ABSTRACT

Title of Thesis: REVIVING CONNECTIONS: A PROPOSAL TO IMPROVE WATER QUALITY OF THE ANACOSTIA RIVER AND CONNECT THE CITY TO ITS RIVER THROUGH SUSTAINABLE URBANISM

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Master of Landscape Architecture, 2023

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A very significant element of the city of Washington D.C. are its rivers. These rivers have been supporting the civilization around them for years. The Anacostia river has been subject to industrialization for centuries and it has been exposed to pollution mainly due to urban waste and storm water runoff. This pollution not only affects the water quality of the river but also impacts the nearby population, aquatic life and other species in many harmful ways. It is essential that development should take place considering the needs of people as well as the environment. Here, application of various green infrastructure techniques plays an important role in creating a balance. This thesis is an effort towards improving the water quality of the Anacostia River, reconnecting the city to its river and ensuring a healthy environment for humans and other dependent species.

REVIVING CONNECTIONS: A PROPOSAL TO IMPROVE WATER QUALITY OF THE ANACOSTIA RIVER AND CONNECT THE CITY TO ITS RIVER THROUGH SUSTAINABLE URBANISM

by

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Thesis submitted to the Faculty of the Graduate School of the
University of Maryland, College Park, in partial fulfillment
of the requirements for the degree of
Master of Landscape Architecture
2023

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Acknowledgments

Throughout the development of this thesis, I have received great guidance and support from many individuals and I would like to express my sincere gratitude to them. Firstly, I would like to thank my thesis advisor Dr. Christopher Ellis for his constant support and guidance throughout research and writing of this thesis project. I would also like to extend my gratitude to my thesis committee members, Dr. Byoung - Suk Kweon and Dr. David Myers for their insightful feedback and guidance that has helped me in this process. I would like to thank my parents, Arti and Priyesh Shah for their unwavering support. Lastly, I am thankful to my friends and colleagues and professors for encouraging me throughout this academic journey.

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Chapter 1 Introduction

1.1 The Anacostia river

The Nation's capital, Washington D.C. is defined geographically by two important rivers, the Anacostia and the Potomac. These rivers are an integral part of the structure of the city and play a vital role in the life of the community. This study will draw from concepts such as Ecological Urbanism, Sustainable Urbanism and implementing Green Infrastructure techniques leading to growth that is sensitive to the environment and support higher quality of life. These waterways have had a reputation for being degraded with trash, toxic contaminants, human waste and increasing rates of polluted urban runoff. (Diemand, n.d.) The district has made continued efforts towards cleaning and restoring these waterways while also making them accessible. The Anacostia river is 8.5 miles long. It flows from the Maryland suburbs of Washington D.C. to the Potomac river near downtown Washington. Although the river is not very long, its watershed covers 176 square miles and contains 13 sub watersheds in southeast Washington, DC and Montgomery and Prince George's Counties in Maryland. (*The Anacostia River*, n.d.) The Anacostia Watershed is a part of the larger Chesapeake Bay Watershed. This watershed consists of three main drainage areas- the Northeast Branch, the Northwest Branch, and the tidal river. The Northeast and Northwest Branches converge in Bladensburg, MD and form the tidal Anacostia River. (*The Anacostia River*, n.d.) This river, that is the home to over 800,000 residents of Washington D.C and Maryland has been exposed to a great deal of pollution that has led to degradation of the water. Every year around 2.5 billion gallons of raw sewage mixed with stormwater is dumped into the District's waterways making it unfit not only for drinking but swimming and fishing as well. Along with environmental issues, the area around the Anacostia

also faces social and environmental justice issues. Environmental gentrification is one such critical issue. Urban growth and development along the river has drawn public attention to the Anacostia that has led to increased land values, thus initiating gentrification. (Avni & Fischler, 2020) This has ultimately caused a division. Development along the river must address the concerns of marginalized residents living in the area. This thesis will focus on understanding the major causes that have led to depletion of water quality overtime and suggest design interventions that not only help in restoring the river but also establish its connection with the district and its residents

1.2 Statement of problem

The Anacostia river has been supporting civilisation around it since the early 17th century, even before the arrival of the first European explorers. The river has been subject to industrialization for centuries. This rapid urbanization and development surrounding the river has resulted in excessive runoff that contains harmful contaminants, thus depleting health of the river. According to American Rivers the Anacostia River is polluted with a variety of substances from different sources. Storm runoff, agricultural runoff, combined sewer overflow (CSO), sediment, heavy metals and other toxics constantly inundate the river to create a level of pollution which has caused American Rivers to categorize the Anacostia River as one of the 10 most polluted rivers in the United States in 1994, 1995 and on their endangered rivers list in 2000. (American Rivers web site 2001) This degrading water quality of the river and rapidly changing urban fabric of the city has led to a loss of connection between the city and its river, transforming the river into an abandoned shoreline overtime.

1.3 Research question, Goals and Criteria

The research question for this study is –

How can an urban site be designed to support people and activities in the area such that it helps reduce degradation and improve water quality of the Anacostia river?

A set of Goals have been formulated for the study and each goal lists a set of criteria that are steps which would help achieve that specific goal.

Figure 1: Goals and criteria of the proposed thesis project

1.4 Assumptions

The purpose of this thesis is to explore how development in an urban environment can take place in a way that does not harm the environment. This thesis focuses improving water quality issue of the Anacostia River through the treatment of stormwater runoff. The thesis focuses on reviving connections with the river and creating a welcoming public space. To achieve these goals, some assumptions were made. One such assumption is that the three different owners of the proposed site would work together for the betterment of the community and environment.

1.5 Importance of the study

Rivers are a vital and vibrant ecosystem for many species around the world. The Anacostia watershed covers 176 square miles in Washington D.C. and Maryland. According to the Environmental Protection Agency, the Anacostia River watershed in D.C and Maryland is home to more than 800,000 people, 43 species of fish and around 200 species of birds. Overtime, rapid urbanization of the watershed has led to a loss of 6500 acres of wetlands and 70% of the forest cover. (US EPA, 2015) Impervious surfaces such as paved roads and parking lots now cover more than 25% of the watershed. It was around the early 19th century when the river began to suffer. As settlers began clearing the fields for agriculture, this led to heavy erosion and sedimentation. This alteration did not stop here, as Washington D.C grew, rapid development took over forests, wetlands, altered stream flows. (March 11 & Turrentine, n.d.)

Another crucial aspect that affects the water quality of the river is the ever increasing amounts of sewage that is fed into the river and the polluted runoff that goes into the river. The Anacostia's biggest threat is this stormwater runoff that is responsible for 75 – 90% of the river's pollution. (March 11 & Turrentine, n.d.) This runoff water brings with it sediments, pathogens,

toxins and trash that lead to pollution of the river and affect the aquatic life. The sewage overflow is a result of the district's combined sewage and flood control system. These sewer pipes collect both sewage and rainwater. In case of rain storm events, these pipes overflow into the nearest river or stream at 17 discharge points, this includes the Anacostia River, Potomac River and the Rock Creek. As per reports, around 2.5 billion gallons of raw sewage mixed with rainwater is fed into the river each year due to the overflow from the old sewer system. ("Washington's Big Dig Aims to Clean up 'Nation's River,'" 2011)

For small amounts of rainfall, the overflow from CSOs typically lasts less than 24 hours. However, with over an inch of rain, the effects of CSOs on water quality can persist up to three days.

Figure 2: Combined sewer area in D.C and a combined sewer overflow warning sign along the Potomac. (Source: D.C. Water)

These systems raise an important issue of concern since it leads to high bacteria level in the river and low dissolved oxygen levels which contributes to fish stress or fish kills and also affects all other aquatic plants and animals. This also creates various health hazards for the population around. The river and its parks have the potential to not only provide abundant

wildlife habitat and improve water quality, but also play a crucial role in community development and public health. (US EPA, 2015) Hence, it is important to understand these existing conditions and create awareness towards improving the water quality of the river in the years to come.

Chapter 2 Literature Review and Background

2.1 History of urban waterfronts

Water has played an important role in human life since the beginning of civilization. Throughout history, people have always lived and settled near water sources in order to sustain their life (Leakey & Lewin, 1979). For centuries, the banks of rivers have supported growth of various cities, these urban waterfronts are the core of many cities. Urban waterfronts began as commerce centers that depended on trade (Ryckbost, 2005). The main focus of the city was on transportation of goods via water. As the industrial revolution began, due to the requirement of reducing transportation costs, manufacturing setups started moving near the ports. It was during this period that shipping and manufacturing began to become powerful sectors in economic growth and waterfronts too moved forward. (Ryckbost, 2005) This period is considered as the period of maximum socioeconomic symbiosis between ports and their hosting cities (Norcliffe, et al. 1996). As a result, heavy machinery was used, massive industrial buildings and warehouses along the waterfront were being built. the scale of the ships themselves changed after the invention of the steam and the internal combustion engines, larger ships meant larger docks, quays and shipyards. Finally, the industrial revolution meant a complete domination of the waterfront by industrial and port activities (Marshall 2001b). This started to separate the waterfront from the city. The waterfronts lacked residential landuse. Some workers, and traders

may have lived near the waterfront, however the area was often dirty and smelly due to manufacturing and industrial uses at the waterfront.(Ryckbost, 2005) Hence, maximum population preferred to avoid these areas in order to live in more peaceful areas of the city. The post – industrial waterfronts had a different story. By the early and mid-20th century the role of these ports began diminishing and waterfronts began to change. With the use of rail and airline transportation, these waterfront properties became vacant were left for other uses or to a gradual decay. Baltimore, Maryland is one such example that faced a similar problem. After the boom in waterfront activity due to World War II, Baltimore's waterfront fell into decay. Large empty buildings dotted its inner harbor. A report in the 1960s indicated that, unless drastic measures were taken, the city would be in dire financial straits in ten years (Ryckbost, 2005). The city leaders then planned a massive redevelopment project that has been a success converting the decaying waterfront into a bustling center. Many cities have worked towards transforming their waterfronts into new destinations where residents reconnect with the waterfront. In addition, the need for these newly designed waterfronts is a result of lack of access to nature, need for improved water quality, economic growth and the growing awareness of green infrastructure developments.

2.2 Anacostia Waterfront Initiative

The district government, various non-profits and private organizations are coming together and have committed themselves to the effort of restoring the Anacostia River. One such project is the Anacostia Waterfront Initiative (AWI). The Initiative was led by the government and 19 federal as well as District agencies. This project focussed on reviving the Anacostia River, its waterfronts and adjoining communities and parks. This $10 billion, 30-year long

project covers the area that borders the Anacostia river, including wards 5,6,7 and 8. It stretches from the Tidal Basin to the districts northeast border with Maryland. (*About AWI*, n.d.)

Figure 3: Anacostia Waterfront Initiative map (Source: AWI website)

Initiated in 2000, AWI promises a clean river environment, new parks, and other recreational facilities, more job creating commercial centers, revitalized neighborhoods and multi – modal transportation options. (*About AWI*, n.d.) In 2003, AWI proposed the Anacostia Framework Plan. The key elements on this plan were –

1. **Transportation** – Re- creating the transportation infrastructure network to promote safe and efficient multi-modal travel throughout the Anacostia Waterfront area.
2. **Environment** – Restoring the river, reducing the developmental impact and improving the overall watershed. Also create awareness on environment education and sustainability.

3. **Economy** – Generate new opportunities with completion of various new projects along the waterfront.
4. **Community** – Revitalize and reconnect existing communities to the river in more sustainable ways.
5. **Recreation -** Through AWI, the District is creating a "RiverPark" system of interconnecting waterfront parks that will ultimately be linked by the Anacostia Riverwalk Trail. As of 2010, more than $100 million had been invested in the designing and constructing the RiverPark system. (*About AWI*, n.d.)

The initiative has achieved many milestones through the years, D.C. Water has reduced combined sewer overflow by 36% and the District has achieved an approximate 50% decrease in nitrogen and sulfur concentrations that lead to acidification of water bodies (Government of the District of Columbia, 2010). The AWI continues to propose and work on different projects in the area to accomplish the vision of revitalization on the Anacostia waterfront as a world class destination and the center on 21st century Washington, DC.

2.3 Ecological Urbanism

Ecological Urbanism is a term that was first coined in 1998. Ecological Urbanism draws from ecology to inspire an urbanism that is more socially inclusive and sensitive to the environment. ("Ecological Urbanism," 2022) The four main objectives of ecological urbanism are compactness, complexity, efficiency and stability. The focus of this model of urbanism is to address the current challenges of the growing urban environment by intertwining sustainability with the urban growth. Architect and planner Miguel Ruano defined ecological urbanism as "the development of multi-dimensional sustainable human communities within harmonious and

balanced environments." Sustainable urbanism has similar environmental goals buts it also focuses on quality of life of the residents.

2.4 Sustainable urbanism

Origin of the term sustainable urbanism dates back to 1990s. Sustainable urbanism focuses on the opportunity to design or redesign the built environment in a manner that supports a higher quality of life and promotes a healthy and sustainable lifestyle. The idea of sustainable urbanism stems from three late 20^{th} century reform movements, namely the smart growth, new urbanism and green building movement. While each of these movements have been successful individually, there has been a lack when it comes to searching for long – term solutions since individually the movements cannot solve the challenges we face today. Sustainable helps bridge the gap here by bringing together these three important movements together and knitting them into a design philosophy so as to allow and create truly sustainable human environments (Farr, 2007). Sustainable urbanism emphasizes that the most successful neighbourhoods are the ones that integrate the five attributes: definition, compactness, completeness, connectedness and biophilia (Farr, 2007). Farr laid out five basic guidelines to achieve sustainable urbanism –

1. **Densification:** Sustainable urbanism needs to strike the right balance between local impacts and global benefits.
2. **Sustainable corridors:** Building communities with transit and biodiversity. Travelling through a network of public transport and ecological corridors.
3. **Ecological neighborhoods:** Neighborhoods with mixed use development comprising housing, retail, public spaces within walking distance. These neighborhoods should be

designed to be compact, complete, connected and ultimately more sustainable and satisfying.

4. **Access to nature:** Providing access to green spaces such as parks, squares and community gardens that serve as a social meeting point and greatly enhance quality of life.
5. **High performance building and infrastructure:** Infrastructures that have low energy consumption and carbon dioxide emissions. Incorporating best management practices in infrastructure design.

These guidelines and principles of sustainable urbanism help build the environment around us such that any development takes into account biodiversity and the quality of life of residents in the area.

2.5 Green infrastructure techniques

The old systems of managing water and other resources that were once successful are no longer able to face the challenges of our cities today. This required implementing advanced strategies that could help build a sustainable future. Green infrastructure refers to ecological systems, both natural and engineered, that act as living infrastructure, these elements exhibit social, economic and environmental benefits. These techniques help reduce pollution in our cities. Further, they are designed to deliver a wide range of ecosystem services such as water purification, space for recreation, air quality, climate mitigation and adaptation that ultimately improves the quality of life.

In the past, communities have relied on grey infrastructure such as system of gutters, pipes and tunnels to move stormwater. However, the capacity of these systems is no longer enough to manage the stormwater and does not address water quality. As a result, this water ends up polluting the river. According to the EPA, runoff from stormwater continues to be a major cause of water pollution in urban areas. It carries trash, bacteria, heavy metals, and other pollutants through storm sewers into local waterways.(US EPA, 2015) Implementing green infrastructure techniques can help prevent combined sewer overflow and address runoff water quality. These techniques can be incorporated at various scales from the neighborhood to the master planning scale. These techniques include rain gardens, bioswales, infiltration basins, stormwater green streets, green roofs, permeable paving, surface detention systems, rain barrels, cisterns and more. These help remove a variety of contaminants before they reach the Ancostia River. The Monumental core framework plan for Washington D.C states different resilience strategies for example, combining grey infrastructure with green infrastructure and other low – impact development strategies. Combined, these infrastructure systems will help to improve stormwater management and water quality, control flooding, and recharge groundwater supplies; reduce ambient air temperature and cool urban heat islands; reduce energy consumption and improve air quality; create wildlife habitat. (*Monumental Core Framework Plan*, n.d.)

Chapter 3 Precedent Study

3.1 The Yards Park, Washington DC

Designed by M. Paul Friedberg and Partners, the Yards Park is a waterfront destination and a green jewel in Washington DC. The Yards Park highlights a regeneration effort that brings local communities and visitors to the Anacostia River while providing a transformative and vibrant public space (*Yards Park—2013 Urban Open Space Award Winner*, 2013). The Yards Park is a 5.4-acre open space that is an essential component of the larger 42- acre sub-neighborhood, designed to be the new urban mixed – use development in 2003. This site was a part of the Navy Yard extension and then became abandoned with no public access. The neighborhood is now developed as a mixed use area that consists of rental apartments, offices, shops, and restaurants. The park offers spaces for various active and passive activities, it celebrates water through the different water features that engage users of different age groups and a sculptural bridge that links the Anacostia riverwalk trail. Added to this, important green infrastructures features were incorporated in design such as underwater trash bins and low impact design streetscape. The Yards Park provides a great example of transforming an abandoned site into an important public space of an urban mixed use development area. It incorporates interesting ideas to accommodate both small and large scale gathering spaces while also focusing on the community benefits and protecting the environment. Figure 4 shows some important elements and attractions of the park.

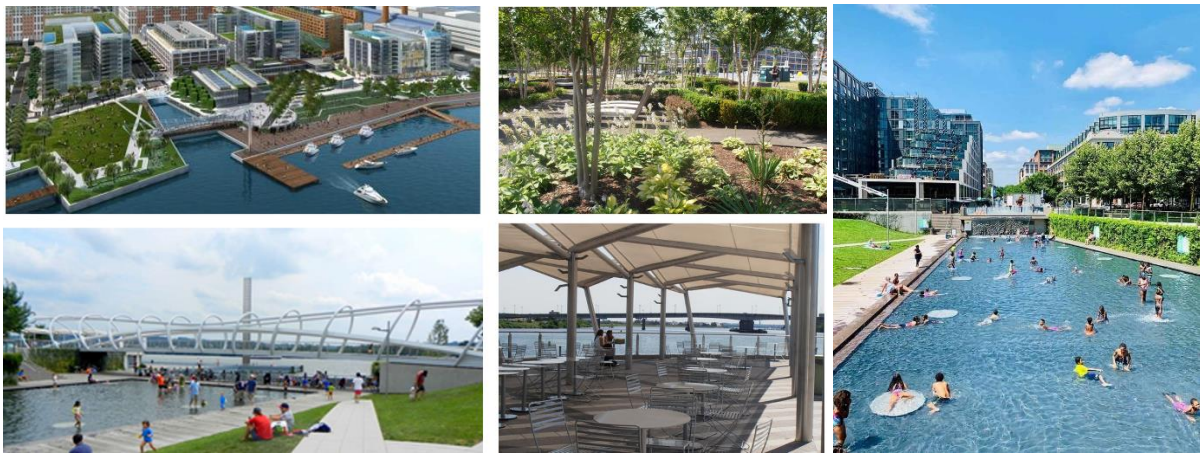

Figure 4: The Yards Parks: Park overview (upper left), River street gardens (upper middle), Canal basin and waterwall (right), Overlook with seating (lower middle) Pedestrian bridge at the park (lower left) (Source: asla.org)

3.2 11th Street Bridge Park, Washington D.C.

The 11th Street Bridge Park connects D.C's Navy Yard one side to the Anacostia Park on the other side. This bridge park that is scheduled to open in 2025 is designed by OMA+OLIN City's first elevated park that includes outdoor performance spaces, playgrounds, urban agriculture, environmental education center, public art and more. This park aims to support the neighborhood's physical, environmental, cultural and economic health. OLIN seeks to ensure a "richly layered landscape" with abundant color and vibrancy in all seasons. Both the bridge park and landings, are designed so that there will be a lot of fall color and ample shade during the summer. All of the new tree and plant life will also be supported by "advanced stormwater systems, including bioretention basins and cisterns, which will capture stormwater for reuse in irrigation *(Green, 2021).* The park also includes a large meadow with woodlands at its edges where native and adapted species will be planted to achieve biodiversity goals established with the Anacostia Watershed Society. Mussels play a crucial role in filtering and cleaning the water, this is highlighted in the "Mussel Power playground that features bivalves with custom shell-

shaped play elements that kids can hide and run through *(Green, 2021).* This play area is designed to promote the environmental education program as well. Design principles of the project are as follows-

- Stitch the city together
- Engage the river
- Elevate public health
- Embrace the water
- Celebrate the rich history of the region
- Explore Innovation
- Activate the space and place
- Capture rhythms of the day and seasons
- Create an eco-system

Figure 5: 11th Street Bridge Park: Park overview (upper left), Park lawns (upper middle), View from the overlook facing west(right), Rain gardens on the west side of the park (lower middle), Pathway to the amphitheater (lower left) (Source: dirt.asla.org)

3.3 Boston Seaport Square, Boston, MA

Boston Seaport Square is a diverse, mixed-use environment with connectivity to Boston's thriving seaport. Designed by Sasaki, James Corner Field Operations and NADAAA, this is the fastest developing areas of Boston that once consisted of industrial warehouses and parking lots. This rapid development is now attracting new residents and businesses to the area. This context is similar to the Yards Park where an abandoned site was transformed into an active public space. Thus both of these precedents are great examples for this thesis as the proposed site is located in a similar context. Development at Boston seaport brings together diverse uses, pedestrian connections, public spaces and better connectivity to the seaport. This re-envisioned master plan includes apartments, offices, shops, restaurants and hotels. The design also includes the Harbor Square, which is the at the heart of the Seaport. The master plan is designed to encourage walkability and alternative mobility options with 39% of the total project area being exclusively devoted to pedestrian-only open space (*Seaport Square Master Plan*, n.d.). A tree lined pedestrian path, plazas and amenity spaces form a critical component of the design and serve as the district's cultural corridor.

Figure 6: Boston Seaport Square: Master Plan (upper left), neighbourhood experience (upper right), View of harbour square (lower left), grand staircase (lower right)(Source: sasaki.com)

3.4 Brooklyn Bridge Park, Brooklyn, NY

Brooklyn Bridge Park designed by Michael Van Valkenburgh Associates, was an abandoned waterfront that was transformed into a thriving public landscape. This 1.3-mile-long Brooklyn Bridge Park was completed in December 2021. The design of this park addresses issues such as climate change and restores the connection of the city with its shoreline. Programming at the park includes active recreational spaces, nature play and other innovative play areas, a massive sound – deflecting landform sheltering the site from the highway noise and works on a self-sustaining economic model. Although the waterfront is completely transformed now, the design considers many of the existing elements of the site that made it unique such as the infrastructure that point towards the history of a working port. The design involved creating "urban junctions" that helped connect the isolated site to more neighborhoods. By creating new

entries at site extensions, the park was also connected to major transportation hubs, thus inviting more users to the site. Further, variety of newly constructed and naturalized shoreline edges supports a host of experiences connecting users to the water (*Michael Van Valkenburgh Associates Inc*, n.d.). Planting at the park includes salt and freshwater wetlands, miniature forests, meadows and gardens. Recycling stormwater is a crucial environmental aspect of the design. Stormwater that falls in the park is collected and naturally treated to water lawns and gardens. Tanks located underneath different piers store this water until required. As part of sustainable design, the park also includes several structures with green roofs. These absorb rainwater, provide building insulation and help to lower urban air temperature. Ecological restoration, microclimate and human comfort form the basis of this 85-acre civic landscape.

Figure 7: Brooklyn Bridge Park: Aerial view of the park (upper left), Sound berm to block sound from the highway (upper right), Use of existing infrastructure (lower left), Aerial view of piers (lower right)(Source: mvvainc.com)

Chapter 4 Site Characteristics

4.1 History and current state of Anacostia River

The 8.5-mile-long Anacostia River starts from the intersection at the Potomac River and ends near Bladensburg, Maryland. Before the arrival of first European explorers, a vibrant American Indian culture existed around the shores of the Anacostia River due to the abundance of fish and other natural resources. In the 1600's the Nacotchtank Indians lived along the eastern shore of the River. These Nocotchtank Indians worked as farmers, gathers, hunters and traders. In 1608 Englishman, John Smith explored the Anacostia. John smith's visit led to the rapid settlement by Europeans around the shores of the Anacostia. This further led to the downfall of the Nacotchtanks. The new settlement also resulted in changes to the watershed's land use. This area of dense forest was cleared for agriculture, causing heavy erosion (*Stream Ecology in the Anacostia Watershed*, 2018). The area was mainly used to grow tobacco and corn, this led to an increase in sedimentation in the Anacostia River. Increased sedimentation resulted in mudflats along the banks of the river. During the civil war, human and industrial waste were dumped in the river. Further, to defend the capital, excessive deforestation took place to create clear views with accelerated land erosion. Above all, overflow from the combined sewers resulted in dumping of raw sewage into the river, this contributed to the pollution of the river. During 1900s, development of the Anacostia Park took place. The appointment of the McMillan Commission by the U.S. Congress in 1901 set the stage for the development of Anacostia Park. Among its recommendations, the Commission urged that the Anacostia 'flats' follow the model of the East and West Potomac Parks – that the swamps be 'reclaimed' and the new lands used as gardens and recreation space for public use(Drive et al., n.d.). In order to meet these requirements, the U.S Army Corps of Engineers constructed a seawall on the banks of the river.

They dredged the river bottom and used the sediments to fill the wetlands. Such projects continued throughout 1920s and 1930s. As a result, these reclamation projects destroyed the natural wetland system (Drive et al., n.d.). The figure below shows the timeline of the Anacostia river through the years, discussing the history and the changes in land use.

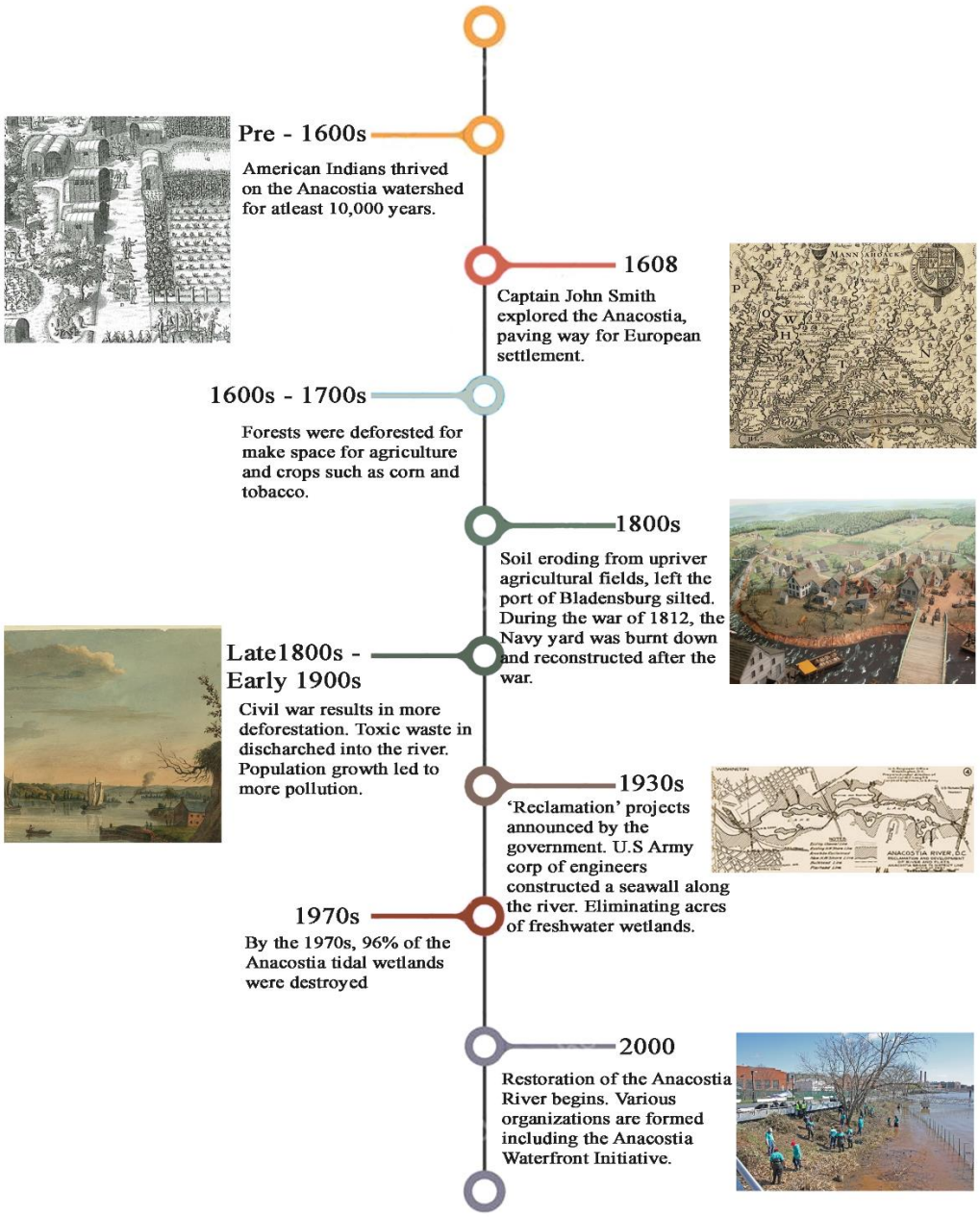

Figure 8: History of the Anacostia river and changes in Land use through the years

As awareness of the degrading condition of the river grew, various organizations were formed to address the environmental needs of the Anacostia River such as the Anacostia Waterfront Initiative and the Anacostia Waterfront Society. These organizations have not only helped in cleaning up the river but also create awareness in environmental education, stewardship and engaging the community in the process to make a difference. These continued efforts are a step towards to goal of making the Anacostia River and its tributaries swimmable and fishable. The current state of the river has some serious concerns due to pollution, storm water runoff and the river being neglected for decades. Overtime, this has negatively affected ecology of the river and the well-being of people living around it. In addition to the on-going efforts, it is important to incorporate better infrastructure and other best management practices that will greatly help is addressing some of these concerns. Additionally, recreation has played a key role in inspiring people to interact with the river and its surroundings where previously they were unaware or even avoided the area. To achieve the goal of a fishable and swimmable river, it is important to protect the river by introducing new infrastructure and bringing communities together to achieve a clean and safe river for the well-being of those living in the watershed and for future generations.

4.2 Site selection

This thesis focuses on a 12-acre site along the Anacostia River in Washington, D.C. to demonstrate how an urban site can be designed to support people and activities in the area to help reduce degradation and improve water quality of the Anacostia river.

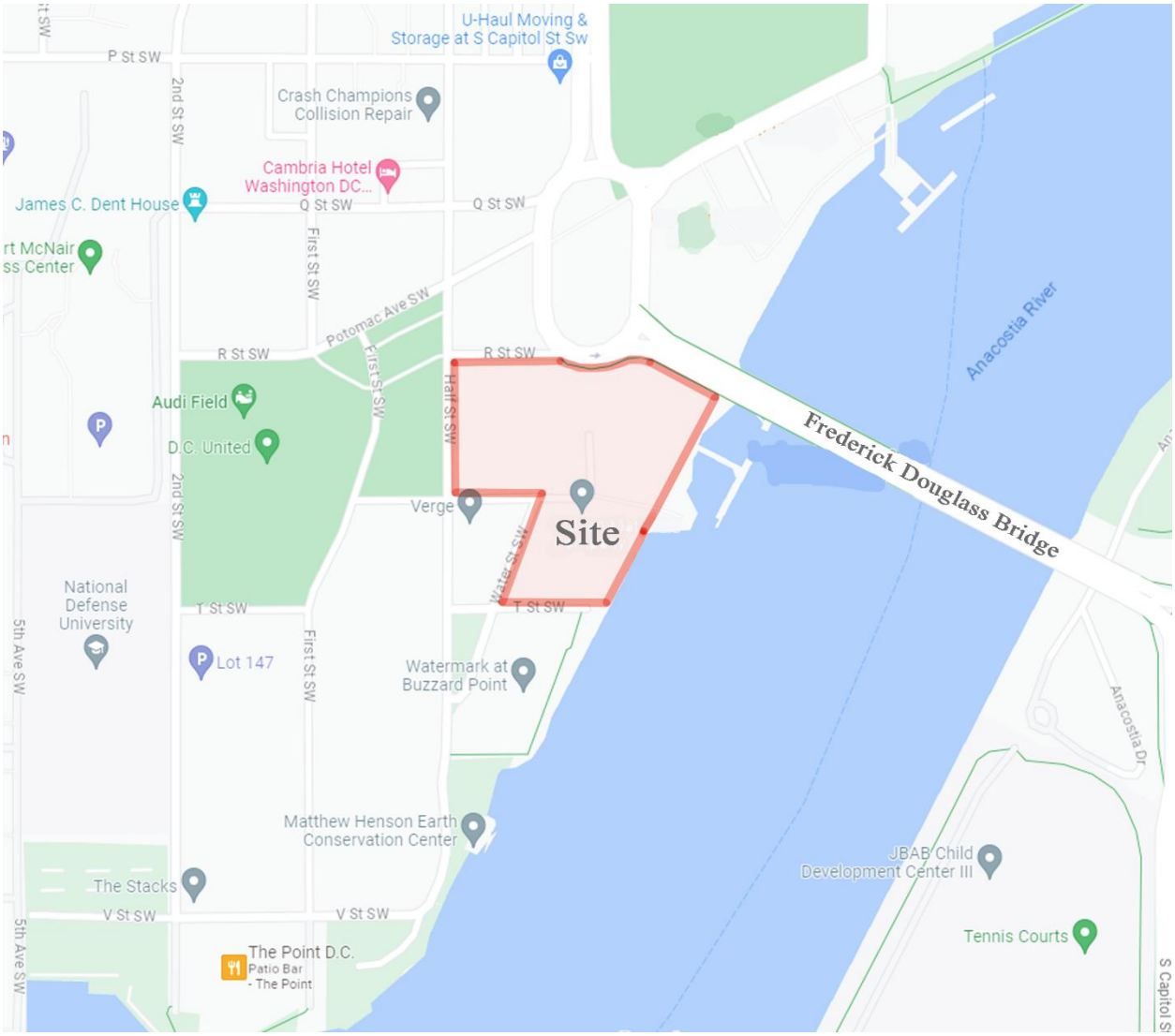

Figure 9: Site location map (Source: Google maps)

The site is very near to Buzzard point and is bound by Half street and Audi Field on the west. A newly developed traffic circle is on the North of the site. This traffic circle connects to the Fredrick Douglass Bridge. The site is also bound by two residential apartment buildings called the Verge and Watermark on the south-west and south side respectively. As the site is located at the water's edge it provides great views of the river and recreational opportunities for future development. In addition to this, the site sits on axis to the United States Capitol, which creates opportunities for visual connections.

4.3 Site inventory and analysis

The site was further studied to understand other parameters such as circulation, context, land use and ecology that impact the site and design considerations. This data was aggregated from District of Columbia's GIS database and used to inform the design.

4.3.1 Context and site views

The National Capital Planning Commission (NCPC) laid out The Monumental Core Framework Plan in 2009. The plan is a flexible tool to inform planning and development decisions over the next thirty years. Goal of the Framework plan is to improve connections between the city, the National Mall, and the waterfront, while achieving the highest level of liveability and sustainability in central Washington (*Monumental Core Framework Plan*, n.d.). Figure 11 indicates the physical and symbolic links between the National mall and different sites on axis with the mall as identified in the Framework plan. The proposed site is identified as one of the emerging destinations in the Framework plan as it is situated on the major axis that connects to the Capitol. This creates various opportunities for development on site such as

connecting the mall with the waterfront, enhancing the waterfront experience by introducing recreational activities, including both, physical and symbolic connections in the design.

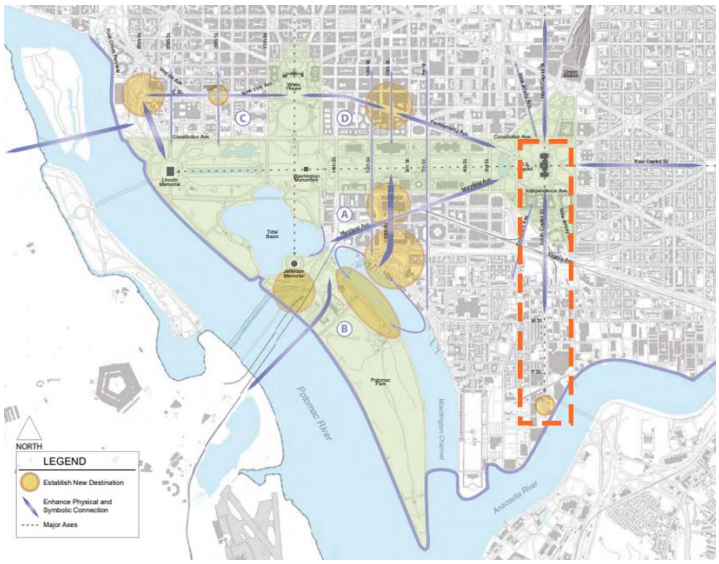

Figure 10: Physical and symbolic links (Source: Monumental core Framework Plan, NCPC)

Figure 11: Connection between site and Capitol

Being located in an urban area, the site surroundings include a number of residential, social and commercial buildings. Two residential apartment buildings are located adjacent to the site towards south of the site. A number of other residential units are located within 0.3 mi radius. This will result in regular footfall on the site. Currently there is no other park or recreational space within 0.3 mi of the site. Hence this site will provide access to nature and other recreational activities to the users in the vicinity. The Audi field and Nationals Park stadium are located very close to the site. This will occasionally result in high footfall on the site. This will also provide opportunity for small scale commercial development on site.

Figure 12: Surrounding context within 0.3-mile radius around the site

Site views discussed below strongly influence the design considerations.

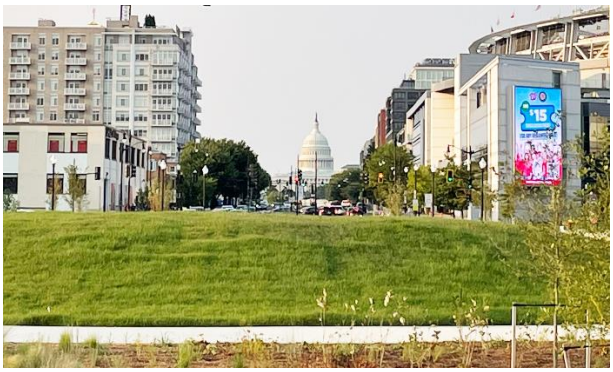

Figure 13: View of the Capitol from the site

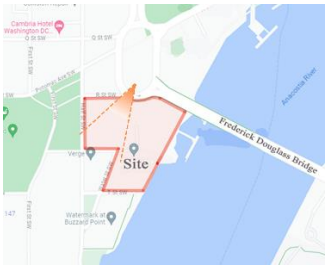

Figure 14: Existing site conditions

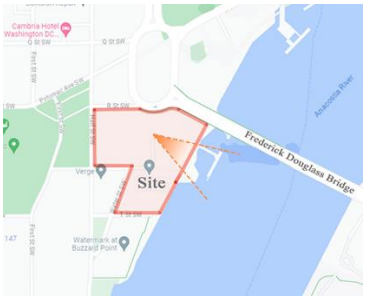

Figure 15: View of the Anacostia River from the site

Figure 16: Existing site conditions and residential buildings around the site

Figure 17: Area below Fredrick Douglass bridge

Figure 18: Part of Anacostia Rive walk trail near Residential buildings around the site

4.3.2 Circulation

Vehicular and pedestrian access to site is drawn from different primary and secondary roads. Figure 11 indicates the identified street hierarchy and connectivity to the site. Potomac Avenue is the primary gateway to the neighborhood. The newly constructed Frederick Douglass Memorial Bridge to the North-East of the site, carries South Capitol street over the Anacostia River. This new bridge has replaced the old 70-year-old bridge, improving not only vehicular but also pedestrian and bicycle connection. Construction of this bridge also led to the construction of the new Traffic oval to the North of the site. The traffic oval connects South capitol street, Potomac Avenue and Q street SW (*Frederick Douglass Memorial Bridge Project | Washington, DC*, n.d.). Half street is the central spine of Buzzard point. Half street and 2nd street form the primary pedestrian connection to the neighborhood. 2nd street also form an important connection to the P street and includes the Anacostia Trail bike route that connects to P street. These streets are not only essential for transportation connections but also provide opportunities to introduce best management practices such as rain gardens to address storm water issues. These streets form

a crucial link that connects people to the waterfront and could be designed to be more inviting by increasing the tree canopy and providing open space and features such as seating and lighting.

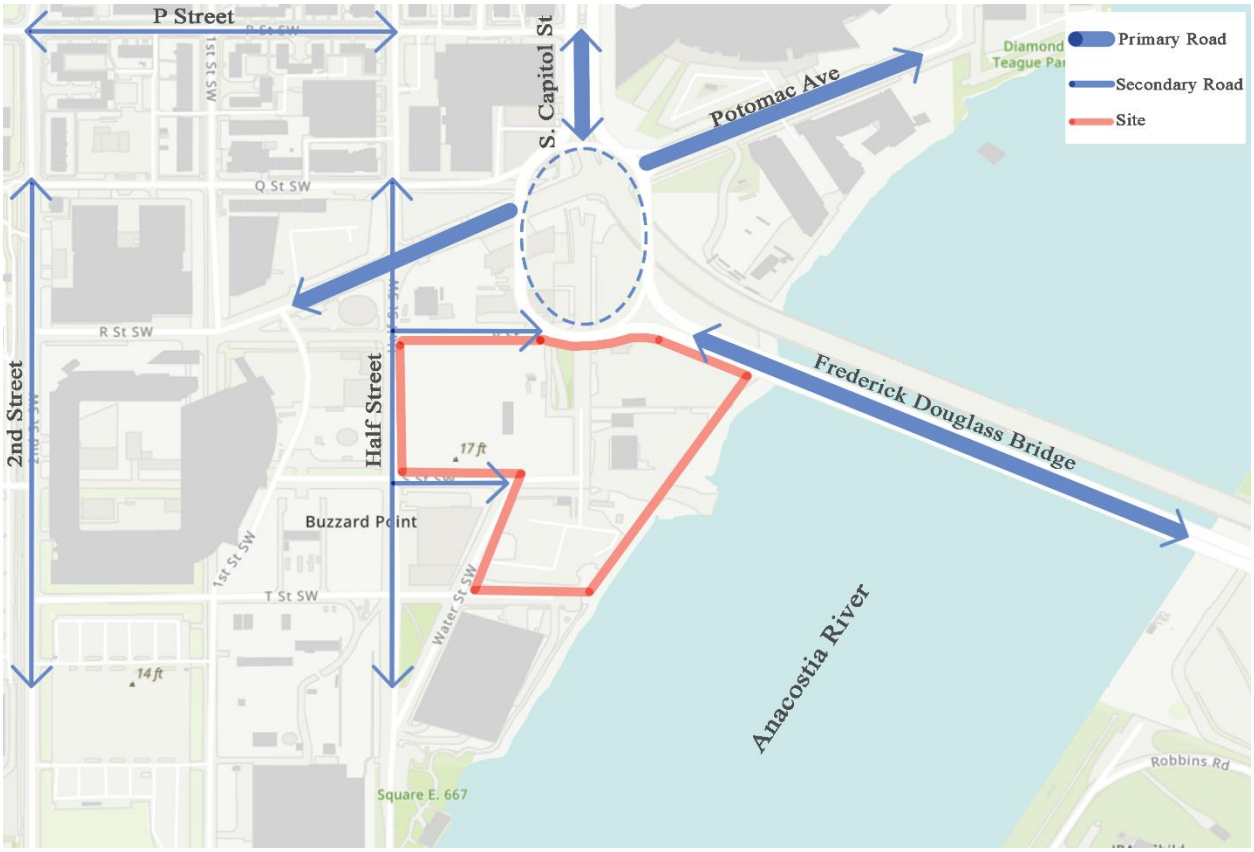

Figure 19: Street hierarchy and connectivity to site

4.3.3 Anacostia Riverwalk Trail connection

The Anacostia Riverwalk trail is an integral part of the Anacostia waterfront that connects residents and communities to the river, each other and other commercial as well and recreational destinations (*Anacostia Riverwalk Trail*, n.d.). The trail covers various destinations along the river from Bladensburg, Maryland through Washington to its point of connection with the Potomac river. While the areas in the upstream offer access to forests, wetlands and wildlife, the downstream includes riverfront recreation, community parks and restaurants. To date, 12 of

the ultimate 20 miles of the Riverwalk Trail are open and heavily used. Other segments to complete the Riverwalk Trail are to be constructed as part of the Buzzard Point Trail Project, South Capitol Street Trail Project, Arboretum Bridge & Trail Project and Lincoln Connector Trail Project.

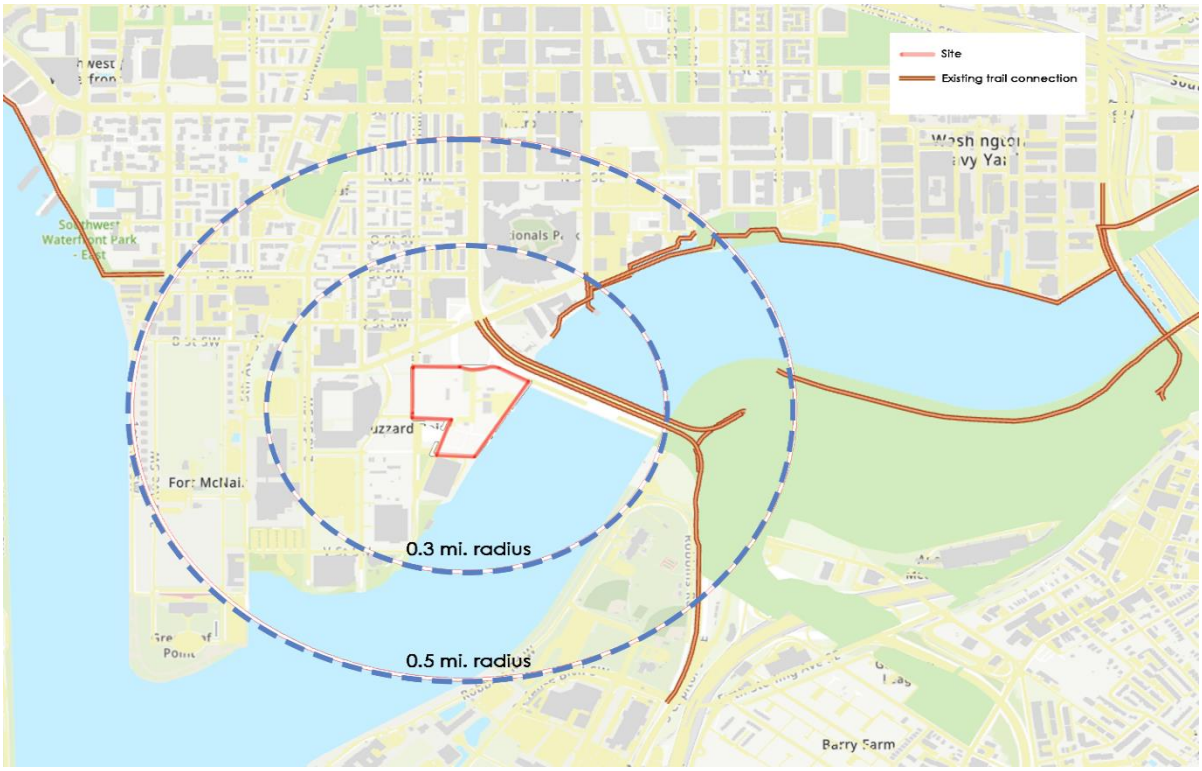

Figure 20: Existing Anacostia Riverwalk trail route

Figure 21: Complete Anacostia Riverwalk trail connection (Source: Anacostia Waterfront Initiative)

Figure 21 and 22 indicate the existing and complete route of the Riverwalk trail, it is evident from this that the site will form an important point of connection to complete the trail. This point of connection will also transform the proposed site into a new destination that users of the trail can visit, thus increasing footfall on the site. As the trail becomes a part of the site, it will also improve connections of the proposed site to other destinations along the trail.

4.3.4 Transportation

Major roadways near the site include South Capitol Street, M street and P street. All of these provide access to the regional network. Currently, no local public transit connects to the east side of the site due to absence of bus stops on that side. The only public transit connection to the site is the Navy Yard – Ballpark metro station and the Waterfront metro station.

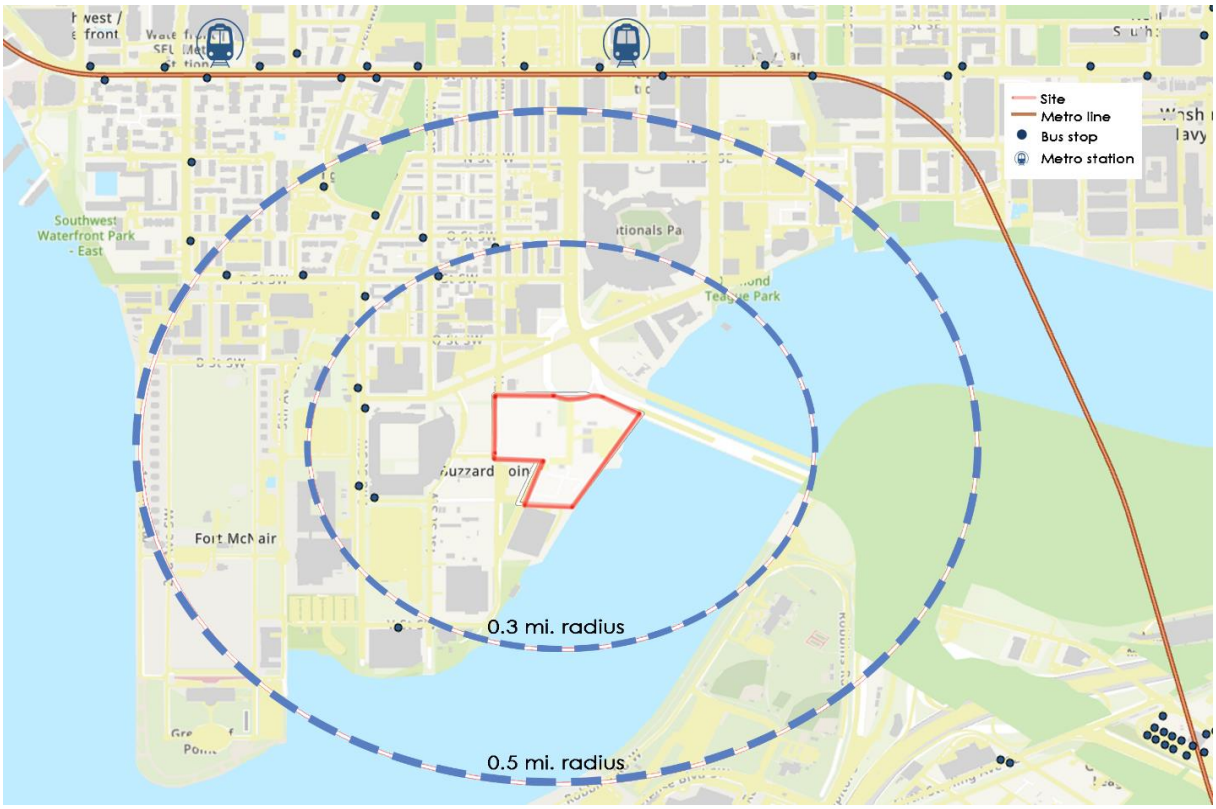

Figure 22: Existing metro route and bus stops

The Buzzard point vision framework includes a proposal with improved transportation network for the area. This includes new bus transit routes, incorporating bike network in the other streets and promoting walking. Along with these improved routes, access from the Water was identified in the Anacostia Waterfront Framework Plan (2003) as a component of a future transportation system serving areas along the Anacostia River. (*Buzzard Point Vision Framework*

and Design Review Guide | Op, n.d.). This could create more opportunities for access to water from the site such as water taxi as transit option.

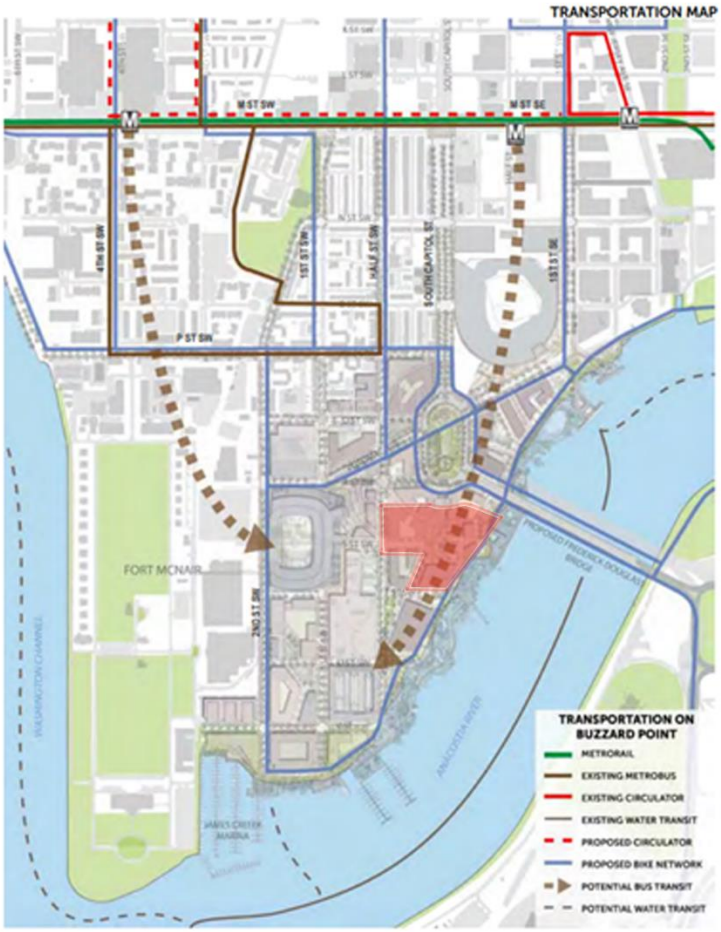

Figure 23: Proposed transportation network

(Source: Buzzard Point Vision Framework)

Development around the site is expected to occur over time with future transit expansion. Design intervention on site will consider these changes.

4.3.5 Topography and Hydrology

The topography of the site is relatively flat with the highest elevation being 24’ and lowest elevation of 8’. It will be essential to treat the site’s stormwater runoff to avoid polluting the river. The stormwater management practice will include various green infrastructure components to address this issue. The topography will also be re-graded as per the design interventions on the proposed site.

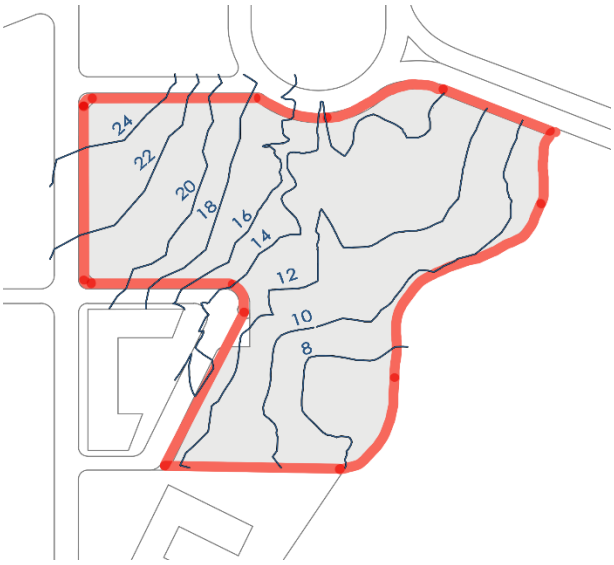

Figure 24: Site topography

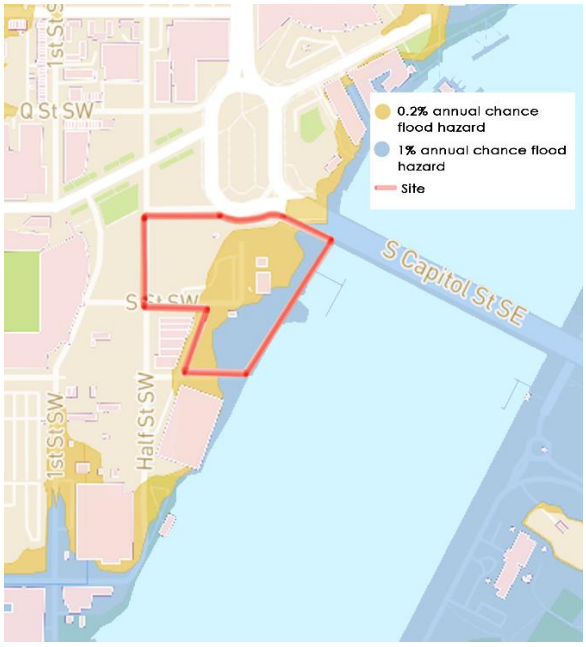

Figure 25: Flood zones (Source:DOEE)

The flood zones map of the site indicates that most of the site falls under moderate flood hazard area. It has a 0.2 percent annual chance of flood hazard (or 500 – year floodplain). Some part of the site also falls under the area that has 1% annual chance flood hazard or the 100 – year flood plain. However, most of the site is outside the floodplain. Best management practices incorporated on site will take in consideration the rainfall and floodplain on site.

4.3.6 Zoning and Land Use

The site is located in CG4 AND CG5 zone. CG4 zone permits medium to high density mixed use development and CG5 zone permits medium density mixed use development. Based on the development standards, maximum permitted height in CG4 zone is 90ft and that in CG5 is 60ft. Figure 27 indicates zoning for the site. Additionally, the Land Use plan also follows the same designation for the site. The Comprehensive plan identifies the land use for the site as medium and high density mixed use development. This zone is intended to encourage a diversity of compatible land uses at various densities in waterfront areas and propose uses including, but not limited to, residential, commercial and recreational development.

Figure 26: Zoning map (Source: Buzzard point vision framework)

Figure 27: Land Use map (Source: Buzzard point vision framework)

Design intervention on the site will take into account the designated zoning and Land Use of the site.

Chapter 5 Program Formulation and Design Concept

5.1 Design Program

A design program was developed based on the research, site inventory, site analysis and the goals formulated for this thesis. The proposed design will address the different issues identified such as reducing degradation of water quality of the river, reviving connection with the existing urban fabric, adopting sustainable practices that address environmental issues, supporting growth of local economy and ultimately improving connections between the community, city and its river. In order to revive these connections, the program includes mixed use development, gathering and recreational areas, educational areas that create awareness amongst elders as well as kids and spaces that promote native ecology on this waterfront site. Urban design, green infrastructure and visual as well as physical connectivity form the basis of this design. The design program is focused around these guiding principles that create a balance between the existing and proposed areas.

Figure 28: Main aspects of program formulation

5.2 Design Concept

In addition to the principles that form the basis of the program, the design concept takes into consideration other important factors such as axis and circulation on site to improve user experience. The design concept revolves around division of the site into different zones like the Commercial and Shopping zone, Recreational zone, Ecological zone, and Learning and Play zone. Activities in these zones are not restricted to the specific area but instead blend with each other to create a holistic experience for the user. The axis plays an important role in designating these spaces as well as establishing the visual connection from the site to the Capitol and from the site to the Anacostia river. The specific activities in each of these zones is discussed in the design section.

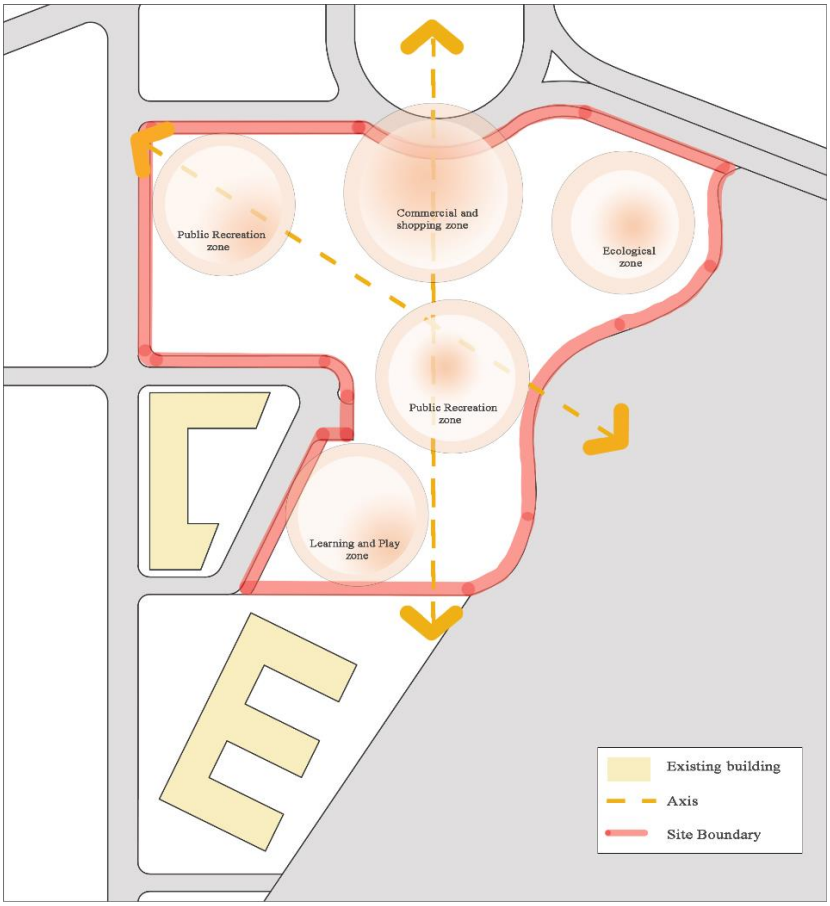

Figure 29: Design Concept

Chapter 6 Site Design

6.1 Site Plan

Figure 30: Site Plan

Figure 31: Plan indicating different zones on site

The site draws pedestrian as well as vehicular access from Half street and R street. Considering the zoning for this site, mixed use development is proposed to promote inclusion of different communities and attract more footfall. Hence the three buildings, all of which include commercial, residential and retail use become an important part of the design and help in tying the proposed deign to the existing urban fabric.

Vehicular access is limited to encourage walking and biking. Underground parking is provided for each of the buildings. This will not only accommodate the vehicles but also generate income due to lack of parking spaces in the area and help reduce the traffic load during events at the stadiums. As discussed in the previous section, the site includes four different zones which are, Commercial and shopping zone, Recreational Zone, Ecological Zone, Learning and Play Zone. Along with different activities, each of these zones incorporate different green infrastructure techniques that help in managing stormwater. Functions of each of these areas are discussed in next sections.

6.2 Commercial and Shopping Zone

As the name suggests, this zone is dedicated to shopping and commercial activities. The location of this area is closer to the main street for better accessibility and to attract more users. Users are drawn into the plaza with trees and planting beds that create a welcoming atmosphere. This plaza consists of seating areas and open space that could also be used as flexible space to set up weekly markets or food kiosks that will ultimately boost the local economy. The terraced

building in this plaza is designed with an overlook on the second level where users can take a look at the surrounding area and the Capitol Building that falls on the axis with the site, thus building the visual connection. Considering mixed use development, restaurants become an important part of this plaza. Outdoor seating for the restaurant not only provides a different dining experience but also creates a transition between the outdoor and indoor space. This space is shaded by Honey locust trees and provides access to nature in the urban environment. A water stream runs from the higher elevation of the site to the lower elevation. This stream is an important storm water feature as well as a recreational component. The crucial green infrastructure components in this zone are the permeable paving and green roof. Permeable paving is used in the plaza as well as the outdoor restaurant space. The building in this zone has terraces on different levels each of which functions as a green roof and helps in the stormwater management. This zone then leads to the recreational zone.

Figure 32: Plan of Commercial and Shopping Zone

Figure 33: View from the street looking towards the shopping plaza

Figure 34: View of shopping plaza entrance

Figure 35: View of shade structure with seating in plaza

Figure 36: Aerial view of plaza and mixed use development

Figure 37: view of outdoor dining area of restaurant

6.3 Public Recreational Zone

The recreational zone forms a major portion of the site. Pedestrian access to this area is drawn from Half street. The entrance plaza is lined with ornamental trees to create visual interest and guide users to the next area. The entire recreational zone is divided into a series of circular gardens, starting with the Sculpture garden. The Sculpture garden consists of a centrally located sculpture with planting bed around it and seating areas for viewers to spend time in the garden. The garden then leads to the event lawn or the picnic space. It consists of large lawn area that could be used as a community gathering space or a family picnic area. The lawn is shaded by a canopy of trees and also includes shade structures as well as barbeque area. The last garden in this series is the flower garden. This space includes a centrally located water feature that is combined with a planting bed containing flowering plants. The space is designed to create a

relaxing atmosphere with seating under the pergola while giving users a clear view of the waterfront. Section closest to the water is the amphitheatre and performance area. These are series of steps combined with lawn and performance area that can host a variety of events and connect users to the waterfront. The walkway from the site also extends over the river as a marina. This marina creates various benefits for the local economy. The boardwalk also creates an enclosed portion of the river that functions as a recreational activity, ‘Drive your boat’. This activity can engage users of different age groups and allow them to use remote controllers to drive their own sail boat. This will provide a fun experience to the users by engaging them with the river water. Another important component of this space is the riverwalk which will be the connection of the Anacostia Riverwalk trail though the site and encourage both walking and biking though the trail while enjoying views of the Anacostia. The green infrastructure components of this zone are permeable paving, green roof and water cisterns that will store the water though the under drains.

Figure 38: Plan of Recreational Zone

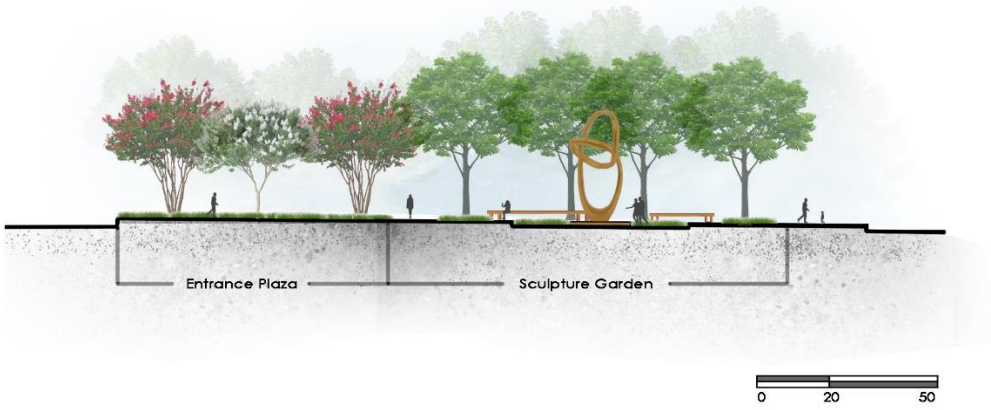

Figure 39: Section A-A'

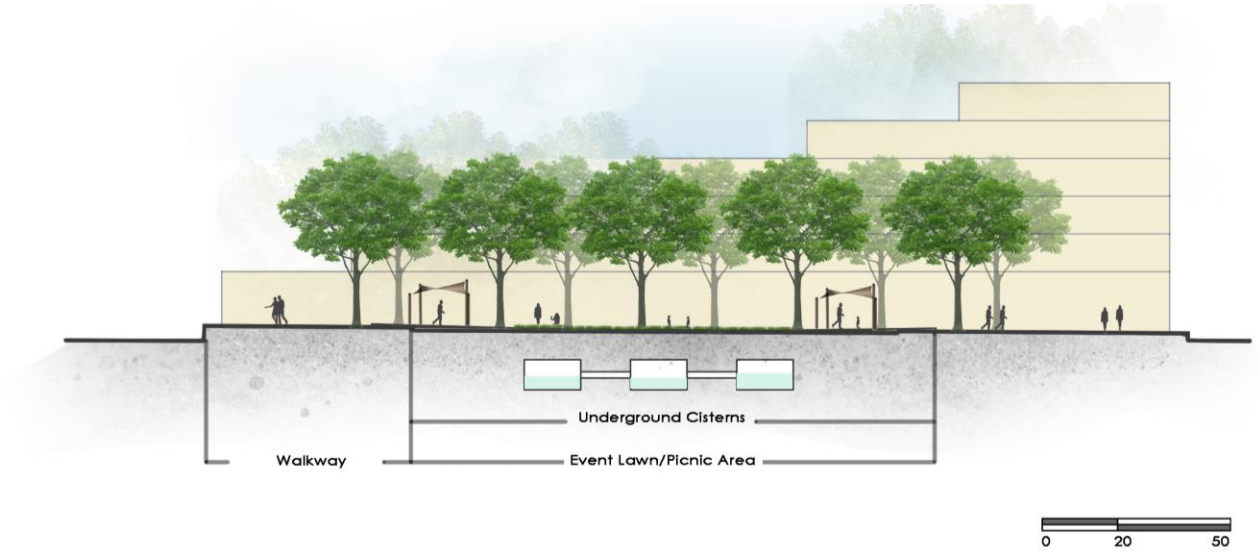

Figure 40: Section B-B'

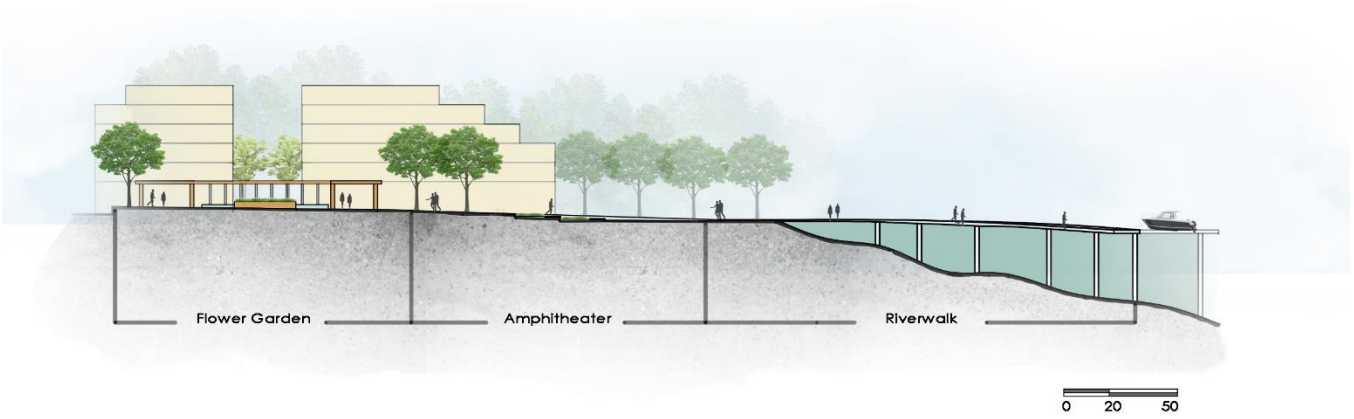

Figure 41: Section C-C'

Figure 42: View of entrance plaza from half street

Figure 43: View of sculpture plaza

Figure 44: View of picnic area

Figure 45: Aerial view of picnic

Figure 46: View of amphitheater and boat activity area

Figure 47: View of riverwalk

6.4 Ecological Zone

The ecological zone forms one of the most important aspects of the site. A large portion of this area is dedicated to bio-retention areas that help in stormwater management. This area includes native plants that would help in reducing runoff water by increasing the soil capacity to store water, reduce air pollution and create a better microclimate. Users can enjoy the views of this area from the outdoor seating at the restaurant. In addition to this, the water stream plays an important role as a stormwater feature. The stream then opens up as a pond providing a different experience to the users by bringing them closer to a water feature along the waterfront. The splash pad next to the pond will engage kids as they get involved in water activities as a part of the waterfront experience.

Figure 48: Plan of ecological zone

Figure 49: View of the pond in ecological zone

Figure 50: View of splash pad in ecological zone

6.5 Learning and Play Zone

The learning and play zone includes nature play areas as well as educational opportunities to learn about water quality, native planting in the surrounding and best management practices through an experimental bio retention area. This space also includes an outdoor fitness area to engage people of different age groups and kids in the same area. This area aims to create awareness amongst users while re-connecting them to the river.

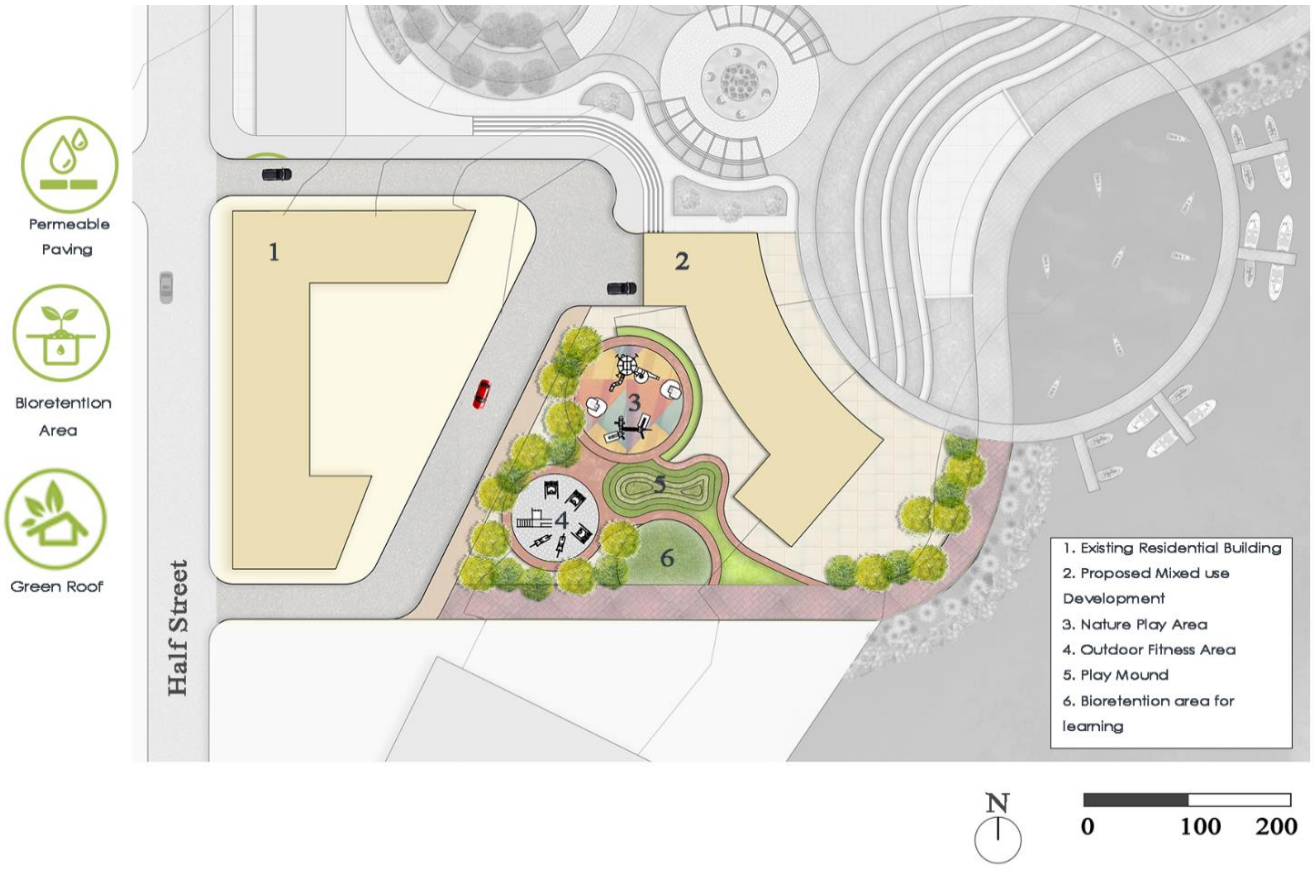

Figure 51: Plan of learning and play zone

Figure 52: View of play area

Figure 53: View of learning area

6.6 Green Infrastructure and Stormwater Management

A crucial aspect of this design is the application of different green infrastructure techniques that help in treating the site's stormwater runoff, reduce pollution of the river and support the environment. These techniques include permeable paving, green roofs, bioretention areas, cisterns and the living shoreline. As indicated on the plan, these techniques are implemented in different parts of the site. Three cisterns of 20,000-gallon capacity are located below the central recreational area. These cisterns are connected to the permeable paving areas through underdrains. Water that lands on the permeable paving will first be stored there, partial runoff will be absorbed into the ground while the remaining stormwater will be directed towards the cisterns. Water from the green roofs and bio retention areas will be routed to the permeable paving first and then connect to the cisterns through underdrains. Water stored in the cisterns will be used for irrigation purpose throughout the site. The water stream on site also functions as a stormwater feature. In absence of rain, water from the cistern can be pumped into the stream to keep it running for recreational purpose. The plan shows a conceptual layout of connections between different areas of the site to the cisterns through underdrains. The living shoreline is also an essential technique along the water's edge that protects the shoreline from erosion, improves water quality and stores nutrients, provide a buffer during flooding events and provide a habitat for fishes and other aquatic organisms.

Figure 54: Plan indicating green infrastructure techniques on site

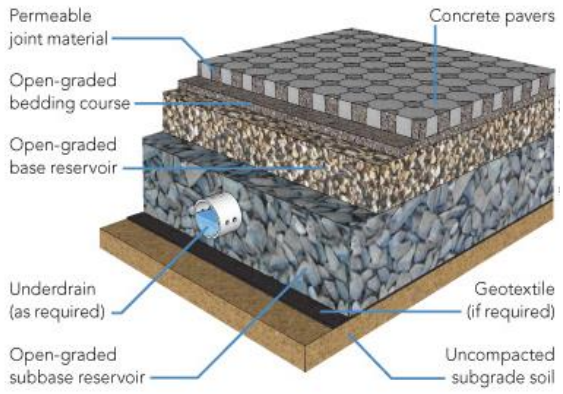

Figure 55: Section of permeable paving
(Source: farleypavers.com)

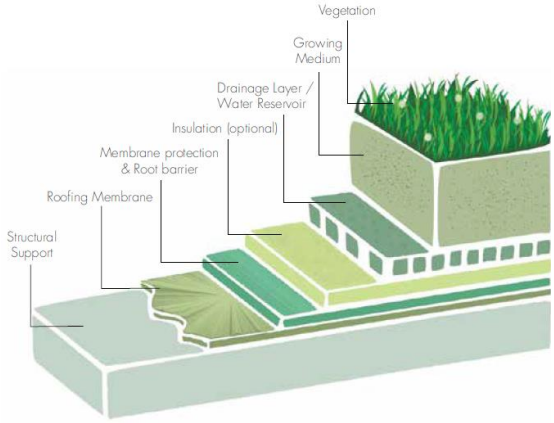

Figure 56: Section of green roofs
(Source: skyrisegreenery.nparks.gov.sg)

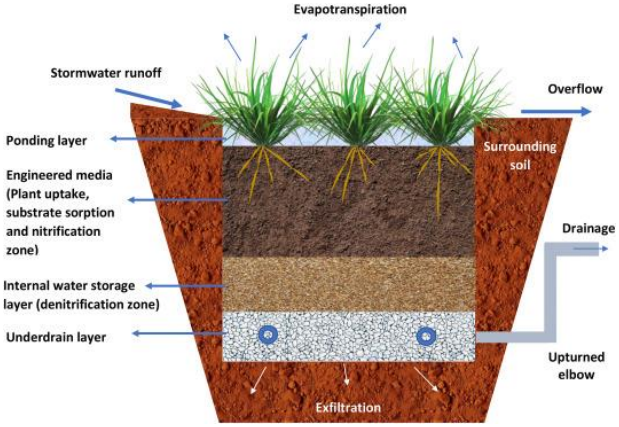

Figure 57: Section of bioretention
(Source: www.sciencedirect.com)

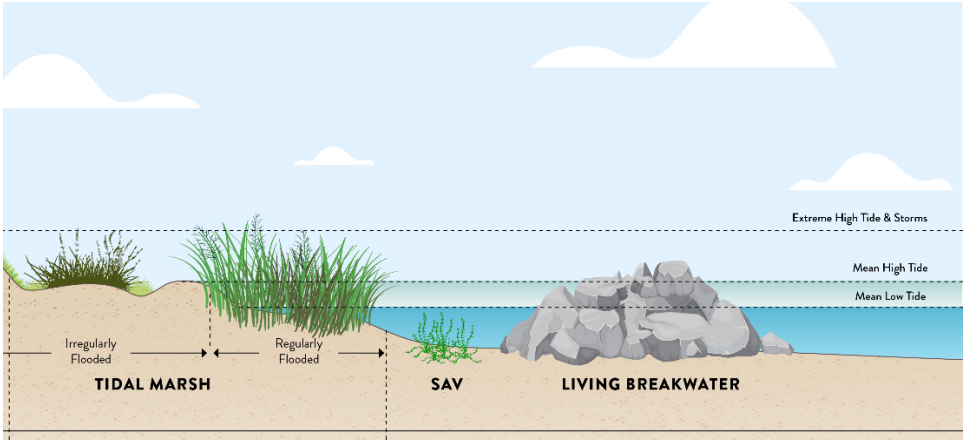

Figure 58: Section of living shoreline
(Source: skyrisegreenery.nparks.gov.sg)

6.7 Stormwater Calculations

Based on the rainfall amount for Washington D.C and study area of different green infrastructure techniques applied, the following calculations were done to calculate the stormwater retention for 1- year and 10-year storm. Based on the information derived from TR-55, the rainfall amount in Washington D.C. for 1 – year storm is 2.7 inches and for 10-year storm it is 5.3 inches.

Calculations for Permeable paving area:

Area of permeable paving = 201,032.45 *(sf)*

Media Depth = 2 *(ft)*

Void Space = 40 percent = 0.40

Volume = Area of permeable paving x Media depth

Volume = 201,032.45 *(sf)* x 2 *(ft)* = 402,064.9 *(cf)*

Stormwater Retention Volume = Volume of Permeable paving x 40 percent void space

Stormwater Retention Volume = 402,064.9 *(cf)* x 0.4

Stormwater Retention Volume = 160,825.96 *(cf)*

Stormwater Volume for 1- year storm

Stormwater Volume for 1-yr storm = 1-year storm depth x permeable paving area

Stormwater Volume for 1-yr storm = 0.225 *(ft)* x 201,032.45 *(sf)*

Stormwater Volume for 1-yr storm = 45,232.3 *(cf)*

Hence, 100 percent of the 1 – year storm is retained.

It is also noted that 28.12% of the total storage capacity of permeable paving is used in the one-year storm. Taking this into consideration, stormwater from the green roofs and bio retention area will also be routed to the permeable paving due to the availability of storage.

Stormwater Volume for 10 - year storm

Stormwater Volume for 10-yr storm = 10-year storm depth x permeable paving area

Stormwater Volume for 10-yr storm = 0.44 *(ft)* x 201,032.45 *(sf)*

Stormwater Volume for 10-yr storm = 88,454.28 *(cf)*

Hence, 100 percent of the 10 – year storm is retained.

It is also noted that 55% of the total storage capacity of permeable paving is used in the 10-year storm.

Calculations for Green Roof area:

Area of Green Roof = 78,174.43*(sf)*

Media Depth = 4 *(in)* = 0.33 *(ft)*

Void Space = 40 percent = 0.40

Volume = Area of Green Roof x Media depth

Volume = 78,174.43 *(sf)* x 0.33 *(ft)* = 25,797.57 *(cf)*

Stormwater Retention Volume = Volume of Green Roof x 40 percent void space

Stormwater Retention Volume = 25,797.57 *(cf)* x 0.4

Stormwater Retention Volume = 10,319.02 *(cf)*

Stormwater Volume for 1- year storm

Stormwater Volume for 1-yr storm = 1-year storm depth x Green Roof area

Stormwater Volume for 1-yr storm = 0.225 *(ft)* x 78,174.43 *(sf)*

Stormwater Volume for 1-yr storm = 17,589.25 *(cf)*

Hence, 58.67 percent of the 1 – year storm is retained.

The excess stormwater will be routed to the permeable paving that has excess storage to accommodate this stormwater.

Stormwater Volume for 10 - year storm

Stormwater Volume for 10-yr storm = 10-year storm depth x Green Roof area

Stormwater Volume for 10-yr storm = 0.44 *(ft)* x 78,174.43 *(sf)*

Stormwater Volume for 10-yr storm = 34,396.75 *(cf)*

Hence, 30 percent of the 10 – year storm is retained.

The excess stormwater will be routed to the permeable paving that has excess storage to accommodate this stormwater.

Calculations for Bioretention area:

Area of Bioretention = 60,572.47*(sf)*

Media Depth = 2 *(ft)*

Void Space = 25 percent = 0.25

Volume = Area of Bioretention x Media depth

Volume = 60,572.47 *(sf)* x 2 *(ft)* = 121,144.94 *(cf)*

Stormwater Retention Volume = Volume of Bioretention x 25 percent void space

Stormwater Retention Volume = 121,144.94 *(cf)* x 0.25

Stormwater Retention Volume = 30,286.23 *(cf)*

Stormwater Volume for 1- year storm

Stormwater Volume for 1-yr storm = 1-year storm depth x Bioretention area

Stormwater Volume for 1-yr storm = 0.225 *(ft)* x 60,572.47 *(sf)*

Stormwater Volume for 1-yr storm = 13,628.80 *(cf)*

Hence, 100 percent of the 1 – year storm is retained.

Stormwater Volume for 10 - year storm

Stormwater Volume for 10-yr storm = 10-year storm depth x Bioretention area

Stormwater Volume for 10-yr storm = 0.44 *(ft)* x 60,572.47 *(sf)*

Stormwater Volume for 10-yr storm = 26,651.88 *(cf)*

Hence, 100 percent of the 10 – year storm is retained.

The bar graph in figure 59 indicates the usage of total permeable paving storage capacity for 1 year and 10-year storm. The graph shows that some of this available storage is used by permeable paving itself. Other available storage is used by stormwater routed from the green roofs. There is still storage available to retain more stormwater if required. The permeable paving areas are also connected to the cistern through underdrains. This will provide any additional storage when required.

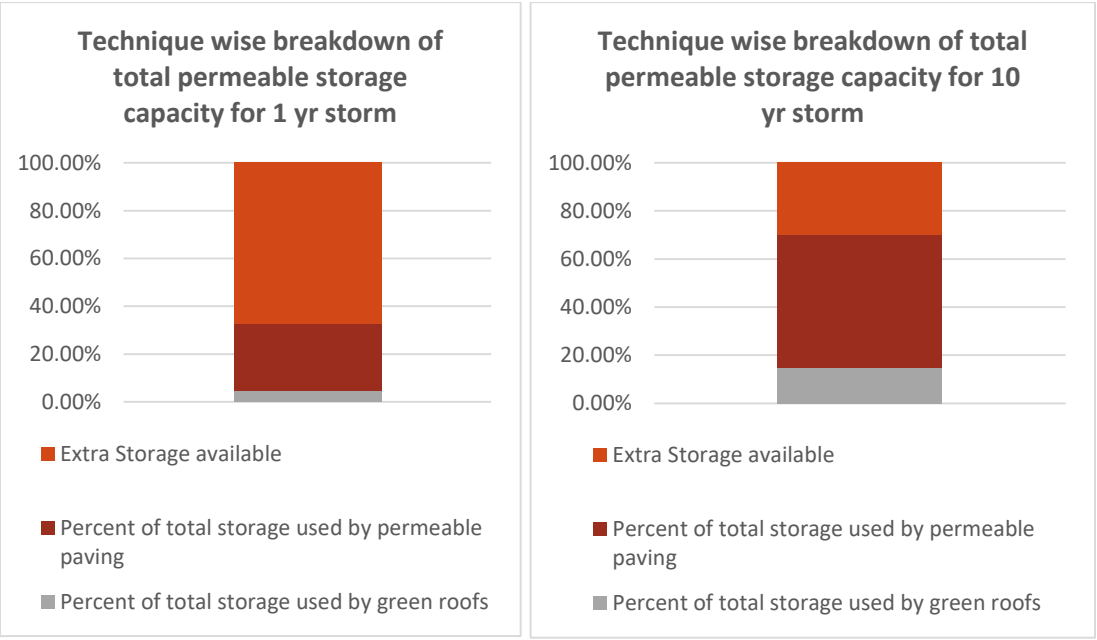

Figure 59: Graph indicating use of total permeable paving storage

Chapter 7 Conclusion

A number of goals and criteria were formulated at the beginning of this thesis and have guided the process. It is essential to reflect upon those goals and discuss the criteria and steps taken to achieve these goals. The first goal was about improving water quality of the Anacostia River. This has been one of the most crucial aspect of this thesis. Criteria of treating at least 1.3'' of stormwater runoff and treating first flush has been addressed by implementing various green infrastructure techniques on site. This site design includes techniques such as permeable paving, green roofs, bio retention and cisterns as discussed in the previous sections. Based on the calculations, these best management practices are also able to retain stormwater from the 1-year storm as well as the 10-year storm. This sets an example for how these techniques could be implemented in various sites along the Anacostia River and ultimately help improve water quality of the River. Further, the design also includes combining stormwater features with recreation. Thus serving different purpose through one solution.

Reviving connection with the urban fabric was the next important goal. People, the city and its connection to the river is highly important to generate awareness and bring about any change. Thus, improving the visual, pedestrian and vehicular access is an important aspect. The visual connection with the other parts of the city such as the Capitol building and the Anacostia River is facilitated through overlooks, outdoor recreational areas, and the riverwalk. The pedestrian experience is improved by limiting vehicular access on the site and connecting to the existing Anacostia Riverwalk Trail that will draw many other users to the site. The design concept strongly takes into consideration the axis with the Capitol and the Anacostia river from the site. Different zones were designated on the site based on this visual and pedestrian connection. A deck is also provided on the second level of building in the shopping and

commercial zone where users can enjoy a view of the surrounding area and the Capitol, thus building the visual connection. A number of different seating and shade areas are design throughout the site to improve the pedestrian experience. A series of gardens designed on site also provides a different experience for users of different age groups.

Sustainable Urbanism is a key theory that guides this thesis, the design follows various principles that support sustainability. This is evident throughout different zones on that site. The ecological zone promotes growth of native habitats while the recreational zone and riverwalk provide access to nature, including mixed use development and ultimately promoting ecological neighborhoods. As identified in the site analysis, currently there is no other existing park within 0.3 mile radius of the site. Hence this site will provide access to nature to the different neighborhoods around. The three key aspects of this thesis are green infrastructure, urban design and connectivity. These aspects work together to set an example of how development can take place through sustainable pratices that also take into account the environmental impact.

Addressing environmental justice and facilitating growth of the local economy are other important goals. These were achieved by designing multiple ways to get to the waterfront from different areas of the neighbourhood, thus keeping the waterfront a public space. Areas such as the commercial and shopping plaza will support a variety of activities such as markets, gatherings and other events that support growth of the local economy and generate opportunities for the communities around. Further, the marina and the recreational activity associated with it will also generate a source of income. Incorporating mixed use development will welcome more people so the use of the site will not be limited the users in the surrounding area or the residential building adjacent to the site. These different activities along the waterfront will help in rebuilding the connection of people with the river.

Ultimately, it is essential to create a space where users that relax and take a break. Hence the design includes places for recreation and relaxation for users of different age groups. These activities not only offer a play space but also promote learning and generate educational opportunities that ultimately improve the waterfront experience. This is incorporated in the learning and play zone where users can learn about the river and other environmental aspects. This will ultimately help generate the awareness that is required to create an impact. The family picnic area, barbeque space, amphitheatre, event space and the boat activity at the marina are examples of different activities designed throughout the site to create areas of recreation and relaxation.

Rivers play a vital role since they are a vibrant ecosystem for many species. People depend on rivers for their way of life and livelihood. Healthy rivers are economic drivers that facilitate growth of communities, businesses and improve quality of life. It is crucial that development takes place in a way that does not harm our environment but creates a balance between our needs and the ecology.

Bibliography

About AWI. (n.d.). DDOT AWI. Retrieved May 14, 2022, from https://www.anacostiawaterfront.org/about-awi

Anacostia Riverwalk Trail. (n.d.). DDOT AWI. Retrieved November 29, 2022, from https://www.anacostiawaterfront.org/anacostiariverwalktrail

Avni, N., & Fischler, R. (2020). Social and Environmental Justice in Waterfront Redevelopment: The Anacostia River, Washington, D.C. Urban Affairs Review, 56(6), 1779–1810. https://doi.org/10.1177/1078087419835968

Buzzard Point Vision Framework and Design Review Guide | op. (n.d.). Retrieved November 29, 2022, from https://planning.dc.gov/publication/buzzard-point-vision-framework-and-design-review-guide

Diemand, M. (n.d.). Our Nation's River: A Troubled Past, A Bright Future. Potomac Conservancy. Retrieved May 12, 2022, from https://potomac.org/blog/2014/6/27/dc-water-troubled-past-bright-future

Drive, M. A. 1900 A., Washington, S. E., & Us, D. 20020 P. 202 472-3884 C. (n.d.). History & Culture—Anacostia Park (U.S. National Park Service). Retrieved April 23, 2022, from https://www.nps.gov/anac/learn/historyculture/index.htm

Ecological urbanism. (2022). In Wikipedia. https://en.wikipedia.org/w/index.php?title=Ecological_urbanism&oldid=1107474360#cite_note-1

Farr, D. (2007). Sustainable Urbanism: Urban Design with Nature. John Wiley & Sons, Incorporated. http://ebookcentral.proquest.com/lib/umdcp/detail.action?docID=822423

Frederick Douglass Memorial Bridge Project | Washington, DC. (n.d.). FDMB. Retrieved April 30, 2023, from https://www.newfrederickdouglassbridge.com

Green, J. (2021, October 26). Washington, D.C.'s 11th Street Bridge Park Nears Final Design. THE DIRT. https://dirt.asla.org/2021/10/26/washington-d-c-s-11th-street-bridge-park-nears-final-design/

Government of the District of Columbia (2010, September). "10 Years of Progress." Anacostia Waterfront Initiative. Retrieved from http://www.capitolriverfront.org/_files/docs/awi10yearprog.pdf

Leakey, R. & Lewin, R. 1979, People of the Lake: Man; his Origin, Nature & Future, Collins, London.

Marshall, R. 2001b, 'Contemporary Urban Space-Making at the Water's Edge', in R. Marshall, (ed.) Waterfronts in Post-industrial Cities, Spon Press, London, pp. 3-14.

March 11, & Turrentine, 2016 Jeff. (n.d.). Healing the Anacostia's Troubled Waters. NRDC. Retrieved May 12, 2022, from https://www.nrdc.org/stories/healing-anacostias-troubled-waters

Michael Van Valkenburgh Associates Inc. (n.d.). Retrieved April 13, 2023, from https://www.mvvainc.com

Monumental Core Framework Plan. (n.d.). Retrieved November 23, 2022, from https://www.ncpc.gov/plans/framework/

Norcliffe, G., Bassett, K. & Hoare, T. 1996, 'The Emergence of Postmodernism on The Urban Waterfront; Geographical Perspectives on Changing Relationships', Journal of Transport Geography, vol. 4, no. 2, pp. 123-134.

Ryckbost, P. (2005, 14). Waterfront Redevelopment. http://websites.umich.edu/~econdev/waterfronts/

Seaport Square Master Plan. (n.d.). Sasaki. Retrieved March 24, 2023, from https://www.sasaki.com/projects/seaport-square-master-plan/

Stream Ecology in the Anacostia Watershed. (2018, February 8). [Text]. https://serc.si.edu/urban-ecology-engagement-initiative-stream-ecology/stream-ecology-anacostia-watershed

The Anacostia River. (n.d.). Retrieved May 12, 2022, from https://www.umass.edu/ecologicalcities/watershed/anacostia.htm

US EPA, O. (2015, September 30). What is Green Infrastructure? [Overviews and Factsheets]. https://www.epa.gov/green-infrastructure/what-green-infrastructure

Washington's big dig aims to clean up "nation's river." (2011, December 28). Reuters. https://www.reuters.com/article/uk-usa-environment-potomac-idUSLNE7BR01S20111228

Yards Park—2013 Urban Open Space Award Winner. (2013, November 7). ULI Americas. https://americas.uli.org/yards-park-2013-urban-open-space-award/