Infiltration & Soil Compaction
Important Environmental Concerns

By Abigail Fair, ANJEC Water Resources Director

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Under natural conditions over 50 percent of the precipitation that falls to earth infiltrates and recharges groundwater. As development occurs, less and less precipitation infiltrates, more and more runs off. In fact, most stormwater management practices over the last decade have resulted in increased volumes of runoff and reduced infiltration. Wet weather produces more and more flash flooding. And even minor dry spells result in streams with little or no water in them. As more water runs off our land, less recharges the groundwater and aquifers that supply drinking water for about half NJ’s population.

NJDEP is currently amending state regulations to change stormwater management for new development projects. The regulations aim to mimic the natural water cycle instead of merely rushing the stormwater off site as efficiently as possible. The reason? Most current stormwater management regulations deal only with the rate of runoff. They require that the peak rate after development must be no greater than before construction. While this approach was a step in the right direction, it effectively ignores the substantial increase in amount of water that flows off land after development and prevents groundwater recharge. It also results in extended peak flows and increased flooding downstream.

Development and Water
Developing a tract of land dramatically alters the hydrologic cycle of the site and ultimately of the entire watershed. The initial clearing removes the trees, bushes and other vegetation that intercepted and absorbed rainfall. The grading takes away natural depressions that stored rainfall, and allowed the water to infiltrate into the ground or evaporate back into the atmosphere. And as construction vehicles move over the site they further reduce the land’s capacity to absorb rainfall as their weight compresses the soil. This results in a greater volume of runoff. In fact, according to one study, one-third of disturbed urban soils allow virtually no infiltration. All the rain that falls on them runs off. In terms of stormwater and runoff, these soils are just like concrete or asphalt.

To maintain the state’s groundwater and aquifers, the proposed stormwater regulations set specific criteria for groundwater recharge, requiring applicants to demonstrate they will meet one of the two following conditions.

● After development, the site will maintain 100 percent of the average annual pre-construction recharge volume; or,
● The increased stormwater runoff from pre-construction to post-construction for the two-year storm is infiltrated.

The proposal specifically exempts areas of high pollutant loading like industrial and commercial developments from stormwater infiltration.

Stormwater infiltration is key to recharging groundwater. Best Management Practices (BMPs) like dry wells, infiltration trenches, swales or basins have long been in use, but without any particular standards. NJDEP’s new regulations will include design and maintenance criteria for at least a dozen BMPs.

“If we can encourage a raindrop to soak into the ground instead of running off, it will moisten our soil without eroding it and help feed our groundwater supply.”
— David Friedman, Director
Ocean County Soil Conservation District

Water Cycle with 75-100% Impervious Surface

Water Cycle with Natural Groundcover
Good infiltration soils have a structure relative to each other - is important. Soil particles are arranged organic material. Soil structure - the contain minerals, water, air, and pollutant removal agents in properly use of soils as effective filter nonpoint pollutant sources.

In addition, OCSD noted that many lawn areas on sandy, porous soils remained saturated for extended periods of time, resulting in premature death of landscape plants, and runoff even from brief irrigation. Working with the US Department of Agriculture’s Natural Resources Conservation Service (NRCS) and consultant engineers, the OCSCD conducted a study of soil compaction and its impact on infiltration. Reporting on the study’s findings, OCSCD District Director David Friedman states that soil’s ability to infiltrate rainwater is a crucial function that must be both protected and restored. Porosity determines soil’s infiltration capacity, the best generally being near the surface.

Heavy construction equipment compresses the ground, removing the pore spaces vital to rainwater absorption. In many housing developments and athletic fields there has been so much compression that the soils’ bulk density is the equivalent of concrete.

According to studies reported in the Center for Watershed Protection’s journal Watershed Protection Techniques, nearly every kind of development compacts the soils. The weight of grazing livestock tramples pastures’ soils. Heavy farm machinery compresses the soil up to two feet below the surface. As construction begins, grading equipment compacts the surface and exposes fine subsoils. Then as trucks and construction equipment crisscross the property they compress the soils even more.

Soil compaction increases stormwater runoff and creates drainage problems because the soils lose their water-holding capacity. A 1994 study found that compacted soils produced from 40 to 60 percent of the annual runoff in small developed drainage areas.

Making Infiltration Work

Making infiltration work requires careful site evaluation and planning. Soil permeability comparable to that required for septic systems, water table and bedrock at least three feet below the surface, and slope gradients are important considerations. To prevent sediment and pollutants like petroleum from reaching the groundwater, it is important to pretreat runoff from streets, driveways and parking lots before it enters any infiltration device. Pretreatment techniques like grass swales, grass channels, or filter strips are generally effective filters for particulates.

Runoff from most roofs (except galvanized) is clean enough to be piped directly to dry wells that ultimately infiltrate the water into the surrounding soil.

NJDEP has established pollutant removal rates for different best management practices (BMPs). The Department recognizes that combining BMP’s is frequently more effective than use of a single BMP. In other words two BMP’s used together may meet the required per cent removal rate, where individually they may not.

The Dangers of Soil Compaction for Infiltration

Healthy soils support plant growth, cycle nutrients, receive and store water, resist soil erosion and filter nonpoint pollutant sources. Witness use of soils as effective pollutant removal agents in properly designed septic systems. Soils contain minerals, water, air, and organic material. Soil structure - the way soil particles are arranged relative to each other - is important. Good infiltration soils have a structure that maintains porosity through air pockets or pores.

In the late 1990’s the Ocean County Soil Conservation District (OCSCD) observed that the runoff from many recently constructed housing developments was greater than it should have been, given stormwater management calculations. In addition, OCSD noted that many lawn areas on sandy, porous soils remained saturated for extended periods of time, resulting in premature death of landscape plants, and runoff even from brief irrigation.

In a project sponsored through the Barnegat Bay Estuary Program, the OCSCD and NRCS worked to restore the physical, chemical and biological functions of stormwater management basins that were no longer infiltrating runoff. Restoring physical functions is basically a dig and drop process to restore the soil porosity so that plants and soil organisms can survive and the soil can infiltrate rainwater. Prior to restoration, an evaluation measured soil bulk density, depth of compaction, and classified the soil texture.

County road department staff excavated a few failed basins down to a subsoil layer, to remove the compacted topsoil. They spread and mixed lime, gypsum and compost from the Ocean County Recycling Center with the existing soils to help balance nutrients and encourage plant growth in these acid soils. The compost supported soil organisms that are essential to improving infiltration rates and promoting plant growth. Finally, the county road department seeded the basins with a mixture of drought tolerant and native grasses and planted native shrub and tree seedlings to help mimic a natural wooded depression or rain garden.

This project has helped to demonstrate the significance of improving soil health in stormwater management and the importance of incorporating soil health into future basin retrofits. The results of restoration are encouraging. Runoff is infiltrating instead of ponding. Within one day of major storm events, these basins are dry.

How Environmental Commissions Can Help

Environmental commissions can help their communities protect and restore the quality of their soils.

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<tr>
<th>Permeability Measurements of Ocean County Sampled Layers</th>
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<tbody>
<tr>
<td>Site</td>
</tr>
<tr>
<td>Woods</td>
</tr>
<tr>
<td>Pasture</td>
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<tr>
<td>Single House</td>
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<td>Cleared woods</td>
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<tr>
<td>Subdivision lawn</td>
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<tr>
<td>Athletic Field</td>
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<td>Concrete</td>
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• Encourage residents to plant rain gardens, using native plants that absorb precipitation and need little or no fertilizer or pesticides.
• Encourage residents to reduce lawn areas and plant groundcovers.
• Work with the planning board and governing body to incorporate soil protection measures into site plan review including
  • Minimum area of site disturbance;
  • Construction sequence requiring equipment and machinery not to move onto undisturbed areas;
  • Protection of stockpiled top soil;
  • Retention of vegetation and trees outside construction area.
• Encourage use of (or retrofit old basins into) bio-retention basins, where soils and conditions are appropriate.
• As soon as possible, work with planning board and governing body to adopt stormwater ordinances that require infiltration where conditions allow. Infiltration is a BMP that the state Residential Site Improvement Standards encourage. “Development shall use the best available technology to accommodate stormwater management by natural drainage strategies where possible and practicable.” N.J.A.C. 5:21-7.5.

For Further Information
  Center for Watershed Protection, www.cwp.org
  Nonpoint Education for Municipal Officials on the web at: http://nemo.uconn.edu
  Ocean County Soil Conservation District study and general information, www.ocscd.org