Soil Health Fact Sheets – Ocean County

Stormwater Basins

USDA, Natural Resources Conservation Service - New Jersey January 2011

What are Stormwater Basins?

Stormwater basins are impoundments or excavated basins for the short term detention of stormwater runoff from a completed development area followed by controlled release from the structure at downstream, pre-development flow rates. There are several types of detention devices, the most common being the dry detention basin and the extended dry detention basin. These structures hold and release the water through a controlled outlet over specified time period based on the design criteria. The extended detention basin drains more slowly or may retain a permanent pool of water. Stormwater *infiltration basins* are facilities constructed within highly permeable soils that provide temporary storage of stormwater runoff. An infiltration basin does not normally have a structural outlet to discharge runoff from a specific design storm. Instead, outflow from an infiltration basin is through the surrounding soil. An infiltration basin may also be combined with an extended detention basin to provide additional runoff storage from both stormwater quality and quantity management.

Bay Avenue Basin held water for 35 years prior to soil restoration. Soil was unable to function with standing water 365 days a year.

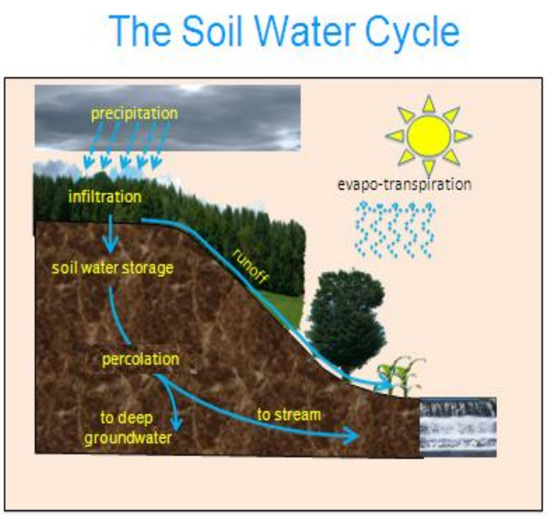
Bay Avenue Basin now drains within 48 hours of a rain event due to the benefits of Soil Health restoration. Water is able to infiltrate through the soil because soil is no longer compacted and vegetation has become established. Ocean County Soil Conservation District has identified 3500 basins within the county.

What is Soil?

Soil is a natural body comprised of solids (minerals and organic matter), liquid, and gases that occurs on the land surface. It consists of mineral particles of different sizes (sand, silt, and clay), organic matter, water, air, and numerous living organisms. Soil has biological, chemical, and physical properties. It is not an inert, lifeless medium but rather a living matrix of solid, liquid, and gas, with microorganisms, earthworms, fungi, bacteria, insects, living and decayed organic matter, water, air, and nutrients, all engaged in a biological and chemical give-and-take of energy and elements.

What is Soil Quality?

Soil Quality is simply how well soil does what we want it to do. More specifically, soil quality is the capacity of a specific kind of soil to function, within natural or managed ecosystems, to sustain plant and animal productivity, maintain or enhance water and air quality, and support human health and habitation. In stormwater detention basins soil quality may mean a fully functioning basin, providing the results it was designed for. Soil Quality is the integration of the physical, chemical and biological properties of the soil.



Soil regulates and partitions rainfall. Soil also regulates flow and storage of water and solutes, including nitrogen, phosphorus, pesticides and other nutrients and compounds that are in dissolved water. Soil stores, moderates the release of, and cycles plant nutrients and other elements. Soil acts as a living filter that serves to protect and enhance our entire ecosystem. Soil also supports structures and preserves and protects archaeological treasures. Changes in the capacity of a soil to function are reflected in soil properties that change in response to management or climate.

How does Soil Health in Stormwater Basins affect Groundwater Quantity and Quality?

Infiltrated water is critical in that it recharges groundwater supplies and provides base flow to streams, while maintaining water quality and habitat needed for aquatic organisms. Stormwater runoff is associated with flooding, delivery of pollutants, stream channel erosion, decreased base flow, poor water quality, and reduced richness and abundance of fish species. Infiltration basins are used to remove pollutants and to infiltrate stormwater back into the ground rather than have them leave the site in the form of erosion. Under natural conditions, approximately 10% of precipitation runs over the surface of the land and about 50% infiltrates back into the soil. This 50% is vital to environmental health as it is the water that replenishes groundwater supplies and provides base flow to streams. The remaining 40% of stormwater is used in plant uptake and evapo-transpiration.

What are Inherent and Dynamic soil properties?

Soil has both inherent and dynamic qualities. *Inherent* soil quality is a soil's natural ability to function. For example, sandy soil drains faster than clayey soil. Deep soil has more room for roots than soils with bedrock near the surface. These characteristics do not change easily. *Dynamic* soil quality describes the changes that result from management decisions. For example, soil compaction occurs from the use of heavy equipment under the wrong moisture conditions.

Note the compacted zone below the roots at the bottom of the photo. This compacted soil prevents roots from growing and can prevent water from infiltrating through the soil profile.

Soil in this basin has been compacted due to improper construction methods that led to this basin retaining water and causing subsequent compaction from the sheer weight of the water column.

Compaction

Soil Compaction is a common reason for basins to not function properly. Low organic matter levels in the soils of basins can be a potential reason for basin failure. Organic residues on the soil surface and within the soil profile have been shown to cushion the effects of compaction. Organic matter acts like a sponge in that the organic matter is compressed and then springs back to its normal shape. Plant debris and residues attach to soil particles and keeps them from compacting. Organic matter binds micro-aggregates into macro-aggregates in the soil. Soil compaction has a biological component and the *root* cause of soil compaction is a lack of actively growing plants and active roots in the soil. Plant roots create voids and macro-pores in the soil for air and water movement.

Plant roots act like a biological valve to control the amount of oxygen in the soil to preserve soil organic matter. Plant roots supply food for soil microbes and soil fauna. Residual organic residues (plants, roots, microbes) are lighter and less dense than soil particles. Polysaccharides from plants and glomalin (soil glue) from fungus weakly hold the micro-aggregates together but are consumed by bacteria so they need to be continually reproduced in the soil to improve soil structure.

Organic Matter is the Key!

Many soil properties impact soil health but organic matter is the most limiting factor. It affects several critical soil functions and can be manipulated by management practices. Organic matter enhances water and nutrient holding capacity and improves overall soil structure. Managing for soil carbon or organic matter enhances the productivity and environmental quality of our ecosystems. Soils high in organic matter content can typically reduce the severity and costs of natural disasters such as drought, flood and diseases. Moreover, increasing soil organic matter levels can reduce atmospheric CO_2 levels that contribute to climate change.

What are Soil Health Indicators that can help determine overall Soil Function?

Indicators of soil quality can be categorized into four general groups: visual, physical, chemical and biological. ***Visual indicators*** may be obtained from observation or photographic interpretation. Exposure of subsoil, change in soil color, ephemeral gullies, ponding, runoff, plant response, weed species, blowing soil and deposition are only a few examples of potential indicators. ***Physical indicators*** are related to the arrangement of solid particles and pores. Examples include topsoil depth, bulk density, porosity, aggregate stability, texture, crusting, and compaction. Physical indicators primarily reflect limitations to root growth, seedling emergence, infiltration, or movement of water within the soil profile. ***Chemical indicators*** include measurements of pH, salinity, organic matter, phosphorus concentrations, cation-exchange capacity, nutrient cycling, and concentrations of elements that may be potential contaminants or those that are needed for plant growth and development. The soil's chemical condition affects soil-plant relations, water quality, buffering capacities, availability of nutrients and waters to plants other soil organisms, mobility of contaminants, and some physical conditions such as the tendency for a surface soil crust to form. ***Biological indicators*** include measurements of micro- and macro-organisms, their activity, or byproducts. Respiration rates can be used to detect soil microbial activity, specifically soil microbial decomposition of organic matter, which is the key to the formation and stability of soil aggregates.

When the soil is disturbed it loses its' natural ability to absorb and infiltrate rainfall making it necessary to collect, channel, store and filter stormwater. Management choices affect the amount of soil organic matter, soil structure, soil depth, water and nutrient holding capacity. Soils respond differently to management depending on the inherent properties of the soil and the surrounding landscape.

Notice the good root development and abundant pore space. This pore space allows for nutrients and water to flow and be utilized by the plants above ground.

How does Soil Structure and Bulk Density help determine Soil Health?

Soil structure is of particular importance in the absorption of water and the circulation of air. A desirable structure should have a high proportion of medium-sized aggregates and an appreciable number of large pores through which water and air can move. Good soil structure is crucial to proper drainage, infiltration, and productivity. In soils with poor structure, root penetration is limited thus reducing the plants access to water and nutrients. There are three very important aspects of soil structure. They are (a) the arrangement into aggregates of a desirable shape and size, (b) the stability of the aggregate, and (c) the configuration of the pores, that is, whether or not they are connected to the surface by channels or isolated. Pores that are not connected to the surface do not improve infiltration. Aggregates that are stable in water permit a greater rate of absorption of water and greater resistance to erosion. Aggregates that are unstable in water tend to slake and disperse. These aggregates, when exposed to raindrops, are particularly subject to dispersion and the resultant crusting of soils. The stability of aggregates is due to the kind of clay, the chemical elements associated with the clay, the nature of the products of decomposition or organic matter, and the nature of the microbial population.

Bulk density Bulk density refers to the weight of the oven-dry soil with its natural structural arrangement. The pore space between the soil particles is a part of the volume of soil measured for bulk density. Bulk density is expressed as grams per cubic centimeter. The variation in bulk density is due largely to the difference in total pore space. Because finer textured soils have higher percentages of total pore space, it follows that finer textured soils have smaller bulk density values. Compacted soils have lower percentages of total pore space and therefore, higher bulk densities. High and low bulk densities have great influences on engineering properties, water movement, rooting depth of plants, and many other physical limitations for soil interpretations. Bulk density is a critical soil property in assessing proper soil function.

How can native vegetation restore soil function in stormwater basins?

Stormwater basins have become so common that they represent an integral part of our growing urban and suburban landscape. Landscaping these stormwater basins with native plants can increase their value and improve their water treatment functions. Native landscaping means using plants, trees, and shrubs known to exist in the project area during pre-settlement times. Native plants and their functions have a number of advantages over their non-native counterparts when used as landscaping for a stormwater basin. The goals of the landscaping plan range from an improvement in water quality to provision of wildlife food and habitat. If wisely chosen, native plants are also esthetically pleasing and blend well with most surrounding developments and landscapes.

Use of native plants in the several landscaping zones around a basin can provide a rich visual environment as well as wildlife habitat. The combination of wetland plants with flowering prairie plants and, in some cases, trees and shrubs in upland areas provides far more visual appeal throughout the year than large areas of mowed lawn. Once established, native vegetation may require far less maintenance. This benefit is particularly important as suburban growth replaces historic woodlots and fields. In the upland areas of a stormwater basin, for example, tall grasses, trees and shrubs provide habitat for a variety of song birds, amphibians and reptiles and can provide critical habitat for native pollinators.

What are the principles of stormwater basin success?

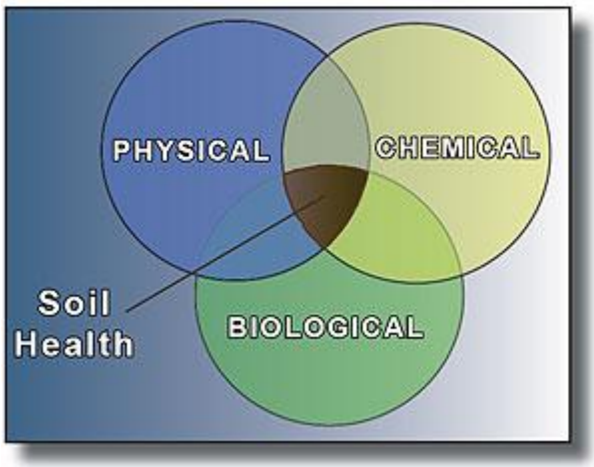
- Add organic matter in the form of vegetation or mulch.
- Keep ground covered with vegetation or mulch as soon as possible after disturbance.
- Prevent or remediate compaction.
- Schedule excavation during low rainfall periods, when possible.
- Fit development to the terrain.
- Keep soil covered with vegetation and don't allow it to be exposed for months or years.
- Divert water from disturbed areas until they are stabilized.
- Control concentrated flow and runoff to reduce the volume and velocity of water from work sites to prevent the formation of gullies.
- Minimize the length and steepness of slopes.
- Prevent sediment from leaving the site.
- Inspect and maintain structural control measures.
- Plan and install windbreaks if necessary.
- Avoid compaction by restricting the use of trucks and heavy equipment to limited areas.

Where can I get more information on Soil Health?

For additional information go to the following websites:

- www.nj.nrcs.usda.gov
- www.soils.usda.gov/sqi
- www.soilhealth.org

The full series of Soil Quality Information Sheets is available at http://soils.usda.gov/sqi



References

ANJEC. *Municipal Options for Stormwater Management.* ANJEC Resource Paper .

Hanks, D. and A. Lewandowski. *Protecting Urban Soil Quality: Examples for Landscape Codes and Specifications.* USDA NRCS.

DEQ NW Region Oregon. *Restoring Soil Health to Urbanized Lands.*

DeVries, A. *Health From the Soil.*

NJDEP. *NJ Stormwater Best Management Practices Manual.*

NRCS Soil Quality Institute. Soil Quality Tech Note No. 5 *Managing Soil Organic Matter The Key to Air & Water Quality.*

NRCS Soil Quality Institute. Soil Quality Urban Tech Note 1 *Erosion & Sedimentation on Construction Sites.*

NRCS Soil Quality Institute. Soil Quality Urban Tech Note No. 2 *Urban Soil Compaction.*

Pennsylvania Environmental Council. *Improving Stromwater Detention Basins for Better Stormwater Managment.*

Raabe, C. *Basin Basics Dig and Drop- Not Rock & Roll*

University of Wisconsin-Extension & Wisconsin Department of Natural Resources. *Storm Water Basins Using natural landscaping for water quality & esthetics.*

USGS Water Science for Schools. *The Water Cycle: Infiltration.*

William C. Lucas Integrated Land Mangement Inc. *Modeling Impervious Area Disconnection with SWMM.*

This publication has been a joint effort between the USDA Natural Resources Conservation Service NJ and the Ocean County Soil Conservation District.