Alexandria Waterfront: Flood Mitigation Implementation

Summary of Preliminary Flood Mitigation Analysis

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Sign-off Sheet

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Definitions, Acronyms, and Abbreviations

ACFCMA	Atlantic Coastal Fisheries Cooperative Management Act
ASMFC	Atlantic States Marine Fisheries Commission
Core Area	The project area in the City of Alexandria as defined in Figure 1 of this report
DGIF	Department of Game and Inland Fisheries
EFH	Essential Fish Habitat
FMIP	Flood Mitigation Implementation Project
FMP	Fishery Management Plan
GER	Geotechnical Engineering Report
IPAC	Information for Planning and Consultation
ISI	Institute for Sustainable Infrastructure
LOD	Limits of Disturbance
MSFCMA	Magnuson-Stevens Fishery Conservation and Management Act
NAVD	North American Vertical Datum
NEFMC	New England Fishery Management Council
NLEB	Northern Long-eared Bat
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NRCS	Natural Resources Conservation Service
NRHP	National Register of Historic Places
NWI	National Wetlands Inventory
PJD	Preliminary Jurisdictional Determination
RMA	Resource Management Area
RPA	Resource Protection Area
SAV	Submerged Aquatic Vegetation
SWM	Stormwater Management
TOYR	Time of Year Restriction
USACE	United States Army Corps of Engineers
USGS	United States Geological Survey
WOUS	Waters of the United States
WQIA	Water Quality Impact Assessment
WSAP	Waterfront Small Area Plan

Executive Summary

The City of Alexandria, Virginia is home to a historically significant waterfront that currently serves as an outdoor entertainment venue and cultural hub for the community. The Flood Mitigation Implementation Project was commissioned in the Waterfront Small Area Plan (WSAP) to address the common flooding that occurs at and around King Street on the waterfront. The project limits, referred to as the "Core Area," extend from Duke Street to Queen Street and from Union Street to the shoreline. This is a particularly important area on the waterfront as the end of King Street, adjacent to the Potomac River, is a popular destination and has historically been considered the gateway to the City. While the WSAP was being drafted, Alexandrians overwhelmingly expressed their desire for this location to become the foremost place for outdoor social activities on the waterfront.

Figure 1: Nuisance Flooding at King and Union

The subject of this report is the Flood Mitigation Implementation Project (FMIP); the FMIP is intended to address and mitigate the frequent flooding experienced in the Core Area. Flooding is a common occurrence, especially at the low-lying intersections at King and Union Streets and along Strand Street. The most frequent flood event is categorized as *nuisance flooding* and can occur from an event as minor as high tide. Small flood events typically cause minor road access disruptions along Strand Street; larger flood events can produce significant negative impacts to commerce as well as physical damage to homes, businesses, and infrastructure. The City of Alexandria has commissioned Stantec to oversee the preliminary design phases of the FMIP with the intention of reducing the risk of nuisance flooding and lessening the impact of larger, less frequent flood events that disrupt the Core Area. Implementing this portion of the WSAP will allow the City of Alexandria to invest in an expansive and highly visible revitalization project on the waterfront.

The FMIP started with the Potomac River Waterfront Flood Mitigation Study prepared by URS for the City, which was completed in 2010. This report was supplemented by the Alexandria Waterfront Pricing Design Schematic prepared by OLIN in 2012. The Flood Mitigation Study identified specific flooding problems and their causes, evaluated strategies to solve these problems, and recommended the most effective solutions. Of the recommended strategies, the preferred option was to construct a structural bulkhead that would act as a flood barrier for river water levels up to six feet. An enhanced storm drain system connected to pump stations is proposed as a supporting component of the flood mitigation system; these elements work together to remove stormwater trapped inland by the structural bulkhead. The purpose of the initial design phase is to evaluate the feasibility of constructing and operating a flood mitigation

system for the area. Additionally, the City is identifying secondary improvements and public amenities that can be incorporated into the project.

The design team has performed necessary project reviews, including research and field investigation, to support the initial and final engineering designs. A land survey was conducted throughout the project Core Area and a bathymetric survey was performed in the Potomac River extending 300 feet out from the shoreline. Additionally, an archeological review, architectural review, geotechnical investigation, environmental assessment, and water quality impact assessment were conducted to fulfill regulatory requirements. Apart from regulatory reviews, a Master Storm Water Management Plan and Master Utility Plan were created to evaluate and confirm the feasibility of the supporting utility elements of the project. These reports, investigations, assessments, and reviews completed during the initial design phase will allow for the City of Alexandria and the design team to be well prepared moving forward.

The initial design reviews, reports, and coordination with the many parties involved in the project have allowed the design team to create a layout that can be further detailed in the final design phase. This design proposes two pump stations to convey water from the storm system directly into the Potomac River, reducing the impacts of rain events in the Core Area. The first pump station is located in Waterfront Park and the second is adjacent to Thompsons Alley. Proposed storm piping will replace existing outfalls and convey storm water to the pump stations. The pump stations will have both low flow and high flow pumps that will turn on depending on the severity of the storm; backup pumps are provided in case of an operating pump malfunction. The electrical equipment and generator for the pump stations will be located on the second level, above the 100-year storm water surface elevation, to ensure the equipment will not be damaged by flooding. The pump stations will outlet at the structural bulkhead; the outfall pipes will be equipped with valves to ensure the system will not backup due to tidal fluctuation.

Figure 2: Proposed Pedestrian Promenade

This project will bring many new public amenities to the Core Area of the City. Point Lumley, Waterfront Park, and Thompsons Alley will have numerous improvements, including revised grading, landscape plantings, and pathways. A pedestrian promenade at the bulkhead line will create a walkable path for visitors and residents along the Potomac River, connecting from Robinson Terminal South to Queen Street. Lighting along the promenade and in the interior park spaces will allow pedestrians to enjoy the area at night. Waterfront Park will have a shade structure along Strand Street and will connect to a newly designed “King Street Square”, which is planned to include a water feature/splash pad, creating an enjoyable experience for Alexandrians of all ages. The public plaza in this area will be able to be reconfigured to host events and accommodate many residents.

As the result of this project, the City of Alexandria will have an iconic destination that will enhance the image of the City and increase its visibility in the region. The information gathered in the preliminary design phase will allow the City to begin the final stages of design documentation for the Core Area. Once the Flood Mitigation Implementation Project is constructed, the City of Alexandria will have the foundation to begin waterfront redevelopment projects throughout the Core Area.

Background

Challenges of Flooding in Old Town Alexandria

Figure 3: Existing Stormwater Infrastructure

The City of Alexandria experiences frequent flooding from heavy rainfall, tropical storms, and nor'easters which affects businesses, residences, and infrastructure along the waterfront. The relatively low ground elevation and numerous stormwater systems along the waterfront are impacted by tidal fluctuations, storm surge, and the increase in water level due to upstream watershed runoff resulting from intense rainfall and/or snow melt. Frequent nuisance flooding occurs at the King Street intersections with Strand Street and Union Street, as this area has the lowest elevation along the waterfront.

The cost to the City of Alexandria was estimated in 2010 to be $32,000 per flood event, with an average of one flood event per month[1]. This estimate does not include the cost of lost business revenue and damage incurred by businesses and residences. Flood events range from the common nuisance flood, affecting pockets of low-lying areas, to extreme flood events that submerge extensive portions of the waterfront, causing damage to homes and businesses. Additionally, utility services along the waterfront can be damaged and rendered unusable during flood events. If electrical elements are located in areas affected by flooding, this equipment could short circuit and impact the services to the residents and businesses in the Core Area.

[1] *Stemming the Flood in Oldtown, Alexandria*: Alexandria Times, 2012.

The scope of the FMIP is limited to the Core Area, as shown below, and contains approximately one-half mile of Potomac River shoreline. The Potomac River, Queen Street, Duke Street, and Union Street provide boundaries for the Core Area. These limits are further defined in the Waterfront Small Area Plan Design Schematic Pricing Set drawings (dated 9/10/2014) and the Waterfront Flood Mitigation Project 15% Concept Design submission drawings (dated 7/31/2014), both provided by the City of Alexandria.

The structural bulkhead is proposed to run north-south along the Potomac River from Duke Street through the Marina and ending at Queen Street. The proposed bulkhead will create a continuous protective flood barrier in the Core Area of the City (Figure 4).

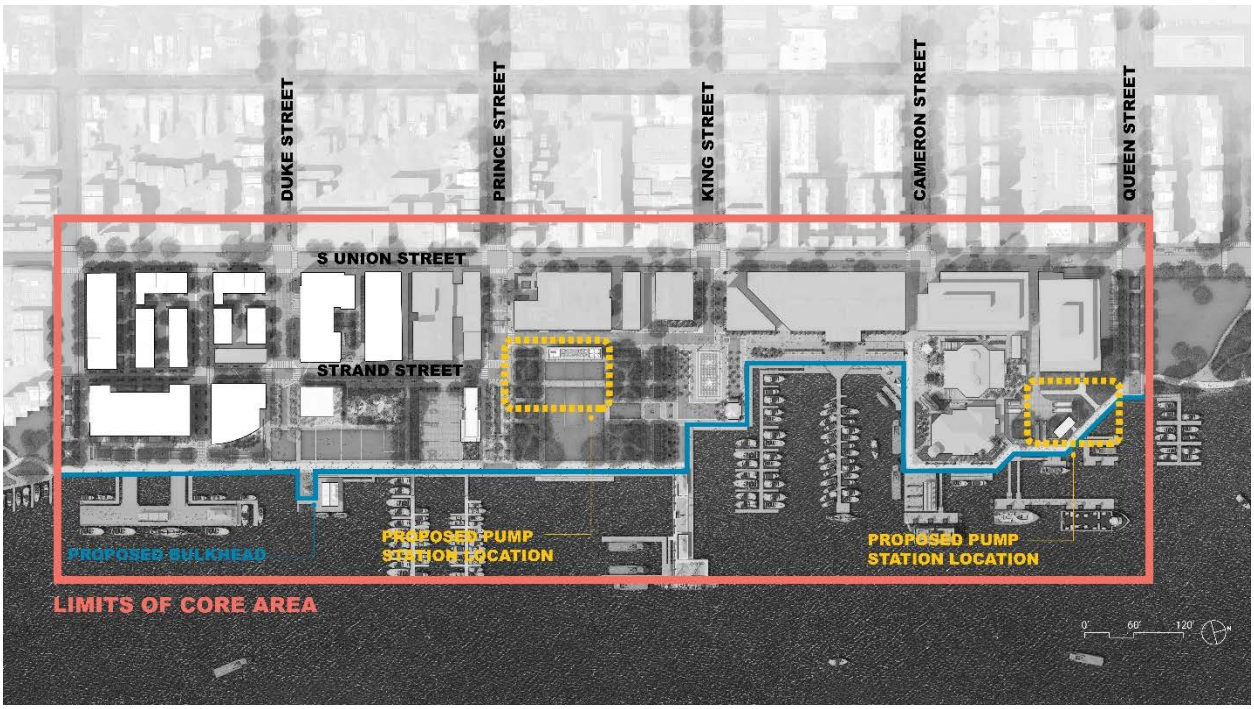


Figure 4: Core Area Limits

Types of Flooding Events

Sunny Day Flooding

"Sunny Day Flooding" is common in the core area of the city, typically occurring during exceptionally high tide events. This type of flooding causes the inundation of the storm pipe system and low-lying areas. These events are common when new and full moons occur.

Nuisance Flooding

Nuisance flooding inundates the storm system and low-lying areas similar to "Sunny Day Flooding" events. Nuisance flooding, however, is associated with smaller storms, quick snow melts, and sea level rise. Nuisance flood events are events that do not cause major property damage or seriously

threaten public safety; however, these events can cause issues with City infrastructure such as roads and utilities, discourage tourism, and impact residents and businesses.

Storm Surge – Example: Hurricane Isabel

Due to the low ground elevation of Old Town Alexandria and the proximity to the Potomac River, the waterfront area is susceptible to regular flooding from storm surge, especially when the storm surge coincides with high tide. A strong offshore low-pressure system caused by passing weather fronts, nor'easters, and tropical storms, will exert a force that produces higher than average water surface elevations on the Potomac River. When combined with high tide, this often results in flooding along the lower portions of the Strand during nuisance flood events. A strong storm surge can cause flooding to reach near the extreme flood level as defined in Table 1. In 2003, the storm surge from Hurricane Isabel caused the Potomac River to reach an elevation of 9.5 feet NAVD[2] in Old Town Alexandria while local rainfall totals were less than 3 inches.

Heavy Rainfall – Example: Tropical Storm Lee

Short duration storms with high intensity rainfall are the most frequent cause of nuisance flooding along the Waterfront. A major factor impacting flooding in the Core Area during these events is the undersized storm drain system.

The majority of runoff entering the storm drain system in the Core Area comes from the uphill area west of Union Street. The volume of water in the storm drain system during these events can cause downstream manholes and inlets to be overwhelmed. Under the right circumstances, this may lead to flooding in the Core Area higher than the current water level of the Potomac River. In 2011, Tropical Storm Lee brought minimal storm surge but over 10 inches of rain to Northern Virginia over a period of a few days. The existing storm drain system was unable to handle the runoff volume from the storm, which caused stormwater to overflow manholes and inlets, flooding the Core Area.

[2] Data retrieved from National Weather Service Storm Data, September 2003

Potomac River Waterfront Flood Mitigation Study

The City of Alexandria commissioned a Potomac River Waterfront Flood Mitigation Study which was completed in 2010[3]. The purpose of the study was to identify specific flooding problems and their causes, identify and evaluate solutions, and recommend the most effective solutions to reduce the impact of nuisance flooding along the waterfront.

Table 1 and Figure 5 show the flood levels (elevation) and frequencies (return period) determined in the Potomac River Waterfront Flood Mitigation Study:

Flood Categorization	Elevation (feet)	Return Period (years)
Nuisance	4.0’	1.5
6-foot flood	6.0’	10
Intermediate	8.0’	30
Extreme	10.2’	100

Table 1 - Flood Levels Determined in Potomac River Study

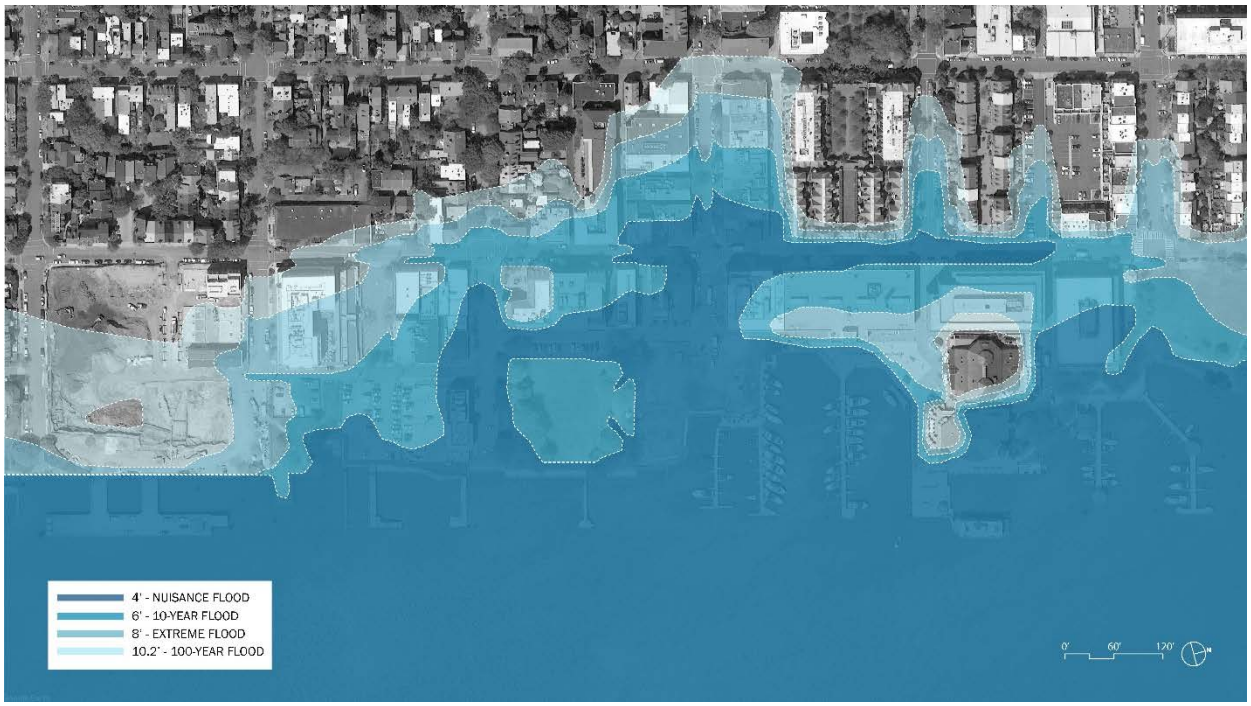


Figure 5: Flood Level Elevations

[3] URS Corporation. *Potomac River Waterfront Flood Mitigation Study*. Evaluation and Recommendation of Mitigation Measures. Gathersburg, MD, 2010.

Background

Flood mitigation measures were classified into five categories with multiple potential solutions identified for each. The following table lists the potential flood mitigation measures considered in the Potomac River Waterfront Flood Mitigation Study:

Measure	Solution
Property Protection	Floodproofing of structures in floodplain
	Acquisition of properties in floodplain
	Elevation of structures in floodplain
Structural Projects	Floodwall
	Raised boardwalk acting as floodwall
	Storm drain improvements (upsizing)
	Underground storage
	Detention structures
	Construct an offshore groin
Prevention	Sewer backflow preventers
	Enhancement of floodplain ordinances
Emergency Services	Minimizing electrical and gas outages after a flood
	ID system
	Flood warning system
	Emergency response
	Temporary structures
	Cleanup program
Public Education and Awareness	Media involvement and outreach
	Transportation plans
	Insurance outreach

Table 2 - Potential Solutions to Flooding Problem

The identified solutions were ranked according to a weighted scoring matrix, which was approved by the City prior to publication of the study. The heaviest weight was given to project capital cost, the reduction of nuisance flooding, and protection of structures. The next level was reserved for criteria targeting extreme and intermediate flood protection, aesthetics, reduction of damages and flooding events, loss of business revenue, and environmental impacts to the Potomac River. The third level was assigned to constructability, City liability, maintenance costs, private property acquisition, state and federal funding availability, and protection of repetitive loss structures. The lowest weight was given to flood insurance costs, property ownership, environmental impacts, loss of recreational use, and regulatory requirements. The overall ranking for each flood mitigation solution, including a "do nothing" option, is listed in the following table.

Rank	Solution
1	Build an engineered structure to act as a barrier between the Potomac River and Alexandria.
2	Build a pedestrian boardwalk that would also be a floodwall structure.
3	Acquire properties experiencing frequent flooding.
4	Provide sandbags or other flood deterrents for residents and businesses.
5	Increase the inlet and road elevation to prevent overflow from nuisance flooding events.
6	Elevate structures.
7	Provide dry floodproofing to prevent waters from entering buildings.
8	Improve the City's floodplain and zoning ordinances.
9	Relocate internal supplies, products/goods, and utilities above the flooding depth.
10	Improve flap gate operation at outflow points.
11	Provide wet floodproofing to make uninhabited portions of structures resistant to flood damage.
12	Add backflow preventers in homes to prevent stormwater and sewer backups.
13	Isolate service so that only the buildings affected by flooding will lose service.
14	Relocate external electrical boxes.
15	Improve the City's emergency response.
16	Inform business and residents about reimbursement for damages other than just exterior building damages.
17	Do nothing.

Table 3 - Solutions as Ranked by the City's Scoring Matrix

The top flood mitigation measures were selected for further evaluation. Subsequently, an engineered structural bulkhead with an elevated boardwalk was chosen to best fit the City's needs.

Proposed Flood Mitigation Components

Structural Bulkhead

The main component of this project is the construction of a structural bulkhead along the shoreline of the Core Area with a cap elevation of 6.0 feet NAVD. The proposed bulkhead will extend approximately 2,000 feet from Robinson Terminal South to Founders Park. The bulkhead alignment south of the marina was selected to provide a linear promenade along the shoreline, minimize conflicts between existing infrastructure/trees and the bulkhead anchoring system, and forego the need to remove existing shoreline structures. The new southern shoreline will be, on average, 15 feet riverward of the existing shoreline except at Waterfront Park, where the new bulkhead will be placed within 18 inches of the existing bulkhead. The alignment of the bulkhead on the north segment was designed to provide sufficient land to support the planned pump station and the

extension of the promenade to Founders Park. This new northern shoreline will be an average of 50 feet riverward of the existing shoreline.

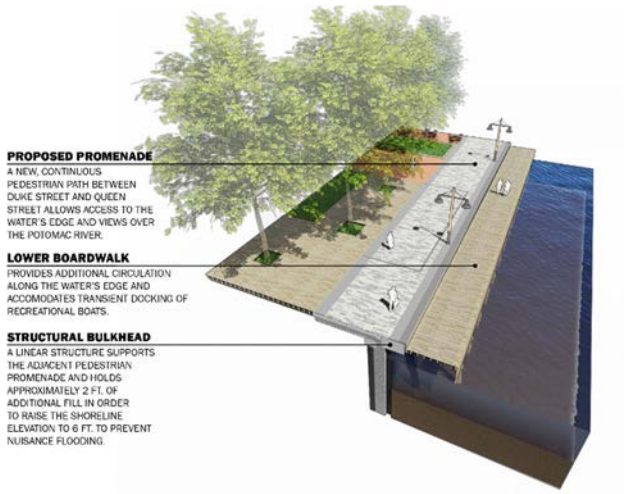


Figure 6: Proposed Structural Bulkhead

A primary design concern is to limit the landward extent of the bulkhead anchoring system. This will avoid impacts to existing tree canopy and utilities as well as to the proposed park and building infrastructure, including the Old Dominion Boat Club facility at Prince Street. Several anchoring alternatives and ground improvement options have been evaluated to minimize the lateral extent of anchoring and disruption during construction. In addition, the bulkhead was designed to accommodate differential hydrostatic loads when river water levels are low but upland areas are inundated by rainfall events.

The bulkhead will reduce the frequency and impact of flooding in the Core Area from rising river levels and storm surge up to elevation 6 feet NAVD. As such, it will provide flood risk reduction up to and including the 10-year return period storm events. Stormwater runoff from areas behind the bulkhead will be managed by two pump stations and associated storm sewer outfalls as part of the Flood Mitigation Implementation Plan.

Rehabilitated Local Storm Sewer

Once the Flood Mitigation Project is implemented, the local storm sewer system will convey stormwater to two proposed pump stations. The local storm sewer system is designed to mitigate the 10-year frequency storm and, accordingly, will have structures at elevation 6.0 feet and lower.

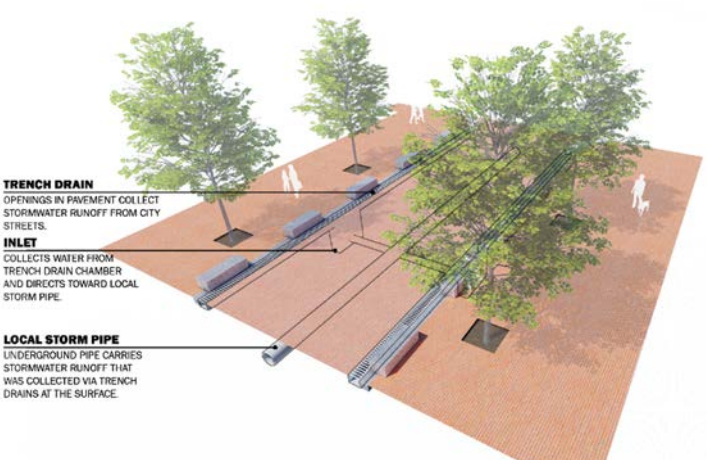


Figure 7: Proposed Streetscape & Storm Sewer Improvements

To improve the capacity and functionality of the system, most of the existing stormwater pipe and structures will be replaced. The project proposes two local storm sewer systems. The local storm sewer system between Duke Street and King Street will direct stormwater flow into Pump Station 1 at Waterfront Park. The local storm sewer system between Cameron Street and Queen Street will direct stormwater flow into Pump Station 2 at the end of

Thompsons Alley. Land that was not rerouted into the pump station will maintain the existing drainage pattern.

Pump Stations

Two pump stations are proposed along the Waterfront to address landside flooding from stormwater runoff. The pump stations are designed to remove water faster than received during a 10-year storm event and to remove flood water when the river overtops the bulkhead. One pump station will be located in Waterfront Park and the other at the end of Thompsons Alley. The pump stations have been located such that they will collect stormwater from the Core Area.

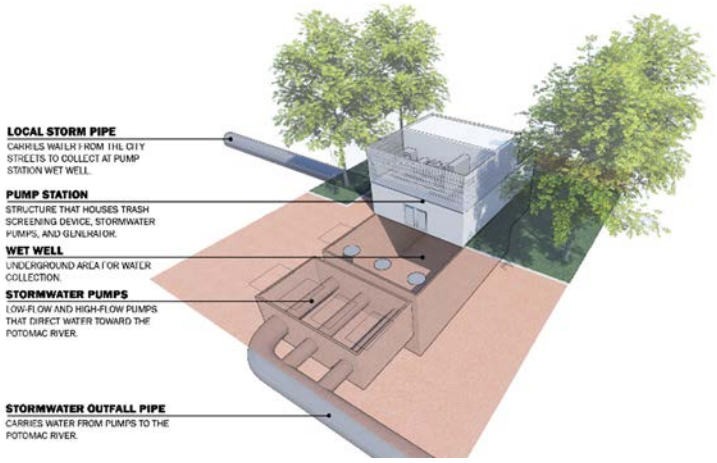


Figure 8: Proposed Pump Station

Each pump station will be housed in a building incorporating the pump works and elevating emergency equipment above the 100-year storm event elevation. Each pump station will contain trash screening equipment, pumps, valve works, a back-up generator with its associated fuel source, force main piping to the bulkhead outfall, and all related mechanical equipment and controls. Trash screening is incorporated to protect the pump equipment from large debris which may find its way into the storm sewer system. It also provides the benefit of limiting trash and debris from being discharged into the Potomac River. The pump stations will have energy saving devices and controls, such as variable speed drives, to reduce the operation and maintenance costs incurred by the City throughout the expected life of the flood mitigation system.

Operations of Flood Mitigation System

Storm Surge/High River Elevation for the 10-year storm

During storm surge events or events in which upstream storms cause the river elevation to rise, the primary objective of the flood mitigation system is containment of Potomac River water through the structural bulkhead barrier. The cap elevation of the proposed bulkhead is set at the Potomac River's local 10-year storm elevation of 6.0 feet NAVD.

Localized flooding is possible at the existing Duke Street and Cameron Street outfalls when the Potomac River approaches 6.0 feet elevation but does not breach the bulkhead. The possibility of minor flooding is caused by water backflowing upstream through the storm drain outlets. To lessen this effect, backflow preventers are proposed to be installed on the pipe outlets. Backflow preventers act as valves that allow water to exit into the river while preventing river water from entering the outfall pipe. The drainage areas in each existing storm system, at Duke and Cameron Streets, are small and unlikely to pond at the inlets.

The pump stations will collect any stormwater runoff from the local storm drain systems and discharge into the Potomac River.

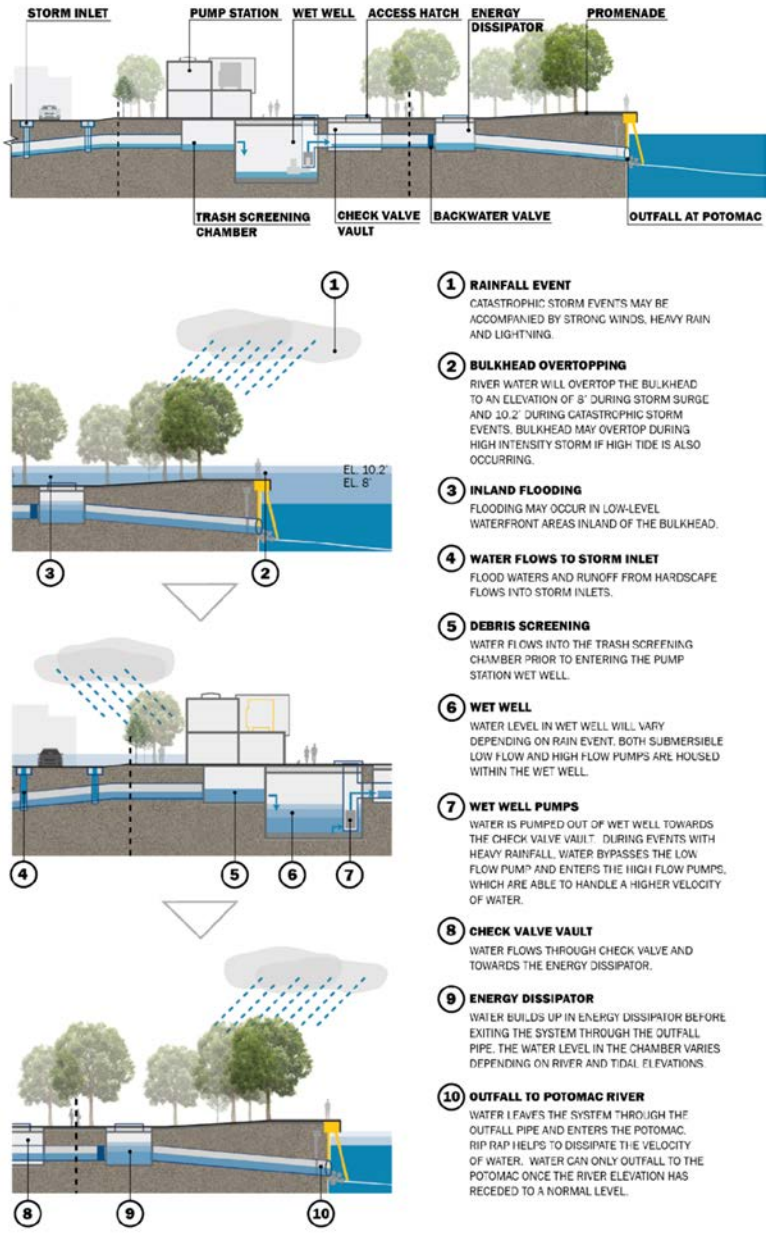


Figure 9: Flood Mitigation System Operations

High Intensity Storm

During a high intensity storm, the objective of the proposed flood mitigation system is to route the stormwater generated in the watershed of the Core Area through the local storm drain system to the pump stations.

In a typical rain event, the river level will stay below the bulkhead. Provided the bulkhead is not breached, minimal to no flooding is expected, even during heavy rain. Both pump stations have low flow pumps for smaller storm events and high flow pumps for larger storm events. Pump Station 1's system (Waterfront Park) and Pump Station 2's system (Thompsons Alley) have a discharge capacity up to the 25-year storm.

The peak runoff rate for storm events lasts for a short period of time relative to the overall duration of the storm. The Rational Method, which is currently being used for stormwater modeling, accounts for the peak runoff rate, with the intention of sizing storm water conveyance pipes conservatively. The next phase of design will use more advanced modeling, such as the NRCS TR-20 method, which will model the entire duration of the storm, including flow rates and total flow volume. A mass balance model will then evaluate the incoming stormwater runoff volume throughout the duration of the storm, the output of the pump station, and the storage volume available within the pump station and storm sewer pipes. It is expected that this type of modeling will demonstrate that the pump stations, as currently designed, have the capacity to handle larger storm events than the evaluation using the Rational Method suggests.

Catastrophic Storm Events

During a catastrophic storm event (greater than the 10-year storm), the Potomac River will overtop the proposed structural bulkhead. While these events are occurring, the objective of the proposed flood mitigation system is to minimize the impacts of the flooding.

In any situation where the Potomac River rises above the bulkhead, the pump stations will pump flood water behind the bulkhead back into the river; this will be effective once the elevation of the Potomac River subsides below the top of the bulkhead. In the scenario where the bulkhead is flooded just above the 10-year storm elevation of 6.0 feet, the system is designed to drain accumulated floodwater within approximately 92 minutes at Pump Station 1 and approximately 45 minutes at Pump Station 2, with all pumps operating.

The two bypass storm systems are expected to flood in this situation, thus the pump stations will receive storm water from the Duke Street and Cameron Street areas in addition to their local drainage areas. The relatively small amount of runoff that would flow downstream, instead of entering the bypasses, is expected to have a minimal impact on the pump system.

Deploying the Flood Mitigation System

Extents of the Proposed Bulkhead

The Alexandria Waterfront's Core Area encompasses approximately one-half mile of Potomac River shoreline. The Potomac River, Queen Street, Duke Street, and Union Street provide the boundaries for the Core Area. The bulkhead is proposed to run north-south along the Potomac River from Duke Street through the Marina and ending at Queen Street. The proposed bulkhead will create a continuous protective barrier in the Core Area of the City.

Implementation of Proposed Stormwater Infrastructure

The proposed storm system will need to be constructed while the existing storm drain system is still functioning. Once the proposed pump stations and outfalls are constructed, the existing storm drains to be retained will be tied in to the proposed system. The existing storm drain demolition can begin once this change over has been completed.

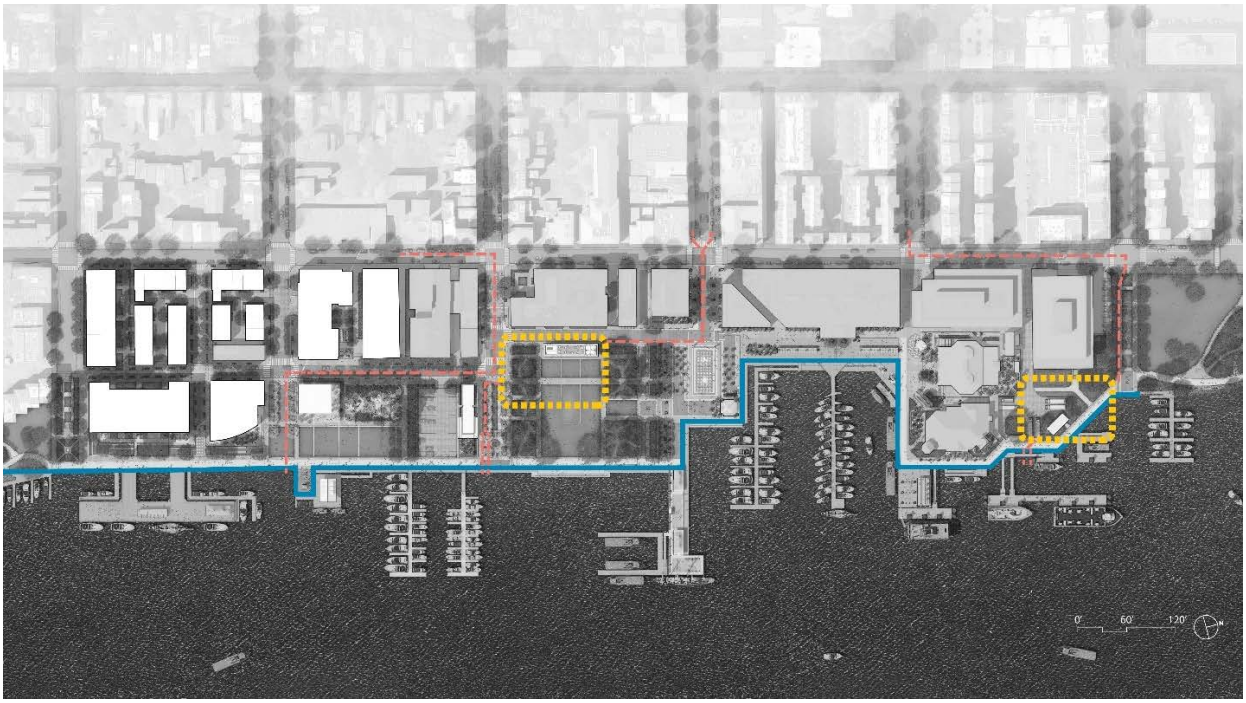


Figure 10: Flood Mitigation System Implementation Area

The existing storm drain outfalls to remain will continue to convey stormwater directly into the Potomac River from portions of Duke Street and Cameron Street where routing stormwater into the pump system is not feasible. These systems will bypass the pump stations and will have new outfall structures and rip rap where the system discharges into the Potomac River at the proposed structural bulkhead. To eliminate storm surge flooding through the pipe system, a backflow preventer will be installed at the existing and proposed outfalls on Duke Street and Cameron Street.

General Location of Proposed Pump Stations

There are two (2) pump stations proposed with the FMIP. The first pump station is planned to be located in Waterfront Park and the second pump station is planned to be located further north along the waterfront at the end of Thompsons Alley.

Conclusion

The Flood Mitigation Implementation Project will provide Alexandria's waterfront business owners and residents protection from nuisance flooding and lessen the impact of the larger flood events which have troubled the Alexandria Waterfront for decades. This preliminary portion of the project provides the City of Alexandria with the information to begin final design and construction documents. The information gathered during this phase promotes well-informed decisions for this significant infrastructure project. Additionally, the process of securing the appropriate local, state, and federal permits required for construction is underway.

Figure 11: Proposed Infrastructure Improvements

The proposed infrastructure along the Waterfront will feature a new structural bulkhead and pump stations as well as a refurbished storm drain system. Once infrastructure is constructed, the flood protection from the new system will allow the City of Alexandria to continue the park expansion and revitalization component of the Waterfront Small Area Plan.

The development of the Flood Mitigation Implementation Project and the Waterfront Small Area Plan is expected to provide economic benefits to the City, residents, and businesses, provide a premier source of outdoor entertainment, and increase the already distinguished area's desirability as a world-class waterfront destination.

Appendices

Appendix A Related Studies

Archaeological Review

Stantec prepared a Phase IA Archaeological Assessment for the City of Alexandria's Waterfront Flood Mitigation Implementation project. The approach taken for the archaeological assessment was in accordance with the City of Alexandria's *Archaeological Standards* (Alexandria Archaeology 2007), the Virginia Department of Historic Resource's (2011) *Guidelines for Conducting Historic Resources Survey in Virginia*, and the standards and guidelines set forth in the Secretary of the Interior's *Standards and Guidelines for Archeology and Historic Preservation* (Federal Register 1983).

Both the City of Alexandria and Federal regulations require an archaeological assessment. For the City of Alexandria, the Alexandria Archaeological Protection Code (Zoning Ordinance Section 11-411 (D) 1992) requires an assessment for preliminary or combined site plans or other development applications. As the project will impact the Potomac River, a U.S. Army Corps of Engineers permit is also anticipated. To obtain this permit, the City of Alexandria will comply with Section 106 of the National Historic Preservation Act of 1966, as amended, and the National Environmental Policy Act. Both require the applicant (the City of Alexandria) to consider impacts of the project on historic resources, including archaeological resources.

Stantec reviewed the land-use history of the project's Limit of Disturbance (LOD) from the mid-eighteenth through mid-twentieth century based on the study of over 17 historic maps and extensive documentary and database research. Minimally, portions of 11 wharves, some of which have structural cores dating to the late eighteenth century, and remains of up to 22 structures, dating from the late eighteenth to the early twentieth centuries, are potentially present within the project area. It is presumed that these elements could be impacted by construction related to the proposed project based on overlays of the mapped wharves and structures and proposed facilities depicted on the 15-30% Design Schematic prepared by OLIN.

Based on the historical research, the project area has a high potential for archaeological resources. Such resources could include the wharf structures (portions of which could predate the nineteenth century), fill within the wharves, and structure foundations, privies, and deposits of artifacts associated with the wharves and related structures. Fill and the existing parking lot caps may have preserved such resources, as has been demonstrated at other wharves in the Old Town neighborhood. Finally, while demolition and the installation of utilities have impacted archaeological resources within the project area, such impacts appear to be limited in extent.

Based on the high potential for archaeological resources, Stantec recommended that additional archaeological investigations be conducted within the project area prior to commencement of construction to determine the presence, nature, and significance of archaeological resources, provide for the National Register of Historic Places (NRHP) evaluation of archaeological resources

located, and determine whether any additional archaeological mitigation or monitoring investigations would be required prior to or during construction.

Architecture Review

The Flood Mitigation Implementation Plan anticipates pump stations at two locations, Waterfront Park and Thompsons Alley. These pumping facilities will each house a below-ground wet well with pumping equipment, an at-grade trash screen, and an emergency generator on the roof above the 100-year flood elevation.

At both locations the Waterfront Pricing Design Schematic indicates the pump station will have dimensions of approximately 30 feet by 30 feet. The heights of these pavilions must comply with the applicable code restrictions at each location. At Thompsons Alley, there are additional constraints imposed by National Park Service covenants.

The architectural design of the pavilions and shade structures is to follow a language consistent with both the character of the historic working waterfront and the approved Waterfront Small Area Plan common elements. Architectural development has been presented to the City and is under review.

Land Survey

Stantec was tasked to perform a land survey for the proposed project area. Work performed included a topographic survey over the project area and areas outside of the anticipated project area that drain into the Waterfront's Core Area, right-of-way survey, utility location, and title research. An accurate survey is essential to design and will allow a more efficient construction process.

Right-of-Way

Services for the right-of-way survey task included extensive research of public deeds and street dedications and accessing existing field data and records from the north right-of-way of Queen Street to the South right-of-way of Duke Street and from the West right-of-way of Union Street to the Potomac River.

Stantec has created an electronic drawing file that establishes an accurate right-of-way survey that will allow all disciplines working on the project to stay within the public domain.

Topographic Survey

The topographic survey was completed for the site and includes curb and gutters, walkways, street lighting, utility poles, buildings, trees, finished floor elevations, party walls, bulkhead, sea walls, surface utilities, and sub-surface utilities. The extent of the topographic survey is bounded on the north fifty (50) feet past Queen Street, on the south fifty (50) feet past Duke Street, on the west at the Lee Street intersection and the Potomac River on the east. The area of topographic survey west of Union Street is considered the offsite drainage area.

Stantec created an electronic drawing file that establishes topographic survey with one (1) foot contours and spot shots.

Utility Location

Sub-surface utility location was performed by Mid-Atlantic Utility Locating Services and recorded by Stantec as utility data was discovered. Sub-surface utility locating reveals underground locations of utilities between manholes and/or handholes. The captured sub-surface utility data was included in the topographic survey provided by Stantec.

Utility locating test pits will be performed at selected locations to determine the precise location and elevation of various underground utilities to be needed for the design phase.

Bathymetric Survey

Bathymetric survey of the Potomac River was provided by Gahagan & Bryant Associates, Inc. and was performed under the direction of a Professionally Licensed Land Surveyor and Nationally Certified Hydrographer. The bathymetric survey was conducted at twenty-five foot intervals 300 feet into the Potomac River from the project limits at Duke Street and Queen Street. The result of the bathymetric survey was a digital drawing of the Potomac River with one (1) foot contour intervals, channel lines, features, and other significant structures.

Stantec created an electronic drawing file that combines the bathymetric survey with the land survey.

Geotechnical Investigation

Stantec was tasked with performing a preliminary geotechnical investigation for the project. The objective of the investigation was to gather the existing boring data and perform a limited investigation for use by the design team to develop preliminary schematic designs for the bulkhead and pump stations.

Based on the new test borings, previous explorations and geologic data, the site consists of a surface layer of 10 to 40 feet thick urban fill, with the deeper depths near the Potomac River. The fill consists of a combination of soil and construction debris placed to fill in the site and construct the wharves. Below the fill, very soft alluvium clays were encountered at depths of 50 to 65 feet below the existing ground surface. Variable density, granular Terrace Deposits are present below the alluvium in some borings. Very stiff, Potomac Group Clay soils were encountered below the alluvium or Terrace soils

The existing fill and alluvium are very weak soils and are not suitable for foundation support. Therefore, the pump stations will need to be supported by a deep foundation. The groundwater table is shallow and the pump station excavation will require consideration of the control of groundwater during excavation or design of a secant pile or diaphragm wall which integrates

excavation support, groundwater control, foundation support and below grade walls into a single system.

The bulkhead will need to retain the loose urban fills. The alluvium below the fills is very soft and will provide little lateral support. The bulkhead will require lateral restraint which is typically provided by soil anchors. Due to site constraints, anchors are not preferred, so the wall restraint will need to be provided by others means integral to the wall such as battered piles.

Additional geotechnical challenges for the site include groundwater dewatering for below grade excavations, measures to mitigate noise and vibration during construction in an active park setting, measures to minimize ground settlement from construction activities to prevent damage to adjacent buildings and structures, evaluation and mitigation of settlement of the soft soils from new loads or basal heave from excavations, and construction change orders associated with encountered buried debris.

The results of the study are provided in Schnabel Engineering, LLC's Phase 1 Geotechnical Data Report. The results of the geotechnical analysis and recommendations are provided in their Phase 1 Geotechnical Engineering Report (GER). The GER provides preliminary recommendations for the final subsurface exploration program, including recommendations based on environmental testing results, which were conducted for each boring sample. Additional geotechnical testing will be required for final design of the project.

Environmental Assessment

The Environmental Assessment consists of the individual studies and reports needed to gain regulatory agencies approvals and acquire permits. Components include the wetland delineation, Resource Protection Area (RPA) determination, Submerged Aquatic Vegetation (SAV) study, Essential Fish Habitat (EFH) study and Threatened and Endangered Species coordination.

Delineation of Waters of the U.S.

A delineation of Waters of the U.S. (WOUS), including wetlands, was performed to determine the resource limits under the authority of the U.S. Army Corps of Engineers (USACE). Prior to conducting fieldwork, Stantec consulted the U.S. Geological Survey (USGS) 7.5-minute Topographical Quadrangle Map for Alexandria, Virginia (created 1998), the National Wetlands Inventory Interactive Mapper (NWI), administered by the U.S. Fish and Wildlife Service, and the Web Soil Survey, administered by the Natural Resources Conservation Service (NRCS). The USGS quad map depicted a level site comprised of developed land. The NWI map depicted the tidal Potomac River within the project boundaries, with no wetland features present. Additionally, the soil survey indicated that the site is underlain primarily by Urban land – Grist Mill and Grist Mill sandy loam, both of which are classified as non-hydric by the NRCS in the City of Alexandria, Virginia.

Fieldwork was conducted during March 2016 using the Routine Determination Method as outlined in the *1987 Corps of Engineers Wetland Delineation Manual* and methods described in the *2010*

Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Atlantic and Gulf Coastal Plain Region (Version 2.0). The data sheets and representative site photos were collected and the delineation map, which shows the limits of wetlands and other water features as well as data point locations, was created.

The only jurisdictional feature identified by Stantec within the project limits is the Potomac River. The jurisdictional limits identified in the field correspond to the approximate mean high tide elevation associated with the river. Most of the Waterfront is developed, with jurisdictional limits occurring along existing bulkheads and stabilized shoreline. Non-developed areas within the project consist of park land comprised of maintained open area, bounded by bulkheads and/or stabilized shoreline.

The USACE confirmed the delineation report and issued a Preliminary Jurisdictional Determination (PJD) on October 13, 2016, which is valid for five (5) years.

Resource Protection Area

The Virginia General Assembly enacted the Chesapeake Bay Preservation Act (Act) in 1988 to improve water quality in the Bay and its tributaries. The Act defines perennial streams, Resource Protection Areas (RPAs), and Resource Management Areas (RMAs) that are all components of the natural environment and conservation strategy. The City provides a map, last updated in 2004, that illustrates the location of perennial streams and RPAs within the City. Alternately, the RPAs can be determined with a field study by delineating a resource and providing a 100-foot buffer.

For this project, the RPA is located along the Potomac River, extending 100 feet landward of the shore. No other RPA features were identified in the project area. Impact to the RPA will be coordinated with the City and will be addressed by the Water Quality Impact Analysis which is detailed below.

Submerged Aquatic Vegetation

Submerged Aquatic Vegetation (SAV) is habitat for a variety of species and impacts to SAV represent loss of essential fish habitat. The project area was mapped by Stantec divers in May 2016. Stantec conducted dive surveys beyond the direct project area to evaluate existing conditions and the presence of SAVs. By completing documentation of SAV percent coverage along transects from the shoreline to the approximate ends of existing dock structures, a comprehensive study area was established. The river bottom in the vicinity of the project footprint is in a dredged and maintained area and SAV density was very low, at less than 1% coverage; therefore, essential fish habitat is limited. Depending upon the final bulkhead type, extent of fill, and construction methodology, some impacts to SAV may occur and will need to be mitigated.

Essential Fish Habitat

Amendment 1 to the Fishery Management Plan (FMP), prepared by the New England and Mid-Atlantic Fishery Management Council (Council) and the Atlantic States Marine Fisheries Commission (Commission), is intended to manage various fisheries pursuant to both the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA) of 1976, as amended

by the Sustainable Fisheries Act (SFA) and the Atlantic Coastal Fisheries Cooperative Management Act (ACFCMA). The goal of the FMP is to conserve fisheries resources.

The National Marine Fisheries Service (NMFS) coordinates with other State and Federal agencies to conserve and enhance Essential Fish Habitat (EFH). Parties proposing work within the waters of the greater Atlantic region must consult with NMFS and present an EFH assessment that states the potential adverse effects of a proposed action, including any impact that reduces quality or quantity of EFH (50 CFR Part 600.810). Adverse effects may include direct or indirect physical, chemical, or biological alterations of the waters or substrate and loss of, or injury to, benthic organisms, prey species and their habitat, and other ecosystem components. Adverse effects to EHF may result from actions occurring directly within EFH or indirectly from outside of EFH and may include site-specific or habitat-wide impacts, including individual, cumulative or synergistic consequences of actions.

The proposed project footprint extends into the Potomac River for approximately 25 feet along its length, affecting subaqueous bottom as potential EFH. As previously discussed, SAV coverage within the northern area is less than 1%, based on Stantec's dive survey; therefore, these areas likely represent low value EFH for non-pelagic species. Further south on the project, SAV covers 25-35% of the subaqueous bottom.

Federally managed species potentially found near the study area were queried using the Guide to Essential Fish Habitat Designation in the Northeastern United States online NECOAST image map webpage, provided by the National Oceanic and Atmospheric Administration (NOAA). Of the species managed by the Council, two are known to occur within the Potomac River. These include Bluefish (Pomatomus saltatrix) and Summer Flounder (Paralicthys dentatus). Three of the pelagic migratory species managed by the South Atlantic Council, including King Mackerel (Scomberomorus cavalla), Spanish Mackerel (Scomberomorus maculatus), and Cobia (Rachycentron canadum), are also listed as having EFH within the Potomac River, as well as Windowpane Flounder (Scopthalmus aquosus), managed by the NEFMC under the Northeast Multispecies Fishery Management Plan (FMP) (Groundfish), and red drum(Sciaenops occelatus), managed by the Atlantic States Marine Fisheries Commission (ASMFC), through Amendments 1 and 2 of the Interstate FMP.

The proposed actions will minimally affect available habitat and potential spawning areas for the species discussed herein. Permanent impacts to the subaqueous bottom will occur contiguous to the shoreline, and permanent structure (revetment) will extend into the channel approximately 20 feet along the existing bulkhead. Very little SAV is present within the northern vicinity and has been verified and documented by Stantec scientific divers as having less than 1% cover; therefore, impacts to SAV are negligible. Higher percent cover SAV areas along the shoreline to the north and surrounding the dock structure to the east, as well as any SAV areas more central to the river, will be affected depending upon the proposed bulkhead type and amount of fill.

The most effective way to avoid potential impacts to EFH for species that may utilize the study area is to implement a schedule for construction to occur outside of spawning times. Virginia

Department of Game and Inland Fisheries (DGIF) typically recommends a time of year restriction (TOYR) for anadromous fish between February 15 and June 30. Construction outside of this TOYR should also minimize effects to adults except those who remain year-round. As an area with low SAV cover, the habitat along the seawall and immediate vicinity likely contains transient, non-resident individuals. Fish species may be minimally affected by temporary construction disturbances; however, best management practices will be utilized to avoid and minimize these effects, including preparation of an Environmental Protection Plan by the construction contractor, barge operation timing to avoid grounding, and the use of turbidity barriers.

Threatened and Endangered Species

The Endangered Species Act of 1973 (16 U.S.C. 1531-1544, 87 Stat.884) as amended, and the Bald and Golden Eagle Act (16 U.S.C. 668-668c, 54 Stat.250) as amended provide protection to species facing extinction and their habitat. Online databases maintained by the US Fish and Wildlife Service (Information for Planning and Consultation (IPAC)), the Virginia Department of Conservation and Recreation (DCR-Natural Heritage), and the DGIF were used to create a list of potential species and habitat present in the vicinity of the project. The species list includes the Northern long-eared bat (Myotis septentrionalis) (NLEB), wood turtle (Gleyptemys insculpta), Atlantic sturgeon (Acipenser oxyrinchu), Appalachian grizzled skipper (Pyrgus Wyandot), brook floater (Alasmidonta varicose), migrant loggerhead shrike (Lanius ludoviciannus migrans), upland sandpiper (Bartramia longicauda), loggerhead shrike (Lanius ludovicianus), Henslow's sparrow (Ammodramus henslowwii), and peregrine falcon (Falco peregrinus). Coordination with the USFWS indicates that this project is not likely to affect any of these species.

Water Quality Impact Assessment

The Water Quality Impact Assessment (WQIA) is required by City of Alexandria Code. This document associated with the development is intended to address broad water quality concerns relative to site development based on potential impacts to the Resource Protection Area (RPA), which is established based on presence of jurisdictional features within the Chesapeake Bay Preservation Area. The WQIA is developed after an initial site plan is determined, as specific information related to RPA impacts, stormwater management (SWM) strategy, erosion and sediment control, and landscaping are key components of the document. As part of the WQIA, impacts to the RPA are presented and explained, and mitigations options, whether it is through overtreatment by stormwater practices, landscaping enhancements, buffer restoration, or other opportunities are identified. At this preliminary stage, it appears that overall SWM strategy for the Waterfront area development will more than compensate for the RPA impacts presently identified.

Master Planning

Master Storm Water Management Plan

Stantec was tasked with preparing a Master Storm Water Management plan for the Flood Mitigation Implementation. The plan, which includes the Water Quality Impact Analysis reviewed and confirmed the mitigation measures recommended in the 2010 Potomac River Waterfront

Flood Mitigation Study and the 15% Concept Design of the Waterfront Flood Mitigation Project plan set. The plan includes preliminary location and sizing of the storm water conveyance and storm water management components within the project area. The plan includes analysis of the proposed pump stations, bulkhead, and storm drain system.

Stantec submitted the Master Storm Water Management Plan report with supporting documentation and exhibits for City review.

Master Utility Plan

Stantec was tasked with preparing a Master Utility Plan for the Flood Mitigation Implementation. The plan addresses the public and private utilities needed to facilitate the proposed uses in the waterfront schematic design, including new sanitary sewer, telecommunications/data, water (domestic, irrigation, fire), gas, and electric services. Also addressed in the plan is the feasibility of undergrounding existing aerial facilities.

Stantec submitted the Master Utility Plan report with supporting documentation and exhibits for City review.

Phasing Plan

Stantec was tasked with developing a construction phasing plan that accounted for the anticipated funding schedule. The phasing plan was created to provide guidance to the City on what portions of the FMIP can be built when portions of the funding became available.

The preliminary phasing plan is separated into two major phases. The first phase consists of construction from Duke Street to King Street including the Torpedo Factory. This includes the southern segment of the structural bulkhead, Pump Station 1 and its associated local storm sewer system, bypass storm sewers at Duke, Prince, and King Streets, road realignment for Strand Street, King Street, and Prince Street, as well as utility undergrounding on Strand Street and Prince Street.

The second phase consists of construction from Cameron Street to Queen Street, including Thompsons Alley. This includes the northern segment of the structural bulkhead, Pump Station 2 and its associated local storm sewer system, and the bypass storm sewer at Queen Street.

Stantec submitted the Phasing Plan recommendations to the City as a part of the preliminary work.

Appendix B Envision

The City plans to incorporate aspects of the Envision™ system into the Waterfront Project. Envision™ is a system that provides a holistic framework for planning, evaluating, and rating the community, environmental, and economic benefits of all types and sizes of infrastructure projects. It encourages, evaluates, grades, and gives recognition to infrastructure projects that use transformative and collaborative approaches to assess the sustainability indicators over the course of the project's life cycle. Envision™ is the product of a collaboration between the Zofnass Program for Sustainable Infrastructure at the Harvard University Graduate School of Design and the Institute for Sustainable Infrastructure (ISI). Envision™ addresses both public and private sector interests regarding increased and more sustainable infrastructure investment by introducing social, economic, and environmental variables in a consistent and transparent manner into infrastructure decisions at the national, state, and local levels of government.

An Envision™ Sustainable Professional educational program trains participants to use Envision™ to incorporate systems-level thinking into their approach to sustainability, while considering the broader and often overlooked impacts of a project. Stantec provided The City of Alexandria with Envision™ Sustainable Professional training, such that the City can implement Envision™ practices and principles in the planning and design of the Waterfront Flood Mitigation Implementation Project, and other capital projects as deemed appropriate.

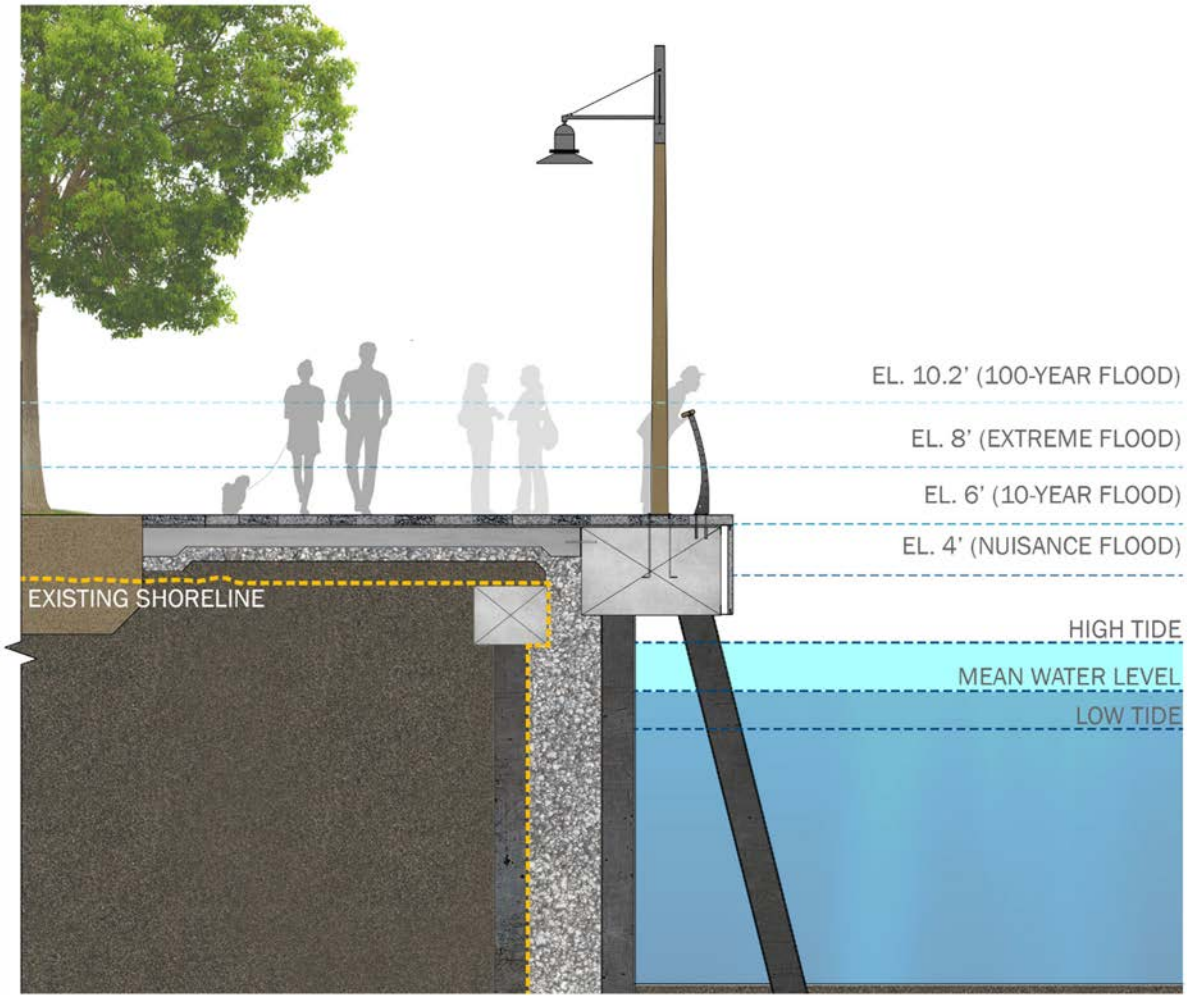
Envision™ has 55 sustainability criteria (called 'credits') organized into five categories: Quality of Life, Leadership, Resource Allocation, Natural World, and Climate and Risk. Sustainability ratings for infrastructure projects are established through a performance assessment that awards points for up to five levels of achievement within each credit: conventional, improved, enhanced, superior, conserving, and restorative. Ratings are awarded based on a threshold of applicable credits achieved, of which there are four levels of award: Bronze, Silver, Gold, and Platinum.

The first phase of applying Envision™ to this project is the facilitation phase, which involves the process of applying the framework to the project during the project planning and design stages. Initial mapping and target setting for the project was performed during this preliminary phase. A workshop was conducted with City staff to discuss sustainability priorities and goals for the project. During the workshop, the group worked through each credit of the Envision™ framework, completing the credit potential and responsible entity for implementation on the project. The Stantec Envision Roadmap tool was deployed to perform this assessment. Based on the workshop held with Stantec and the City of Alexandria, it was determined that the low level of achievement could reach Silver certification (30-39% of applicable credits achieved), and the high level of achievement could reach Platinum certification (50%+ of applicable credits achieved).

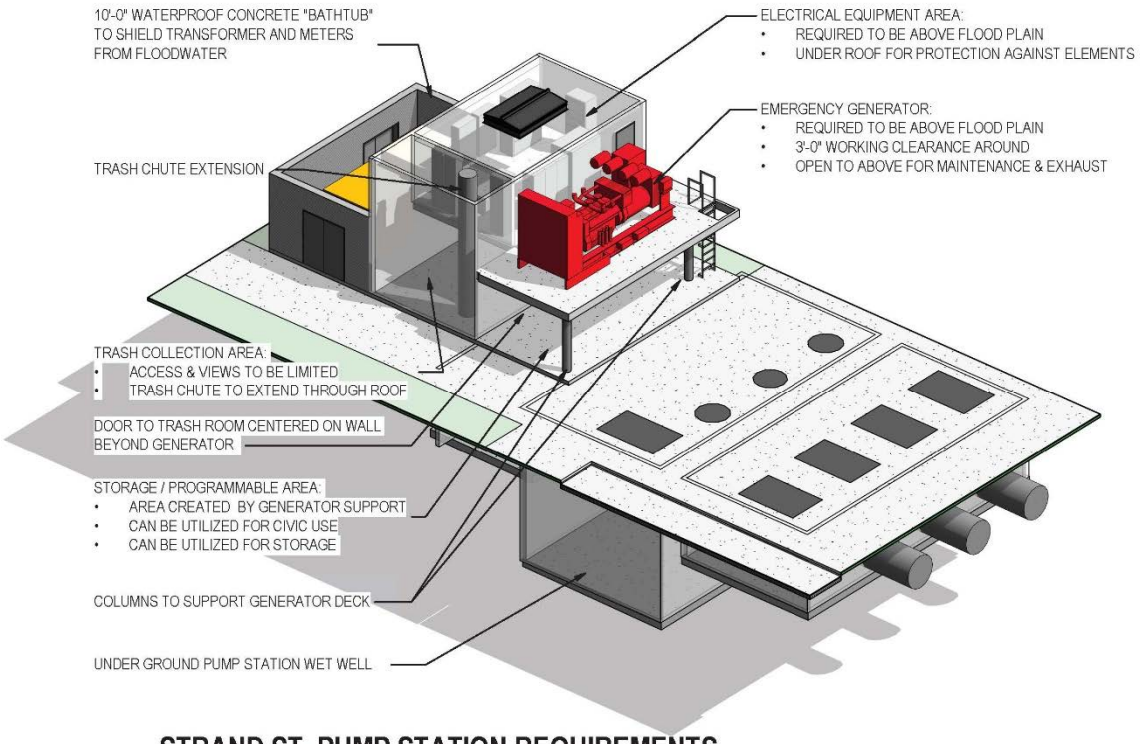
Integration of the Envision™ criteria during the design stage will position the project for successful achievement of certification upon design completion. As the Envision™ framework assesses design choices and contribution to overall sustainability, it is essential to consider the implication of the Envision credits as design choices are being made. Stantec will review and contribute to

environmental reports/studies, engagement activities, and in-progress design documents and specifications to ensure alignment with targeted Envision™ credit requirements. Between the 60% and 90% design completion, a formal recommendation on potential Level of Achievement will be provided to the City. Certification requires the preparation of individual credit packages to ISI and will be possible once the project has reached 90% design or at the start of construction.

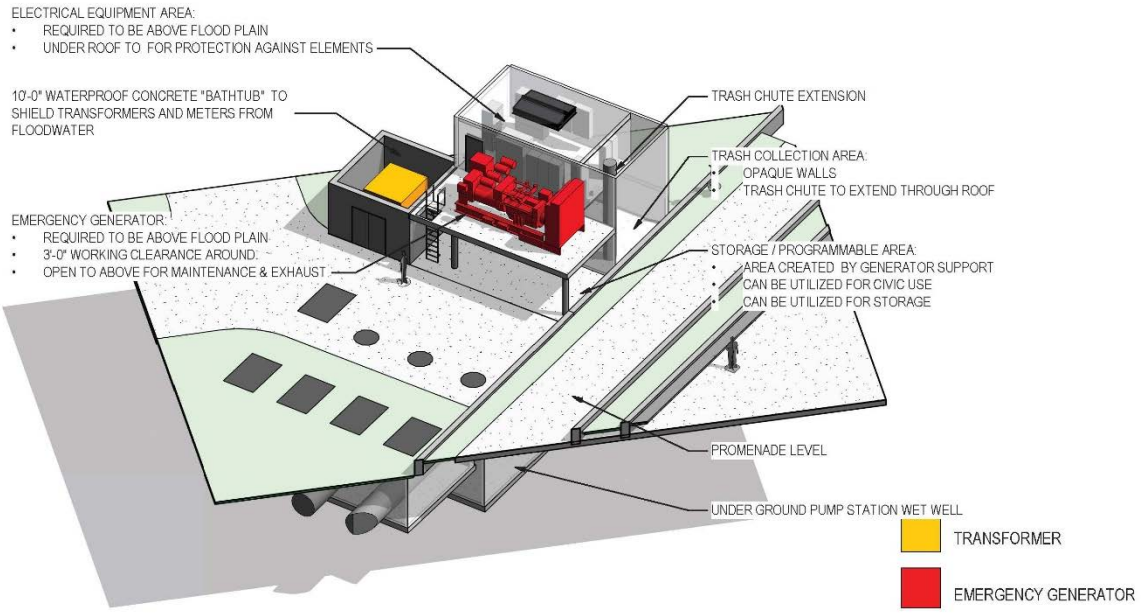
Appendix C Bulkhead Profile View



Appendix D Pump Station Programming



STRAND ST. PUMP STATION REQUIREMENTS



THOMPSONS ALLEY PUMP STATION REQUIREMENTS