Subappendix F-5: Typical Sections and Kit of Parts

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1.0 Kit of Parts for Alternative 1

Modular Wall System – wall, bench, canopy, and planter

The Modular Wall System is a pre-fabricated concrete system that provides public realm benefits and structural flood reduction. It was designed to sit at top of bank and tie into the 7 feet NAVD 88 contour. The system was designed in 25 feet units to meet transportation and construction constraints. Four units were developed: modular wall unit, bench unit, planter unit, and canopy unit. The pieces were designed to be combined in different combinations along the alignment. The modular system was under consideration for the northern interior alignment options and for the northern residential section. The system was ultimately dismissed due to existing building conflicts and construction challenges.

Concrete Floodwall

The Concrete Flood Wall is a basic floodwall with a continuous flat footing that provides stability in soft soils. It is designed with nine variations, as shown in the structural sheets of the Alternative 1 Feasibility Plan Set. This strategy is used primarily in the Central Segment of the alignment.

Single Sheet Pile Wall

The Single Sheet Pile Wall is used along the alignment, where soils permit, to provide basic flood protection with a minimal footprint and low cost. For greater resistance against the flood and wave load and for aesthetic purposes, a 2-foot thick concrete casing is applied on both the protected and flood sides of sheet pile.

Double Sheet Pile Wall

The double sheet pile wall is used to provide basic flood protection with a minimal footprint and low cost.

Deep Foundation T-Wall

The Deep Foundation T-Wall is a basic floodwall with a continuous shallow footing utilizing 60-foot deep, two-battered H-Piles every 12 feet and a continuous line of sheet pile seepage cut-off wall that is 10 feet deep.

Cantilever Sheet Pile Walkway

The Cantilever Sheet Pile Walkway system provides flood protection, but is also 16 feet wide to allow for public realm amenities. The forward edge of the design, along the Hackensack River, is comprised of a continuous line of back-filled sheet piles with a mechanically attached pre-cast concrete fascia. The public realm includes a concrete walkway, a 4-foot planting strip that accommodates planting up to shrub height with occasional seating elements, and a screening trellis fence. The public realm elements are anchored with a concrete footing at the back end of the system. This system is used in the Northern Segment of the alignment.

Cantilever Walkway

The Cantilever Walkway system provides flood protection and public realm at two widths: 10 feet and 25 feet. The 10-foot width allows only for pedestrian access, while the 25-foot width allows for pedestrian access and public realm amenities, such as custom seating and planter units that sit on top of the structural deck. The forward edge of the design, along the Hackensack River, is comprised of a continuous line of back-filled concrete-encased sheet piles. Behind the forward edge, a concrete slab is paved and populated with the aforementioned public realm components. The 10-foot wide Cantilever Walkway is anchored by concrete-encased sheet piles at the back end. The 25-foot option is anchored by either a concrete wall and footing or a two to one graded slope at its back end. There is also special 25-foot wide Cantilever Walkway section designed specifically to interface with an existing pump station. The structure of this section has concrete columns on the Hackensack River edge and a modified version of the Deep Foundation T-Wall at its back end. The wall at the back end is punctured by existing pump station outlets where needed. The Cantilever Walkway system is used in the Central Segment of the alignment.

Grading with Sheet Pile

Grading with Sheet Pile reinforcement is used at the proposed Fluvial Park, in the Central Segment of the alignment. This structural system allows for “natural” looking grading that has additional sheet pile reinforcement. The sheet pile reinforcement is hidden just below the graded surface.

Regrading/Road Raising

Regrading is used, where possible, to bring the topographical grade up to the flood protection height of 7 feet NAVD 88. Also, in a few areas along the alignment, road raising is proposed to meet the required flood elevation.

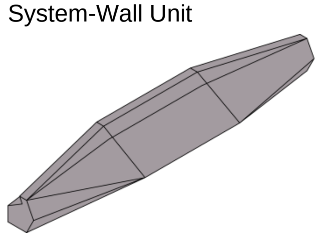
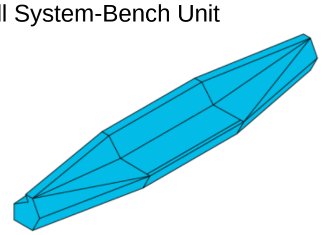
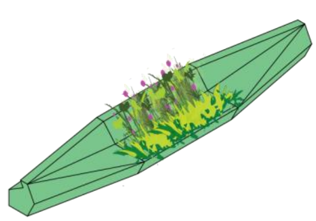
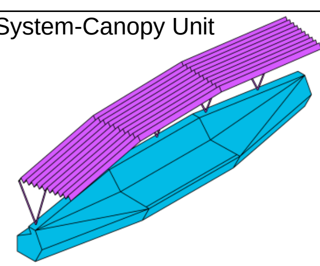
Berm + Path

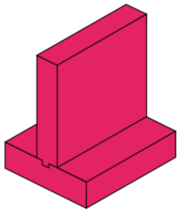
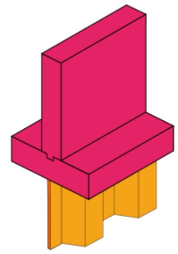
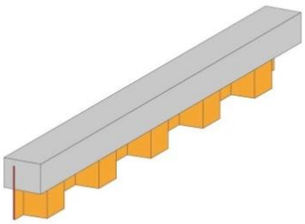
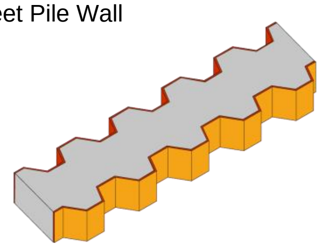
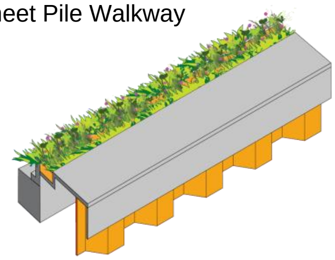
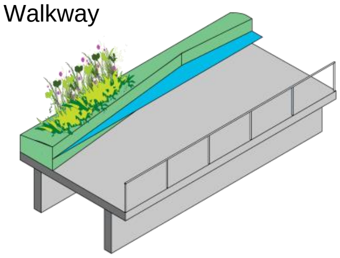
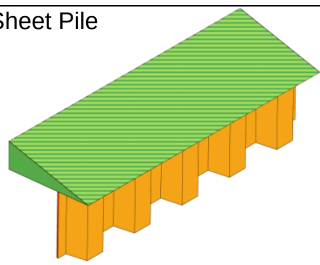
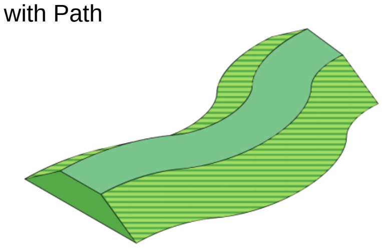
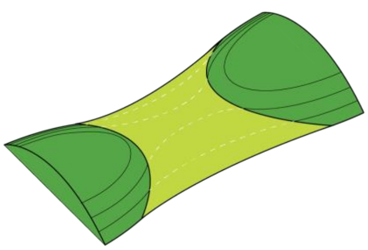
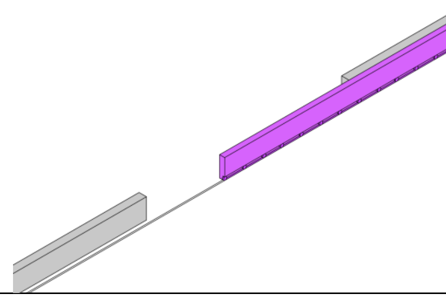
The Berm with Path system incorporates earthen flood protection and integrated public realm and access. Levee options were not used in the final feasibility design because of cost and footprint constraints.

Deployables

Deployables were considered for interior alignment options at access points. There was initial concern about the cost and maintenance of these systems. Ultimately, these were not used in the final alignment design.

Table F4-1: Kit of Parts for Alternative 1

Modular Wall System-Wall Unit 	Modular Wall System-Bench Unit 
Modular Wall System-Planter Unit 	Modular Wall System-Canopy Unit 

Concrete Flood Wall 	Deep Foundation T-Wall 
Single Sheet Pile Wall 	Double Sheet Pile Wall 
Cantilever Sheet Pile Walkway 	Cantilever Walkway 
Grading with Sheet Pile 	Berm with Path 
Re-Grading/Road Raising 	Deployable 

2.0 Kit of Parts for Alternative 2

Bioswale

Bioswales are essentially rain gardens in the form of a channel. Bioswales collect stormwater and convey it toward an outlet. During this process, the stormwater has the opportunity to infiltrate the ground or be taken up by vegetation, thus decreasing the amount of stormwater that reaches the outlet. Like rain gardens, bioswales also help to filter out pollutants before stormwater reaches a receiving waterbody (USEPA 2016). Depending on location, bioswales can be 4 to 8 feet wide and up to 40 feet long.

Rain Garden

Rain gardens are landscaped stormwater collection basins that are designed, based on the soil and vegetative composition, to absorb and filter stormwater. Rain gardens are often located such that they can collect stormwater from roofs, streets, and other impervious areas. They allow collected stormwater to infiltrate the ground or be absorbed by vegetation, thereby reducing stormwater flow that could cause flooding and relieving stress on the overall stormwater drainage infrastructure. Additionally, rain gardens help to improve water quality. As stormwater travels through these systems, soil, pollutants, sediment, and excess nutrients settle out. Stormwater runoff is a major source of pollution for surface waterbodies, such as streams and rivers. By directing stormwater into the soil or vegetation, rain gardens help to filter out these pollutants before they reach a receiving waterbody (USEPA 2017).

Storage Trench/Tree Trench

Storage trenches are non-vegetated subsurface basins typically used where the ground surface needs to be repaved or reestablished as lawn due to the existing site use. Street runoff is diverted to storage trenches by stormwater inlets, where it either infiltrates to native soil, or, where infiltration is not feasible, the system underdrains back into the existing stormwater sewer system. A typical storage trench consists of up to 4-feet of stone aggregate wrapped in geotextile fabric and an underdrain that reconnects to the existing stormwater system. Where existing site conditions allow for small unpaved areas like tree pits, trees may be added to a storage trench to enhance street landscapes, and these systems are typically referred to as tree trenches. Tree trenches do not capture runoff or provide surface runoff treatment like bioswales, but do allow for stormwater uptake through the tree root systems, which reduces the volume of runoff reaching the existing storm sewer system.

Permeable Paving

Impervious surfaces are a leading cause of stormwater drainage challenges in developed areas. Impervious surfaces prevent infiltration and convey all rainfall into the stormwater drainage infrastructure, whereas in undeveloped areas the stormwater is naturally absorbed, to a large degree, by the land. Permeable pavement provides a surface that is mostly paved, but that permits some infiltration of rainfall into the ground, thereby decreasing the amount of stormwater that must be conducted offsite by the drainage infrastructure. Permeable pavement can be created with a variety of materials, including porous asphalt, pervious concrete, or spaced paver stones (USEPA 2016).

Wetland Improvements

Wetlands provide similar functions as rain gardens. However, wetlands remain saturated on a seasonal or year-round basis, while rain gardens are normally dry, except after storm events. Wetlands capture and store stormwater, and remove pollutants, sediment, and nutrients. Additionally, wetlands provide valuable habitat for a wide variety of plant and animal species.

Channel Improvements
Channel improvements can take several different forms depending on local conditions. Channels can be widened or deepened to increase stormwater capacity. They can also be relocated or reshaped (e.g., straightened) to improve conveyance. Finally, channels can be improved to prevent erosion and/or enhance ecological conditions and values, which benefit both water quality and biological resources.

Settling Basin & Forebay
Settling basins are generally earthen depressions that collect and retain stormwater long enough to allow suspended solids (i.e., sediment) to settle out of the water. Forebays serve a similar function, except are located immediately upstream of another waterbody. By removing pollutants, sediment, and excess nutrients, settling basins and forebays help to prevent water pollution and to increase water quality.

Street Bioswale
When placed along streets, bioswales may be installed in a series with breaks between them to allow for pedestrian access to the street. Where sidewalks are narrow or no sidewalk exists, bioswales can be placed within existing grass areas adjacent to the street and are typically 4 to 8 feet wide trapezoidal sections that may extend 40 feet or more.

Pond Berming
Berms may be installed along ditches or ponds in order to improve their stormwater storage and conveyance capacities. Berms consist of compacted earth. The core of these structures, generally composed of clay, is impermeable so as to prevent seepage and structural weakening (FEMA 2007). The outer layer is vegetated in order to prevent erosion.

Pump Stations
Pump stations are constructed to move water from one location to another, and vary significantly in terms of the volume of water they are capable of moving reliably. Pump stations may be installed either in locations that regularly require water to be pumped, such as flat areas where drainage is naturally difficult, or in locations that accumulate large amounts of water during floods and need to be pumped on occasion. In the Project Area, pump stations are often located behind tide gates or along ditches, so that they can keep water flowing in locations where drainage is either naturally difficult or impeded by a closed tide gate.

Force Main & Backflow Prevention
A force main is a pressurized pipe. Stormwater pipes most often operate using the force of gravity to keep the stormwater flowing. However, in some cases, pipes must be installed where gravity is not sufficient to keep stormwater flowing, such as when the pipe must be installed at a nearly flat angle, or when the pipe must go uphill. In these situations, pumps or compressors are used to pressurize the pipes to keep the stormwater flowing. Backflow preventers are flapgates, valves, or other devices used to prevent water from flowing backwards through the stormwater drainage infrastructure. For example, it is possible that a spring tide or storm surge in the Project Area could increase the elevation of the Hackensack River above the elevation of some stormwater drainage outfalls. Without backflow preventers, this could result in river water traveling backwards through the stormwater drainage pipes and into the streets of the Project Area.

New & Improved Open Space
New or improved parks or open spaces provide additional opportunities for water to be collected and absorbed by the land. These areas also provide additional recreational opportunities, such as playing

fields. Within the Project Area, such areas would provide public access to the Hackensack River, as well as include targeted habitat improvements.

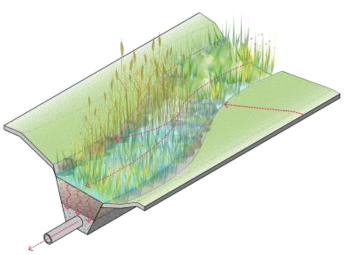
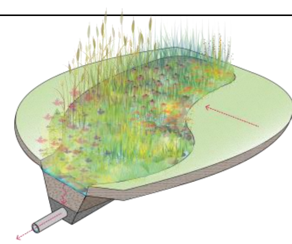
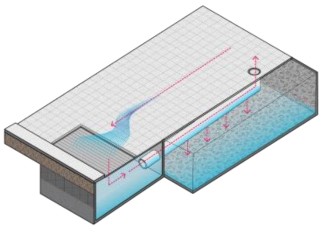
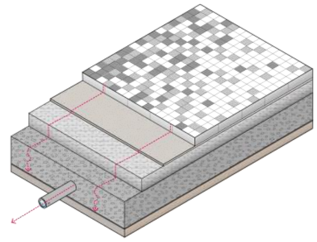
Off-Channel Storage
Off-channel storage refers to areas to where stormwater can be diverted when the capacity of the drainage infrastructure is exceeded. This type of storage can take various forms, including retention/detention basins, underground vaults, parks, and parking lots.

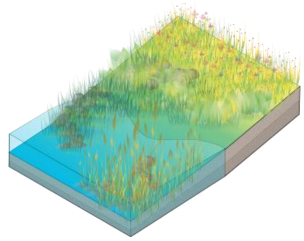
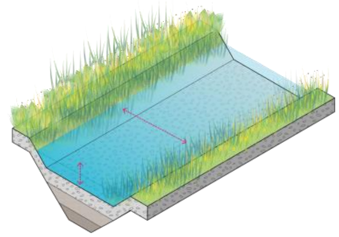
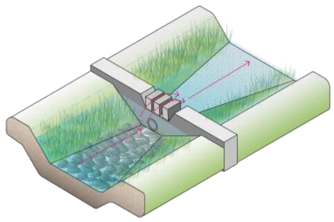
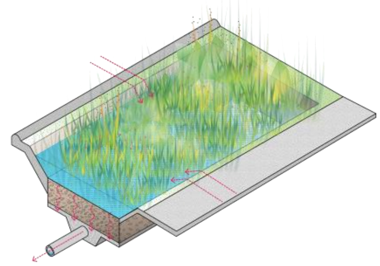
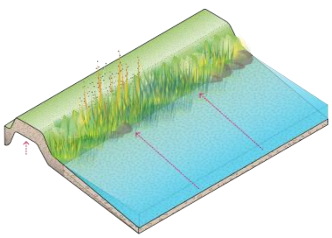
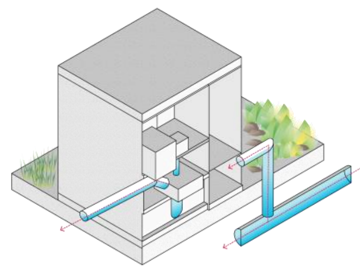
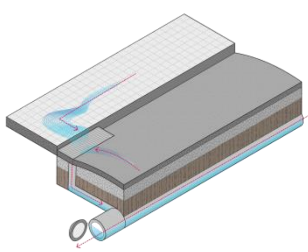
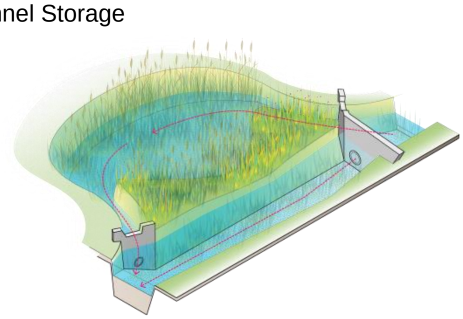
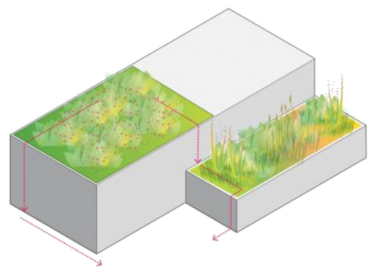
Green Roof
Green roofs are systems that can be installed on the roofs of residences, commercial and industrial buildings. Extensive green roofs have minimal soil depth, while intensive green roofs can allow denser planting on roofscapes due to deeper soil media available. These systems reduce the total amount of rainwater that arrives to the ground surfaces, helping to reduce runoff volumes and flow rates on urbanized catchments. Green roofs were investigated, but dismissed as they do not meet the independent utility requirement.

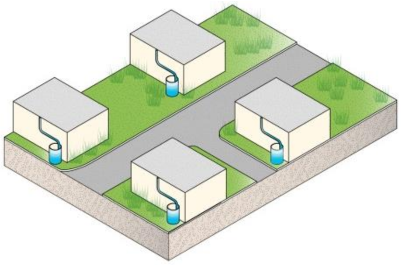
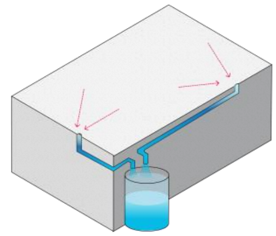
Rain Barrel
Rain barrels serve as above ground detention tank systems that collect rainwater that falls on roof surfaces. Fed by downspout connections, these are often added at private residences due to easy installation and maintenance. They can also provide re-usable greywater for irrigation and toilet flushing. Rain barrels help to reduce the amount of runoff from catchments when adopted by numerous homes in a specific location. Rain barrels were investigated, but dismissed as they do not meet the independent utility requirement.

Aboveground Cistern
Aboveground cisterns are similar to rain barrels, but are typically added to large commercial or industrial buildings. Cistern tanks collect rainwater that falls on roof surfaces. The water can be re-usable greywater for irrigation and toilet flushing and help to reduce runoff during a storm. Cisterns were investigated, but dismissed as they do not meet the independent utility requirement.

Table F4-2: Kit of Parts for Alternative 2

Bioswale 	Rain Garden 
Storage Trench 	Permeable Paving 

Wetland Improvements 	Channel Improvements 
Settling Basin & Forebay 	Street Bioswale 
Pond Berming 	Pump Stations 
Force Main & Backflow Prevention 	New & Improved Open Space 
Off-Channel Storage 	Green Roof 

Rain Barrels 	Cistern 

3.0 Typical Sections

Please refer to Sheet S-401 through S-409 in Alternative 1 Plan Set for typical sections.

4.0 References

FEMA. "Selecting Appropriate Mitigation Measures for Floodprone Structures." March 2007. https://www.fema.gov/media-library-data/20130726-1609-20490-5083/fema_551.pdf (accessed March 16, 2017).

USEPA. *Soak Up the Rain: Rain Gardens.* January 24, 2017. https://www.epa.gov/soakuptherain/soak-rain-rain-gardens (accessed March 16, 2017).

—. *What is Green Infrastructure?* September 23, 2016. https://www.epa.gov/green-infrastructure/what-green-infrastructure (accessed March 16, 2017).