The Development of Swimmable Water Quality in Washington D.C: a Case Study

Exploring the economic, social, and environmental benefits of swimmable urban waters.

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Abstract

The purpose of this thesis is to analyze how Washington D.C can become a swimmable city. Not only improving the water quality for swimming, but also to have a positive social, economic, and environmental impact. The research looks at the history, the current infrastructure, and future plans to determine how swimmable water quality can be best achieved. Desk research was supplemented with a series of interviews with water quality program professionals in Copenhagen and Washington, DC. Field observations and in-person interviews were preluded due to the Covid-19 pandemic. Henrik Lund's Choice Awareness Theory was utilized to present a model for radical change to bring about swimmable water quality for the Potomac and Anacostia Rivers in Washington. Deficiencies were detailed in Washington's current water quality infrastructure. Proposed remedies included additional green infrastructure projects, the reduction of local and upstream pollutants, and community support for these necessary changes. The criteria for the development and location of swimmable sites were outlined. The proposed changes would enhance the quality of life for the residents of Washington, DC and add to the economic viability of the community as well.

Key words: Wastewater treatment, Washington D.C, swimmable, water quality, green infrastructure,

Acknowledgements

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I would like to thank Dr. Larsen for providing helpful insights and constructive comments, as well as being supportive throughout the entire semester. I am appreciative of her flexibility and understanding, especially in these uncertain times. I would also like to thank Mr. Champion, Mr. Clauson-Kaas, and Mr. Dalpra for taking time out of their busy schedules to share their knowledge with me. Lastly, would also I like to thank my family and friends for all of their love and support

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Abbreviations and Acronyms

D.C = District of Columbia

CAT = Choice Awareness Theory

CRIAC = Clean Rivers Area Charge

CSO = Combined Sewer Overflow

CSS = Combined Sewer System

CWA= Clean Water Act

DOEE = DC Department of Energy and Environment

HOFOR= Greater Copenhagen Utility

ICPRB = Interstate Commission on the Potomac River Basin

NPDES = EPA National Pollutant Discharge Elimination System

SDG = UN Sustainable Development Goal

SSS = Sanitary Sewer System

USD = US Dollar

WWT = Wastewater Treatment

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1.0 Introduction

1.1 Urban Waterway Pollution

Cities throughout history have been built along rivers, for commerce, water supply, and travel. Unfortunately, many of these urban rivers and harbors have become known for their extreme pollution. These waterways became and often still are unsightly waste dumps, that are unable to support aquatic plants and animals. Waterways were and are still being used to help dilute pollutants and to have waste products washed away. This issue is only going to get worse as the globe is urbanizing at a rapid rate. Currently, around half of the world's population live in urban areas and it is expected to increase to two-thirds by 2050 (UN, 2021). This population increase will only add to water pollution issues and put more pressure on aquatic ecosystems. The issue of urban water pollution has become a global concern and is a focus of the United Nations Sustainable Development Goals (SDG). SDG 6 targets the sustainable management of water and improved sanitation for all (UN DESA, 2021). Specifically, SDG 6.3 looks to improve water systems and reduce hazardous water pollution (UN DESA, 2021). Reducing untreated wastewater and hazardous pollutants from being released into water helps other SDGs, especially for improving aquatic and human health. Clean water and proper sanitation are considered human rights by the United Nations, but it is still unattainable for millions of people around the world. It is estimated that 2 billion global citizens use a drinking water source that is contaminated with sewage (WHO, 2021). Proper wastewater management is essential to improving human and environmental health, but it is expensive to build and maintain. In high-income countries it is estimated that 70% of wastewater is treated, compared to only 8% in low-income countries (UN, 2017). Not only is it important to treat sewage wastewater, but also the water coming from agriculture and industrial processes. The agricultural sector alone accounts for almost 70% of global freshwater use and is one of the largest sources of water pollution (FAO, 2017). The environmental impacts from these sectors will only worsen, as they try meet the demands of the growing global population.

Climate change has become another factor in the accessibility to clean drinking water and the improvement of global sanitation infrastructure. The changes in global climate patterns are adding pressure to water resource systems. Increasing temperatures and extreme weather events, such as droughts, are creating shortages in global water supply. Freshwater is already in short supply, by 2030 the demand for freshwater is expected to exceed supply by 40% (UNEP, 2016). Water infrastructure can be overwhelmed by stronger rainfall events, flooding, and extreme temperature changes (Lechevallier, 2014). Increased natural disasters can be devastating to water infrastructure, for example power outages can make water treatment plants non-functional. Most of the existing water infrastructure is not built to handle sea level rise or deal with extreme storms, leading to failures of systems even in developed countries (Lechevallier, 2014). Developing countries who are in the process of building or updating their water systems face the challenge of an unpredictable climate. Response to water system failures is remarkably expensive and creates major issues with public health (Howard et al, 2016). If water systems are impacted, people may not be able to get clean drinking water and flood waters can become contaminated with sewage or industrial pollutants. This is especially hazardous in urban areas, as people are reliant on a central infrastructure system, rather than having their own water well and septic systems.

Traditionally cities have been built along or by rivers, harbors, and oceans for many reasons. This is still the case for a significant portion of major global cities, including Tokyo, London, Cairo, and Los Angeles. These cities face immense pressure to supply goods and services to their citizens, who in turn create enormous amounts of waste (Wilson & Velis, 2014). It is difficult for utilities to manage the massive amounts of trash and wastewater that are created daily. People living in urban areas do have higher rates of clean water and sanitation access compared to their rural counterparts, but this figure is highly dependent on socioeconomic status (IHC, 2016). Urban areas have to keep expanding to be able to deal with population growth. In developing nations, it is very difficult for water utilities to keep up with urban expansion. This can lead to big gaps in access, especially in urban areas of Southeast Asia and Sub-Saharan Africa, between high and low-income citizens (IHC, 2016). Clean water and sanitation not only beneficial to human health and the environment, but also improves education and employment opportunities. Healthy people are able to be more productive at work and be able to attend more days of school. Cities around the world need to invest in proper water management infrastructure, as it has huge social, economic, and environmental returns.

1.2 Urban Water Management

Urban water infrastructure has to manage water supply, wastewater, and stormwater in high volumes often with limited space. Water has to be transported from wastewater or drinking water facilities, collected from homes and businesses, and stormwater can be stored or released into nearby surface waters. Water infrastructure is traditionally planned in a large-scale centralized format that is often rigid and inflexible. These systems look to get an output, like greywater, back to a facility, such as a water treatment plant, as quickly as possible to be processed. This requires an extensive amount of piping infrastructure and resources to clean and and move drinking and wastewater. The quality of water management systems is highly dependent on the age and the location of an urban area. Older cities are dealing with wastewater infrastructure that is potentially centuries old and in need of an update.

Most commonly a combined sewer system (CSS) or a sanitary sewer system (SSS) is used in urban water management (OWP, 2008). A CSS combines the sewerage system and urban stormwater drainage in the same piping infrastructure. This means that wastewater treatment plants are not only cleaning and processing sewage, but also stormwater runoff. The excess volume of water can overwhelm a facility and increase costs, along with the potential of system backups. The biggest concern with a CSS is that they can become overwhelmed with stormwater, allowing wastewater to discharge out of stormwater drainage pipes (Tibbets, 2005). Developed regions, including the United States and the European Union have been looking to update CSSs and reduce overflow events in order to improve the quality of surface water (European Commission, 2021). In a sanitary sewer system, wastewater is directly piped from homes and buildings to a wastewater treatment facility. Stormwater is managed independently, using storm sewers, holding tanks, or with infiltration methods. This type of sewer still can overflow, the system capacity is inflexible and can also have maintenance failures (EPA, N.D).

1.3 Barriers for Urban Water Quality

Urban waters have been under immense stress since the formation of cities. They have been used as a way to disperse pollution and take waste products of cities, especially with the rise of industrialization (Haidvogl, 2019). Industrialized harbors and rivers not only have biological pollutants, like sewage, but also industrial byproducts from petrochemicals to heavy metals. Industries, such as mining, manufacturing, and energy production create a multitude of harmful and persistent pollutants (CPI, 2017). Often it can be difficult to determine where pollution is coming from, it can be split into either a point or nonpoint pollution source. A point source of pollution comes from a known discharge point, such as a factory discharge pipe, and can be regulated by environmental laws. Nonpoint source pollution comes from many different places, often picked up by stormwater runoff and is much more difficult to control. Both harbors and rivers have watershed catchment areas, as water is continuously going through the hydrological cycle and back into the ocean. The upstream area or watershed catchment zone increases the surface area and the amount of pollutants going into urban waters. Cities are not able to control the pollution runoff from a watershed if it extends past their jurisdiction.

Urban areas struggle with stormwater runoff, as more land is covered by impermeable surfaces, such as streets, parking lots, and sidewalks. The impact of pollution runoff can be lessened if it is not able to directly flow into surface water. Increasing surface permeability with green infrastructure, including rain gardens, bioswales, and living roofs, can reduce the amount of runoff draining into surface water. Stormwater can also be managed with grey infrastructure, holding tanks or large tunneling systems can be used to reduce runoff and combined sewer overflow events. These updated systems can come at a steep cost, the U.S Environmental Protection Agency (EPA) estimates that updating 31 US cities will cost over 29 billion USD (Kinney, 2016). Many cities around the world don't have the budgetary means or political capital to invest in wastewater and stormwater infrastructure projects.

1.4 Decay of Cities and Urban Waterway Sustainability

Creating clean urban waterways is not only good for the environment, but also has economic and social benefits. Clean rivers and harbors can become sources for drinking water, waterfront areas can be developed into vibrant neighborhoods, and citizens can use the waterfront for recreation. Industrialized cities relied on their waterfronts to support manufacturing and other industries. Waterfronts created an easier way to transport goods and allowed businesses to access water for industrial purposes. Often power stations were placed along rivers or in harbors, so coal and oil ships could make deliveries efficiently (Davidson, 2013). As industries left in the second half of the 1900s, many cities lost their manufacturing base and fell into a decline as a result. Urban areas were able to make an economic comeback in the 1990's, as they moved away from industrialization to service and knowledge-based economies (Voith and Watcher, 2014). To meet the demands of an increased population cities have had to invest millions of dollars to revitalize their urban cores and create attractive waterfront districts (RICS, 2018). Waterfront revitalization has become an important focus as these areas are often centrally located, have a high return on investment, and allow for the creation of public spaces (Davidson, 2013). Cities have to balance out the expensive waterfront developments and businesses with public spaces, like parks or walkways. It is also important for cities to keep some of the cultural aspects of a waterfront. For example, in Washington D.C they developed a neglected waterfront area while keeping its cultural heritage. They brought back the historical name "The Wharf" and preserved the centuries old fish market (DC Wharf, N.D). Keeping historic buildings, getting support from local communities, and supporting small businesses are all ways to create a sustainable waterfront district.

1.5 Copenhagen: Industrial Harbor to Swimmers Haven

One city in particular has been able to turn their polluted post-industrial harbor and canals into clean and swimmable recreation areas. Copenhagen, the capital city of Denmark, has made a huge effort to get the urban water quality to swimming safe levels. This city has been settled since the 11th century and has been an important point of commerce and government for Denmark. Copenhagen, like many other industrialized cities, was having its industries close down or move away leading to an economic decline (Noring and Katz, 2017). The city invested millions of dollars into public transportation, developed new neighborhoods, and restructured their port (Noring and Katz, 2017). Industrial waterfront neighborhoods, like Sydhavn, became a focus of urban revitalization. The city had to encourage residential and business development with amenities such as public transport and a swimmable harbor (City of Copenhagen, N.D).

Up until the mid 1990's Copenhagen was having wastewater discharge into the harbor, which made both swimming and fishing illegal (Bloomberg, 2015). The Greater Copenhagen Utility, known as HOFOR, took steps in the mid-1990's to improve the harbor's water quality. Not only was wastewater discharge an issue for HOFOR, but also industrial waste, oil spills, and high levels of algae (SOG, 2015). Over 440 million USD was spent to update the sewer systems, develop overflow barriers, as well as create underground water storage (Bloomberg, 2015). These underground tanks are able to hold stormwater after a heavy rain event, in order to prevent it from overwhelming the sewerage system. Green infrastructure was built, along with unique aboveground stormwater holding areas in parks and playgrounds. The city also had to remediate the soil around the harbor or place aluminum sheeting to prevent leaching into the water (Clauson-Kaas, 2021). By 2002, Copenhagen's Inner Harbor was clean enough for the first harbor bath to be built off of the Islands Brygge neighborhood (SOG, 2015). The harbor water is checked continuously to ensure that bacteria levels are at a safe level for swimming, as it is still possible for wastewater to discharge after heavy rainstorms (Clauson-Kaas, 2021). There is a system that constantly monitors the underground structures and will alert if wastewater gets into the harbor (SOG, 2015). Copenhagen has been able to reduce the discharge of wastewater from 1.6 million cubic meters in 1996 to 350,000 cubic meters in 2017 (City of Copenhagen, N.D). The harbor also has reduced levels of heavy metals, suspended solids, and biological oxygen allowing aquatic plants and animals to thrive (City of Copenhagen, N.D). The city still has to remediate the polluted harbor sediment and actively adapt to extreme weather events caused by climate change. Copenhagen is an excellent example of waterfront revitalization and the ability to go from a polluted, industrial harbor to a safe and swimmable one.

1.6 American Waters

The United States, like many other industrialized nations, is facing a multitude of water management issues, from cleaning up toxic industrial pollutants to updating centuries old sewerage. Up until the passage of the Federal Water Pollution Control of 1948, little was done to control the industrial and wastewater pollution (ACWI, 2015). Public health was a leading reason for federal intervention, as water-borne illnesses were on the rise in the 1900s. The environmental impact from industrial pollutants, fertilizers, and acidification led to the passage of the Clean Water Act (CWA) in 1972 (NOAA, N.D). This bill had more regulatory power than its predecessors, as it created the National Pollution Discharge Elimination System (NPDES) and required municipalities to better manage their wastewater (ACWI, 2015). The NPDES requires that any point source pollution going into surface water will need a permit to do so. The CWA does have its limitations, it is unable to control nonpoint source pollution and has exemptions for agricultural runoff and stormwater (EPA, N.D). Wastewater overflows and stormwater runoff have been major barriers for swimmable and safe surface water quality in American cities.

Washington D.C has long been struggling with the water quality of its two rivers, the Anacostia and the Potomac. The city's first water infrastructure was built in 1810, in order to drain storm and ground water off the streets (DC Water, 2021). However, this was not a connected system, nor did it treat wastewater. It was not until after the American Civil War and the subsequent urban population increase that a sewer system was developed. In the early 1870's the Board of Public Works built an estimated 80 miles of sewers, but it was found to be poorly planned and even structurally unsound (DC Water, 2021). Much of the sewage flowed into above-ground canals and was discharged into the nearby marshes. By the late 1800s, the noxious canals were moved underground, and a rudimentary combined sewage system was built (Washington Tunnels, 2021). First wastewater treatment plant, Blue Plains, was built in 1938 with a capacity of 130 million gallons a day, almost 150 years after DC's founding (ICPRB, 2021). By 1957, the United States Public Health Service announced that the Potomac River was unsafe for swimming (ICPRB, 2021). Water contact sports were banned in the Anacostia and Potomac Rivers by the D.C Council in 1971, one year before the CWA was passed (ICPRB, 2021). In 2005, Washington D.C had one of its largest infrastructure projects, since building the Metro, to update and upgrade the sewerage system (Rycerz et al, 2020). The project, known as the Clean Rivers Project, will invest 2.6 billion dollars in sewerage infrastructure over 20 years (Rycerz et al, 2020). Currently, the Blue Plains Wastewater Treatment Plant has become one of the largest of its kind and on average treats 384 million gallons of wastewater daily, with a capacity of one billion gallons/day (DC Water, N.D). Even with these upgrades, an estimated 2 billion gallons of mixed waste and stormwater discharges into D.C's rivers each year (Rycerz et al, 2020). Swimming is still illegal in Washington D.C, however in 2012 the rules changed to allow permitted swimming events, like triathlons, if the water quality meets safety requirements (DOEE, N.D). The release of wastewater, stormwater and upstream river pollution make the city's rivers unsafe for swimming and other contact recreation.

2.0 Scope

2.1 Problem Formulation and Research Questions:

1) How can Washington D.C achieve the status of being a swimmable city?
   a) What changes would be necessary to create a swimming area, and how could this be achieved?
   b) Where could public swimming areas be placed for the best socio-economic benefits?

3.0 Theory

3.1 Choice Awareness Theory

In this chapter, the choice awareness theory (CAT) can be used to determine what the barriers are to improved urban water quality in Washington D.C. Although choice awareness theory is mostly associated and used in studies of the energy sector, as it was first introduced by Lund in *"Renewable Energy Systems"* (Lund, 2014). This theory looks to understand and analyze why better alternative choices are not made. Lund argues that public participation is important aspect to making sustainable decisions, as it creates an awareness of alternative choices. The theory separates choice into true and false. A true choice has at least two or more actual options, while a false choice is simply having the illusion of options (Lund, 2014). The second part of the theory, awareness, requires a person to be cognizant and able to understand the different options. CAT is focused on utilization of radical technological change, which is defined as a "change of more than one of the four elements of technology" (Lund, 2014, 7). The four elements of technology are technique, knowledge, organization, and products, while profit can be considered as a fifth element. There is a heavy focus on organization, as organizations and institutions are often responsible for maintaining the status quo and have a different perspective compared to individuals. Lund states that radical technological changes should not be initiated by organizations linked closely to the existing system (Lund, 2014). Choice awareness should not only focus on the organizations, but society as a whole, it is important to include stakeholders with different perspectives.

In the case of Washington D.C. radical technological change implies shifting the paradigm of traditional water management to an integrated system, in order to bring the water quality to swimmable levels. As well as including improved stormwater management. It is argued to be radical, since it involves a change in existing infrastructure and the extent of water quality management. There is also a required shift in thinking, from the idea that pollution problems should only be fixed with more conventional methods, such as grey infrastructure or chemical/physical remediation methods. Methods based on natural processes, like green infrastructure and bioremediation, can prove to be just as effective and create less potentially toxic byproducts. Radical technological change doesn't always mean reverting to high-tech and expensive methods, but something that is unconventional, yet still effective. The paradigm of water quality management has had to shift from a singular, more definite solution, like improving wastewater treatment, to a more holistic, systems approach. This thesis will demonstrate the utility of the CAT in planning the remediation of the water quality deficiencies in Washington D.C.

4.0 Methodology

The following chapter explains which methods were used to answer the research questions in this report.

4.1 Research Design

4.1.1 Case Study

In this report, Washington D.C is used as case to determine the barriers for the creation of urban swimmability, along with the potential benefits. Copenhagen, Denmark was used as an example of a successful urban waterfront revitalization in a post-industrial city. A case study creates detailed and in-depth knowledge about a specific setting in order to best answer the research questions (Flyvbjerg, 2006). It was found as the most appropriate research design, as this thesis is looking to determine the possibility and process of improving urban water quality to swimmable standards in Washington D.C. Although knowledge produced in case studies is usually considered to be nonreplicable, Flyvbjerg argues that: *"(...) it is incorrect to conclude that one cannot generalize from a single case. It depends on the case one is speaking of and how it is chosen" (*Flyvbjerg, p. 225, 2006*).* This city is not unique in this issue, there are many cities in the United States that are struggling to update their water infrastructure and improve water quality to the standards of Clean Water Act. This idea of improving urban quality to swimmable standards was uncommon but has become a popular concept in many post-industrial cities. Based on Flyvbjerg's case selection strategies, an information-oriented case was chosen to make the most of out of a single case (Flyvbjerg, 2006). It would be categorized as a paradigmatic case, looking to change the current paradigm and preconceived notions of urban water management.

4.2 Qualitative Research

The qualitative research methods that were used are explained in this section.

4.2.1 Desk Research

Empirical data for this report is complemented with desk research. Research material was often selected from the Aalborg University (AAU) Library database and from key organizations themselves, including DC Water, the DC Department of Environment and Energy, and the US Environmental Protection Agency. Keywords used in the process of finding articles in the database included: wastewater, green infrastructure, urban pollution, Potomac River, Anacostia River, swimmable, and water quality. Quantitative data was found through desk research, including water quality numbers, depth charts, and project costs. Additional sources were also sent via email after an interview was complete, in order to fully round out the information given.

4.2.2 Interviews

The aim of the interviews was to obtain context-based information of the process of creating a swimmable harbor in Copenhagen and to have better understanding of the barriers of swimmable water quality in Washington D.C. All of the interviews were semi-structured, to allow interviewees to speak from their own perspective and share additional knowledge that may have not been picked up from the questions. An interview with Copenhagen's greater utility service, HOFOR, was important to determine how they were able to clean up their harbor and how locations were selected to be swimming areas. The interviews with the DC Department of Energy and Environment (DOEE) and the Interstate Commission on the Potomac River Basin (ICPRB) were helpful to fill in any gaps from the desk research and discuss the future of swimming in Washington D.C. Interviews covered main themes including water quality issues, environmental policy, contaminates of concern, stormwater, and parameters for swimming locations. The interview questions are in Appendix I, all interviews were done over the phone or via Microsoft Teams.

Name	**Company**	**Interview Style**	**Date**
Jes Clauson-Kaas	**HOFOR**	**Microsoft Teams**	**May, 2021**
Jonathan Champion	**DOEE**	**Phone**	**May, 2021**
Curtis Dalpra	**ICPRB**	**Phone**	**May, 2021**

4.3 Limitations

It is important to recognize that there were limitations over the course of this project. The lack of in person communication due to COVID-19 reduced interaction with faculty, supervisors, and peers. This was also limiting to the ability to tour facilities and interview people in person. To improve the social aspect ideally it would have been beneficial to interview local citizens and business owners. There was a limitation on collecting firsthand data without access to a water quality lab, along with the shorter duration of the study. This limitation was further compounded by the fact that water quality data is not collected year-round, nor daily so it has to be based on the weekly sample collections during the summer and early autumn by the Anacostia Riverkeeper volunteers. While acknowledging these limitations, the analysis for this thesis remains a viable option for further research.

5.0 Site Analysis

5.1 Washington D.C

Washington D.C, the capital district of the United States, is 157 square kilometers with a population of 700,000 people (US Census, 2021). The District was formally founded in 1790 and was planned to be a modern city, with European inspiration. It is bordered by Maryland and Virginia, creating one of the largest metropolitan areas in the country with 6.2 million residents (Census Reporter, N.D). The district is cornered by two rivers, the Potomac and Anacostia, and is quite flat and low-lying, which has given its nickname "The Swamp". Washington D.C is unique in the fact that they do not have federal representation and must get congressional approval for budgets and new legislation. The local government has a mayor, a 13-member council, and its own court system (D.C Chamber, N.D). The mayor oversees the congressionally set 8.8 billion USD budget to run city services and the public school system (D.C Chamber, N.D).

Demographically, the city is 46% White, 46% Black, 11% Hispanic, and 4.5 Asian, with a median household income of 86,000 USD (US Census, N.D). The population is highly educated, with more than 50% of people having a bachelor's degree or higher (US Census, 2020). The city has increased in population by 100,000 people in the past ten years and has become more racially diverse (US Census, N.D). This increase in population and density creates additional pressure on water infrastructure, as well as impacts from land use change. The city is pushing for denser developments and is converting industrial and underdeveloped areas to create more housing. In 2020, D.C approved the Comprehensive Plan, which is a development plan for the next 20 years (Schweitzer, 2021). It aims to increasing housing density, affordable housing, and to create cross-system infrastructure, but it has been viewed with the potential of increasing gentrification and social inequality. Still, it is not considered to be a very dense city, with around 9,900 people per square mile, compared to a city like New York with 26,000 people per square mile (US Census, N.D). The District has plenty of potential for sustainable development, from creating walkable and affordable neighborhoods to green infrastructure.

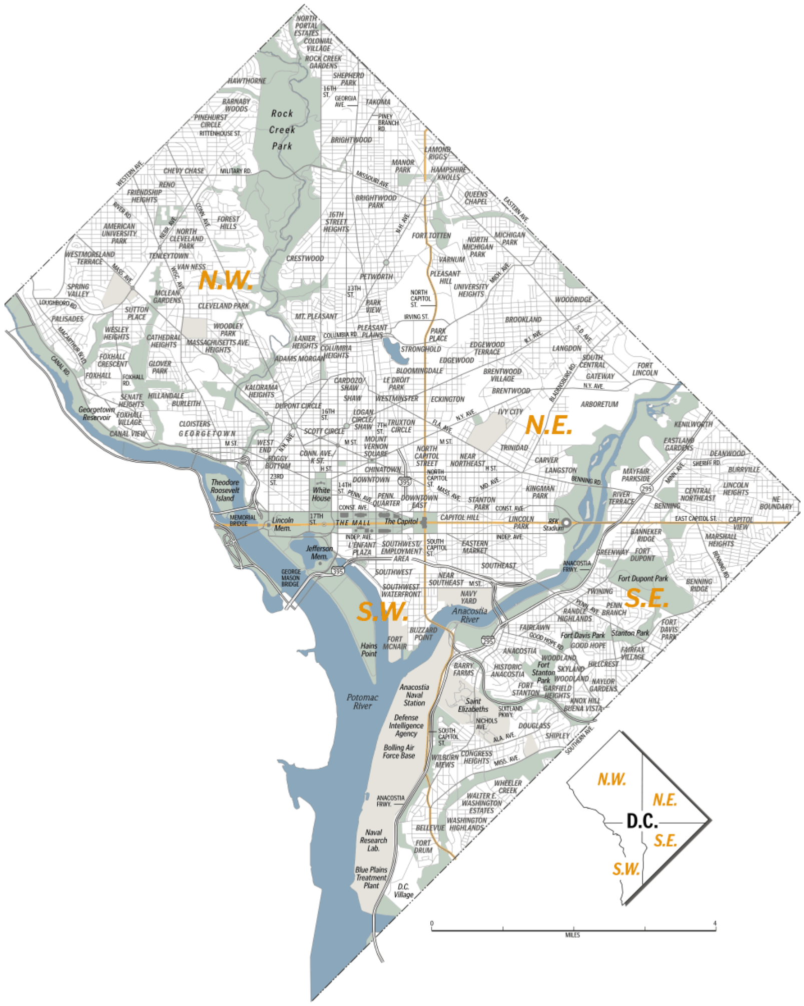

Figure 1. Neighborhoods of Washington D.C.
Source: Washington Post

5.2 Social Issues in Washington D.C

Although Washington D.C is a diverse city, it is still quite segregated and has high levels of income inequality. A 94% of majority white neighborhoods have less than 10% of the population under the poverty line, compared to 22% of majority black neighborhoods (Butler and Grabinsky, 2015). The economic and racial divide is still very prevalent, the wealthier and predominately white neighborhoods are largely in the northwest part of the city. Areas below the Anacostia River, known as Southeast, has stayed segregated, as more and more parts of the Washington D.C are being redeveloped. This section still lacks access to quality healthcare providers and has limited public transit options (Reff, 2020). Social inequality leaves behind a portion of society from being able to enjoy the new urban revitalization amenities. These amenities can include full size grocery stores, health care providers, and safe recreation areas. These urban improvement projects benefit those who can afford it, often people who are young, white, and well-educated (Nijman and Wei, 2020). People aged 18-34 make up more than a third (35%) of D.C's population, compared to 23% of the U.S. population. New developments, including Nationals

Park, the Wharf, and the Navy Yard are displacing low-income and minority residents. Referencing Figure 1, these three developments are all located in the Southwest quadrant in the city. In comparing Figure 2 and Figure 3, the largest change looks to be occurring in Southwest section of Washington D.C. Southwest has had its median household income nearly double in 10 years, from 230,000 to 417,000 USD in 2019 (Brown, 2020). Its population doubled between 2000-2016, while low-income households and the percentage of black residents fell (Brown, 2020). Urban revitalization can only be successful if it is inclusive of local residents and can be accessible to people of varying socio-economic status.

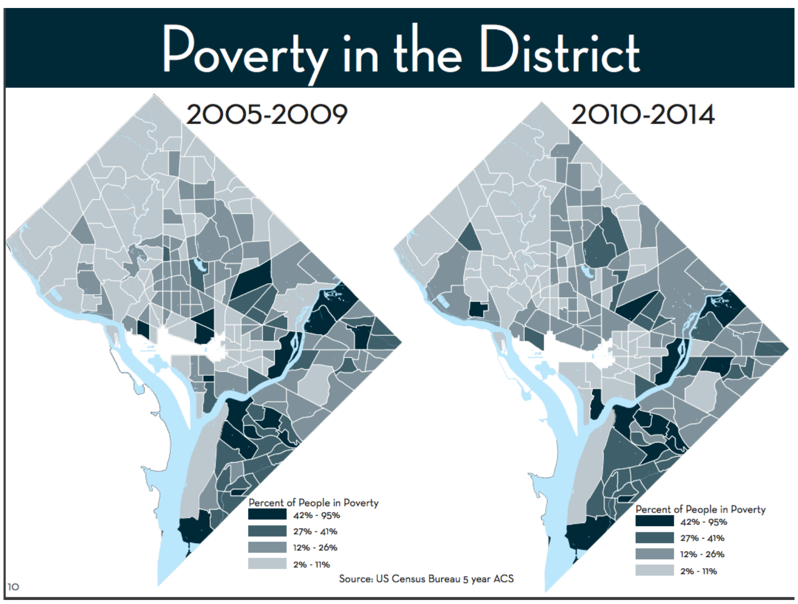

Figure 2: Shifts in Poverty in Washington D.C

Source: D.C Office of Planning

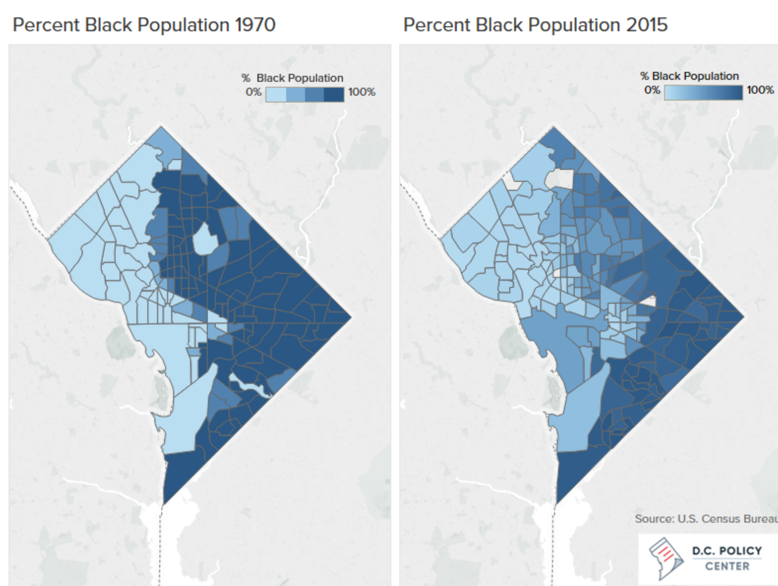

Figure 3: Changes in Racial Demographics in D.C

Source: D.C Policy Center

5.3 Geography and Climate Impacts in Washington D.C

Washington D.C is in the Mid-Atlantic region and has a temperate four-season climate. It is known for its hot and humid summers and mild winters. Nearly one-quarter of the city is covered in parkland or other open spaces (NCPC, N.D). The parks and open spaces are not only beneficial for stormwater management, create places for people to recreate, and are often popular tourism destinations. The city is part of the Potomac, Anacostia, and Rock Creek watersheds which span over 5 states, shown in Figures 4 and 5 (DC Water, N.D). D.C water quality is impacted from agricultural, industrial, and municipal wastes from upstream areas miles away. These watersheds, especially the Anacostia, are densely populated and are rapidly urbanizing. The Anacostia compared to the Potomac River, has higher bacteria, dissolved oxygen and turbidity levels (Calma, 2020). 43% of the samples taken from the Anacostia River did not meet the District's water standards (Calma, 2020). The increased urbanization, both in the city and the surrounding suburbs, has the biggest impact on water quality. Development in the DC Metropolitan area has doubled from the 1980s, the annual rate of expansion has gone from 6 to 12 kilometers (Metcalfe, 2016). The urbanization can be visualized with Figure 6 and Figure 7, showing the intensification of development in the District and along travel corridors. This development intensification of the surrounding suburbs impacts D.C both directly, as inputs into their wastewater treatment system, as well as indirectly as stormwater runoff.

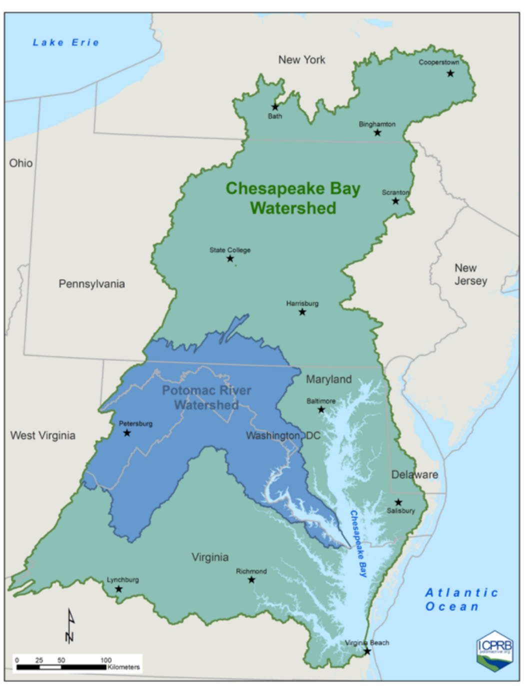

Figure 4. Potomac River Watershed
Source: ICPRB

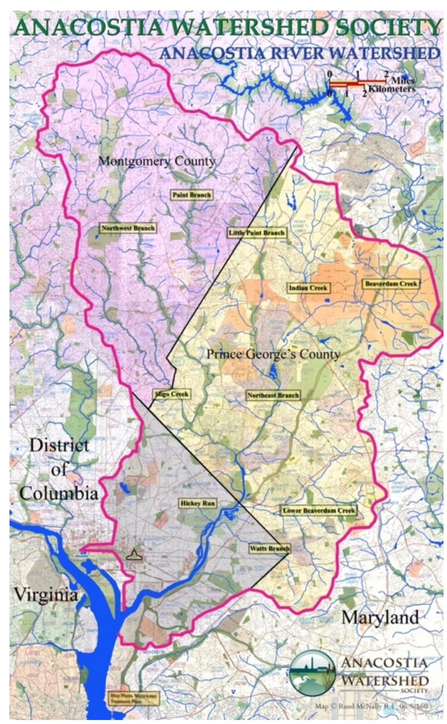

Figure 5. Anacostia River Watershed
Source: Anacostia Watershed Society

Climate change is already having an impact on Washington D.C. The city is experiencing increased extreme heat days, longer heat waves, and a higher annual average temperature (DOEE, N.D). These extended heat waves can be detrimental to vulnerable populations, such as the elderly or homeless. The district is not experiencing much of an increase in annual precipitation, but it is shifting seasonally, with more rain in the fall and winter instead of the summer (DOEE, N.D). More extreme weather events, from flash floods to snowstorms, have become more common, and are creating increased stormwater pollution. By 2050, a once considered 100-year storm could become a 25-year storm, making it difficult to plan for a maximum stormwater capacity (Fenston, 2019). Even though the city is not on the Atlantic Ocean, its two tidal rivers, the Anacostia and Potomac, are influenced by the ocean and will be impacted by sea level rise. Both rivers have increased by 11 inches in the past 90 years (DOEE, N.D). It is estimated that D.C will an additional 3.4 feet of sea level rise by 2080 (DOEE, N.D). This will put additional pressure on the sewage and stormwater infrastructure, they can be overwhelmed by heavy rainfall or flooding.

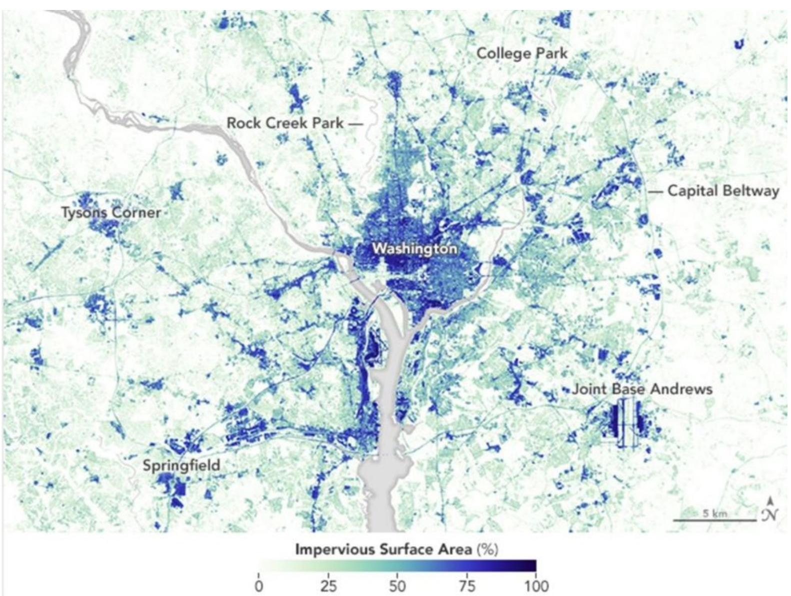

Figure 6. Impervious Surface Area in 1984
Source: NASA

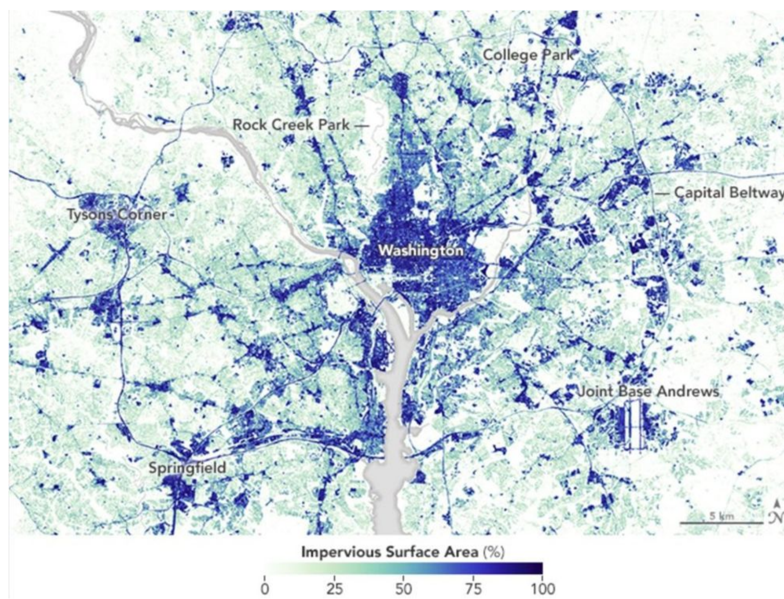

Figure 7: Impervious Surface Area in 2010
Source: NASA

5.4 Current Situation

Washington D.C has been spending enormous amounts of money to improve the water quality of the Anacostia and Potomac Rivers. As mentioned in the Introduction, its main wastewater treatment plant (WWT), Blue Plains, treats on average 384 million gallons of wastewater for 1.6 million people living in Washington D.C and the surrounding suburbs shown in Figure 8 (DC Water N.D). Two-thirds of the city have separate wastewater and stormwater sewerage, while older parts of the city still have combined sewers (EPA, 2017). Within the District there are 1,800 miles of sewers, multiple stormwater and wastewater pumping stations, and 22 flow metering stations (EPA, 2017). It has two permitted outfall points, both into the Potomac River, one for fully treated wastewater and the other discharges primary-treated water to prevent system overloads if needed (EPA, 2017). Most recently, Blue Plains WWT has been upgraded to improve its circularity, including a thermal hydrolysis process to treat sludge and a combined heat and power plant to be more energy efficient (DC Water, N.D). The cogeneration plant has reduced the facility's energy use by a third and it is able to sell the Class A biosolids as agricultural fertilizer (DC Water N.D.). The facility also has added an anerobic digester to create biogas that can be used to power plant operations. Blue Plains WWT has had to improve its nitrogen and phosphorous removal to better comply with its federal NPDES permit (EPA, 2017).

Figure 8. Blue Plains WWT Service Area. Source: DC Water

The Blue Plains WWT plant is only able to improve its own treated wastewater discharge, not reduced combine sewer overflow events. The Clean Rivers Project was developed to reduce CSO overflow volume by 96% by 2025 with a combination of grey and green infrastructure. The project is a legally-binding agreement with the US Environmental Protection Agency (EPA). For grey infrastructure, the city planned to build 18 miles of large underground tunnels that can function as holding areas to reduce CSO events. The first tunnels were completed in 2018 and have reduced overflows by 89% to the Anacostia River (Fenston, 2021). The Northeast Boundary Tunnel, shown in Figure 9, is expected to be completed by 2023 and will divert sewage and stormwater to Blue Plains, cutting overflows in the Anacostia River by 98% (Fenston, 2021). The Potomac River Tunnel is proposed to start construction in 2023 and reduce combined sewer overflow to the Potomac River seen in Figure 3 (DC Water N.D). Green infrastructure was not in the original plan but was added later as a way to cut costs. DC Water halted the construction of 7,500 ft of storage tunnels for Rock Creek Park, estimated to cost 237 million USD and replaced it with a 90 million USD green infrastructure plan (Kenyon, 2014). Rock Creek Park is Washington D. C's largest greenspace and is twice as large as New York's Central Park, making it an ideal stormwater catchment area (Figure 10). This first green infrastructure plan, known as Rock Creek Project A, developed 160 facilities over 163 acres to retain the volume of 1.2 inches of rainfall (NCPC, 2016). This design included permeable pavement for parking and alleys, as well as bioretention on traffic strips and extended curbs (NCPC, 2016). Rock Creek Project B is still being finalized and is expected to finish construction by 2022 (DC Water, N.D).

To mitigate the increase in impervious surfaces and offset the projects costs DC Water put the Clean Rivers Area Charge (CRIAC) in place (DC Water, N.D). Residential single-family homes pay from a tiered system based on square footage, while non-residential users pay by the total amount of impervious surfaces on their lot (DC Water, N.D). They have also included support for low-income customers who may already struggle to pay for their water bill. DC Water considers any surface that cannot be easily penetrated by water an impervious surface, including patios, tennis courts, covered areas, and swimming pools. CRIAC has been justified as a way to fund the 2.6 billion USD needed for the Clean Rivers Project (Hawkins and Wells, 2017). The DC Department of Energy and Environment (DOEE) has its own stormwater fee based upon the amount of impervious surfaces on a property (DOEE, N.D). Both fees are approximated using Geographic Informational Systems (GIS) analysis and flyover image data (DOEE, N.D). Residents can reduce their CRIAC and Stormwater Fee by installing their own green infrastructure, including green roofs, permeable pavement, and rain gardens. DC Building Codes requires that large new or renovated developments have to manage a set amount on stormwater on location (Champion, 2021). The District also has a 5-cent tax on disposable bags, the collected revenue goes to the Anacostia River Clean Up and Protection Fund (DOEE, 2020). To further reduce trash pollution, DC has also banned single use polystyrene (Styrofoam) food containers, plastic stirrers, and plastic straws (DOEE, 2020). Even with billions spent on improved waste and stormwater management, the District still has a way to go before their rivers can be swimmable and fishable.

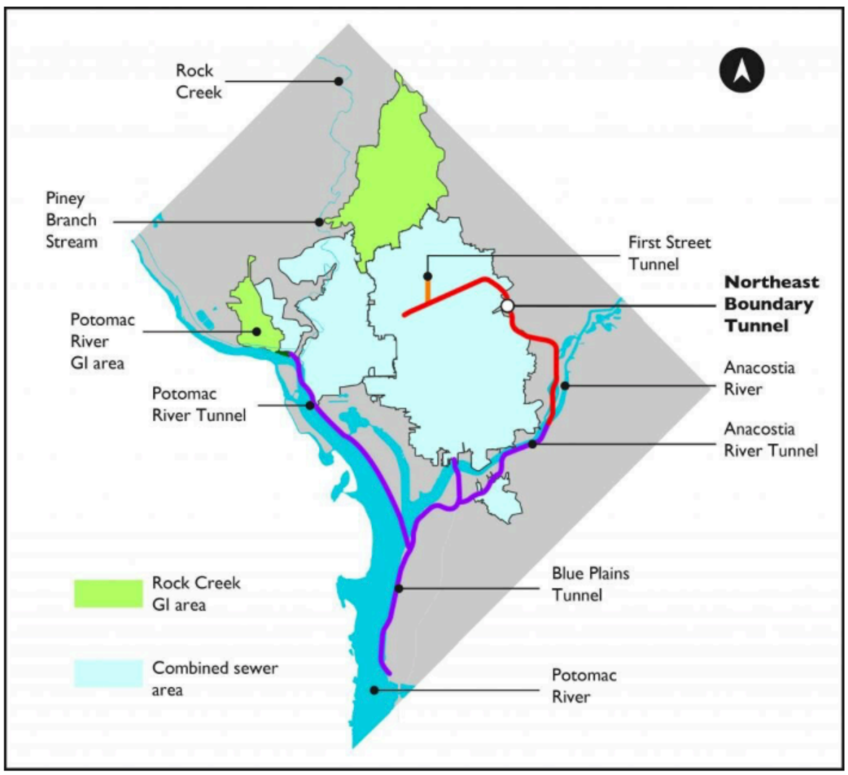

Figure 9. Clean Rivers Project Tunnels.

Source: DC Water

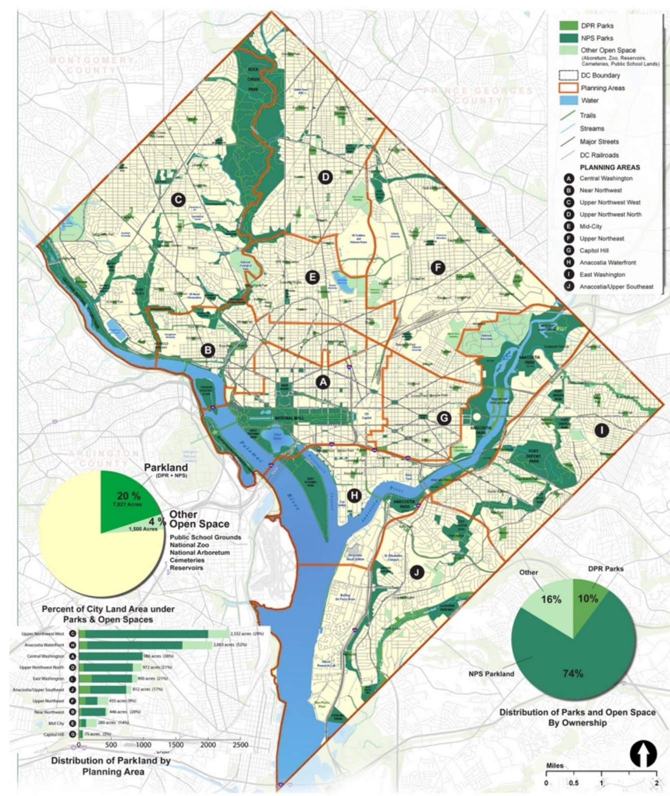

Figure 10. Parks and Other Open Spaces in D.C.
Source: NCPC

5.5 Swimming Location Parameters

Creating designed swimming areas will require an important set of parameters. Potential locations will not only require safe water quality levels but should also have positive social and economic impacts. In Copenhagen, they located their swimming areas away from combined sewer overflow outlets and be deep enough to keep swimmers away from the bottom sediments. They also chose underdeveloped neighborhoods, like Islands Brygge, which has been advocating for public waterfront development, rather than all private homes and businesses (Clauson-Kaas, 2021). A minimum depth of 9 feet would be recommended, it is considered a safe diving depth by the American Red Cross. It is important for these sites to have continuous water quality monitoring to ensure that bacteria levels are safe. Currently, the DOEE has two public continuous monitoring sites, one on each river, which can be checked online. The DOEE also has a monthly monitoring program in place at main stems of both rivers and Rock Creek (Champion, 2021). In the summer months the testing increases to 5 samples weekly for E. coli (Champion, 2021). Volunteers from local non-profits, like the Anacostia Riverkeeper, take water quality samples in the summer months. Tissue samples from fish are taken every two to three years and are tested for pollutants like heavy metals, chemicals, and fertilizers (Champion, 2021). This is important to see how pollutants are bioaccumulating in the ecosystem, as there is still little known about effects of short-term exposure with these contaminants. The District follows the US EPA's recreation water quality standards which recommend an E. coli geometric mean limit of 126 cfu /100 ml, a pH value between 7-8, and low turbidity (DOEE, N.D). A geometric mean limit is an average of at least 5 samples over a 30-day period, it better represents overall water quality compared to single day data (Fishtahler, 2020). E. coli values have been seen as one of the most important water quality parameters, as it has a direct negative impact on human health, both with skin contact and ingestion. Water that is too acidic or basic can cause irritation or harm to both the skin and eyes (DOEE, 2021). Low turbidity is especially important in Washington D.C, as the suspended sediments could contain legacy chemicals from industrial processes. Having clear water is important for safety, to ensure that people can be seen if they are having a difficult time swimming.

In Washington D.C the two rivers are shallow along the banks, so either sediment remediation or sites further from the banks will be needed. The Anacostia River Sediment Project from the DOEE has studied the sediments and found elevated levels of contaminants like PCBs, PAHs, heavy metals, and pesticides (DOEE, N.D). They have not implemented a clean-up strategy yet, but have identified three hot spots, Pepco Power Facility, Washington Gas Station, and the DC Navy Yard (DOEE, 2019). Other areas of concern are the 47 CSO outfall points in the District, but they really only of concern after a heavy rainfall (DC Water, N.D). Swimming points should ideally be distanced from marinas, or other areas with heavy boat traffic to prevent any accidents. Some parts of the Potomac River can have strong undercurrents, while the Anacostia River is known for its slow-moving tide (Turrentine, 2016). The Anacostia's slow currents have led to its high-pollution levels, but it may be beneficial for swimmers once the water quality is improved.

Having a great swimming area won't be important if people are not able to easily access it. Ideally it would be assessable by public transport and be close to shops and restaurants. Creating a neighborhood feel, where anyone can come to swim and spend the afternoon would be ideal. Anyone from any neighborhood or socioeconomic status should be able to come swim and not feel out of place or unwelcome. An attraction like a swimming area would likely boost the surrounding neighborhood, as people could spend money at locally owned businesses. The economic boost of a swimming area could potentially help offset the costs of the new infrastructure or remediation efforts. Having accessible swimming areas will also create another way for people to recreate and exercise, which can improve mental and physical health. The neighborhoods around the Anacostia River have long been underdeveloped and underserved would likely benefit the most environmentally, socially, and economically from having swimming areas built. These swimming locations should meet the EPA recreational water quality guidelines, have enough depth for diving, be distanced from CSO outfalls and boat traffic, as well as be accessible by public transport. The District still needs to improve in areas like monitoring and soil/sediment remediation before swimming areas can be built.

6.0 Changes/ Solutions

6.1 Technological Changes

Lund's choice awareness theory, as outlined in his book*, "Renewable Energy Systems"*, conceptualizes a means for the implementation of the needed political and social support for the necessary changes in technology. He puts forth the idea that the belief that choice among options for technological change is essential. The belief that there is no choice is put forth by organizations or groups seeking to maintain the status quo. He states that it must be made clear that there is choice to allow radical change through the implementation of technology. If the water quality of the Potomac and Anacostia Rivers is to be made swimmable, there must be the belief that such a choice to act is possible. Also mentioned in the CAT, is that a change in one or more elements of technology is needed to make an impact. Washington D.C has made major improvements in their river's water quality by investing in their wastewater and stormwater infrastructure. Fixing the wastewater treatment plant and improving stormwater collection exposed the other sources of pollutants, as they were always seen as the reasons for the poor water quality in Washington D.C's rivers.

The other two of the four major water quality impacts, contaminants and upstream pollution, will need their own solutions (Champion, 2021). Often the hardest part of any project is getting from good to great, so determining what steps D.C will have to take to have swimmable water quality may be the biggest challenge. In the interview with Mr. Clauson-Kaas from HOFOR, he stated that Copenhagen had to invest in their wastewater treatment systems and create stormwater holding areas. The implementation of a continuous monitoring water quality system was seen as one of the most important factors. Washington D.C has two continuous monitoring sites and takes samples weekly in the summer months. An improved monitoring program could help the District pinpoint areas of concern and apply needed mitigations efforts in that area. An improved monitoring system could also use a change in organization. Instead of the DOEE being responsible for the entire program they could contract out like HOFOR has done or distribute responsibilities to the local environmental groups. HOFOR has had DHI, a Danish engineering consultancy, develop a continuous monitoring system that produces easily accessible real-data to users, as well as create models to forecast pollution and flooding (Clauson-Kaas, 2021). That would be a positive change in knowledge, it could be used to develop a more flexible and precise water quality program. As for upstream pollution, there have been watershed policy efforts between the local governments. The Anacostia River Watershed is only Washington D.C and two counties in Maryland, so it would be more manageable compared to the larger Potomac River Watershed. This densely populated watershed created a restoration plan in 2010 with a goal to improve aquatic habitats for fish and invertebrates (USACE, N.D). It can be difficult to place responsibility on polluters, especially if it is coming from a non-point source. A change in organization would be needed, one that places responsibility not only on governments, but the people and industries that are polluting. Washington D.C is very close to having its rivers be swimmable and fishable, but it will require technological change to get to that point.

6.2 Solutions

Working backwards from improved data collection could also help determine what stormwater systems are working best. It would decentralize the stormwater system and put more reliance on well-placed green infrastructure. It is expensive to treat wastewater to meet its discharge requirements, while stormwater doesn't need as extensive of a treatment. Stormwater does carry pollutants, but they could be filtered as the water percolates into the soil using green infrastructure. Increasing green infrastructure projects would help save time and money, less water at the treatment plants and fewer grey infrastructure projects to build.

Knowing which points are most affected could aid in the soil and sediment remediation programs and prevent overspending. Select areas could be capped with a solid or biological cover, rather than dredging most of the Anacostia River. In Denmark they used aluminum sheeting along the banks to prevent contaminated soil from getting into the harbor (Clauson-Kaas, 2021). Improving the banks with a biological cap, like a carbon layer, along with the restoration of the wetlands would bring back ecosystem services. 90% of the Anacostia River's wetlands have been destroyed or removed by increasing development and urbanization (DOEE, N.D). Wetlands are great filters, help catch and settle sediments, increase biodiversity, as well as reduce the impact of flooding (EPA, N.D.). American cities like New York and Philadelphia have been restoring wetlands to not only improve the ecosystem, but to help mitigate the impacts of climate change.

In regard to swimming, bacteria levels are one of the major concerns due to its direct impact on human health. This focus goes towards the point source of bacterial pollution which is from combined sewage overflow. There are other non-point sources of bacteria, like pet and wildlife waste. Pet waste, mostly from dogs, was mentioned as a source of E. coli in both Copenhagen and Washington D.C. The district already has fines in place, but improved pet waste infrastructure like more trash cans and bag stations could increase compliance. It would also be beneficial to increase awareness of the environmental harm of pet waste with signs at pet stores, dog parks, and other popular pet spots. Waste from wildlife is much more difficult to control, but population control efforts on the deer in the district is not only good for water quality, but for the park's ecosystem. Likely the best solution will be time, with the 98% reduction in CSO events with the completion of the Clean Rivers Project in 2025.

6.3 Ideal Swimming Locations

The physical parameters outlined in Section 5.5, including public transport, contaminated areas, boat yards and monitoring sites are shown in Figure 11. The red points represent the contaminated sites of concern, the blue boats icons are marinas, grey icons for metro stations, and the purple point is the DOEE continuous monitoring station. The other two important parameters, depth and water quality are shown in Figure 12/13 and Figure 14. CSO outfall points on the Anacostia River are shown in Figure 15. The Anacostia River is quite shallow, areas with a depth over nine feet are mostly in the lower part of the river or around bridges. The depth could be changed by dredging the bottom sediments or by having a no-diving rule in place.

The main water quality factor for swimming is E. coli levels. The Anacostia Riverkeeper volunteers take water samples weekly from May 1st to October 30th from seven points on the river. (Swimguide, 2021). They stated that the pH, turbidity, and water temperature levels were all in a safe swimming range for all the sites in 2020 (Anacostia Riverkeeper, 2020). Ideally this data would be monitored continuously, but it provides good generalization and trends for the sites. The lower river sites tend to have higher pass rates, with the Washington Channel and Buzzard Point being the safest. There are notably less CSO outfalls in the lower part of the river, likely contributing to the lower E. coli levels. These two locations do have marinas around, but the swimming areas could be enclosed for safety. Ideally there would be a swimming area on the eastern bank of the river, off of Anacostia Park for accessibility.

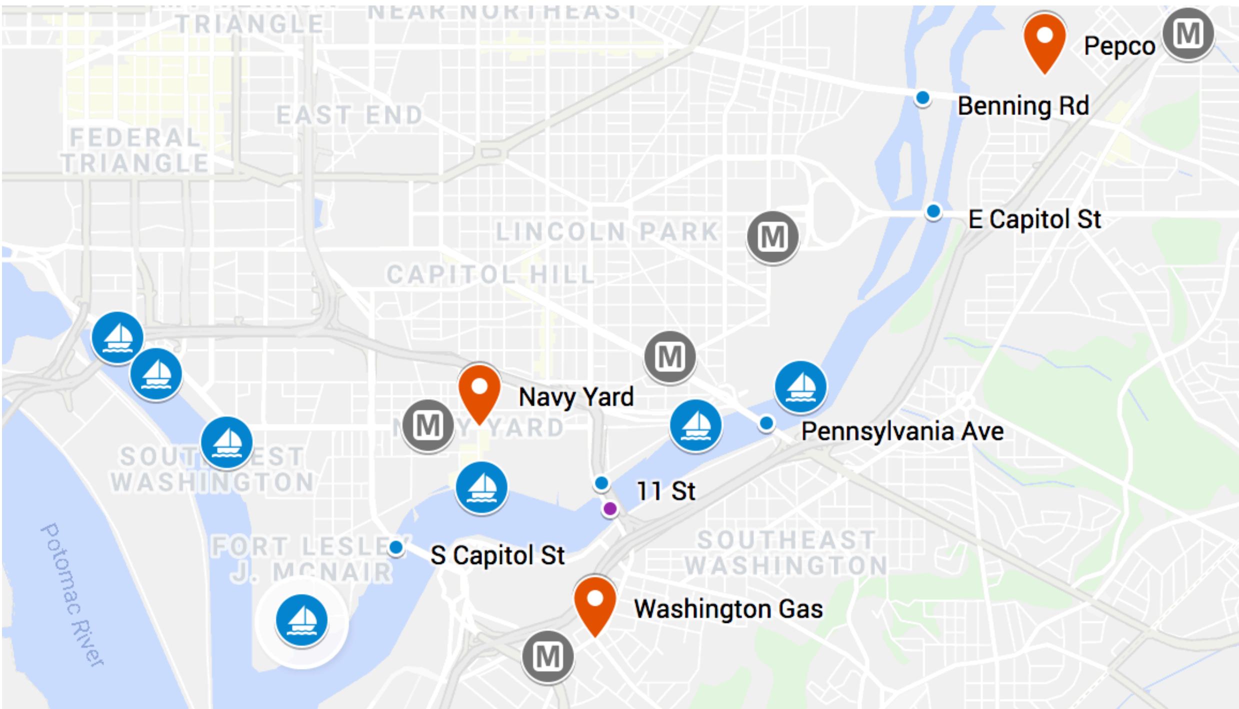

Figure 11. Parameters Map
Source: Google Maps

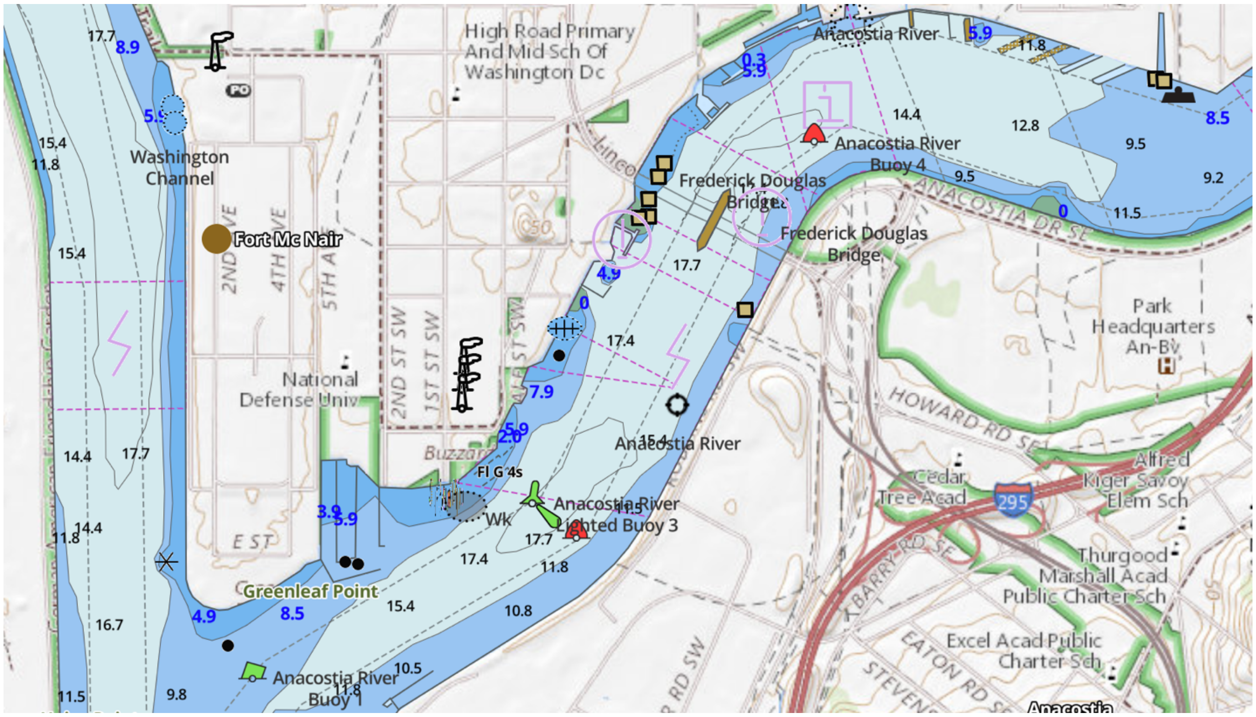

Figure 12. Depths (ft) in the Lower Anacostia River
Source: I-Boating

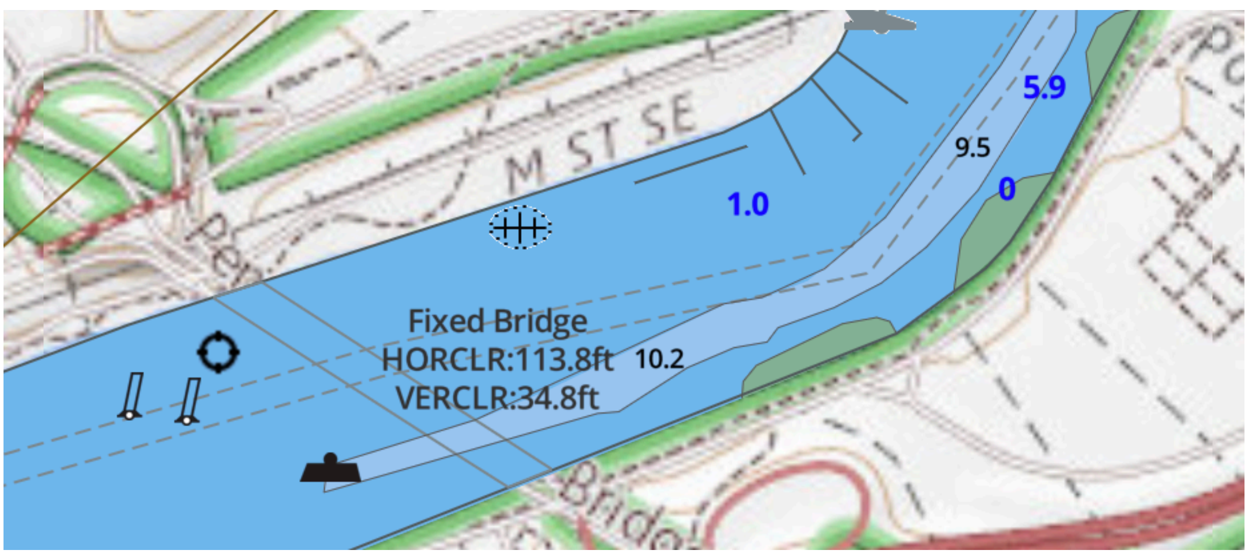

Figure 13. Depths (ft) around Pennsylvania Ave Bridge
Source: I-Boating

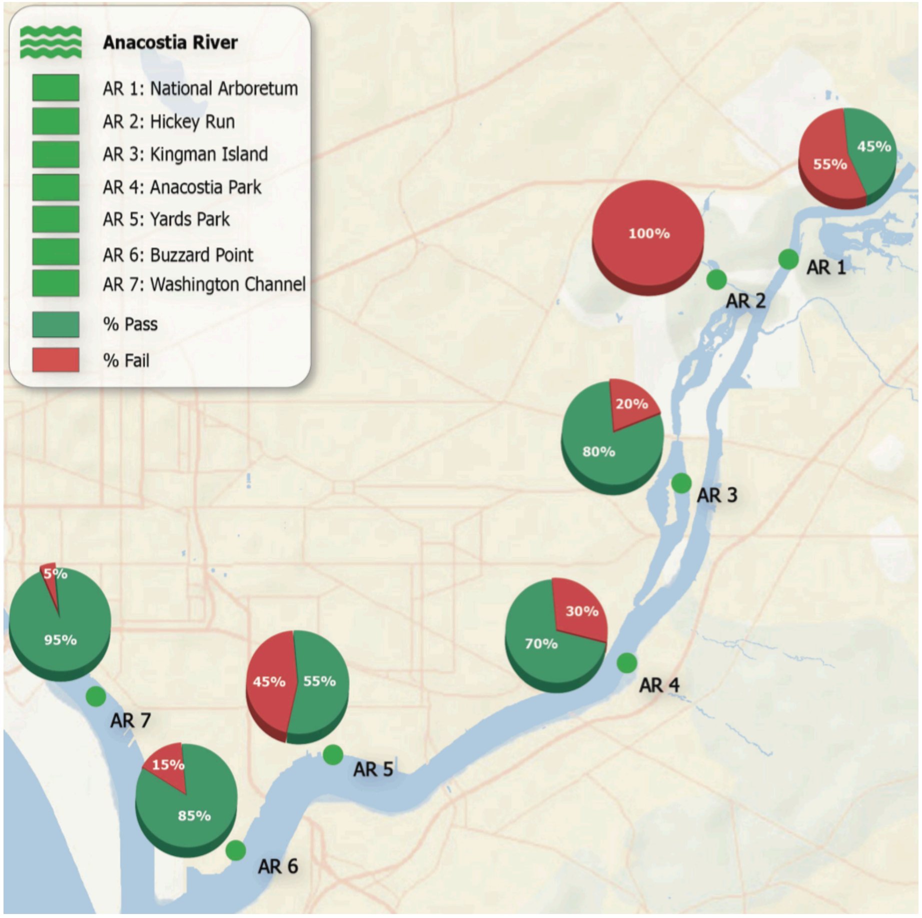

Figure 14. 2020 Average Pass/ Fail for E. coli on the Anacostia River

Source: Anacostia Riverkeeper

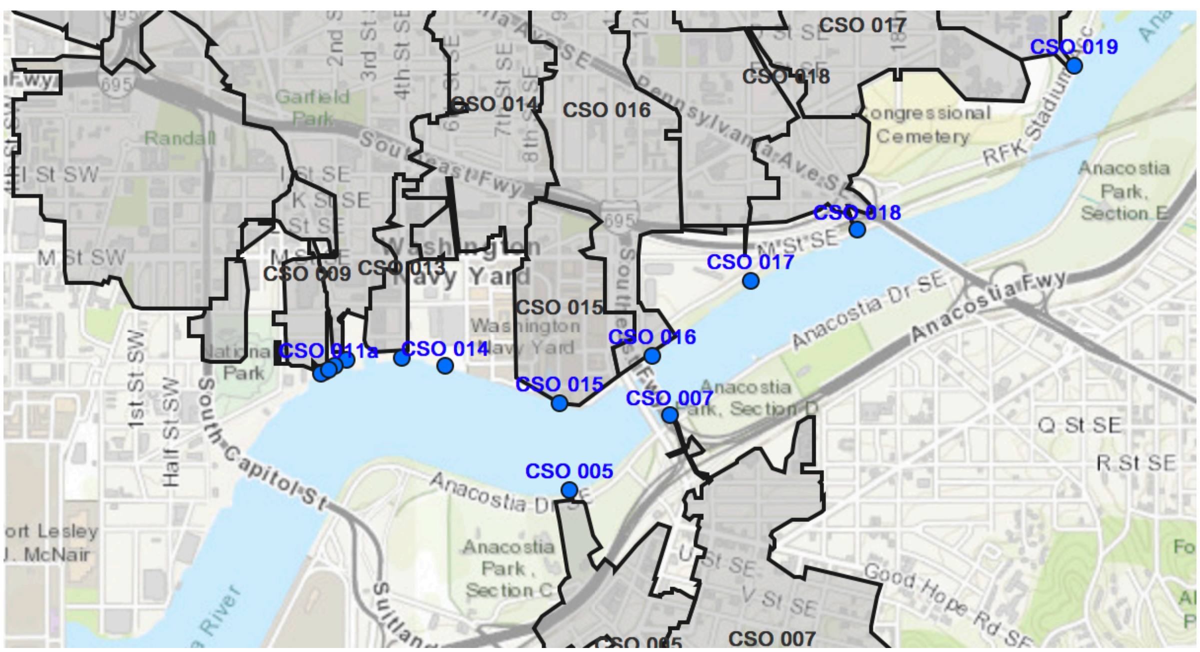

Figure 15. CSO Outfall Points on the Anacostia River
Source: DC Water

7.0 Discussion

The concept of urban swimming has become quite popular in post-industrialized cities as a way to attract people and to revitalize long neglected waterfronts. The success story of Copenhagen's harbor baths is often recognized as a model for other cities. Washington D.C and Copenhagen have many similarities; both have heavily invested in their wastewater treatment systems and are dealing with industrial soil and sediment contaminants in order to improve waterfront districts. Both cities have similar population sizes, are densely populated, are popular tourism destinations, and have strong economies. Washington D.C however has to deal with upstream pollution on its rivers and a highly populated metropolitan area, as well as more complex social issues, along with unique governmental structure. One of the weaknesses of the report is that it is based on a single case study, so it would be interesting to see where else this could be applied. Many American cities are struggling to update their wastewater infrastructure, over 700 cities still have combined sewers (EPA, N.D). The American Society of Civil Engineers gave the United States a D+ grade on its wastewater treatment systems, noting issues such as the cost of replacement and lack of climate resilience (ASCE, 2021). The exorbitant costs of repairing and updating wastewater infrastructure is likely prohibitive to small and medium sized cities. Large cities, like New York, have had to invest billions into their systems to meet the requirements of the Clean Water Act. It can be difficult to justify wastewater infrastructure spending as it doesn't directly improve the economy, but in the long-term clean water can attract people to move back into cities. Mr. Jensen-Kaas from HOFOR said that waterfront development came as a response to the cleaner harbor and said that "the investments in bathing water was paid back many times" (Jensen-Kaas, 2021). American cities will likely need federal grants or loans to improve their systems. Luckily, the US Federal Government has put an emphasis on infrastructure spending, especially for sustainable systems like green infrastructure.

Washington DC can be an American model for urban swimming, it will just take a few more years. The investment in an advanced wastewater treatment plan with feedback loops, lowered their nutrient output and increased efficiency. But the most common thread between swimmable cities and cities trying to reach this goal is the reduction in combined sewer overflow. This can be approached from different angles, Portland looked to build underground tanks and tunnels to hold excess stormwater. Smaller sized cities, like Alexandria, Virginia, looked to update their entire sewerage system from combined to sanitary sewers to prevent overflows. Other large cities like Philadelphia, have developed green infrastructure in order to reduce CSOs and stormwater runoff. The District does have a combination of sanitary and combination sewers, which is common in old cities. With the development of the Clean Rivers Project, Washington D.C later added green infrastructure to reduce the need for additional grey infrastructure. The hybrid approach of updated sewers, stormwater holding facilities, and green infrastructure can likely be applied to any city. The impact of non-point sources of pollution and legacy contaminants greatly vary on a city's age, location, and industrial history.

8.0 Conclusion

The aim of this project was to determine what the barriers are to creating swimmable rivers in Washington D.C and how they could be implemented to best benefit the triple bottom line. The steps taken in Copenhagen to create harbor baths was also explored. There were similarities in the steps taken in both cities, but Washington D.C presented some unique challenges. The theoretical basis for this report looked to the choice awareness theory from Henrik Lund. It was important to look at how technological change can happen if there are changes to the elements of technology. Qualitative data was used to build a case study design, in order to better understand the historical and current social, economic, and environmental conditions. Washington DC's history, geography, and social issues were discussed in the site analysis (Chapter 5) to ensure that the swimming sites would have a positive impact and be sustainable in the long term.

To answer the main research question, research was needed on the historical and current river conditions. This research was paired with expert knowledge from interviews with representatives from the Interstate Commission on Potomac River Basin and the D.C Department of Energy and Environment. There has been immense progress made from improvements to the wastewater and stormwater systems, but the District still has not met the water quality requirements needed for swimming. Looking at the sub questions, first the other sources of water pollution had to be determined. There is concern about pollutants coming from the watershed, as well as industrial contaminants in the soil and sediment. The current system infrastructure isn't perfect either, D.C is still experiencing combined sewage overflow and having issues with stormwater runoff. Secondly, the potential location for swimming areas had to take into account water quality, depth, boat traffic, CSO outfalls, and contaminated sites. Swimming locations should benefit the local economy and be accessible and welcoming to local citizens. As noted by Mr. Clauson-Kaas of HOFOR, the improvement of water quality in Copenhagen Harbor led to meaningful development of the area's waterfront property. One would hope that the improvement in the water quality of these two rivers would lead to both optimism on personal and economic level that would bring an enhanced quality of life in the area.

9.0 Appendix

9.1 HOFOR Interview Questions

Interviewee: Jes Clauson-Kaas, Chief Consultant at HOFOR

Via: Microsoft Teams

Questions:

What were the parameters for determining a harbor bath location?

Are the water quality regulations based off of EU guidelines, or does Denmark have their own?

What were the first steps in bringing the harbor's water quality to a swimmable standard?

Were the harbor baths seen as a way to revitalize the historically industrial waterfront?

Will it ever be possible to completely stop combined sewage overflow?

Who is responsible for the harbor's water quality monitoring system?

How often do the harbor baths need to be closed due to unsafe bacteria levels?

What other contaminates are of concern in the harbor?

What green infrastructure strategies are used most commonly to reduce stormwater runoff?

What are the concerns related to the pollutants in the bottom sediment?

Is there a big pollution impact from the harbor's watershed, like agriculture or industrial runoff?

Is all of the stormwater runoff treated at wastewater treatment plants?

What concerns are there related to climate change, from rising sea levels to increased severe weather?

What benefits did the harbor baths bring to Copenhagen?

9.2 Interstate Commission on the Potomac River Basin Interview Questions

Interviewee: Curtis Dalpra, Communications Manager at ICPRB

Via: Telephone

What are the biggest barriers to better water quality in the Potomac River?

What more can be done from a policy or political standpoint to create watershed agreement and reduce pollution?

Do you think the Potomac River will be able to meet the goals set in the Clean Water Blueprint, by 2025?

What industries have the biggest impact on the Potomac River Watershed?

How can the impact of increasing urbanization in the watershed be mitigated?

What strategies is the ICPRB recommending to improve the Potomac River's water quality?

The Potomac has improved its water quality score from a D to B in 10 years, how can an A score be achieved?

What are the pollutants of most concern in the Potomac River?

What stormwater runoff solutions does the District have in place or are looking to develop further?

How is water quality monitored in the Potomac River?

9.3 DC Department of Energy and Environment Interview Questions

Interviewee: Jonathan Champion, Associate Director, Water Quality Division

Via: Telephone

What kind of monitoring is done in the rivers and how often is it taken?

How much rain has to fall before the combined sewers are overwhelmed?

Is there any treatment for stormwater in its separate system?

What green infrastructure strategies is the DOEE planning to develop?

Where are some potential sites for swimming areas?

What other contaminants are of concern?

What kinds of toxicity testing is being done, for example fish tissue testing?

Is there concern about pollutants in the sediments and what are the plans going forward?

Is the river flow too fast in the Potomac to make it safe for swimming?

How much of an impact does upstream pollution have on the DC rivers?

What policy strategies are being used to implement changes in behavior to reduce stormwater runoff?

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