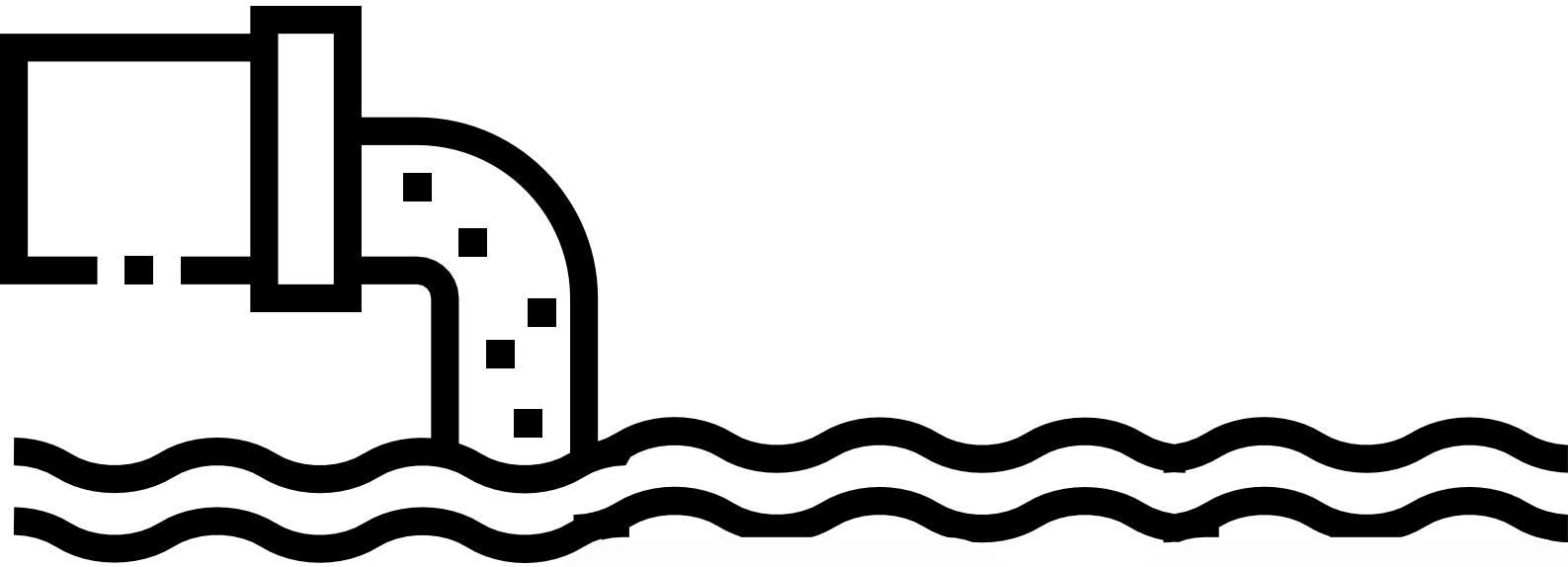
Stormwater: Green Infrastructure and Low Impact Development



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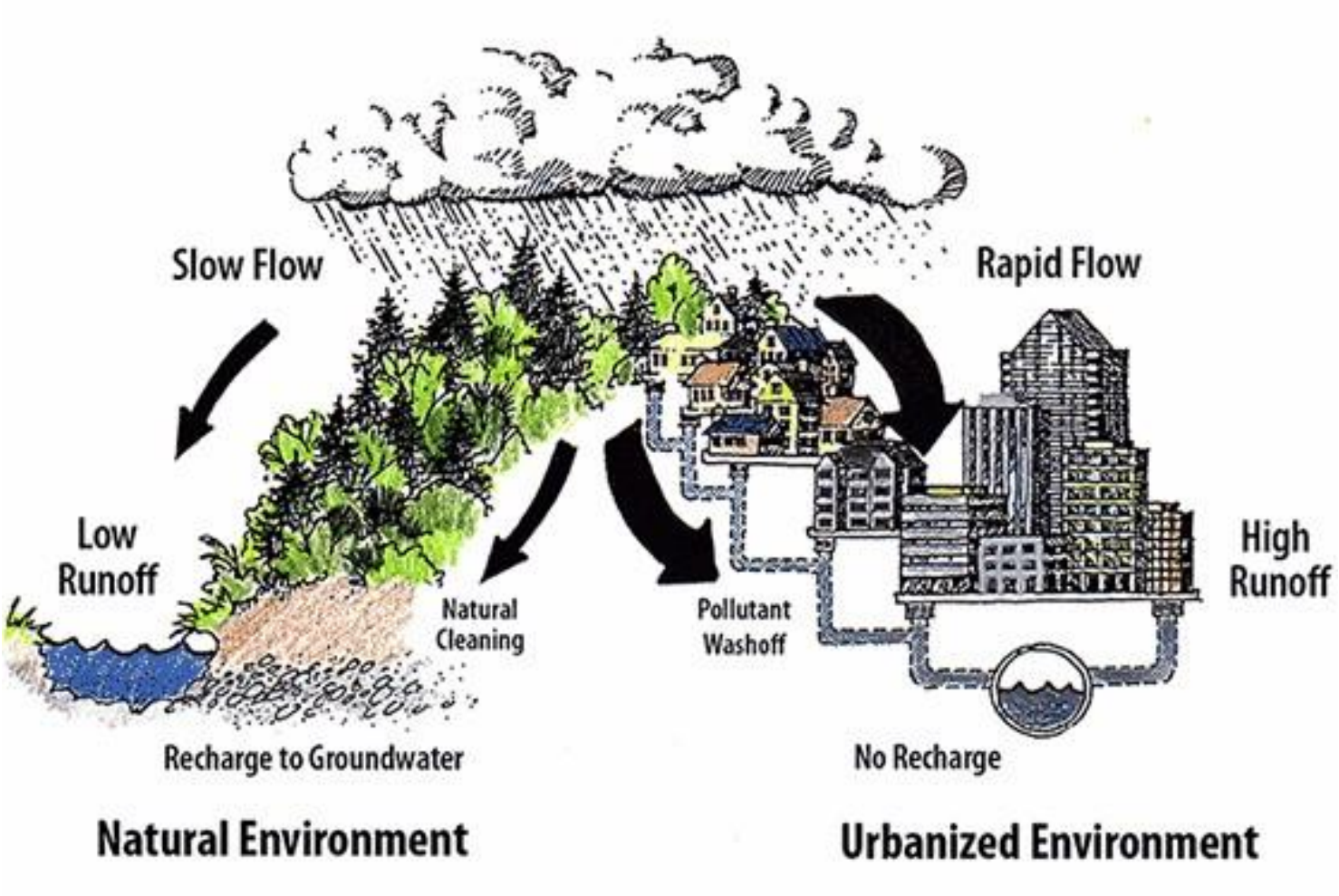
Water Cycle: Natural Vs Urbanized



The natural water cycle is free of human-made objects and infrastructure and is mostly composed of pervious surfaces. These pervious surfaces promote infiltration, resulting in high levels of groundwater recharge (absorption or replenishment) and groundwater flow when compared to stormwater runoff.

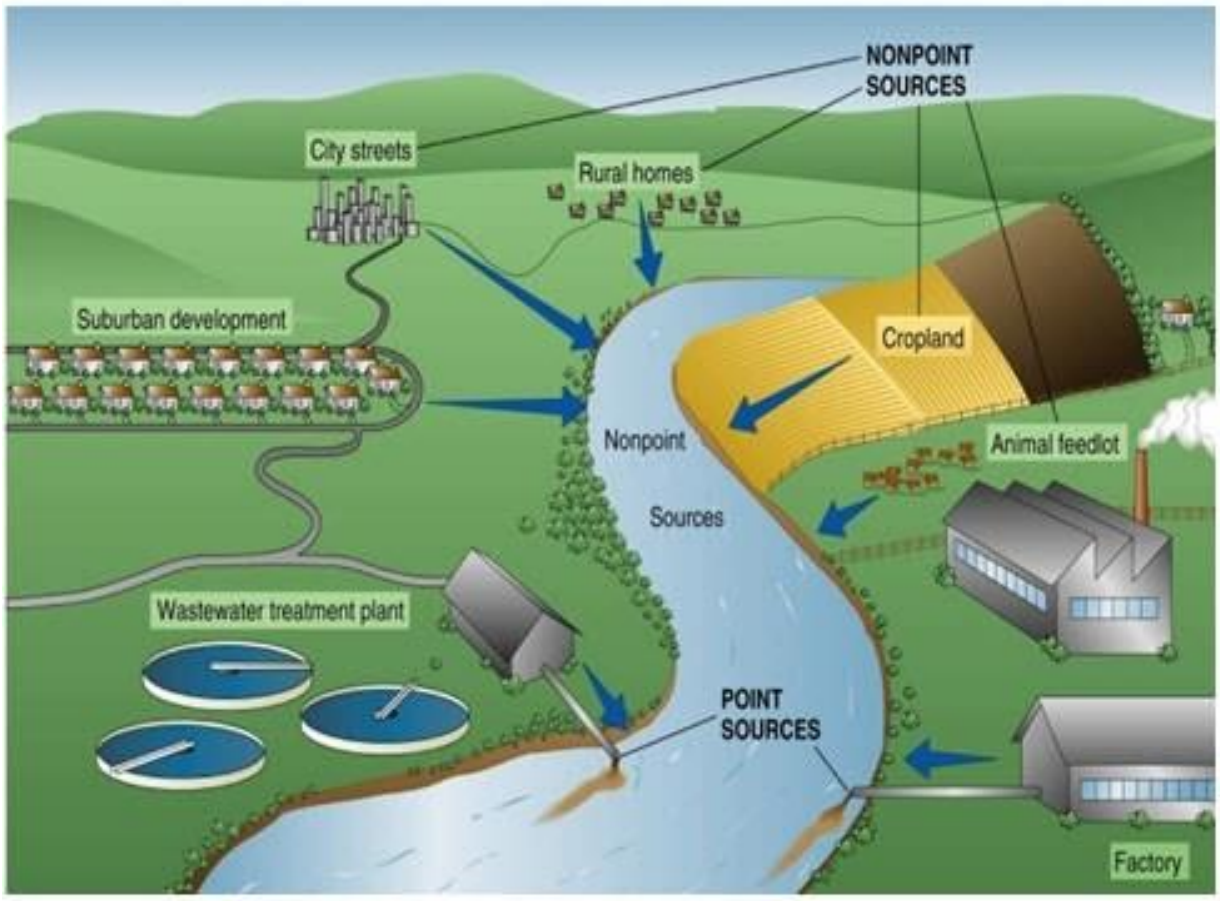
The natural water cycle has been modified by people to create the Urban Water Cycle. The urban water cycle ensures a constant water supply and the safe disposal of wastewater. The Urban Water Cycle incorporates the Water Supply System, Wastewater system and the Stormwater system.

What Does Stormwater Got To Do With It?

Stormwater is water that originates from precipitation (storm), including heavy rain and meltwater from hail and snow. This water is called stormwater runoff. The problem is that as runoff flows through our community, it picks up pollutants like bacteria from pet waste that wasn't picked up, chemicals on the roads and parking lots left behind by our cars, and even trash that didn't quite make it into the trash can. All these pollutants and more flow with our stormwater runoff into the stormwater system and out into our local waterways, **UNTREATED**.

Environmental Impacts: Pollution

Pollution is considered any substances, natural or man-made, that contaminate water, air, or physical place with. Stormwater Runoff Pollutants include trash, bacteria from pet waste, over-used chemicals used on our lawns and gardens, dirt, oils, and greases from our cars.



Point vs Non-Point Source:

Non-point source pollution- comes from many different sources such as runoff from land, precipitation, deposits from the atmosphere, drainage, or any other water seepage

Point-source pollution- discharge from a single discernible source such as a pipe from a textile mill, wastewater plant, or an oil refinery.

Physical Pollution

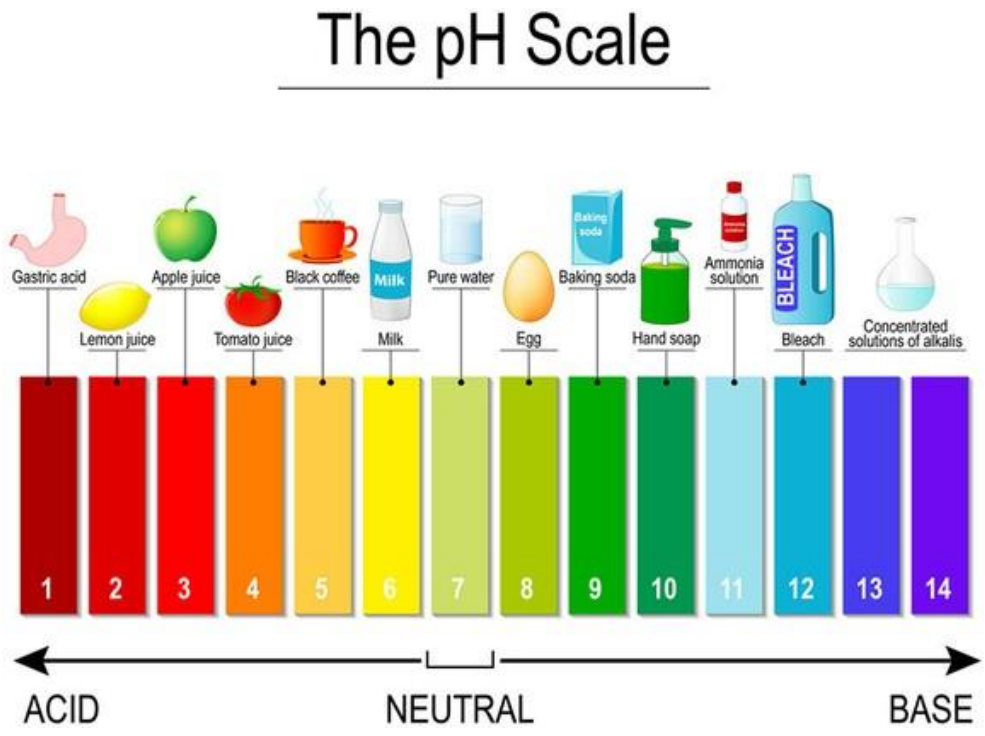
- Trash is considered anything deemed worthless, useless, or discarded. This type of pollution is the easiest for people to see and relate to because it's everywhere!

- Sediment is different sizes of rock, minerals, and decaying matter. Sediment is considered a serious pollutant in the CSRA because it can have major environmental impacts such as:
  - Burying streams and wipe out entire populations of organisms.
  - Carrying spilled or historical chemicals into a stream.
  - Creating discoloration in the water that is enough to block sunlight and stop natural processes which can kill plants and animals over time.

Construction sites can disturb tons of sediment at one time. That is the most likely place to find sediment entering storm drains or being dumped into creeks during heavy rains. For that reason, construction sites must be permitted for stormwater runoff discharge. Techniques to prevent offsite impacts of soil are silt fences, vegetated swales, sediment traps, grassing bare areas, working on small parts of the site at a time, and installing filters at all drains.

Chemical Pollution

- pH- Nature depends on balance, and although some rain is naturally acidic, with a pH level of around 5.0, human activities have made it worse. Normal precipitation—such as rain, sleet, or snow—reacts with alkaline chemicals, or non-acidic materials, that can be found in air, soils, bedrock, lakes, and streams. These reactions usually neutralize natural acids. However, if precipitation becomes too acidic, these materials may not be able to neutralize all of the acids. Over time, these neutralizing materials can be washed away by acid rain. Damage to crops, trees, lakes, rivers, and animals can result.



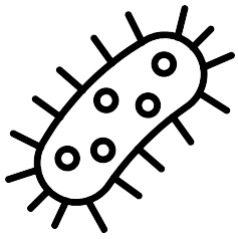
- nitrogen and phosphorus- Too much nitrogen and phosphorus in the water causes algae to grow faster than ecosystems can handle. Significant increases in algae harm water quality, food resources and habitats, and decrease the oxygen that fish and other aquatic life need to survive.

Bacterial Pollution

Bacteria is everywhere but too much can cause public safety, as well as environmental, issues. Bacteria can find its way into our waterways by not picking up after your pet, livestock farms, or even large populations in nature such as deer, canadian geese, or wild hogs.

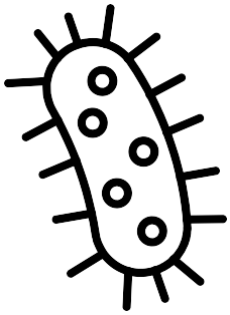
Total Coliform

A group of bacteria that can be found in plant material, water, soil, and animals. EPA considers total coliforms a useful indicator of other pathogens for drinking water.



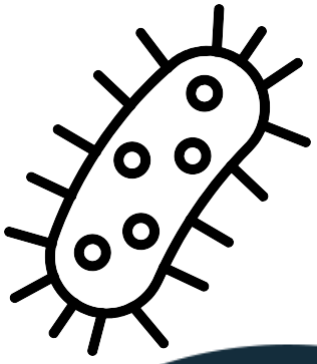
Fecal Coliform

A group of coliform type bacteria that reside in the intestines and also feces of exothermic animals including humans.



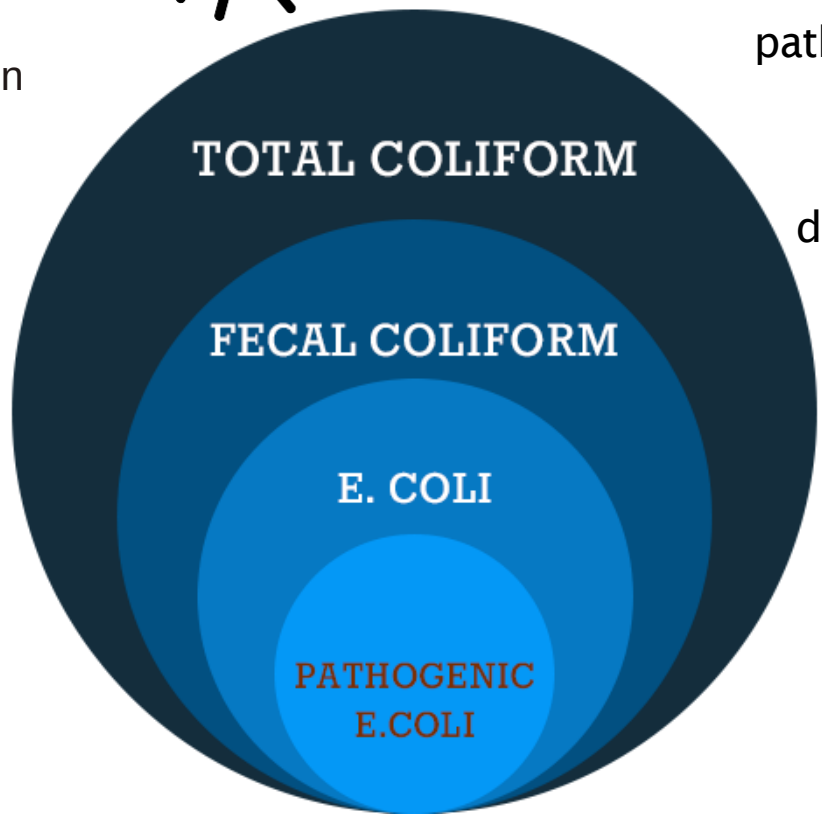
E.Coli

Escherichia coli (E. coli) bacteria, a specific type of fecal coliform bacteria that is considered in most cases harmless and actually an important part of a healthy human intestinal tract.



Pathogens

Some types E.coli are pathogenic, meaning they can cause illness, either diarrhea or illness outside of th intestinal tract.

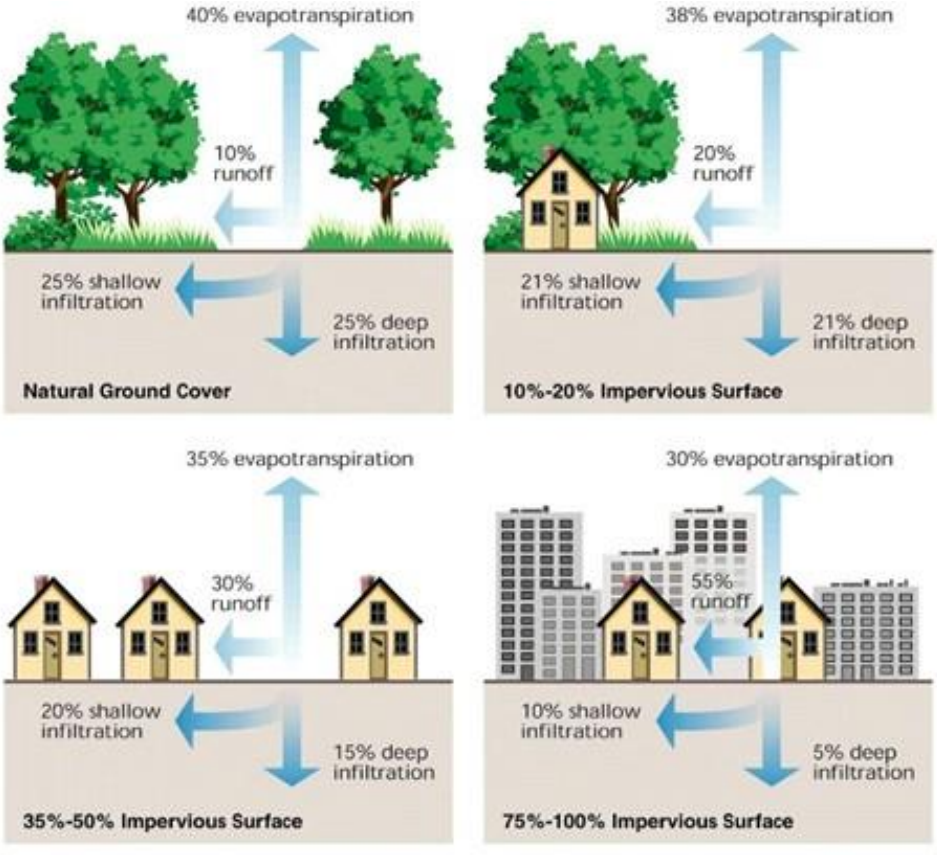


Hydrology

Hydrology is the study of movement, distribution, and quality of water throughout the Earth. In a natural environment, such as a forest, the stormwater runoff is minimal. The infiltration (both shallow and deep) rate is 50% and the runoff rate is only 10%. In an urban environment, such as a city, this runoff will not be able to soak into the ground as effectively as in a natural environment due to impervious surfaces like streets, sidewalks, and buildings. The infiltration rate decreases to 15% and the runoff rate increases to 55%.

Impervious surfaces- any surface that is hard and water cannot drain through it (Latin: 'im' meaning not / 'pervious' meaning 'that may be passed through')

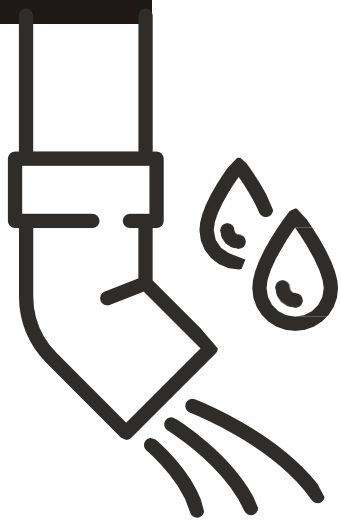
Velocity -refers to how fast an object is moving 'in a particular direction'. Infiltration is a part of the water cycle and occurs when water moves into the ground from the surface and begins to soak into the soil and rock layers underneath. The water can make its way to the surface from the earth by rain, snow melting or in human activity such as watering.



Stormwater Management

The Central Savannah River Area (CSRA) that we all live in is a growing area with a lot of land disturbance activities. In order to develop land, you will need an engineered site plan from a civil engineer to help collect, direct, and manage stormwater runoff both during and after construction. Stormwater Management is the designed effort to reduce runoff caused by rainwater or melted snow into streets, lawns, and other areas of our communities. Stormwater can be managed by using different types of infrastructure such as gray infrastructure, green infrastructure or a combination of the two together.

Gray Infrastructure



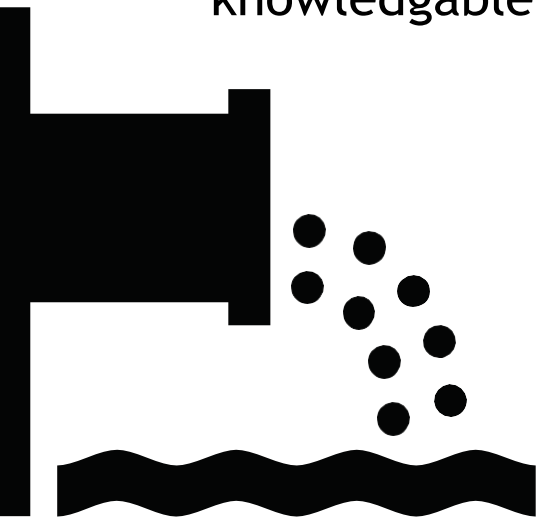
Gray Infrastructure is considered the traditional form of stormwater management. It is generally a network of drains, pipes, ponds, and outlet structures that take stormwater runoff away from our roads, homes, and schools and directs it into a local tributary.

Pros:

- Protects property by directing water away from properties
- Keeps water off road ways
- Cheaper cost to install and maintenance
- Development community knowledgable

Cons:

- Can cause downstream flooding
- Stream bank erosion
- Increased turbidity (muddiness created by stirred up sediment) from erosion
- Habitat destruction
- Contaminated streams, rivers and coastal water with pollution



Swale

An earthen or concrete depression in the ground that carries stormwater runoff by gravity away from structures to prevent damage. Swales can lead to a catch basin, storm drain, pond or even directly into a nearby stream.

Storm Drain

An inlet into the stormwater pipe network that is designed to carry rainfall runoff without any kind of treatment to a stormwater pond or directly into a nearby stream.

Storm drains can be found throughout your community, especially in low-lying areas. They also come in different sizes and shapes.

Pipes

Stormwater pipes are used to connect underground infrastructure within the storm network. Pipes are also used to connect drainage areas. Stormwater pipes are generally made from concrete.

Ponds

A pond is a type of stormwater management facility designed to collect rainwater and pollutants and prevent downstream flooding. There are two kinds of stormwater ponds. Wet ponds (retention ponds) always have a pool of water and dry ponds (detention ponds) only have water after rain.

Ponds have an embankment (called a dam) to hold back water that is entering the pond. All stormwater ponds also have a control structure that releases water at a much slower rate than the stormwater entering the pond. While water remains in the pond, pollutants have time to settle at the bottom.

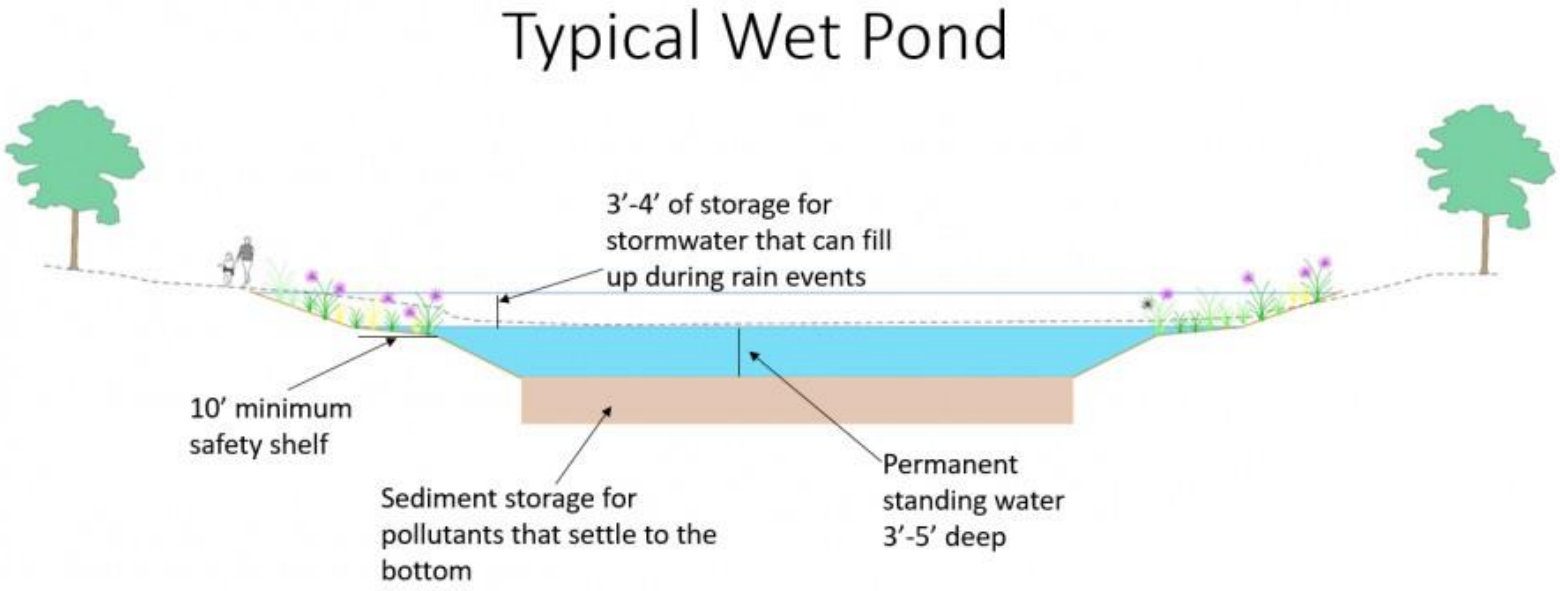
Calculating Detention

A one inch of rainfall on an acre of land is approximately 27,000 gallons of water, or approximately 3600 cubic feet. When new construction is finished, there are a lot of impervious surfaces such as concrete, roofs, and parking lots that prevent water from being absorbed into the ground. The result of all these impervious surfaces is runoff. To prevent flooding from runoff, engineers design structures called detention ponds to “detain” water and release it slowly over time.

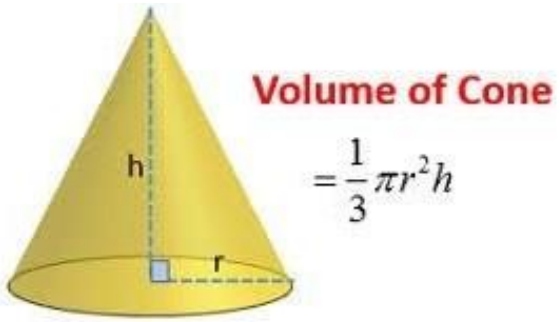
An example for you to consider: A new grocery store was constructed on a 3-acre lot. They check their rain gauge after a heavy downpour and see that they received an inch of rain. How much water did their detention pond have to retain?

27,000 gallons x 3 acres = 81,000 gallons or 10800 cubic feet of water needs to be retained

Calculating Detention Cont.



Engineers design these detention ponds using a formula for finding the volume of a cone. Ponds are not perfect spheres or rectangles, they start out wide at the top and get narrower the deeper you go. The formula for the volume of a cone is:



V=1/3 πr^2 h

In this case V is the volume of the detention pond, pi (π) is a constant that equals 3.14, r is the radius of the pond, and h is the depth of the pond.

To take the previous problem a bit further. The engineer only has enough space to put in a detention pond with a radius of 25 feet. How deep does the pond have to be? To solve this we can rearrange the volume of a cone formula to solve for h.

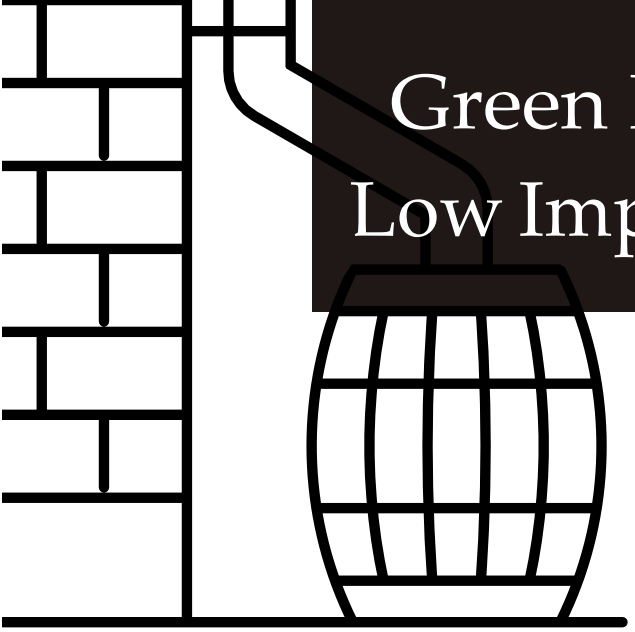
h=3V/(πr^2)

When you fill in the variables with the numbers we know you get:

h=(3(10800 sq.ft.of water))/((3.14) 〖(25 ft.radius)〗 ^2)

Once you do the math h = 16.5 feet. This example shows just how much space is needed to detain just 1 inch of rain over a small 3 acre area. Just think about how much space and the amount of ponds a development of over 25 acres would take.

Green Infrastructure & Low Impact Development



The term low impact development (LID) refers to systems and practices that use or mimic natural processes in order to protect water quality and associated aquatic habitat. EPA currently uses the term green infrastructure to refer to the management of wet weather flows that use these processes, and to refer to the patchwork of natural areas that provide habitat, flood protection, cleaner air and cleaner water. At both the site and regional scale, LID/GI practices aim to preserve, restore and create green space using soils, vegetation, and rainwater harvest techniques. LID is an approach to land development (or re-development) that works with nature to manage stormwater as close to its source as possible.

Water Infrastructure Improvement Act defines green infrastructure (GI) as "the range of measures that use plant or soil systems, permeable pavement or other permeable surfaces or substrates, stormwater harvest and reuse, or landscaping to store, infiltrate, or evapotranspirate stormwater and reduce flows to sewer systems or to surface waters."

Gray To Green Infrastructure

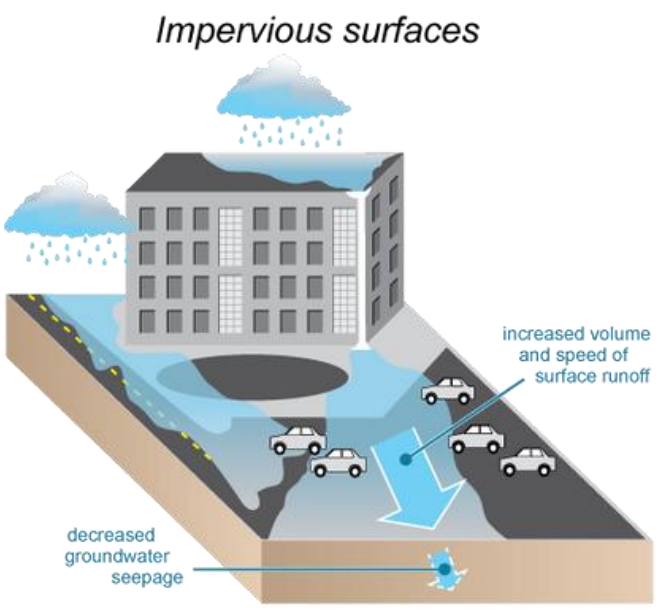


Image of Impervious Surfaces -- "hard" surfaces like roofs, roads, and parking lots that increase the volume of stormwater runoff.
Impervious 'hard' surfaces (such as roofs, roads, large areas of pavement, and asphalt parking lots) increase the volume and speed of stormwater runoff. Swift surges of water damage the natural landscape and deliver pollutants into canals and bodies of water.

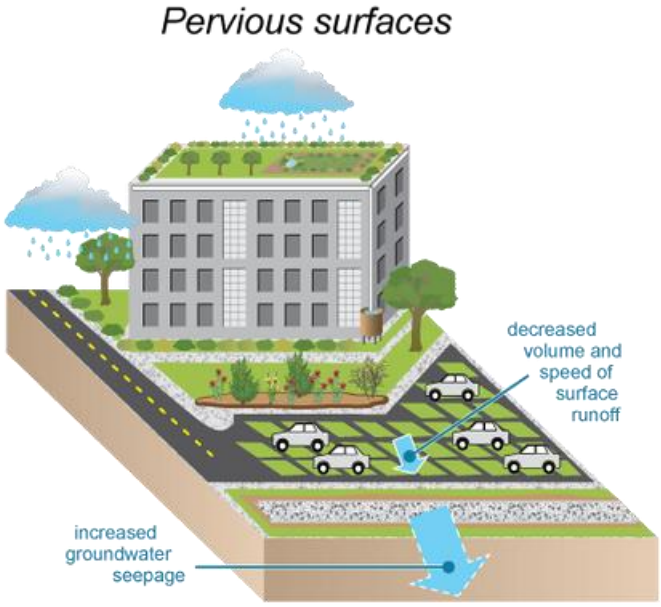


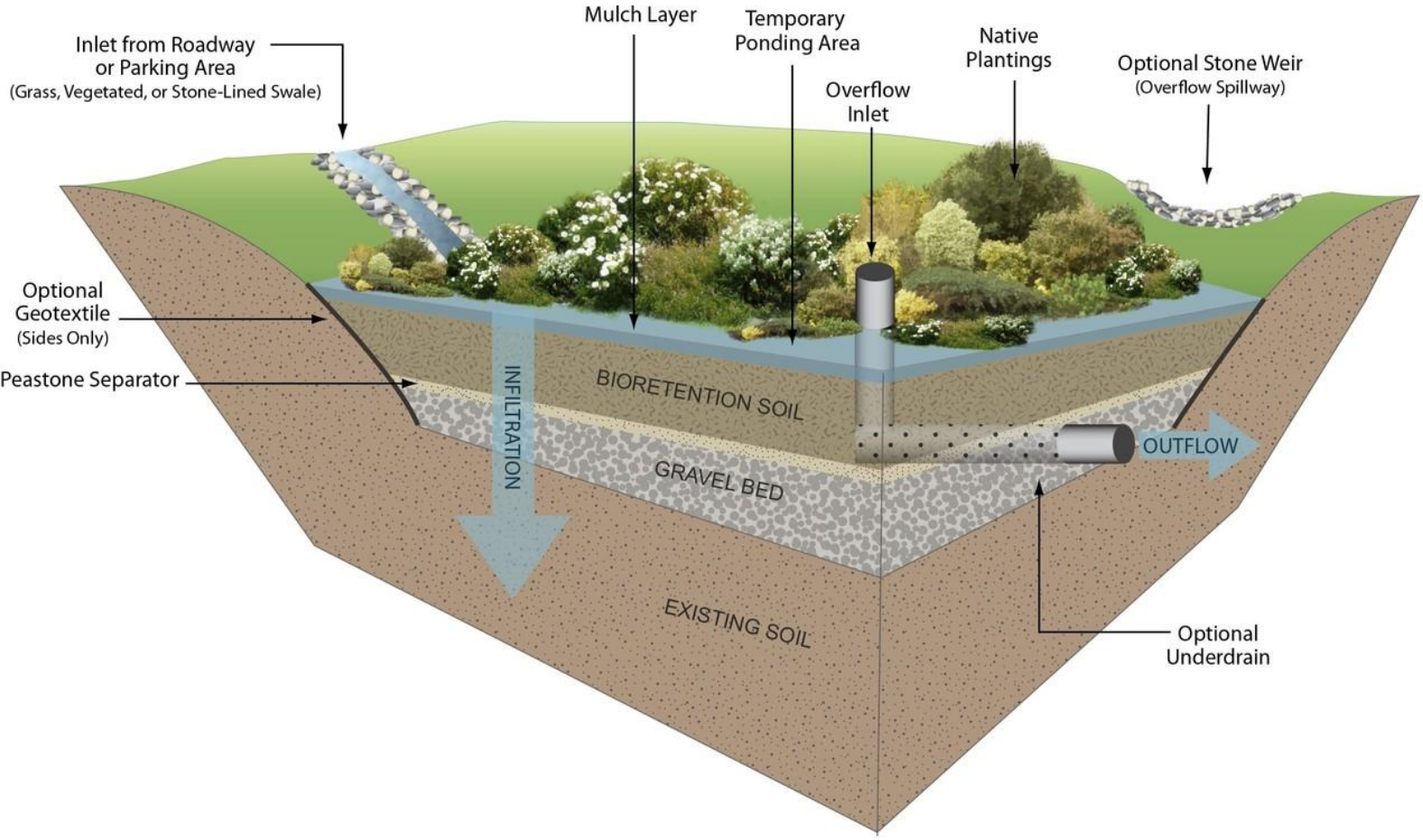
Image of a pervious surface -- "soft" surfaces like green roofs or rain gardens that decrease the volume of stormwater by soaking it into the surface medium.
Pervious 'soft' surfaces (such as green roofs, rain gardens, permeable pavement, and retention basins) decrease the volume and speed of stormwater runoff. The slowed water seeps into the ground, which recharges the water table and filters out pollutants; native vegetation is also nurtured by the water.

Pros:

- Decreases runoff
- Promote infilitration charging groundwater
- Provide cleaner air and water
- Flood protection
- Diverse habitat
- Beautiful green spaces.

Cons:

- Can be expensive
- Function can be compromised without maintenance.
- Must develop community knowledge



Bioretention

Bioretention areas (also referred to as bioretention cells or rain gardens) use soil, plants and microbes to treat stormwater before it is infiltrated or discharged. Bioretention areas are shallow depressions filled with sandy soil, topped with a thick layer of mulch, and planted with dense vegetation.

Stormwater runoff flows into the bioretention area, percolates through the soil (which acts as a filter) and eventually drains into the groundwater; some of the water is also absorbed by the plants. Bioretention areas are usually designed to allow ponded water and with an overflow outlet to prevent flooding during larger storm events. Where soils have low permeability or where faster drainage is desired, designers may incorporate a perforated underdrain that routes to a storm drain system.

BioSwale at work in Cream city Farm

BioSwales

Bioswales are landscape features that collect polluted stormwater runoff, soak it into the ground, and filter out pollution. Bioswales are similar to rain gardens but are designed to capture much more runoff coming from larger areas of impervious surfaces like streets and parking lots. They also have more complicated design features such as layers of engineered soil and gravel, perforated pipe underdrains, and overflow structures to help handle runoff from bigger storms. Similar to rain gardens, bioswales use native plants to help absorb more water and prevent erosion. Typically, an engineer and a landscape architect are needed to ensure the bioswale is designed and built correctly.

What are the Benefits of Bioswales?

- Beautify your neighborhood
- Help protect our streams and Lake Michigan from pollution by reducing stormwater runoff
- Reduce the risk of flooding and drainage problems
- Provide habitat for pollinators and birds
- Improve air quality

Rain Barrel (Photo Credit - CT DEEP)

Rain Barrel

Rain barrels capture water from a roof and hold it for later use such as on lawns, gardens or indoor plants. Collecting roof runoff in rain barrels reduces the amount of water that flows from your property. It's a great way to conserve water and it's free water for use in your landscape.

Remember that as rain water flows over a roof surface it can pick up pollutants such as bacteria from birds and other animals, and chemicals from roof materials - factors to consider when thinking about using rain barrel water on edible plantings.

U.S. Department of Transportation Headquarters extensive green roof

Green Roof

A green roof, or rooftop garden, is a vegetative layer grown on a rooftop. Green roofs provide shade, remove heat from the air, and reduce temperatures of the roof surface and surrounding air. Using green roofs in cities or other built environments with limited vegetation can moderate the heat island effect, particularly during the day. Green roof temperatures can be 30–40˚F lower than those of conventional roofs and can reduce city-wide ambient temperatures by up to 5˚F

Benefits

- Reduced air pollution and greenhouse gas emissions
- Reduced energy use
- Improved human health and comfort
- Improved quality of life
- Enhanced stormwater management and water quality

Permeable pavers UConn Spring 2016

Permeable Pavement

Alternatives to traditional pavement on our paved surfaces can help reduce runoff by infiltrating rain water and melting snow. These alternative materials which include pervious asphalt, pervious concrete, interlocking pavers, and plastic grid pavers, allow rain and snowmelt to seep through the surface down to underlying layers of soil and gravel. In addition to reducing the runoff from the rain that falls on them, permeable pavements can help filter out pollutants that contribute to water pollution. Permeable pavements can also reduce the need for road salt and reduce construction costs for residential and commercial development by reducing the need for some conventional drainage features.

Green Street

Green Streets

A green street is a stormwater management approach that incorporates vegetation (perennials, shrubs, trees), soil, and engineered systems (e.g., permeable pavements) to slow, filter, and cleanse stormwater runoff from impervious surfaces (e.g., streets, sidewalks). Green streets are designed to capture rainwater at its source, where rain falls. Whereas, a traditional street is designed to direct stormwater runoff from impervious surfaces into storm sewer systems (gutters, drains, pipes) that discharge directly into surface waters, rivers, and streams.

EPA's Green Streets: The Road to Clean Water video highlights green streets as a technique for managing stormwater and providing other economic and community benefits
https://www.youtube.com/watch?v=TxqxEqnHIKw

Urban Tree Canopy

Urban Tree Canopy

Urban tree canopy (UTC) is the layer of leaves, branches, and stems of trees that cover the ground when viewed from above. In urban areas, the UTC provides an important stormwater management function by intercepting rainfall that would otherwise run off of paved surfaces and be transported into local waters though the storm drainage system, picking up various pollutants along the way. UTC also reduces the urban heat island effect, reduces heating/cooling costs, lowers air temperatures, reduces air pollution, increases property values, provides wildlife habitat, and provides aesthetic and community benefits such as improved quality of life.

Glossary

1. Bioretention-use soil, plants and microbes to treat stormwater before it is infiltrated or discharged. Bioretention areas are shallow depressions filled with sandy soil, topped with a thick layer of mulch, and planted with dense vegetation.
2. Bio-Swale-landscape features that collect polluted stormwater runoff, soak it into the ground, and filter out pollution.
3. E.Coli-Escherichia coli (abbreviated as E. coli) are bacteria found in the environment, foods, and intestines of people and animals.-
4. Fecal Coliform-microscopic organisms that live in the intestines of warm-blooded animals. Hydrology-the study of movement, distribution, and quality of water throughout the Earth
5. Green Infrastructure-the range of measures that use plant or soil systems, permeable pavement or other permeable surfaces or substrates, stormwater harvest and reuse, or landscaping to store, infiltrate, or evapotranspirate stormwater and reduce flows to sewer systems or to surface waters.
6. Green Roof- a vegetative layer grown on a rooftop
7. Grey Infrastructure-is considered the traditional form of stormwater management. It is generally a network of drains, pipes, ponds, and outlet structures that take stormwater runoff away from our roads, homes, and schools and directs it into a local tributary.
8. Impervious-not able to be passed through
9. Infiltration-the flow of water from aboveground into the subsurface
10. low impact development (LID) - systems and practices that use or mimic natural processes in order to protect water quality and associated aquatic habitat.
11. Non-point source pollution-comes from many different sources such as runoff from land, precipitation, deposits from the atmosphere, drainage, or any other water seepage
12. Pathogen-a bacterium, virus, or other microorganism that can cause disease
13. Pervious-can be passed through
14. PH-How acidic or basic a liquid is.
15. Pollution-any item that contaminates the water, air, or place with harmful or poisonous substances

Glossary

16. Point- Source Pollution-discharge from a single discernible source such as a pipe from a textile mill, wastewater plant, or an oil refinery
17. Pond-a type of stormwater management facility designed to collect rainwater and pollutants and prevent downstream flooding.
18. Rain Barrell- capture water from a roof and hold it for later use such as on lawns.
19. Rain Garden-a depressed area in the landscape that collects rain water from a roof, driveway or street and allows it to soak into the ground.
20. Runoff- the draining away of water (or substances carried in it) from the surface of an area of land, a building or structure.
21. Sediment-dirt and debris; can be a serious pollutant by burying a stream and wiping out entire populations of organisms
22. Stormwater-water from rain, snow of other forms of precipitation that runs off of roads, roofs, sidewalks, parking lots etc.
23. Swale-An earthen or concrete depression in the ground that carries stormwater runoff by gravity away from structures to prevent damage
24. Total Coliform-include bacteria that are found in the soil, in water that has been influenced by surface water, and in human or animal waste
25. Velocity-refers to how fast an object is moving ‘in a particular direction.
26. Water Cycle-the continuous movement of water within the Earth and atmosphere.

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