INNOVATIVE HOUSING ANALYSIS

TASK 5: SITE PLANNING: INNOVATIVE AND ENVIRONMENTALLY SUSTAINABLE TECHNIQUES

Montgomery County, MD

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EXECUTIVE SUMMARY

This report showcases a series of sustainable site planning techniques that can be applied to housing at a variety of scales. The table below summarizes the strategies and their associated costs, complexity, and performance enhancement.

The systems listed below are grouped by overall technique or technology. Each system is given a rating for its ability to be applied to projects in Montgomery County.

LEVEL 1 APPLICABILITY RATING indicates that the system could be applied to most or all projects when considering both cost and benefit. Level 1 rated systems are generally low to moderate cost, applicable to most sites in the county, and provide benefits to the larger county in terms of stormwater mitigation, habitat creation, and reduction of heat island effects.

LEVEL 2 APPLICABILITY RATING indicates that a system could be used on most sites but at a moderate to high cost. Level 2 systems do provide a high return on investment.

LEVEL 3 APPLICABILITY RATING indicates use or fewer sites. Costs for Level 3 rated systems are generally high. These systems can be used on many sites if funding is available. Return on investment is low to moderate.

1.0 BUILDING LOCATION AND ORIENTATION FOR PASSIVE LIGHTING, HEATING AND COOLING

1.1 Passive Solar Lighting, Heating and Cooling **LEVEL 2 APPLICABILITY RATING**

a. **Description:** The concept of using building orientation and systems to help regulate internal temperature and light levels by harnessing the sun's energy selectively and beneficially in an attempt to improve the energy efficiency.

Example: Discover Elementary School, Arlington, VA – VMDO Architects

i. **Location and Orientation**: Solar orientation of a building and rooms within a building can take advantage of passive solar strategies to heat and illuminate buildings.

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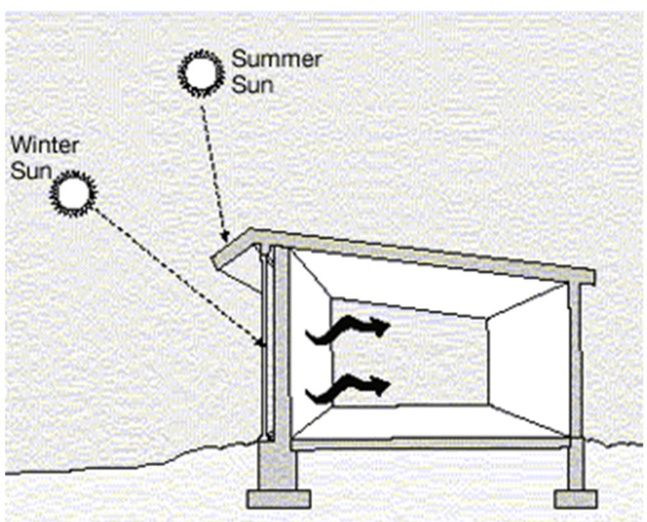
1. South facing glazing and longest facades facing south and north. Shade structures mitigate solar heat in the summer months and allow maximum solar benefit in the winter.

Example: Trombe Wall, source: https://energyeducation.ca/encyclopedia/Passive_solar_heating_and_cooling

ii. **Trombe Walls:** For heating: Created with a south facing wall, faced with a dark material that has a glazing layer placed in front – creating an air column gap. The air in the gap is heated and then vented into the building. As the air cools, it sinks to lower areas in the building. Vents at the base of the trombe wall allow cooled air to enter the space adjacent to the sunny side of the wall to be reheated and passed back into the interior space. At night, when there is no solar heating, vents are closed to prevent cold air from moving into the interior spaces.



Example: Trombe Wall Section, source: https://energyeducation.ca/encyclopedia/Passive_solar_heating_and_cooling

b. **Opportunities and Challenges**
   i. Provides improvement from baseline for lighting, heating and cooling structures by using less energy for supplemental lighting, heating and cooling.
   ii. Not all sites provide the flexibility needed for this application.

  iii. Can be added to existing structures if they have the proper solar orientation opportunities.
  iv. Uses traditional building materials and techniques.
  v. MEP engineering is required to determine effectiveness at each location.
  vi. May not completely eliminate the need for traditional lighting and HVAC systems but could reduce fossil fuel usage.

c. **Typical Maintenance**
  i. Same as traditional building materials

d. **Cost Implications**
  i. Dependent on technology chosen.
  ii. The larger the structural addition, the more initial expense.
  iii. Larger applications may improve effectiveness.
  iv. Effective use of this concept could mean a return on investment via reduced fuel costs as well as reduced costs for lighting and HVAC equipment.

1.2 Vegetative Interventions LEVEL 1 APPLICABILITY RATING

a. **Description:** Using vegetation to maximize opportunities for shading buildings in hot months and protecting from winter winds.
  i. **Example 1:** Grouping deciduous shade trees on south, west, and east sides of residences for passive cooling in summer. During winter, the same deciduous trees allow solar gain on structures since their leaves have fallen, allowing sunlight to warm buildings.
  ii. **Example 2:** Creating windbreaks by placing evergreen screening shrubs and trees on the northwest side of structures can protect them from prevailing winds that blow from the northwest from October through June. This could lead to lower heating costs in the winter months.

b. **Opportunities and Challenges**
  i. Requires space on site in the “right place”.
  ii. Existing sites may have conflicts with best practice locations for planting.
  iii. Provides significant protection from winter winds and reduces costs for heating and cooling.
  iv. Utilizing native and adapted species could make a positive contribution to Montgomery County’s environment.
  v. Increase in planting of trees can provide enhanced ecosystem services such as cleaner air, shade, and habitat.

c. **Typical Maintenance**
  i. Typical planting maintenance – watering, weeding, pruning and insect and disease treatments as needed.
  ii. Also need to mitigate deciduous leaf drop on the ground and on buildings including gutters on buildings.

d. **Cost Implications**
  i. Dependent on the number and sizes of trees and shrubs used, and the size of the structure protecting. Larger plantings will be more expensive but potentially give a quicker benefit. Selecting trees and shrubs that are native or adapted to Montgomery County, MD will yield the most benefit due to their ability to grow quickly under our local climactic conditions.
  ii. Return on investment is seen economically by the reduction in cooling costs in the summer months. Additional non-monetary returns are seen in the creation of habitat for animals and beneficial insects; stormwater mitigation by the update of stormwater by plants; the creation of shade outside of homes; and the improvement of air quality.

2.0 ON-SITE ENERGY GENERATION

2.1 Solar

Source: A Maryland Consumer's Guide to Solar

a. **Roof Mounted Solar Capture Units (panels)** LEVEL 2 APPLICABILITY RATING

i. **Description:** Transforms solar energy into electrical energy that can be used directly, sent back through the electrical grid, or stored in on-site batteries for later use. Can be used for new or existing homes.

ii. **Opportunities and Challenges.**
1. Initial expenditure can be significant.
2. Programs are available to mitigate costs through grants and over-time payments.
3. Reduces dependence on electricity from "the grid".
4. Can offset installation costs with energy savings over time.
5. Provides a long-term energy generation solution.
6. In conjunction with on-site batteries can eliminate complications from weather related power outages
7. Orientation of panels affects performance.
8. Orientation of roof and surface area of roof impacts the amount of solar panels that can be used. The more panels used the more energy harnessed.
9. Tree cover and other shade elements adjacent to roofs can reduce solar panel effectiveness.
10. Can be used to fuel batteries that can charge electric vehicles.

iii. **Typical Maintenance**
1. Panels need to be kept clean for maximum efficiency.
2. Yearly inspection needed to ensure maximum efficiency.

iv. **Cost Implications**
1. Expensive initial capital outlay if not mitigated through payment plans or grants.
2. Battery Backup solutions are an additional cost.
3. Return on investment is seen in the reduction or elimination of energy costs from external sources, and independence from the electrical grid.

b. **Roof Shingles** - https://www.tesla.com/solarroof **LEVEL 2 APPLICABILITY RATING**

Source: GAF Energy

Source: Tesla

i. **Description:** Solar shingles replace traditional roof shingles. They will function to protect the home as well as harness solar energy – similar to how solar panels operate. Can replace roofing for existing homes or be integrated into new home construction.

ii. **Opportunities and Challenges**
   1. Similar to solar panels.
   2. Maximizes the amount of surface area available for solar energy capture.
   3. May not be as effective as solar panels to energy capture.

iii. **Typical Maintenance**
   1. Similar to traditional roof.
   2. Needs yearly inspection to maximize performance.

iv. **Cost Implications**
   1. Initial cost is high.
   2. Long term costs and benefits are similar to solar panels.
   3. Cost can be incorporated into new home construction. These shingles replace traditional singles, so a single product is providing both roof protection and energy generation.

4. Return on investment is seen in the reduction or elimination of energy costs from external sources, and independence from the electrical grid.

2.2 Wind LEVEL 3 APPLICABILITY RATING

a. **Small Scale wind turbines (100 kW or less)**
   i. **Description:** residential scale wind energy capture devices.
   ii. **Opportunities and Challenges**
      1. Require much less space compared to large scale wind turbines.
      2. Generate smaller amount of energy.
      3. Can be used in combination with other energy gathering devices.
      4. Multiple small scale wind turbines can be used to increase yield.
      5. Need a foundation or to be securely fixed to a structure.
   iii. **Typical Maintenance**
      1. Yearly evaluation to ensure maximum yield and confirm proper operation.
   iv. **Cost Implications**
      1. Low-cost mechanism and electrical connections.
      2. Return on investment is seen in the reduction of energy costs from external sources.
   v. **Case Study 1:** HULL, MASSACHUSETTS – WIND POWER In December 2001, Hull, Massachusetts, a coastal town on a peninsula south of Boston, purchased a 660 kW wind turbine to replace a pre-existing structure that had once served the town's high school. Within its first two years, the turbine produced nearly 3,000 MWh of energy, demonstrating a capacity factor of 27 percent. A second turbine, commissioned in May 2006, has a capacity of 1.8 MW. Combined, the two turbines generate enough electricity to supply 11 percent of Hull's load. The electricity from the turbines is generated at a cost of 3.4¢ per kWh, which is less than half of the 8.0¢ it would cost from the grid. The town of Hull is now looking into offshore wind projects. Source: Hull, 2008; Hull Municipal Light Plant, 2013.
   vi. **Case Study 2:** In 2012, the oceanfront city of North Myrtle Beach, South Carolina, finished installing its second small-scale wind turbine. Together, the two turbines generate about 4 kilowatts of electricity to power a concession stand and a water slide on the beach. Rather than generating significant amounts of electricity, the project is meant to provide data to inform future offshore wind development opportunities (Carolina Live, 2012).

2.3 Geothermal LEVEL 2 APPLICABILITY RATING

a. **Description:** Geothermal systems capture the earth's heat for use in generating electricity and providing heating and hot water. In direct use applications, steam from beneath the earth's surface can be used to power turbines to produce electricity. This type of geothermal application is dependent on the availability of adequate geothermal reservoirs (reservoirs of water with temperatures between 68o F and 302o F), which are more common in the western United States.
   i. A second type of geothermal technology uses heat pumps to capture the earth's natural heat to warm liquid that is pumped into buildings from underground piping to provide central heating or to heat water. In warmer seasons, geothermal heat pumps can exchange warm surface air for cooler below-ground air (U.S. DOE, 2006). Geothermal heat pump systems are typically installed at shallow depths **(e.g., 4 to 6 feet below the surface).** Because shallow ground temperatures are fairly constant throughout the United States, geothermal heat pumps can be effective in most locations (U.S. DOE, 2007a).

b. **Opportunities and Challenges**
   i. Passive system – no moving parts once installed for traditional geothermal, heat pumps used for shallow version.

ii. Uses earth's ambient temperature below grade to keep interior space temperatures consistent.
iii. Requires little or no additional energy from fossil fuel sources.
iv. Off-grid
v. Requires space for wells, but at-grade uses can be combined – such recreational uses or even paved surfaces.

c. **Typical Maintenance**
   i. Yearly inspections to ensure functionality and to maximize efficiency.

d. **Cost Implications**
   i. Expensive initial cost, low maintenance cost.
   ii. Cost could be spread over several units potentially.
   iii. Return on investment is seen in the reduction of energy costs for heating and cooling.

3.0 INFRASTRUCTURE FOR ELECTRIC VEHICLES

3.1 Charging Infrastructure LEVEL 3 APPLICABILITY RATING

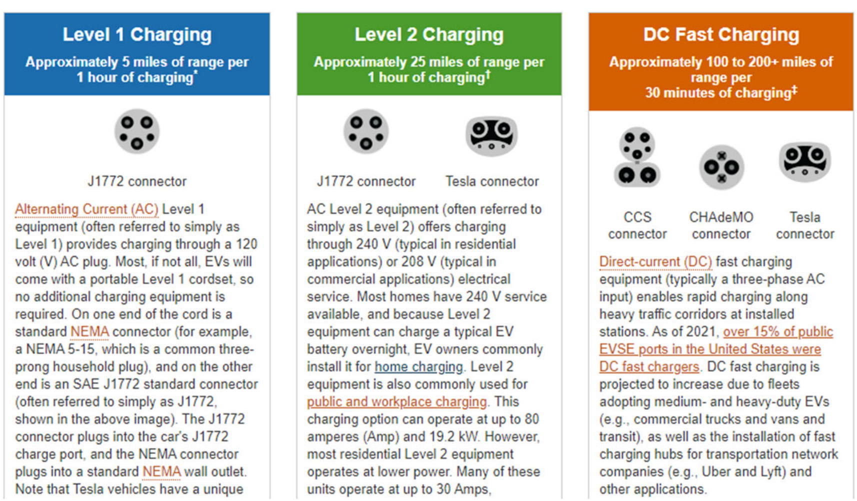
a. **Description:** Providing means to charge electric vehicles in residential environment.

b. **Opportunities and Challenges**
   i. Providing enough energy to effectively charge multiple passenger vehicles.
   ii. Reduce dependence on fossil fuels.
   iii. Need time and space for charging.
   iv. Can be combined with solar energy capture and batteries for off-grid solution.
   v. Higher voltages required for faster charging.

c. **Typical Maintenance**
   i. Periodic inspection and repairs of charging stations.

d. **Cost Implications**
   i. Initially High – but reduces costs over time and improves environment.
   ii. Return on investment is seen in the elimination of the need to purchase fossil fuels, and elimination of maintenance of combustion engines and associated mechanisms.

e. **Additional Information:** AC Level 1 or 2 charging equipment (120 or 240 vol).



Source: US Department of Energy

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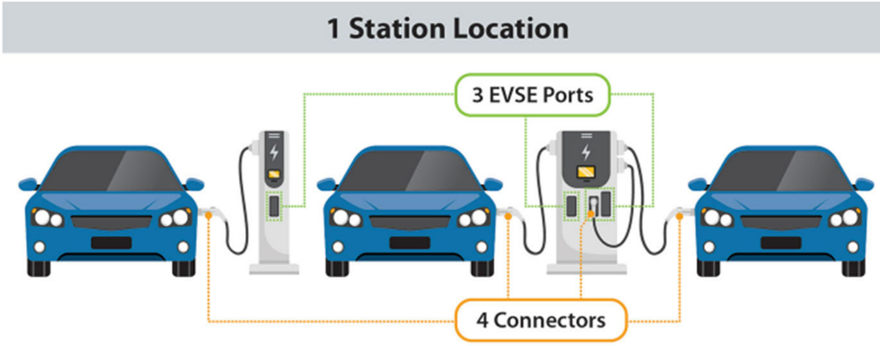
i. DC Fast charging



Source: US Department of Energy

ii. **Inductive Charging** - Inductive charging equipment, which uses an electromagnetic field to transfer electricity to an EV without a cord, has been introduced commercially for installation as an aftermarket add-on. Some currently available wireless charging stations operate at power levels comparable to Level 2, though this technology is more common for transit or other fleet operations at higher power levels comparable to DC fast.

4.0 INNOVATIVE PERVIOUS SURFACE TREATMENTS

Note: Montgomery County specific challenge – Department of Permitting Services allows permeable paving to count as a stormwater mitigation measure, but the Planning Department does not. In order for the County to take advantage of the benefits of permeable paving, the Planning Department will need to change its stance and allow permeable paving as a stormwater mitigation method.

4.1 Porous Pavers LEVEL 1 APPLICABILITY RATING

Source: Unilock

a. **Description:** Pavers installed with voids to allow stormwater to infiltrate and reduce runoff.
b. **Opportunities and challenges**: Similar to porous pavement but more feasible for lighter traffic areas including pedestrian ways such as sidewalks and overflow parking areas. The smaller size of the pavers makes them both easier to replace if damaged but also easier to dislodge under higher stress conditions. Thicker bases can be designed to accommodate emergency vehicle loading.
c. **Typical Maintenance:**
   i. A lower level of winter maintenance is required.
   ii. Maintain planting materials away from pavements.

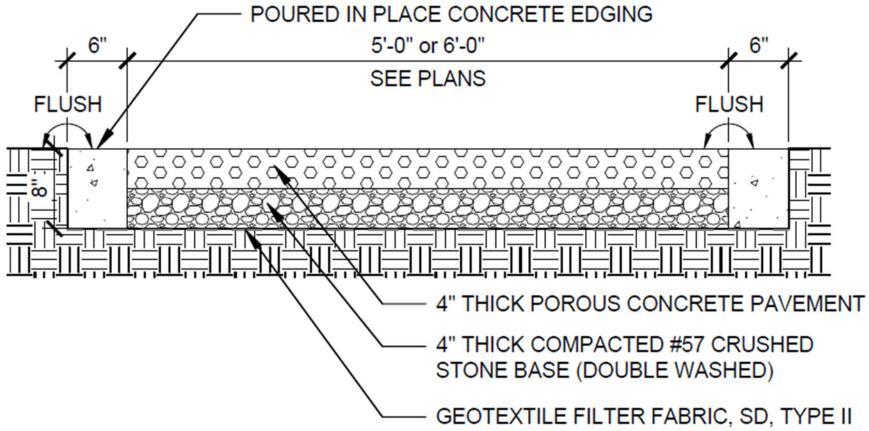
iii. Occasional replacement of joint material and weeding are required.
iv. Sweeping of debris is required to maintain infiltration rates.
v. Underdrain monitoring and flushing is required.
vi. ADA issues in areas with primary pedestrian circulation.

d. **Cost Implications:**
   i. Similar cost to impervious pavers.
   ii. If storing stormwater below, then depth of substrate material will increase cost if deeper than minimum required for use case.
   iii. Return on investment is indirect – as the systems perform similarly to impervious systems when maintained. Indirect return on investments come from reducing the need for and capacity of traditional storm sewer system infrastructure.

4.2 Permeable Pavement LEVEL 1 APPLICABILITY RATING

a. **Porous Concrete**

Source: https://pavementinteractive.org/reference-desk/pavement-types-and-history/pavement-types/permeable-pavements/



Example construction detail for permeable paving

i. **Description:** Poured Concrete paving – with integral air space that allows for water flow through the surface.

ii. **Opportunities and challenges**: Ideal for pedestrian ways such as sidewalks and overflow parking areas. Poured nature of product facilitates rapid installation. More color options available due to aggregate selection and substrate tinting. Thicker bases can be designed to accommodate emergency vehicle loading.

iii. **Typical Maintenance:**
   1. Joint filtering material would need to be replaced occasionally.
   2. Maintain planting materials away from pavements.
   3. Underdrain monitoring and flushing is required.
   4. Periodic vacuuming of debris is required to maintain infiltration rates.
   5. Frequency of maintenance will be determined on a case-by-case basis.
   6. A lower level of winter maintenance is required.
   7. Surface sealants should not be used.

iv. **Cost Implications:**
   8. Similar to exposed aggregate poured concrete. Higher maintenance costs for vacuuming debris from surface to maintain optimal permeability.
   9. Return on investment is indirect – as the systems perform similarly to impervious systems when maintained. Indirect return on investments come from reducing the need for and capacity of traditional storm sewer system infrastructure.

b. **Porous Asphalt**

Source: https://pavementinteractive.org/reference-desk/pavement-types-and-history/pavement-types/permeable-pavements/

i. **Description**: Poured in place pavement surfaces designed with voids to allow stormwater to infiltrate and reduce runoff.

ii. **Opportunities and Challenges:** Permeable pavement works best in lower traffic areas where vehicles will not make sharp turns or sudden stops that can create stresses that deforms pavement (even standard impermeable pavement develops a waving form at intersections from repeated vehicle stopping). It can be used on roads, parking lots, and sidewalks and provides the benefit of infiltrating water while maintaining a flat surface with a high structural bearing capacity for vehicles and pedestrian traffic. Because water infiltrates though the pavement rather than ponding on top, it has an added benefit in the winter of disposing quickly of ice – even in winter, sunlight can cause ice to melt and drain through the permeable pavement before nightfall can refreeze the melt water. Challenges are that permeable pavement more than most best practices can fail if not properly and frequently maintained.

iii. **Typical Maintenance:**
   1. Joint filtering material would need to be replaced occasionally.
   2. Maintain planting materials away from pavements.
   3. Underdrain monitoring and flushing is required.
   4. Periodic vacuuming of debris is required to maintain optimal infiltration rates.
   5. Frequency of maintenance will be determined on a case-by-case basis.
   6. A lower level of winter maintenance is required.
   7. Surface sealants should not be used.

iv. **Cost Implications:**
   1. Similar to traditional asphalt paving with higher maintenance costs for vacuuming debris from surface to maintain permeability. Overall life span can be longer than traditional asphalt.
   2. Return on investment is indirect – as the systems perform similarly to impervious systems when maintained. Indirect return on investments come from reducing the need for and capacity of traditional storm sewer system infrastructure.

4.3 Open Graded Aggregate **LEVEL 1 APPLICABILITY RATING**

Source: Gravel Pave 2 https://www.invisiblestructures.com/products/gravelpave-2/

a. **Description:** Gravel paving with open graded stone typically 1-3" diameter but can be smaller if gravel reinforcing material is used. Use of surface determines depth of stone.

b. **Opportunities and Challenges**
   i. Wide range of colors and textures.
   ii. Simple and fast to install.

iii. Requires an edging material to keep aggregate from migrating away from intended application area.
iv. More successful when used in conjunction with aggregate reinforcing systems.
v. Allows high volume of water movement through system.
vi. Can store stormwater in and below system depending on design thickness.
vii. Can support large vehicles such as fire trucks when reinforcing grid system such as gravel pave is used.

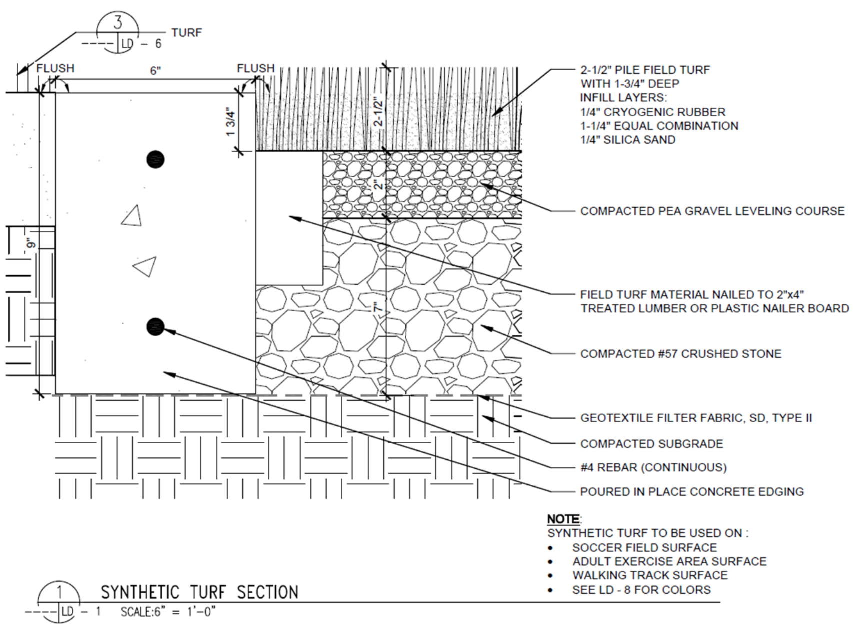
c. **Typical Maintenance**
i. If reinforcing grid is used, then gravel typically stays in place leading to less maintenance over time.
ii. Leaf and debris removal
iii. Eliminating ruts in damaged areas

d. **Cost Implications**
i. Low compared to other paving types – good for large areas of parking or infrequently used roadways.
ii. Return on investment is indirect – as the systems perform similarly to impervious systems when maintained. Indirect return on investments come from reducing the need for and capacity of traditional storm sewer system infrastructure.

4.4 Artificial Turf LEVEL 2 APPLICABILITY RATING

Example: Shepherd Park Artificial Turf Field, Washington DC – storm water is stored below entire

soccer field



Example: Construction detail showing gravel layer below turf used to store stormwater

a. **Description:** Surfacing made to resemble vegetative turf. Comes in a wide variety of colors. Typically installed on a gravel base that can be used to store stormwater.

b. Opportunities and Challenges:

i. Stable – low maintenance – aesthetically pleasing.
ii. Can get hot – no evapotranspiration.
iii. Can cause significant abrasions.
iv. Substrate (typically crumb rubber) between synthetic grass blades gets transferred to players cleats and clothing.
v. Can use coconut infill instead of crumb rubber filler to mitigate rubber issues.
vi. Can store stormwater below in aggregate base. Increase size of base to fit storm water storage needs.
vii. Does not require watering, fertilization or mowing, which significantly reduces maintenance cost and reduces the use of fossil fuels.

viii. Consistent play surface as opposed to vegetative turf.

a. **Typical Maintenance:**
   i. Removal of leaves in fall.
   ii. Periodic replacement of sections that see extreme use.
   iii. Replacement of "turf" that lifts from base.
   iv. Periodic replacement of substrate (crumb rubber or coconut infill).

a. Cost Implications:
   i. More expensive than vegetative turf.
   ii. Less maintenance than vegetative turf.
   iii. Return on investment is seen on the maintenance side – as mowing with combustion engine lawn mowers is eliminated – reducing yearly maintenance costs significantly.

4.5 Rain Gardens and Conservation Landscapes **LEVEL 1 APPLICABILITY RATING**

a. **Description:** Planting areas that feature native and adapted plant species in earthen depressions that allow stormwater to pond for short durations. The storm water filters through growth media – i.e. specialized soils to recharge aquifers if possible and/or slows the rate of storm water flow into municipal storm water systems which reduces overflows creating dangerous flooding. Rain gardens at the residential scale work in tandem as a system to reduce the overall impact of stormwater to a municipal system.

b. **Opportunities and Constraints:**
   i. Reduces flooding.
   ii. Increases habitat and biodiversity.
   iii. Treats and slows storm water where falls.

c. **Typical Maintenance:**
   i. Similar to residential planting bed maintenance: weeding, elimination of pests, pruning.
   ii. Yearly inspection of overflow devices to ensure operation.
   iii. Occasional replanting of plants that fail.

d. **Cost Implications:**
   i. Cost dependent on size of rain garden and density of planting
   ii. Initial cost is moderate.
   iii. Maintenance cost is low.
   iv. Return on investment is measured in improvement to the local environment. As rain gardens mature they reduce the need for expanded capacity for traditional stormwater system infrastructure which is extremely expensive. Conservation landscapes created with native species increase ecosystem services such as providing biohabitat, providing shade, strengthening local ecology, mitigating stormwater and reducing heat-island effects.

e. **Existing support program:** Montgomery County Rainscapes programs offer homeowner rebates to install these. https://www.montgomerycountymd.gov/water/rainscapes/

5.0 GREEN ROOFS AND VERTICAL GREEN INFRASTRUCTURE

5.1 Green Roof LEVEL 2 APPLICABILITY RATING

Example: Green Roof on structure at Shady Grove Equipment Maintenance and Operations Center

a. **Description:** Vegetated/planted building roof surface to promote stormwater retention and filtering.

b. **Opportunities and challenges**: Green roofs can be intensive or extensive. The intensive system has a higher substrate volume and weight that can capture more water and support larger, lusher plantings. The higher weight of the intensive system requires a stronger roof system but also provides more insulation to reduce heating and cooling costs. An extensive system typically consists of succulents that are lighter and could even be placed atop existing buildings that were not previously designed to support a green roof. The upfront capital costs are higher for a green roof while the long-term costs are lower because the design requirements result in a sturdier roof that lasts longer than a typical roof system.

c. Typical Maintenance:

i. Periodic watering.
ii. Protection and monitoring to prevent vandalism.
iii. Replacement of dead vegetation.
iv. Weeding and removal of invasive plants.

d. Cost Implications

i. Additional cost to building.
ii. Significantly impacts cooling costs in summer and heating costs in winter.
iii. Return on investment is measured in improvement to the local environment. As green roofs mature they reduce the need for expanded capacity for traditional stormwater system infrastructure which is extremely expensive. Green roofs increase ecosystem services such as providing biohabitat, strengthening local ecology, mitigating stormwater and reducing heat-island effects.

Case Study: Pepco Building in Georgetown 3303 water street – intensive green roof

5.2 Vertical Green Infrastructure LEVEL 3 APPLICABILITY RATING

Case Study 1: Trellis, Finnish Embassy, Washington, DC

Photo from inside building – showing effect of vegetation on light/shade and cooling during summer months.

a. **Description:** Applying structure adjacent to building facades that facilitate growth of vegetation to cool buildings.

b. **Opportunities and Challenges**
   i. Provide both cooling in summer and opportunity for warming in winter when deciduous vegetation is dormant.
   ii. Orientation determines success of vegetation based on species selection.

c. **Typical Maintenance**
   i. Ensuring stability of structure.
   ii. Plant maintenance – irrigation, suitable soil, fertilization, pruning, attachment to trellis.

d. **Cost Implications**
   i. Additional cost to building
   ii. Significantly impacts cooling costs in summer months.
   iii. Return on investment is measured reduction of cooling costs to building in summer months. Return on investment is also measured by their ability to increase

ecosystem services such as providing biohabitat, strengthening local ecology, mitigating stormwater and reducing heat-island effects.

e. **Case Study 2**: Pepco Building in Georgetown, Washington DC. Trellis used to cool brick façade.

Case Study 2: PEPCO Substation in Washington, DC

6.0 ON-SITE WATER RECYCLING AND REUSE TECHNIQUES

6.1 Cistern **LEVEL 2 APPLICABILITY RATING**

Example above grade cistern

a. **Description:** Sub-surface or surface storage tanks designed to accommodate excess stormwater quantity. Water reuse opportunities could include irrigation, toilet flushing or exterior washing (e.g. car washing).

b. **Opportunities and challenges:** These systems can be fit into many areas and shapes including above ground, below ground, inside buildings, on roofs and beside buildings. Outdoor, above ground cisterns reduce the need for pumping, if any, to reuse the harvested stormwater for irrigation on internal building uses like toilet flushing, dish washing or laundries. But water within above ground systems can freeze in colder seasons. Below ground and indoor systems may be protected from the cold but can require higher pumping costs to remove water from the system. It can be a challenge to have a water reuse plan that removes enough water from the cistern so that adequate volume is created to capture runoff from the next precipitation event.

c. **Typical Maintenance:**
   i. Periodic inspection.
   ii. Periodic removal of sediment build-up.
   iii. Regular use of harvested water is required.
d. **Cost Implication:**
   i. Cost vary depending on size of cistern and amount of connections needed to direct water to cistern.
   ii. Return on investment can be seen in the reduction in purchased water from local utilities. Additional return on investment can be seen in the reduction in the volume of stormwater going to the county storm water infrastructure.

6.2 Rain Barrels LEVEL 1 APPLICABILITY RATING

e. **Description:** Small scale residential capture of water from downspouts into barrels. Water is then reused for irrigation or other non-potable residential water uses. Not recommended for use on crops.
f. **Opportunities and Challenges:**
   i. Slows and reduces storm water entering into municipal storm water system.
   ii. Captures “free” water.
   iii. Keeps water on-site.
   iv. Easy DIY for residents.
   v. Educational Benefit for kids and adults.
g. Typical Maintenance:
   i. Periodic removal of leaves and debris from system.
   ii. Maintenance by residents who use the rain barrels.
h. Cost Implications:
   i. Low – accessible through local and regional programs.
   ii. Return on investment can be seen in the reduction in purchased water from local utilities. Additional return on investment can be seen in the reduction in the volume of stormwater going to the county storm water infrastructure.
   iii. Leverage as a component of the Montgomery County Rainscapes Rebates.
      1. https://www.montgomerycountymd.gov/water/rainscapes/rebates.html

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7.0 STRATEGIES FOR PRESERVATION AND ENHANCEMENT OF TREE CANOPY

7.1 Shade Tree Planting LEVEL 1 APPLICABILITY RATING

Example Street Tree Planting

a. **Description:** Trees provide a key role in the urban and suburban environment by reducing runoff volumes into the stormwater system, adding real estate value to neighborhoods, and wildlife habitat.

b. **Opportunities and challenges:**
   i. The rate at which rainwater enters the stormwater system is slowed by tree canopies that capture water prior to landing on impervious surfaces. Some of this rainwater can be taken in by the tree itself, while other portions can be directed into the planting strip where it can be utilized by groundcover plantings.
   ii. Real estate values are higher with street tree plantings than without.
   iii. Songbirds and other wildlife can use tree canopies for cover and refuge, fruit and nuts as food sources, and benefit from the many larval host insects that depend on the trees as host plants.
   iv. Adding new trees requires coordination with utilities which can be challenging given the existing conditions. Soil volume and health is required for optimal growth, and some neighborhoods may be comprised of imported fill absent of organic matter.
   v. Adding to a shade canopy increases community desire to traverse and linger, which is good for community spirit and business development. Shade cover reduces the heat island effect and, if trees are larger and contiguous across longer reaches, can support natural habitat for song-bird populations. In these ways, shade tree plantings reduce the quantity of stormwater going into the system, as well as improve overall water quality through simple filtration.

c. **Typical Maintenance:**
   i. Aeration of soil
   ii. Fertilizing
   iii. Pruning
   iv. Watering

d. **Cost Implications:**
   i. Varies with scope of planting.
   ii. Return on investment is measured in improvement to the local environment. As tree plantings mature they increase ecosystem services such as providing shade, biohabitat, strengthen local ecology, mitigate stormwater and reduce heat-island effects.

7.2 Species Selection LEVEL 1 APPLICABILITY RATING

a. When choosing to replace or plant new trees, select native or regionally adapted species that can withstand current and future climatic conditions.
   i. Example – Callery Pear was used extensively, but has a short life span, splits and breaks when at end of life – causing cost, and potentially harm to landowners. Also, the Callery Pear is an invasive species that is spreading unchecked throughout the region. The Bradford pear displaces native and regionally adapted species that provide ecosystem services and habitat.
   ii. https://msa.maryland.gov/msa/mdmanual/01glance/html/trees.html
   iii. Considering species selection as keystone species by ecoregion.
      1. Dr. Doug Tallamy has tool to determine which trees and perennials provide the most benefit for the local food web. Not all MD natives are effective in all areas of the state.
      2. https://www.nwf.org/nativeplantfinder

7.3 Provide Adequate Soil Volume for New Trees LEVEL 1 APPLICABILITY RATING

a. Trees require a minimum soil volume to grow to their fullest and provide the most ecosystem services to the community.
b. City of Bethesda, MD minimum standard volume of soil is 600 cubic feet for street trees.
c. https://montgomeryplanningboard.org/wp-content/uploads/2020/09/Bethesda-Streetscape-Standards_100120.pdf
d. Less volume for trees is shown to significantly impact the ability of trees to maximize tree canopy which directly relates to the amount of air that the tree can filter and the amount of water it can consume.

7.4 Improving Soil Texture and Organic Content LEVEL 1 APPLICABILITY RATING

Soil section

a. Soil Amendments
   i. **Description:** The addition of any substance to the soil that helps to promote plant growth. Examples of amendments include peat, yard compost, and wood chips. Soil amendments directly affect the ability of water to either flow over or percolate into the soil.
   ii. **Opportunities and challenges**: Compacted soils reduce the volume of stormwater that can infiltrate, sometimes to the extent that they behave almost like impervious surfaces. Soil amendments restore infiltration capacities, promote

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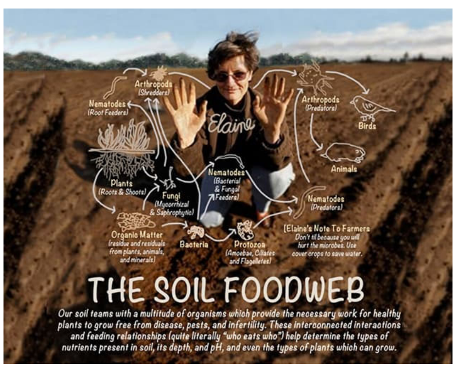
healthy and sustained plant growth, and improve the pollutant removal capacity of the soil and vegetated system. Amended soils need to be protected so that they do not become compacted by future vehicle or pedestrian traffic and are most beneficial when placed where they will receive frequent precipitation and stormwater flow.

iii. **Typical Maintenance:**
   1. Mechanical aeration.
   2. Organic amendments.
   3. Maintaining soil stability.

iv. **Cost Implication:** Low
   1. Return on investment is measured in improvement to the local environment. Improved soil texture and organic content supports the growth and overall strength and resilience of plants which increases ecosystem services such as supporting biohabitat, strengthening local ecology, mitigating stormwater and reducing heat-island effects.

7.5 Restore Biological Function to Soils **LEVEL 2 APPLICABILITY RATING**

a. Utilize the Soil Food Web approach by Dr. Elaine Ingham- https://www.soilfoodweb.com/
b. Restore the Soil Food Web by re-introducing biology into soils through targeted inoculum. This restoration increases productivity of landscapes and results in substantial levels of carbon sequestration, and has the potential, if implemented on a global scale, to return atmospheric carbon to the safe level as identified by the IPCC.



8.0 TECHNIQUES AND AFFORDABILITY

The following table compares the cost, complexity of implementation and environmental performance of various techniques aimed at increasing sustainability of housing buildings and sites.

Environmental Performance Category	Environmental Performance Strategy	Cost to Implement $ - Low $$ - Mid $$$ - High	Return on Investment $ - Low $$ - Mid $$$ - High	Complexity and Scale of Implementation 1- Homeowner 2- Community 3- Developer	Environmental Performance Enhancement 1- Low 2- Medium 3- High
Building location and orientation for passive heating/cooling	Architectural Interventions	$$($)	$$	1,2,3	1
	Planting Strategies	$	$$	1,2,3	1
On-Site Energy Generation	Solar	$$$	$$	1,2,3	2
	Wind	$$$	$	1,2,3	2
On-Site Water Recycling and Reuse Techniques	Rain Barrels	$	$	1	1
	Rainwater Cisterns	$$	$	2	2
	Underground Storage	$$$	$$	3	2
Strategies for Preservation and Enhancement of Tree Canopy	Shade Tree Planting	$	$$	1, 2, 3	3
	Species Selection	$	$	1, 2, 3	3
	Provide adequate soil volume	$$	$$	3	3
	Improve soil texture and organic matter content	$	$$	3	3
	Restore biological function to soils	$	$$	2,3	3

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9.0 ENVIRONMENTAL PERFORMANCE ACROSS SCALES OF HOUSING

The following technologies can be implemented at the scales below to increase the environmental performance of the housing buildings and sites.

Technology	Single Family	Duplex/Tri/Quadplex	Multi-Family (over 4 families)
Building location and orientation for passive heating/cooling	New homes and additions can be designed to gain benefits from orientation and passive heating and cooling	All units in smaller structures and some in larger quads can receive benefits	All units in smaller structures and some in larger quads can receive benefits
Solar for building electrical needs	Roof – main building and/or garage.	Roof and shade structures over grouped vehicle parking.	Roof and shade structures over grouped vehicle parking.
Electric vehicle charging	From solar or electric utility – single vehicle charging.	From solar or electric utility – multiple vehicle charging station.	From solar or electric utility – multiple vehicle charging station – possibly multiple stations depending on need.
Wind Turbines	Small scale turbines can be combined with other energy capture devices to reduce need from electric utilities	Multiple small scale turbines can power lighting for interior and exterior common areas and parking areas.	Multiple small scale turbines can power lighting for interior and exterior common areas and parking areas.
Geothermal	Can provide effective interior climate control. High cost for single unit.	Can provide effective interior climate control. Cost can be spread over several units to reduce individual unit cost.	System may not be as affective for large unit developments due to space needed for wells and capacity of each well.
Green Roof	Primarily for flat roofs – main building or garage.	Primarily for flat roof and shade structures for vehicles.	Primarily for flat roof and shade structures for vehicles. Can be combined below Solar panels if panels are built 18” over green roof on lightweight structure.
Rain Gardens	Direct roof or paving runoff to single rain garden to slow runoff to the storm water system.	Direct roof or paving runoff to multiple rain gardens to slow runoff to the storm water system.	Direct roof or paving runoff to multiple rain gardens or bioretention cells to slow runoff to the storm water system.
Rain Barrels	For capture and reuse of limited volume of storm water.	For capture and reuse of limited volume of storm water.	Would have to be maintained and water distributed by central entity. Could be used to irrigate a community garden.
Cisterns	Greater cost and capacity than rain barrels. Could be suitable for some single-family homes.	Greater cost and capacity than rain barrels. The more units, and square footage of roof to capture storm water, the greater the	Above or below grade to capture roof runoff. Higher volumes runoff gathered from larger roof and paving areas can be used

Technology	Single Family	Duplex/Tri/Quadplex	Multi-Family (over 4 families)
		possibility to use the water for flushing toilets. Need enough water to justify cost. Above or below grade.	to flush toilets and for irrigation of sites.
Permeable Paving	For driveways walkways, terraces and open parking areas.	Permeable paving – driveways, walkways, terraces, and open parking areas (not recommended for drive aisles).	Permeable paving – driveways, open parking, walkways, terraces, and common areas (not recommended for drive aisles).
Vegetative Screening	Deciduous planting can provide effective shading – cooling structures in summer and allowing warming sun in winter. Wind break plantings can require significant space.	Deciduous planting can provide effective shading – cooling structures in summer and allowing warming sun in winter. Wind break plantings can require significant space.	Space for planting may be an issue for more intensive developments. Trellised vines can provide significant summer shading without taking up much space but do require structure to climb.
Artificial Turf	Eliminates weekly mowing. Expensive for single family residence. Lower maintenance than vegetated lawn.	Eliminates weekly mowing. Expense can be spread over several units. Lower maintenance than vegetated lawn.	Eliminates weekly mowing. Expense can be spread over several units. Lower maintenance than vegetated lawn. Can be used on roof structures.
Tree Canopy Enhancement	Increases shade, reducing heat island effect. Requires space and adequate soil volume and water.	Increases shade, reducing heat island effect. Requires space which may be less available on multi-unit sites. Also requires adequate soil volume and water.	Increases shade, reducing heat island effect. Requires space which may be less available on multi-unit sites. Can also use to shade parking areas. Requires adequate soil volume and water.

10.0 MOVING TOWARD THE COUNTY'S CLIMATE ACTION GOAL

The following section summarizes recommendations for applying sustainable site strategies to a variety of housing scales to ensure positive contribution of housing developments to the County's Climate Action Plan's goals. The primary goal of the Action Plan is to cut greenhouse gas emissions by 100% by 2035.

10.1 Climate Action Plan's Vision Summary

a. **Clean Energy –** carbon free, create clean energy jobs, expand renewable energy generation and distributed energy sources.

b. **Buildings**
   i. High performance buildings.
   ii. Increase energy efficiency, reduce use of fossil fuels.
   iii. Support carbon neutral design.
   iv. Expand access to programs and incentives.

c. **Transportation**
   i. Transition to 100% zero emission vehicles.
   ii. Provide clean, frequent, and reliable transit.
   iii. Reduce personal auto use, encourage active transportation and transit.
   iv. Introduce new technologies & approaches to make a green transportation system.

d. **Carbon sequestration**
   i. Integrate nature-based solutions.
   ii. Support and implement policies and strategies for land conservation.
   iii. Retain increase and restore terrestrial ecosystems.

e. **Climate Adaptation**
   i. Prioritize people and communities that are most vulnerable and sensitive to impacts of climate change.
   ii. Reduce risks from extreme climate hazards by providing a robust infrastructure.
   iii. Protect public health from climate driven impacts.

10.2 Linking Innovative Site Strategies to the County's Climate Action Plan Goals

Climate Action Plan Category	Site Development Strategies that support the Climate Action Plan Goal
Clean Energy	Solar Energy Harvesting. Wind Energy Harvesting. Reduction of demand for traditional energy sources.
Buildings	Optimized building orientation. Façade and roof construction techniques that reduce reliance on traditional HVAC systems. Glazing to maximize light and heat gain. Vegetative screening of buildings to reduce cooling costs.
Transportation	Permeable paving for parking cars. Charging facilities for electric vehicles.
Carbon Sequestration	Green roof (also cools building and slows storm water flow). Rain gardens (nature-based stormwater solution). Improve soil texture and organic matter. Provide adequate soil volume for trees. Vertical Green Infrastructure.
Climate Adaptation	Green roofs, tree plantings, rain gardens, rain barrels, cisterns, and soil improvements slow storm water. Solar & wind energy harvesting and geothermal systems at point of use reduce reliance on power grid that is susceptible to disruption during hazard events.