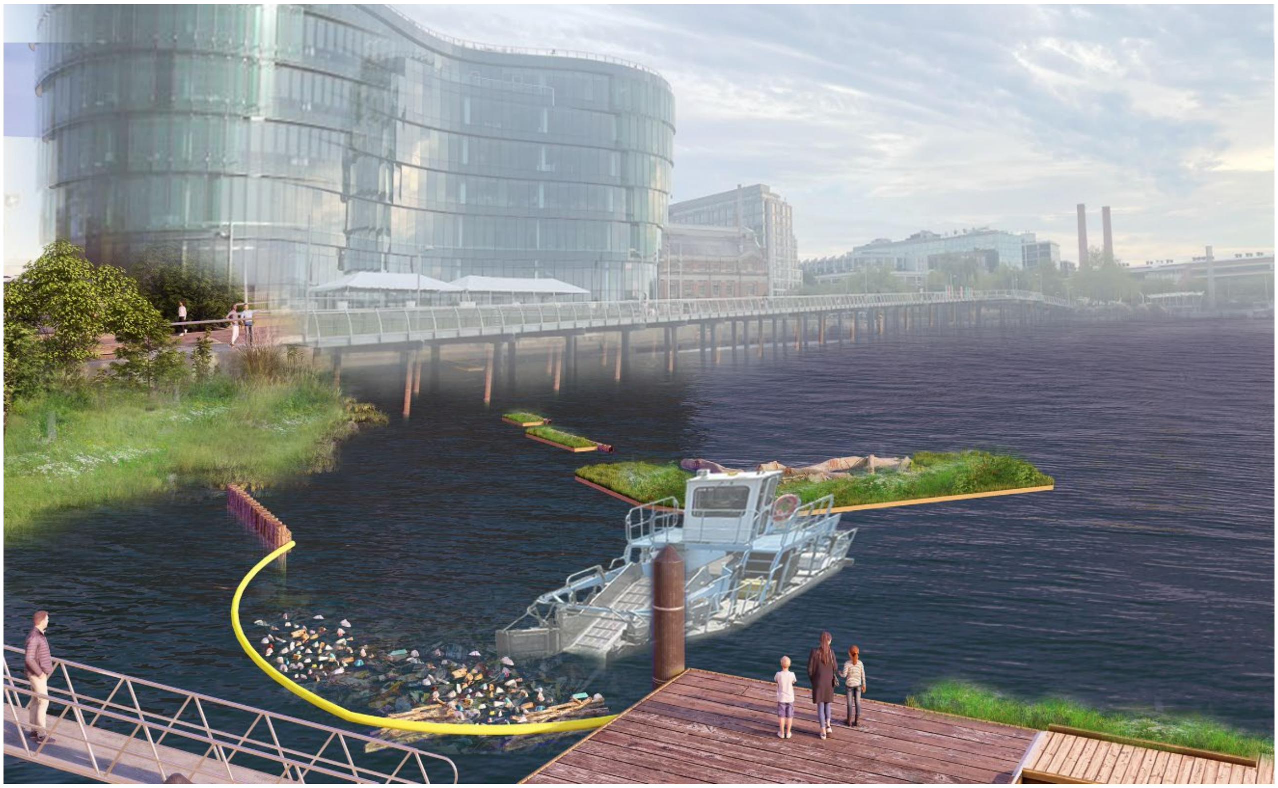


Figure B.2

Skimmer Boat Observation

Note. Render by author (2026)

Figure B.3

Return Tide Debris Collection Pocket

Note. Render by author (2026)

Figure B.4

Shoreline Night Sculptures

Note. Render by author (2026)

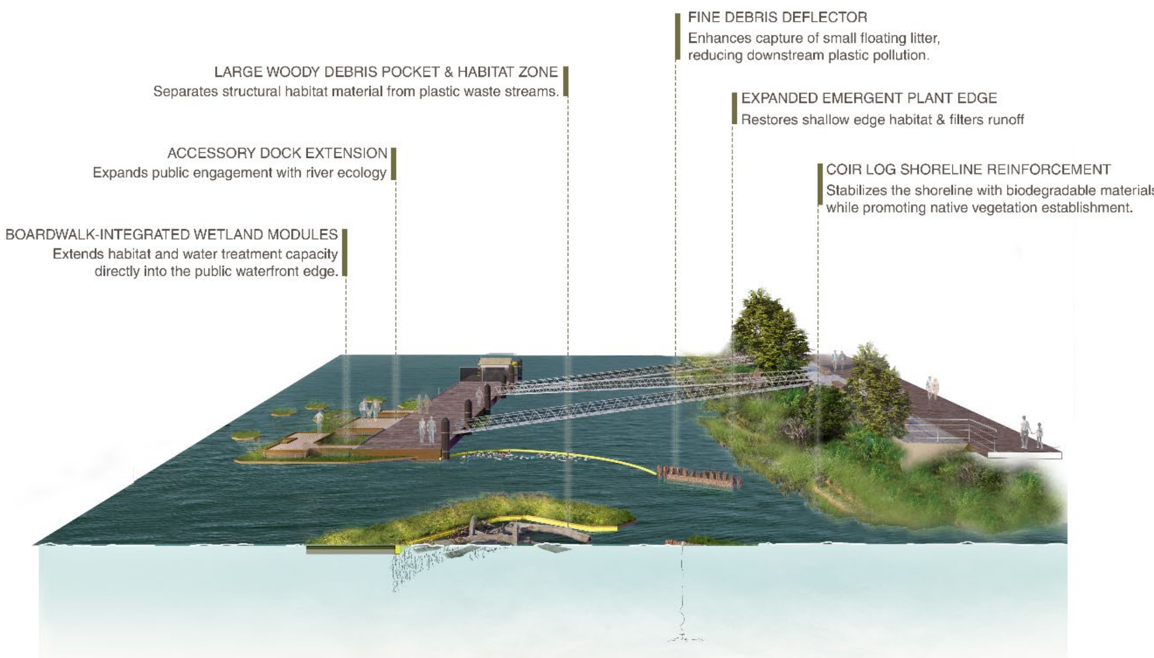


Figure B.5

Shoreline Section

Note. Render by author (2026)

Figure B.6

Shoreline Enhancement

Note. Render by author (2026)

PLANT SCHEDULE		
Shoreline		
Emergent Wetland Zone		
Latin	**Common**	
Carex vulpinoidea	Brown Fox Sedge	Grass
Leersia oryzoides	Rice Cutgrass	Grass
Sparganium americanum	Bur Reed	Grass
Asclepias incarnata	Swamp Milkweed	Perennial
Iris versicolor	Blue Flag Iris	Perennial
Sparganium americanum	American Bur Reed	Perennial
Wet Meadow Transition Zone		
Panicum virgatum	Switchgrass	Grass
Spartina pectinata	Prairie Cordgrass	Grass
Eupatorium perfoliatum	Boneset	Perennial
Hibiscus moscheutos	Swamp Rose Mallow	Perennial
Lobelia cardinalis	Cardinal Flower	Perennial
Verbena hastata	Blue Vervain	Perennial
Riparian Shrub Zone		
Elymus virginicus	Virginia Wild Rye	Grass
Cephalanthus occidentalis	Buttonbush	Shrub
Cornus amomum	Silky Dogwood	Shrub
Ilex verticillata	Winterberry	Shrub
Salix discolor	Pussy Willow	Shrub
Engineered Wetland Soil Mix	50-60% sand, 20-30% topsoil(loam), 10-20% compost	Coir Roll Backfill Soil
Wetland Modules		
Latin	**Common**	
Carex lurida	Lurid sedge	Grass
Carex stricta	Tussock sedge	Grass
Juncus effusus	Soft Rush	Grass
Schoenoplectus tabernaemontani	Softstem bulrush	Grass
Acorus americanus	Sweet Flag	Perennial
Helenium autumnale	Common sneezeweed	Perennial
Iris versicolor	Blue flag iris	Perennial
Lobelia cardinalis	Cardinal flower	Perennial
Mimulus ringens	Allegheny monkeyflower	Perennial
Pontederia cordata	Pickerelweed	Perennial
Sagittaria latifolia	Arrowhead	Perennial
Sagittaria latifolia	Broadleaf arrowhead	Perennial
Saururus cernuus	Lizard’s Tail	Perennial

Table A.1

Shoreline and Modular Wetland Planting Schedule

Note. Table by author (2026)

Mechanism	Function
Roots & Rhizomes	Absorb nitrogen and phosphorus from the water column, reducing excess nutrients
Dense Root Network	Slows water velocity and traps suspended sediment, improving clarity
Root-Associated Microbes	Break down pollutants and facilitate nutrient cycling
Root Zone Sediment	Captures sediment where metals and PCBs bind, reducing mobility
Vegetation Structure	Traps floating debris and microplastics within stems and root zones
Habitat Structure	Provides refuge and complexity for fish, invertebrates, and other species

Table A.2

Wetland Module Water Quality and Sediment Treatment

Note. Table by author (2026)

System	Dimensions / Qty	Unit Cost / Breakdown	Total Cost	Includes Installation?
Coir Logs	20 logs (12" x 10')	$165/log (bulk)	$5K–$8K	Yes
Shoreline Planting	~3,000–3,500 SF planted (5-gal shrubs + 1-gal perennials)	$12–15/SF	$42K–$52.5K	Yes
Wetland Modules	7.5' x 3.75' (~28 SF) 122 modules total	Unplanted: ~$40–55/SF Planted: ~$60–85/SF Per module: ~$1.7K–$2.4K	$200K–$285K (fully planted system)	Yes
AccuDock	~835 SF	$130–170/SF	$110K–$142K	Yes
GRAND TOTAL			**$357K – $487.5K (~$415K midpoint)**	**Installed conceptual cost**

Table A.3

Conceptual Cost Estimate

Note. Table by author (2026)

Zone Name	Typical Depth	Distance from Shoreline	Velocity (ft/s)	Typical Debris Typology	Movement Behavior
Edge / Shoreline Zone	0–3 ft shallow edge water	0–30 ft	0.1–0.3	Plastics, small litter, leaves, and small woody fragments	Low velocity conditions. Eddies form and debris frequently accumulates along banks and structures.
Nearshore Transition Zone	3–8 ft moderate depth	30–80 ft	0.3–0.7	Mixed plastics, floating litter, and small woody debris	Moderate flow. Debris is transported laterally along the river edge.
Outer / Channel Zone	8–15+ ft deeper channel	80–150 ft	0.7–1.0	Large woody debris, floating logs, and mobile plastics	Higher velocities transport debris downstream, especially during ebb tide.

Table A.4

Debris Transport Patterns Within Anacostia River Water Column

Note. Table by author (2026)

Dissolved Oxygen (mg/L)	Ecological Condition
> 5 mg/L	Healthy conditions for most aquatic life
3–5 mg/L	Stressful conditions for many fish and invertebrates
< 3 mg/L	Hypoxic conditions (low oxygen) where fish avoidance or mortality may occur

Table A.5

Hypoxia Thresholds Table

Note. Table by author (2026)

$$\text{Removal Rate (g/m}^2\text{/day)} = (C\_in - C\_out) \times Q / A$$
C_in = influent concentration (g/m^3)
C_out = effluent concentration (g/m^3)
Q = flow rate (m^3/day)
A = treatment area (m^2)
q = hydraulic loading rate (m/day)
$$\text{Annual Removal (kg/year)} = (\text{Removal Rate} \times \text{Area} \times 365) \div 1000$$

Equation A.1

Wetlands Removal Calculation

Note. Calculations by author based on standard mass balance and treatment wetland removal rate equations.

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