Texas Water Resources Institute

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Controlling Highway Erosion

Texas A&M, UT Austin, TxDOT Work to Keep Soil in Place and Prevent Pollution

By Ric Jensen, Information Specialist, TWRI

Photo by Ric Jensen/ TWRI

Tim Tucker of the Texas Transportation Institute measures the flow of water through this culvert at the

On a typical Central Texas summer day with 98° temperatures and 95% humidity, engineering technician Tim Tucker toils amid a grid of abandoned airplane landing strips. In the background, lies a huge man-made hill covered with alternating brown- and green-colored strips of now mostly dead grasses and blankets made of fabrics and textiles. On this August day, Tucker, who works for the Texas Transportation Institute (TTI), powers a pump that sends a pulse of water down a series of drainage channels. His job is to measure how fast the water flows down each ditch and how much dirt washes away from the canal banks. Ultimately, the information will be used by the Texas Department of Transportation (TxDOT) to gauge which erosion control materials will be allowed for use in Texas to lessen the amount of sediment runoff. "Results of these tests are vitally important to the companies that develop and market erosion control products and those who want to use them," Tucker explains. "Passing the evaluations is required if erosion control mulches and liners are to be authorized for use on TxDOT projects."

Roughly 100 miles away in Austin, meanwhile, researcher Michael Barrett of the University of Texas Center for Research in Water Resources is investigating the effectiveness of runoff and sediment controls. Barrett takes me on an exploratory trip down a major Austin highway. After traveling only a few miles, we pull over onto the shoulder, get out of the car, and try to maintain our balance as we walk down a steep embankment. Our destination is a detention pond that lies underneath and out of sight of traffic. The pond and a vertical sand filter have been installed to store and treat runoff pollutants. A few moments later, we run quickly across the four-lane highway to stop in the wide grassy median that separates traffic. There, Barrett shows me a site that has been instrumented to measure the effectiveness of stormwater runoff treatment systems. "We located this site under the highway to collect data after major storms," Barrett explains, "and provide us information on how effectively these ponds and sand filters remove sediments."

Why are these people, and numerous counterparts throughout Texas, doing this?

The answer is relatively simple. Dating back to the passage of the Federal Clean Water Act in the 1970s, water managers realized that pollution problems could not be addressed solely by looking at point sources (mainly, wastewater treatment plants). As a result, regulators and scientists began many studies to better understand and quantify pollution caused by stormwater, runoff, and other hard to identify non-point sources.

Although much work has been done to document the extent of non-point pollutants and to investigate ways of reducing adverse impacts, many water managers in Texas will tell you much more still needs to be done. Specifically, local regulators and those associated with construction projects are looking for practical "best management practices" (BMPs) that can be implemented to remove as much non-point source pollution as possible. Sediments constitute a major non-point pollutant, in large part because bulldozing a site strips away vegetation and exposes so much bare soil. Runoff problems are especially problematic near highways — both new roads under construction and heavily trafficked freeways — because of the large amount of paved surfaces, the absence of significant vegetation, and contaminants that wash off cars, trucks, and roads during heavy rains.

This issue of Texas Water Resources focuses on two major stormwater issues —sedimentation and erosion — caused by runoff from highway construction and maintenance. Research being conducted at Texas universities for TxDOT and other studies are highlighted.

Background Information

Construction activities often increase non-point pollution by increasing the amount of paved surfaces (impervious cover) and by removing existing vegetation and ground cover that keeps soils in place. Construction practices can introduce hazardous contaminants into the environment. Potential pollutants include fuels, grease, lime, cement, and other wastes related to construction.

Many studies suggest that the most effective way to reduce sediment losses is to prevent erosion. A report by the North Central Texas Council of Governments (NCTCOG) states that the use of natural ground covers and mulches can reduce erosion by as much as 98%, while silt fences and detention ponds may remove only 70% of sediments found in runoff.

Photo by Ric Jensen/ TWRI

Roger Glick of the City of Austin stands in front of this rock berm that diverts stormwater runoff into a wet detention basin.

Texas cities with 100,000 or more residents are required to establish stormwater management plans as part of the federal National Pollutant Discharge Elimination System (NPDES). The Clean Water Act played a key role in the development of stormwater regulations — it states that no one has the right to pollute U.S. waters and provided the basis for current stormwater regulations.

Stormwater management plans should include a description of how site planning will be conducted, requirements for structural and non-structural BMPs, procedures to inspect sites and enforce control measures, and education and training resources and programs for construction site managers.

NPDES permits are required for construction activities including clearing, grading, and excavation, that result in the disturbance of less than five acres of land. A NPDES general permit for construction provides only for the release of sediments from construction sites. Additional permits and requirements may apply for specific conditions that produce contaminated waters that may flow from a construction site.

Related issues covered by stormwater regulations include flows from municipal storm sewers, runoff from industrial and manufacturing sites, and contaminants from highways, airports, and vehicle traffic.

TxDOT Pr ograms

The Texas Department of Transportation (TxDOT) operates many programs to construct and maintain highways throughout Texas. One of the main purposes of their programs is to lessen stormwater runoff and sediment losses through establishing and maintaining highway landscapes.

TxDOT encourages the planting of wildflowers and other native plants in medians and rights of way as one way to reduce the amount of chemical inputs needed to sustain landscapes. As part of TxDOT's Pesticide Management Program, the agency has developed strategies for insect and vegetation management. This program provides highway managers with tools to lessen erosion and runoff pollution. Strategies recommended in this program include planting and maintaining vegetation to keep slopes intact and utilizing vegetated buffer strips to filter contaminants.

TxDOT publishes stormwater management guidelines for construction activities. This report provides information on stormwater pollution prevention plans, how to design stormwater controls, practices to stabilize sites to lessen erosion, structural controls, and how to apply for NPDES permits.

TxDOT sponsors research projects at universities throughout Texas dealing with strategies to minimize erosion and sedimentation and highway pollutants, as well as ecologically sound vegetation management and many other issues.

NCTCOG Stor mwater Pr ograms

The North Central Texas Council of Governments (NCTCOG) has provided leadership for many regional and statewide stormwater projects. NCTCOG's Department of Environmental Resources worked with the seven largest cities in the Dallas/Fort Worth metroplex and local TxDOT Districts to develop a regional strategy for stormwater management in North Central Texas. Through participation with the Texas Public Works Association, NCTCOG was instrumental in forming the Statewide Storm Water Quality Task Force. The Task Force recently received a Section 319 Non-point Source grant from the Texas Natural Resource Conservation Commission to develop an Internet-based Texas non-point source reference manual. NCTCOG is providing administrative support and guidance for the project.

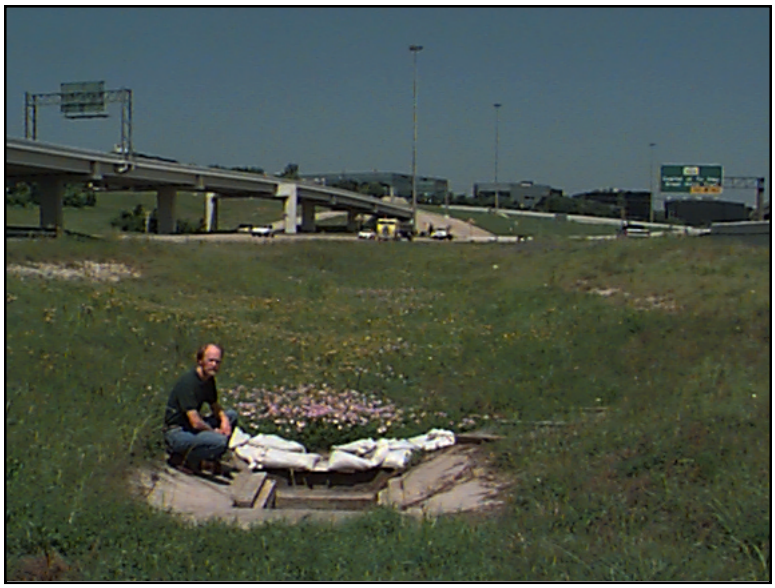
The North Central Texas regional strategy for stormwater management included sampling 7 storm events by the U.S. Geological Survey from a network of 30 regional "wet weather" monitoring sites for 186 parameters. The sites sampled storm sewers located in residential, commercial, industrial and highway watersheds. Results showed that stormwater quality in North Central Texas was lower than national values for most parameters, except total suspended solids (TSS) and carbonaceous oxygen demand (COD). Sampling results yielded a list of "constituents of concern" similar to lists developed for the Texas Clean Rivers Program for the Trinity River basin. Parameters included trace metals, nutrients, fecal coliform bacteria and oxygen demands. The regional program used NCTCOG's geographic information system to map outfalls, and field screening to identify and target illicit connections to storm sewers. A public information campaign, which included storm drain stenciling, was part of the program.

A key product of the regional stormwater program was the development of a BMP manual for construction activities which is now widely used across the metroplex. The manual provides information on how to design structures to control erosion and sediment losses. It includes a guide to help project managers select the most appropriate BMP to control erosion, prevent sediment losses and to manage wastes from construction sites. The manual contains fact sheets describing 22 BMPs and provides detailed construction specifications for 14 others. It describes NPDES permit requirements, instructs project managers on how to develop plans to prevent stormwater pollution, and provides several case histories.

Strategies identified in the NCTCOG manual include limiting the area disturbed by construction, temporarily stabilizing and protecting sensitive areas to lessen erosion, impounding waters with significant amounts of sediments, and the use of structural controls. The manual classifies different strategies to control erosion and sediment losses. Within each category, individual BMPs are described and their effectiveness is ranked.

NCTCOG and the Statewide Storm Water Quality Task Force of the Texas Public Works Association are working with a consultant to develop a World Wide Web (WWW) site titled the "Texas Nonpoint Source Book." The site, which is now being developed, will include detailed information on many facets of stormwater management, including guidance for small and large communities, how to characterize urban waterways, ways to set community water quality goals, the cost-effectiveness of BMPs, drainage management strategies, and references.

Local participation will be important in making the site a success. Storm Water Quality Task Force members are gathering local data on stormwater quality, BMP performance, and case histories that will be put on the web site. The Source book will serve as a key tool in providing public works officials across Texas with the information they need to make sound decisions in stormwater management.



Mike Barrett of UT Austin shows how this vegetated area can trap runoff pollutants and sediments. This site is on the MoPac Expressway in Austin.

Photo by Ric Jensen/ TWRI

Local and Regional Ef for ts

Many river authorities, water districts, and cities have implemented stormwater management programs. Common elements of many of these plans include local ordinances to protect water quality, use of temporary controls during construction, sampling areas thought to be most affected by stormwater pollutants, and requiring specific structural controls, especially for large developments

In 1990, the City of Austin began to evaluate the water quality characteristics of stormwaters from various land uses in the region. They found that the amount of paved surfaces and population density often significantly influence pollutant loads. Since that time, Austin has monitored stormwater at more than 55 sites and tested the performance of wet and dry ponds, sand filters, and oil and grit separators to remove stormwater pollutants. Analyses of this program suggest that streambank erosion and materials washed off land surfaces are significant sources of pollution. Effective BMPs now being tested in the region include systems with wet ponds and sand filtration basins, vegetated channels with mild slopes, and pretreatment followed by dry ponds. Austin sponsors many community education and outreach programs, retrofits watersheds with known stormwater pollution problems, and has refined procedures to weigh the costs and benefits of BMPs.

Many innovative stormwater management strategies are being utilized throughout Texas. Dallas and other cities conduct regular inspections to look for illicit discharges. In El Paso, stormwater management includes encouraging the use of silt detention basins near new developments. Fort Worth and San Antonio sample stormwater runoff from tunnels under their cities. Many Texas cities conduct education programs, which range from stenciling storm drains to sponsoring workshops for construction professionals.

Resear ch at UT Austin

Throughout the 1990s, scientists with the Center for Research in Water Resources (CRWR) at UT Austin have tested many aspects of highway runoff. The projects fall into a two categories: characterizing the pollutants and flows associated with runoff, and assessing how well various treatment methods work to treat runoff pollutants in field settings and laboratory experiments.

In 1993, Barrett and other researchers published a report that summarized TxDOT-funded studies to assess the quantity and quality of runoff from existing and newly completed sections of the MoPac Expressway in Austin. Three sites, which reflect varying levels of urbanization and traffic volumes, were instrumented and monitored. The researchers evaluated many factors that influence runoff, including drainage systems, traffic volume, and nearby land uses. They studied if pollutants were concentrated at the beginning of a storm (the "first flush") and then decreased significantly. Results show that total pollutant loads are a key factor in assessing the effects of runoff on the environment. The study demonstrated that grassy swales can be very effective as a pollution mitigation tool, often removing more than 90% of contaminants.

Barrett, UT student Sean Tenney, and CRWR colleagues also examined the field performance of a system that uses vertical sand filters, hazardous material traps, and sedimentation basins to remove pollutants commonly found in highway runoff. The evaluation of vertical sand filters is important because more than 1,000 of these systems have been installed in the Austin area within the last decade. These systems are popular because, in theory, they may provide excellent treatment while they can be installed in a relatively small area. Results of this study suggest that there may be many factors that limit the effectiveness of vertical sand filters. High flows through these units were shown to wash out the sands, resulting in inadequate detention times and little filtration. The research implies that the best way to limit sediment runoff may be to increase detention times by installing rock gabions and baffles. The researchers also studied the performance of a system that utilizes a horizontal sand filter and a below-ground drainage system to filter and collect runoff waters. They found that these systems require extensive maintenance to prevent the buildup of algae on the surface of the sand filter and to lessen the risk of pore clogging.

Throughout the project, UT researchers developed many innovative strategies to gauge how highway runoff can adversely impact

Photo by Ric Jensen/ TWRI

Researchers at the Pickle Research Center at UT Austin measure the amount and quality of water that flows from landscaped

water quality. In one study, CRWR researchers employed a rainfall simulator to cause a man-made storm to fall over a stretch of the MoPac freeway. The simulations were carried out during actual highway conditions, when many vehicles traveled the highway. This was the first time such tests had been conducted in the United States. Runoff drained to a curb inlet where water quality samples were collected to analyze the pollutants that washed off moving vehicles. Results were useful in developing correlations between highway conditions, rainfall events, and individual contaminants such as oil and grease, copper, lead, iron, zinc, and nutrients.

In another TxDOT -funded project, CRWR scientists compared the ability of different temporary runoff controls to limit erosion and sediment losses. The project was led by Barrett and UT students John Kearney and Terry McCoy. It inventoried the number and type of temporary runoff controls used in the Austin area and evaluated their effectiveness. The study found that rock berms and sediment fences were the most commonly used erosion controls on construction sites. Sediment ponds were used often in early stages of construction, while erosion control blankets were often employed after projects were underway. Field evaluations showed that geotextile silt fences and single rock berms may not be effective in reducing turbidity and improving water quality.

TAMU Resear ch

Researchers at Texas A&M University (TAMU) are working with TxDOT to evaluate the effectiveness of products and management strategies to reduce pollutants in highway runoff.

Much of the work is carried out by researchers in the TTI Erosion Control Field Laboratory, which is headed by Harlow Landphair. Many of the hands-on studies are supervised by Jett McFalls and are conducted at the TAMU– Riverside campus west of Bryan. A detailed description of the field laboratory and research conducted there is available on the TTI WWW site at http://tti.tamu.edu/divisions/econ/env_management/sp_facilities/hydraulic_lab/.

At the field laboratory, TTI has evaluated the performance of many different materials to control erosion since 1989. Products evaluated by TTI include erosion control and soil retention blankets, hydraulic mulches used to establish vegetation, and flexible channel liners used to line culverts and drainage channels. The evaluations are critically important because only materials that pass TTI testing criteria are allowed by TxDOT for use on Texas highways.

The field laboratory covers 22 acres. Much of the testing is conducted on a one-of-a-kind man-made hill that is roughly 22 feet high and 875 feet long. The hill was designed and built to allow researchers more flexibility in designing and carrying out field evaluations. Sections of the hill can be divided into as many as 70 50-foot x 20-foot experimental plots. Concrete boxes sited at the bottom of the hill capture runoff and sediments from each experimental plot. Each box stores roughly 110 gallons of water. One side of the hill consists of clay soils, while the other was built from sandy loams. Native soils at the site are generally low in organic matter. Each side of the hill features a different slope (2-to-1 on one section and 3-to-1 on the other).

The site features 10, 85-foot drainage channels which are used to test products to line culverts and drainage ditches. Six of the channels were built at a 7% grade while the others have a 3% slope. At their broadest point, the channels are roughly 3 feet wide. Because one goal of this facility is to measure how well channel liners perform under extreme flows, the site is designed so that flows of up to 36,000 gallons per minute can be generated and routed through the system.

Four rainfall simulators are available for use in the slope tests and drainage runoff studies. The simulators are powered by a 10-horsepower pump and can provide 1 to 12 inches of rainfall per hour. TTI used weather data from a region stretching from Houston to Austin to Dallas to College Station to determine how much water the rainfall simulators should apply. Other equipment at the facility includes pump houses and weather monitoring stations. Three reservoirs at the site cover 6.5 acres and store rainfall and groundwater. The site is laid out so that water used in any of the experiments is routed back to the ponds so it can be continually recycled and reused.

"We feel the site has a number of features that make it great for the types of testing we conduct," McFalls explains. "The site is located near an abandoned airport runway, so we're able to simulate the effects of heat stress that result from large amounts of paved surfaces. This creates an environment that is similar to many urban areas in the region. Because the site is so large, we're able to test many different types of products and combinations of materials. As a result, products are submitted to us for evaluations from throughout Texas and much of the Southwest." Before the Field Laboratory began operations, McFalls explains, TxDOT only approved two products for roadside landscape management because more complete testing was not possible.

Typically, manufacturers submit products for analysis to TTI early in the year. In the spring, individual plots are seeded with vegetation recommended by TxDOT (for the Bryan area, this includes a mix of Bermuda-, Indian-, switch- and bluestem-grasses as well as green spangletop). Later, the specific erosion control products are installed. These products are evaluated under a number of variable conditions, including different installation methods and slopes. Throughout the growing season, TTI researchers gather and analyze data on specific field performance

Photo by Ric Jensen/ TWRI

TTI staff members install an erosion control blanket on this man-made hill at the TAMU - Riverside campus this spring. TTI uses the site to test how well various materials retard erosion.

characteristics such as vegetation coverage and sediment losses. To measure the amount and quality of vegetation in each plot, TTI researchers take digital photographs. They use a computer program titled "VeCAP" to determine vegetation type and abundance based on the number of different colored pixels in the image.

Results from the field laboratory are impressive. Some objectives often used by TTI to evaluate the success of a product include determining how well vegetative cover is established, and gauging the field performance of erosion control blankets, channel liners, and hydraulic mulches. Criteria used to assess if products are acceptable include measuring sediment losses, determining if erosion control blankets protect seed beds during simulated storms, and observing if these products remain intact during the testing or develop large rips or tears. TxDOT often uses TTI research to develop management recommendations. TTI studies provided data TxDOT used to prescribe a two-step process to apply mulches and to set improved standards for erosion control blankets.

Recently, a TTI study by Danise Hauser and Wayne McCully assessed the environmental impacts of TxDOT landscape management practices near highway roadsides. They wanted to determine if TxDOT efforts to stabilize soils with landscape plants were effective in reducing erosion and improving water quality. This project resulted in "environmentally friendly" management recommendations that can be used near highways. Some of these strategies include scheduling work during times of the year to take advantage of natural plant growth patterns, use of selective herbicides that target nuisance or undesirable plants, and postponing road maintenance when soil erosion is likely. The results helped TTI develop environmental impact statements.

Summary

For some time, sediment losses have been identified as a major non-point source pollution problem in Texas. Areas where construction is occurring and highways are being built and maintained represent sites where special attention to control sediment losses and non-point pollution is essential. As a response to these concerns, many groups have come forth to develop solutions to reduce sedimentation and non-point source pollution. Efforts by NCTCOG and the stormwater management task force will provide additional resources to effectively manage vulnerable sites. Work by TxDOT throughout Texas will have broad implications for the construction and management of thousands of roads statewide. In addition, the contributions of research at Texas universities is significant. Work by the University of Texas at Austin and Texas A&M University is playing a key role in helping us understand non-point source pollution problems and identify the most promising products and process to maintain high water quality.

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News fr om TWRI

TWRI recently published an updated version of its publications catalog. The catalog includes technical reports, newsletters, and special publications produced by TWRI. Publications are listed by date and subject category. The catalog can be accessed at the TWRI WWW site and limited numbers of printed copies are also available.

TWRI also announces a few staff changes. Shelley Nemec has left the Institute to return to school, after having worked as our staff assistant for the past three years. She was replaced by Debi Fisher. Jonathan Jones, a TAMU student who was the Institute's webmaster, is no longer working for TWRI and has gone back to school full-time. He has been replaced by student workers Jason Middleton and Tung Trang.

TWRI encourages people to visit the "Hot Topics" portion of the WWW site. Newly added sections deal with many environmental and water-related topics, including endangered species, microbial contamination of drinking water, property rights, and natural and constructed wetlands.

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Texas Water Resources

Texas Water Resources Institute
301 Scoates Hall
Texas A&M University
College Station, Texas 77843-2118

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