Prepared in cooperation with the Johnson County Stormwater Management Program

Continuous Water-Quality Monitoring of Streams in Johnson County, Kansas, 2002–06

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Introduction

Water quality in Johnson County, Kansas was characterized on the basis of continuous, in-stream monitoring. The results summarized in this fact sheet may be used to better understand concentration and load variability during changing seasonal and streamflow conditions and to assess water-quality conditions relative to water-quality standards and management goals. The baseline information also will be useful for evaluating future changes in land use and effectiveness of implemented best management practices.

Population growth and expanding urban land use in Johnson County, northeast Kansas, affect the quality of streams, which are important for human and environmental health, water supply, recreation, and aesthetic value. Johnson County is one of the most rapidly developing counties in Kansas, with a population increase of about 90 percent in the last 25 years, from 270,269 in 1980 (University of Kansas, 2006) to an estimated 516,731 in 2006 (U.S. Census Bureau, 2007). Urbanization generally affects streams by altering hydrology, geomorphology, chemistry, and biology (Paul and Meyer, 2001). The implementation of total maximum daily loads (TMDLs) and the National Pollutant Discharge Elimination System (NPDES), both required by the Federal Clean Water Act to address water-quality impairments, makes it increasingly necessary to document and monitor water-quality conditions. In addition, as urban areas expand and municipalities including those in Johnson County expend increasing funds on management practices designed to improve water quality, it is necessary to monitor changes in water quality over time.

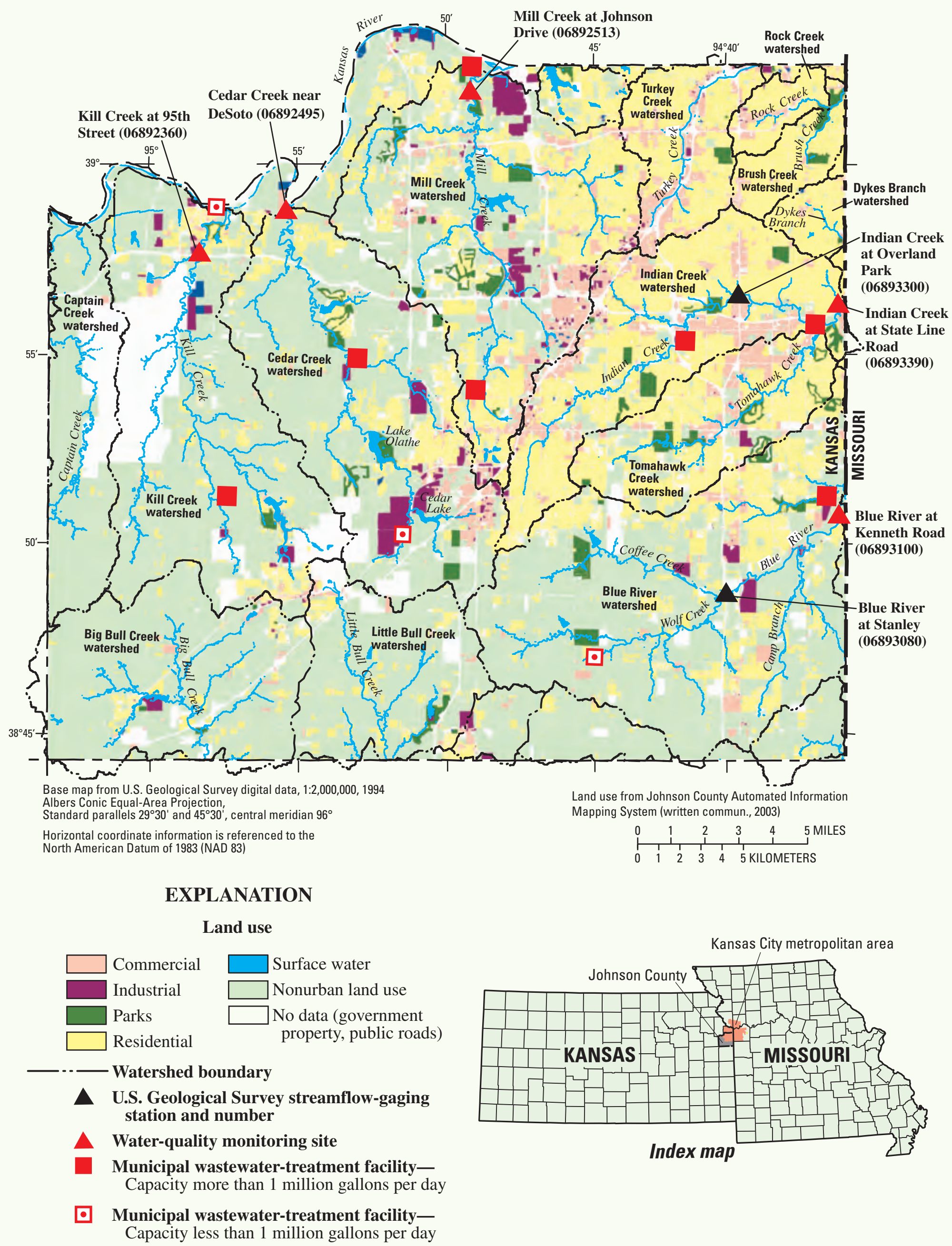

Figure 1. Location of monitoring sites, watershed boundaries, and land use, Johnson County, northeast Kansas.

(A) Kill Creek at 95th Street

(B) Continuous water-quality monitor

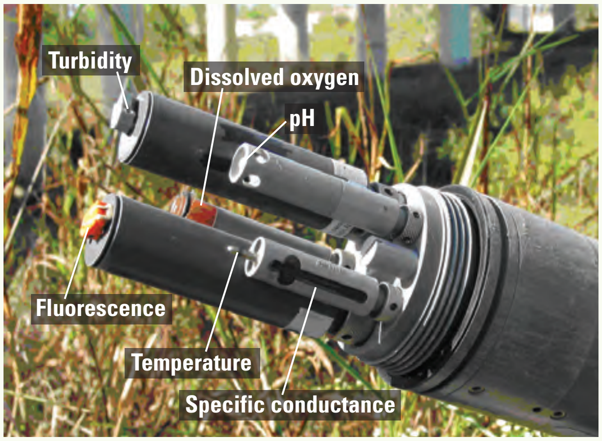

Figure 2. *(A)* Kill Creek at 95th Street, one of five continuous water-quality monitoring sites in Johnson County, Kansas. The water-quality monitor is placed beneath the water surface next to the streambank. *(B)* Monitor used to measure continuous, in-stream specific conductance, pH, water temperature, turbidity, and dissolved oxygen. The fluorescence sensor is pictured, but fluorescence was not monitored continuously during this study.

In 2002, the U.S. Geological Survey (USGS), in cooperation with the Johnson County Stormwater Management Program, began an investigation to characterize the water quality of Johnson County streams and to provide comprehensive information for municipalities to help in developing effective water-quality management plans. Initial study efforts described the effects of nonpoint and selected point contaminant sources on stream-water quality and their relation to land use (Lee and others, 2005). Also, baseline biological conditions were evaluated to characterize stream biology relative to urban development (Poulton and others, 2007). Throughout these studies, water quality was monitored continuously at five sites (fig. 1), each on streams identified as water-quality impaired (Kansas Department of Health and Environment, 2006). The streams were monitored over several years to develop concentration estimation models that were used to characterize variability in constituent concentrations, loads, and yields.

This fact sheet characterizes transport and general sources of selected water-quality constituents in Johnson County, Kansas. Constituent concentrations, loads, and yields are described for five major watersheds of Johnson County using continuous in-stream sensor measurements. Load is the amount of constituent transported in the stream over a specified period of time. Yield is the load divided by the drainage area and is a meaningful way to compare different watersheds. Specific conductance, pH, water temperature, turbidity, and dissolved oxygen were monitored in Cedar and Mill Creeks from October 2002 through December 2006, and in Blue River, Kill and Indian Creeks from March 2004 through December 2006 (fig. 2). Continuous in-stream measurements were used in conjunction with discrete water samples and watershed information to develop regression models for estimating concentrations of selected constituents. Continuous regression-based concentrations were estimated for suspended sediment, dissolved solids and selected major ions, nutrients (nitrogen and phosphorus species), and fecal-indicator bacteria. The complete report from which this information was summarized (Rasmussen and others, 2008) is available on the Web at *http://pubs.er.usgs.gov/usgspubs/*.

Water Quality in Johnson County Streams

Water quality at the five monitoring sites varied according to hydrologic conditions, contributing drainage area, land use, degree of urbanization, relative contributions from point and nonpoint constituent sources, and human activity within each watershed. Many water contaminants in Johnson County, at both urban and nonurban sites, originated primarily from nonpoint sources during storm-runoff periods. Therefore, climate (precipitation and resulting runoff) had a substantial effect on water quality, and larger amounts of rainfall resulted in larger amounts of many contaminants like sediment, nutrients, and bacteria in streams. In addition, the probability that water-quality criteria are exceeded is substantially greater during storm runoff. Sediment yields in the urban watersheds (Indian and Mill Creeks) were larger than in nonurban watersheds. Both urban nonpoint sources of *Escherichia coli (E. coli)* bacteria (leaking sewer lines, wastewater, wildlife, and pet waste) and nonurban sources (wildlife, septic systems, and livestock) were shown to be important contributors to large bacteria densities in Johnson County streams. Nearly all bacteria originated from nonpoint sources. Urban sources of chloride (primarily road salt but also possibly wastewater and industrial runoff) contributed more contaminants than nonurban sources (geology).

Annual yields for suspended sediment and total suspended solids, dissolved solids and selected major ions, nutrients (nitrogen and phosphorus species), and fecal-indicator bacteria were at least five times larger in 2005 than 2006 at the least urban site, Kill Creek (fig. 3). In Indian Creek, the most urban site, yields in 2005 generally were about 25 percent larger than yields in 2006. The annual differences resulted from differences in annual precipitation and subsequent runoff to streams. Loads for all constituents were larger during 2005, when rainfall was about normal, than in 2006 when rainfall was 15 to 30 percent less than normal in each watershed (2005 and 2006 precipitation data obtained from *http://www.stormwatch.com*). In the Blue

River and Indian Creek watersheds, nonpoint storm runoff was the primary source of fecal coliform bacteria, and wastewater-treatment facilities were a substantial source of nutrients.

Suspended Sediment

Sediment transport in Johnson County streams and, therefore, management practices implemented to control sediment are especially important because of the implications for other contaminants such as nutrients and bacteria that are associated with sediment particles. Most of the time (except during substantial storm runoff), suspended-sediment concentrations in Indian Creek were smallest in part because of the large contribution of treated water discharged from the wastewater-treatment facility just upstream from the monitoring site (fig. 1). However, total annual sediment load and yield in Indian Creek were largest because of the disproportional loading that occurs during high streamflow compared to base flow. In June 2005, a single period of runoff on the Blue River lasted about 3 days but contributed more than 50 percent of the total annual sediment load. Suspended-sediment concentration was nearly always largest in Mill Creek, a watershed that is undergoing rapid development that likely is contributing to larger suspended-sediment concentrations. In 2005–06, 90 percent or more of the total suspended-sediment load occurred in less than 2 percent of the time at all five monitoring sites indicating that management practices designed to control sediment during small or medium streamflows will not have a substantial effect on annual loads.

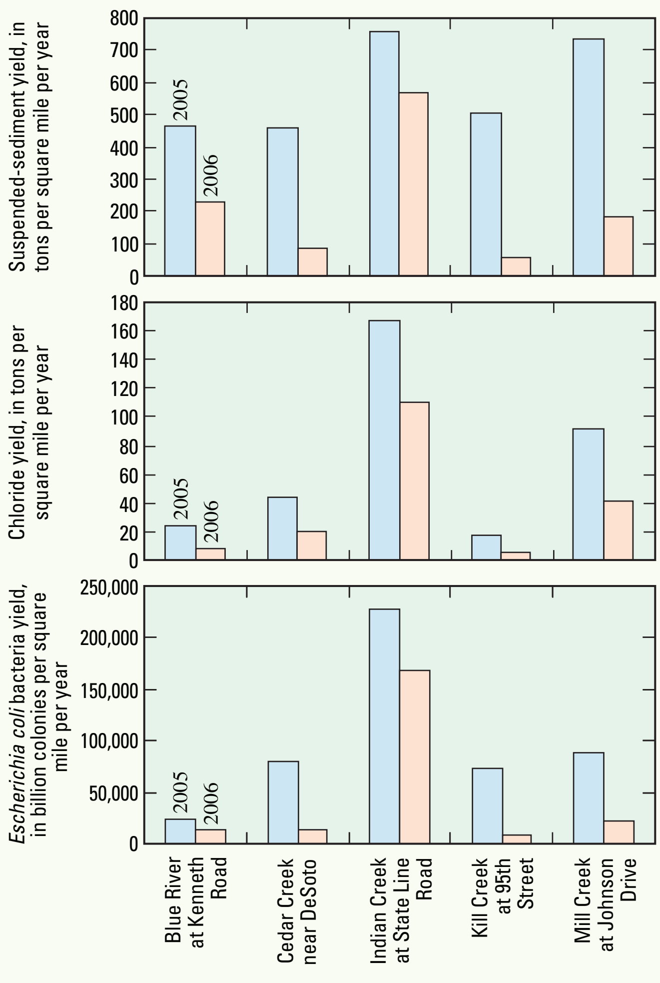

Figure 3. Estimated annual yields for suspended sediment, chloride, and *Escherichia coli* bacteria at five monitoring sites in Johnson County, Kansas, 2005–06.

Indicator Bacteria

From March 2004 through December 2006, *E. coli* density at the Indian Creek site was nearly always largest with a median density more than double that of any other site. The annual *E. coli* bacteria load in Indian Creek also was at least double that of other sites. The primary contact criterion for *E. coli* (262 colonies per 100 milliliters of water; Kansas Department of Health and Environment, 2005) was exceeded about 65 percent of the time at the Indian Creek site and 8 to 25 percent of the time at the other four monitoring sites. More than 97 percent of the fecal coliform bacteria load in the Blue River and Indian Creek originated from nonpoint sources in 2005 and 2006 (fig. 4; calculated from data provided by Johnson County Wastewater, written commun., September 2007). The primary nonpoint sources of fecal-indicator bacteria may include leaking sewer lines, wastewater, wildlife, livestock, and pet waste. Indicator bacteria are used to evaluate the sanitary quality of water and its use as a public-water supply and for recreational activities such as swimming, wading, boating, and fishing. The presence of indicator bacteria indicates the possible presence of pathogens that may cause illness.

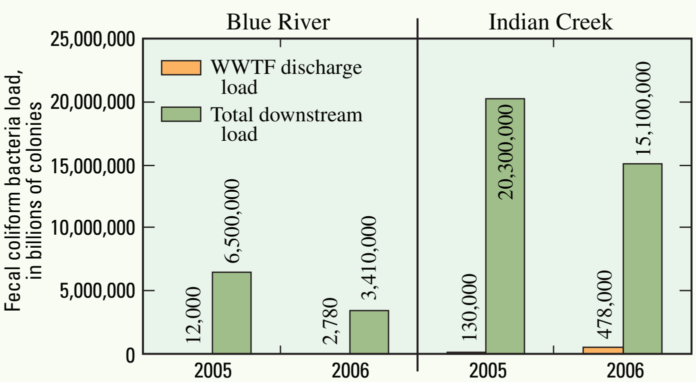

Figure 4. Total annual estimated fecal coliform bacteria loads and loads originating from wastewater-treatment-facility (WWTF) discharges to the Blue River and Indian Creek, Johnson County, Kansas, 2005–06. (Loads from waste-water-treatment facility discharges calculated from data provided by Johnson County Wastewater, written commun., September 2007).

Nutrients

Wastewater-treatment facilities were a primary source of nutrients in the Blue River and Indian Creek. Wastewater-treatment facility nutrient loads were calculated from data provided by Johnson County Wastewater (written commun., September 2007). On the Blue River about 40 percent of the total nitro-

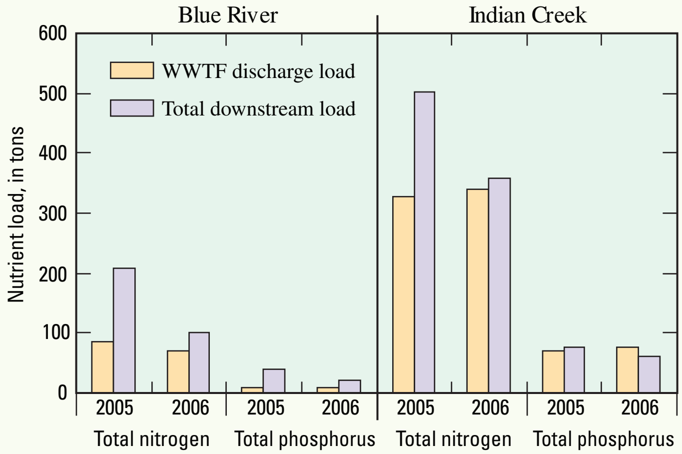

Figure 5. Annual estimated total nitrogen and total phosphorus loads and loads originating from wastewater-treatment-facility (WWTF) discharges to the Blue River and Indian Creek, Johnson County, northeast Kansas, 2005–06. (Loads from waste-water-treatment facility discharges calculated from data provided by Johnson County Wastewater, written commun., September 2007).

gen load in 2005 and 70 percent of the total nitrogen load in 2006 originated from wastewater-treatment discharge (fig. 5). One-fourth (in 2005) to one-half (in 2006) of the downstream total phosphorus load in the Blue River originated from WWTF discharges. Total nitrogen discharged from the two Indian Creek wastewater-treatment facilities accounted for at least two-thirds of the estimated total nitrogen load at the downstream Indian Creek monitoring site in 2005 and 2006 (fig. 5). Total phosphorus load from the Indian Creek wastewater-treatment facilities was 90 percent of the total phosphorus load at the downstream monitoring site in 2005 and 120 percent of the downstream total phosphorus load in 2006.

Nutrient loads from wastewater-treatment facilities were nearly the same in 2005 and 2006. However, because less precipitation occurred in 2006, nutrient loads originating from runoff were smaller compared to 2005. In Indian Creek, the total phosphorus load from wastewater-treatment facilities exceeded the downstream total phosphorus load in 2006 primarily because of additional settling of nutrients along with sediment that occurred within the distance between the wastewater-treatment discharges and the monitoring site, with less flushing from stormwater runoff.

Chloride

During 2005–06, about 10 percent of the time, all during the winter (November–February), chloride concentrations in Indian and Mill Creeks were elevated as a result of runoff from road-salt application. Generally, the chloride concentration from March 2004 through 2006 at the Indian Creek monitoring site was about four times the median at the Kill Creek site, a nonurban site that was not affected by road salt. Two chloride runoff occurrences in January–February 2005 accounted for 19 percent of the total chloride load in Indian Creek in 2005. The effect of accumulated road salt on ground water and base flow is unknown.

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