STORMWATER - POST CONSTRUCT. RUNOFF CONTROLS

North Central Texas Council Of Governments

TO: Storm Water Program Participants

DATE: July 15, 2002

FROM: Jeff Rice, Environmental Planner

SUBJECT: Menu of Management Program Options for Post-Construction

Dear Storm Water Program Participants:

Enclosed is the draft Menu of Management Program Options for the Post-Construction Storm Water Management Minimum Control Measure. The current version contains information from the workshops that were held in April, as well as EPA guidance documents and other sources. This version has been reviewed internally by NCTCOG staff and has received limited outside review, and we are now seeking further input on the document.

Please look over the Menu of Options and provide any comments that you have regarding the document. Please provide your comments by July 26, 2002 by whatever format is most convenient (e-mail, fax, phone). Based on the number and type of comments that we receive, we may convene a committee of participants to review the comments and develop the final version of the text. Please indicate along with your comments whether you would be willing to participate on such a committee that would meet once or twice to finalize the document. Once the final version is completed, we will send the updated version to you and post it on the web.

We hope that the Menu of Management Program Options is useful in your efforts to develop your management program for Post-Construction Storm Water Management and look forward to your comments. Please feel free to contact me at jrice@dfwinfo.com or 817-695-9212 if you have any questions.

Also, please note that the Menu contains information on the Comprehensive Drainage Criteria and Design Manual, which will be a tool to implement the concepts included in the Menu of Options for Post-Construction. The CDCD Manual is a separate cost-share project being initiated by NCTCOG's Public Works Council to assist local governments in managing storm water in their jurisdictions and meeting TPDES permit requirements. If you have any questions about the CDCD Manual, please contact Kenneth Calhoun, NCTCOG, at kcalhoun@dfwinfo.com or 817/695-9224.

616 Six Flags Drive, Centerpoint Two
P. O. Box 5888, Arlington, Texas 76005-5888
(817) 640-3300 FAX: 817-640-7806 recycled paper
http://www.dfwinfo.com

MENU OF MANAGEMENT PROGRAM OPTIONS

Post-Construction Storm Water Management in New Development and Redevelopment

The following "Menu of Management Program Options" has been developed from a number of sources, including suggestions by Regional Program participants at the Post-Construction Storm Water Workshops, EPA documents, and others. Participants may consider these options in the process of developing the post-construction component of their municipal storm water management plan.

These suggestions do not represent the complete universe of alternatives available, nor do they represent an attempt to present a packaged storm water management plan. It is the responsibility of each city or county to develop a complete storm water management plan that meets the regulatory requirements. Consider the regulatory goal of "maximum extent practicable" (MEP) when developing your storm water management plan and realize that implementation of the plan and related ordinances becomes a condition of your storm water permit. Prepare a plan that is functional and can be implemented effectively in your jurisdiction.

The italicized text included below is the language for the "Post-Construction Storm Water Management in New Development and Redevelopment" Minimum Measure taken from EPA's Final Phase II Rule. The Final Phase II Rule establishes the minimum requirements that TNRCC will use in drafting the corresponding storm water permit for small municipalities in Texas. Cities and counties should use these requirements in planning their storm water management programs until TNRCC issues the Texas permit (TNRCC must issue the Phase II municipal storm water permit by December 9, 2002).

You must develop, implement, and enforce a program to address storm water runoff from new development and redevelopment projects that disturb greater than or equal to one acre, including projects less than one acre that are part of a larger common plan of development or sale, that discharge into your small MS4. Your program must ensure that controls are in place that would prevent or minimize water quality impacts.

You must:

- *Develop and implement strategies which include a combination of structural and/or non-structural best management practices (BMPs) appropriate for your community;*
- *Use an ordinance or other regulatory mechanism to address post-construction runoff from new development and redevelopment projects to the extent allowable under State, Tribal or local law;*
- *Ensure adequate long-term operation and maintenance of BMPs.*

Guidance

If water quality impacts are considered from the beginning stages of a project, new development and potentially redevelopment provide more opportunities for water quality protection. EPA recommends that the BMPs chosen: be appropriate for the local community; minimize water quality impacts; and attempt to maintain pre-development runoff conditions.

In choosing appropriate BMPs, EPA encourages you to participate in locally-based watershed planning efforts which attempt to involve a diverse group of stakeholders including interested citizens. When developing a program that is consistent with this measure's intent, EPA recommends that you adopt a planning process that identifies the municipality's program goals (e.g., minimize water quality impacts resulting from post-construction runoff from new development and redevelopment), *implementation strategies (e.g., adopt a combination of structural and/or non-structural BMPs), operation and maintenance policies and procedures, and enforcement procedures.*

In developing your program, you should consider assessing existing ordinances, policies, programs and studies that address storm water runoff quality. In addition to assessing these existing documents and programs, you should provide opportunities to the public to participate in the development of the program.

Non-structural BMPs are preventative actions that involve management and source controls such as: policies and ordinances that provide requirements and standards to direct growth to identified areas, protect sensitive areas such as wetlands and riparian areas, maintain and/or increase open space (including a dedicated funding source for open space acquisition), provide buffers along sensitive water bodies, minimize impervious surfaces, and minimize disturbance of soils and vegetation; policies or ordinances that encourage infill development in higher density urban areas, and areas with existing infrastructure; education programs for developers and the public about project designs that minimize water quality impacts; and measures such as minimization of percent impervious area.

Introduction to Post-Construction Runoff Control BMPs

Storm water best management practices are the primary tool to improve the quality of urban streams and meet the requirements of NPDES permits. Best management practices are defined as schedules of activities, prohibitions of practices, maintenance procedures, the use of pollution control devices and other management practices or policies used to prevent or reduce the amount of pollution introduced to receiving waters from storm water runoff. Stated more simply, BMPs are devices or design considerations that are used to reduce the impacts of development or human activities on water quality. Used individually or in combination, BMPs are intended to be a cost effective, practicable means to reduce pollutants and/or the amount of runoff that reaches receiving waters.

The EPA regulations refer to two categories of best management practices, structural and nonstructural (some BMPs such as grassed swales and filter strips seem to fit into both categories). Structural best management practices are physical devices (i.e., "structures") or landscape features that remove pollutants from storm water runoff through filtration, infiltration, or detention. Structural BMPs such as wet ponds, infiltration basins, and sand filters are the traditional techniques that have been used to treat storm water runoff from developments, and are generally incorporated into projects independently of other design considerations for the project. Nonstructural best management practices are more difficult to define, but involve rethinking the way the built environment is planned and designed, including aspects such as minimizing impervious surfaces (reduced parking and narrower streets), building in the least sensitive areas of the site, preserving natural streams and riparian buffers, directing runoff over vegetated areas, and providing open space.

Management Program Considerations

In formulating a management program to address post-construction impacts, overall objectives for the program should be established for the jurisdiction. Since many of the structural and non-structural BMPs have water quantity management benefits in addition to water quality benefits, it would be useful to consider a comprehensive storm water management program that addresses multiple impacts of post-construction storm water runoff.

An effective program for managing post-construction runoff should include options for implementation of both structural and nonstructural controls. Generally, it is cheaper and more effective to implement design elements that prevent or reduce the generation of storm water runoff and/or pollutants at the source. In many cases, the need for expensive structural controls can be avoided (or they can be reduced in size) if the amount of runoff and entrained pollutants are minimized by the design of the project. Where necessary, structural BMPs used alone or in combination with nonstructural controls are an effective means of reducing the impact of development on receiving waters.

NCTCOG Comprehensive Drainage Criteria and Design Manual

In response to the changing regulatory climate and in recognition of the impact of post-construction storm water runoff on the environment, the Regional Public Works Council, the Regional Storm Water Management Coordinating Council, and the Trinity River Flood Management Task Force are beginning a multi-year, cost-share project to develop a comprehensive drainage criteria and design manual. The manual, to be designed in accordance with the *Regional Strategy for Managing Storm Water Quality in North Central Texas,* will offer step-by-step instructions to help local governments and developers estimate runoff quantities and select, design, and analyze storm water conveyance facilities that incorporate management practices for storm water quality and quantity mitigation in new development and redevelopment. The manual will be designed to meet the applicable elements of the post-construction storm water management requirements of MS4 storm water permits.

Specifically, the Comprehensive Drainage Criteria and Design (CDCD) Manual will integrate storm water quality and quantity management with comprehensive storm water management practices. The manual will be flexible, yet will contain uniform, consistent provisions for specific levels of service that will be applicable to projects of all sizes and locations in the region. The manual will be available in both traditional hard copy and in electronic format with a user-friendly, adaptable program for performing hydrologic and hydraulic analyses and on-line compatibility with links to web sites and other technical data. Soils information and current local rainfall data will be included, and recommended best management practices will be customized for the North Texas Region.

The CDCD Manual will simplify consultant designs, create consistent runoff estimates, facilitate multi-jurisdiction drainage analysis, and enable regional training opportunities. The manual will incorporate practices for storm water quality and quantity mitigation that could serve as a component of MS4 storm water management plans for post-construction runoff control. The TNRCC has submitted written correspondence to NCTCOG regarding the manual stating that *"Texas Pollutant Discharge Elimination System (TPDES) storm water permits for municipal storm sewer systems will contain the requirement that operators of these [MS4] systems develop a minimum control measure for areas of new development and re-development. The TPDES general permit for Phase II systems will be issued by December 2002. Development of the proposed [CDCD] manual, consistent with the requirements of this permit, will result in a valuable tool for permittees."* Correspondence from Steve Ligon, TNRCC Storm Water & General Permits Team Leader to John Promise, NCTCOG Director of Environmental Resources, July 8, 2002.

Suggested Program Development Schedule

The federal Phase II Storm Water Rule states that *"Your NPDES permitting authority* [TNRCC for Texas] *will specify a time period of up to 5 years from the date of permit issuance* [March 10, 2003 for most jurisdictions] *for you to develop and implement your program."* This means that regulated cities and counties will have until March of 2008 to develop and fully implement the storm water management plan, unless TNRCC modifies this aspect of the EPA rule when it issues its permit, which is unlikely.

The following suggested schedule takes full advantage of the allotted time for program development and implementation for the Post-Construction Minimum Measure since this aspect of the regulations is likely the most difficult to address. The schedule could be adapted for use by local governments participating in the CDCD Manual project, as well as those who plan to prepare and implement their own design criteria and standards. The review draft of the CDCD Manual is scheduled to be completed in September 2003 (Permit Year 1) and the final manual is scheduled to be completed in September 2004 (Permit Year 2).

Year 1 (March 2003 – February 2004)
- Review existing drainage criteria and standards.
- Gather technical information on post-construction storm water management (could be accomplished through participation in NCTCOG's CDCD Manual or separately by city staff/consultant).

Year 2 (March 2004 – February 2005)
- Develop draft criteria and standards for post-construction storm water management, to include both structural and non-structural BMPs (could be accomplished through participation in NCTCOG's CDCD Manual or separately by city staff/consultant).
- Initiate review of draft criteria and standards by public works, development services, planning, engineering, administration, planning commission, and city council.
- Prepare procedures for Development Review committee.

Year 3 (March 2005 – February 2006)
- Complete review of and approve criteria and standards (either NCTCOG CDCD Manual, with amendments if necessary, or locally developed criteria and standards manual).
- Develop and adopt an ordinance requiring regulated development and redevelopment projects to comply with the criteria and standards manual, including a system of escalating penalties for noncompliance.
- Develop and adopt an ordinance for maintenance of post-construction storm water management BMPs.
- Conduct an inventory of structural BMPs located in the jurisdiction.
- Develop a program for periodic inspection of both publicly and privately owned BMPs.

Year 4 (March 2006 – February 2007)
- Implement Development Review Committee review of all regulated projects.
- Implement and enforce all applicable post-construction storm water management criteria and standards.
- Implement periodic inspection program for post-construction BMPs.

Year 5 (March 2007 – February 2008)
- Continue Year 4 activities.
- Conduct a review of program and prescribe changes for succeeding permit term if necessary.

Post-Construction Storm Water Management Program Elements

Development Review and Approval Process
- Implement a Development Review Committee to review applicable plans to ensure compliance with post-construction storm water management requirements for all regulated public and private development and redevelopment projects.
- Development Review Committee composition could include staff from development services, planning, engineering, public works, and environmental management as appropriate.
- Require a basic environmental inventory consisting of lakes, ponds, streams, drainages, wetlands, protected trees, and soils to be submitted at the earliest stages of site planning.

- Conduct a pre-platting review of development proposals early in the site planning process to outline storm water management requirements and to ensure that non-structural BMP options are fully explored.
- Require submittal of a preliminary storm water management plan including maps, drawings, narrative, and analysis of existing hydrologic conditions, post-construction hydrologic analysis, storm water management system, and downstream analysis.

Site/Project Type Applicability

- Adopt minimum regulatory requirement of addressing new development and redevelopment projects that disturb greater than or equal to one acre, including projects less than one acre that are part of a larger common plan of development or sale.
- Consider regulating new or redevelopment projects that result in the creation or addition of 5,000 square feet or greater of new impervious area.
- Consider regulating any commercial or industrial new or redevelopment, regardless of size, that is required to obtain a TPDES Multi-Sector Storm Water Permit.
- Consider placing additional requirements on specific land uses that are likely to produce higher than normal pollutant concentrations, including retail gas stations, automotive/vehicle service and repair shops, salvage yards, and waste transfer stations.

Comprehensive Storm Water Management Criteria

The following represents an integrated, comprehensive approach to managing storm water quality and quantity. Because of the synergistic nature of the criteria and multiple benefits to be gained, local governments should consider a similar approach in the management of post-construction storm water runoff. The criteria should be developed by qualified storm water staff or a consultant based on hydrologic analysis. The proposed Comprehensive Drainage and Criteria Design Manual project will result in the development of criteria based on extensive analysis of North Texas hydrology and broad input from local government storm water management professionals.

<u>Protect Water Quality</u>

- Require all regulated new and redevelopment projects to implement a combination of BMPs (non-structural and/or structural) designed to remove a specified percentage of the average annual post-construction total suspended solids (TSS) load (see note).
- Specify that a storm water management system for a site complies with the TSS removal standard if it is sized to capture and treat the runoff volume from a corresponding appropriately specified percentage of the storms that occur in an average year.

> Note: TSS was chosen as the representative storm water pollutant for establishing treatment effectiveness for the following reasons:
> - The use of TSS as an "indicator" pollutant is well established;
> - Sediment and turbidity and other pollutants that adhere to suspended solids (and are consequently removed with TSS) are a significant problem for local urban waterways.

<u>Maintain Pre-Development Hydrology</u>

- Require all regulated new and redevelopment projects to control the peak runoff for a specified range of design storm events.

<u>Prevent/Reduce Flood Damage</u>

- Require all conveyance systems to pass the runoff for a specified design storm event and prohibit development in the full buildout floodplain; and/or
- Where structures have already been built in the 100-year floodplain fringe area, require on-site or regional structural storm water controls to maintain the 100-year floodplain.

Consider Downstream Impacts

- Require all regulated new and redevelopment projects to perform a downstream hydrologic analysis to determine if there are any additional impacts not addressed through the previous criteria.
- Require the analysis to be performed at the outlet(s) of the site, and downstream at each tributary junction to the point(s) in the conveyance system where the area of each of the portion of the site draining into the system is less than or equal to a specified percentage of the total drainage area above that point.

Regulated projects are required to integrate a storm water management system consisting of non-structural and/or structural best management practices into overall layout of the project in order to meet the criteria developed by the local government. Non-structural BMPs are particularly effective since they have inherent storm water quality and quantity benefits, and in addition they reduce the runoff volume and therefore reduce the size requirements for structural BMPs (see discussion of non-structural BMPs below).

Operation and Maintenance Plans

- Require development submittals to include a plan for operation and maintenance of all structural storm water controls and drainage facilities.
- Plans should contain operation, inspection, and maintenance activities, schedule, and responsible parties; and should also address access and safety issues.
- Activities to be addressed should include vegetation maintenance, sediment removal, floatables removal, mosquito control, and outlet structure maintenance.
- Require operation and maintenance plans for structural storm water controls to be recorded with property deed and disclosed upon sale or transfer of properties.

Inspection and Enforcement

- Establish appropriate frequencies for municipal inspection during construction of storm water BMPs to ensure proper installation (i.e., once every two weeks, and/or at other required inspections).
- Conduct inspections of public and private storm water management facilities to ensure proper operation and maintenance on an annual basis (or other appropriate frequency).
- Establish procedures for issuance of warning notice of violation (with no fine associated) for first time offense.
- Establish provisions for fines for violations, with each day of noncompliance constituting a separate offense.
- Establish provisions for the local government to correct violations and charge the offender for reimbursement of costs incurred.

Non-Structural Best Management Practices

Nonstructural best management practices involve rethinking the way the built environment is planned and designed, including aspects such as minimizing impervious surfaces (reduced parking and narrower streets), building in the least sensitive areas of the site, preserving natural streams and riparian buffers, directing runoff over vegetated areas, and providing open space.

This section is organized in accordance with the Develop-*Naturally!* brochure and accompanying Guide to Developing Naturally that were prepared in response to Phase I MS4 storm water permit requirements, but are applicable to Phase II permit requirements as well. Note that the Develop *Naturally!* Brochure and Guide to Developing Naturally in North Central Texas are available on-line at www.dfwstormwater.com/enhancing.html, or may be obtained by contacting Jeff Rice, NCTCOG, at jrice@dfwinfo.com or 817-695-9212.

The Develop-*Naturally!* brochure and guide feature "Ten Keys to Developing Naturally;" keys 1 through 7 of which contain non-structural BMP elements. Under each key below, there is a brief explanation and rationale for the key followed by potential program elements, which are policies proposed for consideration by local governments. Along with each proposed program element there is a partial list of ordinances, codes, and other procedures local governments may use for implementation. In addition, providing educational materials to developers will facilitate compliance with requirements.

1. Maintain existing terrain

Incorporating the development into the existing terrain rather than regrading the site helps preserve tree canopy and other vegetative cover. Maintaining the terrain and natural drainage ways helps to reduce pollution and storm flows from the development and provides protection for environmentally sensitive features on the site.

Potential Program Elements

- Limit allowed clearing and grading to the minimum required to install the infrastructure and buildings – *Grading Ordinance, etc*
- Maintain existing natural topography and drainage patterns of land to be developed – *Drainage Manual, Design Review Meetings, etc*
- Preserve and protect as many trees as possible – *Tree Ordinance, Landscaping Ordinance*
- Avoid clearing and grading of areas with permeable soils – *Environmental Inventory, Grading Ordinance, etc*

2. Minimize impervious surfaces

Impervious surfaces are those such as roads, parking lots, driveways, and rooftops, that don't allow infiltration of storm water into the ground. The increase in storm water runoff, along with the pollutants the runoff picks up from impervious surfaces, cause major problems for our waterways. Narrower streets and smaller parking lots benefit the environment and can make a development more attractive as well.

Potential Program Elements

- Develop residential street standards for the minimum required pavement width needed to support travel lanes, on-street parking, and emergency vehicle access – *Street Specifications, Subdivision Ordinance*
- Consider limiting on-street parking to one side of the street – *Street Specifications, Subdivision Ordinance*
- Incorporate sunken landscaped islands in the middle of cul-de-sac turnarounds – *Street Specifications, Drainage Manual*
- Minimize street length by concentrating development in the least sensitive areas of site – *Zoning Ordinance*
- Reduce parking lot size by lowering the number of parking spaces (minimum and maximum ratios) and by sharing parking among adjacent businesses – *Zoning Ordinance, Development/Engineering Standards*
- Reduce parking requirements for developments in proximity to public transportation – *Zoning Ordinance*
- Provide incentives or opportunities for structured parking rather than surface parking – *Zoning Ordinance*
- Use pavers or porous pavement in parking overflow areas – *Development/Engineering Standards*
- Reduce frontage requirements in residential areas to reduce road length – *Zoning Ordinance*
- Reduce the rooftop area of buildings by constructing multiple level structures where feasible – *Zoning Ordinance*

3. Build in the least sensitive areas
By building in the least sensitive areas, negative impacts on ecologically valuable features are avoided. Areas that should be preserved include wetlands, floodplains, buffer areas adjacent to streams and lakes, prairies, and stands of mature trees. By increasing the density on the remaining portion of the property, approximately the same number of building lots or sites can be created compared to "conventional" designs.

Potential Program Elements

- Require an inventory of a site's natural features including streams, wetlands, wooded areas, and soils – *Environmental Inventory*
- Require homes, buildings, and parking lots to be located away from streams, floodplains, and other ecologically and aesthetically valuable areas – *Floodplain Regulations, Stream Corridor Ordinance, Zoning Ordinance*
- Allow higher densities in suitable areas of sites, while preserving ecologically sensitive or aesthetically valuable features as permanent open space – *Zoning Ordinance*

4. Provide open space/parks
Natural open space is extremely valuable as wildlife habitat, storm water infiltration areas, and as protective buffers for ecologically sensitive areas. Just as important, open space serves as an extension of individual residential lots. Quality open space that provides opportunities for walking, biking, bird watching, and play is becoming extremely popular with residents and homebuyers.

Potential Program Elements

- Implement a program to identify and acquire sensitive ecological areas as open space or parks – *Open Space and/or Parks Master Plan, Comprehensive Plan*
- Require a percentage of development sites to be protected as open space (10 – 20+%, net of roads, easements, floodplains, etc.) – *Zoning Ordinance*
- Require permanent protection of open space areas through acquisition or conservation easements – *Zoning Ordinance, Open Space Ordinance*
- Require developments to provide direct access to open space areas by residents and the public with trails – *Subdivision Ordinance*

5. Preserve streams and floodplains
Natural streams, floodplains, and riparian buffers are vital to the success of natural systems. Buffered with trees and vegetation, natural streams also provide extremely important aesthetic value to neighborhoods and communities. Natural, undeveloped floodplains provide storage for storm flows, minimizing downstream flooding.

Potential Program Elements

- Require streams to be maintained in a natural state, or if not possible, require use of bioengineering rather than hard armoring practices – *Drainage Manual*
- Require hydraulic analyses of streams to determine flow capacity – *Drainage Manual*
- Require vegetated and wooded riparian buffers along streams (50 feet or more on each side) – *Stream Corridor Ordinance, Subdivision Ordinance*
- Prohibit construction of structures in the "full build-out" 100-year floodplain – *Floodplain Ordinance*
- Prohibit placement of fill material in the 100-year floodplain – *Floodplain Ordinance*

6. Direct runoff over vegetated areas
Discharging runoff from roofs, roads, and parking lots onto vegetated areas, rather than directly into storm drains offers an opportunity for infiltration of storm water runoff into the ground. Infiltration of storm water runoff reduces both the quantity of water and the amount of pollutants that would otherwise reach a stream or lake. Landscaped and vegetated areas, particularly in commercial and multi-family residential settings, also provide aesthetic value.

Potential Program Elements

- Require roof drains to discharge onto vegetated areas (rather than driveways and parking lots, or plumbing to storm drains) – *Drainage Manual, Development/Engineering Standards*
- Require a minimum percentage (10 – 20+%) of a parking lot to be landscaped – *Zoning Ordinance, Development/Engineering Standards, Landscape Ordinance*
- Require runoff from parking lots to discharge as sheet flow into vegetated filter strips bordering the lot – *Drainage Manual, Development/Engineering Standards*
- Require depressed vegetated areas (bioretention) within and adjacent to parking lots, rather than raised landscaped areas, to allow runoff to infiltrate – *Development/Engineering Standards, Landscape Ordinance*
- Allow/require open drainage (vegetated swales) where feasible instead of underground storm drain systems – *Drainage Manual, Development/Engineering Standards*

7. Use Texas SmartScape plants

Landscaped areas, with all of their benefits, can also contribute to the pollution of streams and lakes if they are not managed properly. Using native plants, and those that have been adapted to the local climate and conditions, decreases the potential for water pollution by reducing the amount of water, pesticides, and fertilizer that must be applied to keep the plants healthy - and saves money. Texas SmartScape is an interactive multimedia tool on compact disk that can be used to select native and adapted plants for North Texas (more information available at www.dfwstormwater.com).

Potential Program Elements

- Require/encourage native and adapted plants in landscaped areas for commercial developments – *Landscape Ordinance*
- Encourage native and adapted plants in landscaped areas for commercial developments – *Public Education Materials*

Structural Best Management Practices

Structural BMPs such as wet ponds, infiltration basins, and sand filters are the traditional techniques used to treat storm water runoff from developments, and are generally incorporated into projects independently of other design considerations for the project. These controls generally work by capturing and holding a portion of the runoff and then releasing it slowly over a sufficient period of time to promote settling out of pollutants, resulting in improved water quality and reduce the "peak" flow from the site. Also categorized as structural BMPs, grassed channels/swales and filter strips treat storm water runoff by using vegetation to filter and settle pollutants. Swales and filter strips also function to attenuate post-development peak discharge rates for small storm events when compared to concrete channels as a result of runoff velocity reduction and limited infiltration.

Detention controls, or dry detention ponds, fill up during storms but they discharge completely and are dry during the periods between storms. With proper design and maintenance, dry ponds can be used for recreation when they are dry. Retention controls are known as wet ponds since they maintain a permanent pool of water between storms. The banks and outlet of a wet pond are constructed to provide for storage and subsequent slow release of storm water runoff. Wet ponds look much like any other pond, and with careful attention to design and maintenance, they can serve as an attractive water feature in residential and commercial developments. Infiltration basins also collect storm water runoff, but rather than release the water gradually, they hold the water and allow it (and any pollutants) to infiltrate into the ground. Proper design and construction of infiltration basins is vital to achieve treatment of polluted runoff in the soil path prior to percolation into ground water.

Land intensive or expensive structural BMPs (detention and retention ponds, infiltration basins, and sand filters) should be considered only after non-structural BMPs have been explored and implemented to the greatest extent possible. In many cases, the need for structural controls can be avoided (or they can be reduced in size) if the amount of runoff and entrained pollutants are minimized by the design of the project. Generally, it is cheaper and more effective to implement design elements that prevent or reduce the generation of storm water runoff and/or pollutants at the source.

Oil and grit separators fall into a different category of treatment device and are designed specifically to trap oil, grease, and grit, which are common pollutants generated by automobile use. Oil and grit separators should be considered for use to treat the runoff from high volume parking lots and businesses such as gas stations, car washes, or automobile service garages. Unlike the other treatment devices discussed above, oil and grit separators offer no benefits for reduction in storm water runoff volume or flow, but they may be utilized as a pretreatment device upstream of wet ponds, infiltration basins, etc.

Potential Program Elements

- Incorporate non-structural BMPs, grassed swales, and filter strips to the greatest extent possible.
- Evaluate the need for and design retention/detention ponds, sand filters, and infiltration basins after incorporation of non-structural BMPs.
- Integrate treatment controls in a manner that they function as amenities.
- Use oil and grit separators in areas where large amounts of oil and grit can be expected (parking lots with heavy automobile traffic, gas stations, service stations).

The following descriptions of structural BMPs contain links to "BMP Fact Sheets" which were developed for the NCTCOG Residential/Commercial BMP Manual. These Fact Sheets contain basic design information for structural best management practices and are included for information purposes only. These designs are nearly a decade old and no longer represent the state of the art in post-construction storm water management. The designs also lack sufficient detail to ensure proper construction and should not be adopted as part of a drainage manual or ordinance. Through the proposed Comprehensive Drainage Criteria and Design Manual project, NCTCOG intends to develop current structural (and non-structural) BMP designs specifically tailored for the North Central Texas region.

Note: for the purposes of this draft, there are no active links to BMP Fact Sheets. The BMP Fact Sheet for wet ponds is included as a separate document as a sample of the BMP Fact Sheets. The final electronic version will include live links to all BMP Fact Sheets.

Grassed Swales *(Link to BMP Fact Sheet)*
Grassed swales are storm water conveyances that are specifically designed to filter runoff as it passes through the swale. Pollutants are removed through the filtration by the grass, by deposition, and by infiltration into the soil. Grassed swales must be placed on gentle slopes to provide for shallow flow and low velocities. Grassed swales should also be used on relatively permeable soils to promote infiltration and to prevent standing water. Maintaining healthy cover of turfgrass is essential to performance of grassed swales.

Filter Strip *(Link to BMP Fact Sheet)*
Filter strips are landscaped or natural areas that filter runoff as it flows over vegetation. The vegetation can range from grasses to woody species, or a mixture of the two. They may closely resemble many natural ecosystems, such as grassy meadows or riparian forests. The dense vegetative cover facilitates sediment deposition and infiltration, thereby removing pollutants from

runoff as it flows over the filter strip. Maintaining a healthy stand of vegetation and periodic maintenance to remove rills or channels is essential to proper function of filter strips.

Sand Filter (Media Filtration) *(Link to BMP Fact Sheet)*
Sand filters are devices designed to remove pollutants from storm water runoff by passing the water through a layer of sand acting as a filter media. Sand filters typically consist of an inlet structure designed to capture runoff, a sediment chamber to remove excessive sediment, and a concrete basin or chamber to hold the filter media. Water leaving the filter is collected in pipes underlying the sand and returned to the stream or channel. Sand filters remove pollutants from runoff through the processes of sedimentation, adsorption, chemical transformation, and decomposition. Since sand filters do not provide for infiltration or detention of runoff, they do not offer any benefits with respect to downstream flooding or stream channel erosion.

Infiltration Trench *(Link to BMP Fact Sheet)*
Infiltration trenches are shallow excavated ditches that have been backfilled with stone to form an underground reservoir. Storm water runoff diverted into the trench gradually infiltrates from the trench into the subsoil and eventually into the ground water. Infiltration trenches are effective in removing both dissolved pollutants and particulates. Infiltration trenches, where feasible, are also effective in preserving pre-development hydrologic conditions on developed sites. Infiltration trenches are ideal for small drainage areas and may be used as complements to filter strips and swales.

Infiltration Basin *(Link to BMP Fact Sheet)*
Infiltration basins or ponds temporarily store storm water runoff until it gradually infiltrates into the soil surrounding the basin. Infiltration basins work on the same principle as infiltration trenches, but are designed to treat larger drainage areas, and infiltrate storm water through the basin bottom rather than a trench. Infiltration basins are effective in removing both dissolved pollutants and particulates. Infiltration basins are also effective in preserving pre-development hydrologic conditions on developed sites. Infiltration basins can serve relatively large developments (up to 50 acres in size).

Porous Pavement *(Link to BMP Fact Sheet)*
Traditional asphalt and concrete are impervious to infiltration of water, causing storm water to flow off of the road and accumulate in conveyances. Alternatively, porous pavement surfaces allow the infiltration of storm water and associated pollutants through the pavement into the ground. The most common form of pervious surface for roadway use is a coarse asphalt that has more open pore space than typical asphalt. When performing properly, porous pavement is comparable in cost and effectiveness to traditional paving techniques and associated storm water management systems.

Extended Detention Pond (Basin) *(Link to BMP Fact Sheet)*
Extended detention basins are impoundments that capture a portion of storm water runoff during a storm event and release the stored volume of water slowly over a period of time. The detention of storm water allows suspended solids, particularly sediment, to settle out of the runoff. Generally, runoff must be retained for approximately 48 hours to provide adequate settling of suspended solids. Extended detention dry basins are designed to drain completely and to remain dry between storm events. A healthy cover of turfgrass or native prairie vegetation should be maintained on the bottom and side slopes of the basin to prevent erosion.

Wet Pond *(Link to BMP Fact Sheet)*
Wet ponds are similar to extended detention basins, except that a permanent pool of water is maintained. Storage above the base pond elevation is provided to capture and temporarily store runoff and release it at a controlled rate. In addition to removal of suspended solids through sedimentation, wet ponds are effective at reducing nutrients through biological activity and uptake by aquatic plants growing in and around the edge of the pond. Wet ponds are usually designed as multi-purpose facilities to achieve pollutant removal and peak flow attenuation. Wet ponds require a year-round source of water to maintain a permanent pool of water.

Constructed Wetlands (Vegetated Treatment Pond) *(Link to BMP Fact Sheet)*
Constructed wetlands are engineered systems designed to simulate natural wetlands in their ability to capture and treat surface water runoff pollutants. Constructed urban runoff wetlands differ from artificial wetlands created to comply with mitigation requirements in that they do not necessarily replicate all of the ecological functions of natural wetlands. Constructed wetlands systems provide effective treatment of storm water runoff over a wide range of pollutant loading and hydraulic conditions. The mechanisms by which wetlands remove pollutants include a combination of sedimentation, adsorption, filtration, chemical precipitation, microbial interactions and uptake by vegetation. Harvesting of vegetation and maintenance of constructed wetlands are needed to ensure long-term effectiveness. Constructed wetlands require a year-round source of water to maintain a permanent pool of water.

Water Quality Inlet (Oil and Grit Separators) *(Link to BMP Fact Sheet)*
Water quality inlets are underground retention systems designed to remove suspended solids, oil, and grease. Water quality inlets, like ponds, rely on gravity settling and retention time to remove large particulates before discharging water to the storm sewer or other collection system. Oil and grease are trapped by allowing time for them to rise to the surface of the oil separation chamber while the water flows out at a lower level. Water quality inlets may also be designed to trap floatable trash and debris. Water quality inlets provide limited treatment of runoff from very small drainage areas. These devices must be maintained frequently to remove trapped sediment, hydrocarbons, and trash.

PHASE II BMP AND MEASURABLE GOAL EXAMPLES

POST-CONSTRUCTION STORM WATER MANAGEMENT IN NEW DEVELOPMENT/REDEVELOPMENT MINIMUM MEASURE

- EPA's Regulatory Requirements
- **BMP**: Reduce directly connected impervious surfaces through the use of low impact development and better site design techniques
- **BMP**: Develop a program for maintenance of structural storm water controls
- **BMP**: Develop and implement a storm water ordinance and guidance or a design manual that include performance standards designed to control runoff impacts

New development and significant redevelopment projects offer a host of opportunities to install structural runoff controls on both the site and regional scales.

Hypothetical Case Study: Smalltown, USA, has substantial existing development and many neighborhoods that are still growing. For existing development, the City plans to use on-lot treatment to handle some storm water by disconnecting impervious surfaces. The City also wants to ensure that existing storm water controls are functioning properly. Growing areas will also be targeted by requiring impervious area disconnection and new storm water controls.

Minimum Measure Objective: Reduce the volume and improve the quality of storm water runoff by disconnecting impervious surfaces and installing and maintaining structural storm water controls.

Top

BMP: Reduce directly connected impervious surfaces in new developments and redevelopment projects by requiring that grassed swales or filter strips be installed along roadsides in lieu of curbs and gutters
Measurable Goal: Directly connected impervious road surfaces in new developments and redevelopment areas will be reduced by 30 percent (relative to the traditional scenario in which curbs and gutters are used) over the course of the first permit term.

Justification: Opportunities abound to provide treatment and infiltration of runoff in the ght-of-way adjacent to roads. This prac would provide on-lot treatment of storm water, reduce the total volume of storm water being discharged from sites, and increase the time of concentration of the runoff that is generated from road surfaces.

Top

BMP: Develop a program for maintenance of structural storm water controls
Measurable Goals: In the first year, conduct an inventory of structural runoff controls. In year 2, develop a GIS to integrate the location of these controls with schedules for regular inspection and maintenance. Conduct four inspections of each structural control per year and conduct regular maintenance as prescribed for each type of practice.
Justification: There are many structural controls located throughout the municipality that are owned and operated by both public and private entities. Before a comprehensive maintenance plan can be implemented to address all of the practices, a complete list of BMPs and their locations and site conditions needs to be compiled. An inspection and maintenance schedule can be developed to maximize efficiency and minimize labor requirements. The system can be expanded to include other types of MS4 maintenance, including street sweeping, catch basin cleaning, storm drain flushing, etc.

Top

BMP: Develop and implement a storm water ordinance and guidance or a design manual that include performance standards designed to control runoff impacts
Measurable Goal: By year 3 of the permit term, 95% of all building permits will include descriptions and plans regarding storm water control practices and site designs that comply with the criteria and guidance specified or referenced in the municipal code.
Justification: Ordinances are an effective way to establish performance standards for runoff controls. These performance standards might, for example, specify a target for percent removal of annual post-development total suspended solids loadings, require maintenance of annual ground water recharge rates, or limit runoff volumes and rates such that receiving waters are not negatively impacted.

Top

POST CONSTRUCTION STORM WATER RUNOFF CONTROL IN NEW DEVELOPMENT / REDEVELOPMENT

List of Measurable Parameters

- Measurable Goals
- Public Outreach & Education on Storm Water Impacts
- Public Involvement/Participation
- Illicit Discharge Detection & Elimination
- Construction Site Storm Water Runoff Control
- Post Construction Storm Water Runoff Control in New Development & Redevelopment
- Pollution Prevention/Good Housekeeping for Municipal Operations
- Menu of BMPs
- Storm Water Phase II

ALTERNATIVE TURNAROUNDS

- The reduction in impervious cover.
- The number of turnarounds modified.
- Whether or not development codes were changed to allow alternative turnarounds.
- The reduction in runoff quantity.
- Changes in the physical characteristics of streams downstream from modified areas.

ALTERNATIVE PAVERS

- Whether or not development codes were changed to allow for alternative pavers.
- The amount of new alternative paver installations added or replaced.
- The number of new development sites that use alternative pavers.
- The reduction in runoff quantity.
- Changes in the physical characteristics of streams downstream from areas with alternative paver installations.

ALUM INJECTION

- Whether or not an inventory of sites where alum injection was used was completed.
- Changes in water quality.
- Changes in biological populations.

BIORETENTION

- The reduction in impervious cover.
- The reduction in runoff quantity.
- Changes in runoff water quality (nutrients, sediments, metals, organics, etc.).
- The number of new bioretention cells installed (both commercial and residential).
- The number of acres that are drained by bioretention cells.

Top

BMP INSPECTION AND MAINTENANCE

- The frequency of inspection and maintenance activities.
- The number of problems that were identified and remedied.
- The change in the proportion of BMPs that are well-maintained as a result of inspection and maintenance.

Post-Construction Storm Water Management in New Development and Redevelopment

The italicized text included below is the language for the "Post-Construction Storm Water Management in New Development and Redevelopment" Minimum Control Measure taken from EPA's Final Phase II Rule. The Final Phase II Rule establishes the minimum requirements that TNRCC will use in drafting the corresponding storm water permit for small municipalities in Texas. Cities and counties should use these requirements in planning their storm water management programs until TNRCC issues the Texas permit (TNRCC must issue the Phase II municipal storm water permit by December 9, 2002).

Following the regulatory language, NCTCOG staff has assembled some guidance materials to supplement the regulations for use by local governments in early program assessment and formulation processes. Note that this is <u>not</u> the Menu of Management Program Options for Post-Construction Storm Water Management, which will be issued at a later date.

<u>NPDES Phase II Regulatory Text</u>

You must develop, implement, and enforce a program to address storm water runoff from new development and redevelopment projects that disturb greater than or equal to one acre, including projects less than one acre that are part of a larger common plan of development or sale, that discharge into your small MS4. Your program must ensure that controls are in place that would prevent or minimize water quality impacts.

You must:

- *Develop and implement strategies which include a combination of structural and/or non-structural best management practices (BMPs) appropriate for your community;*
- *Use an ordinance or other regulatory mechanism to address post-construction runoff from new development and redevelopment projects to the extent allowable under State, Tribal or local law;*
- *Ensure adequate long-term operation and maintenance of BMPs.*

Guidance
If water quality impacts are considered from the beginning stages of a project, new development and potentially redevelopment provide more opportunities for water quality protection. EPA recommends that the BMPs chosen: be appropriate for the local community; minimize water quality impacts; and attempt to maintain pre-development runoff conditions.

In choosing appropriate BMPs, EPA encourages you to participate in locally-based watershed planning efforts which attempt to involve a diverse group of stakeholders including interested citizens. When developing a program that is consistent with this measure's intent, EPA recommends that you adopt a planning process that identifies the municipality's program goals (e.g., minimize water quality impacts resulting from post-construction runoff from new development and redevelopment), implementation strategies (e.g., adopt a combination of structural and/or non-structural BMPs), operation and maintenance policies and procedures, and enforcement procedures.

In developing your program, you should consider assessing existing ordinances, policies, programs and studies that address storm water runoff quality. In addition to assessing these existing documents and programs, you should provide opportunities to the public to participate in the development of the program.

Non-structural BMPs are preventative actions that involve management and source controls such as: policies and ordinances that provide requirements and standards to direct growth to identified areas, protect sensitive areas such as wetlands and riparian areas, maintain and/or increase open space (including a dedicated funding source for open space acquisition), provide buffers along sensitive water bodies, minimize impervious surfaces, and minimize disturbance of soils and vegetation; policies or ordinances that encourage infill development in higher density urban areas, and areas with existing infrastructure; education programs for developers and the public about project designs that minimize water quality impacts; and measures such as minimization of percent impervious area.

Introduction to Post-Construction Runoff Control BMPs

Storm water best management practices are the primary tool to improve the quality of urban streams and meet the requirements of NPDES permits. Best management practices are defined as schedules of activities, prohibitions of practices, maintenance procedures, the use of pollution control devices and other management practices or policies used to prevent or reduce the amount of pollution introduced to receiving waters from storm water runoff. Stated more simply, BMPs are devices or design considerations that are used to reduce the impacts of development or human activities on water quality. Used individually or in combination, BMPs are intended to be a cost effective, practicable means to reduce pollutants and/or the amount of runoff that reaches receiving waters.

The EPA regulations refer to two categories of best management practices, structural and nonstructural (some BMPs such as grassed swales and filter strips seem to fit into both categories). Structural best management practices are physical devices ("structures") or landscape features that remove pollutants from storm water runoff through filtration, infiltration, or detention. Structural BMPs such as wet ponds, infiltration basins, and sand filters are the traditional techniques that have been used to treat storm water runoff from developments, and are generally incorporated into projects independently of other design considerations for the project. Nonstructural best management practices are more difficult to define, but involve rethinking the way the built environment is planned and designed, including aspects such as minimizing impervious surfaces (reduced parking and narrower streets), building in the least sensitive areas of the site, preserving natural streams and riparian buffers, directing runoff over vegetated areas, and providing open space.

Management Program Considerations

In formulating a management program to address post-construction impacts, overall objectives for the program should be established for the jurisdiction. Since many of the structural and non-structural BMPs have water quantity management benefits in addition to water quality benefits, it would be useful to consider a comprehensive storm water management program that addresses multiple impacts of post-construction storm water runoff. Some of the objectives for post-construction storm water management being considered by EPA in its proposed Construction and Development Effluent Guidelines (proposed rule release deadline May 15, 2002) include*:

- remove suspended solids and associated pollutants entrained in runoff that result from activities occurring during and after development;
- decrease the erosive potential of increased runoff volumes and velocities associated with development-induced changes in hydrology;
- retain hydrological conditions to closely resemble those of the predisturbance condition;
- preserve stable, natural stream channels including in-stream habitat;
- minimize potential for flooding damage to structures.

* Based on Public Meeting Briefing Packet (and referenced document) from EPA Construction and Development Effluent Guidelines Public Meeting held in July 2001.

An effective program for managing post-construction runoff should include options for implementation of both structural and nonstructural controls. Generally, it is cheaper and more effective to implement design elements that prevent or reduce the generation of storm water runoff and/or pollutants at the source. In many cases, the need for expensive structural controls can be avoided (or they can be reduced in size) if the amount of runoff and entrained pollutants are minimized by the design of the project. Where necessary, structural BMPs used alone or in combination with nonstructural controls are an effective means of reducing the impact of development on receiving waters.

Structural Best Management Practices

Structural practices to control urban runoff rely on three basic mechanisms to treat runoff: removal of pollutants from runoff using filtration by vegetation or sand; infiltration of storm water runoff and pollutants into the ground; and detention of runoff to allow sedimentation of suspended pollutants. The following is a brief description of some of the structural BMPs used to manage post-construction storm water runoff.

Filtration BMPs

Filtration practices, such as grassed channels/swales, filter strips, and sand filters, treat storm water runoff by using vegetation or sand to filter and settle pollutants. In some cases infiltration and treatment in the subsoil may occur. Swales and filter strips also function to attenuate post-development peak discharge rates for small storm events when compared to concrete channels as a result of runoff velocity reduction and limited infiltration.

Grassed Swales

Grassed swales are storm water conveyances that are specifically designed to filter runoff as it passes through the swale. Pollutants are removed through the filtration by the grass, by deposition, and by infiltration into the soil. Grassed swales must be placed on gentle slopes to provide for shallow flow and low velocities. Grassed swales should also be used on relatively permeable soils to promote infiltration and to prevent standing water. Maintaining healthy cover of turfgrass is essential to performance of grassed swales.

Filter Strip

Filter strips are landscaped or natural areas that filter runoff as it flows over vegetation. The vegetation can range from grasses to woody species, or a mixture of the two. They may closely resemble many natural ecosystems, such as grassy meadows or riparian forests. The dense vegetative cover facilitates sediment deposition and infiltration, thereby removing pollutants from runoff as it flows over the filter strip. Maintaining a healthy stand of vegetation and periodic maintenance to remove rills or channels is essential to proper function of filter strips.

Sand Filter

Sand filters are devices designed to remove pollutants from storm water runoff by passing the water through a layer of sand acting as a filter media. Sand filters typically consist of an inlet structure designed to capture runoff, a sediment chamber to remove excessive sediment, and a concrete basin or chamber to hold the filter media. Water leaving the filter is collected in pipes underlying the sand and returned to the stream or channel. Sand filters remove pollutants from runoff through the processes of sedimentation, adsorption, chemical transformation, and decomposition. Since sand filters do not provide for infiltration or detention of runoff, they do not offer any benefits with respect to downstream flooding or stream channel erosion.

Infiltration BMPs

Infiltration practices, such as infiltration basins and trenches, and porous pavement rely on absorption of runoff into the ground to treat urban runoff discharges. Water is percolated through soils, where filtration and biological action remove pollutants. In addition to water quality benefits, infiltration

practices reduce runoff volume and peak discharge rate. Infiltration of storm water runoff helps to reduce downstream flooding and stream channel degradation and replenishes groundwater supplies, thus contributing to low stream flow augmentation. Infiltration BMPs must be built on sites where the natural permeability of the soils is high to allow for the maximum possible infiltration of water.

Infiltration Trench
Infiltration trenches are shallow excavated ditches that have been backfilled with stone to form an underground reservoir. Storm water runoff diverted into the trench gradually infiltrates from the trench into the subsoil and eventually into the ground water. Infiltration trenches are effective in removing both dissolved pollutants and particulates. Infiltration trenches, where feasible, are also effective in preserving pre-development hydrologic conditions on developed sites. Infiltration trenches are ideal for small drainage areas and may be used as complements to filter strips and swales.

Infiltration Basin
Infiltration basins or ponds temporarily store storm water runoff until it gradually infiltrates into the soil surrounding the basin. Infiltration basins work on the same principle as infiltration trenches, but are designed to treat larger drainage areas, and infiltrate storm water through the basin bottom rather than a trench. Infiltration basins are effective in removing both dissolved pollutants and particulates. Infiltration basins are also effective in preserving pre-development hydrologic conditions on developed sites. Infiltration basins can serve relatively large developments (up to 50 acres in size).

Porous Pavement
Traditional asphalt and concrete are impervious to infiltration of water, causing storm water to flow off of the road and accumulate in conveyances. Alternatively, porous pavement surfaces allow the infiltration of storm water and associated pollutants through the pavement into the ground. The most common form of pervious surface for roadway use is a coarse asphalt that has more open pore space than typical asphalt. When performing properly, porous pavement is comparable in cost and effectiveness to traditional paving techniques and associated storm water management systems.

Detention BMPs
Detention practices temporarily impound runoff to control runoff rates and to provide time to allow for settling of suspended solids and associated pollutants. Extended detention basins, wet ponds, and constructed wetlands fall within this category. Detention practices remove storm water pollutants primarily by allowing for sedimentation (gravitational settling of suspended solids). Pond vegetation can also help reduce nutrient loads and also provide terrestrial and aquatic wildlife habitat. In addition to water quality benefits, properly designed detention structures protect downstream channels by controlling peak discharge rates, thereby reducing the frequency of bankfull flooding and resultant stream bank erosion.

Extended Detention Dry Basin
Extended detention basins are impoundments that capture a portion of storm water runoff during a storm event and release the stored volume of water slowly over a period of time. The detention of storm water allows suspended solids, particularly sediment, to settle out of the runoff. Generally, runoff must be retained for approximately 48 hours to provide adequate settling of suspended solids. Extended detention dry basins are designed to drain completely and to remain dry between storm events. A healthy cover of turfgrass or native prairie vegetation should be maintained on the bottom and side slopes of the basin to prevent erosion.

Wet Pond
Wet ponds are similar to extended detention basins, except that a permanent pool of water is maintained. Storage above the base pond elevation is provided to capture and temporarily store runoff and release it at a controlled rate. In addition to removal of suspended solids through sedimentation, wet ponds are effective at reducing nutrients through biological activity and uptake by aquatic plants growing in and around the edge of the pond. Wet ponds are usually designed as multi-

purpose facilities to achieve pollutant removal and peak flow attenuation. Wet ponds require a year-round source of water to maintain a permanent pool of water.

Constructed Wetlands
Constructed wetlands are engineered systems designed to simulate natural wetlands in their ability to capture and treat surface water runoff pollutants. Constructed urban runoff wetlands differ from artificial wetlands created to comply with mitigation requirements in that they do not necessarily replicate all of the ecological functions of natural wetlands. Constructed wetlands systems provide effective treatment of storm water runoff over a wide range of pollutant loading and hydraulic conditions. The mechanisms by which wetlands remove pollutants include a combination of sedimentation, adsorption, filtration, chemical precipitation, microbial interactions and uptake by vegetation. Harvesting of vegetation and maintenance of constructed wetlands are needed to ensure long-term effectiveness. Constructed wetlands require a year-round source of water to maintain a permanent pool of water.

Water Quality Inlet
Water quality inlets are underground retention systems designed to remove suspended solids, oil, and grease. Water quality inlets, like ponds, rely on gravity settling and retention time to remove large particulates before discharging water to the storm sewer or other collection system. Oil and grease are trapped by allowing time for them to rise to the surface of the oil separation chamber while the water flows out at a lower level. Water quality inlets may also be designed to trap floatable trash and debris. Water quality inlets provide limited treatment of runoff from very small drainage areas. These devices must be maintained frequently to remove trapped sediment, hydrocarbons, and trash.

Non-Structural Best Management Practices

Note: The following was adapted from the *Georgia Stormwater Management Manual, Volume 1*, and serves as a tool for assessing your current development regulations/policies and for considering future nonstructural practices (referred to as Better Site Design Practices) that *could* be included in your storm water management plan.

Implementing Stormwater Better Site Design Practices
Communities should actively promote the use of stormwater better site design as a way to both protect watersheds and water resources, and implement cost-effective and lower maintenance stormwater management. However, in order to make better site design a reality, local jurisdictions will often need to review their regulations, development rules, community plans and review procedures to ensure that they support the better site design concepts outlined above.

Often, communities have in place development rules that work against better site design and create needless impervious cover and unnecessary environmental impact. Examples include the minimum parking ratios that many communities require for retail or commercial development and zoning restrictions that limit cluster development designs. Some of the policy instruments that need to be reviewed for compatibility with the better site design principles include:

- Zoning Ordinances and Procedures
- Subdivision Codes
- Stormwater Management or Drainage Criteria
- Tree Protection or Landscaping Ordinance
- Buffer and Floodplain Regulations
- Erosion and Sediment Control Ordinance
- Grading Ordinance
- Street Standards or Road Design Manual
- Parking Requirements

- Building and Fire Regulations and Standards
- Septic/Sanitary Sewer Regulations
- Local Comprehensive Plan

Below is a set of questions that can be used to review a community's local development codes and ordinances with the goal of making it easier to implement stormwater better site design.

Conservation of Natural Features and Resources	**Land Conservation Incentives** • Does the community have a viable greenspace (or open space) program (acquisition, requirements in zoning ordinance, etc.)? • Are there any incentives to developers or landowners to preserve non-regulated (i.e., floodplain) land in a natural state (density bonuses, conservation easements, stormwater credits or lower property tax rates)?
	Natural Area Conservation • Are there any requirements, incentives, or provisions for preservation of important or sensitive environments (mature forests, wetlands, etc.)? • Are there requirements to maintain streams in their natural conditions? What exceptions are allowed? • Is there an ordinance or requirements for the preservation of natural vegetation on development sites?
	Tree Conservation • Does the community have a tree protection ordinance?
	Stream Buffers • Are there requirements to maintain a stream buffer? What is the minimum width? • Do the stream buffer requirements include lakes, freshwater wetlands, or steep slopes? • Do the stream buffer requirements specify that at least part of the buffer be maintained with undisturbed vegetation?
	Floodplains • Does the community restrict or discourage development in the full buildout 100-year floodplain?
	Steep Slopes • Does the community restrict or discourage building on steep slopes?
Lower Impact Site Designs	**Fitting Site Designs to the Terrain** • Does the community provide preconsultation meetings, joint site visits, or technical assistance with site plans to help developers best fit their design concepts to the topography of the site and protect key site resources?
	Clearing and Grading • Are there development requirements that limit the amount of land that can be cleared in a multi-phase project?
	Locating Development in Less Sensitive Areas • Does the community actively try to plan and zone to keep development out of environmental sensitive areas?
	Open Space Development • Are open space or cluster development designs allowed? • Are the submittal or review requirements for open space designs greater than those for conventional development? • Are flexible site design criteria (e.g. setbacks, road widths, lot sizes) available for developers who utilize open space or cluster design approaches? • Does a minimum percentage of the open space have to be managed in an undisturbed natural condition? • Does the community have enforceable requirements to establish associations that can effectively manage open space?
	Nontraditional Lot Designs • Are nontraditional lot designs and shapes allowed?

	Creative Development Design • Does the community allow and/or promote Planned Unit Developments (PUD's) that give the developer or site designer additional flexibility in site design?
Reduction of Impervious Cover	**Roadway Length** • Do road and street standards promote the most efficient site and street layouts that reduce overall street length?
	Roadway Width • What is the minimum pavement width allowed for streets in low density residential developments that have less than 500 average daily trips (ADT)?
	Building Footprint • Does the community provide options for taller buildings and structures which can reduce the overall impervious footprint of a development?
	Parking Footprint • What is the minimum parking ratio for a professional office building (per 1000 ft 2 of gross floor area)? Is there a maximum parking ratio in addition to the minimum? • What is the minimum parking ratio for shopping centers (per 1000 ft^2 of gross floor area)? Is there a maximum parking ratio in addition to the minimum? • What is the minimum required parking ratio for single family homes? • If mass transit is provided nearby, are parking ratios reduced? • What is the minimum stall width for a standard parking space? • What is the minimum stall length for a standard parking space? • Are larger commercial parking lots required to have smaller dimensions for compact cars? • Is the use of shared parking arrangements promoted? • Are there any incentives to developers to provide parking within structured decks or ramps rather than surface parking lots? • Can porous surfaces be used for overflow parking areas? • Is a minimum percentage of a parking lot required to be landscaped? • Is the use of bioretention islands and other structural control practices within landscaped areas or setbacks allowed?
	Setbacks and Frontages • Are minimum frontage and setback requirements excessive?
	Alternative Cul-de-sacs • What is the minimum radius allowed for cul-de-sacs? • Can a landscaped island or bioretention area be created within a cul-de-sac? • Are alternative turnarounds such as "hammerheads" allowed on short streets in low density residential neighborhoods?
Utilization of Natural Features for Stormwater Management	**Using Natural Drainageways** • Are storm sewer systems required for all new developments? Are natural systems allowed?
	Using Vegetated Swales • Are curb and gutters required for residential street sections? • Are there design standards for the use of vegetated swales instead of curb and gutter?
	Rooftop Runoff • Are there incentives or requirements for rooftop runoff to be discharged to pervious areas? • Do current grading or drainage requirements allow for temporary ponding of runoff on lawns or rooftops?

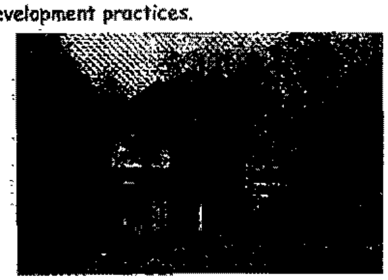
A Guide to Developing Naturally
In North Central Texas

A companion guidebook to the DEVELOP - *NATURALLY!* brochure

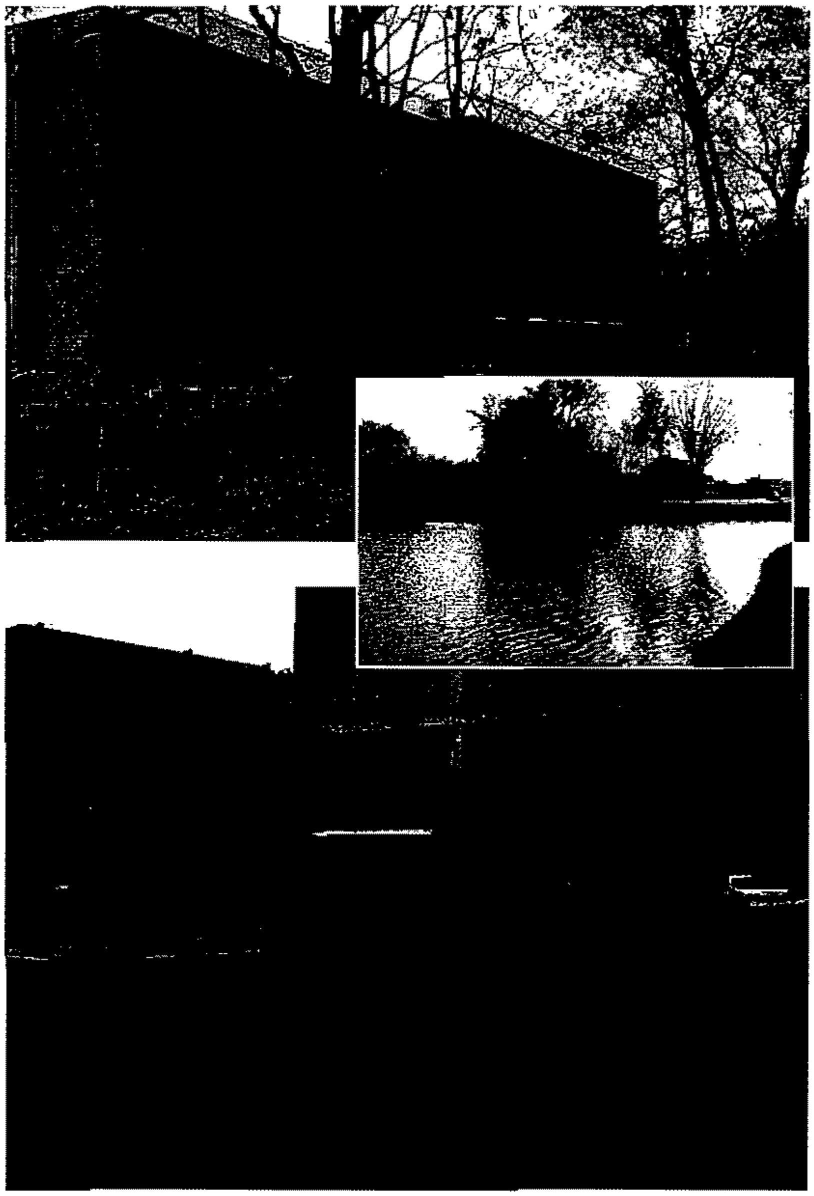
DEVELOP - *NATURALLY!*

What is Land Development? According to Webster's Dictionary, it is to make the land (the surface of the earth and all its natural resources) suitable for residential or commercial purposes. North Central Texas has been blessed with an abundance of land to develop and a current economy that is second to none. Development is necessary for the economic viability of this region but, as we are learning, how this "development" occurs has a profound impact on the natural environment.

We are seeing the consequences of our thriving economy and our development practices on the environment we live in. Some of our most precious natural resources such as the Trinity River, the Ancient Cross Timbers Forest, and our area lakes are being threatened due to impaired water quality and loss of habitat. North Central Texas has a great natural heritage that can be preserved by environmentally sensitive development practices.



Many of the practices for minimizing the impact of development can have benefits for the developer in terms of reduced cost *and* in attracting potential buyers by incorporating features that buyers reportedly consider



Produced by the North Central Texas Council of Governments and the local governments participating in the Regional Storm Water Management Program

Draft

A Guide to Developing Naturally In North Central Texas

Why develop naturally?
Over the last several years, a number of issues have arisen concerning where and how we develop. Many of these issues have grown out of a dissatisfaction with the predominant pattern of development that has occurred over the last fifty or so years. Nearly total dependence on the automobile for travel has resulted in traffic jams and air pollution. Ubiquitous designs for discount stores and fast food restaurants have eliminated local or regional character. Neighborhoods lack a sense of community. Open spaces vanish as suburbs spread farther out into fields and woodlands. Natural streams are channelized when increased runoff from development exceeds the capacity of the natural drainage features. Pollutants from parking lots, roads, and lawns are washed into streams and lakes by storm water runoff.

Who's concerned about the problems?
Increasingly, residents and regulators alike are trying to seek out alternatives to a form of development that has exhibited many shortcomings. Sustainable Development, Smart Growth, New Urbanism, Traditional Neighborhood Development, and Transit-Oriented Development are some of the initiatives that are being promoted nationally in response to what many view as a serious concern. State and federal environmental regulatory agencies are imposing strict requirements to improve air quality and threatening sanctions that include withholding transportation funding to cities that violate Clean Air Standards. Water quality regulations are being expanded to include storm water runoff from small and medium sized cities in urbanized areas in addition to the larger cities, which have been regulated for some time. Phase I and Phase II storm water regulations require cities to modify development practices in their jurisdictions to reduce pollution in runoff from developed areas.

What changes need to be made?
Principles associated with the various progressive development initiatives and regulations differ somewhat, but most share a number of guidelines either as central components or peripheral elements. Land and infrastructure should be used efficiently and provide for alternatives to automobile travel. This generally entails building at higher density (on average) within or adjacent to areas with existing infrastructure. Shops, offices, residences, and schools should be located near to each other to promote walking, biking, or transit usage. Developments should be designed and oriented to pedestrians, rather than the automobile. Narrower streets, windows or porches facing the street, sidewalk amenities, landscaping, and detailed building designs all serve to create an inviting, human-scale atmosphere.

What about neighborhoods?
Residential developments should include amenities such as open space, parks, natural areas and be designed to promote walking or biking. Environmentally sensitive or valuable features such as streams and wetlands should be protected and a natural buffer maintained. Removal of mature trees should be minimized and they should be adequately protected during construction. Neighborhoods should be designed at a human scale with reduced setbacks and narrower streets to encourage interaction between neighbors and make the street pedestrian-friendly. Small, community-oriented commercial areas that provide services such as groceries, dry cleaning, boutiques, and restaurants should be located within walking or biking distance.

What does the consumer want?
Surveys of homebuyer preferences demonstrate widespread support for many of the features outlined. A recent national survey exploring the values of homebuyers determined that a majority rated the following amenities as "extremely important:"

Natural, open space	77%	Clustered retail stores	55%
Walking and biking paths	74%	Wilderness areas	52%
Gardens with native plants	56%	Interesting little parks	50%

In the commercial arena, new town centers and "lifestyle shopping centers" that feature mixed uses such as hotel, office, entertainment, retail, and housing are becoming increasingly popular. Addison Circle in Addison, Legacy Town Center in Plano, and North Richland Hills Town Center in North Richland Hills are local examples of this new trend in development.

Are there advantages for developers?
Fortunately, these design techniques offer benefits to developers as well as to residents and the environment. Developments that incorporate these features will command premium prices and attract buyers. One study found that residents are willing to pay an average premium of 11% to live in neighborhoods that are designed to be walkable and compact, with high quality public spaces and a mix of uses. According to a market researcher, "The amenities that top the list for every demographic group, such as trails, pocket parks and open spaces, are actually some of the least expensive for a developer to include."

Density bonuses offered by cities in return for land set aside as open space can offset the reduction in area that would have otherwise been built upon, resulting in no net loss or only minimal loss of building lots. In addition, by constructing more compact neighborhoods with narrower streets and by incorporating other design features, costs for roads and storm drain systems can be reduced substantially.

Take a serious look at the ***Ten Keys to Developing Naturally*** and see how they can help you meet your objectives and improve our environment. Naturally North Central Texas is going to develop -- so let's do it *naturally!*

Ten Keys to Developing Naturally

Key 1: Maintain existing terrain

By maintaining the existing terrain of the land to the greatest extent practical, rather than regrading the property, many objectives are achieved. More of the native vegetation, including stands of mature trees can be preserved. The capacity of soils to infiltrate storm water is maintained if it is not compacted by construction traffic. Minimizing the area disturbed during construction results in less soil erosion and less sediment entering streams. Natural drainage systems can be utilized and integrated into the comprehensive storm water management system, helping to maintain predevelopment runoff regimes.

Recommendations
- Limit clearing and grading to the minimum required to install the infrastructure
- Clear individual building lots immediately prior to building construction

- Maintain existing natural topography and drainage patterns
- Preserve and protect as many trees as possible
- Avoid clearing and grading of areas with permeable soils

Key 2: Minimize impervious surfaces

Impervious surfaces are those such as roads, parking lots, driveways, and rooftops, that do not allow any infiltration of storm water into the soil. All rainfall that lands on impervious surfaces becomes runoff, which can pick up pollutants on the way to the nearest stream or lake. The extra quantity of water that runs off of impervious surfaces causes streambank erosion and habitat degradation and can also result in downstream flooding.

Excessively wide roads and oversized parking lots also detract from the aesthetic value of neighborhoods and commercial centers. Wide residential streets result in higher traffic speeds, creating dangerous conflicts between cars and residents, particularly children. Cul-de-sacs with their large turn around circles generate lots of storm water and reduce the connectivity of the street network.

Recommendations
- Reduce residential street widths
- Use cul-de-sacs sparingly and incorporate sunken landscaped islands in the middle of turnarounds where cul-de-sacs cannot be avoided
- Minimize street length by concentrating development in least sensitive areas
- Reduce parking lot size by lowering the number of parking spaces and by sharing parking among adjacent businesses
- Use pavers or porous pavement in parking overflow areas
- Reduce the rooftop area of buildings by constructing multiple level structures where feasible

Key 3: Build in the least sensitive areas

Concentrating development in the least environmentally sensitive areas of the property allows natural areas to maintained as open space. Building at higher density in the portion that is developed can result in minimal loss of building lots compared to conventional subdivision layouts. Consumers are accepting of smaller lot sizes if the development is well designed and open space and recreation amenities (walking and biking trails, small parks, etc.) are provided. The commonly held areas essentially become an extension of the individual lot, beyond what would be affordable by individual homeowners, and without the headache of maintaining a large lot. Studies indicate that homebuyers will pay a premium for lots adjacent to natural open space, and that such properties appreciate at higher rates than those in typical subdivisions.

By building in the least sensitive areas, direct impacts from construction activities on ecologically valuable features are avoided. Physical separation also allows for control of runoff from the completed development in order to minimize impacts, both in terms of the quantity of the runoff and the pollutants carried by the runoff. Areas that should be preserved include wetlands, floodplains, buffer areas adjacent to streams and lakes, prairies, and stands of mature trees. In addition, areas with highly permeable soils should be considered for preservation to allow for infiltration of storm water.

Recommendations:
- Conduct an inventory of the property's natural features including streams, wetlands, wooded areas, and soils
- Locate homes, buildings, parking lots away from streams, floodplains, and other ecologically and aesthetically valuable areas
- Build at higher density in suitable areas, while preserving sensitive or valuable features as permanent open space

Key 4: Provide open space/parks

Natural open space is extremely valuable as wildlife habitat, storm water infiltration areas, and as protective buffers for ecologically sensitive areas. Just as importantly, open space serves as an extension of the individual residential lot. Natural open space is visually appealing, as it breaks up the endlessly monotonous pattern of rows and rows of houses. Open space and "pocket" parks provide opportunities for recreation including walking, biking, and bird watching, and play.

Common open space and pocket parks within neighborhoods are particularly appealing to families with children. Younger children can play in playgrounds with other children under the supervision of parents. Parents may allow older children more freedom to play and explore without direct supervision since trails and open spaces are generally located away from traffic and the frequent presence of neighbors provides a measure of security.

Open space sells. Homebuyer preference surveys show that people want open space and recreation facilities within their neighborhoods. Studies also indicate that homebuyers will pay a premium for lots adjacent to natural open space, and that such properties appreciate at higher rates than those in typical subdivisions. Clearly, providing open space in neighborhoods is a win-win proposition.

Open space must be protected from further development in the future by placing a permanent conservation easement on the land. Conservation easements run with the deed to the property and are held by the city or county or nonprofit organization. The conservation easement must specify that the property is to remain undeveloped and must also list what activities are permitted. Ownership of open space and parks should be transferred to a homeowner association, a land trust, or the city. The city will also require that a management plan outlining maintenance activities and responsibilities be submitted and approved as part of the plat approval process.

<u>Recommendations</u>
- Set aside ecologically sensitive or aesthetically valuable areas
- Protect open space areas through conservation easements or by transferring ownership to the city
- Incorporate recreation facilities including walking and biking trails and playground equipment

Key 5: Preserve streams and floodplains

Natural streams, floodplains, and riparian buffers are vital to the success of natural systems. Buffered with trees and vegetation, natural streams provide extremely important aesthetic value to neighborhoods and communities. Natural, undeveloped floodplains provide storage for storm flows, minimizing downstream flooding impacts. Streams, be they natural, tree lined watercourses or concrete drainage ditches are a major indicator of the character of a community.

Maintaining streams and floodplains in their natural condition should be a guiding principle for high quality development projects, which will in turn influence many of the design decisions that follow. In order to maintain viable natural streams, runoff from developments must be controlled. Stream channels can be severely degraded by erosion if post-development storm water flows are significantly higher than predevelopment flows. Many of the keys to developing naturally, including limiting impervious surfaces, providing open space and buffers for infiltration of storm water runoff, maintaining existing terrain, and others must be implemented to some extent if natural streams are to be capable of handling storm flows from developed areas.

Recommendations

- Conduct hydraulic analyses of streams to determine flow capacity
- Maintain vegetated and wooded riparian buffers along streams (100 feet or more recommended)
- Incorporate other keys to developing naturally into project designs to attenuate storm water flows
- Locate all structures out of the *full build-out* 100 year-floodplain
- Do not place any fill material in the 100-year floodplain

Key 6: Direct runoff over vegetated areas

Discharging runoff from roofs, roads, and parking lots into vegetated areas, rather than directly into storm drains offers an opportunity for infiltration of storm water runoff into the ground. Infiltration of storm water runoff reduces both the quantity of water and the amount of pollutants that would otherwise reach a stream or lake. For the runoff that exceeds the infiltration capacity of the soil, the vegetation through which the storm water runoff flows can trap and remove suspended pollutants before the flow reaches a water body.

There are several ways in which this can be accomplished. For rooftops, downspouts should be directed onto grassed areas rather than onto driveways or parking lots. Runoff from parking lots should be also discharged to grassed areas, which are referred to as vegetated filter strips. Filter strips function well when runoff enters and flows across as a "sheet" of water, rather than as a deeper, fast moving channel of water. Vegetated swales, which are engineered to accomplish both infiltration and filtration of concentrated runoff, can be used in lieu of underground piping for conveyance of storm water runoff once it collects into a concentrated flow of water.

Landscaped and vegetated areas, particularly in commercial and multi-family residential settings, also provide an attractive visual buffer to break up the monotonous pattern of buildings and parking lots. Significant areas of grass, trees, and shrubs also serve to reduce temperatures compared to vast expanses of asphalt and concrete under the hot Texas sun. With proper design, and accompanied by other design considerations such as reducing overall impervious surface, etc., vegetated filter strips and vegetated swales can reduce storm drain infrastructure costs as well.

Recommendations
- Direct roof drains onto vegetated areas rather than driveways or parking lots
- Discharge runoff from parking lots as sheet flow into vegetated filter strips bordering the lot
- Incorporate depressed, vegetated areas within parking lots, rather than raised landscaped areas to allow runoff to infiltrate
- Use open drainage (vegetated swales) where feasible instead of underground storm drain systems

Key 7: Use native and adapted plants

Landscaped areas, with all of their benefits, can also contribute to the pollution of streams and lakes if they are not managed properly. The use of plants that are not well suited to the climate and conditions in North Texas can result in the need for frequent use of pesticides and fertilizer to maintain the plants in a healthy condition. What's good for the plants, however, can be damaging to the environment and to human health as well.

The application of insecticides ends up killing not only the "bad" insects, but also the beneficial ones, such as bees, butterflies, and earthworms. Anything eating the poisoned insects such as amphibians, lizards, birds and mammals will also ingest these toxins. In addition, pesticides applied to landscape plants and lawns can be washed into water bodies by storm water runoff, where impacts to aquatic life can occur. Pesticides also present a possible health risk to humans, particularly to children who might play on recently treated lawns.

Fertilizer causes problems as well when it runs off of lawns and landscaped areas and into local waterways. The extra nutrients may cause aquatic plants (including algae) to experience rapid growth. Under the right conditions, these plant and algae "blooms" can reduce oxygen levels in the water and kill fish. Another consideration is that landscaped areas must be covered, either with plants or with mulch in order to prevent soil erosion. Sediment washed into waterways is a form of pollution that needs to be controlled.

The use of native plants, and those that have been adapted to the local climate and conditions, save money by reducing the amount of water, pesticides, and fertilizer that must be applied to keep the plants healthy.

Recommendations
- Use native and adapted plants for their natural resistance to pests and drought tolerance
- Reduce the use of pesticides, fertilizer, and water for irrigation
- Maintain vegetated areas in good condition to reduce soil erosion

Key 8: Consider ways to reduce car travel

Automobiles impact the environment in a number of ways, both directly and indirectly. Most people are aware that automobiles are a major source of air pollution. In the DFW region, car exhaust accounts for almost one-half of the chemicals that contribute to the creation of ozone in the lower atmosphere. Ozone pollution causes a number of health problems including respiratory system irritation, inflammation and damage to the lining of the lungs, and increased asthma attacks. As population in the region increases, more cars on the road, more congestion, and longer commutes will lead to more air pollution and more health problems as a result.

Many are unaware however, that cars are a significant contributor of pollutants that can negatively impact water quality. Petroleum products including gasoline, oil, and grease drip from cars onto roads and parking lots and are then carried into waterways by storm water runoff. Metals such as zinc, lead, copper, cadmium, copper, chromium, and nickel are also used in various car parts that are deposited on roads and parking lots as the parts wear.

Indirectly, automobiles contribute to damage of the environment as a result of the sheer magnitude of impervious surfaces that are required for the operation and parking of vehicles. Roads, parking lots, and driveways generate a tremendous amount of runoff that threatens the equilibrium of natural streams. If runoff from impervious surfaces is not managed properly, natural channels will be overloaded by storm water runoff, requiring that they be converted to concrete drainageways.

The most effective option for reducing the impact on streams is to minimize impervious surfaces, rather than just attempt to manage the runoff by the use of expensive control measures such as retention or detention ponds. In order to reduce the need for more highways, wider streets, and expansive parking lots, alternative to automobile travel must become more feasible for travelers. Incorporating walking and biking trails that feed into a broader network of bicycle and pedestrian transportation facilities is one way to provide alternatives to car use.

Other design options are also effective in reducing automobile travel. Locating concentrated developments near transit facilities gives residents the option to use public transportation rather than their personal vehicle for trips to work, shop, etc. Designing mixed-use developments in which residences, shops, and schools are in close proximity promotes walking to the nearby corner store, restaurant or school. In addition to the water quality benefits, alternatives that reduce automobile travel will result in less vehicle emissions.

All of these options serve to reduce the vast and expensive infrastructure required to support automobile travel and will result in improvements in air and water quality and corresponding benefits for human health. As is the case with many of the keys to developing naturally, the principles outlined here are popular with homebuyers. Homebuyer preference surveys demonstrate there is a strong desire among consumers for walking and biking trails and clustered retail stores in neighborhoods. Everyone wins when developments and transportation systems are designed to meet the needs of people first and automobiles are given secondary consideration.

Recommendations

- Provide walking and biking trails in neighborhoods
- Design and build mixed-use developments that incorporate residential and commercial areas that are within walking or biking distance of each other
- Develop near transit lines/facilities
- Develop at sufficient density to support practical transit usage

Key 9: Incorporate detention/retention controls

There have been a number of changes in the way in which storm water runoff from developed areas is managed. The traditional approach has been to develop with little regard for storm water other than to construct drainage systems that move the water off the site as quickly as possible. More recently, devices have been used (to varying degrees in different parts of the country) for controlling the rate of flow and timing of storm water leaving the site, and in some cases to reduce the amount of pollutants in the runoff as well. These controls generally work by capturing and holding a portion of the runoff and then releasing it slowly over a sufficient period of time to reduce the "peak" flow from the site. As mentioned, the controls are sometimes designed to hold the runoff long enough to permit settling out of some of the pollutants so that water quality is improved at the same time.

Detention controls, or dry detention ponds, fill up during storms, but they discharge completely and are dry during the periods between storms. Dry ponds have grassed bottoms, and with proper maintenance, can be used for recreation when they are dry. Retention controls are known as wet ponds since they maintain a permanent pool of water between storms. The banks and outlet of a wet pond is constructed to provide for storage and subsequent slow release of storm water runoff. Wet ponds look much like any other pond and with careful attention to design and to maintenance, they can serve as an attractive water feature in residential and commercial developments.

Detention and retention controls should be considered only after all other keys for developing naturally have been explored and implemented to the greatest extent possible. In many cases, the need for these "treatment" or "structural" controls as they are sometimes referred to can be avoided altogether, or they can be reduced in size if the amount of runoff and entrained pollutants are minimized by the design of the project. Generally, it is cheaper and more effective to implement design elements that prevent or reduce the generation of storm water runoff and/or pollutants at the source. However, should factors beyond the control of the developer preclude the full use of other *Keys*, detention/retention controls should be incorporated into the project.

Recommendations

- Incorporate the other *Keys to developing naturally* to the greatest extent possible
- Evaluate the need for retention/detention controls based on inclusion of other design elements for reducing storm water impacts
- Integrate retention/detention controls in a manner that they function as amenities

Key 10: Use slotted grates to remove trash

Trash that ends up in streams and lakes is more than an eyesore, it can affect water utilities, residents, and wildlife. Removal of trash and debris is time consuming and expensive for local governments once it is in the waterway. Prevention is the preferable approach to litter control.

In commercial areas, slotted grates can be very effective in preventing trash and debris from entering the storm drain system and being discharged into streams and lakes. More advanced storm drain inserts can also trap oil, grease, and grit. These devices are appropriate for high volume parking lots and businesses such as gas stations, car washes, or automobile service garages. Generally, grates or inserts are not appropriate for use in residential areas (except perhaps apartments) because of the lack of an on-site maintenance staff.

Recommendations

- Place slotted grates in storm drain inlets in commercial areas to capture trash and debris

- Use storm drain inserts (oil and grit separators) in areas where large amounts of oil and grit can be expected (parking lots with heavy automobile traffic, gas stations, service stations, etc.)
- Ensure that the facility owner is aware of maintenance requirements

For more information:

Organization	**Internet Address**	
North Central Texas Council of Governments	www.dfwstormwater.com	
Publications	**Availability**	**Keys**
Storm Water Quality Best Management Practices for Residential and Commercial Land Uses in North Central Texas, July 1993	Ordering information at http://dfwstormwater.com	6, 9, 10
Texas SmartScape CD	(Same as above)	7

Organization	**Internet Address**	
Low-Impact Development Center	http://lowimpactdevelopment.org	
Publications	**Availability**	**Keys**
Low-Impact Development Design Strategies: An Integrated Design Approach, Prince George's County, Maryland, June 1999	Downloadable in pdf format	1, 2, 5, 6, 9

Organization	**Internet Address**	
Center for Watershed Protection	www.cwp.org	
Publications	**Availability**	**Keys**
Better Site Design: A Handbook for Changing Development Rules in Your Community (August 1998)	Ordering information at organization web site	1, 2, 3, 4, 5, 6, 8, 9
Nutrient Loading from Conventional and Innovative Site Development, July 1998	Ordering information at organization web site	2, 3, 4, 5, 6, 9

Organization	**Internet Address**	
Maryland Department of the Environment	www.mde.state.md.us	
Publications	**Availability**	**Keys**
2000 Maryland Stormwater Design Manual Volumes I & II	Downloadable in pdf format	1, 2, 3, 4, 5, 6, 8, 9

Organization	**Internet Address**	
New Urban News	www.newurbannews.com	
Publications	**Availability**	**Keys**
The New Urbanism and Traditional Neighborhood Development: Comprehensive Report and Best Practices Guide	Ordering information at organization web site	2, 3, 4, 5, 8
New Urban News Magazine	Ordering information at organization web site	2, 3, 4, 5, 8

Organization	Internet Address	
Smart Growth America	www.smartgrowthamerica.com	
Publications	**Availability**	**Keys**
Greetings from Smart Growth America	Downloadable in pdf format	1, 2, 3, 4, 5, 8

Organization	Internet Address	
Nonpoint Education for Municipal Officials	www.canr.uconn.edu/ces/nemo	
Publications	**Availability**	**Keys**
Numerous free and low-cost brochures on alternative site design	Ordering information at organization web site	Various

Organization	Internet Address	
American Planning Association	www.planning.org	
Publications	**Availability**	**Keys**
Best Development Practices, Reid Ewing, APA Planners Press, 1996.	Ordering information at www.planning.org/bookstore	Various
The Principles of Smart Development, 1998	Ordering information at www.planning.org/bookstore	1, 2, 3, 4, 5, 6, 8, 9
Conservation Design for Subdivisions: A Practical Guide to Creating Open Space Networks, Randall Arendt, 1996	Ordering information at www.planning.org/bookstore	1, 2, 3, 4, 5, 6, 8, 9
The Next American Metropolis: Ecology, Community, and the American Dream, Peter Calthorpe, 1993.	Ordering information at www.planning.org/bookstore	2, 3, 4, 5, 8

Web Document	Internet Address	Keys
Texas Nonpoint Source Book	www.txnpsbook.org	Various

Organization	Internet Address	
Atlanta Regional Commission	www.atlantaregional.com/design manual	
Publications	**Availability**	**Keys**
Georgia Stormwater Management Design Manual, Draft, May 2000.	Downloadable in pdf format	1, 2, 3, 4, 5, 6, 8, 9

In cooperation with the North Central Texas Council of Governments

Municipal Stormwater Monitoring Program, Dallas-Fort Worth Area, Texas—Summary of Sampling, February 1997–February 2000

During 1992–94, the U.S. Geological Survey (USGS), in cooperation with the North Central Texas Council of Governments (NCTCOG) collected stormwater runoff data for the cities and Texas Department of Transportation (TxDOT) Districts in the Dallas-Fort Worth (DFW) area to meet the regulatory requirements of the application phase for the National Pollutant Discharge Elimination System (NPDES) stormwater permit. The Phase I permit requirements applied to cities with populations of 100,000 or greater and to TxDOT districts with population centers of 100,000 or greater (U.S. Environmental Protection Agency, 1990). The following cities and districts in the DFW area met the population criteria: Arlington, Dallas, Fort Worth, Garland, Irving, Mesquite, Plano, TxDOT Dallas District, and TxDOT Fort Worth District. The permit applications were submitted to the U.S. Environmental Protection Agency (EPA) for approval.

Beginning in 1997, the approved stormwater discharge permits were issued to the seven cities and two TxDOT districts that required a permit-compliance phase with additional sampling for a 5-year period. In 1997, the USGS began a study in cooperation with the NCTCOG to collect stormwater samples and characterize stormwater runoff for the seven cities and two TxDOT districts for the period 1997–2001. At the end of the 5-year permit-compliance phase, the EPA will transfer the stormwater discharge permits to the Texas Natural Resource Conservation Commission for

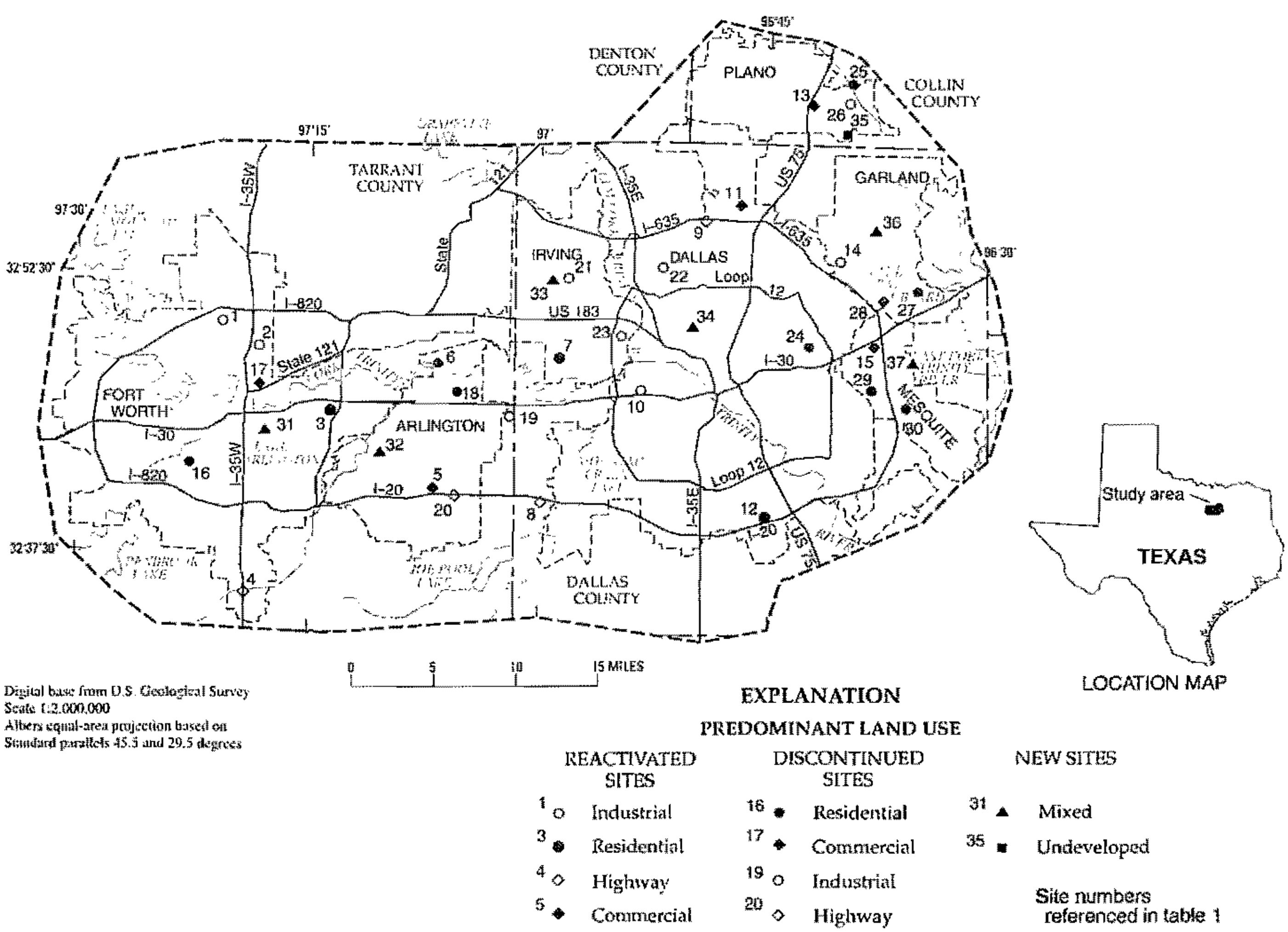
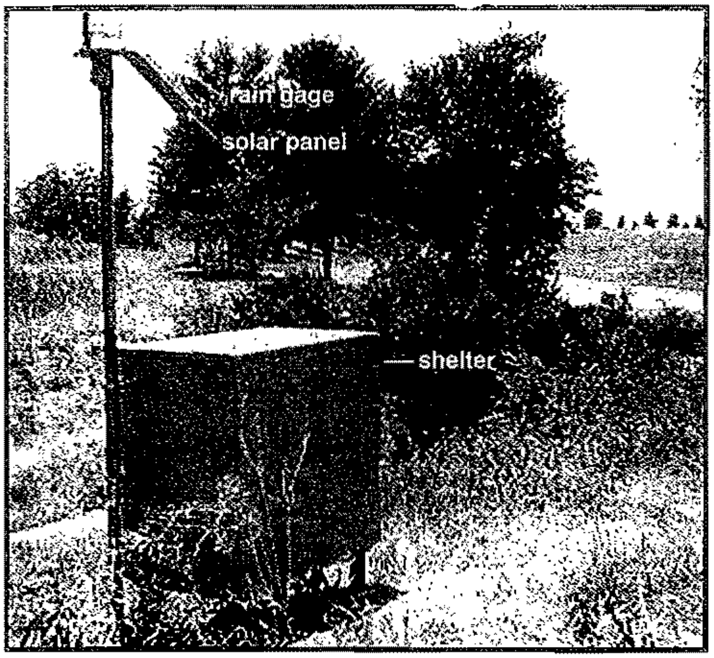
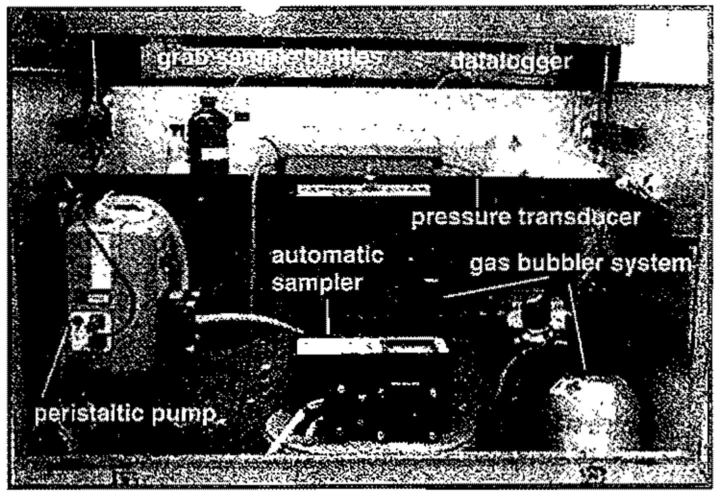


Figure 1. Location of study area and stormwater monitoring sites.



A. Equipment shelter and solar panel for undeveloped site in Plano, Tex.; the rain gage is mounted just above the solar panel.



B. Inside an equipment shelter.

renewal. The USGS, during an ongoing study, will analyze the data collected during the permit-compliance phase and recommend possible changes to the network design and sampling schedule. This fact sheet describes the monitoring network and sampling schedule during the permit-application phase and the 5-year permit-compliance phase (1997–2001) and summarizes the sampling during February 1997–February 2000.

Description of Study Area

The DFW area is located in north-central Texas (fig. 1), and the 1,700-square-mile area lies within Collin, Dallas, Denton, and Tarrant Counties. The DFW area is in the upper Trinity River Basin with three major tributaries of the Trinity River draining the area—West Fork Trinity River, Elm Fork Trinity River, and East Fork Trinity River. Mean annual precipitation in the study area varies from about 31 inches in Tarrant County to 36 inches in Dallas County, with the months of April and May typically the wettest and the months of July and August the driest (Ramos, 1999).

Monitoring Sites

During the permit-application phase, 30 monitoring sites were established during 1992–93 in small (160 acres or less) drainage basins, each categorized by a single predominant land use (11 residential, 9 industrial, 6 commercial, and 4 highway). Five sites each were located in the cities of Dallas and Fort Worth, four in Arlington, three each in Garland, Irving, Mesquite, and Plano, and two sites each in TxDOT Dallas and TxDOT Fort Worth. Fifteen of the original 30 monitoring sites (1–15, table 1) were reactivated in 1997 for the permit-compliance phase, including 4 residential, 4 industrial, 4 commercial, and 3 highway. Three sites each are located in Dallas and Fort Worth, two sites each in Arlington and TxDOT Dallas, and one site each in Garland, Irving, Mesquite, Plano, and TxDOT Fort Worth. The remaining 15 sites were discontinued (16–30, table 1). Seven new sites (31–37, table 1) were established during 1997–98 for the permit-compliance phase. One site is located in each of the seven cities; no new TxDOT sites were established. Six of the new sites are located in drainage basins with mixed land use, and one site is located in an undeveloped drainage basin. Three of the six sites with mixed land use are located at outfalls with drainage areas less than 500 acres, and the remaining three sites are located instream with drainage areas of at least 2,500 acres (table 1). Most of the monitoring sites are located at storm sewer outfalls or concrete-lined open channels. Two sites are located at natural channels.

Each site houses the monitoring equipment in a shelter (photo A). A rain gage and solar panel are attached to the shelter. Inside the shelter (photo B) are an automatic sampler, a peristaltic pump, a datalogger, and a gas bubbler system. The stage of the water in a culvert or open channel is measured using a pressure transducer and a gas bubbler system that regulates the periodic release of a bubble of carbon dioxide through an orifice line below the water surface. The pressure transducer measures the pressure required to force the bubble out of the orifice line and converts the pressure to the stage of the water, in feet. The stage then is used to compute the instantaneous discharge using a different equation specific for a flume, open channel, or weir. The datalogger computes discharge, accumulates the volume of runoff, and stores information, such as date, time, precipitation, stage, discharge, volume, and number of samples collected. The equipment is powered by a 12-volt battery maintained by the solar panel. A telephone line and a modem are installed at each site to provide telemetry to communicate with each site remotely to monitor a storm event, download data, modify program parameters, enable or disable the automatic sampler, and notify personnel of a storm event.

Sample Collection and Analysis

Two conditions are required for sample collection: (1) Antecedent dry weather conditions (no more than 0.1 inch of precipitation in a 24-hour period) should occur for the 72 hours prior to the storm event to allow for accumulation of possible contaminants.

Table 1. NPDES municipal stormwater sites in the Dallas-Fort Worth area and summary of sampling, February 1997–February 2000

[Sites 1–15 established 1992–93 during permit-application phase; sites 16–30 established 1992–93 during permit-application phase and discontinued 1997–98 during permit-compliance phase; sites 31–37 established 1997–98 during permit-compliance phase. USGS, U.S. Geological Survey; TxDOT, Texas Department of Transportation]

Site no. (fig. 1)	USGS station no.	Station name	City or TxDOT district	Predominant land use	Drainage area (acres)	No. of samples		
						Collected 1992–94	Scheduled 1997–2001	Collected Feb. 1997–Feb. 2000
		Reactivated sites						
1	08048505	Pylon Street Outfall at Meacham Rd.	Fort Worth	Industrial	151	7	13	10
2	08048545	Dry Branch Outfall at 33d St.	Fort Worth	Industrial	73.7	7	13	10
3	08048700	Eastern Hills High School Outfall at Weiler Dr.	Fort Worth	Residential	151	7	13	9
4	08048920	Deer Creek Outfall at I–35W	TxDOT Fort Worth	Highway	63.1	7	13	10
5	08049220	The Parks Mall Outfall at I–20W	Arlington	Commercial	38.8	7	13	10
6	08049320	River Legacy Park Outfall at Green Oaks Blvd.	Arlington	Residential	160	7	13	9
7	08049590	Bear Creek Outfall at Shady Grove Rd.	Irving	Residential	65.3	7	13	10
8	08049860	Mountain Creek Outfall at I–20	TxDOT Dallas	Highway	115	7	13	9
9	08055690	Bachman Branch Outfall at I–635	TxDOT Dallas	Highway	12	7	13	3
10	08056390	Bastille Street Outfall at La Reunion Pkwy.	Dallas	Industrial	49.5	7	13	10
11	08057135	White Rock Creek Outfall at Preston Rd.	Dallas	Commercial	59.1	7	13	9
12	08057441	Newton Creek Outfall at Tioga St.	Dallas	Residential	38.9	7	13	9
13	08061525	Spring Creek Outfall at Park Blvd.	Plano	Commercial	22.7	7	13	10
14	08061635	Tributary to Duck Creek Outfall at Hightower Rd.	Garland	Industrial	33.9	7	13	10
15	08061910	South Mesquite Creek Outfall at I–635	Mesquite	Commercial	45.9	7	13	8
		Discontinued sites						
16	08047300	Clear Fork Trinity River Outfall at Oak Hill Cr.	Fort Worth	Residential	61.7	7	--	--
17	08048510	West Fork Trinity River Outfall at Highway 121	Fort Worth	Commercial	136	7	--	--
18	08049360	Tributary to West Fork Trinity River Outfall at Baird's Farm Rd.	Arlington	Residential	77.0	7	--	--
19	08049470	Tributary to Johnson Creek Outfall at I–30 East	Arlington	Industrial	85.5	7	--	--
20	08049950	Fish Creek Outfall at I–20	TxDOT Fort Worth	Highway	40.9	7	--	--
21	08055570	Hereford Rd. Outfall at Walnut Hill Ln.	Irving	Industrial	43.4	7	--	--
22	08055590	Joe's Creek Outfall at Denton Dr.	Dallas	Industrial	9.0	7	--	--
23	08056100	Tributary to Elm Fork Trinity River Outfall at Cascade St.	Irving	Industrial	43.9	7	--	--
24	08057310	Ash Creek Outfall at Whittier St.	Dallas	Residential	71.3	7	--	--
25	08061510	Rowlett Creek Outfall at Willow Creek Park	Plano	Residential	51.4	7	--	--
26	08061530	Spring Creek Outfall at Avenue F	Plano	Industrial	49.0	7	--	--
27	08061660	Sleepy Hollow St. Outfall at Northwest Highway	Garland	Residential	67.3	7	--	--
28	08061690	I–635 Outfall at Centerville Rd.	Garland	Commercial	36.2	7	--	--
29	08061915	South Mesquite Creek Outfall at South Parkway	Mesquite	Residential	45.4	7	--	--
30	08061940	South Mesquite Creek Outfall at Bruton Rd.	Mesquite	Residential	46.2	7	--	--
		New sites						
31	08048542	Sycamore Creek at Scott Ave.	Fort Worth	Mixed	21,760	--	24	12
32	08049240	Rush Creek at Woodland Park Blvd.	Arlington	Mixed	17,024	--	24	10
33	08055550	Cottonwood Branch Tributary Outfall at Sky Cir.	Irving	Mixed	127.7	--	24	6
34	08056450	Knights Branch Tributary at Cedar Springs Rd.	Dallas	Mixed	486.4	--	24	12
35	08061515	Beck Branch Outfall at Wyngate Blvd.	Plano	Undeveloped	70.4	--	24	9
36	08061545	Mills Branch Tributary at N. Fifth St.	Garland	Mixed	268.8	--	24	13
37	08061850	North Mesquite Creek at Beltline Rd.	Mesquite	Mixed	2,500	--	24	9

(2) The total storm precipitation should range between 0.2 and 1.5 inches (Baldys and others, 1998).

During the permit-application phase, seven samples were collected at each of the 30 sites and analyzed for 188 selected properties and constituents (Baldys and others, 1997). During the 5-year permit-compliance phase, the 13 samples scheduled for the 15 reactivated sites and the 24 samples scheduled for the 7 new sites will be analyzed for a reduced list of 23 required properties and constituents. The permit-compliance sampling schedule is divided into 6-month periods (September–February and March–August), during which a predetermined number of samples are to be collected. For the reactivated sites, five samples were scheduled in the first year (two samples in the first 6-month period and three samples in the next period) and two samples per year (one in each 6-month period) for the following 4 years. For the new sites, six samples per year (three in each 6-month period) are scheduled for the last 4 years of the 5-year period. Table 1 lists the number of samples scheduled for the permit-compliance period and the number of samples actually collected during February 1997–February 2000. Some samples were not collected as scheduled because of extended periods of little or no precipitation.

Two types of samples are collected for analysis of water-quality properties and constituents. Grab samples are collected manually, and composite samples are collected by the automatic sampler. The samples are analyzed for selected properties and constituents in accordance with guidelines set by EPA (U.S. Environmental Protection Agency, 1992). Figure 2 shows an example of the accumulated precipitation, the discharge, and the times of the grab and composite aliquot samples for a storm sampled on May 15, 1997, at site 08056390 Bastille Street Outfall at La Reunion Parkway, Dallas, Texas.

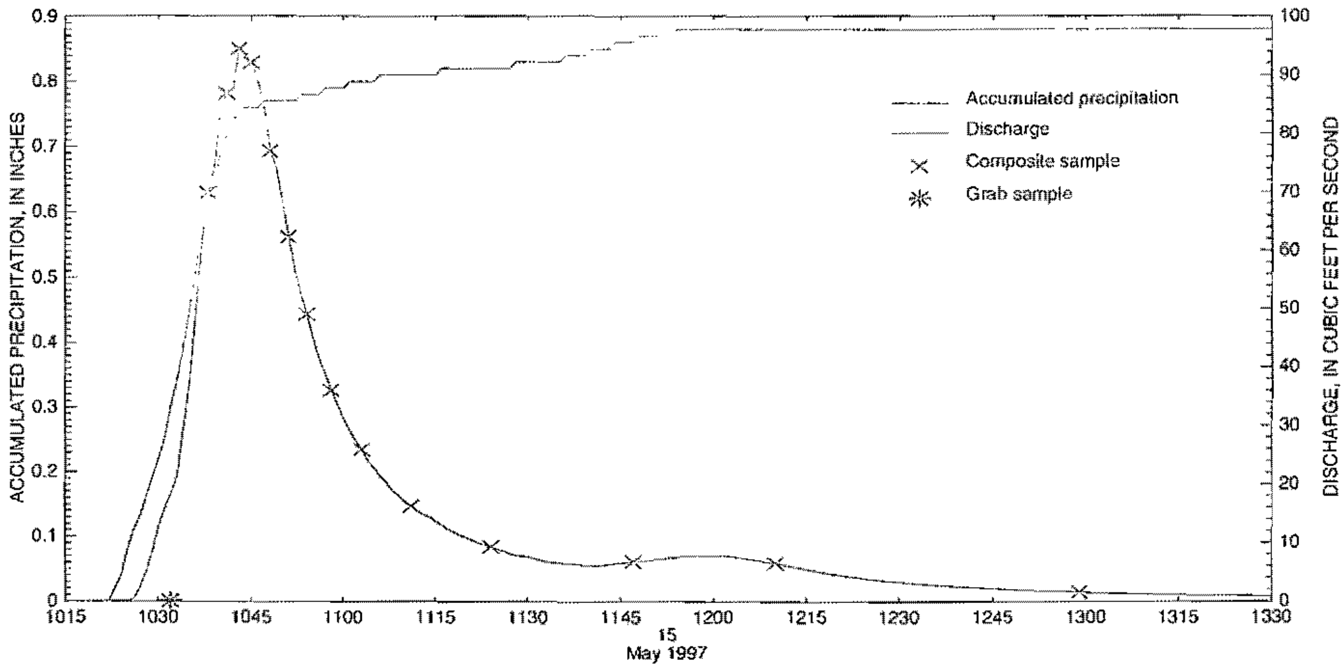


Figure 2. Hydrograph showing accumulated precipitation, discharge, and times of composite- and grab-sample collection at 08056390 Bastille Street Outfall at La Reunion Parkway, Dallas, Texas, May 15, 1997.

The grab sample typically is collected during the first 2 hours of a storm to catch the first flush of the basin—the initial stormwater runoff that often contains accumulations of possible contaminants. The grab sample is analyzed for fecal coliform bacteria, fecal streptococcus bacteria, oil and grease, phenols (TxDOT Dallas only), and field properties. The field properties—specific conductance, pH, and water temperature—are measured at the time of sample collection.

The composite sample is a combination of discharge-weighted sample aliquots collected throughout a storm by the automatic sampler programmed to collect discrete samples after a site-specific pre-specified volume of discharge has passed the site. The composite sample is analyzed for biochemical oxygen demand, chemical oxygen demand, suspended solids, dissolved solids, ammonia plus organic nitrogen, nitrite plus nitrate nitrogen, total phosphorous, dissolved phosphorous, arsenic, cadmium, chromium, copper, lead, nickel (TxDOT Dallas only), zinc, and diazinon.

Data Analysis and Use

The concentration data compiled by the monitoring program are used primarily for permit compliance to characterize the stormwater runoff in the DFW area. The event-mean concentration data can be used to (1) characterize stormwater runoff, both for individual land uses and for the entire DFW area; (2) estimate storm loads and mean annual loads for selected constituents to receiving waters; and (3) provide policy makers with information to develop effective management practices. These data also are useful for comparison and analysis in other parts of the state and country.

References

Baldys, Stanley, III, Raines, T.H., Mansfield, B.L., and Sandlin, J.T., 1997, Hydrologic data for the urban stormwater studies in the Dallas-Fort Worth area, Texas, 1992–94: U.S. Geological Survey Open-File Report 96–482, 256 p.

_____1998, Urban stormwater quality, event-mean concentrations, and estimates of stormwater pollutant loads, Dallas-Fort Worth area, Texas, 1992–93: U.S. Geological Survey Water-Resources Investigations Report 98–4158, 51 p.

Ramos, M.G., ed., 1999, 2000–2001 Texas almanac: The Dallas Morning News, 672 p.

U.S. Environmental Protection Agency, 1990, National Pollutant Discharge Elimination System permit application regulations for stormwater discharges—Final rule: U.S. Federal Register, v. 55, no. 222, p. 47,989–48,091.

_____1992, National Pollutant Discharge Elimination System stormwater sampling guidance document: U.S. Environmental Protection Agency, 121 p.

—Stephanie J. Moore, Timothy H. Raines, and Stanley Baldys III

Information on technical reports and hydrologic data related to this study can be obtained from:

Fort Worth Subdistrict Chief
U.S. Geological Survey
Fort Worth Field Headquarters
2775 Alta Mesa Blvd.
Fort Worth, TX 76133

Phone: (817) 263–9545
FAX: (817) 361–0459
World Wide Web:
http://tx.usgs.gov/

☆ U.S. GOVERNMENT PRINTING OFFICE: 2000 — 673-089 / 52021 Region No. 8