note

Effects of urbanization and structural runoff controls on water quality of streams in the Austin, Texas area

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Introduction

For many years, much concern and speculation have been expressed regarding the effects of urbanization on the water quality of streams in the Austin area. Since about 1975, the U.S. Geological Survey (USGS), City of Austin, and other governmental agencies have been monitoring the water quality of many streams in the Austin area. Many dozens of streams have been sampled in Travis County and range in size, location, physical characteristics, and extent of development. In 1990, the USGS published a report summarizing its data and presenting findings regarding the effects of impervious cover on water quality (Veenhuis and Slade, 1990). In the same year, the City of Austin (1990) published findings from their water-quality monitoring programs.

Eighteen stream sites for large multiple land-use basins were included in the USGS study—the impervious cover of the basins ranged from less than 1 percent to 42 percent. The sites represent most major streams in the Austin area. The basin drainage areas range from 6.3 square miles on Williamson Creek to 166 square miles on Onion Creek. Filter ponds, grass-lined swells, and other runoff controls exist in many of the basins. The number of water-quality samples for each site ranged from 9 to 147, with at least 20 samples available for 13 of the sites.

Eight stream sites for small single land-use suburban basins ranging from 3 to 95 percent impervious cover were included for the City of Austin study. The sites, which include data from their Surface Water Monitoring Program and the National Urban Runoff Program (NURP) in Austin, range in size from 3 to 371 acres. Storm water-quality loads were calculated for each site—the number of storm loads for each site ranged from 12 to 26.

Effects of urbanization on water quality

For the USGS study, the water-quality data for each site were aggregated into one of three flow categories for purposes of interpretation—base flow, rising stages (before the peak stage), and falling stages (after the peak). Furthermore, each of the 18 sites was aggregated into one of four development classifications: rural (less than 1 percent impervious cover); mostly rural (2 to 7 percent impervious cover); partly urban (9 to 20 percent impervious cover); and urban (greater than 40 percent impervious cover).

The report concluded that water-quality concentrations for storm samples are greatly increased with increased impervious cover. For example, the median suspended-solids concentration for rural basins is 6 milligrams per liter (mg/L) for rising-stage samples. For urban basins the median concentration is 4,100 mg/L, an increase of 6,700 percent (Table 1). The median concentrations and percent changes in median concentrations from a rural basin to an urban basin for samples collected during rising stages for the eight major water-quality constituents investigated are presented in Table 1.

The City of Austin report presents findings similar to those from the USGS report: water-quality degradation due to full urbanization for the above and other water-quality constituents represents hundreds if not thousands percent increases. Such findings are comparable to those from NURP studies around the Nation.

Table 1. Median water-quality concentrations for rural and urban basins, for samples collected during rising stream stages.

Water-quality constituent	Median value for rural basins	Median value for urban basins	Percent change in median concentration from rural to urban basin
dissolved solids	245	130	47 % decrease
suspended solids	6.0	410	6700 % increase
biochemical oxygen demand	0.95	6.0	530 % increase
total organic carbon	4.0	18	350 % increase
total nitrogen	0.5	2.15	330 % increase
total phosphorus	0.02	0.45	2150 % increase
fecal coliform	1,000	42,000	4100 % increase
fecal streptococci	1,200	75,000	6150 % increase

Note: Values for all constituents are in mg/L except for fecal constituents, which are in colonies per 100 milliliters.

Best management practices

In an effort to mitigate the impacts of urbanization on the quality of storm water, the City of Austin and other agencies have required structural best management practices (BMPs) be designed and installed throughout the area. More than 1,000 BMPs exist in the area and more are being built. The BMPs generally represent public information programs, wetlands, wet ponds, dry ponds, filters, grass swells, irrigation, and street sweeping. In 1987, the USGS published a report presenting the data and effects of two different runoff controls on runoff quality in Austin

(Welborn and Veenhuis, 1987). The largest sand filter pond at Barton Creek Square Mall was monitored for the quantity and water quality of inflow and outflow from the pond. The inflow and outflow water-quality loads were determined for 22 storms. Also, the reduction in water-quality loads between the inflow and outflow was calculated for each storm—load reductions depict those removed by the filtering pond and thus represent the efficiency of the pond in removing water-quality loads. The average (mean) removal efficiency based on all 22 storms then was calculated for each of the analyzed water-quality constituents. The mean change in water-quality load (as a percent) from the inflow to the outflow is presented in Table 2 for the constituents.

The runoff control for the other site is a grass-lined swell at Alta Vista Planned Unit Development. Analyses of water-quality samples at the inflow and outflow from this site indicate that the swell had no measured effect on water quality. However, the swell was limited in size and contained steep slopes. Studies of other local sites indicate significant removal efficiencies of water-quality concentrations for vegetated areas. The effectiveness of such controls is dependent on site characteristics such as area size, type and extent of soils and vegetation, land slope, and the type, location, and extent of development.

Table 2. Mean percent removal by Barton Creek Square Mall BMP for analyzed water-quality constituents

Water-quality constituent	Mean change in water-quality load due to filtering pond
dissolved solids	13 % increase
suspended solids	78 % decrease
biochemical oxygen demand	76 % decrease
total organic carbon	60 % decrease
total nitrogen	27 % decrease
fecal coliform	81 % decrease
fecal streptococci	81 % decrease
biochemical oxygen demand	76 % decrease
chemical oxygen demand	62 % decrease
dissolved volitile solids	21 % decrease
dissolved lead	33 % decrease
dissolved iron	55 % decrease
dissolved zinc	60 % decrease

The City of Austin has conducted several studies evaluating the effectiveness of BMPs. A summary of those studies and presentation of related reports are presented online at http://www.ci.austin.tx.us/watershed/stormwater_treatment.htm. Also, many other agencies have conducted studies of the effects of BMPs on water quality of urban runoff. The National Urban Runoff Program sponsored by the U.S. Environmental Protection Agency and the USGS conducted many of the studies, many of which are presented on the Internet at http://www.bmpdatabase.org/. Based on these studies, Table 3 is a summary of the general removal efficiencies for different types of BMPs.

Some grassy swells and wet ponds are being used in the Austin area but sand filters probably represent the most prevalent BMP in the area. Removal efficiency of filters is dependent upon maintenance of the filter material. Field inspections and other evidence indicate that many of the filters are not being maintained or properly maintained, thus the efficiency of such filters might be lower than indicated in the table. Also, the efficiency of filters and ponds is substantially reduced if stormwater bypasses or overflows the filter.

A relatively new BMP being used, especially on the Edwards aquifer, involves impoundment and irrigation of urban-runoff. Information or data regarding removal efficiency for this type BMP could not be found. However, the removal effectiveness of such a BMP is highly dependent on local environmental conditions. For example, thin soils, lack of vegetation, steep slopes, or the presence of recharge features (such as sinkholes, caves, or faults) could reduce surface attenuation of contaminants thus allowing contaminants to recharge the aquifer or runoff from the area. Also, irrigation practices affect contaminant-removal efficiencies—irrigation of urban runoff during or immediately after storms, when soils are wet, would likely cause contaminants to runoff from the area. Additionally, large storms or multiple storms creating volumes of runoff exceeding the storage capacity of the impoundment would discharge the impoundment without filtration or be required to be irrigated during periods when soils are still saturated from rain.

Table 3. Typical removal efficiencies for various types of BMPs

Type of BMP	Removal efficiencies
Public information program	5-10% for most water-quality constituents
Wetlands	up to 90%; best for nutrients, some metals increased
Wet ponds	60-80%; best for sediment-related constituents
Dry ponds	30-70%; best for sediment-related constituents
Filters	30-70%; most are horizontal; best for sediment-related constituents; efficiency dependent upon maintenance
Grassy swells	10-20%; more efficient for specific sites
Street sweeping	0-10%; some evidence that sweepers can increase water-quality loads

A runoff-filtering system manufactured by AquaLogic Inc., in San Antonio, Texas (http://aqualogic-usa.com/frameset.html) is being used on the Edwards aquifer recharge zone in the San Antonio area. The system contains a sediment-settling basin and standpipes containing 10-micron filtering media, designed to filter all received runoff. AquaLogic Inc. provides frequent inspection and maintenance via contract with property owners, thus assuring that the system performs properly. Maintenance includes removal of all material from the sediment pond and replacement of filter media in the standpipes. Although the effectiveness of this system has not yet been tested for most urban-related contaminants, it is likely more effective than sand filters. Also, it might perform superior to other BMPs simply because it receives scheduled and mandated inspections and maintenance by the manufacturer.

Conclusions

As summarized in Table 1, degradation in water quality due to urbanization for 7 of the 8 constituents range from about 300 percent to about 6,700 percent in the Austin area.

For maintained BMPs, data summarized in Table 3 and from other local studies have verified national findings regarding the efficiency of BMPs: they generally reduce water-quality values by only 30 to 70 percent for most water-quality constituents. Best management practices mitigate water-quality loads but generally do not compensate for substantial water-quality degradation caused by urbanization. Therefore, many ordinances and other rules limiting the location, type, and density of urban development have been developed in order to minimize water-quality degradation.

References

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