OLF-8 HYBRID PLAN

CIVIL AND ENVIRONMENTAL ANALYSIS

REVISION 2

SUBMITTED TO

TERRI BERRY, PMP

PROJECT MANAGER

Water Quality & Land Management Division
3363 West Park Place Pensacola, FL 32505

Georgio Tachiev, PE PHD
GIT CONSULTING LLC
2665 S Bayshore Dr, #220
Coconut Grove, FL 33133

EXECUTIVE SUMMARY

This document provides a summary of the Integrated Civil and Environmental Engineering analysis of the OLF-8 project with emphasis on Green Infrastructure implementation for stormwater management. The proposed Project covers approximately 540 acres all of which are currently undeveloped. The topography varies between 70- and 145-feet elevation in the North American Vertical Datum of 1988 (NAVD 88); however, most of the site is relatively flat or at elevations above 100 feet NAVD 88. The site's flat topography areas are appropriate for a broad range of urban development alternatives. The low areas are partially occupied by wetlands and are considered undevelopable land. A prior wetland delineation investigation (completed in 2019) established that approximately 23 acres of wetlands are present on site. Initial soil investigation shows that the site is covered by silty material with poor conductivity, and the groundwater table is lower than the surface except within the wetland areas. The proposed development and introduction of large impervious areas will potentially alter the hydrology for areas with greater building density, and there will be a need for stormwater management to minimize potential flooding and provide stormwater management and resolution of water quality issues.

The stormwater management approach discussed in this document relies on a system of interconnected and distributed stormwater storage infrastructure (lakes, dry ponds, and smaller green infrastructure components), and conventional stormwater conveyance components to ensure adequate management of the stormwater runoff. The project area was delineated into 11 watersheds based on topography, soil, and proposed infrastructure, and analysis was conducted to determine post-development runoff and define the most efficient configuration of the stormwater system which would minimize the runoff, increase aquifer recharge, and ensure compliance with water quality requirements. The urban plan introduced 11 lakes (with a total area of 24 acres ranging between 0.3 and 4 acres in size) and more than 80 dry ponds (with a total area of 32 acres ranging in size between 0.1 to 2 acres). The proposed wet and dry ponds are interconnected with overland and subsurface conveyances to distribute and treat water storage within the site. The system was conceptualized to maximize infiltration and aquifer recharge of excess runoff during storms.

The analysis provided in this document is based on land use provided in the hybrid master plan and is based on limited information for the infiltration properties of the soils as obtained from previous studies. In addition, the calculations are based on the initial grading of the site which may be subject to change if a different type of use is required. Additional adjustments of the stormwater storage components (wet and dry ponds) may be required for the final design based on possible modified requirements.

Considering that the project has environmentally preserved areas (the wetlands to the south, west, and north), one of the main objectives for the development of the site plan was implementing green corridors in the direction of the streams and the conservation areas in order to preserve to the greatest degree of hydrologic connectivity between the watersheds and to preserve the natural pre-development flow. The green corridors include a variety of Green Infrastructure and light Imprint components to accomplish this objective.

Based on the urban plan configuration, the stormwater system for the Hybrid Plan provides enough storage to attenuate post-development 100-year, 24-hour peak discharge rate to pre-development rates. Furthermore, the hybrid plan provides a conveyance system for a 25-year, 24-hour peak discharge rate. An additional optimization is proposed to the thoroughfare components (pavement, sidewalks, on-street parking) to implement semi-impervious materials where possible.

The project has favorable topography for eliminating, to a great extent, the subsurface stormwater system and utilizes a variety of Green Infrastructure components for stormwater management. Therefore, one of the objectives was to propose a site plan which has minimal impervious infrastructure and the optimal surface of semi-impervious areas (parking lots, low traffic areas). The green infrastructure components reduce the need for conventional stormwater infrastructure and lower the costs and ensure the best environmental performance of the project.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1 INTRODUCTION

1.1 Site Hydrology

The OLF-8 property is located within Sections 4 and 5, Township 1 South, Range 31 West in Escambia County, Florida. The OLF-8 site provides an opportunity for a new development that is environmentally sustainable and resilient, compact, diverse, and well-connected. The overall approach for civil and environmental engineering is to protect resources and reduce construction and operating costs in the long run by using sustainable civil engineering practices that are coordinated with urban design.

1.1.1 Topography

The topography for this project was derived from the Digital Elevation Model (DEM) containing a georeferenced digital representation of the ground surface elevations providing the vertical position above NAVD 88 in feet. Data is encapsulated in grid format (raster), based on Light Detection and Ranging (LiDAR) for ground elevations and conventional surveys for canal cross-sections.

The topography varies from 70 to 145 feet elevation in the North American Vertical Datum of 1988 (NAVD 88); however, most of the site is primarily flat and at elevations above 100 feet NAVD 88. With less than 15% of the site area at an elevation less than 100 feet, the site has favorable topography for a broad range of urban development; additionally, this area is primarily occupied by wetlands and considered undevelopable land, Figure 1. The figure shows ground surface elevations, adjacent parcels, wetlands, and existing drainage ponds.

The pre-development drainage from the site flows via natural land depressions and channels to wetlands and into perennial streams located on the southern and eastern boundaries. Surface runoff from the site is routed to Eleven Mile Creek, which is located approximately 4,500 feet to the east boundary as shown in Figure 1. Rainfall that exceeds the infiltration capacity of soils, results in surface runoff that is routed to drainage channels in the southern and eastern portions of the site. These channels ultimately discharge into Eleven Mile Creek.

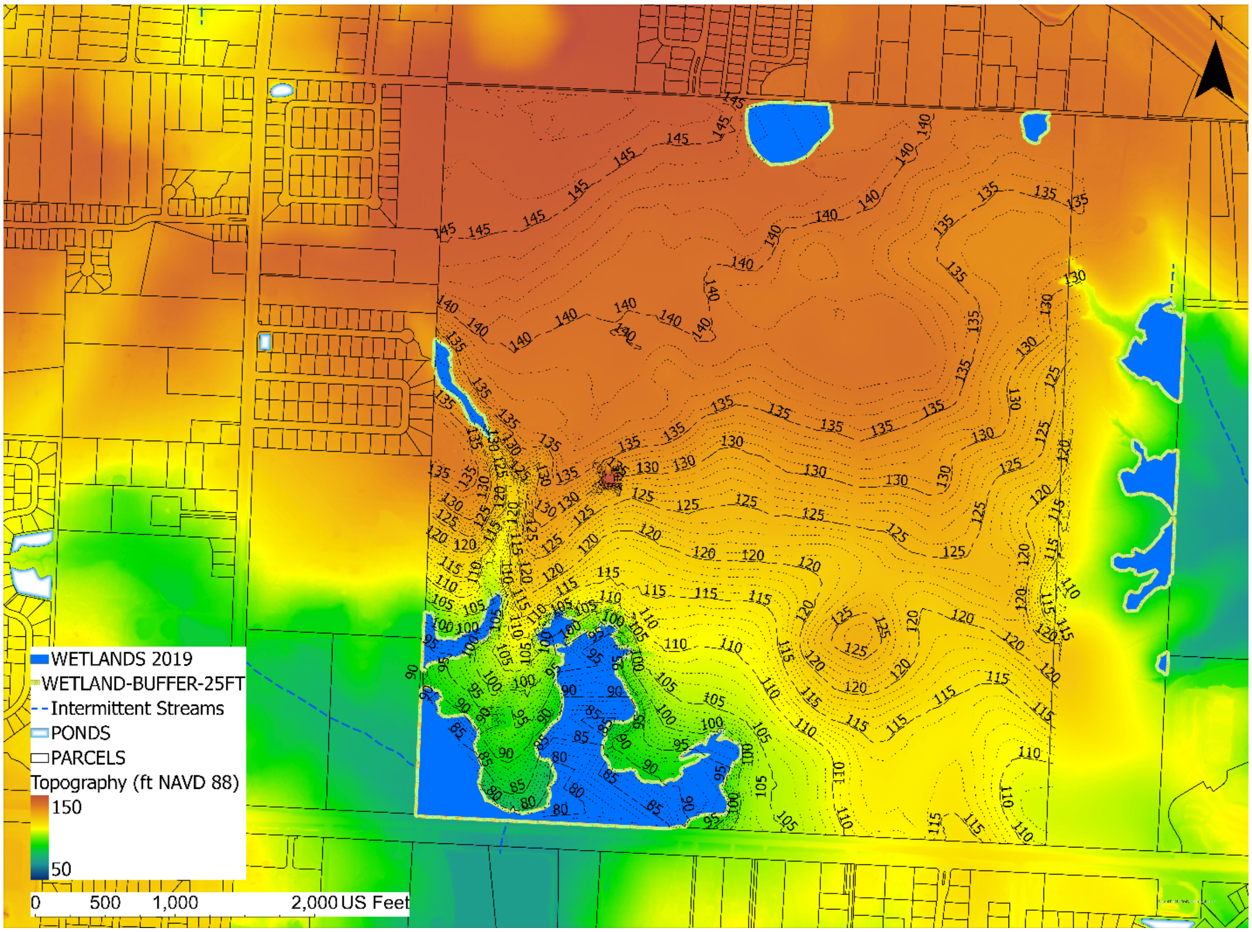


Figure 1 Site Topography in feet North American Vertical Datum of 1988

The site has natural drainage patterns, and no impervious areas exist to inhibit the natural recharge of the aquifer. Without comprehensive stormwater management, urban development will result in increased runoff from the impervious areas. Left untreated, these areas reduce aquifer recharge and increase stormwater surface runoff during rainfall events. Context-sensitive stormwater strategies are recommended to decrease the run-off peak postconstruction and avoid increasing pollutants downstream.

The natural slope for most of the project area (84.6% of total acreage) is below 5 % (Figure 2). Areas with slopes between 5% and 15% are less than 3.7 % of total acreage.

Areas with slopes steeper than 15% are less than 11.7 % of total acreage and are in the southwest corner of the project domain where wetlands also additionally exist therefore this land is not suited for development. In summary, the topography across the site, except for the SW corner, poses no constraints to urban development.

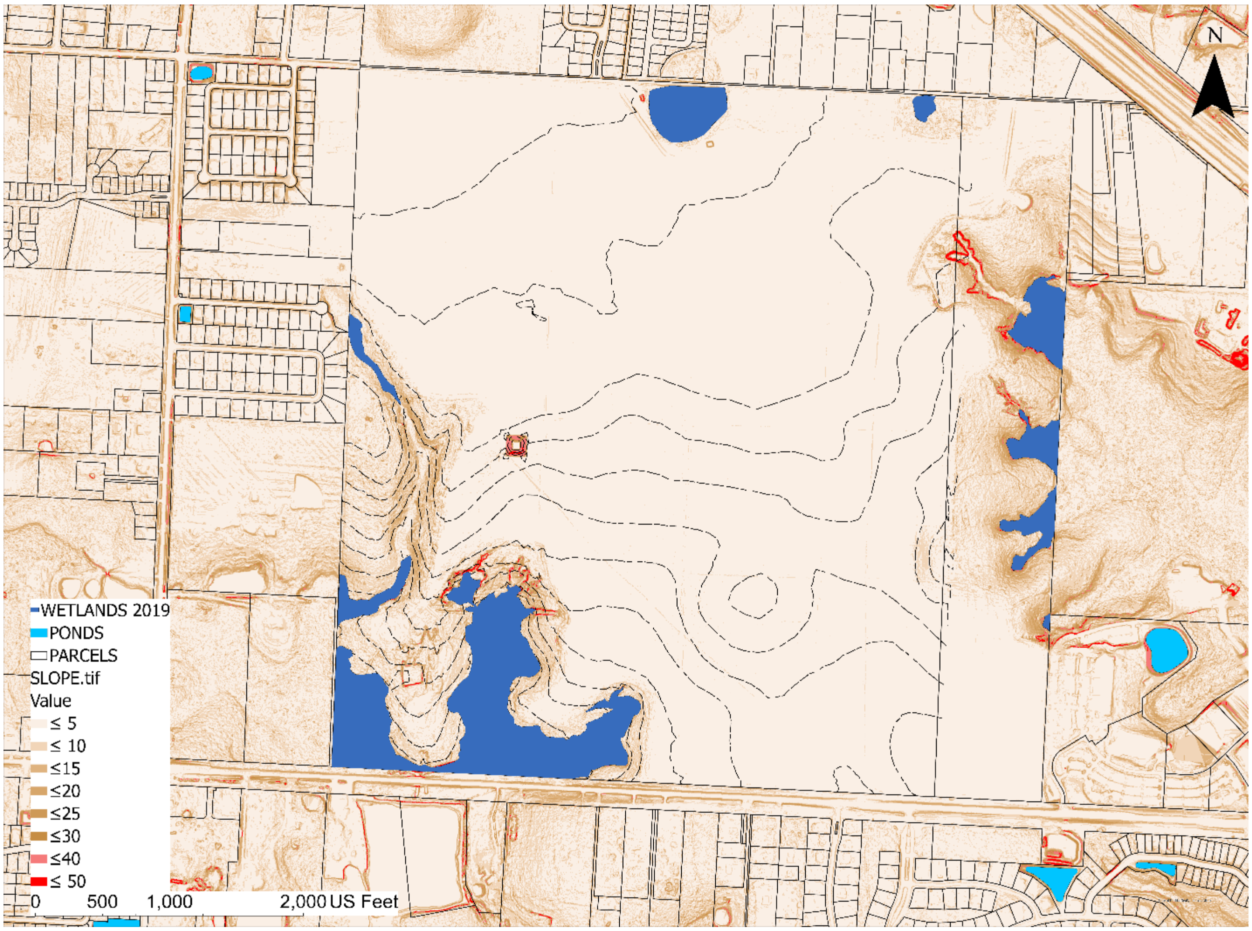


Figure 2 Ground surface slopes, adjacent parcels, wetlands, and existing drainage ponds.

The proposed urban development will result in the addition of impervious and semi-impervious areas, which will reduce aquifer recharge and will increase stormwater surface runoff during rainfall events generating higher runoff peaks and volumes and increasing pollution downstream. The impervious and semi-impervious areas can be classified in the following categories based on their perviousness and accessibility:

i) Impervious surfaces mainly from building roofs and footprints.

ii) Semi-impervious surfaces with public access, including light traffic roads, sidewalks, parking areas, and other public spaces.

iii) Pervious green infrastructure components are designed to provide stormwater storage including green areas, parks, detention areas, stormwater trees (trees with the capacity to accommodate runoff), this includes natural preserves. These areas are located within the blocks in proximity to the buildings and are used for stormwater retention.

iv) Pervious natural green areas, which are preserved in their native state.

To ensure that the overall site hydrology is preserved, the urban plan implements multiple strategies to reduce the impacts of impervious areas such as:

i) Reduce impervious areas to reduce surface runoff and increase the aquifer recharge

ii) Increase on-site storage to retain stormwater to maintain the pre-development drainage hydrology

iii) Use native vegetation to reduce stormwater runoff velocities, increase evapotranspiration, and improve water quality

iv) Provide a series of inline cascading storage features (dry, wet, and retention ponds) to attenuate post-development peak runoff and provide water quality treatment, while providing watercourse park amenities

1.1.2 Groundwater

The project is a greenfield site and there are no areas with known groundwater pollution, therefore, infiltration and use of surface drainage features are not expected to mobilize groundwater contamination. Tests provided most recently, January 2019, showed no presence of organic pollution in groundwater. The depth to groundwater beneath the project site during the wet season indicates available storage for infiltration even though the infiltration rates could be slow.

The surficial aquifer is underlain by the sandy to clayey surficial horizons of the Citronelle Formation that are time-equivalent to the hydrogeologic Sand & Gravel Aquifer. The Sand

& Gravel Aquifer is 275 to 300 feet thick in this area (Wilkins, et. al., 1985). In Southern Escambia County, the Sand & Gravel Aquifer is the source of all domestic and municipal water in Pensacola (ECUA, 1987).

1.1.3 Wetlands

A wetland Delineation investigation was completed in 2019 (Figure 3). The investigation established that the wetlands are comprised of four distinct ecological communities, wetland bay gall, wetland shrub bog, wetland dome swamp, upland mesic hardwoods, and disturbed uplands.

Figure 3 Wetland Delineation (2019)

The previous delineation from 2013 identified approximately 23.21 acres of palustrine wetlands (rooted in water but growing above the surface) along the northern, eastern, and southwestern borders of the site. Approximately 0.08 acres of emergent wetlands exist along the western border of the property. Upland and forested drainage channels are present, draining to the wetlands.

Approved jurisdictional determination for 17.08 acres of the wetlands along the west, South, and Eastern boundaries was issued by the USACE in April of 2013 due to their drainage to Eleven Mile Creek, which is a tributary to traditionally navigable water. Wetlands along the northern border of the property are classified non- jurisdictional because these areas (6.05 acres) are isolated from, or not adjacent to traditional navigable water or other waters of the U.S. Upland buffers with a minimum width of 15-feet and an average width of 25-feet shall be provided abutting those wetlands under the regulatory jurisdiction of the State of Florida under 62-340. A 10-feet average upland buffer shall be required for development activities that avoid impacts to wetlands.

1.1.4 Soils and Infiltration

The soil types within the County were determined from the United States Department of Agriculture (USDA) Natural Resources Conservation Service’s (NRCS) Soil Survey and are known as Soil Survey Geographic (SSURGO) and State Soil Geographic (STATSGO2) databases (ref 2).

The SSURGO2 database contains information about soil which can be displayed in tables or as maps. The information was gathered by walking over the land and observing the soil and by laboratory analysis. The maps outline areas are called map units and are linked in the database to information about the component soils and their properties for each map unit.

Each map unit may contain one to three major components and some minor components. The map units are typically named for the major components. Examples of information available from the database include available water capacity, soil reaction, electrical conductivity, and frequency of flooding; yields for cropland, woodland, rangeland, and pastureland; and limitations affecting recreational development, building site development, and other engineering uses.

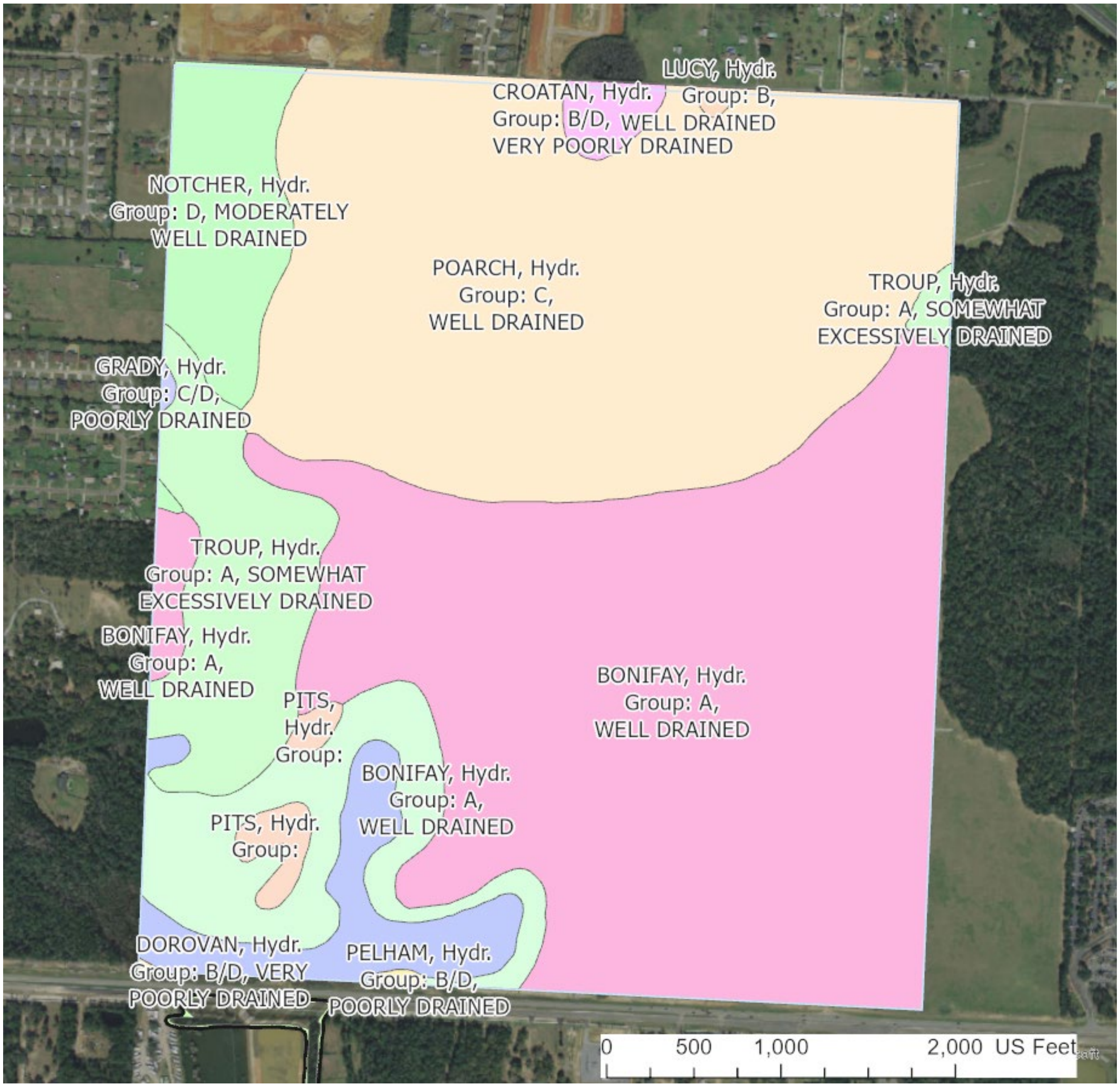


Figure 4 NRCS Soil Survey

For a large portion of the project and natural conditions, the NRCS provides a classification of group A (Figure 4). As a result of urbanization, the underlying soil may be disturbed or covered by a new layer which may lower the infiltration capacity. Soils types with dual classifications (e.g., Type B/D) generally represent areas where there is a lens of poorly drained soils lying above a section of better draining soils. Typically, the lower (Type-D) classification is used to determine infiltration rates, unless the soil is disturbed, such as a field of row crops where it is likely the upper lens has been penetrated. Based on the investigation by Terracon the predominant soil type encountered on-site was silty to clayey fine-grained sand.

To determine the runoff and the infiltration rates and capacity, a hydrological model was based on the Curve Number (CN) methodology described in USGS published "Urban Hydrology for Small Watersheds (TR-55)". The CN is a dimensionless number depending on hydrologic soil group, cover type, treatment, hydrological condition, and antecedent moisture conditions. This number has a valid range from 0 to 100 with typical values between 60 and 90 for most encountered conditions and ranging up to 98 for impervious surfaces.

Soil classification is based on Hydrologic Soil Groups (HSG). Typical soil classifications are Types A (>10 in/hr infiltration rate), B (7-10 in/hr), C (5-7 in/hr) and D (less than 5 in/hr). For fully developed urban areas (vegetation established), the CN values were obtained from Urban Hydrology for Small Watersheds TR-55 and summarized in the following table:

Table 1 CN values for land use and hydrologic soil group

Land Use	Hydrologic Soil Group			
	A	B	C	D
Urban Areas				
Open Space Poor Condition (grass cover < 50%)	68	79	86	89
Open Space Fair Condition (grass cover 50 to 75%)	49	69	79	84
Open Space Good Condition (grass cover > 75%)	39	61	74	80
Developing Urban Areas				
Newly graded areas (pervious only, no vegetation)	77	86	91	94

The hydrologic soil group listed for each map unit was used to derive the Curve Number (CN).

- **Group A** is sand, loamy sand, or sandy loam types of soils characterized by low runoff potential and high infiltration rates even when thoroughly wetted. They consist chiefly of deep, well to excessively drained sands or gravels and have a high rate of water transmission.

- **Group B** is silt loam or loam with a moderate infiltration rate when thoroughly wetted and consists mainly of moderately deep to deep, moderately well to well-drained soils with moderately fine to moderately coarse textures.
- **Group C** soils are sandy clay loam with low infiltration rates when thoroughly wetted and consist mainly of soils with a layer that impedes downward movement of water and soils with moderately fine to fine structure.
- **Group D** soils are clay loam, silty clay loam, sandy clay, silty clay, or clay characterized by the highest runoff potential. They have very low infiltration rates when thoroughly wetted and consist mainly of clay soils with a high swelling potential, soils with a permanent high-water table, soils with a claypan or clay layer at or near the surface, and shallow soils over nearly impervious material.

For infiltration analysis, an Open Space Poor Condition (grass cover 50% to 75%) was used for assigning the CN values.

Three categories can be used to provide the impact of the preexisting soil conditions:

- ARC I (dry soils),
- ARC II (typical conditions)
- ARC III (saturated soil after heavy rainfall)

The analysis was based on ARC II (typical conditions), and therefore no adjustments to CN values were performed based on antecedent moisture conditions. The soil layer HSG types were joined to the corresponding CN values from Table 6, then spatially joined to the sub-watershed delineation to determine the weighted average CN value for each sub-watershed.

1.1.5 Flood Hazard Mapping

The National Flood Insurance Program (NFIP) is a federal program managed by the Federal Emergency Management Agency (FEMA) intended to reduce the impact of flooding on private and public structures by providing affordable insurance and encouraging communities to adopt and enforce floodplain management regulations aimed at mitigating the effects of flooding on new and improved structures. Flood hazard mapping and the Community Rating System (CRS) are key components of this program.

Flood hazard mapping is an important part of the NFIP, as it forms the basis of the NFIP regulations and flood insurance requirements. Data is maintained and updated through the FIRMs. The FIRM is the official map which that roads and map landmarks that shows the community's base flood elevations and delineated the flood zones and floodplain boundaries. To identify a community's flood risk, FEMA conducts a Flood Insurance Study. The study includes information on canal and stream flows, storm tides, hydrologic and hydraulic analyses, and rainfall and topographic surveys. FEMA uses this data to create the FIRMs that outline each community's different flood risk areas.

FEMA performs a Flood Insurance Study (FIS) to investigate the existence and severity of flood hazards. An initial countywide Flood Insurance Study (FIS) was done on January 21, 1998, and later revised on February 23, 2000, July 17, 2002, on September 29, 2006, and most recently October 2019 (ref 1). FIRMs are available online at the following web address: https://msc.fema.gov/portal/home.

The project site is in FEMA's flood Zone X, which is designated as an area of minimal flood hazard, as per the FEMA Floor Insurance Rate Map (FIRM) Map No, 12033C0290G which is effective as of October 2019. Zone X is the flood insurance rate zone that corresponds to areas outside the 500-year floodplain where average depths are less than 1 foot.

The project is not located within FEMA-designated special flood hazard areas. The entire site is in zone X (Figure 5), designated for minimal flood hazard, and located outside the Special Flood Hazard Area and at higher than the 0.2-percent-annual-chance flood.

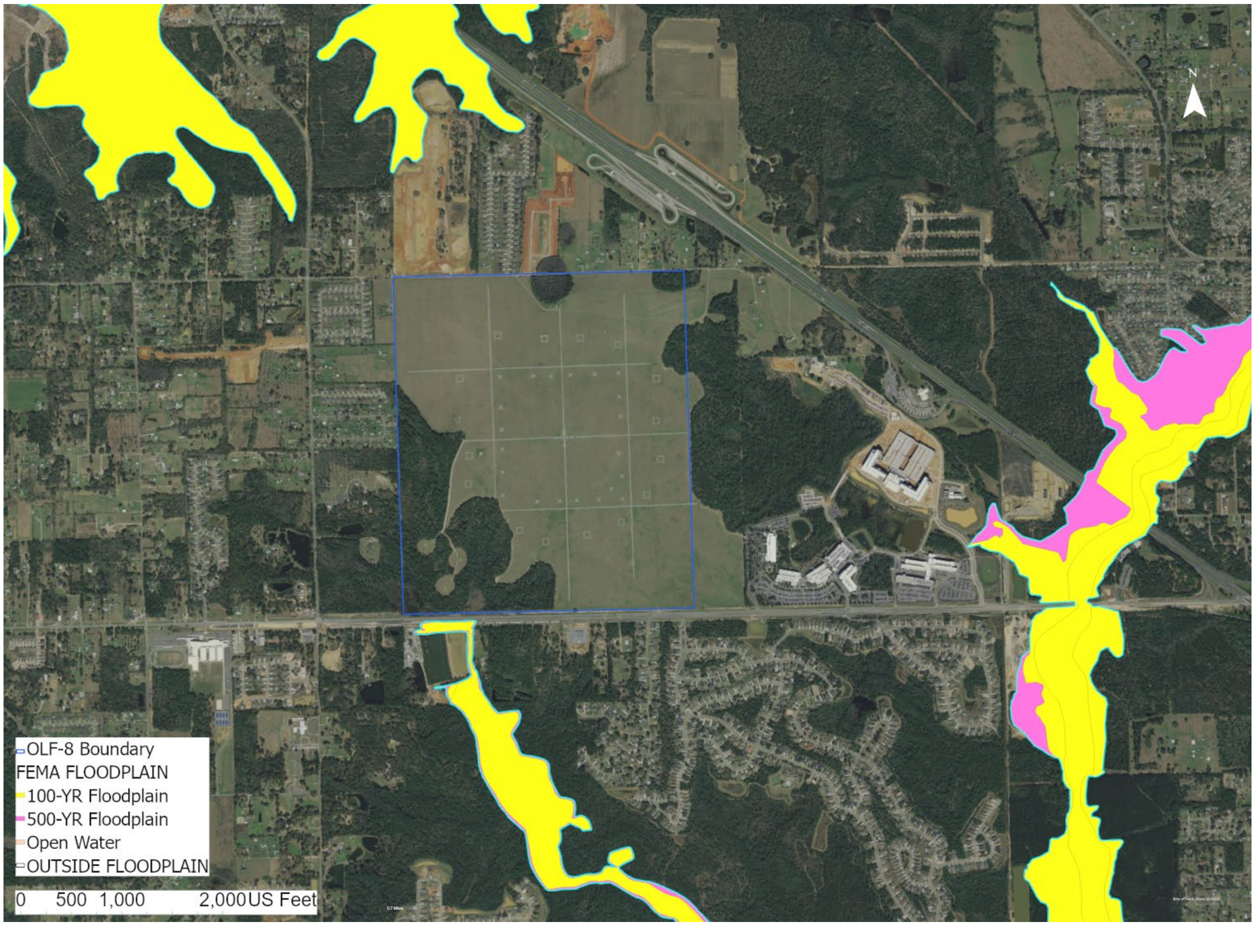


Figure 5 FEMA Flood Hazard Zones, October 2019

Flooding in Escambia County results primarily from tidal surges and the overflow of streams and swamps associated with rainfall-runoff. Major rainfall events occur because of hurricanes, tropical storms, and thundershowers associated with frontal systems. Some of the worst floods to occur in this area were the result of high-intensity rainfall during a hurricane (particularly in 2020, Hurricane Sally nearly 30" inches of rain were recorded within a few days and with maxim 3 -day rainfall (ref 3).

1.2 Environmental Characteristics of the Site

A summary of potential environmental site development characteristics and constraints of the site which was provided in the limited environmental assessment completed in 2019 is provided in Table 2. Eleven Mile Creek has an established TMDL for fecal coliform, a contaminant that results from a variety of non-point sources (failed septic systems, livestock, wildlife, and domestic animals).

Table 2 Summary of Potential Site Development Constraints

Resource Area	Constraints Anticipated	Additional Notes
Air Quality	No	No significant impacts are anticipated. No mitigation measures are warranted to reduce impacts to less than significant levels.
Water Resources	Yes	Jurisdictional Wetlands Delineated on site (approximately 17 acres), Requirements: No impacts required or mitigation measures with USACE Surface runoff currently discharging into Eleven Mile Creek Drainage Basin with TMDL requirements. The site will implement comprehensive stormwater plan to retain and treat stormwater runoff. Site will implement retention on site and will not generate pollutant discharges
Geological Resources	No	Topography, Geology and Soils, no impacts expected, Depending on the extent of the civil infrastructure, modifications of topography for grading will be needed at locations with land depressions possibly in the SW section of the site
Cultural Resources	No	No Archaeological, Architectural resources and traditional communities identified
Biological Resources	No	No threatened, endangered, and other special status species, including vegetation, terrestrial wildlife identified Only Gopher Tortoise was observed on site out of 17 potential species Wooded areas have potential for several other species, including birds
Noise	No	Nearest sensitive land use is residential houses which are located within the residential subdivisions known as Brunson Meadows and Blackberry Ridge
Infrastructure	No	Potable water for OLF Site 8 is municipally supplied, no on-site potable water wells are located on or utilized by the property Wastewater generated at OLF Site 8 is managed on-site via a sanitary septic system connected to existing buildings plumbing systems Surface water runoff infiltrates or is discharged eventually to Eleven Mile Creek, the site will implement comprehensive stormwater management plan to retain and treat stormwater on site Solid waste managed by ECUA
Hazardous Materials and Wastes	No	Regulations governing the handling and storage of petroleum products have been implemented on current site and no contamination has been recorded

2 STORMWATER MANAGEMENT

Man-made infrastructure and buildings can significantly modify the distribution of the water fluxes and contaminating the water and soil resources. Impervious surfaces intercept precipitation and affect the natural hydrological cycle by: a) Redirecting a significant portion of the precipitation to stormwater management facilities and reducing recharge of the aquifer, b) Increasing evaporation from impervious surfaces, and c) Polluting the surface runoff water.

Increased quantities of lawn nutrients, urban pesticides, rooftop runoff, and the first flush of stormwater, contamination by heavy metals, suspended and deposited sediments, and biocontamination are additional factors that are attributed to urbanization and urban pollution. The typical impact of the built environment is the deterioration of ecosystems and declining biodiversity.

Watersheds contain the human habitat and preservation of the services provided by the watersheds, including water quality and quantity; biodiversity and assimilative capacity are essential for sustainability. The continuous expansion of the infrastructure of human society increases the stress and impacts the natural, sustainable conditions of the watersheds. Minimization of the impact of the built environment is critical for maintaining the ecological balance and biodiversity of ecosystems within a watershed. Watersheds contain the human habitat; therefore, preservation of services (water quality and quantity, biodiversity, and assimilative capacity) are essential for sustainability.

In a natural setting, the following hydrologic functions occur:

- **Rainfall interception:** In a vegetated watershed, the surfaces of trees, shrubs, and grasses capture initial light precipitation before it reaches the ground. The interception of precipitation can delay the start and reduce the volume of stormwater runoff.

- **Shallow surface storage which is available for storage:** The shallow pockets present in natural terrain store rainfall and stormwater runoff, filter it, and allow it to infiltrate. This shallow surface storage can delay the start and reduce the volume of stormwater runoff.
- **Evaporation and transpiration:** Evapotranspiration, reduce the volume of stormwater runoff, locally return moisture into the atmosphere, and provide local cooling effects. Evapotranspiration occurs mainly through the foliage and preserving the vegetation to the maximum extent is beneficial. In addition, plants act as a pump extracting groundwater and releasing it into the air, thus keeping available infiltration storage.
- **Infiltration:** Infiltration is the movement of surface water down through the soil pores into groundwater. This movement provides natural treatment by filtration, reduces the volume of stormwater runoff, and replenishes groundwater supplies.
- **Runoff:** Runoff is the flow of water across the land surface that occurs after rainfall interception, surface storage, and infiltration reach capacity. In natural settings, most of the precipitation is either infiltrated into the soil or lost to evapotranspiration.

2.1 Urbanization and Development

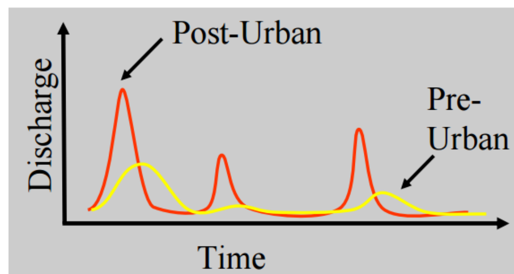
With urbanization and development, previous surfaces (such as forests and meadows) are converted into impervious areas (i.e., building footprints, driveways, parking lots), and the percentage of precipitation that becomes stormwater runoff increases. The impact of such conversion includes:

- Higher peak flow rates and stormwater runoff volumes produced by storms (Figure 6).
- Increased concentrations of nutrients, toxic pollutants, and bacteria in surface receiving waters, including adjacent land and habitat creeks, estuaries, and storm drain outlets.
- Decreased wet season groundwater recharge due to a reduced infiltration area.
- Increased dry weather urban runoff due to outdoor irrigation.

- Introduction of base flows in ephemeral streams due to surface discharge of dry weather urban runoff (i.e., irrigation runoff);
- Increased stream and channel instability and erosion due to increased stormwater runoff volumes, flow durations, and higher stream velocities
- Increased stream temperature, which decreases dissolved oxygen levels and adversely impacts temperature-sensitive aquatic life, due to loss of riparian vegetation as well as stormwater runoff warmed by impervious surfaces.

A summary of post-urban impacts includes:

- Increased Peak Flow
- Increased Overall Discharge
- Reduced Infiltration
- Reduced Storage in Soil
- Reduced Evapotranspiration
- Considerably faster stormwater events
- Loss of water
- Stream Erosion
- Discharge of contaminants



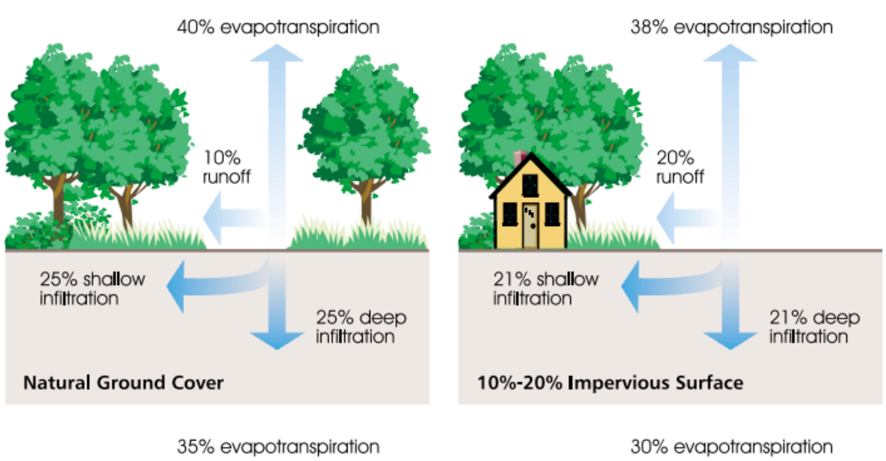


Figure 6 Changes of hydrologic distribution of water flux caused by urban environments (USGS)

2.2 Local Requirements and Guidelines

As per Section 3.3.1 of Environmental Resource Permit Applicant's Handbook Volume II, applicants may propose to utilize applicable storm event, duration, or criteria specified by a local government, a state agency (including FDOT), or stormwater utility with jurisdiction over the project.

Escambia County Land Development Code requires projects to provide attenuation of the runoff from a 100-year critical duration event, up to and including 24-hour duration so that the post-development runoff rate does not exceed the pre-development runoff rate when a positive discharge route is present.

2.3 Onsite retention criteria

To retain the 100-year 24-hr volumes and the difference between pre-and post-development runoff, for 25-year a-day event rainfall volumes, the stormwater system includes a series of distributed retention ponds. Depending on the anticipated density and total impervious areas, the approximate fraction of retention areas may range between 5% up to 15% for very low to high density. Retention-based stormwater quality control measures are more effective on level or gently sloped sites than steeply sloped sites, therefore, the retention green infrastructure components should preferably be placed in the flatter and lower areas to allow drainage by gravity. To accomplish zero stormwater discharge by retaining the maximum quantities of stormwater onsite, the following two strategies will be adopted:

- Use of lakes - the storage is determined based on the water level within the lake and the elevation of the freeboard;
- Use of natural preserves - the storage is determined based on the groundwater level and the elevation of the freeboard;

The configuration of the wet retention ponds will be carefully calibrated for the different master plans. Lakes and wet retention ponds best practices include recommendations include:

- The center portion of any man-made lake should be excavated deep enough to maintain a water depth greater than 10 feet.
- Constructed at a minimum of twenty-five feet distance from existing or proposed residence, other structures, or road right-of-way.
- Constructed at a minimum of fifty feet from existing or proposed soil absorption, on-site, sanitary waste disposal system.
- The perimeter of the man-made lake, pond, or waterway is landscaped and seeded after completion of the excavation.
- Excavated material from the site is shaped and spread to blend with the natural landforms in the area.
- Natural run-off and/or other waterway fed are the only water sources allowed for the man-made lake, pond, or waterway
- The constructed man-made lake, pond, or waterway meets the requirements of the local floodplain ordinance.

2.4 Preservation of Natural Features and Conservation:

Preservation of natural features, listed in Table 3, includes methodologies to identify and preserve natural areas that can be used to protect water, habitat, and vegetative resources. Conservation includes designing elements of the development in a way that the site design takes advantage of a site's natural features, preserves sensitive areas, and identifies constraints and opportunities to prevent or reduce negative effects of development. An evaluation of the preservation of natural features and conservation planning practices is provided in Table 3:

Table 3 Methodologies for Preservation of Natural Site Features

Practice	Description
Preservation of Undisturbed Areas	Delineate and place into permanent conservation undisturbed forests, native vegetated areas, riparian corridors, wetlands, and natural terrain.
Preservation of Undisturbed Areas	Define, delineate, and preserve naturally vegetated buffers along perennial streams, rivers, shorelines and wetlands.

Preservation of Undisturbed Areas	Limit clearing and grading to the minimum amount needed for roads, driveways, foundations, utilities and stormwater management facilities.
Preservation of Undisturbed Areas	Use clustering, conservation design or open space design to reduce impervious cover, preserve more open space and protect water resources.
Preservation of Undisturbed Areas	Restore the original properties and porosity of the soil by deep till and amendment with compost to reduce the generation of runoff and enhance the runoff reduction performance of post construction practices.

2.5 Reduction of Impervious Areas:

Reduction of impervious cover includes methods listed in Table 4 is accomplished by minimizing the number of rooftops, parking lots, roadways, sidewalks, and other surfaces that do not allow rain to infiltrate into the soil. An evaluation of the reduction of impervious cover techniques is provided in Table 4.

Table 4 Reduction of Imperivous Areas

Practice	Description
Roadway Reduction	Minimize roadway widths and lengths to reduce site impervious area
Sidewalk Reduction	Minimize sidewalk lengths and widths to reduce site impervious area
Parking Reduction	Reduce imperviousness on parking lots by eliminating unneeded spaces, providing compact car spaces and efficient parking lanes, minimizing stall dimensions, using porous pavement surfaces in overflow parking areas, and using multi-storied parking decks where appropriate.

2.6 Future demand

Identify and estimate future demand and corresponding facilities required to serve projected local and regional growth

Develop and implement the Master Plan of Drainage for the near and long-term protection of the community and its residents

The analysis of the proposed master plan was performed using three scenarios:

- Analysis of preexisting conditions (Pre-Development)
- Analysis of post-development of each delineated watershed (Post-Development Conventional)
- Analysis of post-development of the entire site including Green Infrastructure. (Post-Development Green Infrastructure)

Green engineering is an important component in this master planning effort. The purpose of Green Infrastructure is to reduce total surface runoff and peak discharge rates, and duration of flow using site design and stormwater quality control measures. The benefits of reduced stormwater runoff volume include reduced pollutant loadings and increased groundwater recharge and evapotranspiration rates.

Stormwater quality control measures that incorporate green infrastructure principles will be placed throughout the site in small, discrete units and distributed near the source of impacts. Green Infrastructure strategies designed to protect surface and groundwater quality, maintain the integrity of ecosystems, and preserve the physical integrity of receiving waters by managing stormwater runoff at or close to the source will be expected.

Based on preliminary site understanding and conditions, the main green infrastructure strategies may include the following:

- use of bioretention/infiltration landscape areas,
- disconnected hydrologic flow paths,
- reduced impervious areas,
- functional landscaping, and grading to maintain natural hydrologic functions that existed before development, such as interception,
- shallow surface storage,
- infiltration, evapotranspiration, and groundwater recharge.

By implementing Low Impact Development (LID) strategies, this project site will be designed to be an integral part of the environment by maintaining undeveloped hydrologic functions through the careful use of stormwater quality control measures.

The runoff will be routed downstream through green infrastructure components, which provide additional storage and retention of the stormwater. The master plan will require optimization of the thoroughfare components (pavement, sidewalks, on-street parking) and implementation of pervious materials where possible. Proper implementation of green infrastructure requires detailed grading and analysis of the conveyance capacities of the system.

For this project, context-based strategies for a gradual transition from natural to urban settings are implemented and a set of relevant Light Imprint and green infrastructure tools were optimized for each character area. Retention-based stormwater quality control measures were developed. Space for distributed stormwater quality control measures will be planned and implemented throughout the project site. This may influence the configuration of roads, buildings, and other infrastructure. Flood control will be considered early in the design stages and control measures will be implemented to minimize stormwater runoff storm events that may exceed the design storm events.

3 ANALYSIS OF POST-DEVELOPMENT HYDROLOGY

3.1 Site Planning

A review of previous hydrologic studies and available data was conducted to identify physical site constraints, reduce costs of downstream stormwater quality control measures, and prevent potential project site re-design.

The following design criteria have been considered during the early planning stages:

- Applied a multidisciplinary approach for site planning that included collaborative effort between planners, engineers, landscape architects, and architects at the initial phases of the project the Pre- and Post- Charrette.
- Considered retention-based stormwater quality control measures as early as possible in the site planning process. Hydrology was the main organizing principle integrated into the initial site assessment planning phases.
- Planned for the space requirements of stormwater quality control measures.
- Distributed stormwater quality control measures throughout the project site. This influenced the configuration of roads, buildings, and other infrastructure.
- Considered flood control early in the design stages with the understanding that even sites with stormwater quality control measures will still have stormwater runoff during large storm events that exceed the size of the design storm event.

The topography of the site requires careful adjustment of the road spatial locations to ensure:

- Road slopes and parcel slopes that are within requirements
- Minimization of earthmoving volumes
- Optimization of location and sizing of green infrastructure components

Proper grading is critical for the optimal operation of the green infrastructure components. Exemplary site grading for a commerce block is shown in Figure 7.

The site is graded away from the building's finished floors, and it is sloped down towards Bioretention swales. Similarly, roadways are designed to slope down from bid block towards intersections, where the intersections are at a low point (Figure 8 and Figure 9). Also, roadway cross-sections are designed to route stormwater towards the bioretention swales in the medians, where available.

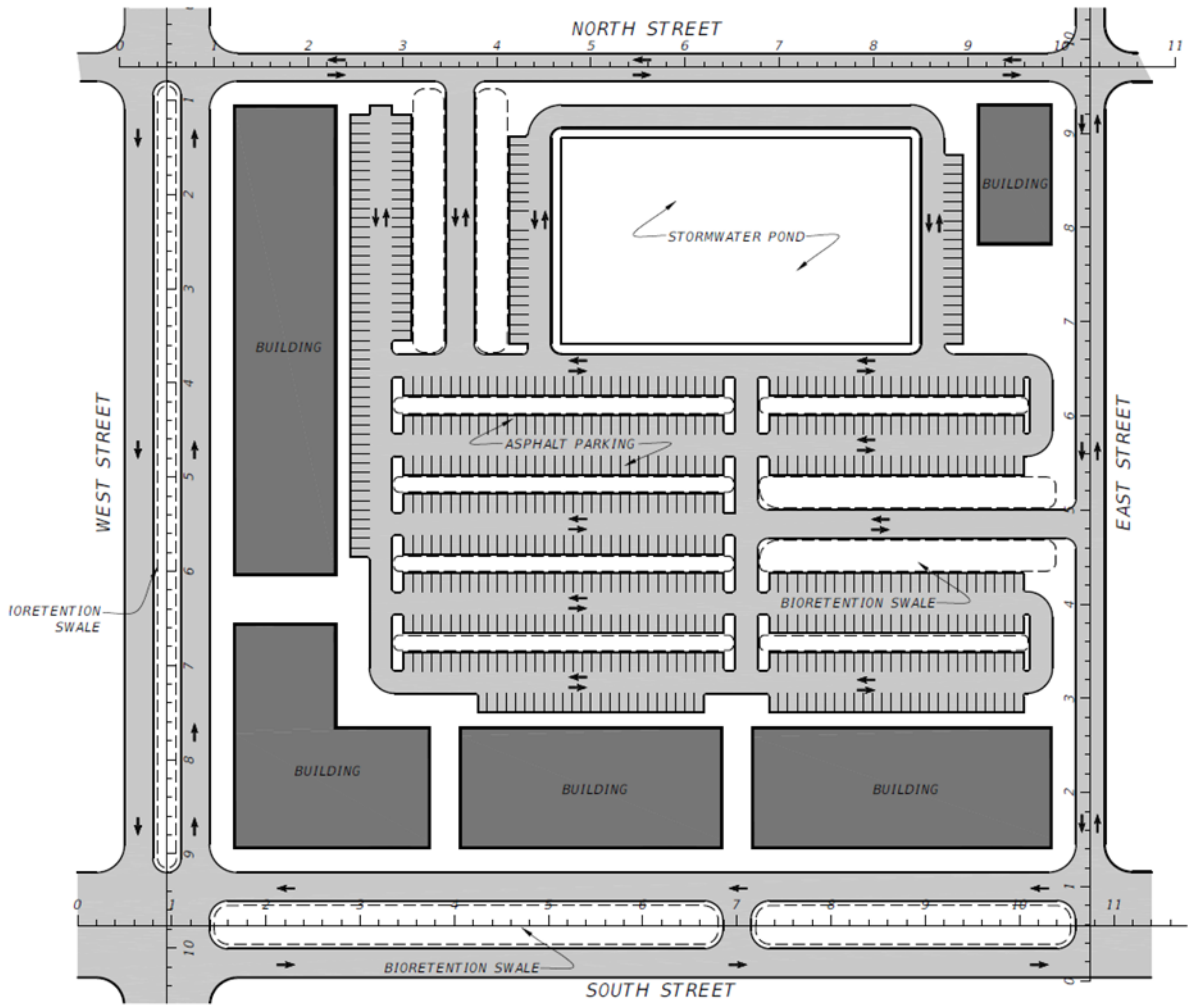


Figure 7 Site Plan for a Commerce Block

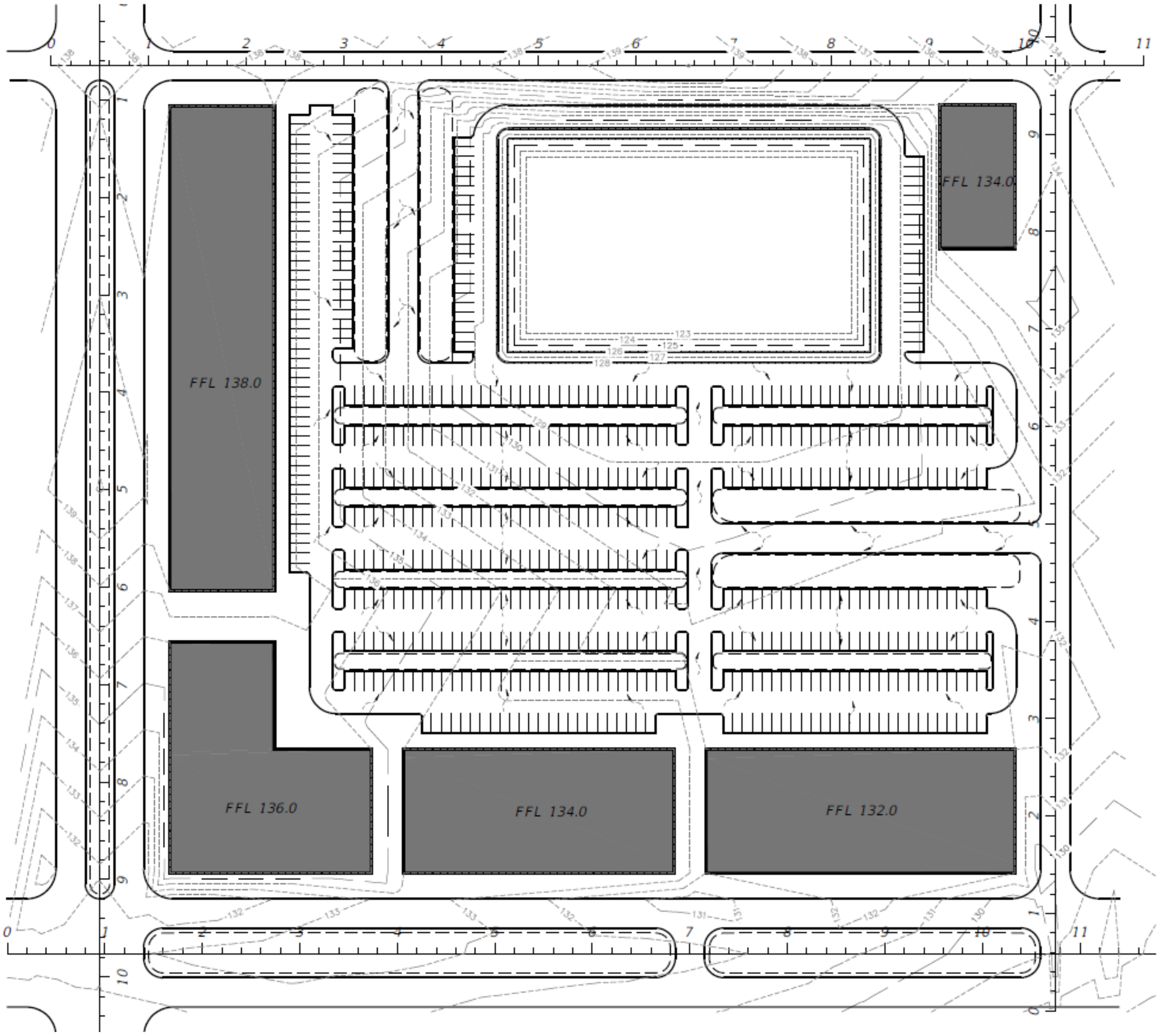


Figure 8 Grading Plan for a Commerce Block

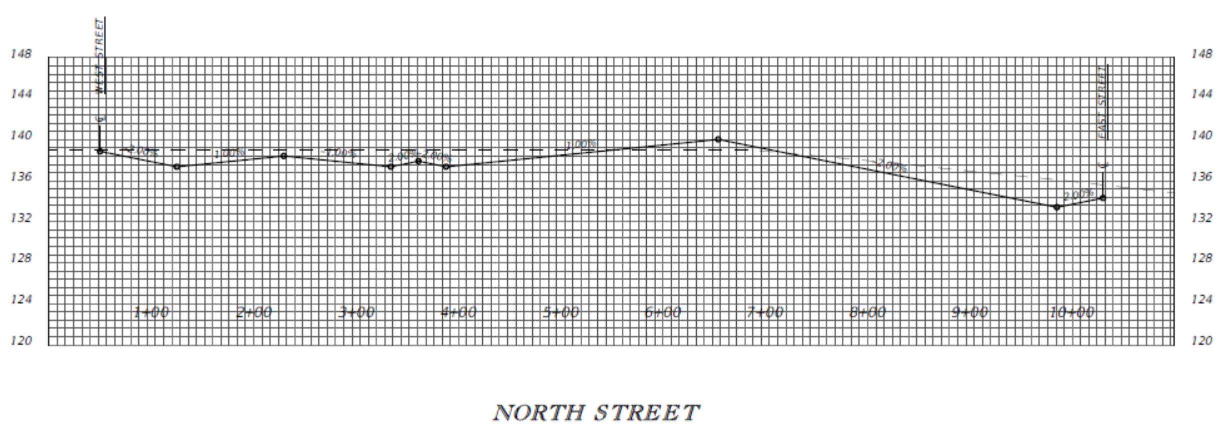


Figure 9 Typical Roadway Profile

3.2 Watersheds Delineation

The project has been delineated into 10 watersheds as shown in Figure 10. Each of these drainage basins will include green infrastructure techniques. The remaining highlighted watershed area at the southwest corner of the project is within the conservation limits and no development is proposed.

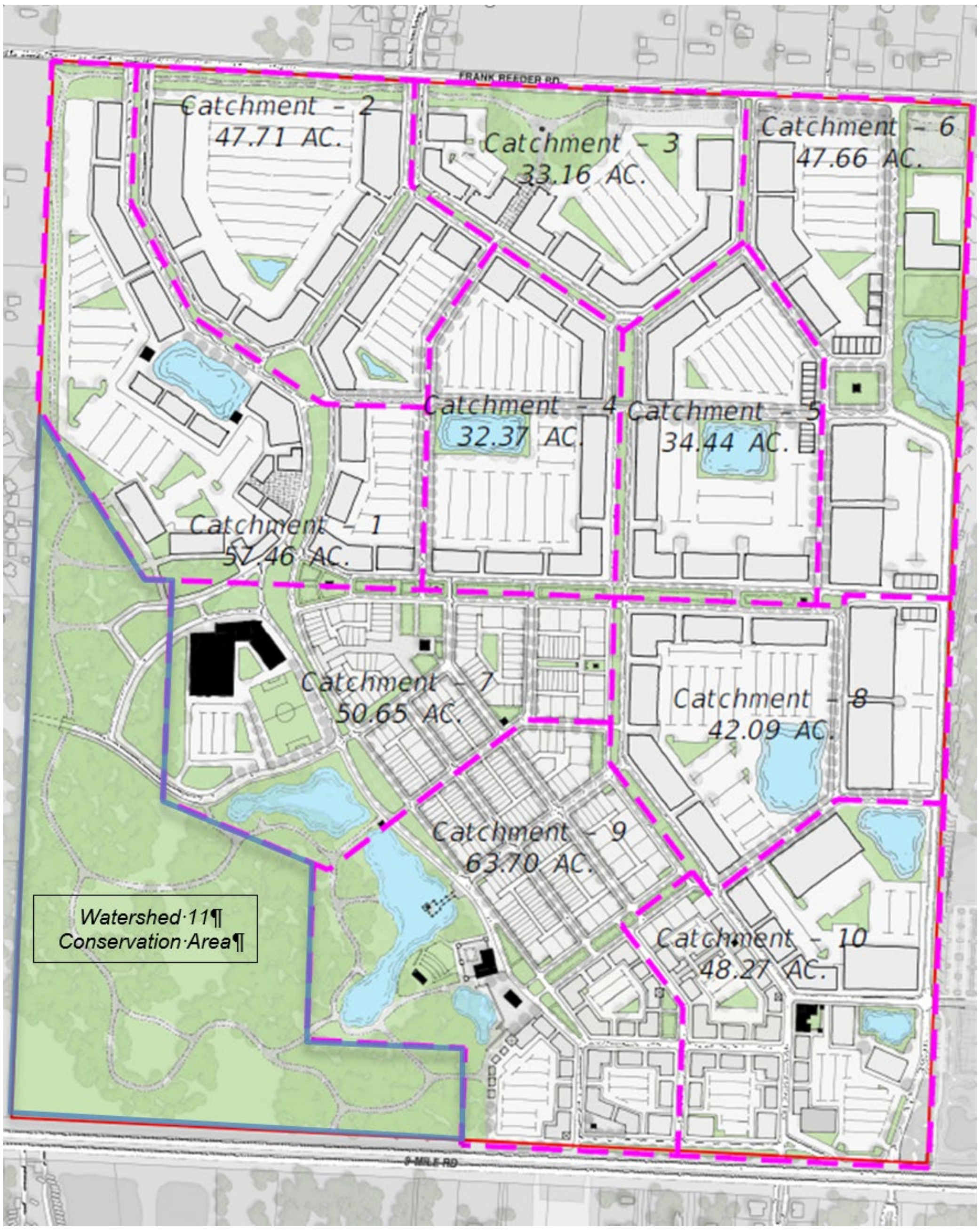


Figure 10 Post-Development Watersheds

The watersheds were delineated based on the topography and the proposed urban plan and pre-development drainage patterns with the intent of preserving the drainage direction. Based on the proposed master plan which provided conceptual location and sizing of green areas, lakes, and proposed buildings, the following table represents the areas that significantly impact the stormwater management, distribution, and mitigation.

Table 5 Summary of Dry Ponds, Lakes and Buildings Areas.

Watershed	Dry Ponds (acre)	Lakes (acre)	Buildings (acre)
Watershed 1	2.87	2.29	10.12
Watershed 2	3.59	0.30	9.55
Watershed 3	6.30		6.35
Watershed 4	0.63	2.27	5.29
Watershed 5	3.66	2.38	6.14
Watershed 6	3.00	2.60	10.04
Watershed 7	7.10	2.86	12.41
Watershed 8	1.67	3.01	9.85
Watershed 9	2.47	5.61	13.96
Watershed 10	1.14	2.55	11.20
Watershed 11*	0.99		
Total (acres)	**33.43**	**23.88**	**94.92**
* Watershed 11 covers the conservation area with no proposed development			

To total acreage was used to develop input files for the stormwater analysis.

3.3 Design Storm Events

The following are the design storm events are used for the design of the project. Storm events are referencing NOAA precipitation frequency estimates with 90% confidence intervals.

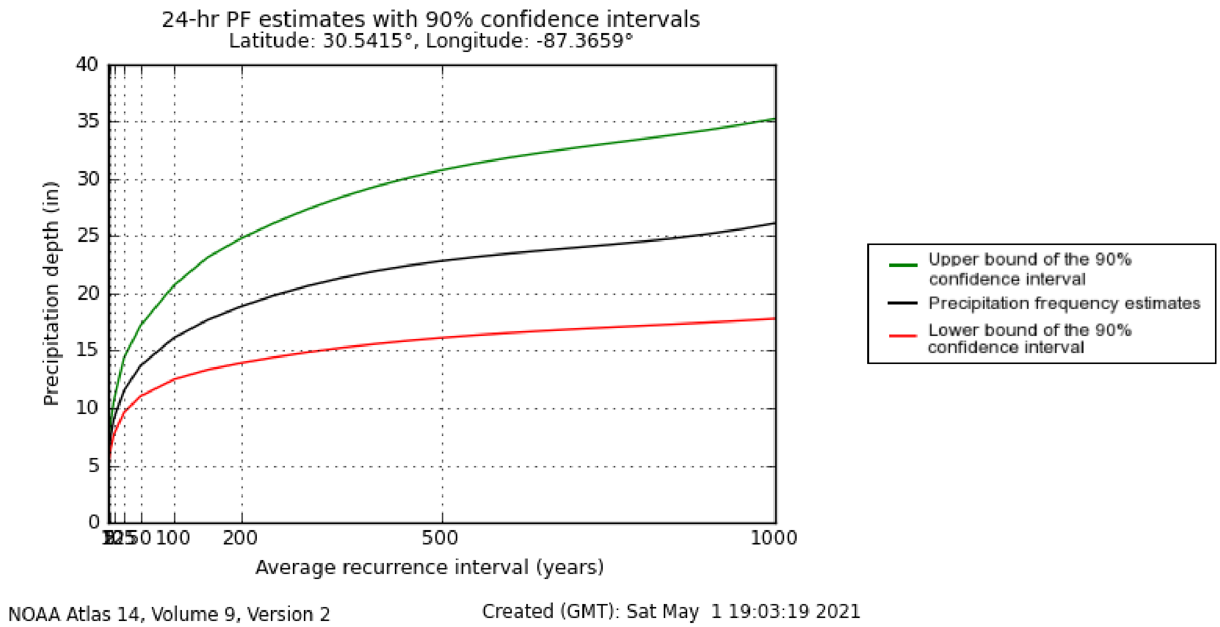


Figure 11 NOAA Precipitation Frequency Estimates

The recurrence intervals for 24-hour event and the rainfall depth are provided in the list below:

1 – Year,	24 Hour:	5.11“
5 – Year,	24 Hour:	7.47”
10 – Year,	24 Hour:	9.02”
25 – Year,	24 Hour:	11.5”
50 – Year,	24 Hour:	13.7”
100 – Year,	24 Hour:	16.2”

The predevelopment surface drainage patterns follow the topography. Additional infrastructure will be needed to improve the drainage of the flat areas and should be maintained to keep flood potential low.

The drainage basin Time of Concentration (TOC) is the time for a drop of water to reach the basin discharge point from the most hydraulically remote point in the basin. The watershed lag method is being used for the conceptual modeling. The watershed lag method spans a broad set of conditions ranging from heavily forested watersheds with steep channels and a high percent of runoff resulting from subsurface flow to meadows providing a high retardance to surface runoff, to smooth land surfaces and large paved areas.

$$T_c = \frac{\ell^{0.8}(S+1)^{0.7}}{1{,}140Y^{0.5}}$$

where:
L = lag, h
T_c = time of concentration, h
ℓ = flow length, ft
Y = average watershed land slope, %
S = maximum potential retention, in

$$= \frac{1{,}000}{cn'} - 10$$

where:
cn' = the retardance factor

3.4 Analysis of Watershed 1

Watershed 1 is 57.46 acres in size (Figure 12) and consists mostly of commerce use.

Figure 12 Configuration of Watershed 1

Summary of Hydrological calculations is shown as follows:

Table 6 Pre- and Post-Development Hydrology of Watershed 1

Pre-Development Conditions				
Storm Event	Precipitation (in)	Runoff Amount (in)	Peak Flow (cfs)	Runoff Volume (acre-ft)
1-Year	5.12	1.169	17.62	5.598
5-Year	7.49	2.651	44.62	12.694
10-Year	9.04	3.762	65.22	18.014
25 -Year	11.50	5.692	100.54	27.255
50-Year	13.70	7.531	134.12	36.061
100-Year	16.20	9.706	173.44	46.476

Post-Development Conditions				
Storm Event	Precipitation (in)	Runoff Amount (in)	Peak Flow (cfs)	Runoff Volume (acre-ft)
1-Year	5.12	3.887	140.60	18.612
5-Year	7.49	6.187	219.13	29.625
10-Year	9.04	7.709	269.92	36.913
25 -Year	11.50	10.139	349.93	48.549
50-Year	13.70	12.321	420.93	58.997
100-Year	16.20	14.806	501.31	85.261

For 100-Year storm even attenuation volume extreme, size is determined using the TR-55 "Short-Cut Method," which relates the storage volume to the required reduction in peak flow and storm inflow volume (Figure 13).

Vr=46.476

Qi=501.31

Qo=173.44

Qo/Qi=0.346

Using Figure 12*,*

Vs/Vr=0.350

Required Storage (acre-ft) = *16.266*

Additional 10-15% storage is recommended when multiple levels of extended detention are provided inclusive of the 100-year storm. Total required volume for attenuation = 1.15 x 16.266= 18.7 acre-feet.

Watershed 1 features a wet pond to provide stormwater storage. Profile view of the wet pond is shown in Figure 14. The proposed depth is 9 feet, and the approximate volume provided is 19.01 acre-feet, which is greater than the required attenuation volume of 18.7 acre-feet.

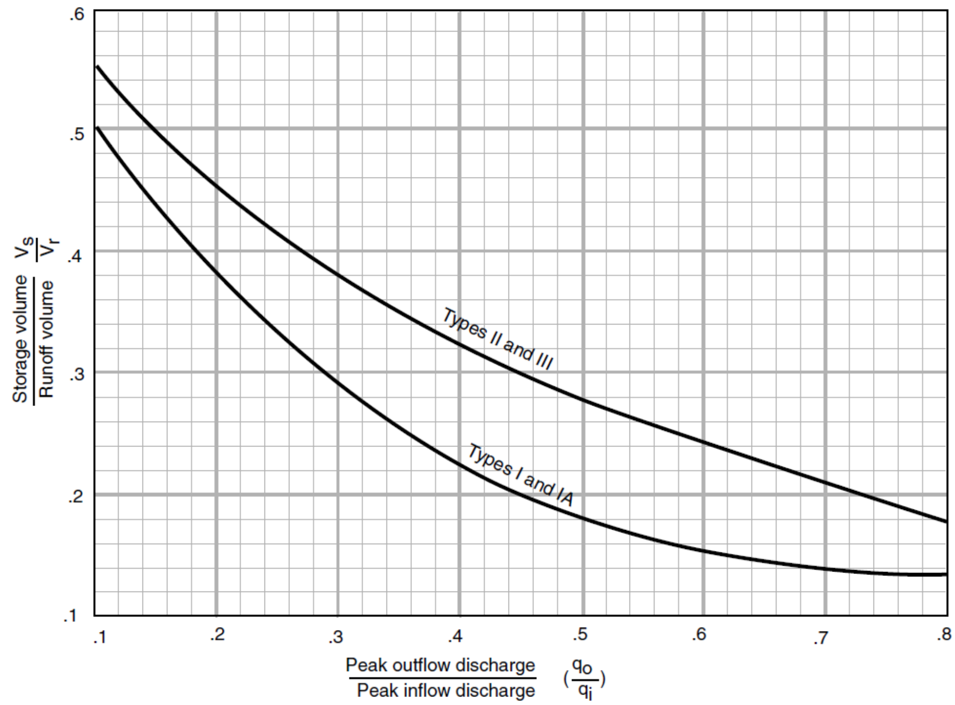


Figure 13 Approximate Detention Basin Routing for Rainfall Types I, IA, II, and III Source: TR-55, 1986

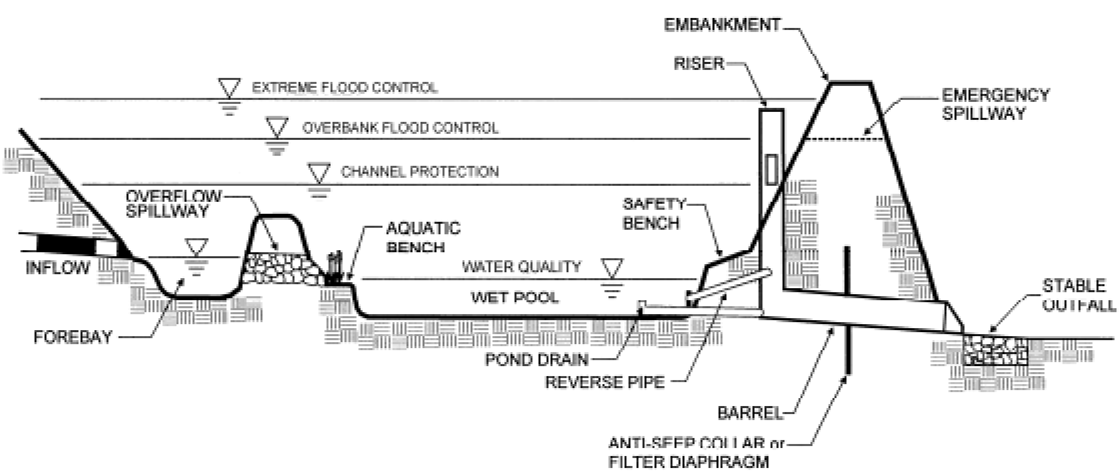


Figure 14 Typical Inline Stormwater Wet Pond with Positive Discharge (EPA). The slopes of the banks are 6:1 (Horizontal to Vertical) according to LDC, DSM Section 1-1.4(b)(2)a, b, & c

The Green Infrastructure tools for Watershed 1 include bioretention swales, pervious pavement and pavers, blue roofs and green roofs, and stormwater harvesting systems.

Generally, bioretention systems, green roofs, and pervious pavement/pavers provide a considerable amount of runoff reduction (10% to 20%) and peak flow reduction (25% to 65%).

Being on the conservative side and assuming 25% of peak flow reduction, the required attenuation volume can be calculated as follows:

Vr=	46.476
Qi=	376.01
Qo=	173.44
Qo/Qi=	0.461
Using Figure 12,	
Vs/Vr=	0.290

Required Storage (acre-ft) + 15% = 15.5, which provides approximately 18% reduction in the 100-year attenuation volume.

3.5 Analysis of Watershed 2

Watershed 2 is 47.71 acres in size (Figure 15) and consist of commerce use.

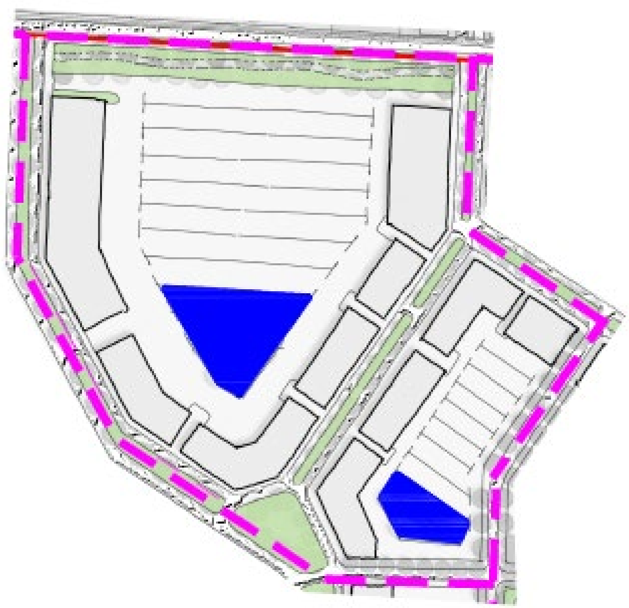


Figure 15 Configuration of Watershed 2

Summary of Hydrological calculations is listed in Table 7:

Table 7 Pre- and Post-Development Hydrology of Watershed 2

Pre-Development Conditions				
Storm Event	Precipitation (in)	Runoff Amount (in)	Peak Flow (cfs)	Runoff Volume (acre-ft)
1-Year	5.12	1.169	18.19	4.648
5-Year	7.49	2.651	46.27	10.540
10-Year	9.04	3.762	67.40	14.957
25 -Year	11.50	5.692	103.72	22.630
50-Year	13.70	7.531	137.83	29.942
100-Year	16.20	9.706	178.26	38.589

Post Development Conditions

Storm Event	Precipitation (in)	Runoff Amount (in)	Peak Flow (cfs)	Runoff Volume (acre-ft)
1-Year	5.12	3.887	128.56	15.454
5-Year	7.49	6.197	200.00	24.638
10-Year	9.04	7.709	246.28	30.650
25 -Year	11.50	10.139	319.43	40.311
50-Year	13.70	12.321	383.78	48.986
100-Year	16.20	14.805	457.02	58.862

For 100-Year storm even attenuation volume extreme, size is determined using the TR-55 "Short-Cut Method," which relates the storage volume to the required reduction in peak flow and storm inflow volume (Figure 13).

Vr= 38.589

Qi= 457.02

Qo= 178.26

Qo/Qi= 0.390

Using Figure 12,

Vs/Vr= 0.322

Required Storage (acre-ft) =12.426

Experience has shown that an additional 10-15% storage is required when multiple levels of extended detention are provided inclusive of the 100-year storm. Total required volume for attenuation = 1.15 x 12.426= 14.29 acre-feet.

Watershed 2 features two (2) wet ponds to provide stormwater storage. For both ponds, the proposed depth is 9 feet, and the approximate volume provided is 15.8 acre-feet, which is greater than the required attenuation volume of 14.29 acre-feet.

The Green Infrastructure tools for Watershed 2 include bioretention swales, pervious pavement and pavers, blue roofs and green roofs, and stormwater harvesting systems. Generally, bioretention systems, green roofs, and pervious pavement/pavers provide a

considerable amount of runoff reduction (10% to 20%) and peak flow reduction (25% to 65%).

Being on the conservative side and assuming 25% of peak flow reduction, the required attenuation volume can be calculated as follows:

Vr=	38.589
Qi=	342.765
Qo=	178.26
Qo/Qi=	0.520
Using Figure 12;	
Vs/Vr=	0.270

Required Storage (acre-ft) + 15% = 11.9, which provides approximately 16% reduction in the 100-year attenuation volume.

3.6 Analysis of Watershed 3

Watershed 3 is 33.16 acres in size (Figure 16) and consist of commerce use.

Figure 16 Configuration of Watershed 3

Summary of Hydrological calculations shown as follows:

Table 8 Pre- and Post-Development Hydrology of Watershed 3

Pre-Development Conditions				
Storm Event	Precipitation (in)	Runoff Amount (in)	Peak Flow (cfs)	Runoff Volume (acre-ft)
1-Year	5.12	1.168	10.31	3.228
5-Year	7.49	2.651	26.20	7.326
10-Year	9.04	3.761	38.11	10.393
25 -Year	11.50	5.692	58.92	15.729
50-Year	13.70	7.530	78.51	20.808
100-Year	16.20	9.706	101.45	26.821

Post Development Conditions				
Storm Event	Precipitation (in)	Runoff Amount (in)	Peak Flow (cfs)	Runoff Volume (acre-ft)
1-Year	5.12	3.887	92.78	10.741
5-Year	7.49	6.196	144.52	17.122
10-Year	9.04	7.709	177.70	21.303
25 -Year	11.50	10.139	230.36	28.017
50-Year	13.70	12.321	277.09	34.047
100-Year	16.20	14.805	329.97	40.911

For 100-Year storm even attenuation volume extreme, size is determined using the TR-55 "Short-Cut Method," which relates the storage volume to the required reduction in peak flow and storm inflow volume (Figure 13).

Vr= 26.821

Qi= 329.97

Qo= 101.45

Qo/Qi= 0.307

Using Figure 12,

Vs/Vr= 0.375

Required Storage (acre-ft)=10.058

Experience has shown that an additional 10-15% storage is required when multiple levels of extended detention are provided inclusive of the 100-year storm. Total required volume for attenuation = 1.15 x 10.058= 11.56 acre-feet.

Watershed 3 features a wet pond to provide stormwater storage. The proposed depth is 9 feet, and the approximate volume provided is 24.81 acre-feet, which is greater than the required attenuation volume of 11.567 acre-feet.

The Green Infrastructure tools for Watershed 3 include bioretention swales, pervious pavement and pavers, blue roofs and green roofs, and stormwater harvesting systems. Generally, bioretention systems, green roofs, and pervious pavement/pavers provide a

considerable amount of runoff reduction (10% to 20%) and peak flow reduction (25% to 65%).

Being on the conservative side and assuming 25% of peak flow reduction, the required attenuation volume can be calculated as follows:

Vr=	26.821
Qi=	247.47
Qo=	101.45
Qo/Qi=	0.410
Using Figure 12,	
Vs/Vr=	0.315

Required Storage (acre-ft) + 15% = 9.71, which provides approximately 16% reduction in the 100-year attenuation volume.

3.7 Analysis of Watershed 4

Watershed 4 is 32.37 acres in size (Figure 17) and consist of commerce use.

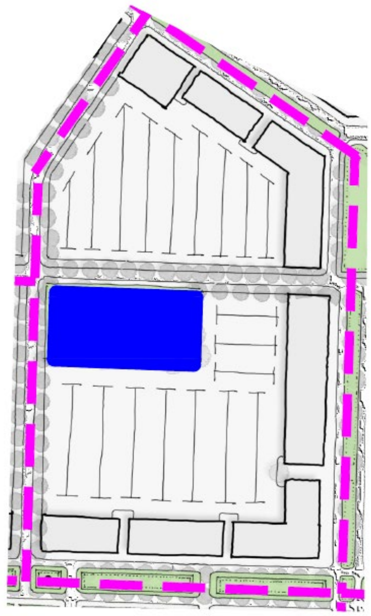


Figure 17 Configuration of Watershed 4

Summary of Hydrological calculations shown as follows:

Table 9 Pre- and Post-Development Hydrology of Watershed 4

Pre-Development Conditions				
Storm Event	Precipitation (in)	Runoff Amount (in)	Peak Flow (cfs)	Runoff Volume (acre-ft)
1-Year	5.12	1.169	24.48	3.153
5-Year	7.49	2.652	62.04	7.154
10-Year	9.04	3.762	90.12	10.148
25 -Year	11.50	5.693	138.21	15.357
50-Year	13.70	7.531	183.70	20.315
100-Year	16.20	9.707	236.61	26.185

Post Development Conditions

Storm Event	Precipitation (in)	Runoff Amount (in)	Peak Flow (cfs)	Runoff Volume (acre-ft)
1-Year	5.12	3.887	92.33	10.485
5-Year	7.49	6.196	143.87	16.714
10-Year	9.04	7.709	177.03	20.795
25 -Year	11.50	10.139	229.41	27.350
50-Year	13.70	12.321	276.03	33.236
100-Year	16.20	14.805	328.54	39.936

For 100-Year storm even attenuation volume extreme, size is determined using the TR-55 "Short-Cut Method," which relates the storage volume to the required reduction in peak flow and storm inflow volume (Figure 12).

Vr= 26.185

Qi= 328.54

Qo= 236.61

Qo/Qi= 0.720

Using Figure 12,

Vs/Vr= 0.203

Required Storage (acre-ft)=5.315

Experience has shown that an additional 10-15% storage is required when multiple levels of extended detention are provided inclusive of the 100-year storm. Total required volume for attenuation = 1.15 x 5.315= **6.113 acre-feet.**

Watershed 4 features a wet pond to provide stormwater storage. The proposed depth is 5 feet, and the approximate volume provided is 8.44 acre-feet, which is greater than the required attenuation volume of 6.113 acre-feet.

The Green Infrastructure tools for Watershed 4 include bioretention swales, pervious pavement and pavers, blue roofs and green roofs, and stormwater harvesting systems. Generally, bioretention systems, green roofs, and previous pavement/pavers provide

considerable amount of runoff reduction (10% to 20%) and peak flow reduction (25% to 65%).

Being on conservative side and assuming 25% of peak flow reduction, the required attenuation volume can be calculated as follows:

Vr=	26.821
Qi=	246.40
Qo=	236.61
Qo/Qi=	0.960
Using Figure 12,	
Vs/Vr=	0.180

Required Storage (acre-ft) + 15% = 5.42, which provides approximately 12% reduction in the 100-year attenuation volume.

3.8 Analysis of Watershed 5

Watershed 5 is 34.44 acres in size (Figure 18) and consist of commerce use.

Figure 18 Configuration of Watershed 5

Summary of Hydrological calculations shown as follows:

Table 10 Pre- and Post-Development Hydrology of Watershed 5

Pre-Development Conditions				
Storm Event	Precipitation (in)	Runoff Amount (in)	Peak Flow (cfs)	Runoff Volume (acre-ft)
1-Year	5.12	1.168	13.93	3.352
5-Year	7.49	2.651	35.48	7.608
10-Year	9.04	3.762	51.52	10.797
25 -Year	11.50	5.692	79.43	16.336
50-Year	13.70	7.530	105.60	21.611
100-Year	16.20	9.706	136.32	27.856

Post Development Conditions				
Storm Event	Precipitation (in)	Runoff Amount (in)	Peak Flow (cfs)	Runoff Volume (acre-ft)
1-Year	5.12	3.887	100.40	11.156
5-Year	7.49	6.197	156.42	17.785
10-Year	9.04	7.709	191.97	22.125
25 -Year	11.50	10.139	249.07	29.099
50-Year	13.70	12.321	299.75	35.361
100-Year	16.20	14.805	356.89	42.490

For 100-Year storm even attenuation volume extreme, size is determined using the TR-55 “Short-Cut Method,” which relates the storage volume to the required reduction in peak flow and storm inflow volume (Figure 12).

Vr=27.856

Qi=356.89

Qo=136.32

Qo/Qi=0.382

Using Figure 12,

Vs/Vr=0.337

Required Storage (acre-ft)=9.388

Experience has shown that an additional 10-15% storage is required when multiple levels of extended detention are provided inclusive of the 100-year storm. Total required volume for attenuation = 1.15 x 9.388= **10.796 acre-feet.**

Watershed 5 features a wet pond to provide stormwater storage. The proposed depth is 6 feet, and the approximate volume provided is 11.17 acre-feet, which is greater than the required attenuation volume of 10.796 acre-feet.

The Green Infrastructure tools for Watershed 5 include bioretention swales, pervious pavement and pavers, blue roofs and green roofs, and stormwater harvesting systems. Generally, bioretention systems, green roofs, and previous pavement/pavers provide thw

considerable amount of runoff reduction (10% to 20%) and peak flow reduction (25% to 65%).

Being on the conservative side and assuming 25% of peak flow reduction, the required attenuation volume can be calculated as follows:

Vr=	27.856
Qi=	267.66
Qo=	136.32
Qo/Qi=	0.509
Using Figure 12,	
Vs/Vr=	0.278

Required Storage (acre-ft) + 15% = 8.9, which provides approximately 17% reduction in the 100-year attenuation volume.

3.9 Analysis of Watershed 6

Watershed 6 is 47.66 acres in size (Figure 19) and consist of commerce use.

Figure 19 Configuration of Watershed 6

Summary of Hydrological calculations shown as follows:

Table 11 Pre- and Post-Development Hydrology of Watershed 6

Pre-Development Conditions				
Storm Event	Precipitation (in)	Runoff Amount (in)	Peak Flow (cfs)	Runoff Volume (acre-ft)
1-Year	5.12	1.168	16.85	4.639
5-Year	7.49	2.651	42.91	10.529
10-Year	9.04	3.762	62.51	14.941
25 -Year	11.50	5.692	96.38	22.607
50-Year	13.70	7.531	128.22	29.911
100-Year	16.20	9.706	165.72	38.549

Post Development Conditions				
Storm Event	Precipitation (in)	Runoff Amount (in)	Peak Flow (cfs)	Runoff Volume (acre-ft)
1-Year	5.12	3.887	115.70	15.438
5-Year	7.49	6.197	180.39	24.612
10-Year	9.04	7.709	221.86	30.618
25 -Year	11.50	10.139	287.99	40.269
50-Year	13.70	12.321	346.16	48.935
100-Year	16.20	14.805	412.12	58.801

For 100-Year storm even attenuation volume extreme, size is determined using the TR-55 "Short-Cut Method," which relates the storage volume to the required reduction in peak flow and storm inflow volume (Figure 12).

Vr= 38.549

Qi= 412.12

Qo= 165.72

Qo/Qi= 0.402

Using Figure 12,

Vs/Vr= 0.322

Required Storage (acre-ft)=12.413

Experience has shown that an additional 10-15% storage is required when multiple levels of extended detention are provided inclusive of the 100-year storm. Total required volume for attenuation = 1.15 x 12.413= **14.275 acre-feet.**

Watershed 6 features a wet pond to provide stormwater storage. The proposed depth is 5 feet, and the approximate volume provided is 17.29 acre-feet, which is greater than the required attenuation volume of 14.275 acre-feet.

The Green Infrastructure tools for Watershed 6 include bioretention swales, pervious pavement and pavers, blue roofs and green roofs, and stormwater harvesting systems. Generally, bioretention systems, green roofs, and previous pavement/pavers provide

considerable amount of runoff reduction (10% to 20%) and peak flow reduction (25% to 65%).

Being on conservative side and assuming 25% of peak flow reduction, the required attenuation volume can be calculated as follows:

Vr=	38.549
Qi=	309.09
Qo=	165.72
Qo/Qi=	0.536
Using Figure 12,	
Vs/Vr=	0.264

Required Storage (acre-ft) + 15% = 11.7, which provides approximately 18% reduction in the 100-year attenuation volume.

3.10 Analysis of Watershed 7

Watershed 7 is 50.65 acres in size (Figure 20) and consist of medium intensity single family and civic space use.

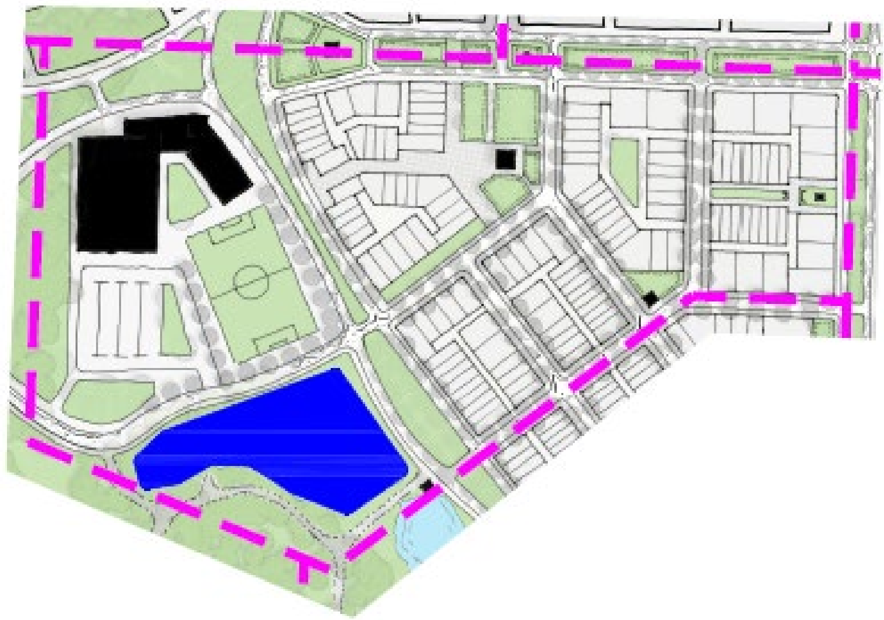


Figure 20 Configuration of Watershed 7

Summary of Hydrological calculations shown as follows:

Table 12 Pre- and Post-Development Hydrology of Watershed 7

Pre-Development Conditions				
Storm Event	Precipitation (in)	Runoff Amount (in)	Peak Flow (cfs)	Runoff Volume (acre-ft)
1-Year	5.12	1.168	16.35	4.930
5-Year	7.49	2.651	41.47	11.189
10-Year	9.04	3.762	60.45	15.879
25 -Year	11.50	5.692	93.22	24.025
50-Year	13.70	7.530	124.39	31.783
100-Year	16.20	9.706	160.88	40.967

Post Development Conditions				
Storm Event	Precipitation (in)	Runoff Amount (in)	Peak Flow (cfs)	Runoff Volume (acre-ft)
1-Year	5.12	1.734	53.26	7.319
5-Year	7.49	3.494	111.56	14.748
10-Year	9.04	4.750	152.85	20.049
25 -Year	11.50	6.872	221.26	29.006
50-Year	13.70	8.848	283.78	37.346
100-Year	16.20	11.152	355.74	47.071

For 100-Year storm even attenuation volume extreme, size is determined using the TR-55 "Short-Cut Method," which relates the storage volume to the required reduction in peak flow and storm inflow volume (Figure 13).

Vr= 40.967

Qi= 355.74

Qo= 160.88

Qo/Qi= 0.452

Using Figure 12,

Vs/Vr= 0.299

Required Storage (acre-ft)= 12.249

Experience has shown that an additional 10-15% storage is required when multiple levels of extended detention are provided inclusive of the 100-year storm. Total required volume for attenuation = 1.15 x 12.249= 14.087 acre-feet.

Watershed 7 features a wet pond to provide stormwater storage. The proposed depth is 6 feet, and the approximate volume provided is 14.73 acre-feet, which is greater than the required attenuation volume of 14.087 acre-feet.

The Green Infrastructure tools for Watershed 7 include bioretention swales, pervious pavement and pavers, blue roofs and green roofs, and stormwater harvesting systems. Generally, bioretention systems, green roofs, and pervious pavement/pavers provide a

considerable amount of runoff reduction (10% to 20%) and peak flow reduction (25% to 65%).

The Green Infrastructure tools that are used for the Watershed 6 include bioretention swales, pervious pavement and pavers, blue roofs and green roofs, and stormwater harvesting systems. Generally, bioretention systems, green roofs, and previous pavement/pavers provide considerable amount of runoff reduction (10 to 20%) and peak flow reduction (25% to 65%).

Being on the conservative side and assuming 25% of peak flow reduction, the required attenuation volume can be calculated as follows:

Vr=	40.967
Qi=	266.80
Qo=	160.88
Qo/Qi=	0.603
UsingFigure 12,	
Vs/Vr=	0.240

Required Storage (acre-ft) + 15% = 11.3, which provides approximately 20% reduction in the 100-year attenuation volume.

3.11 Analysis of Watershed 8

Watershed 8 is 42.09 acres in size (Figure 21) and consist of commerce use.

Figure 21 Configuration of Watershed 8

Summary of Hydrological calculations shown as follows:

Table 13 Pre- and Post-Development Hydrology of Watershed 8

Pre-Development Conditions				
Storm Event	Precipitation (in)	Runoff Amount (in)	Peak Flow (cfs)	Runoff Volume (acre-ft)
1-Year	5.12	1.168	15.42	4.097
5-Year	7.49	2.651	39.26	9.298
10-Year	9.04	3.762	57.18	13.195
25 -Year	11.50	5.692	88.10	19.965
50-Year	13.70	7.530	117.16	26.411
100-Year	16.20	9.706	151.46	34.044

Post Development Conditions				
Storm Event	Precipitation (in)	Runoff Amount (in)	Peak Flow (cfs)	Runoff Volume (acre-ft)
1-Year	5.12	3.887	120.06	13.634
5-Year	7.49	6.197	187.08	21.736
10-Year	9.04	7.709	230.19	27.039
25 -Year	11.50	10.139	298.30	35.563
50-Year	13.70	12.321	358.93	43.216
100-Year	16.20	14.805	427.20	51.929

For 100-Year storm even attenuation volume extreme, size is determined using the TR-55 "Short-Cut Method," which relates the storage volume to the required reduction in peak flow and storm inflow volume (Figure 12).

Vr= 34.044

Qi= 427.20

Qo= 151.46

Qo/Qi= 0.452

Using Figure 12,

Vs/Vr= 0.355

Required Storage (acre-ft)=11.677

Experience has shown that an additional 10-15% storage is required when multiple levels of extended detention are provided inclusive of the 100-year storm. Total required volume for attenuation = 1.15 x 11.667= **13.429 acre-feet.**

Watershed 8 features a wet pond to provide stormwater storage. The proposed depth is 6 feet, and the approximate volume provided is 14.42 acre-feet, which is greater than the required attenuation volume of 13.429 acre-feet.

The Green Infrastructure tools for Watershed 8 include bioretention swales, pervious pavement and pavers, blue roofs and green roofs, and stormwater harvesting systems. Generally, bioretention systems, green roofs, and previous pavement/pavers provide a

considerable amount of runoff reduction (10% to 20%) and peak flow reduction (25% to 65%).

Being on conservative side and assuming 25% of peak flow reduction, the required attenuation volume can be calculated as follows:

Vr=	34.044
Qi=	320.40
Qo=	151.46
Qo/Qi=	0.473
Using Figure 12,	
Vs/Vr=	0.291

Required Storage (acre-ft) + 15% = 11.3, which provides approximately 15% reduction in the 100-year attenuation volume.

3.12 Analysis of Watershed 9

Watershed 9 is 63.7 acres in size (Figure 22) and consist of commerce use.

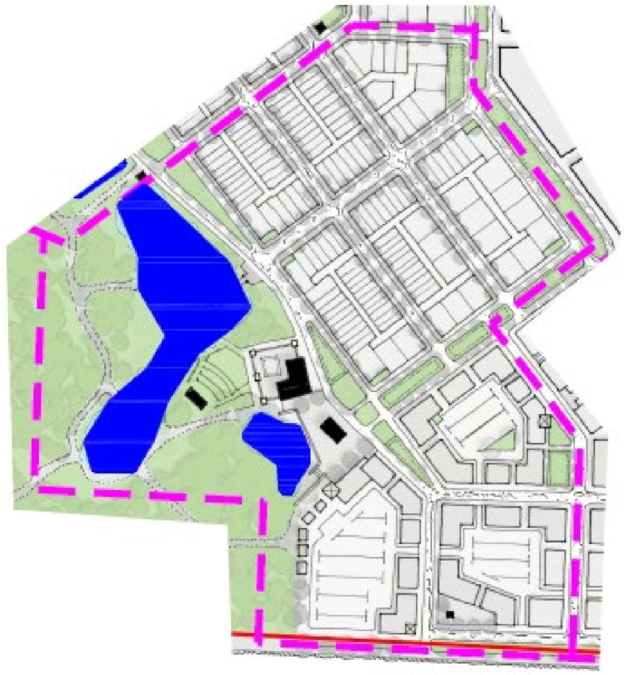


Figure 22 Configuration of Watershed 9

Summary of Hydrological calculations shown as follows:

Table 14 Pre- and Post-Development Hydrology of Watershed 9

Pre-Development Conditions				
Storm Event	Precipitation (in)	Runoff Amount (in)	Peak Flow (cfs)	Runoff Volume (acre-ft)
1-Year	5.12	1.169	24.09	6.205
5-Year	7.49	2.652	61.32	14.078
10-Year	9.04	3.762	89.17	19.970
25 -Year	11.50	5.692	137.21	30.215
50-Year	13.70	7.531	182.68	39.977
100-Year	16.20	9.706	235.80	51.523

Post Development Conditions				
Storm Event	Precipitation (in)	Runoff Amount (in)	Peak Flow (cfs)	Runoff Volume (acre-ft)
1-Year	5.12	1.887	59.31	10.017
5-Year	7.49	3.710	120.17	19.694
10-Year	9.04	4.998	162.68	26.531
25 -Year	11.50	7.160	233.16	38.008
50-Year	13.70	9.164	296.92	48.646
100-Year	16.20	11.494	369.79	61.014

For 100-Year storm even attenuation volume extreme, size is determined using the TR-55 "Short-Cut Method," which relates the storage volume to the required reduction in peak flow and storm inflow volume (Figure 12).

Vr= 51.523

Qi= 369.79

Qo= 235.80

Qo/Qi= 0.638

Using Figure 12,

Vs/Vr= 0.231

Required Storage (acre-ft)= 11.902

Experience has shown that an additional 10-15% storage is required when multiple levels of extended detention are provided inclusive of the 100-year storm. Total required volume for attenuation = 1.15 x 11.902= 13.687 acre-feet.

Watershed 9 features two (2) wet ponds to provide stormwater storage. The proposed depth is 4 feet, and the approximate volume provided is 16.26 acre-feet, which is greater than the required attenuation volume of 13.687 acre-feet.

The Green Infrastructure tools for Watershed 9 include bioretention swales, pervious pavement and pavers, blue roofs and green roofs, and stormwater harvesting systems. Generally, bioretention systems, green roofs, and pervious pavement/pavers provide a

considerable amount of runoff reduction (10% to 20%) and peak flow reduction (25% to 65%).

Being on conservative side and assuming 25% of peak flow reduction, the required attenuation volume can be calculated as follows:

Vr=	51.523
Qi=	277.34
Qo=	235.80
Qo/Qi=	0.850
Using Figure 12,	
Vs/Vr=	0.170

Required Storage (acre-ft) + 15% = 10.07, which provides approximately 26% reduction in the 100-year attenuation volume.

3.13 Analysis of Watershed 10

Watershed 10 is 48.27 acres in size (Figure 23) and consist of mixed and commerce use.

Figure 23 Configuration of Watershed 7

Summary of Hydrological calculations shown as follows:

Table 15 Pre- and Post-Development Hydrology of Watershed 10

Pre-Development Conditions				
Storm Event	Precipitation (in)	Runoff Amount (in)	Peak Flow (cfs)	Runoff Volume (acre-ft)
1-Year	5.12	1.169	19.22	4.702
5-Year	7.49	2.651	48.92	10.664
10-Year	9.04	3.762	71.23	15.133
25 -Year	11.50	5.692	109.73	22.896
50-Year	13.70	7.531	145.79	30.293
100-Year	16.20	9.706	188.66	39.042

Post Development Conditions

Storm Event	Precipitation (in)	Runoff Amount (in)	Peak Flow (cfs)	Runoff Volume (acre-ft)
1-Year	5.12	3.886	95.77	15.631
5-Year	7.49	6.196	149.25	24.923
10-Year	9.04	7.709	183.54	31.009
25 -Year	11.50	10.139	238.45	40.784
50-Year	13.70	12.320	287.12	49.557
100-Year	16.20	14.805	341.81	59.553

For 100-Year storm even attenuation volume extreme, size is determined using the TR-55 "Short-Cut Method," which relates the storage volume to the required reduction in peak flow and storm inflow volume (Figure 12).

Vr=	39.042
Qi=	341.81
Qo=	188.66
Qo/Qi=	0.552
Using Figure 12,	
Vs/Vr=	0.260

Required Storage (acre-ft)=10.151. Experience has shown that an additional 10-15% storage is required when multiple levels of extended detention are provided inclusive of the 100-year storm. Total required volume for attenuation = 1.15 x 10.151= 11.674 acre-feet.

Watershed 10 features two (2) wet ponds to provide stormwater storage. Proposed depth is 6 feet, and the approximate volume provided is 12.66 acre-feet, which is greater than the required attenuation volume of 11.674 acre-feet.

The Green Infrastructure tools for Watershed 10 include bioretention swales, pervious pavement and pavers, blue roofs and green roofs, and stormwater harvesting systems. Generally, bioretention systems, green roofs, and pervious pavement/pavers provide a

considerable amount of runoff reduction (10% to 20%) and peak flow reduction (25% to 65%).

Being on conservative side and assuming 25% of peak flow reduction, the required attenuation volume can be calculated as follows:

Vr=	39.042
Qi=	256.35
Qo=	188.66
Qo/Qi=	0.736
Using Figure 12,	
Vs/Vr=	0.198

Required Storage (acre-ft) + 15% = 8.89, which provides approximately 24% reduction in the 100-year attenuation volume.

The configuration of the system of lakes and conveyances is shown on Figure 24

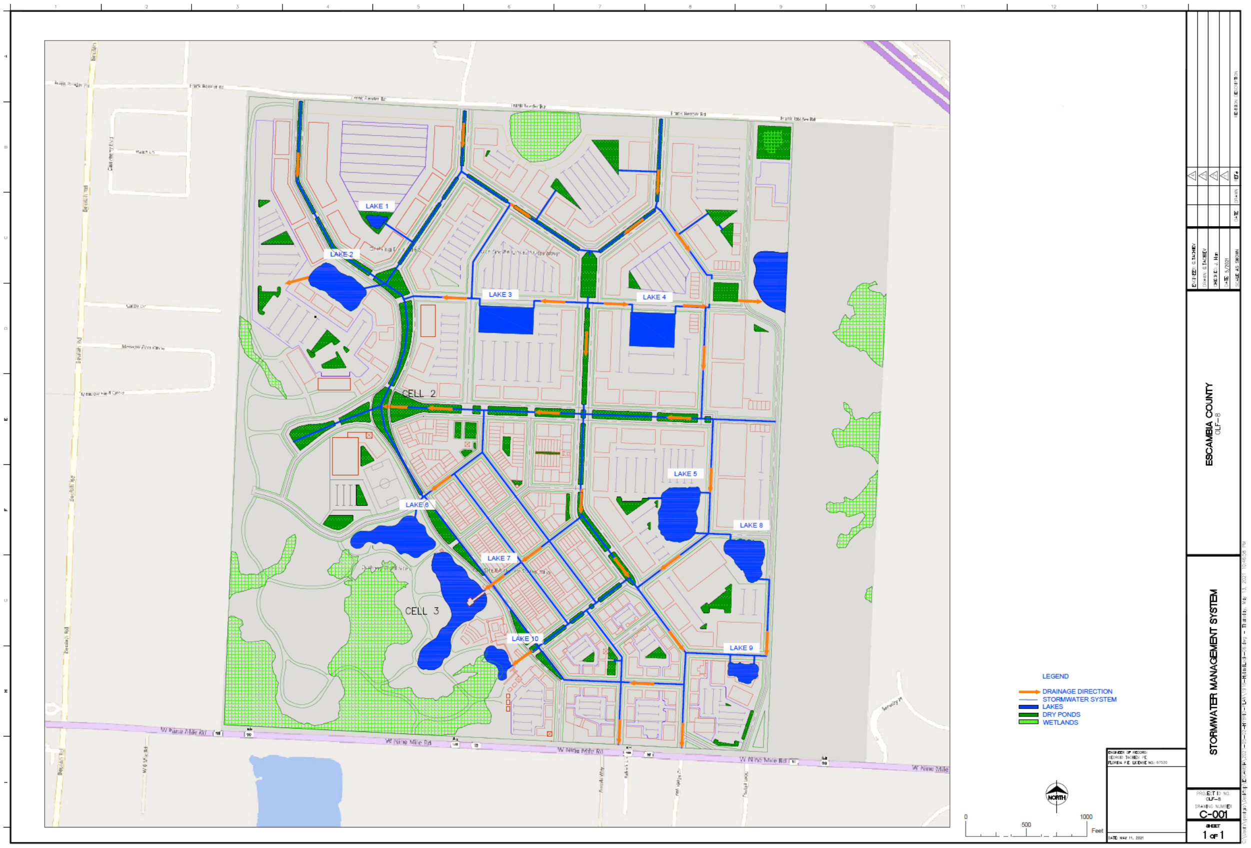


Figure 24 Configuration of Stormwater Management System

4 SITE DEVELOPMENT RECOMMENDATIONS

The principles of New Urbanism, which have been applied in this project, offer a better planning philosophy for minimization of the overall impact of the built environment. The tools of Green Infrastructure (GI) and Light Imprint (LI) integrate urban and engineering practices to offer a sustainable framework for development on regional, neighborhood, and block scales and to support sustained growth while preserving natural resources; protect biodiversity; reduce pollution and reduce consumption of two resources: energy and land. The combined use of New Urban Practices and GI+LI offers a superior planning strategy based on traditional neighborhood patterns favoring high density, mixed-use, and reduced use of transportation and building energy.

The GI+LI tools ensure the sustainability of watersheds on regional, neighborhood, and block levels and prevent disruption, and damage in urban/suburban areas, loss of biodiversity, and ecosystem changes. These tools are calibrated with New Urban planning philosophy to prioritizing compact and mixed-use urban patterns, increased density and walkable urban areas, energy, and environmental sustainability. Thus, GI+LI naturally accommodates a broader range of development standards necessary for the community-oriented design. The resulting development is a complete antidote to the conventional planning practices which lack connectivity and rely on arterials, collectors, and cul-de-sacs for traffic mobility and provide connectivity, compactness and structured open space, and use engineering design which requires expensive infrastructure for piping and storage of stormwater.

The main effects of GI+LI applications include enhanced watershed protection, by application of environmental and sustainability concepts to minimize the effects of the impervious surfaces. The GI applied in this project promotes numerous environmental qualities characteristic and include technologies for preserving the natural hydrological cycle including pervious pavements, light infrastructure, natural drainage, gravel swales, and very light infrastructure with reduced amounts of curbs. Furthermore, reduced maintenance is accomplished by using xeriscape and reducing the irrigation, eliminating pesticides and agricultural pollution.

Ultimately, the increased stormwater pollutant load, if not managed properly, will adversely affect local water bodies. To mitigate these impacts, prior stormwater program efforts primarily focused on conventional stormwater quality control measures (e.g., BMPs), such as detention basins, which temporarily detain stormwater runoff and release it over a period of time.

Stormwater quality control measures that incorporate Green Infrastructure principles are placed throughout the site in small, discrete units and distributed near the source of impacts. Green Infrastructure strategies are designed to protect surface and groundwater quality, maintain the integrity of ecosystems, and preserve the physical integrity of receiving waters by managing stormwater runoff at or close to the source.

The purpose of Green Infrastructure is to reduce and/or eliminate the altered areas of the post-development hydrograph, by reducing the peak discharge rate, volume, and duration of flow using site design and stormwater quality control measures. The benefits of reduced stormwater runoff volume include reduced pollutant loadings and increased groundwater recharge and evapotranspiration rates.

The main Green Infrastructure strategies include the use of bioretention/infiltration landscape areas, disconnected hydrologic flow paths, reduced impervious areas, functional landscaping, and grading to maintain natural hydrologic functions that existed prior to development, such as interception, shallow surface storage, infiltration, evapotranspiration, and groundwater recharge. By implementing GI+LI strategies, a project site can be designed to be an integral part of the environment by maintaining undeveloped hydrologic functions through the careful use of stormwater quality control measures.

Historically, stormwater management has consisted of a network of impervious surfaces that directly convey stormwater runoff to curb and gutter systems, the storm drain conveyance system, and downstream receiving waters. Until recently, conventional storm drain and flood control systems were designed to convey stormwater away from developed areas as quickly as possible to manage the risk of floods for homes and development. However, in order to protect the natural hydrological cycle, a more comprehensive approach to address stormwater runoff water quality and groundwater recharge opportunities.

4.1 Protection of Natural Areas

Conservation of natural areas, soils, and vegetation helps to retain numerous functions of pre-development hydrology, including rainfall interception, infiltration, and evapotranspiration was the primary consideration of the planning process. This project site has unique topographic, hydrologic, and vegetative features, which were taken into consideration.

The most sensitive areas, such as streams and their buffers, floodplains, wetlands, steep slopes, and highly permeable soils, were protected by moving away from the development. Slopes can be a major source of sediment and will be protected and stabilized. The following design features or elements have been considered:

- Preserve historically undisturbed areas. Identified the streams and their buffers, floodplains, wetlands, and steep slopes.
- Reserve areas with low permeability soils for either open space or retention stormwater quality control measures (such as lakes)
- Preserve the existing trees into site layout and consider planting stormwater trees along the main roads to reduce road drainage.
- Identify and avoid areas susceptible to erosion and sediment loss, such as the areas in proximity to the wetlands in the southwest corner
- Concentrate or cluster development with greater density on less sensitive areas of the project site and with minimal slope, while leaving the remaining land in a natural, undisturbed state.
- Protect slopes from erosion by safely conveying stormwater runoff from the tops of slopes.

- The project will limit the clearing and grading of the existing forested areas, and native vegetation at the project site to the minimum amount needed to build lots, allow access and provide fire protection.
- The project will maintain to the maximum extent the existing topography and existing drainage divides to encourage dispersed flow.
- The project will maximize trees and other vegetation at the project site by planting additional vegetation, clustering tree areas, and promoting the use of native and/or drought-tolerant plants.

4.2 Minimization of Land Disturbance

The purpose of this site design principle is to protect water quality by preserving the natural hydrologic function of the project site to the maximum extent. By designing the project site layout to preserve natural hydrology and drainage ways at the project site, the need for grading and disturbance of native vegetation and soils has been reduced.

The buildings and impervious surfaces have been sighted away from steep slopes, drainage ways, and floodplains to limit the amount of grading and clearing necessary and to reduce the hydrologic impact. This site design principle is most applicable for this project because it is a greenfield site.

The objective was to reduce clearing, grading, and heavy equipment to remove and compact native soils and to reduce the soil infiltration capacity. The development envelope was established by identifying the minimum area needed to build lots, allow access, provide fire protection, and protect and buffer sensitive features such as streams, floodplains, steep slopes, and wetlands. The buildings and paved areas were concentrated on the least permeable soils, with the least intact habitat. For example, the lakes will be constructed in a location which already has natural water bodies, the groundwater is close to the surface which will provide the least impact.

4.3 Minimization of Impervious Area

The potential for discharge of pollutants in stormwater runoff from a project site increases as the percentage of the impervious areas within the project site increases because impervious areas increase the volume and rate of stormwater runoff.

Pollutants deposited on impervious areas are easily mobilized and transported by stormwater runoff. Minimizing impervious areas through site design is an important method to reducing the pollutant load in stormwater runoff.

Minimizing impervious areas will also reduce the stormwater runoff coefficient, which is directly proportional to the volume of stormwater runoff that must be retained on-site.

The following strategies for minimizing impervious areas through site design were applied:

- Used minimum allowable roadway and sidewalk cross-sections, driveway lengths, and parking stall sizes.
- Reduced building and parking lot footprints. Building footprints may be additionally reduced by building taller.
- Use pervious pavement material, such as modular paving blocks, turf blocks, porous concrete and asphalt, brick, and gravel or cobble, to accommodate overflow parking, if feasible.
- Cluster buildings and paved areas to maximize pervious area.
- Maximize tree preservation or tree planting.
- Use vegetated swales to convey stormwater runoff instead of paved gutters.
- Build compactly at redevelopment sites to avoid disturbing natural and agricultural lands and to reduce per capita impacts.

Site design with Green Infrastructure provides efficient protection of sensitive environmental features such as riparian areas, wetlands, and steep slopes. The intention of site design principles is to reduce stormwater runoff peak flows and volumes and other impacts associated with land development.

4.4 Classification of Green Infrastructure Tools

The green infrastructure tools are based on the following four categories:

Paving - to provide vehicular and pedestrian access Paving is a prominent feature in the landscape which provides vehicular and pedestrian access. It plays a large role in receiving, producing, and distributing stormwater runoff. Paving GI+LI tools included in this project include choices for paving materials of various degrees of permeability. The best features of each paving tool were maximized by selection based on mode and volume of traffic and low maintenance requirements. For example, a very stable material that is less pervious will be used in the urban zones which will have larger amounts of commercial and vehicular traffic. Furthermore, areas with heavy traffic require low maintenance and sturdy paving material to keep repairs to a minimum. Less sturdy materials were applied for light traffic volume and pedestrian areas. All low traffic thoroughfares should be based on using semi-impervious materials

Channeling - Channeling provides water conveyance features. Paving GI tools were applied throughout the project to ensure capturing and channeling stormwater to areas that can maximize on-site water retention. The channeling GI+LI tools were positioned to take into consideration pedestrian movement and the fraction of impervious surface. Some channeling tools provide an opportunity to produce an art form for the movement of water. The main function of the Channeling tools was to maximize the functions of storage and filtration. The site implements multiple channeling functions within the variable median of the thoroughfares.

Storage - Storage tools provide water retention on-site to reduce the surface runoff and to provide sufficient time for water to infiltrate the subsurface. Overly large ponds limit traditional neighborhood development because of size, volume, and flow regulations, however, for these sizes large wet and dry detention ponds are recommended. The GI+LI Storage tools in this project were calibrated to the topography. Public spaces such as parks, plazas, and greenways were used to provide storage. Public spaces with a storage functionality as the main component was preferably located in low areas to allow water to drain naturally. Cost is also minimized by the need for less grading and by eliminating large subsurface storage tanks and conveyances (piping, manholes). Storage tools that were applied provide distributed storage capacities that cumulatively attain the capacity required by the development.

Filtration - Filtration was incorporated in all GI+LI tools by avoiding concrete surfaces for storage and conveyance features. Maximizing the infiltration rates and capacities are important to increase aquifer recharge while reducing surface water run-off. Many current stormwater filtration processes involve the use of expensive, highly technological methods that accomplish the same results that natural processes have throughout history. The main function of the filtration GI+LI tools is to mimic the natural system with its general simplicity of allowing water to recharge the aquifer. The expensive filtration tools are economically feasible in the more urban zones of the transect. The filtration tools can also serve as civic amenities when they are well integrated into a design. Rain gardens can be beautiful public features; green fingers can be very active parks. Waterscapes can serve as beautiful teaching tools in urban plazas. There are many filtration processes in this toolbox that are successful in improving water quality within the built and natural environment.

4.5 Runoff Reduction Methods:

Green infrastructure techniques use the natural features of the site and promote runoff reduction through micromanaging runoff, promoting groundwater recharge, increasing losses through evapotranspiration, and emulating the existing hydrology.

4.5.1 Stormwater Ponds/Lakes

Stormwater ponds/lakes and wet basins are earthen depressions constructed with a substantial permanent water pool to provide both temporary and long-term storage of stormwater runoff, and they can be used to attenuate peak flows and provide Water Quality treatment through both pollutant removal and slow release. Ponds attenuate peak flows using an outlet control structure and provide storage capacity above the permanent pool, while water held within the system, including the permanent pool, is treated through a variety of physical, chemical, and biological processes. Wet basins can also achieve minimal volume reduction through evapotranspiration.

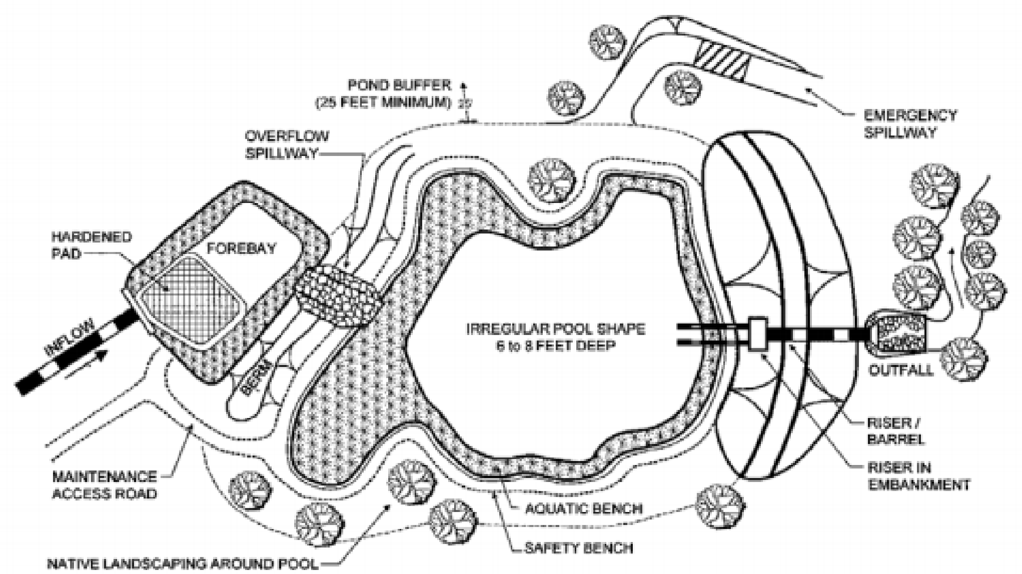


Figure 25 Plan view of a wet pond, source; NYSDEC. The slopes of the banks are 6:1 (Horizontal to Vertical) according to LDC, DSM Section 1-1.4(b)(2)a, b, & c

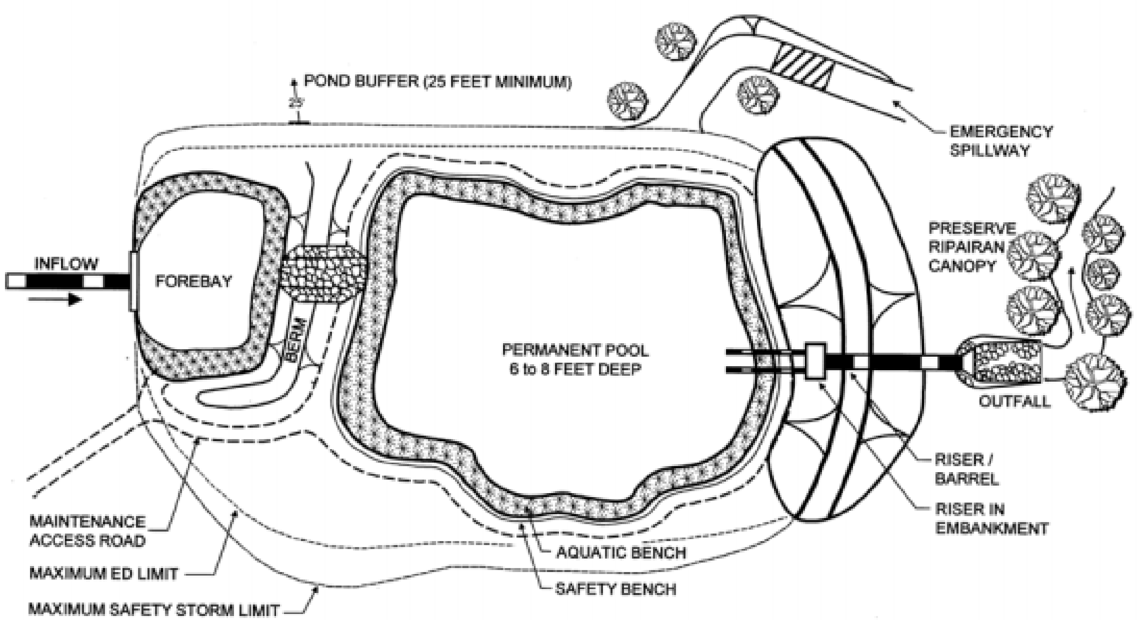


Figure 26 Plan view of a wet extended detention pond, source; NYSDEC. The slopes of the banks are 6:1 (Horizontal to Vertical) according to LDC, DSM Section 1-1.4(b)(2)a, b, & c

Stormwater ponds are practices that have either a permanent pool of water, or a combination of a permanent pool and extended detention, and some elements of a shallow marsh equivalent to the entire water quality volume.

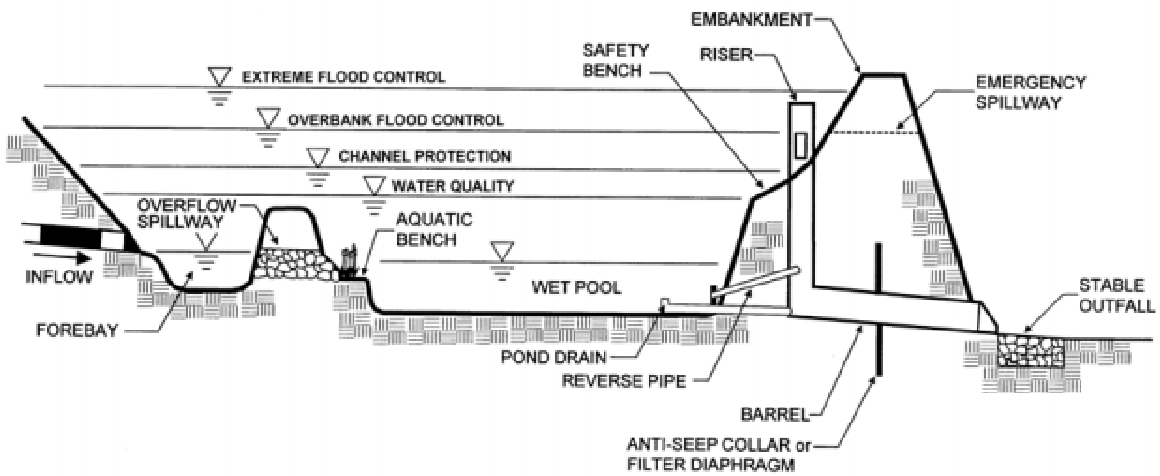


Figure 27 Profile view of a wet extended detention pond, source; NYSDEC. The slopes of the banks are 6:1 (Horizontal to Vertical) according to LDC, DSM Section 1-1.4(b)(2)a, b, & c

Where required, stormwater ponds have an embankment surrounding them. Part or all of the embankment acts as a dam to keep the water in the pond. The embankment is sloped and should be stabilized.

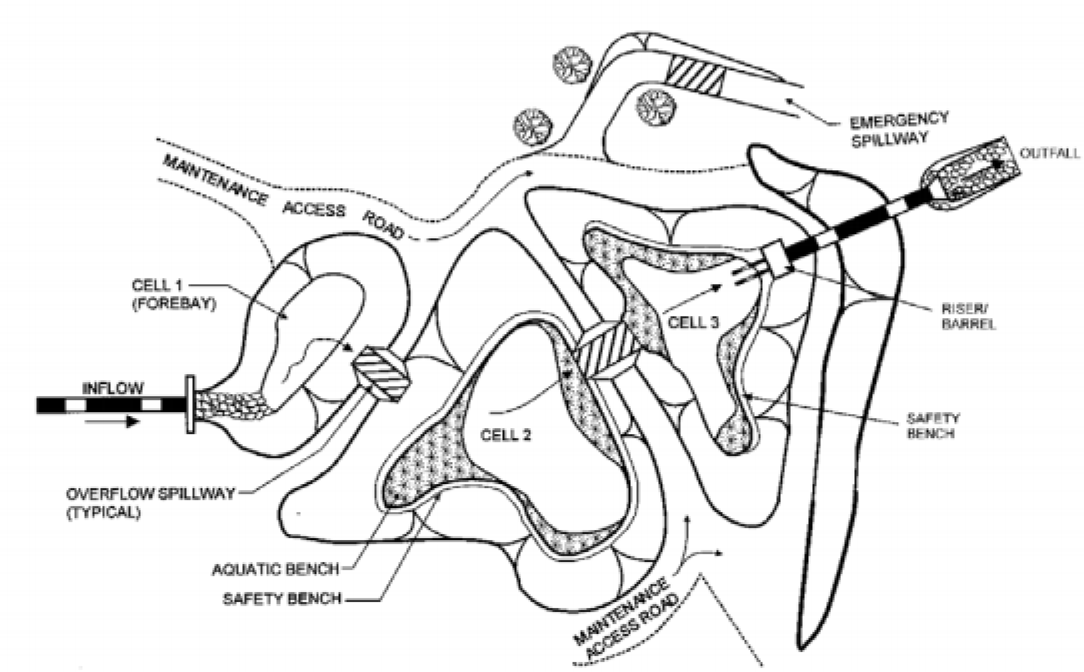


Figure 28 Plan view of a multiple pond system, source; NYSDEC . The slopes of the banks are 6:1 (Horizontal to Vertical) according to LDC, DSM Section 1-1.4(b)(2)a, b, & c

Wet ponds, wet extended detention ponds, and multiple interconnected ponds are a good choice for this project due to each watershed being greater than 25 acres.

Pretreatment is critical to the design of stormwater ponds. Properly designed pretreatment systems help to sustain required stormwater management function, extend service life, and reduce maintenance costs. The primary goal of pretreatment systems is to capture sediment, trash, and debris. This can be done by incorporating a forebay, which helps to decrease the peak stormwater velocities to allow sediment to settle or by filtering incoming stormwater through vegetation to remove sediment. If the site conditions do not allow a forebay, then equivalent upstream treatment should be included such as bioswales, rain gardens, or a hydrodynamic separator. The forebay should be designed in such a stable way to ensure that non-erosive conditions exist for at least the 2-year storm event.

The perimeter of all deep pool areas (four feet or greater in depth) shall be surrounded by two benches except when the pond side slopes are 6:1 or flatter. An aquatic bench that generally extends up to 15 feet inward from the normal shoreline should be included. Aquatic benches have an irregular configuration and have a maximum depth of 18 inches below the normal pool water surface elevation. The slope proceeding from the aquatic bench to the pond basin floor shall not exceed 2:1.

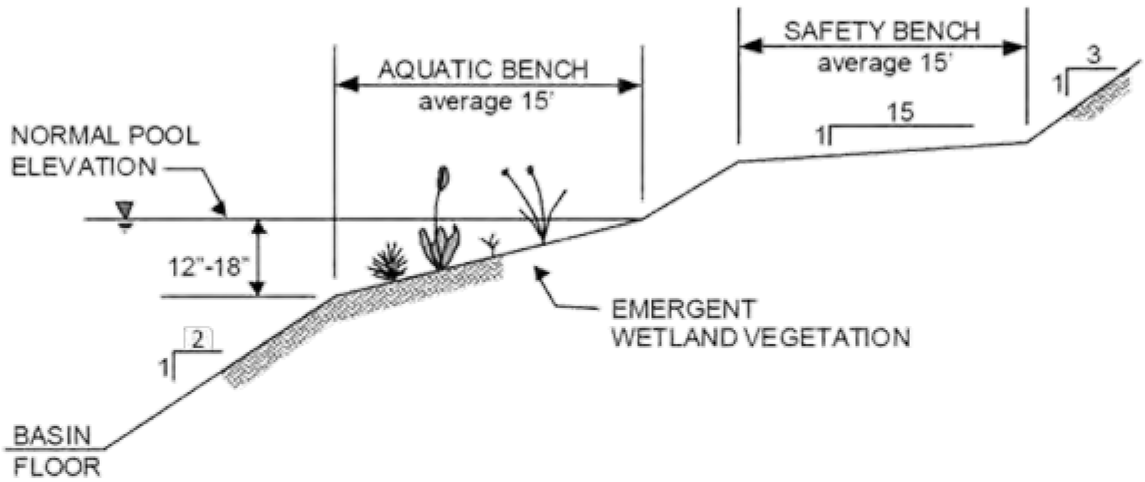


Figure 29 Slope diagram, source; NYSDEC . The slopes of the banks are 6:1 (Horizontal to Vertical) according to LDC, DSM Section 1-1.4(b)(2)a, b, & c

4.5.2 Vegetated Swales

The natural drainage paths, or properly designed vegetated channels, can be used instead of constructing underground storm sewers or concrete open channels to increase the time of concentration, reduce the peak flow, and provide infiltration.

Figure 30 Vegetated Swale

4.5.3 Stormwater Trees

Planting and conserving trees reduce stormwater runoff, increase nutrient uptake, and provide bank stabilization. Trees can be used for applications such as landscaping, stormwater management practice areas, conservation areas, and erosion and sediment control. Trees which provide additional space for storage and attenuation of stormwater runoff

4.5.4 Disconnection of Rooftop Runoff

Disconnection of rooftop runoff directs runoff from residential rooftop areas and upland overland runoff flow to designated pervious areas to reduce runoff volumes and rates. This can be achieved, by grading the site to promote overland vegetative filtering or by providing infiltration areas.

Figure 31 Disconnection of rooftop to designated vegetated areas. Otter Creek, NY, NYSDEC

4.5.5 Rain Gardens

Rain gardens are used to manage and treat small volumes of stormwater runoff using a conditioned planting soil bed and planting materials to filter runoff stored within a shallow depression. The rain garden is suitable for a townhouse, single-family residential, and in some institutional settings.

Figure 32 Rain garden, NYSDEC

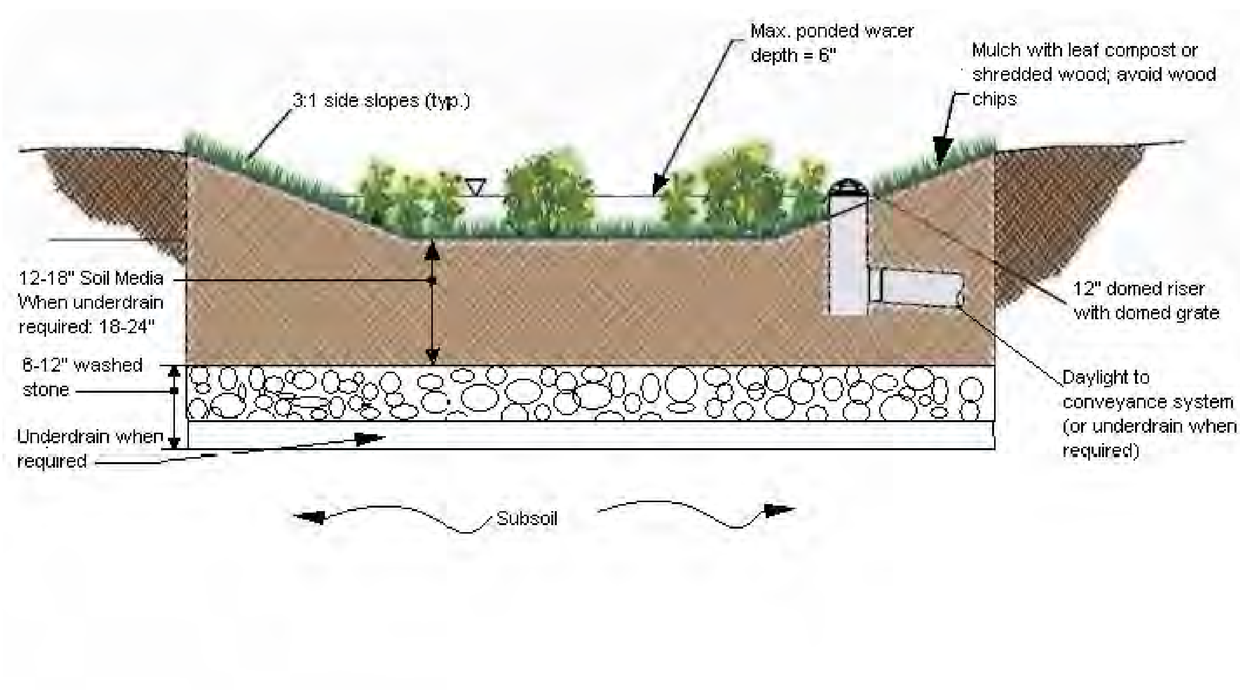


Figure 33 Profile of a typical rain garden, NYSDEC

4.5.6 Blue and Green Roofs

Green roofs capture runoff by a layer of vegetation and soil installed on top of a conventional flat or sloped roof. The rooftop vegetation allows evaporation and evapotranspiration processes to reduce the volume and discharge rate of runoff entering the conveyance system.

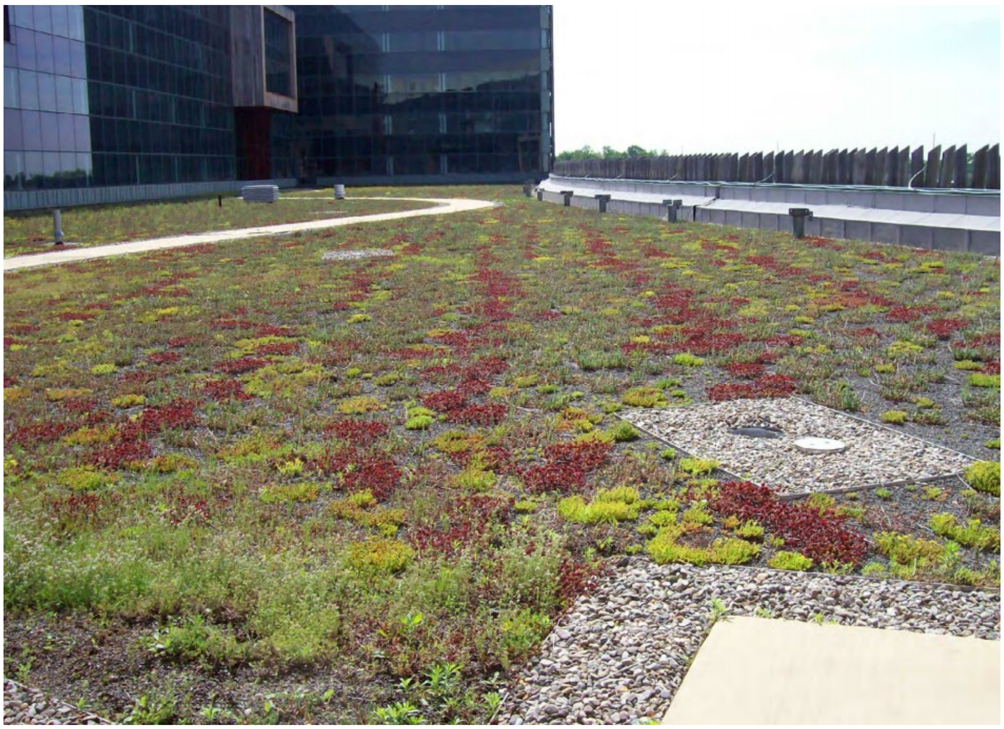


Figure 34 Green roof, GSA, Suitland, MD

Figure 35 Green roof layers

4.5.7 Stormwater Planters

Stormwater planters are small, landscaped stormwater treatment devices that can be designed as infiltration or filtering practices. Stormwater planters use soil infiltration and biogeochemical processes to decrease the stormwater quantity and improve water quality.

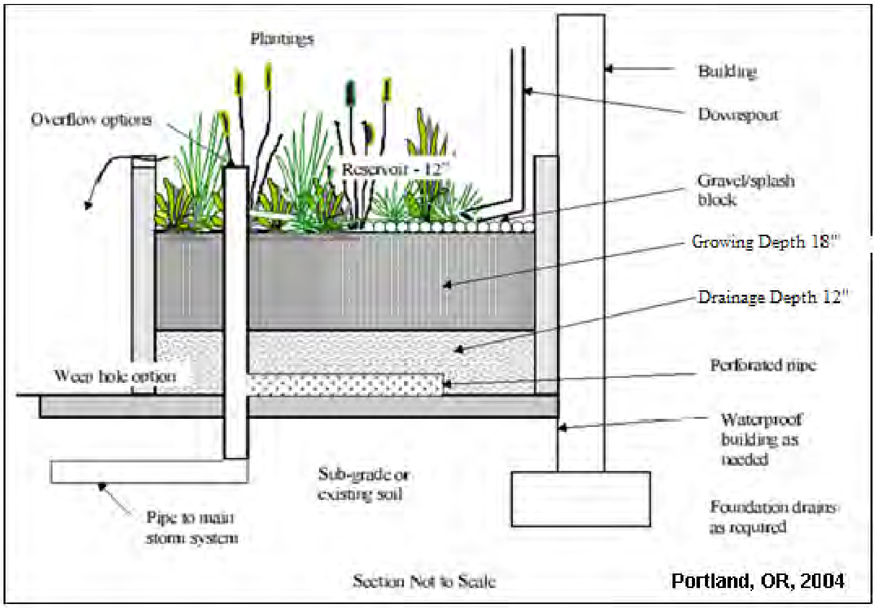


Figure 36 Infiltration stormwater planter, Portland, OR 2004

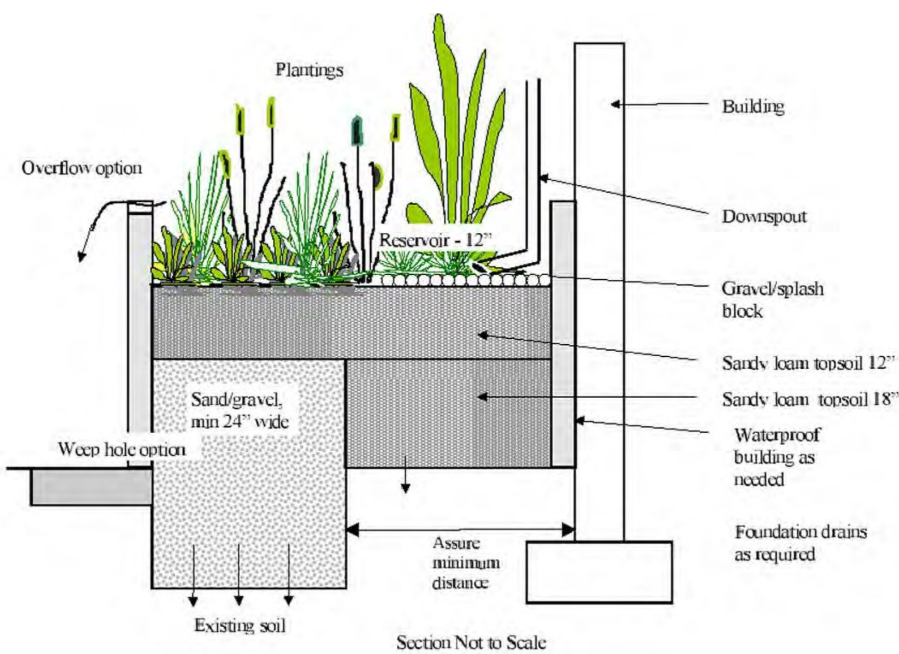


Figure 37 Flow-through stormwater planter

4.5.8 Rain Barrels and Cisterns

Rain barrels and cisterns capture and store stormwater runoff to be used for irrigation systems or filtered and reused for non-contact activities. Rain Barrels and cisterns may be constructed of any water-retaining material; their size varies from hundreds of gallons for residential uses to tens of thousands of gallons for commercial and/or industrial uses. The storage systems may be located either above or below ground and may be constructed of on-site material or pre-manufactured.

Figure 38 Rainwater collection system, Rainharvest.com

4.5.9 Porous Pavement

Porous pavements provide an alternative to conventional paved surfaces, designed to infiltrate rainfall through the surface, thereby reducing stormwater runoff from a site and providing some pollutant uptake in the underlying soils. Permeable paving has three main design components: surface, storage, and outflow. The surface types of paving can be broken into two basic design variations: porous pavement and permeable pavers.

Porous pavement is a permeable asphalt or concrete surface that refers to a material composed of aggregate bound with a black solid or semisolid substance distilled from a petroleum byproduct. Pervious asphalt uses open-graded (uniformly sized) aggregate, as opposed to the finely graded (various size) aggregate used in standard asphalt. Using open-graded aggregate leaves voids between the aggregate that allow water to flow through. Also, pervious asphalt uses less asphalt binder to ensure that many of the voids between pieces of aggregate are not clogged. Pervious asphalt is laid over an aggregate base that retains stormwater until it can filter through to be absorbed by the subsurface.

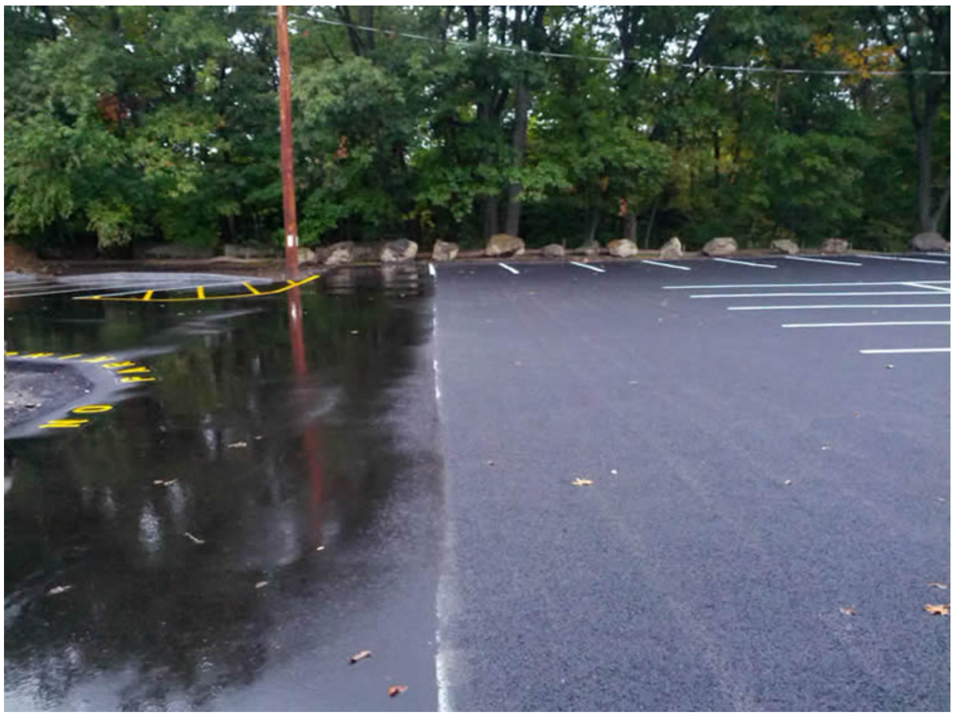


Figure 39 Porous Pavements, EPA, St. Albans, VT

Pervious pavers consist of cast or pressed concrete pavers are solid blocks set on a surface with joints that leave open spaces between each unit. The joints may be filled with loose aggregate or pervious material such as pea gravel, sand, or soil. Another option is to plant grass in the joints. Concrete pavers may be dyed during the manufacturing process. Additionally, the blocks can be pressed with a pattern that simulates other more expensive materials such as brick, stone, or wood.

Figure 40 Pervious Pavers, Seaside, FL

4.6 Infrastructure Cost Reduction strategies

The combination of New Urbanism Principles and GI+LI implementation ensures that the overall costs can be significantly reduced. Most of the tools provide multiple functionalities, e.g., rain gardens may provide storage and filtration, while also performing conveyance features. The range of reduction can be in the range of 30 to 50% when the following main principles are followed.

- Maximizing pervious surfaces (green areas which are completely pervious):
- Private - include privately accessible green areas
- Public - include public open space, parks, green alleys.

- Substituting impervious surfaces with semi-impervious surfaces where possible
- Private - includes privately accessible alleys.
- Public - includes thoroughfare for light and pedestrian traffic.
- Reducing the impervious surfaces to building roofs only and roads with heavy vehicular traffic
- Building’s footprints are completely impervious and cause stormwater runoff
- Roads for heavy vehicular traffic, which may be from concrete blocks, or from asphalt, which are mainly impervious.

The main cost reduction is based on the combined effect of

i) Development of an urban plan which increases the connectivity while minimizing road infrastructure expressed by vehicular thoroughfare per capita,
ii) Eliminating stormwater onsite storage which is typically required for water quality purposes and
iii) Eliminating or significantly reducing the subsurface conveyance (pipes and other stormwater infrastructure.

Many assessments of green infrastructure costs and benefits find that total benefits outweigh the total costs, particularly relative to grey infrastructure strategies and at comparable scales. For example, a 2007 U.S. EPA study found lower total costs for 11 of 12 green infrastructure projects when compared to equivalent grey infrastructure projects.

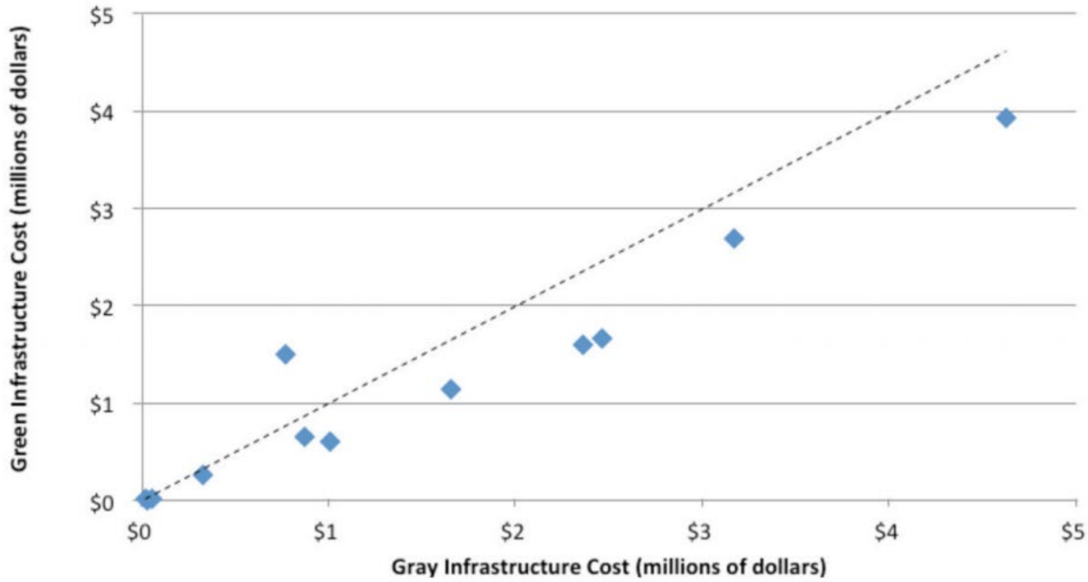


Figure 41 LID and Conventional Cost Comparison ($ Millions)

A survey of members of the American Society of Landscape Architects (ASLA) concerning recent green infrastructure projects revealed many reasons that stormwater professionals select green infrastructure over grey. They reported that green infrastructure offers benefits not available from grey, green options were less costly, and that long-term operation and maintenance expenses could be less particularly when combined with other efficiencies such as those corresponding to LEED certification. The reported cost savings over grey approaches were particularly substantial when large new equipment capacity would be otherwise necessary, or new conventional equipment would require more space than was available. In some cases, planners combined grey and green components to find the most cost-effective option.

5 CONCLUSIONS

To reduce the requirements of the stormwater system, the project will rely on a distributed system of lakes, dry ponds, and stormwater conveyances that are interconnected. The project area was delineated into 11 watersheds based on topography, soil and proposed infrastructure, and analysis was conducted to determine post-development runoff and define the most efficient configuration of the stormwater system which would minimize the runoff, increase aquifer recharge, and ensure compliance with water quality requirements. The urban plan introduced 11 lakes (with a total area of 24 acres ranging between 0.3 and 4 acres in size) and more than 80 dry (with a total area of 32 acres ranging in size between 0.1 to 2 acres). The proposed wet and dry ponds are interconnected with overland and subsurface conveyances to distribute and treat water storage within the site. The system was conceptualized to maximize infiltration and aquifer recharge of excess runoff during storms.

Considering that the project has environmentally preserved areas (the wetlands to the south, west and north), implementing green corridors in the direction of the streams was implemented in order to preserve to the greatest degree of hydrologic connectivity between the watershed and preserve the natural flow. The green corridors include a variety of Green Infrastructure and light Imprint components to accomplish the objective of providing infiltration areas for aquifer recharge and storage components.

Based on the urban plan configuration, the system for the Hybrid Plan provides enough storage to attenuate post-development 100-year, 24-hour peak discharge rate to pre-development rates. At the same time, the hybrid plan is to provide a conveyance system to convey a 25-year, 24-hour peak discharge rate.

A series of calculations were applied to determine the required storage volume and discharge rates for each type of pond.

The plan follows the topography and will not require significant modifications or grading. Best considerations of topographic features include placing the residential areas at the highest. The location of the industrial area is in proximity to the retention areas on the east side which is the most optimal for environmental purposes

Distributed open space within the plan and preservation of large open space area at the southwest section provides the most optimal approach to protecting open space and use within the urbanized areas.

The plan is expected to have minimal environmental impacts based on the distributed large number of green areas within the project which provide infiltration and correspondingly improve water quality and aquifer recharge, therefore reducing potential aquifer and downstream impacts.

The plan will provide the required flood protection capacity based on the minimized fraction of directly connected impervious areas which include multiple green corridors to provide storage and interrupt flow over such areas.

All potable water for the site will be municipally supplied, no on-site potable water wells are located on or utilized by the property. Wastewater generated at the site is currently managed on-site via a sanitary septic system connected to existing buildings' plumbing systems. The plan will include a sewer system that will be built in phases and which will connect to a regional wastewater treatment plant managed by Emerald Coast Utilities Authority (ECUA). Surface water runoff infiltrates or is discharged eventually to Eleven Mile Creek with no NPDES Permits requirements. Solid waste managed by ECUA. Electricity is provided by Gulf Power and electricity.

6 REFERENCES

1. FEMA Flood Hazard Zone, NFIP, , Florida, , Digital Flood Insurance Rate Map, Riverine flooding, Special Flood Hazard Area, 20191016, 2019, Flood Insurance Rate Map, FLOOD, SFHA, DFIRM Database, DFIRM, FEMA, environment, FLOOD HAZARD, Floodway, FIRM
2. Soil Survey Staff, Natural Resources Conservation Service, United States Department of Agriculture. Web Soil Survey. Available online at http://websoilsurvey.nrcs.usda.gov/. Accessed April 2021
3. https://www.weather.gov/mob/september2020climatesummaries September 2020 Climate Summaries Mobile Alabama and Pensacola Florida Area, Accessed December 2020
4. Escambia County Low Impact Design Bmp Manual, 2016
5. NWFWMD ERP Applicant's Handbook Volume II
6. NOAA's Rainfall Atlas V 14, https://bit.ly/326cfRL, Accessed March 2021
7. Wetland Sciences Inc, OLF-8 Wetland Delineation
8. LAND DEVELOPMENT CODE (LDC) Escambia County
9. Municipal Code, Escambia County

7 APPENDIX A CONCEPTUAL STORMWATER PLAN

8 APPENDIX B HYDROLOGIC CALCULATIONS