CENTER FOR TRANSPORTATION RESEARCH
THE UNIVERSITY OF TEXAS AT AUSTIN

Center for Transportation Research
The University of Texas at Austin

Project Summary Report 0-4252-S
Project 0-4252: Process Framework for Identifying and Prioritizing Water Quality Improvement for Meeting TMDLs in Texas
Authors: Samantha L. Hon, Michael E. Barrett, and Joseph F. Malina, Jr.
August 2003

PROJECT SUMMARY REPORT

Process Framework for Identifying and Prioritizing Water Quality Improvement for Meeting TMDLs in Texas: A Summary

Background

The Clean Water Act of 1972 was amended in 1987 to include storm water discharges. This act requires states to assess the condition of surface waters to determine whether they support designated uses such as fishing and swimming. When the water quality of a particular water body is not sufficient to support these beneficial uses, the water body is considered to be impaired and is required to be reported to the Environmental Protection Agency (EPA) under Section 303(d) of the Clean Water Act. The document that contains the list of impaired water bodies in the state is referred to as the Section 303(d) list. EPA requires that a total maximum daily load (TMDL) be developed for each of the listed water bodies for the constituents that are contributing to the impairment. The TMDL is the maximum amount of a pollutant that a water body can assimilate without impacting the beneficial uses. After a TMDL is developed, dischargers may be required to implement Best Management Practices (BMPs) to reduce their contribution of the pollutant. TxDOT is a potential stakeholder in the TMDL process and may be required to implement BMPs to reduce contributions of a particular pollutant to receiving water bodies. The implementation of BMPs may be required for new construction or for highways undergoing rehabilitation or repair within the contributing watershed of the impaired water bodies. Project delays and cost overruns could be the result of these requirements, if the need for BMP implementation is not identified early in the planning process. The objectives of this research are to help TxDOT understand its liability under the TMDL process and to provide the necessary data to respond to regulators and others as TMDLs are developed.

What We Did...

Impaired Water Bodies of Texas

The major causes of impairment of water bodies in Texas are bacteria and low dissolved oxygen concentrations. Of the 299 water bodies on the Draft 2002 303(d) List, 192 water bodies are impaired by bacteria. Many of these segments are located in the Houston/Galveston area. There are currently 104 water bodies impaired by low dissolved oxygen concentrations. These water bodies are located mainly in East Texas and along the Gulf of Mexico. Low dissolved oxygen concentrations in water bodies can be caused by eutrophication. Eutrophication is the process whereby a water body receives excessive nutrients like nitrogen and phosphorus causing the expanded growth of algae and other aquatic plants. The die-off and decomposition of these aquatic plants will

deplete dissolved oxygen concentrations in the water body. All other pollutants are individually responsible for the impairment of no more than 15 water body segments.

An ArcGIS geodatabase was developed to locate and display the impaired streams that are contained in the Section 303(d) list for the state of Texas. To perform this task, all relevant maps were obtained as GIS shapefiles. Shapefiles that were downloaded include county boundaries, subwatersheds or hydrologic unit codes (HUCs), streams and lakes, and highways and roads for the state of Texas. A table of the impaired water bodies in the 303(d) list was first created in Microsoft Excel and converted into a .dbf file that is compatible with ArcGIS. The data in the .dbf table are joined with the impaired water bodies shapefile in ArcMap (a map creation program contained in ArcGIS), which enables the user to query the database of impaired water bodies by constituent. This allows the user to easily identify the location of all impaired water bodies or just those impaired by selected constituents.

Quality of Highway Runoff

Highway runoff monitoring data was obtained for sampling sites in Austin, Beaumont, Corpus Christi, Dallas, Fort Worth, Houston, and San Antonio. The data obtained were entered into a Microsoft Excel spreadsheet. These data from urban highways were analyzed to determine concentrations in highway runoff for total suspended solids, bacteria, total dissolved solids, mercury, nitrate, phosphorus, lead, zinc, chloride, and sulfate. Information about the sampling location and storm event when the water samples were taken is included for the sites for which it was available. This information includes the date the sample was taken, size of the drainage area, amount and duration of the rainfall, runoff volume, flow, intensity, and antecedent rain.

The concentrations of many constituents, particularly bacteria and nutrients, commonly exceeded existing or proposed water quality standards. The average concentration of fecal coliform was much higher than the EPA criteria of 200 CFU/100mL at all the monitoring sites. However, studies have indicated that there does not appear to be a strong relationship between the presence of indicator organisms and the presence of pathogens, and that highways do not appear to be a significant source of pathogens. In addition, the volume of runoff from highways is not sufficient to materially affect receiving water bodies. Consequently, other sources of bacteria are more likely responsible for the majority of bacteria observed in surface waters.

EPA specifies nutrient criteria according to ecoregions. There are many ecoregions in Texas and 0.01 mg/L is the phosphorus criteria for Ecoregion XI, which is the minimum concentration among all the other ecoregions in the state. All total phosphorus concentrations in urban highway runoff exceeded the EPA criteria. The total nitrogen concentrations for all the sites also were above the criteria specified by EPA, which is 0.38 mg/L for Ecoregion III.

What We Found...

Assessment of BMPs for Treatment of Highway Runoff

A stormwater BMP is defined by the EPA as a technique, measure, or structural control that is used for a given set of conditions to manage the quantity and improve the quality of storm water runoff in the most cost-effective manner. The primary purpose of a BMP is the protection of the beneficial uses of water resources through the reduction of pollutant loadings and concentrations. There are two main categories of BMPs: structural and non-structural. Structural BMPs are constructed facilities designed to improve the quality and/or control the quantity of runoff. Non-structural BMPs include a range of pollution prevention, education, institutional, management, and development practices that serve to limit the conversion of rainfall to runoff and prevent pollutants from entering runoff at the source of runoff generation.

Structural BMPs that are appropriate for use on TxDOT facilities include sand filters, extended detention basins, wet

basins, infiltration basins, infiltration trenches, vegetated swales, and vegetated buffer strips. The relative performance of these devices was assessed based on the constituents of concern. A matrix was developed after analyzing the available data on performance of the BMPs to show the effectiveness of the BMPs based on the relative removal efficiencies of the constituents of concern. The data indicate that most of the BMPs analyzed are effective in removing solids and metals like zinc from stormwater runoff but are less effective in removing nutrients and bacteria, which are the most important causes of water quality impairments in Texas. In some cases, export of nutrients from BMPs was observed. Reduction in fecal coliform concentrations mostly occurs in wet basins and infiltration systems. These constituents are of interest because most of the impairments in the state are caused by bacteria and low dissolved oxygen concentrations. There are currently no BMPs that effectively address pathogens and nutrients.

Assessment of Currently Installed BMPs

Previous studies have shown that substantial reduction in pollutant concentrations and loads can occur in vegetated areas that are adjacent to highways, even when these vegetated areas are not designed primarily as treatment systems. Consequently, an analysis was done on existing BMPs like grassed swales and vegetated strips using data collected in Texas and California. Three grassed swale sites in Austin, Texas, and four sampling sites in California were analyzed for the purpose of this project. The quality of the water flowing from the grassed strips at these sites was analyzed using log normal probability plots. These plots show the distribution of concentrations of the constituent for the different sites. The edge of pavement data and swale effluent data were compared using log normal probability plots to identify significant differences in water quality.

The pollutant reductions from vegetated areas adjacent to highways were shown to be comparable to what occurs in engineered systems for treating highway runoff. Although vegetated swales and buffer strips were effective in removing total suspended solids and metals, these systems were not effective in removing bacteria and nutrients.

The Researchers Recommend...

Highways could be identified as a contributor to the impairments of Texas water bodies since the concentrations of bacteria and nutrients in highway runoff exceed existing and proposed standards. Highway runoff is a small fraction of total runoff in terms of volume, and therefore, mass loadings of indicator organisms and nutrients may not be significant. Concentrations of other constituents were generally below receiving water standards.

Important findings include:

1. Highway runoff volume is very small compared to runoff from other watershed land uses.
2. There is no specific tool or BMP that effectively addresses water quality concerns related to bacteria and low dissolved oxygen concentrations, which are the main causes of impairment.
3. It would not be cost-effective to implement BMPs that do not address the causes of most water quality impairments.

For More Details...

Research Supervisor: Michael E. Barrett., Ph.D., (512) 471-0935
email: mbarrett@mail.utexas.edu
TxDOT Project Director: Norm King, (512) 416-2705
email: nking@dot.state.tx.us

The research is documented in the following reports:

4252-1 *Process Framework for Identifying and Prioritizing Water Quality Improvement for Meeting TMDLS in Texas*

To obtain copies of a report: CTR Library, Center for Transportation Research,
(512) 232-3138, email: ctrlib@uts.cc.utexas.edu

TxDOT Implementation Status December 2003

The research was conducted to better position TxDOT to comply with upcoming water quality regulations. The research evaluated the potential impact of Total Maximum Daily Loads (TMDLs) on TxDOT operations. This research serves as a foundation compliance tool for TxDOT to deal with future water quality conservation efforts.

For more information, please contact: William E. Knowles, P.E., RTI Research Engineer, at (512) 465-7403 or e-mail wknowle@dot.state.tx.us.

Your Involvement Is Welcome!

Disclaimer

The University of Texas at Austin
Center for Transportation Research Library
3208 Red River, Suite #115
Austin, TX 78705-2650