Prepared in cooperation with the City of Independence, Missouri, Water Pollution Control Department

Condition of Streams in Independence, Missouri:

What is Being Done to Protect Stream Health and How Citizens Can Help

By Shelley L. Niesen[1], Dorris L. Bender[2], Richard H. Champion, Jr.[2], Eric D. Christensen[1], and Thomas E. Harris[1]

Introduction

The City of Independence, Missouri is located on the eastern side of the Kansas City metropolitan area in north-central Jackson County (fig. 1). Within Independence there is a mix of developed (residential, commercial, industrial) and agricultural land. The Independence Water Pollution Control Department (IWPC) maintains more than 13,000 stormwater structures, more than 220 miles of stormwater pipe, and 15 regional stormwater detention basins. The State of Missouri issued a pollution control permit for the City of Independence stormwater system, and the City is implementing a Storm Water Management Program (SWMP), funded by voter-approved, dedicated stormwater-management funds, to minimize pollution in stormwater runoff. The SWMP provides for improved maintenance and increased capacity of stormwater structures to improve stormwater quality, as well as stream monitoring, flood response, and flood prevention activities.

Twelve streams [Rock Creek, Sugar Creek, Mill Creek, and Fire Prairie Creek; and the Little Blue River and its tributaries: East Fork of the Little Blue River, Adair Creek, Crackerneck Creek, Spring Branch Creek, Burr Oak Creek, Bundschu Creek, and West Fire Prairie Creek (fig. 1)] drain most of the land surface within the Independence city limits. The U.S. Geological Survey (USGS), in cooperation with IWPC, began a study in June 2005 to characterize the water quality and ecological health of streams within Independence. Streamflow, physical properties, nutrients, chloride, metals, organic micro-constituents, and bacteria were collected during base-flow (low-flow) and stormwater sampling at five sites (fig. 1) between June 2005 and December 2008. Illicit discharges and other sources of contamination were monitored through the use of dry-weather screenings. Stream ecological health was evaluated using benthic (bottom-dwelling) macroinvertebrate surveys and habitat assessments at seven sites. Initial study results (from June 2005 through December 2008) were released in 2010 (Christensen and others, 2010) and indicated that practices to reduce sediment delivery to streams likely would result in reductions in associated contaminants.

Two stream reaches of the Little Blue River during base-flow and stormflow conditions. [Top left, 39th Street during base flow (site 3, fig. 1); top right, Lake City during base flow (site 6); bottom left, 39th Street during stormflow; bottom right, Lake City during stormflow]. Note the brown color of the streams during storms because of high suspended-sediment concentrations.

Major Factors Affecting Water Quality in Independence and Why Stormwater Quality is Important

Although there are other factors, the quality of stormwater entering urban streams likely has the greatest effect on water quality in urban streams. Several factors can affect stormwater quality and streamflow in urban streams such as those

[1]U.S. Geological Survey.

[2]City of Independence, Water Pollution Control.

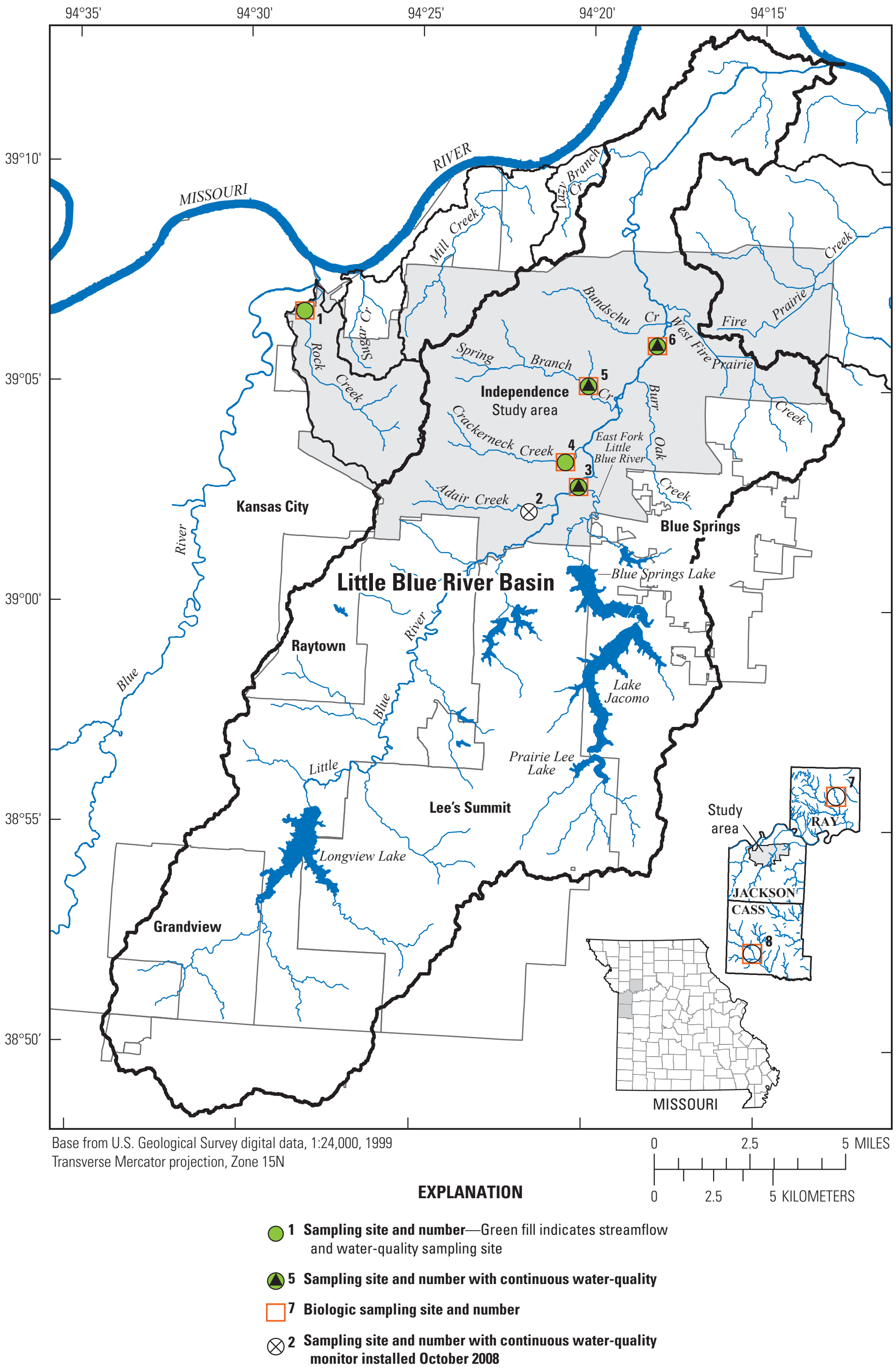

Figure 1. The Little Blue River Basin, sampling sites, study area location, and political boundaries for Independence, Missouri, and surrounding cities.

in Independence, including the amount of impermeable surface in the basin; construction activities; reservoirs; type and condition of sanitary sewer systems; land use and population density; road salt application; handling of animal waste; and the use of lawn and agricultural fertilizers, pesticides, and herbicides.

During storms, rainwater is absorbed by plants or infiltrates into the soil and other permeable surfaces. Rainwater that runs across impermeable surfaces such as driveways, roads, parking lots, and rooftops can mobilize soil and contaminants, including fecal bacteria from domestic or wild animals; petroleum by-products from automobiles and improper disposal of household hazardous waste; nutrients, pesticides, and herbicides from residential and commercial insect control and lawn treatment; salts from winter snow and ice removal; metals from roadways and roofs; and many contaminants from other sources. Excess sediment and associated contaminants washed into streams during storms can adversely affect aquatic life and human communities, both at the point of entry and downstream. Contamination coming from a large land area without a specific point of origin is called nonpoint source pollution. If the contamination source can be identified as coming from a specific location, such as an industrial discharge pipe, then the contamination is considered to be point-source pollution. Any streamwater contamination from any source has the potential under certain conditions (for example, contaminants in combination with one another, at a high concentration, or a lower concentration for a prolonged time period) to have adverse affects on aquatic plants and animals, and humans who come in contact with the water.

Streamflow and Physical Properties

The streams in the Independence study area all drain north to the Missouri River (fig. 1). The Little Blue River and its tributaries drain about two-thirds of the city. Flow in the streams varies throughout the year, which affects the type and concentration of contaminants found in the streams. Calculated average daily flows (average flow for a 24-hour period) for the five study sites ranged from no flow at Spring Branch Creek to 10,500 cubic feet per second (ft^3/s) for the Little Blue River at site 6 (fig. 1) during flood conditions.

The physical properties of a stream are important to stream health. Extremes outside the range of acceptable criteria for environmental (natural) waters, such as water temperatures greater than $32\frac{2}{9}$ degrees Celsius (90 degrees Fahrenheit), can harm aquatic life. Measurements of the physical properties of the stream (temperature, pH, and specific conductance) were taken during each base-flow sampling at all sites. Physical properties also were measured continuously at some sites, along with dissolved oxygen and turbidity (cloudiness of the water as a result of suspended particles), using continuous water-quality monitors (fig. 2) connected to recording and satellite uplink equipment in the gagehouses (fig. 3). The values for physical properties at the three continuously monitored

Figure 2. Continuous water-quality monitor with (clockwise from upper left) turbidity, optical dissolved oxygen, pH, and combined specific conductance and water temperature sensors.

Figure 3. USGS gagehouse (taken at Crackerneck Creek at Selsa Road) containing recording and satellite uplink equipment for transmittal of real-time streamflow and water-quality data.

sites (fig. 1) remained mostly within the expected range for environmental waters. Variations in physical properties outside the expected range typically were associated with storm events. Daily turbidity values, however, frequently were elevated above guidelines, but did not remain elevated for extended periods. Daily dissolved oxygen concentrations also occasionally were low for environmental waters. Low dissolved oxygen concentrations [less than 5 milligrams per liter (mg/L)] primarily occurred in the summer after storm events when water temperatures and suspended-sediment concentrations in streamflow were greater.

Nutrients

Plants and animals require nutrients such as nitrogen and phosphorus to survive; however, excess nutrients can be detrimental to stream health when algae and plant growth are enhanced and dissolved oxygen in the water is depleted when the algae and plants die and decay. Nutrients in Independence streams can originate from several nonpoint sources, such as runoff from fertilized lawns and farm fields, decomposition of yard waste, leaky sewer lines, atmospheric deposition, sanitary sewer overflows, and upstream inputs. In general, nutrient concentrations in the smaller Independence streams were greater than those in the Little Blue River (fig. 4). Nutrient concentrations during stormflow in the smaller streams in Independence were greater in more developed areas.

Chloride and Metals

Chloride naturally occurs in environmental waters, usually at small concentrations (Hem, 1992); however, one potential source of chloride is runoff from road de-icers applied to highways, streets, and parking lots during winter storms. Chloride concentrations vary with time because of differences in weather; precipitation type and frequency; and types, rates, and timing of application of road de-icers. Chloride concentrations in excess of 200 mg/L were measured at all five sampling sites (fig. 1) following a storm in December 2007. Large chloride concentrations such as these can remain elevated in streams for several months (Dougherty, 2007).

Samples were analyzed for total metals (unfiltered samples that include dissolved and suspended metals) including aluminum, arsenic, cadmium, chromium, copper, lead, mercury, and zinc. These metals could have a toxic effect on aquatic animals when present in sufficient bioavailable concentrations (the portion of total metals available for metabolism and use by the body of an aquatic animal). Most metals transported during stormflow are adsorbed to suspended sediment and are not bioavailable. There is a direct correlation between total metals concentrations and suspended-sediment concentrations, and both concentrations were elevated during some storms. To evaluate more readily bioavailable dissolved metal concentrations, one set of stormwater samples collected in October 2007 was analyzed for dissolved metals as well as total metals. Results indicated that the dissolved metals concentrations were small (less than 8 percent of the total metals concentrations).

Organic Micro-Constituents

Micro-constituents in the environment have been broadly defined by the Water Environment Federation (2007) as “Natural and manmade substances, including elements and inorganic and organic chemicals, detected within water and the environment, for which a prudent course of action is suggested for the continued assessment of the potential effect on human health and the environment.” Organic micro-constituents (OMCs), in particular, can have several sources, including, but not limited to, wastewater discharges; runoff from roads, parking lots, lawns, golf courses, agricultural

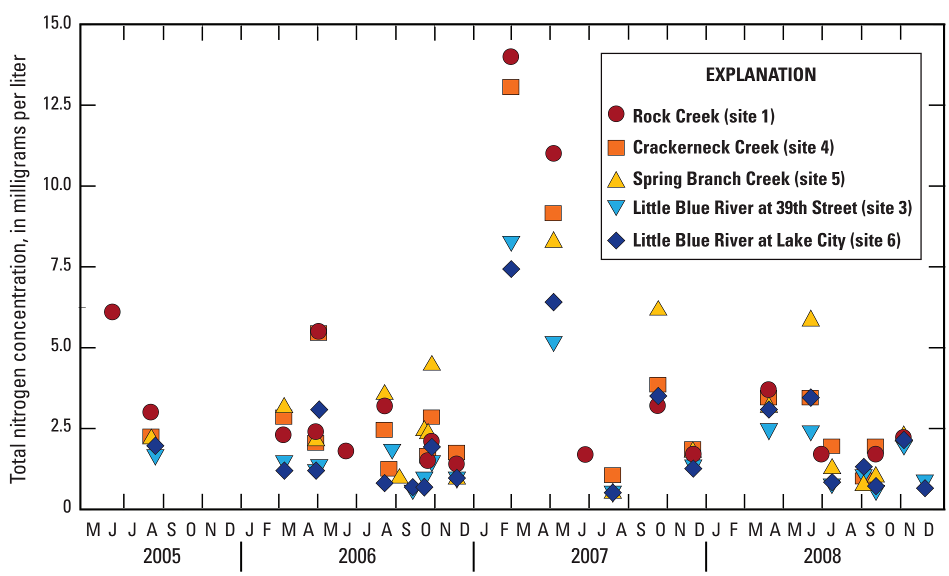

Figure 4. Total measured nitrogen concentrations during base flow and stormflow at five sampled sites (fig. 1).

fields and gardens; organic plant matter; garbage and construction materials; landfills; groundwater; and atmospheric deposition. Many of these compounds have become common in the environment, especially within and downstream from urban areas (Kolpin and others, 2002, 2004; Wilkison and others, 2006, 2009).

A total of 24 base-flow samples collected between June 2006 and September 2008 were analyzed for OMCs. In base flow, two categories of OMCs had samples with detections more than one-half the time; pesticides (100 percent) and plastics (67 percent). A total of 76 stormwater samples collected between June 2005 and December 2008 were analyzed for OMCs. The four categories of OMCs detected most often in stormwater had samples with detections more than 90 percent of the time; pesticides (100 percent), polyaromatic hydrocarbons (PAHs) and combustion by-products (99 percent), plastics (93 percent), and stimulants (91 percent). Most detections for all samples were small (many less than 2 micrograms per liter) or were not quantified because they were less than the laboratory reporting limit. The median concentration of OMCs for stormwater samples was greater than that for base-flow samples. The concentrations of OMCs in stormwater were less in the Little Blue River than in the smaller streams. Rock Creek had the greatest concentrations, likely attributable to proximity to contributions from older sewer pipes or sanitary sewer overflows.

Dry-Weather Screening (Illicit Discharge Monitoring)

From 2006 through 2008 dry-weather screening was conducted jointly by the USGS and IWPC personnel to monitor for illicit discharges. During dry weather, all visible discharges, inflows, or tributaries of the selected stream were sampled (fig. 5) and when possible, traced upstream to their source. Eight basins were screened and two basins (Rock Creek and Adair Creek) were screened multiple times for the presence of total chlorine, total dissolved copper, phenols, and anionic surfactants (detergents). Fourteen percent (75) of the 536 samples collected had detectable concentrations for one or more of three constituents; total chlorine, phenols, and anionic surfactants. Any detection

Figure 5. USGS employees collecting dry-weather screening samples.

was considered a potential point source of contamination; however, for most samples with detections (65 of 75, or 86.7 percent), a source could not be determined. Such instances most likely were attributable to episodic sources such as lawn watering or car washing. Ten samples (1.9 percent of all samples) had identifiable point sources. A previous study using a higher detection level (Schalk, 1993) found 46 detections (20.4 percent of samples) of total chlorine and detergents.

In addition to locating several point sources of contamination, large specific conductance values greater than 2,000 microsiemens per centimeter were measured in the Adair Creek Basin adjacent to Highway I-70 in April 2007 and July 2008, months after the winter road-salt application season. Specific conductance in water is a measure of the ability of the water to conduct an electric current and is dependent on the amount of dissolved solids, such as salt, in the water. Highway I-70 receives more road salt per lane mile than most other state routes (Missouri Department of Transportation, 2006) and these elevated measured specific conductance values may be indicative of extended residence time of de-icers in the environment.

Bacteria and Microbial Source Tracking

Escherichia coli (*E. coli*) bacteria reside in the digestive tracts of warm-blooded mammals and are excreted in their feces. These bacteria were found in all sampled streams in Independence and likely are a result of nonpoint sources. Tributary streams had larger median *E. coli* densities than the Little Blue River during both base flow and stormflow. Stormwater samples at all sites also had greater median *E. coli* densities than base-flow samples, which likely is the result of increased suspended sediment during storms. There is a positive relation at all sites between *E. coli* concentrations and suspended sediment (fig. 6). However, upstream reservoirs on the Little Blue River may act to lessen bacteria densities by attenuating high flows and trapping suspended sediment.

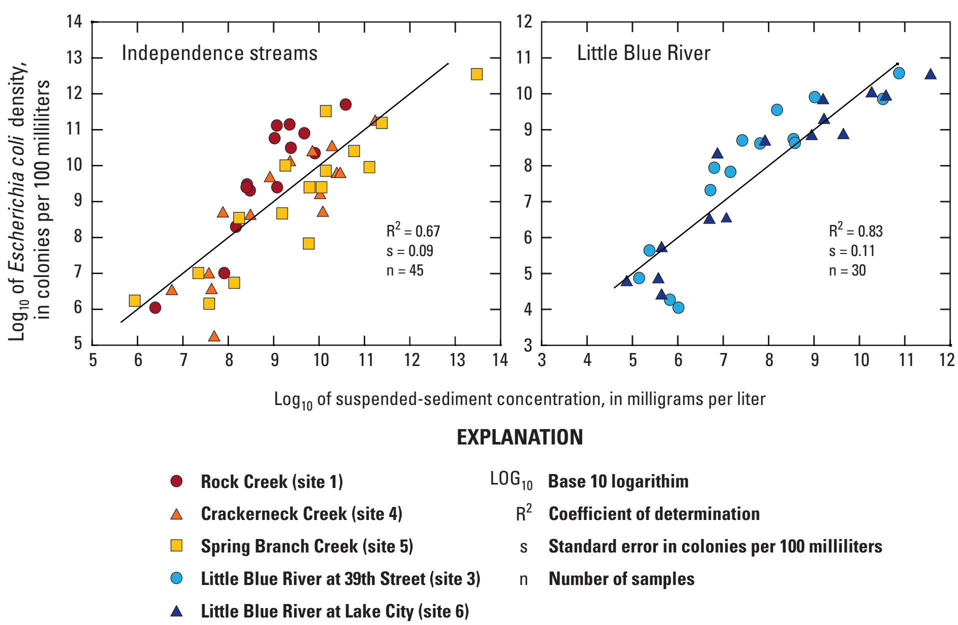

Figure 6. Relation between *Escherichia coli* density and suspended-sediment concentration for Independence streams and the Little Blue River [values on the graph are shown in Log_{10}, which is the exponent to which 10 must be raised to produce the original value (for example, 4.0 equals 10,000 because 10^4 equals 10,000)].

The sources of *E. coli* in Independence streams were evaluated using Microbial Source Tracking (MST) methods to identify the host organisms (sources) of bacteria. MST analysis uses a statistical comparison of genetic markers in sampled *E. coli* bacteria to a library of genetic host markers to determine possible host sources of bacteria in the stream (Stoeckel and Harwood, 2007). A limited number of MST samples were collected and results indicated that most bacteria were from nonhuman sources with a minority from human sources. Human-source *E. coli* likely originates from leaky sewer systems in the older parts of the city in the Rock Creek and Crackerneck Creek Basins and less developed areas of the Spring Branch Creek Basin.

Stream Ecological Health

Benthic macroinvertebrates are freshwater, bottom-dwelling animals without backbones which can be seen by the unaided eye (fig. 7). Benthic macroinvertebrate populations were surveyed in March 2007, and March and September 2008 at five study sites and two reference sites (fig. 1). Reference sites are water bodies that the Missouri Department of Natural Resources (Sarver and others, 2002) has determined to be the least impaired by human activities and they are the standard by which impairments are judged. The Stream Condition Index (SCI; Sarver and others, 2002) was used to evaluate biologic integrity at sites. Based upon these scores, most sites in the study area were considered either partially, or non-biologically supportive of aquatic life. The SCI scores for macroinvertebrate samples collected in the study area compared closely with those from less urbanized and minimally affected reference sites. SCI scores for the reference sites were equal to or slightly less than those for the Little Blue River sites and equal to or slightly greater than those for the smaller streams.

Figure 7. A helgramite (the larval form of a dobsonfly) is an example of a benthic macroinvertebrate found in Independence streams. Approximate length is 3 inches.

Habitat assessments were conducted at four of the five macroinvertebrate sampling sites and at two reference sites in late August and early September 2008. Habitat assessments measure various factors that affect the condition of stream habitat (Sarver and others, 2002). Habitat scores for the Independence sites were slightly greater than one-half of what would be considered ideal habitat for benthic macroinvertebrates. Overall, several factors including high sediment deposition, channel alteration, poor bank stability, and loss or absence of stream vegetation contributed to ecological stress at the four study sites and suppressed habitat scores.

What is the City of Independence Doing to Protect Water Quality in Streams?

Along with the cooperative agreement with the USGS to perform water-quality monitoring, surveys of illicit discharges to local streams, and biological sampling, the Independence Storm Water Management Program (*http://www.ci.independence.mo.us/wpc/*) endeavors to protect stream water quality in numerous other ways. Examples of city efforts to protect water quality include: development projects that include green space, tree preservation, stream setbacks and buffers; improving quality of stormwater runoff by street sweeping and storm structure cleaning; improving regional detention basin water-quality treatment through native vegetation planting (fig. 8); controlling contaminants in industrial stormwater runoff by inspections and enforcement; and employing Best Management Practices for pesticide, herbicide, and fertilizer applications. The program also seeks to reduce illicit discharges, spills, and dumping of contaminants through illicit discharge ordinances, complaint investigations, spill responses, public education and outreach, and monitoring; and to reduce contaminants in construction site runoff through erosion-control ordinances, erosion-control permits, inspections and enforcement, and inspector and construction site operator training. Watershed studies and public improvement projects, such as streambank stabilization, also help to protect stream-water quality.

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What can Independence Residents do to Help Protect Streams?

The City of Independence Water Pollution Control Department recommends the following actions to help protect streams from stormwater pollution:

AUTOMOTIVE

- Use alternate or public forms of transportation (walk, bike, carpool, take the bus)
- Check for fluid leaks and make repairs to fix them
- Never dump automotive fluids down the storm drain; recycle them
- Wash vehicles on a grassy or gravel area that absorbs water or use a commercial car wash
- Empty wash buckets into sinks, toilets, or floor drains

CHEMICALS

- Purchase only chemicals that are needed
- Dispose of hazardous products properly at a household hazardous waste collection site

LITTER

- Never throw trash on the ground
- When hauling, keep loads tightly covered
- Carry a litter bag in the car

PET WASTE

- Pick up pet waste from your yard and when walking pets
- Dispose of pet waste in the trash

SWIMMING POOL

- Don't drain your pool into storm drains or across neighbors' property
- Drain pools and spas into the sanitary sewer through any plumbed drain in your home

YARD

- Have soil tested for nutrient deficiencies before using fertilizers
- Use lawn chemicals sparingly or not at all and never before a heavy rainfall, and keep fertilizers and pesticides out of streets and storm drains
- Choose products with the lowest toxicity that will safely and effectively control pests, or adopt organic gardening practices
- Landscape with native plants, maintain plant cover on your property, and prevent soil erosion
- Reuse yard waste (grass clippings, leaves, limbs, and other similar items) as mulch or compost, or have it picked up for recycling
- Re-direct roof drains away from pavement and toward vegetated areas, or plant a rain garden and use rain barrels to capture rainwater from downspouts and use it to water plants

Figure 8. City of Independence stormwater detention basin planted with native grasses and flowers.

For U.S. Geological Survey real-time data visit: *http://waterdata.usgs.gov/mo/nwis/*

For further information contact:
U.S. Geological Survey
(816) 554–3489
http://mo.water.usgs.gov/

Independence Water Pollution Control Department
(816) 325–7711
http://www.ci.independence.mo.us/wpc/