AgroEcology Gateway Experience: Extending UMD's Agricultural Legacy to the North Gateway

University of Maryland

Student Team D20

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ABSTRACT

Located in the northmost part of the University of Maryland (UMD), the 5-acre site selected by the team includes three parking lots (named P1, NN, and P2), the Chesapeake building that hosts the Human Resources Department, several vegetated areas, and an abandoned space at the edge of the forest. Although situated in the northern gateway, the site is not as warm and welcoming as possible. The three parking lots occupying most of the site are underutilized, cause water pollution, and intensify the urban heat island effect due to their lack of canopy coverage. The current stormwater management system, including a sand filter and traditional stormwater drains, is outdated, hard to maintain, and leads to potential environmental issues. These include erosion and pollution in Campus Creek and Paint Branch, where the stormwater is conveyed.

To solve the existing stormwater management issues and take advantage of the opportunities brought by the historical context of the site, the **AgroEcology Gateway Experience** proposes a design that incorporates green infrastructure and innovative techniques, creates environmental and ecological benefits, highlights UMD's agricultural legacy, enhances the aesthetic of the campus gateway, and expands the University's agroecology corridor. The proposed site will bring educational, environmental, ecological, as well as social benefits.

PROJECT CONTEXT AND SITE SELECTION

SITE CONTEXT

Lying near the fall line between the Piedmont and Coastal Plain, which serves as the transition between the temperate upland oak-hickory forests and the marshy habitats of the Coastal Plain, UMD serves as a microcosm of the transition and is formed by various ecological environments (**Figure 1**). Meanwhile, the University's environmental conditions affect its surroundings, and stormwater is no exception.

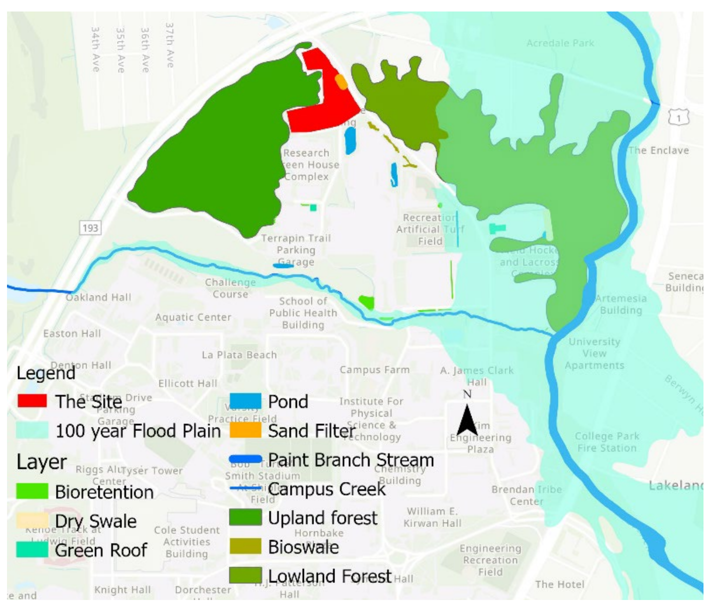


Figure 1: *University of Maryland north district context map*

Campus Creek provides essential habitats to the local vegetation and wildlife while helping with water circulation and regulating its surrounding microenvironment. Currently, it is experiencing a decrease in biodiversity, stream degradation, channel incision, and streambank erosion (*UMCP Campus Creek*, n.d.). As for Paint Branch, impervious surfaces and channelized waterways harm downstream habitats by polluting the stream with toxic metals and eroding stream banks (*Eyes of Paint Branch - EOPB*, n.d.). Sedimentation is also a problem faced by the Paint Branch watershed (*Eyes of Paint Branch - EOPB*, n.d.). Collected and channelized to the Campus Creek and Paint Branch Stream, a large amount of the stormwater from the campus is conveyed to the Anacostia Watershed, one of the most polluted watersheds in the country (*The Anacostia River*, 2006), worsening the situation. UMD's Campus Creek Phase II Stream Restoration proposes to solve this problem by using a "regenerative stream conveyance approach," which will improve the upstream condition by reducing flow rates and bringing back native vegetation. This will minimize sedimentation downstream that flows into the Paint Branch Stream.

UMD has a National Pollutant Discharge Elimination System (NPDES) MS4 Phase II system and takes a wide range of stormwater management measures. Maryland Stormwater Design Manual, which was originally published in October 2000, is used as the official guide for stormwater management in Maryland (*Maryland Stormwater Design Manual*, n.d.). The university itself also developed its stormwater goals. According to the Facilities Master Plan, 2011-2030, the University's goal for the north district is to "Improve ability to store and treat stormwater run-off prior to it reaching Campus Creek to reduce the degradation of the Creek's corridor" (*2011-2030FMP.Pdf*, n.d.). In its 2017 climate action plan, the University is also committed to achieving carbon neutrality by 2025 (*Climate Action Plan | Office of Sustainability*, n.d.). The university incorporates abundant stormwater facilities for stormwater management on campus, such as green roofs, rain gardens, bioretention cells, swales, and permeable pavers. According to a student researcher, 188 stormwater facilities are in use (Collier, 2018). As a global leader in the study of climate change, the university's measures to address climate goals are not limited to green stormwater management. Other green technologies, such

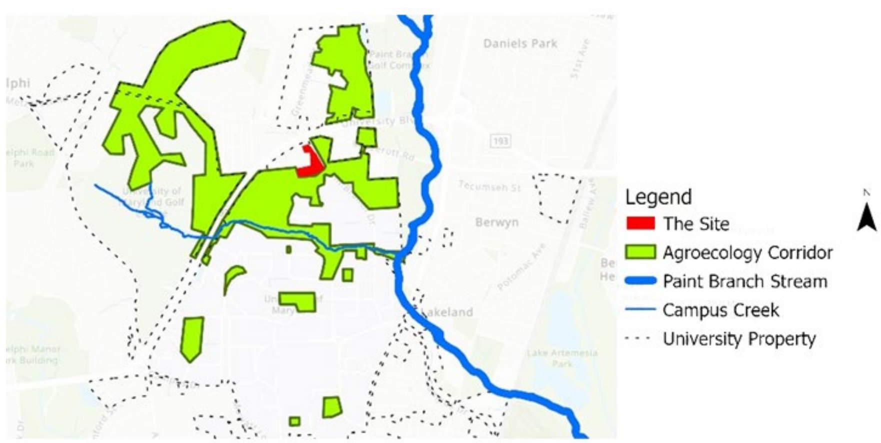


Figure 2: *The site is bounded by the UMD's Agroecology Corridor*

as electric vehicle charging stations, solar energy production, are also promoted.

Tracing its roots back to 1856 when Maryland Agricultural College was chartered, the university's mission was primarily agricultural but evolved to embrace other fields such as engineering (*Timeline*, 2016). The university takes its rich agricultural history and commitment to environmental stewardship seriously. After many years, the university formed the agroecology corridor, a network of greenspaces that provide experiential learning, food, and ecosystem services (**Figure 2**). The goal of the agroecology corridor is to "transform every green space on campus into a project that demonstrates a positive ecological impact" (Dietrich et al., n.d.)

SITE SELECTION

We selected the northern gateway to UMD as our site, which is approximately 5 acres. Unlike a lot of other areas of campus which have been improved with time and address environmental issues, the area has been neglected. The site contains 47% impervious surfaces and 53% pervious surfaces. It is located within a 13.35 acre's micro-watershed, where 11,815 cu ft stormwater needs to be treated to achieve "woods in good" condition (*ESD Design Guidline.Pdf*, n.d.). Because of the generic parking layout and stormwater infrastructure, the environment does not provide an enjoyable experience for the viewers. The parking lots within the site contribute to the stormwater pollution by accumulating oils and heavy metals from vehicular traffic. Some degraded spots on the site also have ponding issues, making it inconvenient and unsafe for pedestrians. The abandoned space at the edge of the forest is underutilized and unsightly.

Although neglected, great ecological values and design opportunities are provided by the site. It is situated within one of the most ecologically diverse portions of campus. According to the campus masterplan, "The area boasts an upland forest, meadow, successional growth area, wooded riparian stream corridor, lowland forest, forested wetland, wetlands, ponds, rain gardens, Campus Creek and the Paint Branch, bioswales, and sand filters'' (*Facilities Master Plan* 2010-2030, p.87). This rich environmental context offers an opportunity to tell the story of Maryland's native ecosystems. Of the 111, 071.5 square feet of pervious surface, 85, 411.82 square feet consists of canopy (77% of pervious surface), making the area a good choice to establish connection between the Wooded Hillock to the west and the Forest Wetland to the east, and therefore, enhance the agroecology corridor. As the north gateway, the site is a competitive candidate to showcase the university's agricultural legacy to the community and demonstrate innovative techniques for managing stormwater and climate change. The site also hosts the Chesapeake building, which staffs the University's human resources department, playing an important role in helping to achieve the university's teaching, research, and outreach missions. A better developed site serves the staff better and symbolizes their supports of the university's values.

Site Inventory and Analysis

WATER FLOW AND DRAINAGE

Stormwater from the forested hillock drains to the site and is then channeled to Paint Branch Stream (**Figure 3**). The site is one part of a treatment train that encompasses the northern part of campus. Stormwater is conveyed from the site to either a sand filter or a retention pond before it makes its way to a bioswale and is then conveyed to Paint Branch Stream via underground pipes.

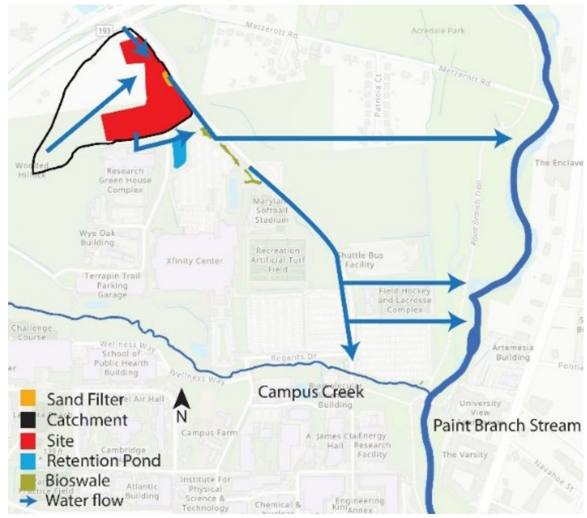


Figure 3: Water flows from the site to a bioswale before entering the Paint Branch

Stormwater flows from parking lot P2 to the degraded sand filter, which causes frequent maintenance issues (**Figure 4**). Since our site is near a main campus gateway, stormwater management should aspire to the same level of innovation as the greenest spots on campus such as the LEAFHouse. The LEAFHouse is "a natural extension of the University of Maryland's history of success in integrated, innovative design" (*LEAFHouse at the University of Maryland | School of Architecture, Planning & Preservation*, n.d.). The sand filter is an industrial way of treating stormwater which conflicts with the north side's green stormwater management style, which is both effective and artful. Besides, the sand filter experiences issues with accumulation of trash and sedimentation.

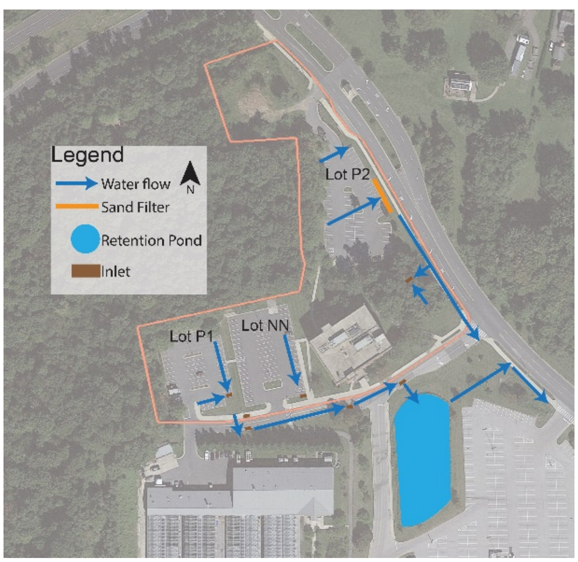


Figure 4: Water from parking lots P1 and NN drains into a retention pond; water from parking lot P2 flows into the sand filter.

Stormwater from parking lots P1 and NN flow into inlets, which convey water to a retention pond to the south of the site before entering Campus Creek. During intense rain events, the retention pond experiences issues with overflow.

SOIL

Because of the construction activities and environmental interactions, the soil types on the site are very diverse (**Figure 5**). They consist of 69% class B soil, 10% class C soil, and 21 percent class D soil (*NRCS*, n.d.).

In addition to quantifying the hydrological soil groups on the site, the team also analyzed the structure of the soil just north of the Chesapeake Building (soil test 1) and the northern tip of the site (soil test 2) to determine if the soil is suitable for any form of agriculture (**Figure 5**). The first soil test indicates slightly alkaline soil with a moderate amount of organic matter and organic carbon. The high amount of clay and higher pH of the second soil test corresponds to the site's prior use as a residential area (**Table 1**). This area is most likely in need of a soil amendment to increase its organic matter and carbon content.

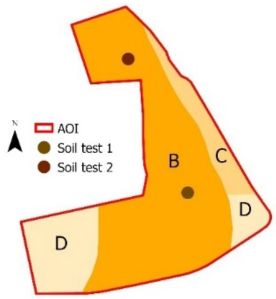


Figure 5: Soil Analysis

Test Item	Soil Test 1 Result	Soil Test 2 Result
Soil classification at surface	Loam	Loam
Clay content	17%	22%
pH	6.68	7.26
Water content (%)	22.9%	21.7%
% Organic matter	8.13%	6.28%
% Organic carbon estimate	4.73%	3.65%
Average Water Infiltration Rate	3.25 in/hr	NA

Table 1: Soil Test Results

VEGETATION

The three parking lots are currently greened by narrow turf strips and small turf islands, with only 4 trees within the lot areas. The wooded hillock, which contains a wide variety of diverse, woody plants, stands in sharp contrast to the barren parking lot (**Table 2**), providing high ecological values.

However, due to lack of maintenance, the invasive species are concentrated in the small patch of trees next to the Chesapeake building (**Table x**). Although providing eye-catching colors, the burning bush used as a hedge along the entrance to the parking lot P1, that acts as a gateway to an area representing multiple native habitats of Maryland, conflicts with the north district's native, regionally appropriate plant palette.

Native	Non-Native
Persimmon *(Diospyros Virginiana)*	Amur Honeysuckle *(Lonicera Maackii)*
Eastern Redbud *(Cercis canadensis)*	Burning Bush *(Euonymus alatus)*
American Sycamore *(Platanus Occidentalis)*	Tree Of Heaven *(Ailanthus altissima)*
American Beech *(Fagus grandifolia)*	Porcelain Berry *(Ampelopsis glandulosa)*
American Sweetgum *(Liquidambar styraciflua)*	Oriental Bittersweet *(Celastrus orbiculatus)*
Mockernut Hickory *(Carya tomentosa)*	
Red Maple *(Acer rubrum)*	
Virginia Creeper *(Parthenocissus quinquefolia)*	

Table 2: Existing Plant Inventory

TEMPERATURE

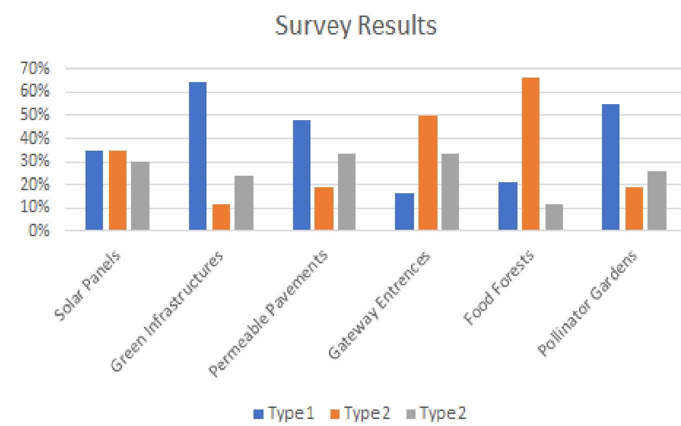
The three parking lots contribute to the urban heat island effect. According to data collected from students in the Department of Environmental Science and

Technology on Nov. 1st, the average temperature of the asphalt, which is 70.29 degree F, and concrete, which is 71.24 degree F, are much higher than vegetated area, which is 52.39 degree F.

According to the USDA, a large portion of southern Maryland is projected to transition to zone 8, which includes Prince George's County in which the site belongs. It can be assumed this will intensify the urban heat island effect, making it more urgent that unnecessary impervious surfaces should be replaced with vegetation or other less heat absorbing surfaces.

PARTICIPATORY PREFERENCE SURVEY

To serve the staff of the Chesapeake building better, a survey, which gained a total of 72– responses, was conducted via Qualtrics to collect information about their preference for future sustainable development. The survey displayed three images of design elements and experiences that might be suitable for the site and asked respondents to choose their preferred images of each category, including rain gardens, pollinator gardens, permeable pavements, campus gateways, solar panels, and food forests (**Chart 1**).



Char1: Survey Results

The results showed that the images incorporating green techniques with eye-catching designs are preferred, encouraging the design team to focus on both practical and aesthetic values.

Project Goals

Our design team seeks to honor the University's commitment to addressing stormwater management and climate change, and to promote the natural beauty and ecological values of the surrounding regional context. After the careful site inventory and analysis, studying the University's climate initiative, meeting with design advisors, and analyzing the results of the survey, the team proposed a design that prioritizes the following goals:

1: Provide **ECOLOGICAL** benefits by addressing climate change, providing green infrastructure, and increasing vegetative cover.

2: Create **EDUCATIONAL** space for the site and connect it to the agroecology corridor by providing research opportunities and environmental education.

3: Increase **ECONOMIC** benefits via renewable energy production, food production, and cost savings with stormwater fee reduction and carbon sequestration.

4: Provide **SOCIAL** benefits by enhancing the northern gateway and fostering community engagement.

Design Solutions

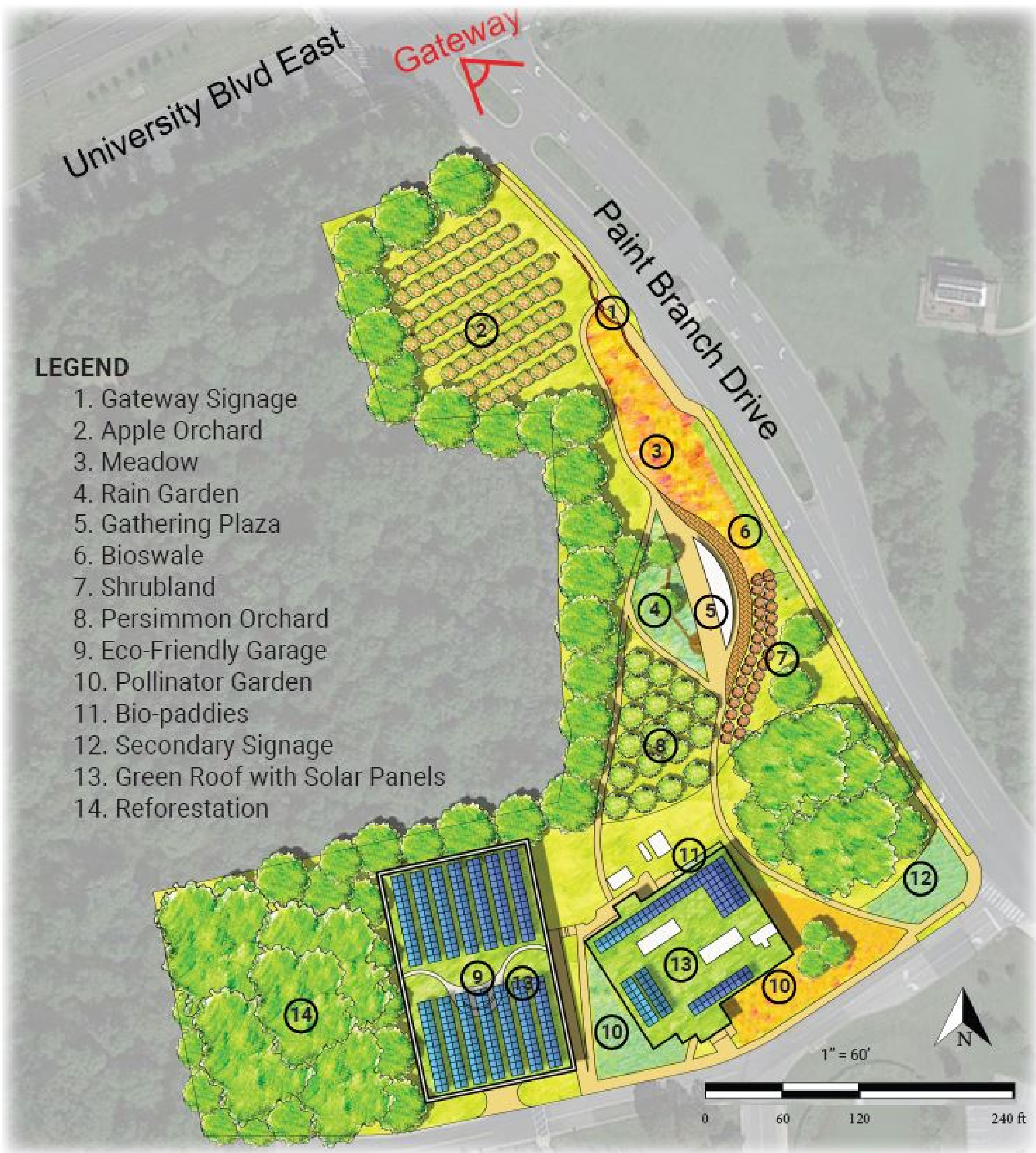


Figure 6: Site Plan

ECOLOGICAL BENEFITS

The application is designed to address the stormwater management goals by proposing a garage to reduce surface parking and transforming the 4.96-acre site into a stormwater treatment, harvesting, and usage system, which reduces the impervious surface from 47.37% a 11.38%. The programs include 31,200 sq ft of green roof area that drains to a 196 sq ft bioretention and two 5,000 gallons cistern for irrigating the 25,100 sq ft orchards; an 1,800 sq ft bioswale to infiltrate stormwater from the sidewalk; 1520 sq ft of sub-raingardens and 1600 sq ft of permeable pavement in the main gathering space; and a 35,000 sq ft reforestation area.

Eco-Friendly Garage

The first step proposed in our design is to introduce a new 3-story parking garage, labeled as **Location 9** in **Figure 6**, that is able to accommodate 200 cars to replace the existing large parking lots. The parking lot is designed to be eco-friendly, with green roofs, solar panels, and a Vehicle-to-building (V2B) energy management system equipped. It makes the rest of landscaping redesign possible, as well as contributing to green energy saving and generation.

Green Roof

Green roofs produce stormwater benefits, mitigate the heat island effect, increase the lifespan of roofing membranes, saving the building cooling/heating costs, and reduce air pollution. Air pollution such as ozone and small particulate matter less than 10 micrometers (PM-10) cause respiratory and cardiovascular health issues. Nitrogen dioxide and sulfur dioxide also cause respiratory problems such as asthma. Plants on green roofs reduce these pollutants by collecting them in their tissues, intercepting small particles in the air, and reduce photochemical reactions that produce ozone by providing shade.

With the existing Chesapeake building and the proposed garage, about 34,000 sq ft of flat roof space will be exposed to sunlight and can be used for green roofs. We plan to cover the Chesapeake building with 12,500 sq ft extensive green roofs (soil depth with less than 15 cm) and the garage with 18,700 sq ft-18, 000 sq ft extensive and 700 sq ft intensive (soil depth greater than 15 cm) for pedestrian access – labeled as **Location 13** (Rowe, 2011). Besides, the infiltrated water is designed to be collected by a 196 sq ft bioretention which is designed to treat 216 cubic feet of stormwater, labeled as **Location 11**, and two cisterns that connect to the persimmon and apple orchards for dripping irrigation.

Rain Garden

Rain gardens is one of the most popular green infrastructures that facilitate ground water recharge, provide wildlife habitat (*Rain-Gardens-Across-Maryland.Pdf*, n.d.), reduce pollutant loading (Li & Davis, 2009), and beautify the environment. A study of two rain gardens in College Park and Silver Spring showed a reduction of pollutants in runoff such as total suspended solids (TSS), chromium, lead and zinc (Li & Davis, 2009).

Location 4 is transformed into a rain garden learning and relaxing area. It includes four sub rain gardens ranging from 300-400 sq ft. Correspond to the ESD Design Guideline, the rain gardens are designed to have a 6-inch ponding depth (*ESD Design Guidline.Pdf*, n.d.). The soil of the rain garden is composed of loamy sand (60-65%), and compost (35% or 40%). Plants are carefully selected to be able to tolerate both wet and dry conditions. The rain gardens are designed to capture1672 cubic feet of surface runoff from the main community gathering space, labeled as **Location 5**.

Bioswale

Bioswales are swales made from engineered soil and vegetation (Xiao & McPherson, 2011). The engineered soil consists of rock and loam soil to maximize porosity. Unlike traditional swales, bioswales infiltrate more stormwater and remove more pollutants. A study in California analyzing pollutant load reduction and stormwater runoff in two parking lots, one with a bioswale and one without, found the bioswale reduced runoff by 88%, nitrogen by 97%, iron by 87%. The bioswale reduced “metals, minerals, organic carbon and solids 95%, 87%, 95%, and 95% respectively”.

In our design, we propose an 8-ft wide bioswale at **Location 6** to replace the sand filter next to Paint Branch Drive to collect about 680 cubic ft surface runoff from the surrounding area, including the sidewalk, which is currently drained to the Paint Branch Drive. Since there’s no strict design guidelines exist for bioswales in Prince George’s County or Maryland, our design follows Montgomery County standards to include “a vegetated surface, a 2 foot planting media layer, a 6 inch think sand layer, and a 12 inch gravel underdrain layer” (*Bio Swale.Pdf*, n.d.). A 5-ft buffer is also proposed by the sidewalk for erosion control.

Permeable Pavement

Permeable paving, like rain gardens and bioswales, infiltrate stormwater and reduce pollutant loading. They can reduce TSS, E.Coli, phosphorous, ammonia, and also loads of copper and zinc (Abdollahian et al., 2018; Fassman & Blackbourn, 2011).

Our design incorporates permeable paving in the proposed gathering space next to the plant walk. Therefore, stormwater can be infiltrated before flowing into the proposed planting area to minimize pollution and the rain garden system will be less likely to be overloaded during intense rain events. The 1602.68 square feet of permeable paving treats 162 cubic feet of storm water.

Reforestation

According to Maryland's 2030 greenhouse gas reduction act plan, forests provide carbon sequestration and economic benefits in the form of wood products (*Greenhouse*

Gas Emissions Reduction Act Plan, n.d.). By 2030, the state plans to provide "afforestation or reforestation" to 68, 530 acres of land. The state also plans on planting 4.6 million trees, 2.5 million of which are urban. In the form of stormwater management, trees provide environmental benefits by intercepting rainfall, increasing the soil's water-holding capacity, and promoting water retention(*Urban Forest Systems and Green Stormwater Infrastructure*, n.d.).

At **Location 14**, where is the edge of the Wooded Hillock and has minimum impact on circulation, we proposed to replace the parking space with 35,000 sq ft reforestation. According to iTree (a software developed by the USDA forest Service that quantifies the benefits of trees), in 30 years, our design's reforestation will intercept 1, 934, 069 338 gallons of stormwater runoff. Because the upland forest simulates a forest ecosystem similar to the Piedmont in which American Beech tends to be the climax species, the reforested area south of the site is comprised of regionally appropriate vegetation, such as American beech and red oak, two species commonly associated with each other ((SWAP_Chapter4.Pdf, n.d.). Beech nuts are highly attractive to "deer, squirrels, chipmunks, mice, raccoons" and other wildlife, providing habitats and foods to them, and therefore, providing considerable ecological values (Looking for American Beech, 2019)

EDUCATIONAL OPPORTUNITIES

To promote the educational opportunities for the students and staff as well as the local community, we propose to maximize the accessibility of each green infrastructure, highlight the current agricultural research and new technologies, and showcase the knowledge by adding introductive signages.

Accessible Green Infrastructure

The prementioned stormwater management infrastructures are all designed to be accessible. A 2,800 sq ft outdoor classroom is design within the green roof area above the garage (**Location 13**), with 2/3 of it shaded by the solar panels to increase comfort during the hot seasons. Decks connected by wooden corridor and equipped with benches are included in the rain garden area for visitors to wander around, observe, learn, and relax (**Location 4**). Each deck is designed to be around a river birch *(Betula nigra)* as a natural shading structure. With the 5-ft buffer designed for the bioswale (**Location 6**), pedestrians are also provided with the change to sit down and take a closer look at the microecosystems within the swale.

Antietam Blush® Apple Orchard

Antietam Blush® apple, developed by Dr. Christopher Walsh and former graduate student Julia Harshman from the UMD's Department of Plant Science and Landscape Architecture, is the University's first-ever patent apple and Maryland's first-ever native apple variety (*Antietam Blush, Maryland's First Native Apple, To Debut In A Few Years*, 2019). Besides their small, compact size that makes them suitable for small, enclosed spaces, the apple is a disease resistant dwarf cultivar with “stronger tree architecture for easier maintenance and harvesting” (27 Years in the Making, UMD Releases Multiple New Apple Varieties Starting with the Harvest of Antietam Blush | College of Agriculture & Natural Resources, University of Maryland, n.d.) and is “bred specifically for the climate and growing culture of the Mid-Atlantic region”.

We proposed to grow about 70 Antietam Blush® apple in the orchard labeled as **Location 2** to honor the great researchers from the UMD as well as highlight UMD’s history as an Agricultural College.

Introductive Signages

Considering the variety of the users, we suggested to add signages to the important spots where the advanced technologies and green infrastructures are prioritized, and the visitors need to be guided. Five spots are chosen to locate the signages, including the apple orchard (**Location 2**), the rain garden (**Location 4**), the southeast corner of the site, labeled as **Location 12**, – a overall introduction of the site for visitors’ way finding, the persimmon orchard on **Location 8** – the introduction of the gravity dripping irrigation system, and by the garage (**Location 9**) – the knowledge about the Vehicle-to-Grid (V2G) energy management system.

ECONOMIC BENEFITS

In addition to the ecological values, our design also provides more tangible benefits by saving the potential electricity and natural gas usage of the Chesapeake building, generating new energy with green technologies, sequestrating carbon emissions, and producing foods for the community.

Green Roof with Solar Panels

The areas of solar panels installed on the roofs of the garage and Chesapeake building (**Location 13**) are 9,800 sq ft and 3,300 sq ft, respectively. Unlike the traditional solar panel installation, our solar panels are combined with green roofs, which enhances the performance of solar panels and reduce the heat island effects produced by the solar panels, according to a study by Peter Irga from the University of Technology Sydney, Australia – green roofs improved the performance of solar panels by 20 percent at peak times and 3.6% over the duration of the experiment (8 months) (“Study Finds Green Roofs Make Solar Panels More Efficient,” 2021).

Energy generated by the solar panels can be used by the Chesapeake building and electric vehicle charging. Based on the footprint of Chesapeake building, the solar panels, which has the potential to generate 70,686 kWh electricity annually, offsets about 8.66% of the building’s electricity use. The green roof underneath can also help with offset the electricity for cooling in summer and natural gas for heating in winter by a total of 3.17%.

Vehicle to Building (V2B) Technique

With the energy supplied by the solar panels, which is enough to charge 2, 356 cars, allowing them to travel 100 miles, the parking garage also incorporates the new concept of V2B energy management technique, which helps to offset peak pricing, lower energy costs, and maximize the use of the produced solar power. Instead of using traditional batteries for storage, V2B uses the electric vehicle to store the electricity generated with solar power during the day. This stored energy can be utilized at night or sold during peak load hours when there's any spare ("How Vehicle-to-Building Charging Can Save Costs, Reduce GHGs and Balance the Grid," 2020). In addition to the cut down on the building's energy costs, vehicle owners may be reimbursed, which benefits both the developers and the users.

Gravity Dripping Irrigation

According to the Center for Neighborhood Technology (CNT), the green roofs are able to retain about 60% of the stormwater, while the rest 40% will be infiltrated(*The Value of Green Infrastructure*, 2011). Besides, due to the structures of the Chesapeake building's roof, which cannot be covered with green roofs, and the paved roof top classroom on the proposed garage, there will be a total amount of the 409054-gallon stormwater leaving the roofs. Instead of letting them to flow away, we include a 5000-gallon cistern by each of the two buildings and connect them to the drip irrigation systems of the two orchards. Taking advantage of the existing 10-ft elevation difference between Lot NN – where the proposed garage is located (**Location 9**), and the proposed persimmon orchard, more than 565 KJ energy can be saved with the gravity dripping irrigation system for the irrigation per cistern.

Carbon Sequestration

With the vegetations added, the proposed design is able to sequestrate a large amount of carbon, and therefore, contributes to economic benefits. According to iTree, in the next 30 years the proposed trees in our design can reduce 325,360 lbs of atmospheric carbon dioxide through CO2, bringing cost savings of $7,567. Combined with the benefits created by the green roofs in 30 years, including the 114,394 lbs C sequestration, 933,261 lbs CO2 avoidance by electricity use reduction, and 268,719 lbs by natural gas use reduction, the site is able to sequestrate 1,641,731 lbs CO2 totally in 30 years, equals to $17,519 savings at the lower bound to $ 58,379 savings at the higher bound (*The Value of Green Infrastructure*, 2011).

Food Production

Besides the prementioned apple orchard, the design also includes an 8,600 sq ft persimmon orchard, labeled as **Location 8**. About 20 American persimmon *(Diospyros virginiana),* known for their sweet fruits they drop in autumn, will be planted. The apple orchard produces 5, 280 lbs fruit annually which can be sold for $6, 969.6. The persimmon orchard has a yield of 2752 lbs, which can be sold for $12, 033.

COMMUNITY ENGAGEMENT

As an application designed to promote the gateway experience and enhance the bound between and UMD and its surrounding community, various measures are included to highlight the site and to improve users' experience.

The Gateway by the Orchard

Currently, the site is not visible enough to the local community as well as the drivers and pedestrians coming from the University Blvd East and the Paint Branch Drive. Taking advantage of the site location, our design will increase the use of the north gateway by transforming it to a destination space. A new gateway with the UMD logo and attractive planting at the bottom is proposed to increase the visibility of the site, labeled as **Location 1**. The apple orchard, standing like lines of solders behind also become an eye-catching landscape.

The Plant Walk and the Gathering Space

A plant walk with vegetation transition from meadow, labeled as **Location 3**, to shrubland, labeled as **Location 7**, to the existing wood land is designed to create visual interests and tell the story of ecological transition. They are by the side of a community gathering space on **Location 5**, with an artful tensile shading structure, bike racks, tables, and benches. Before the proposed interventions, neither the staff of the Chesapeake building nor the community had opportunity to use the outdoor space other than for parking. With our design, now they can stroll through the plant walk and the rain garden, enjoying the wildlife these spaces attract. The community can use the space to celebrate harvesting season as well.

PERFORMANCE

The design reduces the amount of rainfall to be treated to achieve "woods in good condition" by 61% compared with the pre-design condition, with an amount of 4,604 cu ft. With all the green infrastructure, 6,790 cu ft stormwater on site can be treated for the 1-year 24-hour rain event (2.7 inches), 1.5 times as the required by State law. 67,242.5 cu ft stormwater can be harvested for irrigation annually, sufficiently supporting the growth of the proposed orchards.

According to iTree, in 30 years, our design's reforestation will provide total benefits of $15, 702. $3, 021 of this is saved by intercepting 1, 934, 069 338 gallons of stormwater runoff. Another $3, 358 is saved by air quality benefits such as reducing ozone, sulfur dioxide, nitrogen dioxide, particulate matter. This decreases air temperature and reduces heating costs. $7, 567 is saved by capturing carbon dioxide via sequestration. The money saved comes decreased “energy production and emissions”. The remaining $1, 524 is saved by summer heating savings and $233 by winter heating savings.

After our proposed design, the ground average temperature is estimated to change from 60.31 degree F to 54.53 degree F, a temperature decrease of 5.78 degree F.

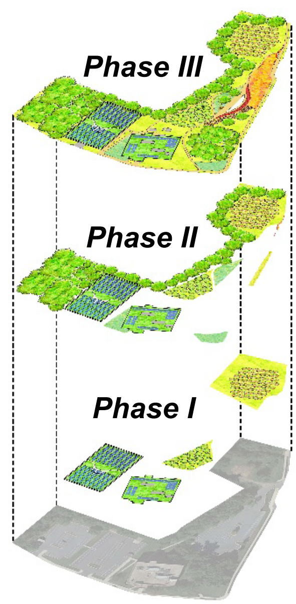
By redesigning the site, the pollutant loads are also deducted a lot compared with the pre-designed site (**Table 3**) (*The Simple Method to Calculate Urban Stormwater Loads*, n.d.).

Load Type	TSS (mg/l)	TP (mg/l)	TN (mg/l)	Cu (mg/l)	Pb (mg/l)	Zn (mg/l)
Before	106.80	0.54	7.00	208.74	110.44	723.76
After	28.34	0.01	0.16	70.77	22.98	216.29
Reduction	78.46	0.53	6.84	137.97	87.46	507.47
%	73.46%	97.98%	97.68%	66.10%	79.19%	70.12%

Table 3: Pollutant Load Reduction

PROJECT PHASING

Phase	Years	Time	Description
I	6	1-year	Present design to the staff of the Chesapeake building and to the University for feedback.
		2-years	Apply for funding from available grants and search for donors.
		5-months	Begin the permitting process for constuction.
		2-years	Construct the parking garage and green roof of the Chesapeake building.
		1-year	Install the apple orchard and persimmon orchard.
II	2	1-year	install the rain garden, bioswale, and the other planted areas around the Chesapeake building, construct the gateway entrance, and demolish parking lot P1.
		1-year	Reforestation
III	2	1-year	Construct the plant walk, gathering space, boardwalk for the rain garden and install the shade structure
		1-year	Install the meadow and shrubland along the plant walk



COST AND MAINTENANCE

Development in Prince George’s County, Maryland, can be expensive, especially when a high-quality installation and maintenance is expected. Nevertheless, the UMD, the surrounding community, and the ecosystem will benefit from the proposed design in a long run. Exclude the $4,000,000 parking garage, the capital cost is showed in **Table 4**, along with a 15 percent contingency, adding up to $4,105,058.

Table 4: Capital Cost

Item	Quantity	Unit	Cost/Unit	Total
Demolition of Asphalt/Concrete	88255	Sq. Ft	$8	$706,040
Rain Garden	1520	Sq. Ft	$16	$24,320
Extensive Green Roof	31200	Sq. Ft	$16	$499,200
Permeable Pavement	1603	Sq. Ft	$32	$51,296
Bioswales	3123	Sq. Ft	$20	$62,460
Fruit Tree Planting & Establishment	25100	Sq. Ft	$20	$502,000
Concrete Pavement	8308	Sq. Ft	$16	$132,928
Solar Panel	182550	w	$2	$401,610
Meadow Planting	15000	Sq. Ft	$16	$240,000
Shrub Planting & Establishment	7460	Sq. Ft	$19	$138,010
Bike Rack	1	Ea	$1,000	$1,000
Gateway Brick Wall	90	Linear Ft	$250	$22,500
Interpretive Signage	5	Ea	$300	$1,500
Biopaddies	197	Sq. Ft	$16	$3,152
Reforestation	35000	Sq. Ft	$20	$700,000
Cistern	2	Ea	$5,000	$10,000
Table with Chairs	3	Ea	$1,500	$4,500
Bench	5	Ea	$820	$4,100
Customized Shading Structure	1	Ea	$40,000	$40,000
Deck	1000	Sq. Ft	$25	$25,000
			SUBTOTAL	$3,569,616
			15% Contingency	$535,442
			TOTAL	$4,105,058

Table 5: Maintenance Cost

Item	Quantity	Unit	Cost/Unit	Total
Rain Garden	32	Hr.	$30	$960
Extensive Green Roof	31200	Sq. Ft	$2	$46,800
Permeable Pavement	1603	Sq. Ft	$4	$6,412
Bioswales	16	Sq. Ft	$30	$480
Fruit Tree Planting & Establishment	90	Ea	$251	$22,590
Solar Panel	524	Ea	$10	$5,240
Meadow Planting	8	Hr.	$30	$240
Shrub Planting & Establishment	4	Hr.	$75	$300
Biopaddies	32	Hr.	$30	$960
			SUBTOTAL	$83,982
			15% Contigency	$12,597
			TOTAL	$96,579

FUNDING

This project is eligible for a variety of funding sources. One such source is the Five Star and Urban Waters Restoration program offered by the National Fish and Wildlife Foundation. This program offers $225, 000 to eligible participants such as educational institutions who initiate projects involving forest restoration. Our design includes reforestation and contributes to the health of the Anacostia watershed, which correspond to its requirement of "address key species and habitats and link directly to established watershed and conservation plans including establishment of wildlife corridors" (*Five Star and Urban Waters Restoration Grant Program*, n.d.). They also need to include community engagement with an educational focus, which also suits our design quite well. The Maryland Beautiful Grant Program also provides funding from The Environmental Education, Community Initiatives and Cleanup Grants. According to the Maryland Department of Natural Resources, "These grants are available to nonprofits, schools and municipalities who initiate environmental education projects, community engagement and neighborhood greening activities." Under this program, the project is eligible for the Citizen Stewardship Grant, which grants up to $5,000 to schools who intend to engage the community ("especially children") in environmental education. Another source of funding is the Stormwater Management Retrofit Program offered by Prince George's County. The purpose of the program is to fund "on-the ground restoration and program activities that improve communities and water quality". Grant amounts for projects in the past have totaled $2, 051, 010. Finally, the 319 Grant Program for States and Territories provides funding for States that supports demonstration projects that help manage nonpoint source pollution. The amount of funding is ample with available money totaling $172.3 million in 2020.

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