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OF ENVIRONMENT AND NATURAL RESOURCES
Bill Holman, Secretary

Land Quality Section
Division of Land Resources
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Urban soils: A new focus in watershed protection

What's not exactly concrete but has nearly the same density and impermeability?

It could be your lawn.

Almost certainly it's the "open space" at your favorite city park and the athletic fields where your kids play soccer or softball.

A growing body of research indicates that when land is developed for suburban and urban purposes, soils become so compacted that even areas that aren't paved lose infiltration capacity and generate high rates of runoff. These seemingly "pervious" areas are now seen as contributing to urban stormwater and water resource problems:

- Compacted soils have been shown to have runoff coefficients (multipliers) as high as 0.5 (as high as some pavements), increasing stormwater flows and making stormwater modeling more complex and less accurate.

- Because of reduced infiltration, compacted lawns and other turf areas produce more runoff of nutrients and pesticides.

- Because compacted soils hold little water, urban lawns, trees and other vegetation must be irrigated more frequently, increasing outdoor water use.

- Because compacted soils have less oxygen, an impoverished soil microbe community, and higher temperatures, urban vegetation tends to be less healthy, requiring increased fertilization and other inputs.

If it were possible to prevent or even reverse the imperviousness of urban soils, could we significantly alter the hydrology of urban watersheds and reduce the need for engineered stormwater structures? If they were managed to promote infiltration, could our lawns, parks, and other urban open spaces provide free stormwater management services and play a major role in watershed protection?

Those are questions that soil and stormwater experts say need serious consideration and research.

Perhaps the clearest voice calling for consideration of urban soil management as a watershed protection technique belongs to Tom Schueler of the Center for Watershed Protection. Schueler and his staff have done an extensive review of research on urban soils and have published several technical notes on the subject as well as articles on the probable effects of soil compaction on watershed hydrology and water quality. Schueler has called for research to determine the role that management of supposedly pervious areas could play in urban stormwater management and protection of urban streams.

The USDA Natural Resources Conservation Service (NRCS) and several urban conservation districts are also working to raise awareness of the importance of soils in urban watershed management and to provide some field data on which management practices could be based.

In New York City (NYC), NRCS, the New York City Soil and Water Conservation District, and Cornell University are conducting the first effort to map, classify, and provide interpretative data of human disturbed soils. The New York City Soil Survey consists of a medium intensity soil survey of the five boroughs that make up NYC; an intensive soil

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survey of open lots, watersheds, city corridors and parks; and special studies on behavior of urban soils.

In New Jersey, NRCS and the Ocean County Soil Conservation District are studying soil compaction in developing areas and using local television news outlets to explain to residents the problems and effects of soil compaction.

In addition, architects, landscape architects and soil scientists across the nation are advocating a focus on soils in urban planning. At a major conference on the ecology of urban soils in June the President of the American Society of Landscape Architects called for collaboration among scientific disciplines and the design and engineering professions to make soil health a measure of the quality of life and a focus in the design and planning of livable communities.

What are urban soils?

Dr. Keith Cassel of the NCSU Soil Science Department says that the term "urban soil" is often used to imply that soil within urban areas is of one uniform type. But, he says, that is not the case.

"Soils in urban areas are extremely variable," Cassel says. "The nature of the soil at any urban site depends upon the characteristics of the natural soil, the past uses of the site, the depth of excavation that went on during construction, the extent of the disturbed area, and even how much rain fell during the construction phase."

In natural, undisturbed soils, Cassel explains, we can observe layers or "horizons." In the forest, there's the top "O" horizon with lots of organic matter, the "A" horizon that most of us think of as topsoil, the "B" horizon or subsoil, and so on. At many urban sites, however, these horizons are not evident.

"Think about what happens when a house or other structure is built," Cassel instructs. "Typically, the site is graded and the top soil is removed. Topsoil may be stored or it may be trucked away from the site. Then, there's some degree of excavation. At the least footers will be dug. Sometimes, basements will be excavated. The excavated soil, which will be subsoil, often is spread around the site."

So, says Cassel, urban soils are mixed, with great variability in what layers have gotten mixed together.

"Organic matter may have been buried deep and clay material may been brought to the surface—or not."

Then, Cassel says, there's construction traffic – both heavy equipment and foot traffic packing down newly disturbed—and therefore loosened—soil. The top 12 to 16 inches of soil can become significantly compacted from general traffic, and "pans" or zones of highly compacted soil can develop where the wheels of heavy equipment have applied intense pressure.

Sometimes, he says, homeowners will find areas of their lawns where grass or other vegetation will absolutely refuse to grow, no matter how often the area is reseeded or how well it's fertilized and watered. Under these dead zones there may be pans where roots simply cannot penetrate.

"The degree of compaction of urban soils is also variable," says Cassel. "How compacted soils get at a site will depend on the kind and volume of traffic and whether or not traffic was allowed on wet soils."

Implications of compaction for erosion and sedimentation control

During construction, disturbed soil can often develop a "crust." Crusting is a kind of compaction that occurs in the top 1 millimeter of soil when rain separates the soil into very small aggregates and individual particles that cement into hard layers when rapid drying occurs. Once formed, a soil crust is impermeable and produces high runoff rates. Cassel says that crusting is a particular problem in clayey and silty urban soils. Vegetation helps prevent crusting, he says, so it's important to seed bare areas as quickly as

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The North Carolina
Sedimentation Control Commission

The Sedimentation Control Commission (SCC) was created to administer the Sedimentation Control Program pursuant to the N.C. Sedimentation Pollution Control Act of 1973 (SPCA). It is charged with adopting rules, setting standards, and providing guidance for implementation of the Act. The composition of the Commission is set by statute to encompass a broad range of perspectives and expertise in areas related to construction, industry, government, and natural resource conservation and quality. All members are appointed by the Governor and serve three-year terms, except for the Director of the Water Resources Research Institute of The University of North Carolina, who serves as long as he remains Director. The chairman of the SCC is named by the Governor.

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possible. However, if crusting occurs before seeds have sprouted, you're likely to have crop failure. That's why mulch that will retain moisture is important for getting grass established on bare soils.

Since disturbance of any kind tends to destroy soil structure and lead to some degree of compaction, the most effective way to prevent erosion and preserve soil infiltration capacity on developed sites is to limit disturbance.

The Center for Watershed Protection says that erosion and sedimentation control programs should strongly encourage limits on clearing and grading on construction sites, that plans should clearly show the limits of disturbance, and that these limits should be enforced.

Implications of compaction for stormwater management

Since it is clear that urban soil compaction affects the infiltration capacity of supposedly "pervious" areas to varying degrees, runoff coefficients for various kinds of "pervious" areas need to be developed so that models that predict changes due to development are more representative. The Center for Watershed Protection says there is an urgent need for research to characterize runoff from lawns and landscaped areas on compacted urban soils.

To help create hydrological reserves within watersheds, communities should examine ways to promote retention of undisturbed soils, says the Center for Watershed Protection. Setting and enforcing limits on disturbance during construction is an obvious way to protect soil infiltration capacity. The U.S. EPA recognizes minimizing soil and vegetation disturbance during construction as an urban stormwater BMP. Revising local requirements for compacted areas along roads and around buildings might help to promote infiltration and reduce runoff. Re-examining grading standards might also reveal opportunities to limit soil disturbance.

Some of the most favored on-site stormwater controls—filter strips, grass swales, and bioretention areas—need to have underlying porous soils to function effectively. The Center for Watershed Protection says that locations for these practices should be clearly shown on site plans and that fencing should be used to strictly prohibit construction activity on these portions of the site.

While planning and construction practices can be used to protect undisturbed soils in developing areas, stormwater managers might also want to consider opportunities for restoring infiltration capacity within existing developed areas. Restoring infiltration capacity of unpaved areas might be an especially important tool for highly developed watersheds where other stormwater retrofit options are limited. Incorporating compost into compacted soils has been shown to be an effective but expensive method of restoring infiltration capacity of lawns and athletic fields. Various studies indicate that lawn runoff could be reduced by up to 74% by use of compost amendments across a small watershed. Restoring infiltration by compost amendment and limiting foot traffic on public open areas such as parks might also produce significant hydrological benefits. Research on the degree of compaction of lawns and other open areas within a watershed should precede such restoration efforts.

With promulgation of the NPDES Storm Water Phase II Final Rule and, in North Carolina, adoption of urban stormwater control rules for the Neuse and Tar-Pamlico River Basins, affected cities, towns and counties are searching for effective and easily maintained best management practices to reduce pollutants from urban stormwater runoff. A growing number of experts believe that the potential benefits of management of soils during and after construction to protect infiltration capacity and efforts to restore infiltration in developed areas deserve consideration.

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Research indicates construction sites generate nutrient loading during stabilization/lawn establishment phase

In a research project aimed at evaluating the effectiveness of sediment traps, researchers have found evidence that nutrient loads from construction sites increase dramatically when establishment of vegetation begins.

The research project is sponsored by the N.C. Sedimentation Control Commission (SCC) and is being conducted by N.C. State University researchers at Carpenter Village near Cary. Nancy White of the NCSU School of Design and Daniel Line of the NCSU Water Quality Group have collected monitoring data on a site in the Carpenter Village development for two years. Sampling began when the site was being cleared and continues through construction of homes and site stabilization and lawn installation. Rainfall, runoff, and sediment yield are being measured. Samples of sediment trap discharge were analyzed for total sediment, total phosphorus and nitrogen. In addition, samples of sediment deposited in the trap were collected and analyzed for total phosphorus to evaluate the effectiveness of the trap in reducing phosphorous loading.

Researcher Dan Line said that there was no effort to measure the nitrogen trapping efficiency of the device because it is generally acknowledged that sediment traps do not trap nitrogen to an appreciable degree.

Monitoring data show that as clearing and grading progressed, runoff rates and export of sediment increased. It also showed, however, that when site stabilization with vegetation and lawn establishment began, sediment export decreased and nutrient export increased.

This result did not surprise Line.

"There was extensive grading on this site. Everything was removed down to the subsoil. There was no organic matter left. To establish vegetation , it is necessary to use fertilizer. You would expect to see nutrients in runoff in such a situation.

"It's a trade-off," said Line. "To control erosion, you need to get vegetation established, and to get vegetation established, you have to use fertilizers. You trade sediment for nutrients."

Line said that it seems clear traditional erosion and sedimentation control BMPs are not designed for control of nitrogen loading from construction sites during what he calls the second phase of development—the home construction phase.

He said he knows of no BMPs that can be used on extensively graded construction sites to effectively control nitrogen loading. He said it might be possible to increase infiltration and reduce runoff with heavy mats of straw or compounds like polyacrylamide, but that the nitrogen loading reduction would likely not be significant.

Line said that limiting disturbed area and minimizing grading are probably the only really effective BMPs for limiting nitrogen loading from construction sites. White concurred and added that good site design can minimize the area required for mass grading. Also, White noted that construction impacts may be a short-term problem, whereas the increases in stormwater runoff and related impacts are not. Continued monitoring to quantify impacts after stabilization is being conducted.

Line and White will complete their research on the efficiency of temporary sediment controls and make a final report to the SCC in the spring of 2001.

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Land Quality personnel changes

- **C.W. Gaskill, Jr.** is new Sediment Education Intern in the Land Quality Central Office.
- **Charles Phillips** is the new environmental technician in the Raleigh Regional Office.

Steve Fowler (left), owner of Fowler Contracting, accepts the Green Dozer Award for a site one to five acres in size from Sedimentation Control Commission chairman Kenneth H. Reckhow.

Donald R. Lee, FAIA of Lee Nichols Architecture accepts the Green Dozer Award for a site larger than 5 acres from Sedimentation Control Commission chairman Kenneth H. Reckhow.

Fowler Contracting and Warrior Golf Club win Green Dozer Awards

At the August 17 meeting of the N.C. Sedimentation Control Commission, Chairman Kenneth Reckhow presented the first Green Dozer Awards for outstanding erosion control and stabilization practices installed on a construction site.

The Green Dozer Award for a site one to five acres in size went to Fowler Contracting of Cary, NC, for their work at Cotswald Subdivision Phase III. Darin Eyster of the Town of Cary Erosion and Sediment Control Program nominated Fowler for the award. Eyster praised Fowler for dedicating a crew to erosion control and for being proactive in implementing new regulations for vegetative stabilization. The company has its own radar and sends a crew to reinforce measures when rain threatens.

"Fowler sees that its people are trained and that they are concerned about getting erosion control done right," said Eyster.

The Green Dozer Award for a site larger than five acres went to the Warrior Golf Club in Rowan County. Donald R. Lee of Lee Nichols Architecture accepted the award on behalf of the families which developed the project: the Lee Family, the Huston Family, the Johnson Family, and the Staton Family.

The project was nominated by Greg Green of Rowan County Environmental Services. Green praised the project for diligent maintenance of erosion and sediment control measures and extraordinary efforts in the establishment of groundcover.

Warrior Golf Course was constructed on Lake Wright, a secondary water supply for the Town of Landis, and 12 of the 18 holes drain to High Quality Waters. Greene said the lake had been very well protected.

"I'm proud of the job they've done there," he said. "The owners' commitment to full compliance and their desire to do things right were the reasons for the success of this project, both during construction and in the completed product. The Warrior Golf Club has proven to be an asset to the community and a friend to the environment."

August action of the N.C. Sedimentation Control Commission

At its regular meeting on August 17, the N.C. Sedimentation Control Commission took the following action:

- Approved a Soil Erosion and Sedimentation Control Ordinance for Jackson County (contingent on staffing), thereby allowing the County to establish its own local erosion and sedimentation control program. The program will be administered by Jackson County Planning and Development, Tamera Crisp, Director. The address is 401 Grindstaff Cove Rd, #204, Sylva, NC 28779. Phone: (828) 586-7575.

- Approved three education projects: ❑ Support for three erosion and sedimentation control workshops in western North Carolina. The workshops will be conducted by Western North Carolina Tomorrow. ❑ Support for reprinting the *Erosion Patrol* Third Grade Curriculum. ❑ Printing 500 copies of the *North Carolina Erosion and Sediment Control Planning and Design Manual* and convening a workgroup to revise the manual within two years.

- Established a committee to make recommendations for guidance about requiring undisturbed riparian buffers on a site-specific basis. According to the Attorney General's office, the Sedimentation Control Commission has the authority to require undisturbed buffers when conditions indicate the need for a buffer. However, according to Mell Nevils, Chief of the Land Quality Section, Regional Engineers and other staff have no guidelines that would help them decide how wide undisturbed buffers should be on various soils and slopes.

Conferences

Delaware Sediment & Stormwater Conference 2000 ... October 24-26, 2000 ... Newark, Delaware ... Fee: $195 before Sept 15; $235 after Sept 15 ... Will focus on erosion, sediment and stormwater management issues, including innovative strategies to meet regulatory challenges and low impact development/nonstructural approaches for stormwater management. Keynote speaker is Eric Livingston of the Florida Department of Environmental Protection. Closing session speaker is Tom Schueler of the Center for Watershed Protection. ... For program and registration information contact Jeanne Feurer, Conference Coordinator at (302) 739-4411 or jfeurer@dnrec.state.de.us.

Soil Erosion Research for the 21st Century ... January 3-5, 2001... Honolulu, Hawaii ... Non-member fee by Nov 16: $330 ... Aimed at providing information to individuals, groups, and agencies about needed directions for soil erosion research activities and funding. There will be facilitated discussions on the topics of wind erosion modeling and control, water erosion modeling and control and soil erosion quantification techniques. Recommendations from the discussions will be summarized and provided to participants and interested organizations. ... *Sponsored by the American Society of Agricultural Engineers and others.* ... For additional information and registration go to: http://asae.org/meetings/erosion01/index.html or call (616) 429-0300

Soil Bioengineering: Sensible Solutions for Our Built Environment ... October 9-10, 2000 ... University of Wisconsin-Madison ... Fee: $645 before September 18, $690 after September 18 ...
An introductory, basic and practical short course focusing on how live cuttings and rooted plants naturally restore, rehabilitate, and reclaim watersheds that suffer from erosion and instability. Instructors: Peter J. Bosscher, professor of civil and environmental engineering, Univ. Wisconsin-Madison. Robbin B. Sotir, president of Robbin B. Sotir & Associates of Marietta, GA. C. Allen Wortley, professor of engineering professional development, Univ. Wisconsin-Madison. ... For additional information and registration go to website http://epdweb.engr.wisc.edu/brochures/A117.html or call 800-462-0876

Linking Stormwater BMP Designs and Performance to Receiving Water Impacts Mitigation ... August 19-24, 2001 ... Snowmass, CO ... Experts from around the world will explore the topic of Best Management Practices and how they effect receiving water impacts of urbanization, namely what is known about these topics and what information and science need to be developed. The conference will feature oral presentations, discussion periods, and workshops. ... *Sponsored by the U.S. EPA, the American Society of Civil Engineers, and others.* ... For additional information and to request a registration form go to: http://www.engfnd.org/1as.html or call the United Engineering Foundation at (212) 591-7836.

7th Environmental Conference, Workshop & Trade Show of the Mid Atlantic Chapter of the International Erosion Control Association ... September 6, 7 & 8, 2000 ... King of Prussia, PA ... For program and registration information visit website: http://ieca.8m.com or call Tom Master (800) 234-7645 or Neil Reinecker (800)245-0551.

National Association of State Land Reclamationists' 28th Annual Conference: Water Quality Issues in Reclamation ... September 11-13, 2000, Knoxville, TN. For information call Bruce Ragon, Conference Coordinator, at (865) 594-6035.

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