Kansas City, Missouri
Water Services Department

Overflow Control Program

Overflow Control Plan

January 30, 2009
(Revised April 30, 2012)

City Contract 770 – City Project 81001

TABLE OF CONTENTS

List of Tables

List of Figures

List of Appendices

Appendix A
Program Guidance and Basic Data
Table of Contents

Appendix B
Separate Sewer System Basin Analyses
Table of Contents

B1 Line Creek / Rock Creek

B2 Shoal Creek/Birmingham Bottoms

B3 Round Grove Creek

B4 Blue River South

Appendix C
Combined Sewer System Basin Analysis
Table of Contents

C4 Middle Blue River

C5 Blue River Interceptor

Appendix D
System Wide Analysis
Table of Content

D1 Wastewater Treatment Plants

D2 City-Wide Alternative Analyses

D3 Water Quality Analyses

D4 Financial Capability and Funding

Appendix E
Wet Weather Community Panel
Table of Contents

E1	Report Title	Report Date
	OCP (2007), Community Panel Meeting Materials	March 1, 2007
	OCP (2007), Community Panel Meeting Materials	March 13, 2007
	OCP (2007), Community Panel Meeting Materials	April 10, 2007
	OCP (2007), Community Panel Meeting Materials	May 8, 2007
	OCP (2007), Community Panel Meeting Materials	June 12, 2007
	OCP (2007), Community Panel Meeting Materials	July 10, 2007
	OCP (2007), Community Panel Meeting Materials	August 14, 2007
	OCP (2007), Community Panel Meeting Materials	September 11, 2007
	OCP (2007), Community Panel Meeting Materials	October 9, 2007
	OCP (2007), Community Panel Meeting Materials	November 18, 2007
	OCP (2008), Community Panel Meeting Materials	January 8, 2008
	OCP (2008), Community Panel Meeting Materials	February 5, 2008
	OCP (2008), Community Panel Meeting Materials	March 11, 2008
	OCP (2008), Community Panel Meeting Materials	April 8, 2008
	OCP (2008), Community Panel Meeting Materials	May 13, 2008
	OCP (2008), Community Panel Meeting Materials	June 10, 2008
	OCP (2008), Community Panel Meeting Materials	August 12, 2008
	OCP (2008), Community Panel Meeting Materials	September 9, 2008
	OCP (2008), Community Panel Meeting Materials	October 14, 2008
	BNIM, Burns & McDonnell (2008), Stakeholder Forum: Overflow Control Plan Public Comments	December 5, 2008
	OCP (2008), Stakeholder Forum: Agenda	November 18, 2008
	OCP (2008), Stakeholder Forum: Meeting Invitation	November 3, 2008
	OCP (2008), Stakeholder Forum: Channel 2 Banner	November 5, 2008
	OCP (2008), Stakeholder Forum: Event Photographs	November 18, 2008
	OCP (2008), Stakeholder Forum: Media Advertisement	November 10, 2008
	OCP (2008), Stakeholder Forum: Outreach Methods Memo to Council & Mayor	November 17, 2008
	BNIM, Burns & McDonnell (2008), Stakeholder Forum: Interactive Survey Results	December 2, 2008
	BNIM, Burns & McDonnell (2008), Stakeholder Forum: Presentation	November 18, 2008
	OCP (2008), Community Panel Meeting Materials	December 9, 2008
	OCP (2003), Community Panel Attendance Record	December 31, 2003
	OCP (2004), Community Panel Attendance Record	December 31, 2004
	OCP (2005), Community Panel Attendance Record	December 31, 2005
	OCP (2006), Community Panel Attendance Record	December 31, 2006
	OCP (2007), Community Panel Attendance Record	December 31, 2007
	OCP (2008), Community Panel Attendance Record	December 10, 2008

Appendix E2
Basin Coordinating Committees
Table of Contents

Appendix E3
Outreach and Public Education
Table of Contents

E3	Report Title	Report Date
	scouts about stormwater quality	
	WSD (2006), Connections: Work in the Blue River Watershed reduces flooding potential, FEMA maps revised	July 1, 2006
	WSD (2006), Connections: UMKC Disconnects Downspouts	July 1, 2006
	WSD (2006), Connections: Construction complete on Huntington Sewer Relief	July 1, 2006
	WSD (2006), Connections: Native plants can help reduce runoff, improve stormwater quality	March 1, 2006
	WSD (2006), Connections: Department conducts isolated sewer inspection program	March 1, 2006
	WSD (2006), Connections: Study reveals stormwater contaminant sources are numerous	October 1, 2006
	WSD (2006), Connections: Wet Weather Solutions Program Basin Coordinating Committees begin meeting	October 1, 2006
	WSD (2008), Connections: Overflow Control Plan Extension Granted	August 1, 2008
	WSD (2008), Connections: WSD receives $1.5 million EPA Award for infrastructure and green solutions	August 1, 2008
	WSD (2008), Connections: Missouri River Cleanup	August 1, 2008
	WSD (2006), Connections: World Water Monitoring Day participants gather at Bruce R. Watkins Cultural Center	December 1, 2006
	WSD (2006), Connections: WSD TV tapes new segments of 'On Tap' - Dr. H2O prepares for web debut	December 1, 2006
	WSD (2006), Connections: 10,000 rain gardens focus on stormwater	January 1, 2006
	WSD (2008), Connections: Wet Weather Solutions Program presents draft Overflow Control Plan	June 1, 2008
	WSD (2008), Connections: Join the WSD Green Team	June 1, 2008
	WSD (2008), Connections: WSD to co-chair city-wide Green Solutions program	June 1, 2008
	KCMO (2008), Fountain Pen: City formally enacts Green Solutions policy	April 1, 2008
	KCMO (2008), Fountain Pen: KC GreenSummit 2008	April 1, 2008
	KCMO (2008), Fountain Pen: Channel 2 program gets onboard with the green movement	April 1, 2008
	KCMO (2008), Fountain Pen: Water Services Department adds rain garden	August 1, 2008
	KCMO (2008), Fountain Pen: On Tap looks at what shouldn't be flushed	February 1, 2008
	KCMO (2008), Fountain Pen: Workshop generates ideas and strategies to incorporate sustainability into operations	July 1, 2008
	KCMO (2008), Fountain Pen: Project Blue River Rescue volunteer effort	June 1, 2008
	KCMO (2008), Fountain Pen: First KC GreenSummit has strong start	June 1, 2008

E3	Report Title	Report Date
	to meet on July 27th	
	OCP (2006), Press Release: Northeast Industrial District Basin Coordinating Committee to meet July 26th	July 21, 2006
	OCP (2006), Press Release: Gooseneck Creek Basin Coordinating Committee to meet on July 25th	July 21, 2006
	OCP (2006), Press Release: KCMO Household Hazardous Waste to sponsor ABOP (Antifreeze, Batteries, Oil & Paint) collection site	June 1, 2006
	OCP (2006), Press Release: Brookside Sewer Improvements – Phase 2 Construction Complete (Huntington Relief Sewer)	May 31, 2006
	OCP (2006), Press Release: University of Missouri-Kansas City Disconnects Downspouts	June 1, 2006
	OCP (2006), Press Release: Wet Weather Community Panel Adopts Program Goals and Objectives	September 5, 2006
	OCP (2007), Press Release: Kansas City's Water Services Department Submits Conceptual Control Plan	October 2, 2007
	OCP (2005), Press Release: Kansas City, Missouri Water Services Department Conducts Smoke Testing of Sewer System	September 7, 2005
	OCP (2005), Press Release: Kansas City, Missouri Water Services Department Conducts Smoke Testing of Sewer System	September 19, 2005
	OCP (2005), Press Release: KCMO Water Services to meet with homeowners regarding improper sewer connections	October 4, 2005
	OCP (2005), Press Release: KCMO Water Services to meet with homeowners regarding improper sewer connections	October 10, 2005
	OCP (2008), Press Release: KCMO CSO program Manager to present at EPA Green Infrastructure Workshop	September 4, 2008
	OCP (2008), Press Release: WSD Green Team plants rain garden at WSD Administration Building	June 23, 2008
	OCP (2007), Press Release: Wet Weather Community Panel Endorses the Kansas City Missouri Stream Buffer Ordinance	August 7, 2007
	OCP (2007), Press Release: Wet Weather Community Panel Endorses Strategies for Overflow Control Program's Conceptual Control Plan	August 15, 2007
	OCP (2007), Press Release: Kansas City's Overflow Control Program Submits Conceptual Control Plan	September 26, 2007
	OCP (2008), Press Release: Green Solutions Administrative Regulation is Signed by the City Manager	February 26, 2008
	OCP (2007), Press Release: Wet Weather Community Panel Endorses Green Solutions Position Paper	August 7, 2007

Appendix E4
Public Hearings
Table of Contents

Appendix E5
Green Integration Collaborative Team
Table of Contents

Appendix E6
Funding Task Force
Table of Contents

ACRONYMS

ADF	Average Daily Flow
ALERT	Automated Local Evaluation in Real-Time
BCCs	Basin Coordinating Committee
BEs	Basin Engineers
BMPs	Best Management Practices
BOD	Biochemical Oxygen Demand
B&V	Black & Veatch
BRIS	Blue River Interceptor Sewer
BRWA	Blue River Watershed Association
BRWWTP	Blue River Wastewater Treatment Plant
BWR	Bucher, Willis & Ratliff Corporation
CCP	Conceptual Control Plan
CCTV	Closed Circuit Television
CDM	Camp, Dresser & McKee
CID	Central Industrial District
CFS	Cubic Feet Per Second
CPH	Cost Per Household
CSM	Continuous Simulation Modeling
CSO	Combined Sewer Overflow
CSS	Combined Sewer System
CWA	Clean Water Act
DAF	Dissolved Air Floatation
DMP	Data Management Protocol
DMS	Data Management System
DO	Dissolved Oxygen
DWOs	Dry Weather Overflows
ENR CCI	Engineering News Record Construction Cost Index
EPA or USEPA	United States Environmental Protection Agency
FAC	Federal Administrative Code
FCA	Financial Capability Assessment
FWS	Flood Warning System
GBA	George Butler & Associates
GIS	Geographic Information System

ACRONYMS

HRF	High Rate Filtration
HRT	High Rate Treatment
I&C	Instrumentation and Control System
I/I	Infiltration and Inflow
IET	Inter-Event Time
ILS	In-Line Storage
ISS	Inline Storage System
IWPP	Industrial Waste Pretreatment Program
KDHE	Kansas Department of Health & Environment
LBVSD	Little Blue Valley Sewer District
MARC	Mid-America Regional Council
MCC	Motor Control Center
MCI	Kansas City International Airport
MDC	Missouri Department of Conservation
MDNR	Missouri Department of Natural Resources
MG	Million Gallons
MGD	Million gallons per day
MG/L	Milligrams Per Liter
MHI	Median Household Income
MKC	Kansas City Downtown Airport
MMAD	Maximum Monthly Average Day
MOM	Management, Operations and Maintenance
NCDC	National Climatic Data Center
NEID	Northeast Industrial District
NMC	Nine Minimum Controls
NMS	National Marine Sanctuaries
NPDES	National Pollutant Discharge Elimination System
O&M	Operations and Maintenance
OCP	Overflow Control Program
ONRW	Outstanding National Resource Waters
PCMP	Post-Construction Monitoring Plan
PCR	Primary Contact Recreational
PIAC	Public Improvement Advisory Committee
POTW	Publicly Owned Treatment Works

ACRONYMS

PPD	Pounds Per Day
QA/QC	Quality Assurance/Quality Control
RDII	Rainfall Derived Infiltration and Inflow
RTC	Real-Time Control
SCADA	Supervisory Control and Data Acquisition
SOR	Surface Overflow Rate
SRT	Solids Retention Time
SSES	Sewer System Evaluation Surveys
SSO	Sanitary Sewer Overflow
SSS	Sanitary Sewer System
SWMM	Storm Water Management Model
TMDL	Total Maximum Daily Load
TRUE	Teaching Rivers in an Urban Environment
TSS	Total Suspended Solids
UAA	Use Attainability Analysis
USACOE	United States Army Corps of Engineers
USGS	United States Geological Survey
UV	Ultraviolet
WAI	Wade & Associates
WBC-A	Whole Body Contact-Category A
WBC-B	Whole Body Contact-Category B
WQMP	Water Quality Monitoring Plan
WSD	Water Services Department
WSWWTP	Westside Wastewater Treatment Plant
WWT	Wastewater Treatment
WWTP	Wastewater Treatment Plant
XP-SWMM	XP Software Inc., Storm Water Management Model

1 EXECUTIVE SUMMARY

1.1 Introduction

Kansas City's City Council Resolution 030764, passed on July 10, 2003, directed the City Manager to prepare a plan for the Comprehensive Wet Weather Control Plan, a long-range plan to manage wet weather flow in both the separate and combined sewers within Kansas City. In response to that resolution, the City of Kansas City, Missouri (the City) Water Services Department (WSD) developed the Wet Weather Solutions Program, a comprehensive approach to managing wet weather issues in the City and composed of three principal components:

- KC-One: A comprehensive stormwater management plan that integrates the results and recommendations of 35 watershed studies and details the City's strategy, policies, goals, and priorities for stormwater management.
- Waterways: A division of WSD that works with the U.S. Army Corps of Engineers to develop and implement major flood control and related work in the City.
- Overflow Control Program: A long-term planning process to develop ways to control overflows from the City's wastewater collection and treatment system.

Through its Overflow Control Program (OCP), WSD prepared this Overflow Control Plan (the Plan) for reducing overflows from the City's wastewater collection and treatment system. Completion of the Plan is estimated to cost $2.48 billion (in 2008 dollars) over the next 25 years.

On January 30, 2009, the City of Kansas City, Missouri (the City; KCMO) completed its Overflow Control Plan (the Plan) and submitted the Plan to the United States Environmental Protection Agency (USEPA) and the Missouri Department of Natural Resources (MDNR). Subsequent to submittal of the Plan, the City, acting principally through its Water Services and Law Departments, continued negotiations with the USEPA and MDNR for the development of a Consent Decree under which the Plan would be implemented. Those negotiations were successfully concluded in April, 2010. On May 18, 2010 the United States submitted the proposed Consent Decree for lodging with the United States District Court for the Western District of Missouri, Western Division, styled as Civil Action No. 4:10-cv-0497-GAF.

On Sept. 27, 2010, following a public comment and review period, the Federal Court approved and entered the Consent Decree, a full copy of which may be found at the following website:

http://www.kcmo.org/idc/groups/public/documents/waterservices/consentdecree.pdf

The Court's order caps a multi-year effort by the City to obtain regulatory approval for a Long Term Control Plan (Plan) to control sewer overflows that is the right Plan for Kansas City. The Consent Decree describes the overflow control measures and performance criteria that must be implemented and achieved, respectively, for decreasing the frequency, volume, and duration of overflows from the City's combined sewer system (CSS) and separate sanitary sewer system (SSS).

The primary emphasis of the Consent Decree negotiations was on establishing an implementation schedule that completed all agreed-upon improvements at the earliest practicable date consistent with Kansas City's financial capability while retaining the original Plan's focus on reducing the problem before trying to finally solve it. While the majority of the technical components of the Plan (and their intended performance) were confirmed in the negotiations, certain modifications were made. Chapter 14 summarizes Plan components reflected in the Consent Decree, which in some instances vary from those presented in Chapter 12 "Selected Plan", and as such represents the "Final Plan" to which the City is committed.

In addition to implementation of the Plan, Section VII of the Consent Decree commits the City to implementation of additional sewer system remedial measures and programs. These additional sewer system remedial measures and programs are listed below, together with the specific location in the Consent Decree in which they are more fully defined, but are not otherwise addressed in the Plan.

- Nine Minimum Controls (NMCs) Plan in the CSS, more fully described in Appendix B of the Consent Decree;
- Capacity, Management, Operation and Maintenance (CMOM) Plan, more fully described in Appendix C of the Consent Decree;
- Supplemental Environmental Project (SEP) Plan that includes the implementation of a Sewer Connection and Septic Tank Closure Program, more fully described in Appendix E of the Consent Decree; and
- Implementation of Disinfection Technology at each of the City's existing WWTPs, the schedule for which is more fully described in Appendix F of the Consent Decree.

The Consent Decree requirement for implementation of disinfection technology at the City's existing WWTPs represents a substantial investment, both in capital cost (approximately $100 million) and for ongoing operations and maintenance (approximately $1.7 million per year in 2008 dollars), that directly impacted and limited available funding for the Overflow Control Plan, particularly in its early years.

1.1.1 Background

Like most communities across the nation (including over 700 cities that have combined sewer systems (CSS), the City is under increasing regulatory pressure to continue and expand its efforts to protect and improve water quality.

The United States Environmental Protection Agency (USEPA) issued a national policy statement entitled Combined Sewer Overflow (CSO) Control Policy in 1994. This policy (40 CFR Part 122) was meant to establish a consistent national approach for controlling combined sewer discharges to the nation's waters utilizing the National Pollutant Discharge Elimination System (NPDES) permit program. Congress subsequently amended the Clean Water Act (CWA), incorporating the requirements of the CSO Control Policy, to ensure that municipalities, permitting authorities, water quality standards authorities, and the public engage in a comprehensive and coordinated planning effort to achieve cost effective CSO controls that ultimately meet appropriate health and environmental objectives.

WSD worked with the regulatory agencies for several years to address the requirements of the CWA. Work plans for developing control plans for the City's combined sewer system (CSS) and separate sewer system (SSS) were published in May 2004, revised in response to regulatory agency comments in September 2005, and accepted by the regulatory agencies (with additional comments) in February 2006. Those work plans committed the City to the submittal of control plans for both the separate and combined sewer systems to the State of Missouri Department of Natural Resources (MDNR) and the USEPA.

1.1.2 City's Sewer System

WSD provides wastewater collection and treatment for approximately 653,000 people, of which approximately 437,000 are City residents. The remaining 215,000 people reside in 27 tributary or "satellite" communities. Figure 1-1 shows the entire area tributary to the City's wastewater collection system (totaling approximately 420 square miles). Of that total area, approximately 318 square miles are within the corporate limits of the City, with the balance in the satellite communities. The most significant satellite customer is Johnson County (Kansas) Wastewater (represents a population of approximately 127,000 people served by the City's system). None of the 27 satellite communities are served by combined sewer systems. Approximately 36 square miles within the City drain to and are served by the Little Blue Valley Sewer District's conveyance and treatment system.

WSD's system includes seven wastewater treatment plants (WWTPs). The five WWTPs north of the Missouri River serve the SSS. The two largest plants (Blue River and Westside) are south of the Missouri River and serve both the CSS and the SSS.

South of the Missouri River, about 56 square miles within the City are served by the CSS. That area is bounded by the Missouri/Kansas state line on the west, 85th Street on the south, the Blue River on the east, and the Missouri River on the north. A small area of 37 acres (0.06 square miles) east of the Blue River (at Winner Road and Interstate 435) is also served by the CSS. The Charles B. Wheeler (Downtown) Airport adds approximately 2 square miles to the total Kansas City, Missouri area served by the CSS. The sewer system serving the Downtown Airport is owned and operated by the Kansas City

Aviation Department. City watersheds served by the CSS are shown in light green on Figure 1-1. A portion of the SSS, serving approximately 221,000 people, drains to the CSS.

For planning purposes, the area served by the CSS was subdivided into seven principal basins, as shown on Figure 1-2. The locations of the City's 90 combined sewer outfalls are also shown on Figure 1-2. Five basins (Gooseneck Creek, Lower Blue River, Town Fork Creek, Brush Creek, and Middle Blue River) are tributary to the Blue River Interceptor Sewer, which generally parallels the Blue River downstream (north) of Brush Creek and discharges to the Blue River WWTP. A sixth basin, Northeast Industrial District (NEID), is served by that same WWTP.

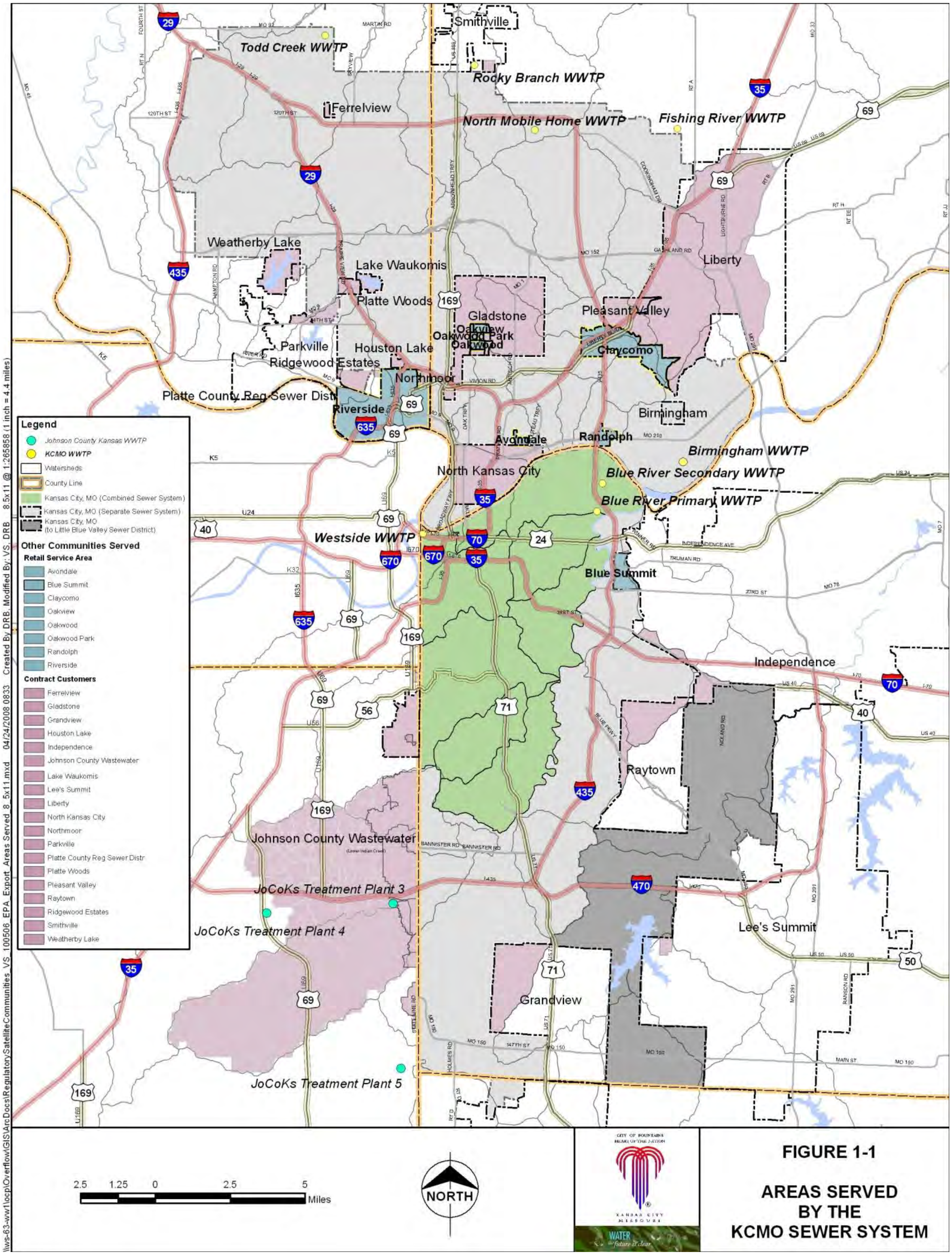


FIGURE 1-1

AREAS SERVED BY THE KCMO SEWER SYSTEM

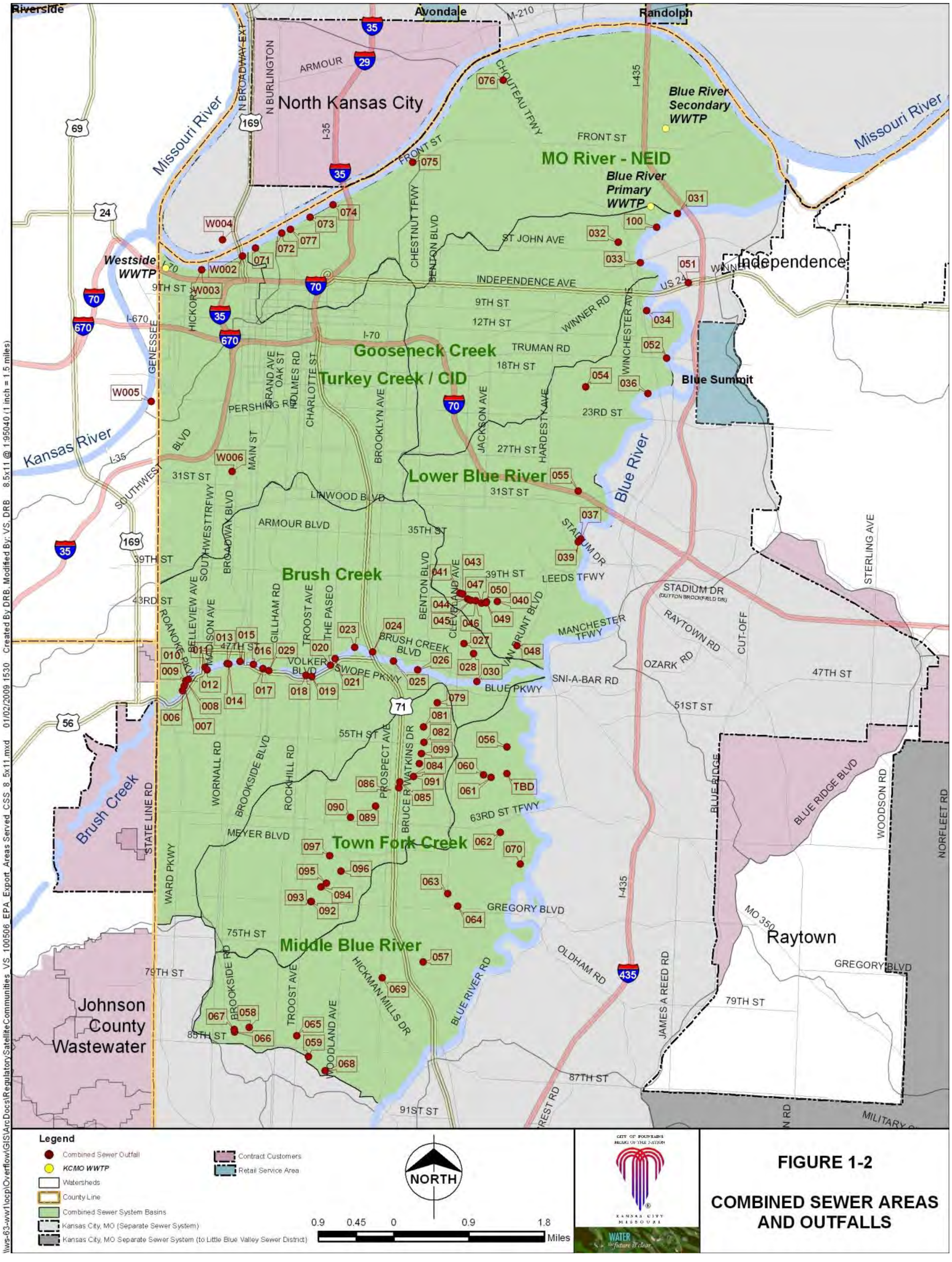


FIGURE 1-2

COMBINED SEWER AREAS AND OUTFALLS

The Blue River WWTP is the City's largest WWTP, with a permitted capacity of 105 million gallons per day (MGD). Primary treatment and solids handling facilities are located just west of Interstate 435 on Hawthorne Road. Secondary treatment consists of trickling filters and clarifiers located east of Interstate 435, north of Front Street. Treated effluent from the Blue River WWTP is discharged to the Missouri River just east of Interstate 435.

The seventh CSS basin (Turkey Creek/Central Industrial District [CID]) discharges to the Westside WWTP. The Westside WWTP is the City's second largest WWTP, with a permitted capacity of 22 MGD. It is located between the Lewis and Clark Viaduct (Interstate 70) and the Missouri River just east of the state line. Sewage from the Downtown Airport and the Harlem area is pumped across the Missouri River to the Westside WWTP. A part of the flow from the Line Creek Pumping Station north of the Missouri River is pumped to the Westside WWTP as well.

The City's SSS serves approximately 244,000 City residents and approximately 212,000 residents in the 27 satellite communities. A part of the City's SSS discharges to the Little Blue Valley Sewer District (LBVSD). LBVSD is an independent regional wastewater collection and treatment entity serving the entire Little Blue River watershed. The overall population tributary to LBVSD's WWTP at Atherton, Missouri, includes approximately 33,000 people, who are served by the City's SSS. Sewage from the remaining 414,000 people served by the City's SSS is treated at the City's seven WWTPs.

For planning purposes, the area within the City's SSS was divided into nine principal basins, four north of and five south of the Missouri River. The four SSS basins north of the Missouri River are shown on Figure 1-3, and include the Northern and Northwestern watersheds, and the Line Creek/Rock Creek and Birmingham/Shoal Creek basins. The five SSS basins south of the Missouri River are shown on Figure 1-4. They are the Blue River North, Round Grove, Blue River Central, Blue River South, and Little Blue Basins.

Sewage from the Northern watershed is treated at the City's four smallest WWTPs (Todd Creek, Rocky Branch, Northland Mobile Home Park, and Fishing River). The total permitted capacity of those four WWTPs is just over 6.4 MGD. Treated effluent from these plants (with the exception of Fishing River) is discharged to tributaries of the Platte River.

The Birmingham WWTP is the City's third largest WWTP (permitted capacity of 20 MGD), and serves the Birmingham/Shoal Creek basin. Sewage is delivered to the Birmingham WWTP from the Birmingham Pumping Station. Treated effluent from the Birmingham WWTP is discharged to the Missouri River. Sewage from the Northwestern and Line Creek/Rock Creek basins is pumped across the Missouri River at the Line Creek and Buckeye Creek Pumping Stations to the Westside and Blue River WWTPs. The City of North Kansas City also delivers its sewage to the Blue River WWTP through a force main that crosses the Missouri River at the Buckeye Creek Pumping Station.

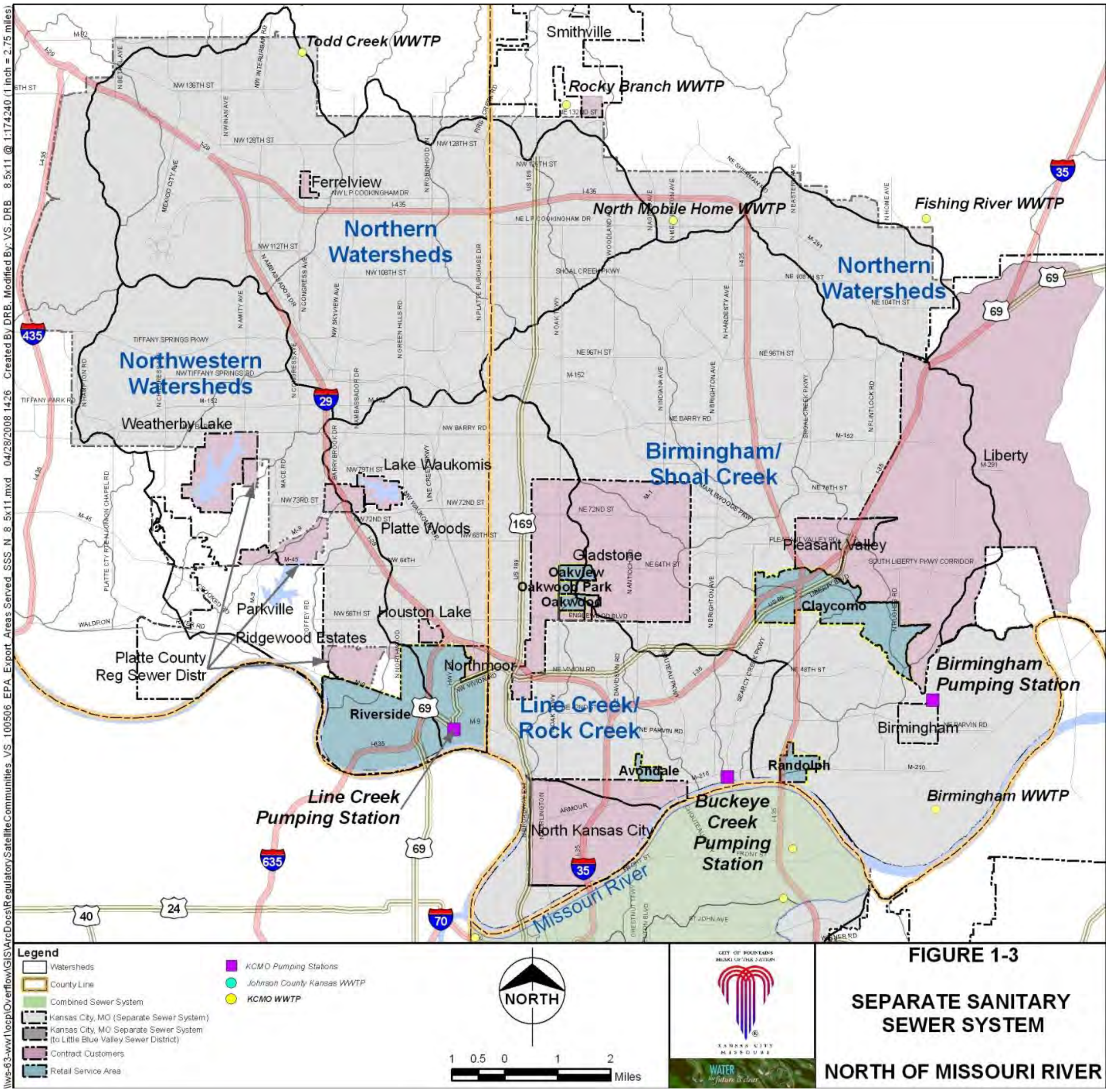


FIGURE 1-3

SEPARATE SANITARY SEWER SYSTEM

NORTH OF MISSOURI RIVER

Sewage from the Blue River North basin is delivered to the NEID Pumping Station, which pumps the sewage to the Blue River WWTP for treatment. That pumping station also delivers flow from the NEID CSS basin, flow from the City of North Kansas City, and sewage from the Line Creek/Rock Creek basin (via the Buckeye Creek Pumping Station) to the Blue River WWTP. Sewage from the remaining SSS basins south of the Missouri River is delivered to the Blue River WWTP through the Blue River Interceptor Sewer. This is the same sewer that carries flow from five CSS basins. SSS flows are pumped to the Blue River Interceptor Sewer from the Round Grove and 87th Street Pumping Stations.

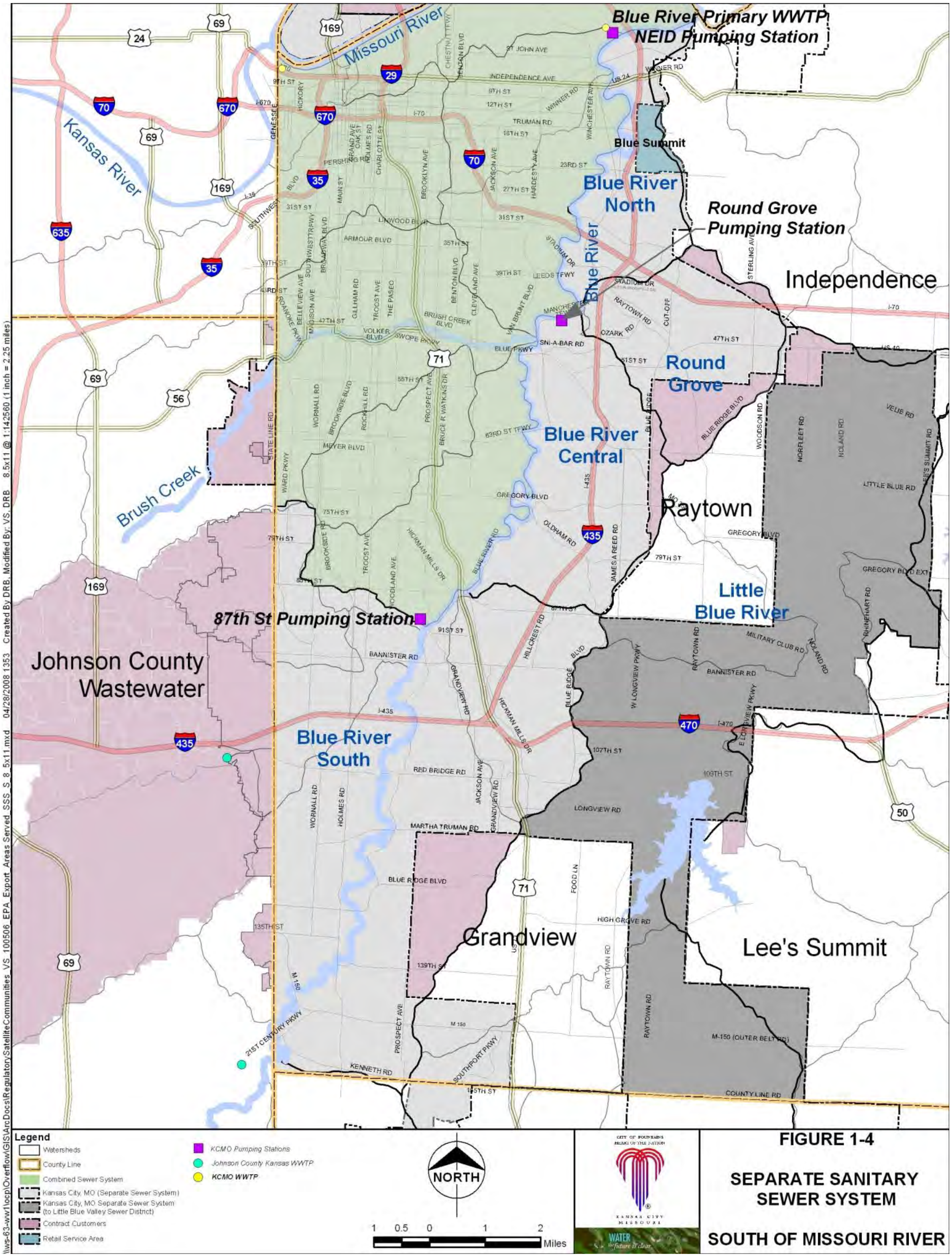


FIGURE 1-4

SEPARATE SANITARY SEWER SYSTEM

SOUTH OF MISSOURI RIVER

The Round Grove Pumping Station, located on the east bank of the Blue River east of its confluence with Brush Creek, delivers sewage from the Round Grove basin and the Blue River Central basin to the Blue River Interceptor Sewer.

Other than the influent pumping station at the Blue River WWTP (which pumps flow from the Blue River Interceptor Sewer to the WWTP), the largest pumping station in the City's wastewater system is the 87th Street Pumping Station. This station, located near Prospect Avenue at the Blue River, delivers flow from a total population of approximately 182,000 to the Blue River Interceptor Sewer. That population includes approximately 55,000 City residents, approximately 124,000 residents of Johnson County, Kansas, and approximately 2,600 residents in the City of Grandview, Missouri.

1.1.3 Kansas City's Streams, Lakes and Rivers

The City's combined sewers overflow to numerous receiving streams. Principal receiving streams include the Kansas River, the Missouri River, the Blue River, and Brush Creek. Brush Creek is tributary to the Blue River, which is tributary to the Missouri River. All of the City's CSS basins are eventually tributary to the Missouri River, but represent only 0.01 percent of the total Missouri River tributary area at the City. The Downtown Airport, the CID, and the NEID are each directly tributary to the Missouri River. The Turkey Creek basin is the only City CSS basin tributary to the Kansas River. The City's CSO receiving streams include no "sensitive areas" as they are defined in the USEPA's CSO Control Policy. This conclusion is explained in detail in Chapter 6.

Figure 1-5 identifies current designated beneficial recreational uses for those stream reaches that receive CSOs. The Missouri River and the Blue River downstream (north of 59th Street) are designated by the State of Missouri as Whole Body Contact – Category B (WBC-B). Between 59th and 95th Streets, the Blue River is designated as Whole Body Contact – Category A (WBC-A). Category A designates public swimming areas and Category B designates all other classified water bodies. Although the Blue River between 59th and 95th Streets is designated as WBC-A, no public swimming areas exist in this reach. The Kansas River has been designated by the State of Kansas for primary contact recreational use (PCR) – Class B (open public access). Brush Creek, although included in this discussion and shown on Figure 1-5, is currently unclassified. The Blue River upstream (south of Bannister Road to the state line) is designated as Whole Body Contact – Category B; Indian Creek between the Blue River and the state line is designated as Whole Body Contact – Category A. Those stream reaches do not receive CSOs.

Figure 1-5 also defines (in blue) the CSS area directly tributary to the Missouri River (including those areas tributary via the Kansas River) and all areas tributary to the Blue River. The map distinguishes between those tributary areas upstream of the City's CSOs (e.g., upstream of the points marked with red stars) and areas directly tributary to those stream reaches that receive CSOs. Within the Blue River basin, areas directly tributary to those stream reaches that receive CSOs include both the CSS (shown in yellow) and the SSS (shown in green).

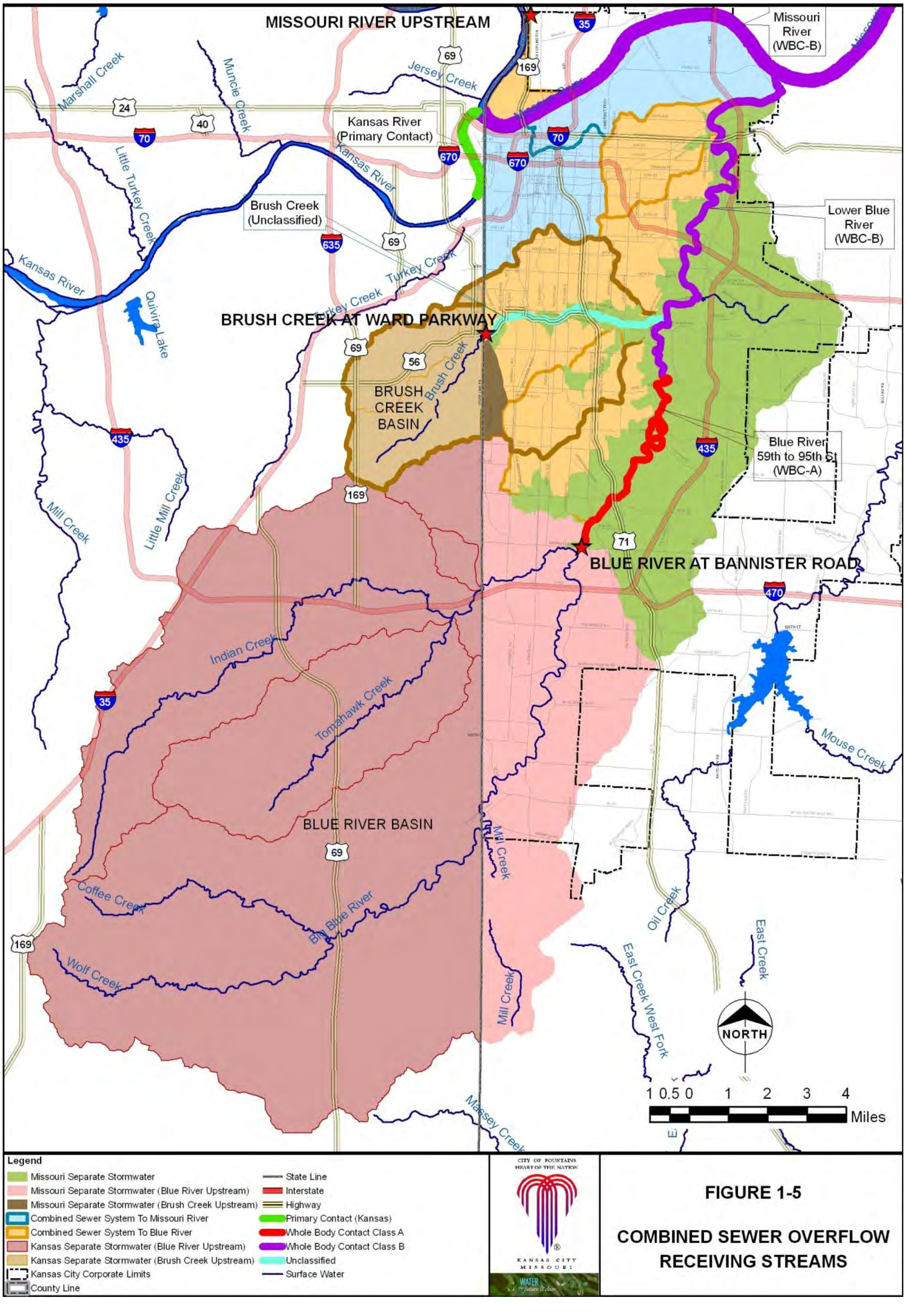


FIGURE 1-5

COMBINED SEWER OVERFLOW RECEIVING STREAMS

Seventy-four percent of the total area tributary to the Blue River is located upstream of those reaches of the Blue River and its tributaries that are impacted by overflows from the City's CSS. The City's CSS serves 10 percent of the total area tributary to the Blue River. The remaining 16 percent of the Blue River tributary area is served by separate storm and sanitary sewer systems.

1.2 Existing Conditions

Existing performance estimates for the City's wastewater collection system were developed utilizing calibrated computer models. Sewer system hydraulic models were calibrated using results from temporary flow metering conducted over an eight-month period in 2005. Receiving stream water quality models were calibrated to the results of detailed water quality sampling conducted in 2005. That data was combined with data generated from the City's ongoing bimonthly stream sampling program and data generated by the United States Geological Survey (USGS) during a detailed eight-year (1998-2006) water quality study of the Blue River.

1.2.1 Separate Sewer System

Four of the nine SSS basins were analyzed using flow meter data and computer models. These four basins (Line Creek/Rock Creek, Birmingham/Shoal Creek, Round Grove Creek, and Blue River South) were selected for detailed analysis because they directly impact the performance of facilities also serving the CSS and are more likely candidates for priority rehabilitation activities, due principally to the age of those systems. Analysis of the remaining five basins was based principally on temporary flow metering results secured during previous infiltration and inflow (I/I) studies. Additional temporary metering was conducted in the Blue River North and Blue River Central basins in connection with preparation of this Plan.

It was concluded that, under existing conditions, the collection systems and WWTPs have adequate capacity to convey and treat dry weather flows. However, only about half of the total annual flow in the SSS was actual wastewater generated by residents and businesses. Increased flows during wet weather I/I contribute the other half.

For the four basins studied in detail, peak flows in the lower ends of the systems during heavy rainfall exceeded normal design allowances (typically 4-5 times the dry weather flow), indicating high I/I quantities. A similar conclusion was reached for much of the system in the other five planning basins, based on analyzing previous flow monitoring results. During heavy rainfall, many sewer lines and manholes surcharge. If the rainfall is heavy enough, the sewer system can cause basement backups and overflow at manholes, releasing untreated sewage to the environment. In the four basins studied in detail, the modeled SSO volume during a 5-year, 24-hour rainfall event totaled 165 million gallons.

In addition to the uncontrolled overflows from the SSS, a constructed SSO is present at the lower end of the Line Creek system. The modeled overflow volume at this location during a 5-year, 24-hour rainfall event was 26 million gallons.

1.2.2 Combined Sewer System

The current performance of the CSS was estimated using computer models calibrated to sewer flow meter and rainfall data. The estimated overflow volume from the City's CSS south of the Missouri River in a typical year was 6.4 billion gallons. Overflow frequency varied significantly, both within the individual basins and across the City. At some outfalls, no CSOs are expected in a typical year; at other outfalls, several overflows can be expected each month. The estimated average overflow frequency at the 89 outfalls south of the Missouri River exceeds 18 times per year.

1.2.3 Water Quality in Streams, Lakes and Rivers

In the City, the principal pollutant of concern in the CSO receiving streams is bacteria. Water quality in streams is impacted by both the flow volume and bacteria levels in discharges from upstream sources and by local discharges (which include CSOs, runoff from separate stormwater areas, and WWTP effluent). Overflows from the City's entire CSS represent 0.02 percent of the volume and 3 percent of the total *E. coli* bacteria in the Missouri River immediately downstream from its confluence with the Blue River. Discharges from the 10 percent of the Blue River tributary area served by the CSS represent 4 percent of the total flow volume in a typical recreation season, but contribute 39 percent of the total *E. coli* bacteria in the Blue River at its mouth. Estimated *E. coli* concentrations in both the Missouri River and the Blue River, upstream of any overflows from the City's CSS, are above the State of Missouri's numeric standards.

1.3 Public Involvement

Public participation efforts were organized to provide the citizens of the City with a comprehensive and consolidated opportunity to participate in development of solutions for all wet weather issues facing the City. An extensive public participation program was initiated in 2001 and expanded throughout the Plan development. The public participation program was designed to educate and involve the public relative to activities of the OCP and is more fully described in Chapter 9. A cornerstone of the public participation process was an intense effort with the Wet Weather Community Panel, a citizen task force appointed in 2003 by the Mayor of Kansas City, coupled with efforts to engage and educate the public at large.

1.4 Development and Evaluation of Alternatives

The City's wastewater collection and treatment system serves a large geographic area that includes both the CSS and SSSs. The pipe networks are interconnected at numerous locations and dynamically interact during both dry and wet weather. Improvements and changes to the SSS directly impact facilities serving the CSS. For that reason, the City's Plan addresses the entire system.

The process followed in the development and evaluation of alternatives is described in Chapters 7, 8, and 10. A detailed description of the component elements of the Plan is presented in Chapter 14. A brief summary of those component elements is included below.

1.5 Overflow Control Plan Components

While this Plan briefly deals with stormwater management in the CSS, KC-One (the City's stormwater management plan) will provide recommendations to address stormwater issues throughout the City. The Plan is designed to work in concert with KC-One to achieve the primary goals defined by the Wet Weather Community Panel:

- Minimize loss of life & injury
- Reduce property damage due to flooding
- Improve water quality while maximizing economic, social, and environmental benefits

Achieving those goals and meeting regulatory requirements will require more than simply decreasing the frequency and volume of overflows from the City's CSS and SSS. A watershed approach is needed, coupling overflow control with forward-looking stormwater management, and a community-wide emphasis on protecting water quality and reducing runoff. Green solutions, stormwater Best Management Practices, and conventional source reduction techniques must all play significant and early roles in an adaptive program structured to achieve those many objectives, at an appropriate cost.

This Plan is based on an adaptive management approach in which design, management, and monitoring are integrated to systematically test assumptions, learn from results, and adapt future plans throughout implementation. The adaptive management framework will be applied to the Plan on various levels. Adaptive management will be part of the overall programmatic approach and will also be specifically applied at the basin and project level. Data gathered throughout project implementation will provide opportunities for feedback that subsequently will provide for informed decision-making at the basin level and, ultimately, City wide.

The Plan is structured to:

- Reduce the problem before trying to solve it by preventing as much stormwater as practicable from entering the CSS and SSS. This will be accomplished through widespread implementation of both green solutions and conventional source controls early in Plan implementation.
- Address flood protection needs, where possible, while reducing CSOs.
- Provide a programmatic platform to facilitate implementation of a comprehensive green solutions initiative across the City.
- Maximize use of the existing collection and treatment systems.

- Establish an adaptive approach to long-term plans for structural solutions so they can be modified to reflect the results and benefits of early efforts (green solutions and conventional source controls) based on the responses of both the CSS and SSS to rainfall events.

The Plan will:

- Reduce typical year CSO volume from 6.4 billion gallons to approximately1.4 billion gallons.
- Reduce Inflow and Infiltration (I/I) in the SSS.
- Provide adequate capacity to store, transport, and treat remaining wet-weather flows (as predicted by modeling) in the SSS.
- Reduce the frequency and severity of basement backups throughout the City.
- Cost approximately $2.5 billion (in 2008 dollars).
- Increase annual costs for operation and maintenance of the sewage collection and treatment system by approximately $31 million per year (in 2008 dollars).

Improved operation and maintenance and an appropriate level of investment in repair and replacement of system components are also needed to overcome deferred maintenance. Costs for those efforts to restore and preserve the integrity of the City's wastewater collection and treatment assets were considered during development of the appropriate level of investment in the Plan.

1.5.1 Blue River Watershed Management Plan

The City's water quality monitoring data reveal that streams receiving CSO generally meet current water quality standards for most pollutant parameters. However, CSO receiving streams do not meet current state standards for bacteria. There are four primary sources of pollution in the streams that receive CSOs: stormwater runoff from upstream sources, stormwater runoff from both SSS areas adjacent to the streams and in the CSS areas, effluent from WWTPs, and untreated wastewater in CSOs. Water quality would not meet state bacteria standards in the Missouri River and in a portion of the Blue River even if the City's CSOs are reduced (or even eliminated). Attainment of appropriate water quality standards in the Blue River requires that substantial reductions for each of the primary sources of pollution be achieved. A watershed approach is needed.

Although not required by the Consent Decree, the Plan includes the preparation of a watershed management plan (WMP) for the entire Blue River Basin. Strategies will be developed that acknowledge the interrelationship of water, land use, and human communities within the watershed. Resultant projects should produce multiple benefits.The Watershed Management Plan is intended to be multi-jurisdictional, bi-state, cost-effective, collaborative, and comprehensive. The Watershed Management Plan will develop goals, objectives, and specific strategies, including an implementation plan. During implementation, progress will be monitored and plan adjustments will be made to ensure real improvement in water quality, directed toward eventual compliance with water quality standards.

1.5.2 Monitor, Evaluate, and Adapt

A critical aspect of adaptive management is the ability to measure and evaluate programmatic and project activities against the Plan's approved performance criteria. As the Plan is implemented, compliance with performance criteria will be measured to evaluate success at both the project and basin levels. Minimum requirements for the Post Construction Monitoring Program (PCMP) are included in Appendix D of the Consent Decree.

The Plan includes installation of flow meters and level sensors in both the CSS and SSS to obtain baseline information before project design begins and to assess compliance with performance criteria upon completion of Plan components.. The results of the monitoring will be evaluated through computer modeling of the sewer system, and will lead to adjustments in the design, construction, and operation of remaining Plan components throughout implementation of the Plan.

The Plan also includes a Water Quality Monitoring Plan (WQMP) for the City's lakes, streams, and rivers. This WQMP will develop the information necessary to document progress toward attainment of water quality standards. A WQMP was prepared and submitted prior to the December 31, 2010 deadline, and it will be updated as needed.

Adjustments to the design, construction, and operation of the entire Plan will result from an evaluation of progress to-date including, but not necessarily limited to, the results of the ongoing monitoring efforts. That evaluation is expected to be a continuous effort throughout the Plan implementation period. Formal updates and revisions to the entire Plan will be conducted on five-year intervals and submitted to the regulatory agencies for concurrence. In addition, intermediate, internal program reviews focusing on the direction of the Plan and its benefit to the rate payers and citizens of the City will be conducted at the midpoint of each 5-year cycle

1.5.3 City-Wide Program of Green Solutions

The City's citizens desire solutions to wet weather problems that produce multiple benefits. Creative partnerships, focused land conservation and restoration, community education, regulations, and sustainable infrastructure projects are all necessary to achieve multiple benefits. These solutions are critical if the City is to succeed in protecting water as a valuable resource. Every decision should be viewed as an opportunity to incorporate a green solutions approach. The City has adopted an "every drop counts" philosophy, meaning it is important to reduce stormwater entering the sewer system wherever practicable. This will be accomplished through changing the way the community develops and redevelops, educating citizens regarding steps they can take to reduce the amount of stormwater entering the sewer system, enabling citizens to take those steps, incorporating green solutions in the design of public infrastructure, and making targeted public investments in green infrastructure projects early in the Plan implementation.

Elements of this Plan directed to promoting and enhancing the City's overall program of green solutions include:

- Dedicated funding for public education and outreach.
- An enhanced rain gardens and downspout disconnection program.
- Funding for job creation and work force development initiatives related to specific program objectives, including "green collar" jobs.
- Enhanced technical models, complemented by a "triple bottom line" evaluation framework, including specified social, economic, and environmental metrics.
- Green infrastructure pilot projects in the CSS basins. Large scale pilot projects will be used to gather the information required to effectively implement green infrastructure on a broad scale while simultaneously constructing a portion of the basin-specific solution. Green infrastructure pilot projects will be also constructed to achieve a significantly higher level of control downstream of the project area.

1.5.4 Separate Sewer System Improvements

Strategies in the Plan related to the SSS are to first reduce I/I by rehabilitating the existing system, where cost-effective, and then to provide a combination of wet weather storage and treatment to address remaining excess inflow. For the Plan, the design storm in the SSS basins is a rainfall event having a duration of 24 hours and a depth that would be equaled or exceeded, on average, once every five years. This design storm would result in a rainfall depth of 4.68 inches.

A total funding of $175 million (in 2008 dollars) is recommended for I/I reduction throughout the City's SSS. The completion of that work is expected to largely restore sufficient capacity in the collection system to control overflows during the design storm. In some instances, additional relief sewer and pumping capacity will also be needed to deliver wet weather flows in the collection system to proposed storage and conveyance systems leading to the City's WWTPs.

Wet weather flows from the Line Creek/Rock Creek and Northwestern basins will be transported through a new conveyance and storage tunnel to the Birmingham Wastewater Treatment Plant (WWTP). That tunnel system will also temporarily store excess wet weather flows from the Birmingham/Shoal Creek basin. The North Bank Tunnel System is expected to include approximately 62,000 feet of 11-foot diameter tunnel and a 30-MGD pumping station at the Birmingham WWTP for dewatering the tunnel.

A constructed SSO exists in the Line Creek/Rock Creek Basin, just upstream from the Line Creek Pumping Station. The North Bank Tunnel System will eventually eliminate this constructed SSO; however, tunnel construction will not begin until I/I reduction work in the basin nears completion.

The Plan includes construction of a new 50-MGD HRT facility at the Birmingham WWTP to address peak wet weather inflows. Discharges from this HRT facility will be blended with flows from the secondary clarifiers for discharge to the Missouri River. The final design capacity and regulatory requirements for this facility will be evaluated in future updates of the Plan. This evaluation and any updates will be based on performance data from the effectiveness of the I/I reduction measures.

It is anticipated that the HRT/disinfection facility will meet permit requirements for biochemical oxygen demand and total suspended solids concentrations in the blended effluent from the Birmingham WWTP. Complying with percentage reduction requirements found in Missouri's secondary treatment standards may be problematic, due principally to reduced plant influent concentrations.

Although it is the City's intention to utilize HRT/disinfection for treatment of excess flows, the Consent Decree requires the City to prepare and submit a no-feasible alternative analysis pursuant to 40 C.F.R. § 122.41(m) by 04-30-2020 prior to implementation of this control measure.

It is presently anticipated that a total storage volume of 68 million gallons will be provided south of the Missouri River to store excess I/I from the Blue River South basin (including flows from Johnson County Wastewater District tributary to the 87th Street Pumping Station). That estimated storage volume was developed considering conditions expected in the Year 2030, following completion of recommended I/I reduction work in the Blue River South basin.

The Consent Decree requires construction of the 68 MG storage facility in two phases. The first phase includes construction of of approximately 20 million gallons of staorage at 87th Street Pumping Station, and rehabilitation and modification of existing pumps and equipment necessary to support wet weather pumping to storage tanks concurrent with operation of duty pumps. The first phase must be operational by 12-31-2016. Construction of the remaining storage , yielding a combined total capacity presently estimated at 68 million gallons, is required to completed in a second phase no later than 12-31-2024. The total storage volume at the 87th Street Pumping Station may be increased or reduced consistent with the results of the I/I reduction program in the Blue River South Basin and updated projections of inflows to the Blue River South Basin from Johnson County Wastewater.

The general location and alignment of Plan components in the SSS are shown in Figures 1-6 (north of Missouri River) and 1-7 (south of Missouri River).

A summary of the estimated capital and additional annual operations and maintenance costs for improvements in the SSS is presented in Table 1-2. All estimated capital costs in Table 1-2 are in current (2008) dollars (Engineering News Record Construction Cost Index [ENR CCI] of 9180).

The total estimated capital cost of Plan improvements in the SSS is $919 million. Of that total, $550 million are associated with improvements north of the Missouri River and $369 million are for improvements south of the Missouri River.

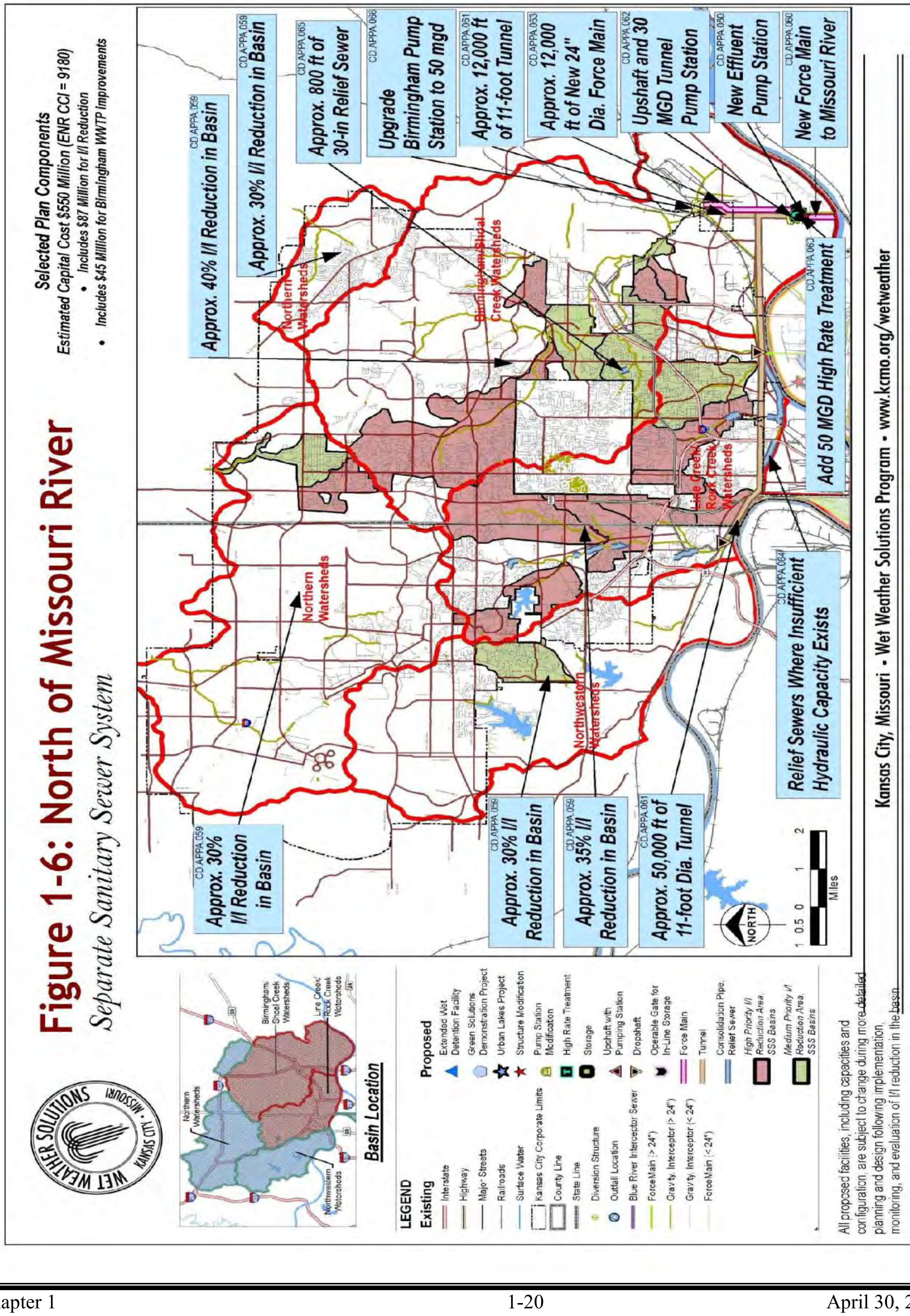


Figure 1-6: North of Missouri River
Separate Sanitary Sewer System
Selected Plan Components
Estimated Capital Cost $550 Million (ENR CCI = 9180)
• Includes $87 Million for I/I Reduction
• Includes $45 Million for Birmingham WWTP Improvements
Approx. 30% I/I Reduction in Basin
Approx. 30% I/I Reduction in Basin
Approx. 35% I/I Reduction in Basin
Approx. 50,000 ft of 11-foot Dia. Tunnel
Approx. 40% I/I Reduction in Basin
Approx. 30% I/I Reduction in Basin
Approx. 800 ft of 30-in Relief Sewer
Upgrade Birmingham Pump Station to 50 mgd
Approx. 12,000 ft of 11-foot Tunnel
Approx. 12,000 ft of New 24" Dia. Force Main
Upshaft and 30 MGD Tunnel Pump Station
New Effluent Pump Station
New Force Main to Missouri River
Add 50 MGD High Rate Treatment
Relief Sewers Where Insufficient Hydraulic Capacity Exists
Northern Watersheds
Northwestern Watersheds
Birmingham/Shoal Creek Watersheds
Line Creek/Rock Creek Watersheds
Basin Location
LEGEND
Existing
Proposed
Miles
Kansas City, Missouri • Wet Weather Solutions Program • www.kcmo.org/wetweather
All proposed facilities, including capacities and configuration, are subject to change during more detailed planning and design following implementation, monitoring, and evaluation of I/I reduction in the basin.

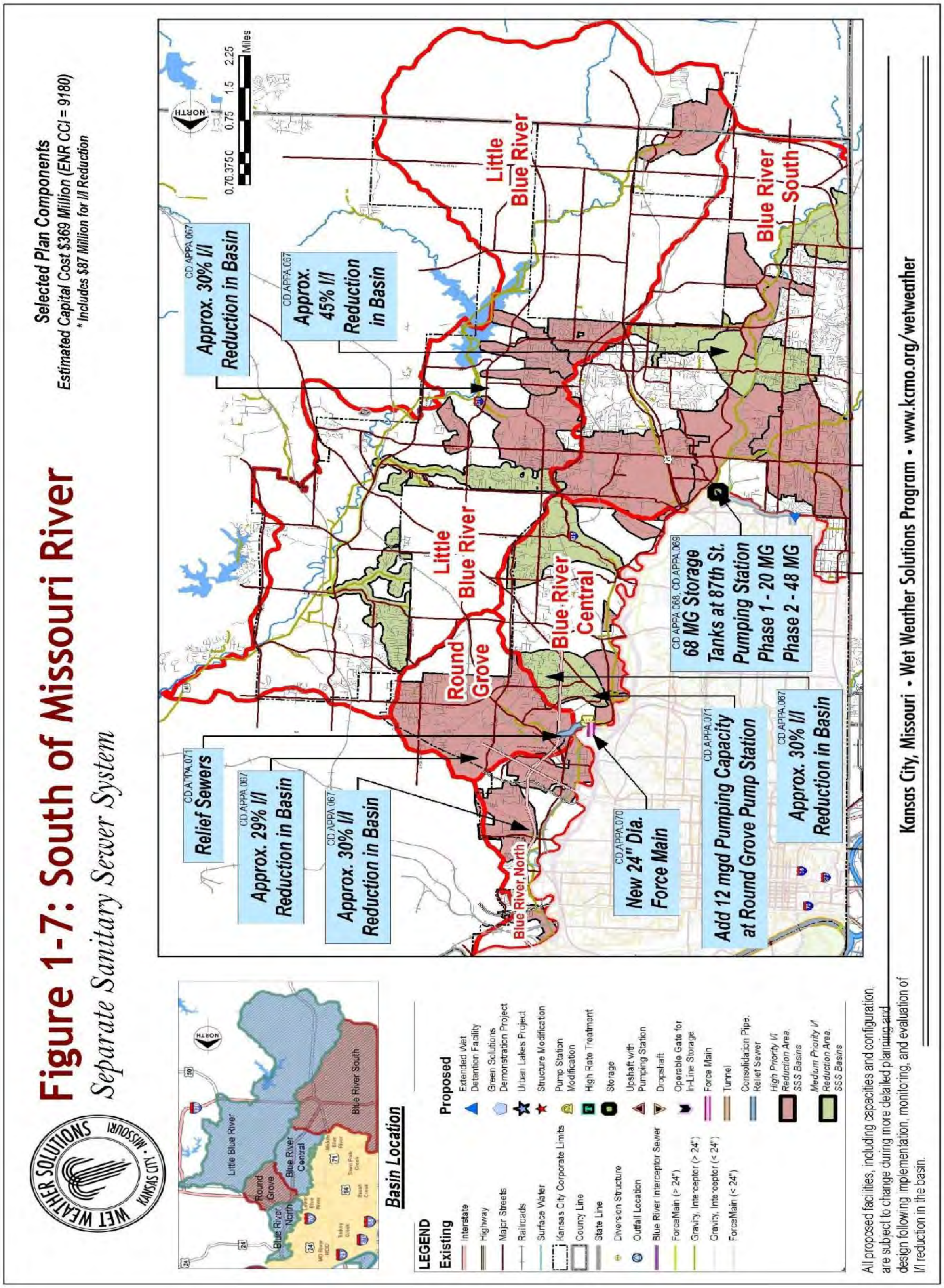


Figure 1-7: South of Missouri River
Separate Sanitary Sewer System
Selected Plan Components
Estimated Capital Cost $369 Million (ENR CCI = 9180)
* Includes $87 Million for I/I Reduction
CD.APPA.071
Relief Sewers
CD.APPA.067
Approx. 29% I/I Reduction in Basin
CD.APPA.067
Approx. 30% I/I Reduction in Basin
CD.APPA.070
New 24" Dia. Force Main
CD.APPA.071
Add 12 mgd Pumping Capacity at Round Grove Pump Station
CD.APPA.067
Approx. 30% I/I Reduction in Basin
CD.APPA.068, CD.APPA.069
68 MG Storage Tanks at 87th St. Pumping Station
Phase 1 - 20 MG
Phase 2 - 48 MG
CD.APPA.067
Approx. 30% I/I Reduction in Basin
CD.APPA.067
Approx. 45% I/I Reduction in Basin
Round Grove
Little Blue River
Blue River Central
Blue River North
Little Blue River
Blue River South
0 0.375 0.75 1.5 2.25 Miles
NORTH
Basin Location
Little Blue River
Round Grove
Blue River North
Blue River Central
Blue River South
LEGEND
Existing
Interstate
Highway
Major Streets
Railroads
Surface Water
Kansas City Corporate Limits
County Line
State Line
Diversion Structure
Outfall Location
Blue River Interceptor Sewer
ForceMain (> 24")
Gravity Interceptor (> 24")
Gravity Interceptor (< 24")
ForceMain (< 24")
Proposed
Extended Wet Detention Facility
Green Solutions Demonstration Project
Urban Lakes Project
Structure Modification
Pump Station Modification
High Rate Treatment
Storage
Upshaft with Pumping Station
Dropshaft
Operable Gate for In-Line Storage
Force Main
Tunnel
Consolidation Pipe, Relief Sewer
High Priority I/I Reduction Area, SSS Basins
Medium Priority I/I Reduction Area, SSS Basins
All proposed facilities, including capacities and configuration, are subject to change during more detailed planning and design following implementation, monitoring, and evaluation of I/I reduction in the basin.
WET WEATHER SOLUTIONS
KANSAS CITY, MISSOURI
Kansas City, Missouri • Wet Weather Solutions Program • www.kcmo.org/wetweather

Table 1-2 Estimated Cost of, Separate Sewer System Improvements

Element	Estimated Cost (in Millions, 2008 $)	
	Capital	Additional Annual O&M
I/I Reduction	$175	---
Increase Collection System and Pumping Capacity	26	$0.03
North Bank Tunnel System	376	1.78
Tank Storage at 87th Street Pumping Station	269	1.13
Additional Pumping Capacity and Wet Weather Treatment at Birmingham WWTP	73	3.16
Totals	**$919**	**$6.08**

1.5.5 Combined Sewer System Improvements

Core strategies followed in selection of recommended improvements include:

- Encourage widespread implementation of green solutions on projects.(see previous discussion in this Chapter).
- Repair and rehabilitate small diameter (equal to or less than 12-inch) sewers to reduce the quantity of flow entering the system and improve service by reducing the frequency and severity of basement back-ups. Approximately 60 percent of the total sewer length in the CSS will be addressed by this strategy.
- Emphasize control of CSOs in the Blue River basins (Middle Blue River, Town Fork Creek, Brush Creek, and Lower Blue River) and expend less effort on basins that drain directly to the Kansas and Missouri Rivers (Turkey Creek, and NEID). Approximately3 percent of the bacteria in the Missouri River just downstream from its confluence with the Blue River are associated with the City's CSOs. Funds expended to address this relatively small bacteria source in the Missouri River could be better spent to address water quality in streams more directly influenced by the City's actions, such as the Blue River and its tributaries, and have more influence on the City’s residents.
- Place a higher investment emphasis and priority on those outfalls where improved flood protection and storm drainage service could result from implementation of CSO control.

The City will be required to meet the performance criteria specified in Appendix A of the Consent Decree for the CSS. The City must demonstrate compliance with both the percent capture of wet weather flows and performance criteria utilizing the collection system hydraulic model described in Chapter 5 and the post construction flow monitoring data. Performance criteria will be achievedthrough a combination of conventional structural controls with green solutions and source controls at or upstream of CSOs. Planned improvements in the CSS are described in detail in Chapter 14 and include:

- Green Solutions Pilot Projects in the CSS: The Plan includes $28 million in funding for green solutions pilot projects and partnerships in the CSS. The first pilot project is currently being implemented in a 100-acre area in the Middle Blue River basin generally bounded by Troost Avenue on the west, Paseo Boulevard on the east, 73rd Street on the north, and 76th Street Terrace on the south.
- Neighborhood Sewer Rehabilitation: Approximately 570 miles of small (generally equal to or less than 12 inch diameter) sewers throughout the CSS will be rehabilitated. While this element of the Plan may contribute to a reduction in CSO volumes, its principal purpose is to restore hydraulic capacity in the tertiary collection system for reducing the frequency and severity of basement backups.
- Sewer Separation: Sewer separation is planned for ten sub-basins covering over 3,400 acres (including 1,200 acres at the Downtown Airport). Stormwater treatment areas using green infrastructure will be provided for discharges from the newly separated storm sewers in six of those sub-basins. In addition, separate stormwater runoff from an area in Wyandotte County, Kansas tributary to the CSS at 47th and State Line will be removed from the CSS and conveyed directly to Brush Creek.
- Outfall Consolidation Piping: Approximately 30,000 feet of outfall consolidation piping ranging from 12 inches to 96 inches in diameter is included in the Plan, principally in the Brush Creek, Middle Blue River, and Town Fork Creek basins.
- Increased Collection System Capacity: The Plan includes approximately 18,200 feet of relief sewers, with diameters varying from 24 inches to 54 inches, for additional conveyance capacity, principally in the Middle Blue River and Lower Blue River. In addition, the Turkey Creek Pumping Station (and force main to the Westside WWTP) and the 15th Street Pumping Station will be substantially reconstructed or replaced.
- In-Line Storage and Other Improvements in the Existing System: Over 25 million gallons of storage capacity available in the existing system will be made usable through the addition or replacement of control gates at the lower end of the OK Creek (in the Turkey Creek basin), Gooseneck Creek, and CID storm drainage systems, with institution of real time control of those gates. In addition, other small improvements (such as installation of flap gates in the Brush Creek and Town Fork Creek basins and increasing manhole top elevations) are included in the Plan.
- Distributed Green Solutions: Overflows from two outfalls (059 and 069) in the Middle Blue River basin will be reduced through construction of distributed green infrastructure storage throughout the 744 acres tributary to those outfalls. It is presently anticipated that not less than 3.5 million gallons of green storage will be needed to attain overflow control goals at those outfalls.

- Deep Tunnel Storage and Pumping: Three deep storage tunnels and two pumping stations for evacuating stored overflow volumes are included in the Plan. Storage tunnels 16 feet in diameter are presently planned in the Brush Creek (approximately 20,600 feet in length) and Town Fork Creek (approximately 13,000 feet in length) basins. These tunnels will be dewatered through a 45-MGD, deep-tunnel pumping station at the confluence of Brush Creek and the Blue River. A third tunnel (26 feet in diameter and approximately 7,500 feet in length) dewatered by a new 30-MGD pumping station at the Turkey Creek Pump Station site is planned for the Turkey Creek basin. The proposed storage tunnels in the Town Fork Creek and Turkey Creek basins are sized for CSO storage, but with proper planning and design, they can also be expected to contribute significantly to flood damage reduction and improved storm drainage service in those basins.
- High-Rate Treatment and Other WWTP Improvements: A total of 310 MGD of HRT (presently expected to consist of ballasted flocculation or its equivalent) and capacity improvements will provide at least the equivalent of primary treatment to CSOs captured under the Plan. That total includes 50 MGD at the Blue River WWTP (which will be coupled with 80 MGD of secondary bypass of primary plant effluent), up to 64 MGD at the Westside WWTP, and 200 MGD in a new facility discharging to the Blue River, just downstream of the river's confluence with Brush Creek.

Improvement capacities and configurations were developed based on the modeled response of the existing CSS to rainfall events and are described in detail in Chapter 14. Improvement capacities will be revised, as appropriate, prior to final design and construction and once the impact of green solutions and other source controls on system response to rainfall have been quantified. The ultimate objective of the CSOs (including both green and conventional structural controls) will remain as elimination, or capture for treatment, of 88 percent of the existing (2007 baseline condition) wet weather flows in the CSS.

The location and general alignment of major CSO components of the Plan are shown on Figure 1-8. Table 1-3 summarizes the presently anticipated capital and additional annual operation and maintenance costs of CSS improvements included in this Plan. All estimated capital costs in Table 1-3 are in current (2008) dollars (Engineering News Record Construction Cost Index [ENR CCI] of 9180).

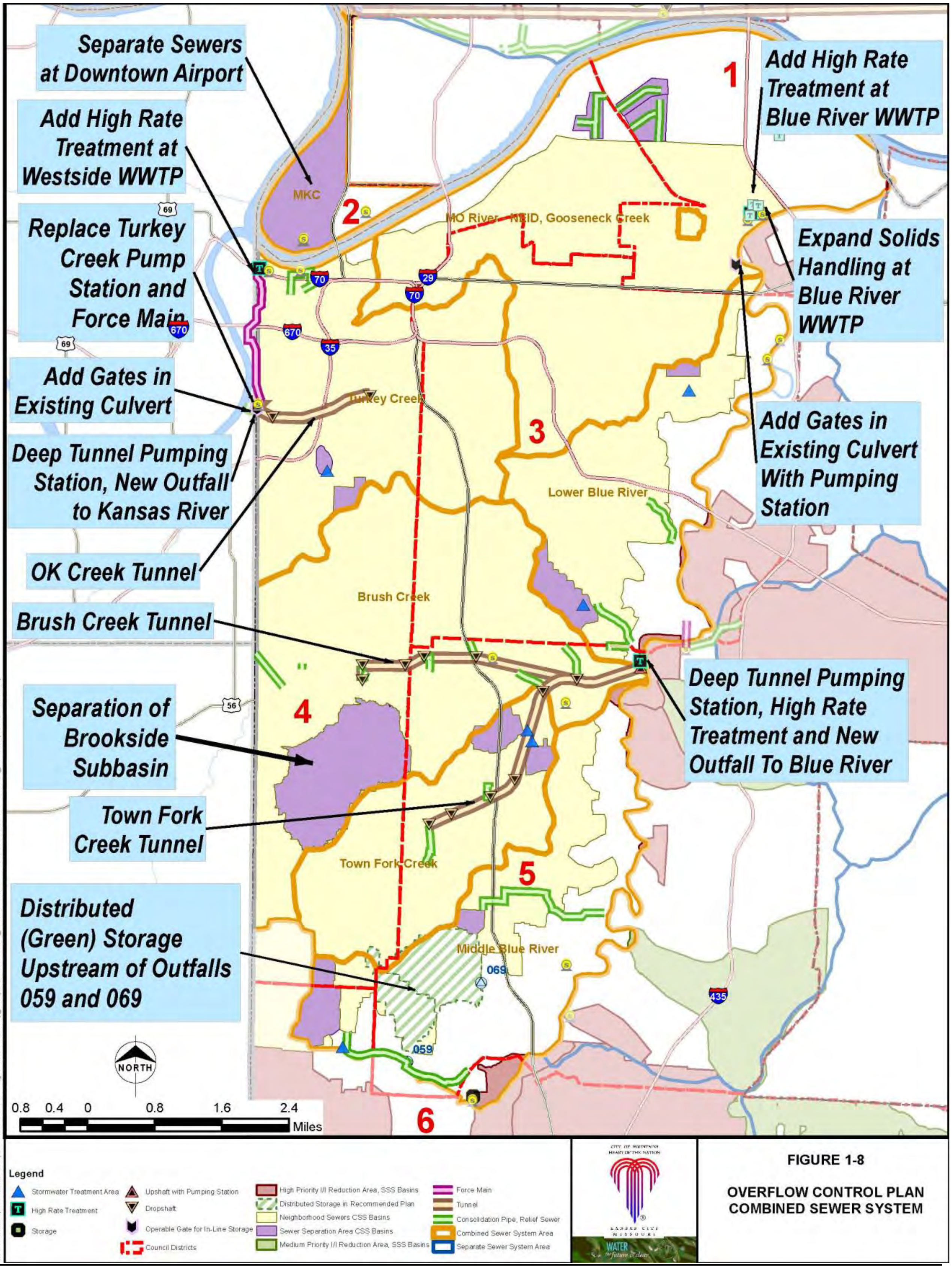


FIGURE 1-8

OVERFLOW CONTROL PLAN COMBINED SEWER SYSTEM

Table 1-3 Estimated Cost, Combined Sewer System Improvements

Element	Estimated Cost (in Millions, 2008 $)	
	Capital	Additional Annual O&M
Green Infrastructure Pilot Projects and Partnerships in CSS	$21	$1.04
Neighborhood Sewer Rehabilitation	124	---
Sewer Separation	129	.09
Outfall Consolidation Piping and Increased Collection System Capacity	82	0.64
In-Line Storage and Other Improvements in Existing System	25	0.16
Distributed "Green" Storage (Outfalls 059 and 069)	40	2.00
Deep Tunnel Storage and Pumping	584	5.34
High Rate Treatment and Other WWTP Improvements	434	15.63
Totals	**$1439**	**$24.90**

1.5.6 Compliance with Water Quality Standards

The USEPA's CSO Control Policy offers two approaches ("Presumptive" and "Demonstration") for development and implementation of an overflow control plan, each with an overall objective to meet water quality standards and protect existing and designated uses.

For the Missouri River, the Plan is based on the Presumptive approach, which requires (as one possible criterion) the elimination, or capture for treatment, of no less than 85 percent, by volume, of the combined sewage collected in the CSS during precipitation events on a system-wide, annual average basis. The Plan design to capture 88 percent clearly meets this criterion.

For the Blue River, the Plan is based on the Demonstration approach. Analyses prepared for this Plan show that:

- Current water quality standards for bacteria in the Blue River cannot be met, even if CSOs are completely eliminated, as a result of bacteria loading from sources upstream of the CSS, and in separate stormwater runoff reaching the CSO receiving streams.
- Overflows remaining after implementation of the Plan will not prevent the attainment of water quality standards in the Blue River.
- The Plan will achieve the maximum pollution reduction benefits reasonably attainable for the Blue River.

- CSO controls in the Blue River basin are structured and will be designed to allow cost-effective expansion, if additional controls are subsequently determined to be necessary to meet water quality standards, including protection of designated uses.

Reduction of bacteria loads in the Blue River from sources upstream of the CSS and in separate stormwater runoff is expected to be one objective of the Blue River Watershed Management Plan.

1.6 Financial Capability and Implementation Schedule

The financial projections discussed in Chapter 11 suggests that between 25 and 33 years will be needed to complete construction of the Plan and other presently identified wastewater utility capital needs. Each of those projections is predicated upon acceptance of a heavy financial burden by the City and its ratepayers. Wastewater rates are expected to almost quadruple over the next 13 years, eventually leading to a cost to residents in the City's retail service area equivalent to 1.7 percent of the City's median household income.

The implementation schedule for major Plan components is as defined in the Consent Decree. The City must implement the CSO Control Measures described herein and must comply with the Project Start Dates, Date of Achievement of Full Operation, Date of Post-Construction Monitoring Plan Submission, and Critical Milestones for each control measure as defined in Appendix A of the Consent Decree. All control measures must be completed by December 31, 2035 and compliance with all performance criteria must be demonstrated by April 30, 2037..

The funding analysis and financial projections prepared in connection with development of the Plan were based on estimates, forecasts, projections, and schedules relating to costs, quantities, and pricing of construction, operations and maintenance costs, and/ sewer rates. Actual results may vary significantly from these current projections. Given the extended time frame of the projections (three decades into the future), the projections should be revisited from time to time throughout Plan implementation. At a minimum, the analysis (including all underlying assumptions) should be reviewed and updated at five-year intervals concurrent with the overall Plan reviews recommended in Chapter 14.

* * * * *

2 INTRODUCTION AND BACKGROUND

This chapter introduces the Overflow Control Plan (the Plan) developed by the City of Kansas City, Missouri Water Services Department (WSD) Overflow Control Program (OCP). Specific details and in-depth discussion of subjects addressed in this section are provided in following report sections or appendices, as noted.

2.1 Overview

This document is the Overflow Control Plan prepared by the City of Kansas City, Missouri (the City), and is being submitted for review by the United States Environmental Protection Agency (USEPA) and the State of Missouri Department of Natural Resources (MDNR), collectively referred to as "the agencies." This Plan presents a city-wide control plan to reduce the frequency and volume of wet-weather overflows to local receiving waters in conformance with Clean Water Act (CWA) requirements.

On September 30, 2007, the City submitted to the agencies a Conceptual Control Plan (CCP). The CCP included:

- General guiding principles used by the City as the bases for identifying and developing wet-weather solution scenarios
- Strategies for employing various types of management practices and control technologies
- Proposed levels of control on a city-wide and sewer-shed basis
- General system improvements and wet-weather control facilities envisioned
- Anticipated impacts on receiving waters
- Estimated capital costs for the system improvements and wet-weather control facilities

Information provided in the CCP was preliminary in nature, and the City indicated explicitly that substantial additional work and refinement would need to be performed to allow for the completion of a comprehensive, defensible overflow control plan. The purpose of the CCP was to provide the agencies with a tool to assess the progress of the City in developing the Plan and an opportunity to comment and work with the City to establish criteria for refining the preliminary information.

The City received comments on the CCP from the USEPA on November 19, 2007. The review comments were prepared jointly by the USEPA and the MDNR. This Plan refines the CCP in response to the comments provided by the agencies; additional public input; continued technical analysis; and funding analyses and financial projections. The process followed in development and subsequent refinement of the CCP is described in Chapter 10; the selected Plan is described in Chapter 12.

2.2 Background

2.2.1 Regulatory Requirements

Approximately 770 cities in the United States have combined sewer systems (CSS) and associated combined sewer overflows (CSO). The USEPA CSO Control Policy defines a CSS as:

> "A wastewater collection system owned by a State or municipality (as defined by Section 502(4) of the CWA) which conveys sanitary wastewaters (domestic, commercial and industrial wastewaters) and storm water through a single-pipe system to a Publicly Owned Treatment Works (POTW) Treatment Plant."

Discharges from CSOs can have an adverse effect on the water quality of the receiving waters because they contain a mixture of sewage and stormwater runoff.

The USEPA issued the National CSO Control Strategy in 1989 and the CSO Control Policy in 1994. The CSO Control Policy states that communities with combined sewer systems should immediately undertake the following three steps:

- Accurately characterize their sewer systems
- Demonstrate implementation of the nine minimum controls (perform proper operation and maintenance, maximize use of the collection system for storage, review industrial pretreatment programs, maximize flow to treatment plants, eliminate discharge to receiving waters during dry weather, control solids and floatable materials in overflows, provide public notification, achieve pollution prevention, and perform monitoring)
- Develop a long-term CSO control plan

The CSO Control Policy (II.C.3) specifically requires the long-term CSO control plan to give the highest priority to controlling overflows to sensitive areas, as determined by the National Pollutant Discharge Elimination System (NPDES) authority in coordination with state and federal agencies. For such areas, the overflow control plan should:

- Prohibit new or significantly increased overflows
- Eliminate or relocate overflows that discharge to sensitive areas wherever physically possible and economically achievable, except where elimination or relocation would provide less environmental protection than additional treatment
    - Where elimination or relocation is not physically possible and economically achievable, or would provide less environmental protection than additional treatment, provide the level of treatment for remaining overflows deemed necessary to meet WQS for full protection of existing and designated uses.

- o Where elimination or relocation has been proven not to be physically possible and economically achievable, permitting authorities should require, for each subsequent permit term, a reassessment based on new or improved techniques to eliminate or relocate, or on changed circumstances that influence economic achievability.

The CSO Control Policy offers the following two approaches to consider when developing an overflow control plan:

- The “Presumptive approach” with performance criteria used as an endpoint for program development and implementation
- The “demonstration approach”, which entails developing and implementing a program that includes a suite of CSO controls sufficient to meet applicable water quality standards.

Under the presumption approach, the controls selected for implementation in the program should be required to meet one of the following criteria:

- No more than an average of four overflow events per year, provided that the permitting authority may allow up to two additional overflow events per year;
- The elimination, or capture for treatment, of no less than 85 percent by volume of the combined sewage collected in the CSS during precipitation events on a system-wide annual average basis; or
- The elimination or removal of no less than the mass of the pollutants identified as causing water quality impairment through the sewer system characterization, monitoring, and modeling effort for the volume that would be captured for treatment above.

The CSO Control Policy identifies four criteria for successful use of the demonstration approach. A program based on the demonstration approach should show that:

- The CSO control program will protect water quality standards unless the standards cannot be met as a result of natural conditions or other pollution sources;
- The overflows remaining after implementation of the control program will not prevent the attainment of water quality standards;
- The planned control program will achieve the maximum pollution reduction benefits reasonably attainable; and
- The planned control program is designed to allow cost effective expansion or cost effective retrofitting if additional controls are subsequently determined to be necessary to meet water quality standards, including protection of designated uses.

2.2.2 Regulators

The Missouri Department of Natural Resources (MDNR) is the state of Missouri's National Pollution Discharge Elimination System (NPDES) permitting authority. In that capacity, MDNR establishes requirements for WWTP discharge characteristics and permitting of CSO outfalls. The MDNR is also charged with enforcing the Missouri Clean Water Act (Chapter 644, RSMo.) and its accompanying regulations. The Kansas Department of Health and Environment (KDHE) is the agency responsible for establishing water quality standards for the Kansas River and streams and rivers in Kansas.

2.2.3 Existing Systems and Receiving Streams

The WSD provides wastewater collection and treatment for the City and 27 tributary or "satellite" communities. The entire area served by the City's wastewater collection system (WCS) is approximately 420 square miles. Of that total area, approximately 318 square miles are within the corporate limits of the City. Figure 2-1 shows the entire area presently served by the Kansas City wastewater collection system

The WCS within the city limits is comprised of a CSS of approximately 58 square miles, and a separate sewer system (SSS) of approximately 260 square miles. The CSS is located in the older areas of the City, south of the Missouri River. Originally, these combined sewers discharged directly to receiving streams. When wastewater treatment facilities were constructed, control facilities were needed to direct dry-weather flows to treatment and divert wet-weather flows in excess of treatment facility capacity to receiving streams. Combined sewer diversion structures were designed to direct dry-weather flows to wastewater treatment plants and to discharge the wet-weather flows that exceed the capacities of the conveyance conduits, pumping stations, or treatment works to surface streams.

The City's information indicates that in the CSS there are 158 diversion structures. These structures are designed and constructed to divert a portion of wet-weather flows to receiving waters during storms. Many of the diversion structures discharge to receiving streams through common CSO outfall structures. The diversion structures discharge to receiving streams through 90 CSO outfalls.

The City's combined sewers overflow to a number of receiving streams. The principal receiving streams include the Kansas River, the Missouri River, the Blue River, and Brush Creek. Brush Creek is tributary to the Blue River; the Blue River is tributary to the Missouri River. All of the City's CSS basins discharge to the Missouri River watershed.

The overall SSS area tributary to the WSD wastewater treatment plants (including satellite communities) is about 326 square miles. An additional sanitary sewer area of 36 square miles within the City is tributary to the Little Blue Valley Sewer District. The SSS area is of concern because inflow and infiltration cause excessive increases in flows during wet weather. Large portions of the SSS area are tributary to the two major wastewater treatment plants (WWTP) in the City, the Blue River and Westside WWTPs. The most significant satellite community is Johnson County,

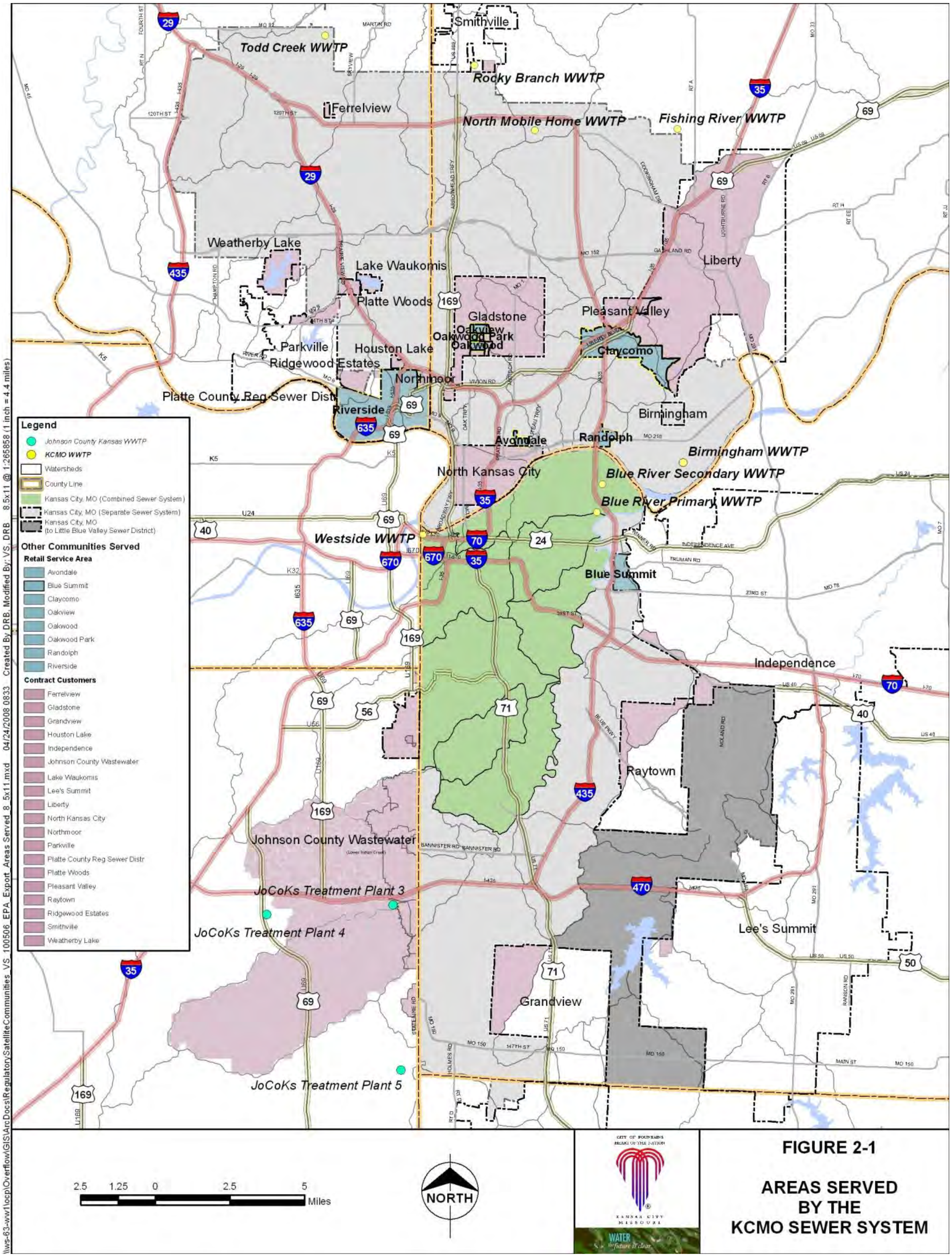


FIGURE 2-1

AREAS SERVED BY THE KCMO SEWER SYSTEM

Kansas, Wastewater with an area of 49 square miles and a population of approximately 127,000. The Plan includes plans for system improvements and wet-weather control facilities in the SSS area.

The City owns and operates seven WWTPs and 38 wastewater pump stations. The Blue River and Westside WWTPs are the only treatment plants that receive flows from the City CSS.

2.2.4 Historical Action Taken to Address CSOs

The City has developed a series of plans to address CSOs since the early 1980s. A CSO Phase I Study was completed in 1982 by the consulting engineer HNTB. This was followed by the 1992 CSO Management Plan and the 1994 CSO Water Quality Impact Analysis, System Hydraulic Modeling, and Recommendation for Corrective Action, both prepared by Burns & McDonnell. The City submitted a Nine Minimum Controls (NMC) Report to the MDNR in 1996 to document the NMC activities and progress. The initial NMC Report has been followed by the filing of annual reports for each year since 1996. The original NMC Report and all of the annual reports have been accepted by the MDNR.

In 1999, Burns & McDonnell completed the Wastewater Master Plan, Kansas City South of the Missouri River. In the Master Plan it was noted that the City had completed the NMC Report and it was recommended that an overflow control plan be developed in order to define how to manage CSOs in accordance with the USEPA CSO Control Policy.

In early 2002, the City contracted with Burns & McDonnell to assist in preparing an overflow control plan. Following the scoping phase, the City amended the contract to include development of the Work Plan for creating the Plan. The Work Plan defined the scope of services, budget, and schedule for preparing a complete overflow control plan.

2.3 Project Goals and Approach

The goals and objectives of the project and guiding principles for execution of the program were developed with input from, and the endorsement of, the Wet Weather Solutions Community Panel (see Chapter 9). This Plan includes proposed projects defined to provide control of overflows from the City's wastewater collection and treatment system in a manner that reflects the community's values, protects public health and the environment, and meets regulations at an appropriate cost.

In addition, as part of the program to develop the Plan, guiding principles were established by the Community Panel to assure that through strong creative leadership and stewardship, the Wet Weather Solutions Program will take action to manage the City's water resources in a sustainable way. The guiding principles are summarized below and are described in detail in Chapter 9:

- **Leadership:**
  - Communication: use plain language

  - Participatory: Citizens will have a meaningful say in actions that affect their lives and spend their tax dollars/user fees
  - Collaborative: Stakeholders are partners in each aspect of the decision-making
  - Accountable: Stakeholders, the project team and the City Council are all accountable in their respective roles for successful program development and implementation
  - Transparent: Strive for openness in all actions.
- **Stewardship:**
  - Watershed-based: Consider all sources of problems and solutions
  - Maximize environmental, community and economic benefits so that the legacy of the Program is a stronger, more appealing, and more prosperous community.
  - Financial: Manage the community's resources with a long-term view, pursuing fairness in the distribution of the economic benefits and burdens.
- **Take Action:**
  - Innovative: Innovate while developing the program – let experience inform future plans
  - Show Progress: Actively seek out existing projects that can demonstrate quick progress.

The general objectives to be met by the Plan include:

- Reduce the sources of wet-weather runoff and inflow through widespread implementation of both "green solutions" and conventional source controls before the implementation of traditional, construction-intensive structural solutions such as large capture facilities.
- Address flood protection needs as part of planning for combined sewer overflows.
- Provide a programmatic platform to facilitate implementation of a comprehensive green solutions initiative.
- Engage the entire metropolitan community in a comprehensive effort to improve our urban lakes, streams, and rivers.
- Maximize use of the existing collection systems through improved operation and maintenance, coupled with an appropriate level of investment in continuing repair and replacement of system components as they age.
- Establish an adaptive approach to long-term plans for structural solutions so that they can be modified to reflect the results and benefits of early efforts, i.e., green solutions and conventional source controls, on the response of the combined sewer system to rainfall events.

Green solutions are strategies that result in projects specifically designed to reduce stormwater runoff, reduce water pollution, create recreational amenities, and protect natural resources through the use of "green infrastructure" (also referred to as "natural systems"), such as rain gardens, bio-retention facilities, stream restoration, stream buffers, and other scientifically proven methods.

This Plan provides wet-weather solutions for both the CSS and SSS areas based on the execution of the following major tasks:

- Collect, review, and evaluate data
- Characterize the performance of the existing collection systems, WWTPs, and receiving streams in response to wet-weather events of various magnitudes
- Involve public participation
- Identify and evaluate alternative wet-weather solutions for specific CSS and SSS basins
- Prepare opinions of probable costs for basin-wide, wet-weather solutions
- Modify basin-wide solutions and integrate them into an overall city-wide overflow control plan
- Identify funding sources and financial capability
- Develop an action plan for plan implementation and next steps
- Prepare and submit an overflow control plan report.

2.4 Project Execution

Efforts to prepare the Plan began in late 2002 with preparation of Work Plans for the CSS and SSS areas. These Work Plans defined how the City's Plan would be developed. The Work Plans were submitted to USEPA and the MDNR in May 2004. Initial phases of the project as outlined in the Work Plans commenced in March 2005.

In September 2005, revised Work Plans were submitted to the agencies (see Appendix A1). These revised Work Plans incorporated comments received from the agencies and WSD's responses. Revisions also included updates to information that were judged to be significant with regard to the Work Plan approach and/or the level of effort to be required. Conditional approval of the Work Plans was obtained from the agencies in November 2006.

Eight Basin Engineers (consulting firms tasked with the detailed analysis of individual basins), along with firms that provided flow metering, sampling, water quality analysis, and rainfall data, were engaged under contract to WSD. Most field work and data gathering was completed in 2005, with model analysis and improvement alternatives development proceeding in 2006. Development of standardized methodologies, reports, public participation programs, and agency coordination continued throughout the process. The Annual Reports submitted to the MDNR by the WSD provided interim program summaries. Annual Reports are included in Appendix A4; their submittal dates are:

Overflow Control Program - 2004 Annual Report	February 10, 2005
Overflow Control Program - 2005 Annual Report	March 27, 2006
Overflow Control Program - 2006 Annual Report	March 26, 2007
Overflow Control Program - 2007 Annual Report	March 29, 2008

By mid-2007, the sewer improvement plan framework was being developed and, on September 30, 2007, the City submitted to the agencies a CCP in conformance with a project schedule approved by the agencies.

2.4.1 Overflow Control Program (OCP) Office

The OCP was created to develop and execute a program for addressing wet-weather issues, including those issues identified by the regulatory agencies.

The OCP monitored internal schedule performance, as well as schedules for professional, specialized, and technical (PST) services (see Section 2.4.2); Basin Engineers (see Section 2.4.3); other consultants; and contractors. Based on an overall schedule for the Plan development, the OCP defined major milestones, coordinated activities, measured and reported on work product performance, evaluated invoices/pay requests, tracked and forecasted cash flow, quantified/coordinated extensions, and generally guided the work that produced the Plan.

2.4.1.1 Protocols

Protocol documents were prepared by the OCP for use during execution of work and preparation of work products related to the Plan. The protocols provided standard procedures and methods of approach to ensure consistency and compatibility among WSD's contractors, facilitate review and use of work products, and facilitate data management. Table 2-1 presents a summary of the protocol documents prepared by the OCP.

Table 2-1 Summary of OCP Protocol Documents

Protocol Title	Date
Hydrologic and Hydraulic Model Protocol	November 9, 2004
Administration Manual	February 25, 2005
Quality Assurance/Quality Control Program (Admin Manual Appendix A)	February 25, 2005
Receiving Water Sampling Plan	April 14, 2005
Water Quality Monitoring, Quality Assurance Project Plan (QAPP)	April 14, 2005
Field Investigation Protocol, Manhole Inspection and Facilities Survey	April 15, 2005
Data Management Protocol	May 20, 2005
CSO/Stormwater Sampling Plan, Revision 1	June 9, 2005
Overflow Control Basis of Cost Manual	January 8, 2007

These protocols can be accessed via hyperlinks provided in Appendix A2.

2.4.1.2 Data Management System (DMS)

A Data Management System (DMS) and associated Data Management Protocol (DMP) were developed to assure data preservation and long-term data availability to improve OCP and WSD efficiency.

Through the use of relational database and geographic information system software, the DMS standardized and simplified the data delivery and acceptance process. The DMP can be found in Appendix A.

2.4.1.3 Kansas City Inter-Program Coordination

In 2003 WSD established a Wet Weather Program to consolidate efforts to address sewer backups, receiving stream water quality, sewer overflows, and stormwater flooding. The program includes three major components:

- Overflow Control Program (OCP)**,** which is focused on the combined and separate sewer systems (as generally described above)
- KC-ONE, which is focused on stormwater management
- Waterways, which is focused on river and stream management.

KC-ONE is an extensive program with a mission to develop a comprehensive stormwater management plan and capital improvements program. This effort began in 2004 and work is continuing to consolidate individual master plans that have been prepared, or are under development, for 35 stormwater watersheds covering the entire city. The OCP and KC-ONE are coordinated to assure compatible system improvements focused on basement backups, surface flooding, overflows, water quality, sewer condition, sewer capacity, and stormwater conveyance capacity.

Waterways began in 1998 as the Special Projects Division in the Public Works Department. This function was transferred to WSD in 2004 to allow closer coordination and improved synergy with other wet-weather programs and activities. Waterways, in cooperation with other agencies, deals with large-scale, multi-purpose projects related to streams and rivers, often utilizing non-traditional funding sources. Work performed to date generally includes waterway development projects on the Blue River, Brush Creek, and Turkey Creek, in cooperation with the U.S Army Corps of Engineers and other local agencies.

2.4.1.4 Agency Coordination

WSD's OCP has coordinated on-going, wet-weather efforts with the agencies and solicited their guidance throughout the Plan development. Coordination activities with the agencies have consisted of defining the Work Plan and schedule, preparing technical submittals and briefing documents, participating in quarterly meetings and monthly conference calls, and addressing follow-up issues requiring clarification.

2.4.1.5 Public Participation

Public participation was a critical element during the Plan development. The OCP made extensive efforts to inform the citizenry and solicit their active participation in developing goals, defining guiding principles for the program, and developing wet-weather solutions to be incorporated in the proposed Plan. OCP's public participation goals included the following:

- Notify the public in advance of opportunities for input and of meetings where public officials would make major decisions as to the Overflow Control Plan in accordance with local, state, and federal requirements.
- Give the public an opportunity to express support for and/or concerns with the proposed Plan.
- Raise awareness, educate, and connect the various constituencies to this issue.
- Change behaviors of property owners, businesses, and developers.
- Build credibility, support, and momentum for future funding initiatives.
- Secure support for investment in a long-term plan.

The general approach taken by the OCP to implement the public participation program was to:

- Inform the public early in the planning process regarding the scope and goals of the program.
- Expand public involvement during development, evaluation, and selection of the wet-weather control strategies.
- Meet public participation requirements of:
    - Federally funded projects as defined in 40 CFR Part 25.
    - State funded projects as defined in State of Missouri, Rules of the Department of Natural Resources, Division 20 Clean Water Commission, and Chapter 4-Grants.
    - Meet public notice requirements of the City.
- Coordinate with other public participation efforts in the area for closely related programs or activities to enhance the economy, the effectiveness, or the timeliness of efforts.
- Evaluate the effectiveness of existing communication methods and materials and utilize them appropriately.

The committees and groups included in the OCP's outreach efforts included:

- City Council
- City Manager
- Wet Weather Solutions City Committee
- Wet Weather Solutions Community/Public Panel
- Brush Creek Community Partners
- Brush Creek Coordinating Committee
- Town Fork Creek Coordinating Committee
- Blue River Summit
- Brush Creek Summit
- Johnson County/Wyandotte County
- Mid-America Regional Council (MARC)

- Greater Kansas City Chamber of Commerce Environment Committee
- Kansas City Area Economic Development Council
- Others (Neighborhood meetings)

The complete record of the public participation program can be accessed via hyperlinks provided in Appendix E.

2.4.2 Professional, Specialized, Technical (PST) Services

In 2004 four firms that provided rainfall data, flow metering, water quality sampling, and water quality analysis were engaged under contract. Most field work and data gathering by these PST firms was completed in 2005. Protocols noted in Section 2.4.1.2 and contract requirements guided contractor efforts.

2.4.2.1 Radar Rainfall Monitoring

WSD contracted with OneRain, Inc., Longmont, CO, to prepare rainfall data for use by Basin Engineers when characterizing the existing collection systems. OneRain also performed an analysis and evaluation of the Kansas City Automated Local Evaluation in Real-Time (ALERT) Flood Warning System (FWS) rain gauge network to assure precipitation data quality. Some limited rain gauge network changes were recommended to improve system usefulness for WSD. The ALERT system consists of 43 rain gauges spaced throughout Kansas City. At present, 13 of the ALERT rain gauges are located within the CSS area, but plans call for expanding this coverage to 29 gauges in 2009. OneRain's report on its analysis and evaluation of the Kansas City ALERT flood warning system rain gauge network can be accessed via hyperlinks provided in Appendix A.

OneRain used precipitation data from Weather Service NEXRAD radar and gauge-corrected the data using readings from the Kansas City ALERT flood warning system. When used with the radar, 15-minute data were generated for each of the 173 flow-metered catchments for an approximately seven-month period. In addition, 1-km by 1-km pixel data were developed to enable the Basin Engineers to further refine data on a sub-catchment basis to support model calibration and verification and to perform simulations for periods most suitable to their respective basins. Rainfall measurements and characterization are discussed in Chapter 5.

2.4.2.2 Flow Metering

The temporary flow metering program began in the spring of 2005 and was completed in the fall of 2005. The temporary flow metering program measured flow at key locations in the CSS and SSS in order to determine average dry-weather flows and collection system responses to wet-weather events. Field inspections, site assessments, flow meter installation, operation and maintenance, and data collection were performed by Hydromax, USA, Florence, Kentucky. Flow metering is discussed in detail in Chapter 5.

2.4.2.3 Water Quality Sampling

CSO, stormwater, and receiving water quality sampling were performed by MEC Water Resources, Inc., Columbia, Missouri. The objectives of the water quality monitoring program were to:

- Meet the requirements of the Federal CSO Control Policy for characterization of receiving waters
- Establish a baseline of water conditions from which to assess future improvements
- Understand the impacts of pollutant sources in the watersheds
- Support the development of water quality models that will be used to simulate the potential benefit of control alternatives and set reasonable expectations
- Support the review and revision of water quality standards for CSO receiving waters, as appropriate

The following data were collected as part of the water quality sampling efforts:

- Water quality concentrations for selected parameters in CSOs and separate stormwater outfalls
- Water quality concentrations for selected parameters in the receiving waters during both dry and wet weather conditions.

Water quality sampling is discussed in detail in Chapter 6.

2.4.2.4 Laboratory Analytical Services

Laboratory analytical services for CSO, stormwater, and receiving water quality sampling were performed by Severn Trent Laboratories, Earth City, Missouri. Detailed information on analytical results is presented in Report Sections 5.5 and 6.5.

2.4.3 Basin Engineer Contracts

In 2004, eight Basin Engineers (consulting firms tasked with the detailed analysis of individual basins), were engaged under contract.

The CSS area was subdivided into seven principal basins for planning purposes. Five of those basins (Gooseneck Creek, Lower Blue River, Town Fork Creek, Brush Creek, and Middle Blue River) are tributary to the Blue River Interceptor Sewer, which generally parallels the Blue River downstream (north) of Brush Creek and discharges to the Blue River WWTP. A sixth basin (Northeast Industrial District [NEID]) is also served by the Blue River WWTP. The seventh principal combined sewer system basin (Turkey Creek/Central Industrial District [CID]) discharges to the Westside WWTP.

The CSS Basin Engineers and their respective basins were:

- Black & Veatch: Turkey Creek, Northeast Industrial District, and Central Industrial District

- Camp, Dresser & McKee (CDM): Brush Creek, Town Fork Creek
- CH2M Hill: Gooseneck Creek, Lower Blue River
- HDR Engineers: Middle Blue River

The SSS area was divided into nine principal basins for planning purposes. Four of these basins (Line Creek/Rock Creek, Birmingham/Shoal Creek, Round Grove Creek, and Blue River South) were studied in more detail than the other five (Blue River North, Blue River Central, Little Blue River, Northern Watersheds, and Northwestern Watersheds). The four priority basins either directly affect the performance of facilities also serving the combined sewer system, or are more likely candidates for priority rehabilitation activities, due principally to the age of those systems, than the remaining SSS basins.

The SSS Basin Engineers and their respective basins were:

- Bucher, Willis & Ratliff Corporation (BWR): Birmingham
- George Butler & Associates (GBA): Blue River Central, Blue River North, Little Blue River
- HDR Engineers: Blue River South
- HNTB: Line Creek/Rock Creek
- Wade & Associates (WAI): Round Grove Creek

2.4.3.1 Major Combined Sewer System Basin Tasks

The major CSS basin tasks as provided for in the scopes of work for the Basin Engineers were:

- Prepare Basin Overflow Control Work Plan: preparation of a work plan that describes project efforts considering basin-specific information and presents a schedule of deliverables and submittal dates.
- Participate in Public Meetings
- Conduct Field Reconnaissance: review collection system schematics for accuracy; inspect all diversion structures and metering sites, selected manholes, and other significant hydraulic structures; and document all inspections.
- Configure Hydraulic Model: develop a mathematical model of the collection system in conformance with specific details provided by OCP.
- Review Flow, Rainfall, and Water Quality Data: review indicated data and report results of findings and evaluations to OCP.
- Calibrate and Verify Mathematical (Hydrologic & Hydraulic) Model: calibrate and verify model with flow and precipitation data provided by OCP.
- Estimate Existing Conditions: use calibrated, verified model of collection system to estimate existing flow characteristics based on design rainfall events provided by OCP.

- Develop Preliminary Basin-Specific Improvement Scenarios: develop basin-specific improvement alternatives with planning level evaluations of facility siting, constructability, and operability.
- Integrate Basin-Specific Improvement Plans into Overall City-Wide Plan: in cooperation with OCP, coordinate basin-specific plans with other basin-specific plans to develop a city-wide overflow control plan that meets overall goals of WSD.
- Determine Improvement Effectiveness: document performance of basin-specific plans as modified to function as part of the selected city-wide Plan that meets overall goals of WSD.

2.4.3.2 Major Sanitary Sewer System Basin Tasks

The major tasks for the priority SSS basins (Line Creek/Rock Creek, Birmingham/Shoal Creek, Round Grove Creek, and Blue River South) as provided for in the scopes of work for the Basin Engineers were:

- Prepare Basin Capacity Assurance Work Plan: preparation of a work plan that describes project efforts considering basin-specific information; and presents a schedule of deliverables and submittal dates
- Participate in Public Meetings
- Document Existing Conditions: review collection system schematics for accuracy
- Conduct Field Reconnaissance: inspect all metering sites, along with selected structures, manholes, and other significant hydraulic structures and document all inspections
- Review Flow, Rainfall and Water Quality Data: review indicated data and report results of findings and evaluations to OCP
- Configure Hydraulic Model: develop a mathematical model of the collection system in conformance with specific details provided by OCP
- Calibrate and Verify Mathematical (Hydrologic & Hydraulic) Model: calibrate and verify model with flow and precipitation data provided by OCP
- Design Storm Event Analyses: use calibrated, verified model of collection system to estimate existing and improved system characteristics based on design rainfall events selected by OCP
- Alternatives Development and Evaluation: develop basin-specific, wet-weather improvement alternatives, with consideration given to reduction of infiltration and inflow (I/I); costs for conveyance and treatment; peak wet-weather flow management; and planning level evaluations of facility siting, constructability, and operability
- Integrate Basin-Specific Improvement Plans into an Overall City-Wide Plan: in cooperation with OCP, coordinate basin-specific plans with other basin-specific plans to develop a city-wide overflow control plan that meets overall goals of WSD

The work for Round Grove Creek also included a higher level of effort to perform a comprehensive sanitary sewer evaluation survey that included extensive manhole inspections, visual pipe (lamping) inspections, building inspections, smoke testing, dyed-water testing, and pipeline cleaning and closed circuit television (CCTV) inspection.

The work for the non-priority SSS areas did not include the development of models and their use in evaluation of improvement scenarios. The goal of evaluations for these basins was to prepare a prioritized summary of sewer system improvement projects to guide the development by OCP of a phased construction program.

2.5 Report Organization

This Plan report is organized as follows:

- Chapter 1 - Executive Summary – provides a stand-alone summary of the OCP and the Plan
- Chapter 2 – Introduction and Background – provides an introduction and background to the need for the project
- Chapter 3 – Existing Conditions – describes existing conditions consisting of project area characteristics, major receiving waters, precipitation conditions, and regulatory requirements and water quality parameters of concern
- Chapter 4 – Existing Systems - describes existing systems consisting of CSS basins, SSS basins, WWTPs, and separate stormwater systems
- Chapter 5 – Collection Systems and Treatment Facilities Characterization – describes characterization of collection systems and WWTPs during wet-weather events of various magnitudes
- Chapter 6 – Receiving Waters Characterization – describes characterization of receiving waters during wet-weather events of various magnitudes
- Chapter 7 – CSO Control Technologies – describes CSO and wet-weather technologies and management practices identified for possible use as part of the Plan
- Chapter 8 – Identification and Evaluation of Technologies – Basin-Specific Alternatives – describes the basin-specific wet-weather solution scenarios identified and evaluated for abating wet-weather overflows in the various basins
- Chapter 9 – Public Participation – describes the public participation process conducted by the City
- Chapter 10 – Integration of Basin Alternatives and Development of City-Wide Overflow Control Plan – describes the process by which basin-specific wet-weather solution scenarios were coordinated and integrated into an overall city-wide overflow control plan
- Chapter 11 – Financial Capability and Implementation Schedule – presents the results of an assessment of the financial capability of the City to afford the proposed Plan and an analysis of possible implementation schedules
- Chapter 12 – Selected Plan – describes the selected Plan with an opinion of probable cost, and a preliminary implementation schedule

- Section 13 – Post Construction Monitoring Plan – post-construction monitoring of Plan performance.

Appendices with supporting material are provided and can be accessed via hyperlinks provided in Appendices A through E or within the text of this document.

* * * * *

3 EXISTING CONDITIONS

3.1 Introduction

This chapter discusses existing project area conditions consisting of wastewater conveyance/treatment system characteristics, local receiving waters, rainfall patterns, and regulatory/water quality concerns. The City of Kansas City, Missouri (the City) and its tributary satellite communities represent an area of approximately 420 square miles with approximately 650,000 inhabitants. Wastewater and stormwater discharges from that area influence receiving water quality.

The Missouri River provides drainage for the entire Kansas City metropolitan area. Descriptions of the current conditions of that river and its local tributaries are mentioned in this chapter. Precipitation data from both national and local sources have been used to establish annual, recreation season, and event rainfall conditions. The results of the precipitation analysis and descriptions of the characteristics that have a major influence on conveyance system performance are also presented. The existing regulatory environment related to developing a capital improvement plan for the City's separate and combined sewer systems is described, as well.

Existing system performance, established based on metered flow (over 2.5 million data sets recorded at 170 locations), measured rainfall (over 3.8 million radar rainfall records), and mathematical modeling of critical system components (all overflow structures and 2.6 million feet of sewer) are discussed in detail in Chapter 5.

Existing water quality conditions were characterized by the City's Water Services Department's (WSD) routine sampling at 10 locations, United States Geological Service (USGS) data collected from the Blue River and Brush Creek watersheds, and detailed sampling conducted during this project (17 receiving water sites, 9 combined sewer outfalls, and 6 stormwater sites, yielding 13,000 analytical results describing 30 water quality parameters). Existing water quality conditions are discussed in Chapter 6.

3.2 General Project Area Characteristics

The WSD provides wastewater collection and treatment for approximately 650,000 people located within the City and in 27 tributary or "satellite" communities. Figure 3-1 shows the entire area presently tributary to the City's wastewater collection system (totaling approximately 420 square miles). Of that total area, approximately 318 square miles are within Kansas City's corporate limits, with the balance in the satellite communities. The most significant satellite community is the Johnson County, Kansas Wastewater District, with a population of approximately 127,000 served by the City's system. An area of approximately 36 square miles within the City drains to and is served by the Little Blue Valley Sewer District's collection and treatment system. Major streams in the area include the Missouri, Kansas, and Blue Rivers; smaller streams considered in the development of the Overflow Control Plan (the Plan) for the combined sewer system (CSS) include Brush Creek and Town Fork Creek.

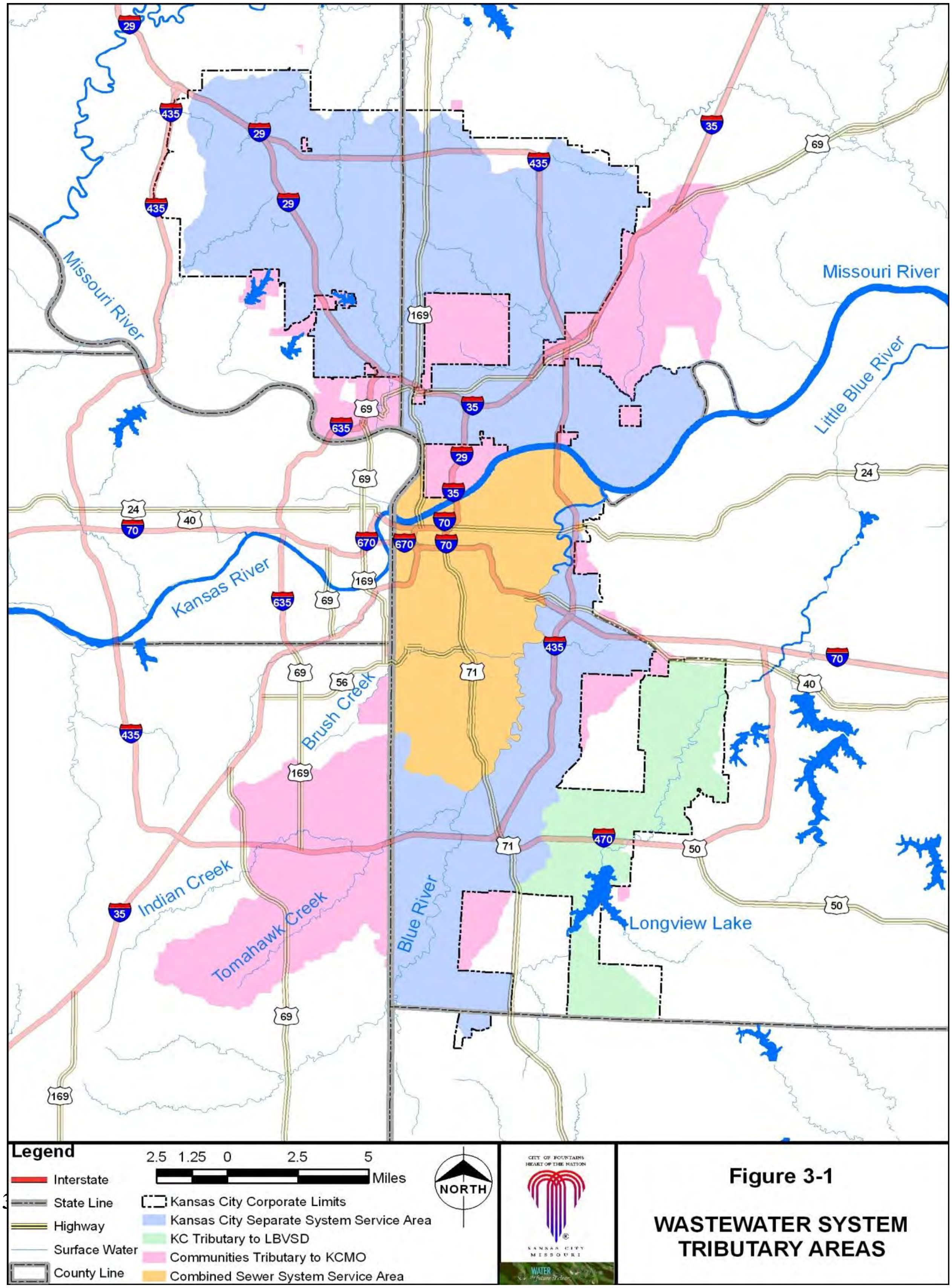


Figure 3-1

WASTEWATER SYSTEM TRIBUTARY AREAS

3.2.1.1 Combined Sewer System Area

Approximately 56 square miles within Kansas City are served by CSSs. That area is bounded by the Missouri/Kansas state line on the west, 85th Street on the south, the Blue River on the east, and the Missouri River on the north. For planning purposes, the area (shown in yellow in Figure 3-1) was subdivided into seven principal basins, as further illustrated in Figure 3-2. Five of those basins (Gooseneck Creek, Lower Blue River, Town Fork Creek, Brush Creek, and Middle Blue River) are tributary to the Blue River Interceptor Sewer, which generally parallels the Blue River downstream (north) of Brush Creek and discharges to the Blue River Wastewater Treatment Plant (WWTP). A sixth basin, Northeast Industrial District (NEID), is served by that same WWTP. The seventh principal CSS basin (Turkey Creek/Central Industrial District (CID)) discharges to the Westside WWTP. CSS basin characteristics are further defined in Table 3-1. In addition to those seven basins, the Charles B. Wheeler (Downtown) Airport is presently served by CSSs, adding approximately 2 square miles to the total area of the City served by the CSS. An additional small area of approximately 37 acres (0.06 square miles) east of the Blue River (at Winner Road and Interstate 435) is also served by the CSS.

Table 3-1 Combined Sewer System Basin Data

Basin	Basin Area (acres)	Basin Population*	Existing Combined Sewer System**		
			Total Length** (ft)	Diversion Structures** (#)	Outfalls** (#)
MISSOURI RIVER BASINS					
Downtown Airport	1,012	115	95,674	3	1
Turkey Creek CID	5,415	25,836	997,746	4	4
Northeast Industrial District	6,466	12,828	427,835	9	8
Missouri River Basin Subtotal	**12,893**	**38,779**	**1,521,255**	**16**	**13**
BLUE RIVER BASINS					
Gooseneck Creek	3,622	28,615	692,042	18	3
Lower Blue River	4,337	23,865	592,254	25	17
Blue Summit (Diversion Structure 205)	37	1,120	10,000	1	1
Town Fork Creek	3,419	19,233	579,424	22	16
Brush Creek	7,781	64,388	1,459,869	43	24
Middle Blue River	5,379	17,637	746,345	33	16
Blue River Basin Subtotal	**24,575**	**154,858**	**4,079,934**	**142**	**77**
CITY WIDE TOTALS	**37,468**	**193,637**	**5,601,189**	**158**	**90**

* 2005 population. In industrial areas, includes one-quarter of industrial employees.
**Combined sewer system designation is subject to refinement as the final detailed analysis of the system is performed and improvement projects are implemented.

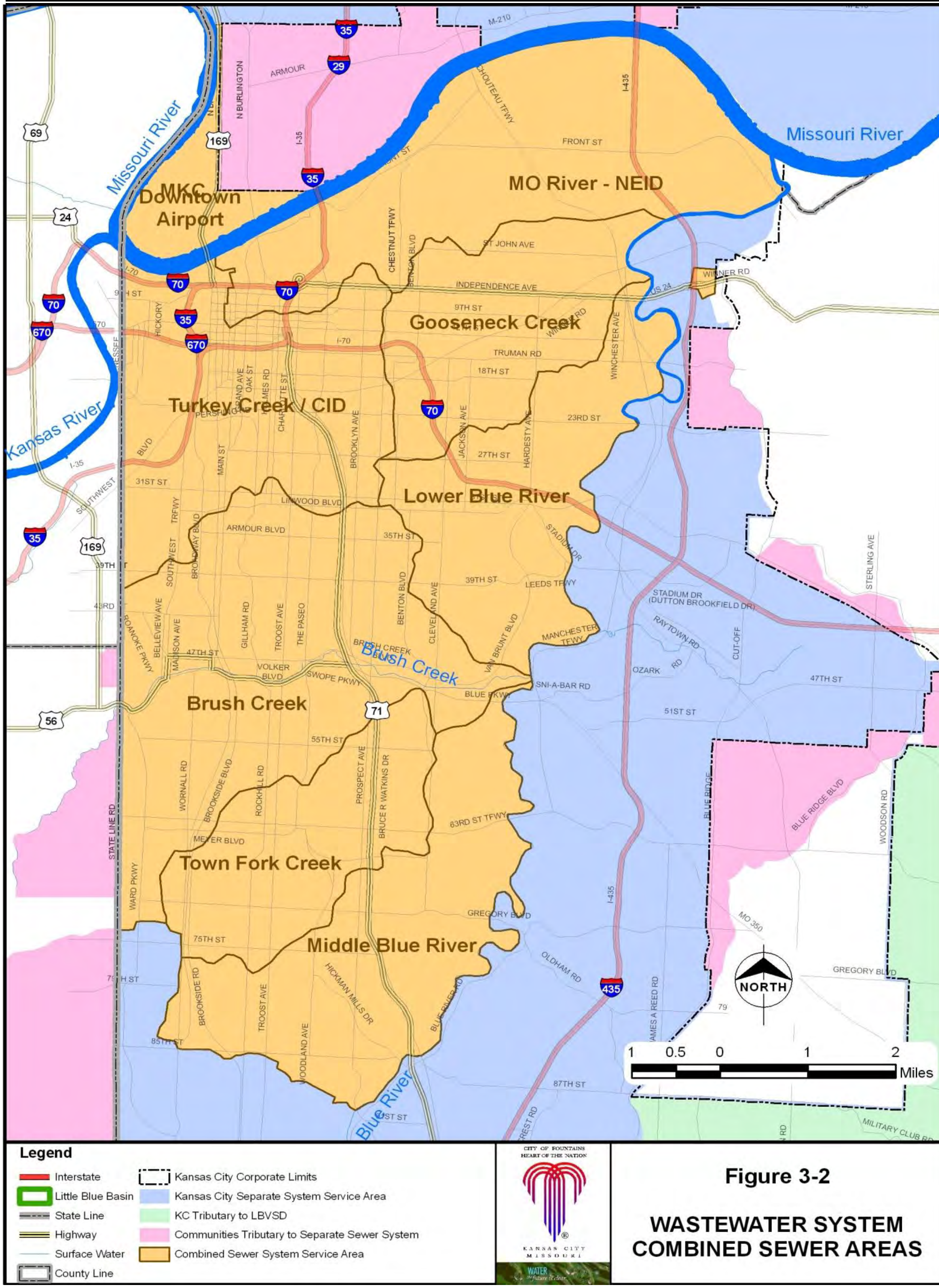


Figure 3-2

WASTEWATER SYSTEM COMBINED SEWER AREAS

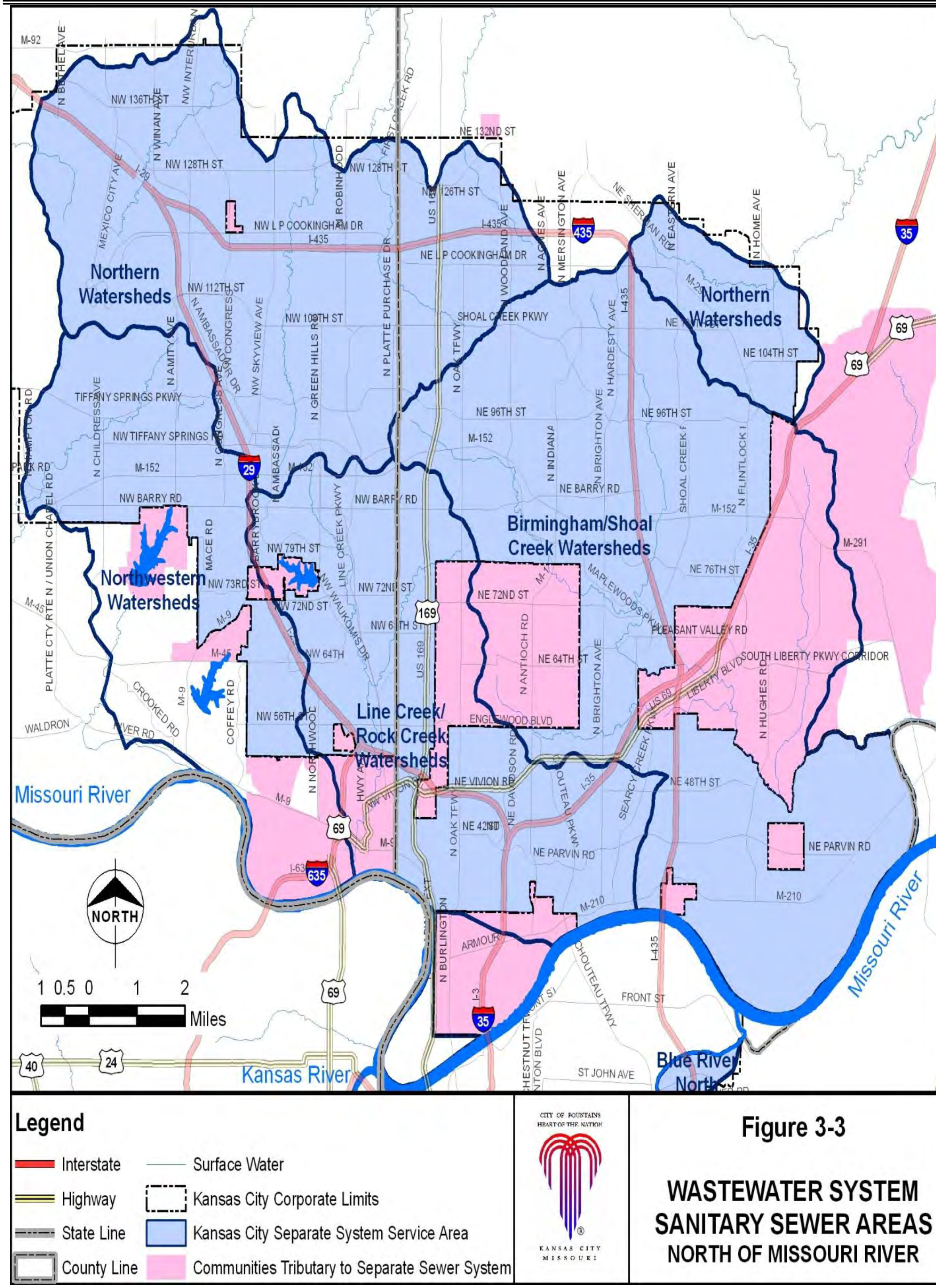
3.2.1.2 Separate Sewer System Area

The separate sewer system (SSS) area (including satellite communities) tributary to WSD WWTPs shown in Figure 3-1 is approximately 347 square miles. This includes approximately 36 square miles of SSS area that are tributary to the Little Blue Valley Sewer District. For planning purposes, the area within the City's SSS was divided into nine principal basins, as shown in Figures 3-3 (north of the Missouri River) and 3-4 (south of the Missouri River). Four of these basins (Line Creek/Rock Creek; Birmingham/Shoal Creek; Round Grove Creek; and Blue River South) were studied in more detail than the other five. These four basins either directly impact the performance of facilities also serving the CSS, or are more likely candidates for priority rehabilitation activities, due principally to the age of those systems, than the remaining SSS basins. Basin characteristics are summarized in Table 3-2.

Table 3-2 Separate Sewer System Basin Data

Basin	Total Basin Area (acres)	Basin Population[1]			Existing Sanitary Sewers	
		Existing (2005)	2030	Ultimate	Total Length[2] (ft)	Maximum Dia. (in)
NORTH OF MISSOURI RIVER						
Northern Watersheds	33,384	15,899	25,341	90,300	846,341	48
Northwestern Watersheds	20,060	15,366	20,190	11,000	542,685	27
Line Creek/Rock Creek	22,125	58,048	69,931	104,100	2,075,897	72
Birmingham/Shoal Creek	45,712	39,235	61,129	107,800	2,064,202	120
Total North of Missouri River	**121,281**	**128,548**	**176,591**	**313,200**	**5,529,125**	
SOUTH OF MISSOURI RIVER						
Blue River Tributary Basins						
Blue River North	4,032	4,282	3,407	7,600	202,224	30
Round Grove Creek	5,374	9,549	9,466	13,300	302,862	60
Blue River Central	7,338	11,278	10,328	16,900	379,938	96
Blue River South	24,404	57,456	54,658	72,900	1,731,781	96
Subtotal, Blue River Tributary Basins	**41,148**	**82,565**	**77,859**	**110,700**	**2,616,805**	
Little Blue River Tributary Basins						
Little Blue River Tributaries	47,181	33,237	35,478	133,400	1,176,562	48
Total South of Missouri River	**88,329**	**115,802**	**113,337**	**244,100**	**3,793,367**	
CITY-WIDE TOTAL	**209,610**	**244,350**	**289,928**	**557,300**	**9,322,492**	

Notes:
(1) Population within Kansas City, Missouri corporate limits. Excludes population in satellite communities, if any.
(2) Excludes satellite community sewer system not owned and operated by Kansas City.


Northern Watersheds
Northern Watersheds
Northwestern Watersheds
Birmingham/Shoal Creek Watersheds
Line Creek/ Rock Creek Watersheds
Blue River North
Missouri River
Missouri River
Kansas River
NORTH
1 0.5 0 1 2
Miles
Legend
Interstate
Highway
State Line
County Line
Surface Water
Kansas City Corporate Limits
Kansas City Separate System Service Area
Communities Tributary to Separate Sewer System
CITY OF FOUNTAINS HEART OF THE NATION
KANSAS CITY MISSOURI
Figure 3-3
WASTEWATER SYSTEM SANITARY SEWER AREAS NORTH OF MISSOURI RIVER

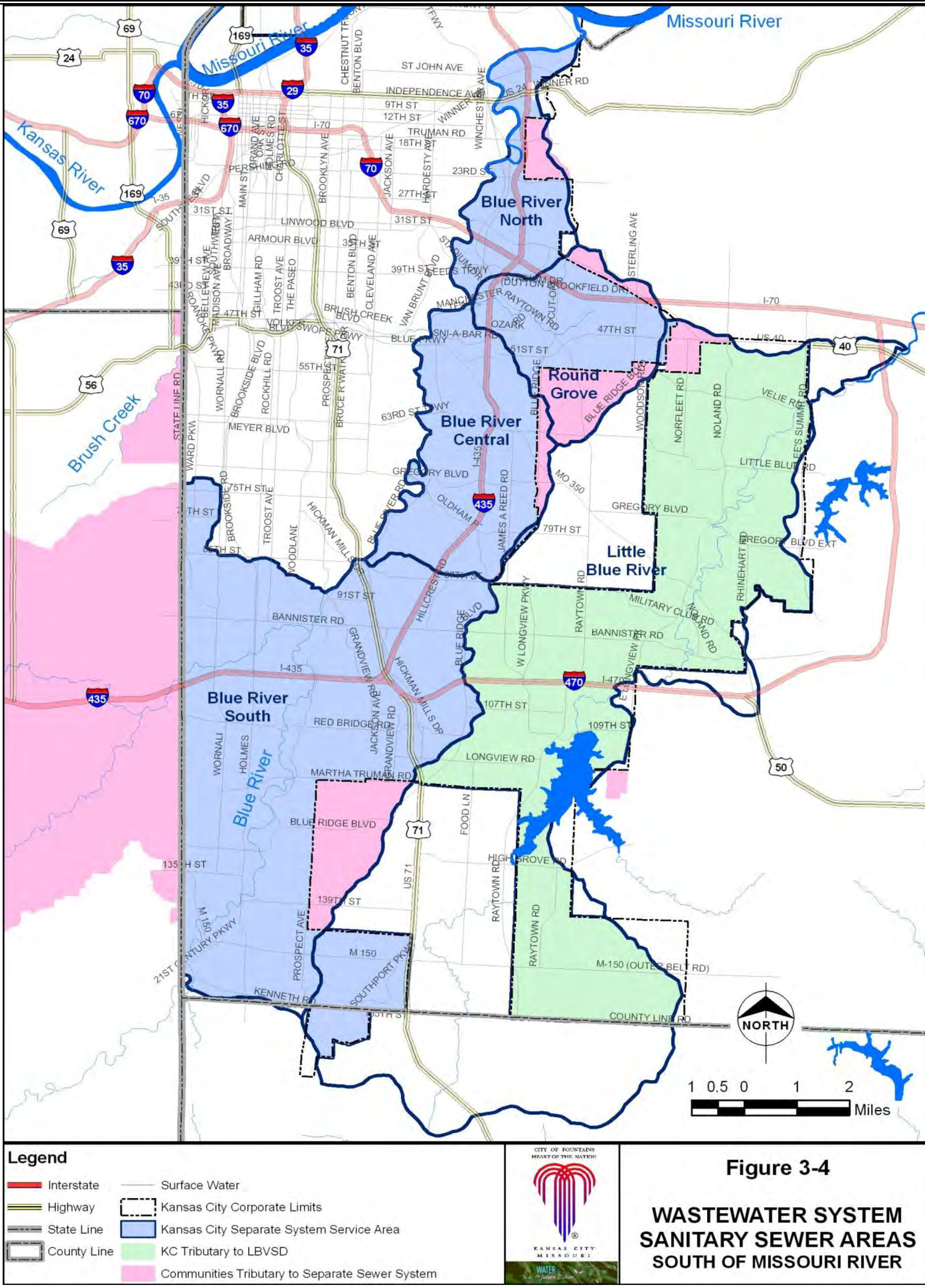


Figure 3-4

WASTEWATER SYSTEM SANITARY SEWER AREAS SOUTH OF MISSOURI RIVER

3.2.1.3 Satellite Communities

Table 3-3 presents information describing the satellite community sanitary sewer systems that are tributary to the City's sewer system. Flows from these sewers were included in the system analysis.

Table 3-3 Satellite Community Sanitary Sewer System Data

	Existing Population Estimate to KCMO System	KCMO Basin	WWTP
Avondale	529	Rock Creek	Blue River
Blue Summit	280	Blue River North	Blue River
Claycomo	1,600	Shoal Creek	Birmingham
Ferrelview	610	Todd Creek	Todd Creek
Gladstone	27,760	Shoal Creek/Line Creek	Birmingham/Blue River (Note 2)
Grandview	2,636	Blue River South	Blue River
Houston Lake	290	Line Creek	Blue River (Note 2)
Independence	1,634	Round Grove	Blue River
Johnson County, Kansas	127,420	Blue River South/Brush Creek	Blue River
Lee's Summit	0	Little Blue	LBVSD
Liberty	28,000	Shoal Creek	Birmingham
American Water (Ridgewood Estates)	252	Burlington Creek	Blue River (Note 2)
North Kansas City	4,900	NEID	Blue River
Northmoor	402	Line Creek	Blue River (Note 2)
Oakview	386	Line Creek	Blue River (Note 2)
Oakwood	32	Rock Creek	Blue River
Oakwood Park	213	Line Creek	Blue River (Note 2)
Parkville	350	Line Creek	Blue River (Note 2)
Platte County Regional Sewer District	2,024	Line Creek	Blue River (Note 2)
Platte Woods	384	Line Creek	Blue River (Note 2)
Pleasant Valley	3,350	Shoal Creek	Birmingham
Randolph	20	Shoal Creek	Birmingham
Raytown	5,375	Round Grove/Blue River Central	Blue River
Riverside	3,500	Line Creek	Blue River (Note 2)
Smithville	417	Rocky Branch	Rocky Branch
Waukomis	917	Line Creek	Blue River (Note 2)
Weatherby Lake	1,872	Line Creek	Blue River (Note 2)
Satellite Community Total	**215,153**		

Notes:

(1) Identifies those KCMO basin(s) to which the satellite community is tributary.

(2) Tributary to both the Blue River and the Westside WWTP by way of the Line Creek Pump Station which conveys flow either directly to Westside or to Blue River by way of the Buckeye Creek PS.

3.2.2 Pump Stations

The City's wastewater collection system includes 38 pump stations; an additional 17 flood pumping stations provide stormwater drainage service. In total, the firm pumping capacity of these stations is approximately 620 million gallons per day (MGD). The largest station, located at the Blue River WWTP, has a total capacity of approximately 228 MGD while the largest in-system station (87th Street) has a total capacity of approximately 89 MGD. Most of the other pump stations are relatively small, with 75 percent having a capacity less than 10 MGD (with one-third of those having a capacity less than 1 MGD). Several large stations are currently being upgraded. Figure 3-5 shows the location of each pump station in the system. Figure 3-6 is a system-wide schematic showing the relationship between major collection system features.

3.2.3 Land Use

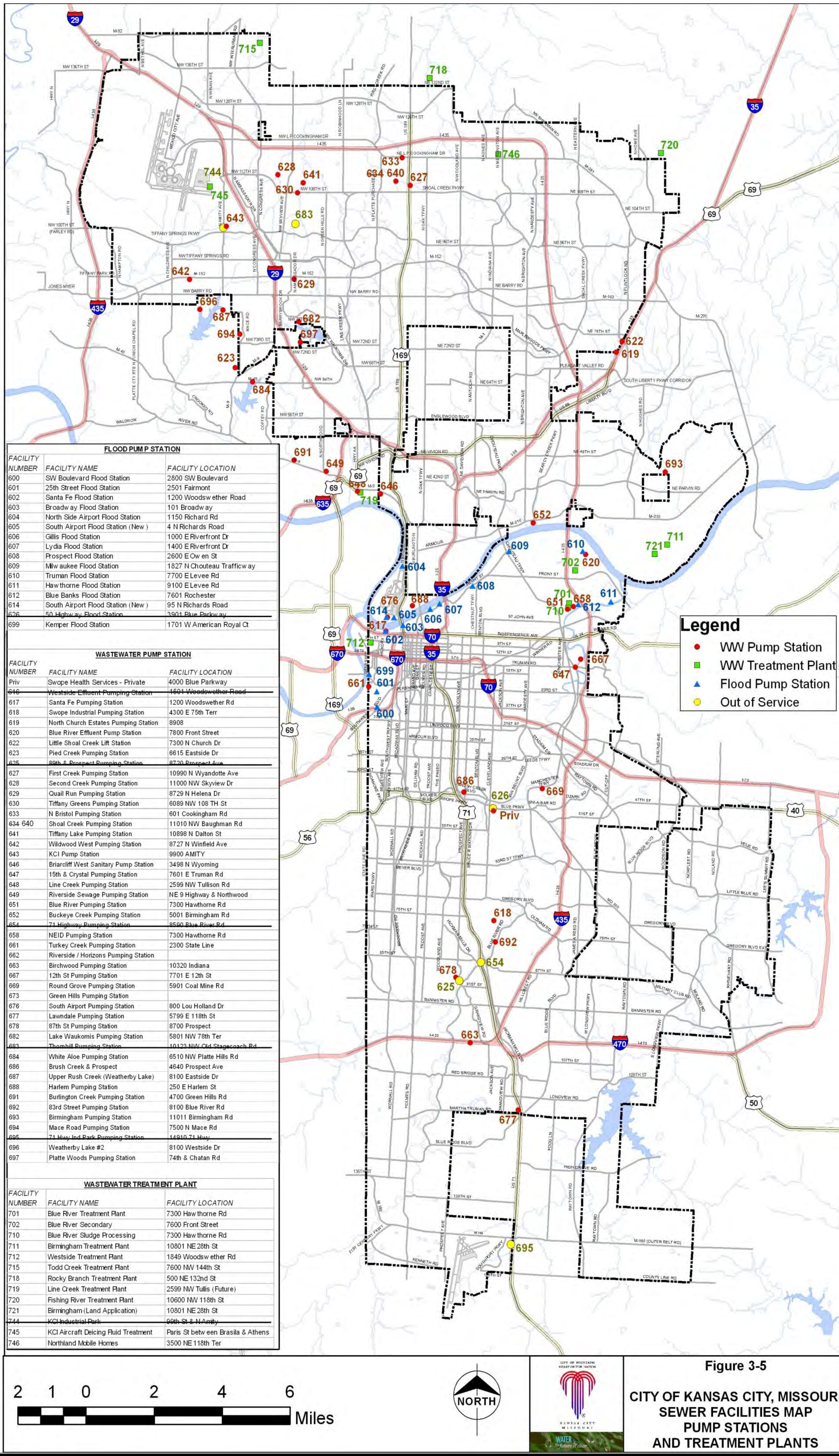
Table 3-4 summarizes the City's GIS database information on existing and future land use classifications for each separate and combined sewer system drainage basin.

Land use in developed areas is primarily residential (single-family and multifamily) with commercial and industrial uses being significant in most cases, as well. The single-family use category includes single-family residential and mobile home parks. The multifamily use includes townhouses, duplexes, condominiums, and other multifamily dwellings. The commercial classification includes uses such as hotels and motels, and both office and non-office commercial uses. The industrial classification includes heavy- and light-industrial, solid-waste management, storage, distribution, and vehicle sales and service. The institutional use includes schools, libraries, medical facilities, cemeteries, and emergency response and public training facilities.

Lesser land uses include transportation, mass assembly, leisure activities, natural resources, and other unclassified facilities. The transportation classification includes uses such as sidewalks, garages, paved parking, streets, railroads, airports, and water-based movement. The mass assembly category includes uses such as theater, spectator sports, convention and exhibit halls, social and cultural assembly halls, churches, museums, and historical sites. The leisure activities classification includes uses such as parks, golf courses, common areas, and other recreation areas. The natural resources classification includes uses such as agricultural and horticultural areas. Unclassified uses include vacant residential and non-residential properties and permanent open space.

3.2.4 Population

As detailed in previous tables, within the City, the CSS serves a population of approximately 194,000 while the SSS serves a population of approximately 244,000. An additional population of approximately 215,000 is tributary to satellite community systems that discharge to the City's systems. The total existing service population is approximately 650,000, primarily in the City's SSS area and in adjacent satellite communities.



FLOOD PUMP STATION

FACILITY NUMBER	FACILITY NAME	FACILITY LOCATION
600	SW Boulevard Flood Station	2800 SW Boulevard
601	25th Street Flood Station	2501 Fairmont
602	Santa Fe Flood Station	1200 Woodswether Road
603	Broadway Flood Station	101 Broadway
604	North Side Airport Flood Station	1150 Richard Rd
605	South Airport Flood Station (New)	4 N Richards Road
606	Gillis Flood Station	1000 E Riverfront Dr
607	Lydia Flood Station	1400 E Riverfront Dr
608	Prospect Flood Station	2600 E Owen St
609	Milwaukee Flood Station	1827 N Chouteau Trafficway
610	Truman Flood Station	7700 E Levee Rd
611	Hawthorne Flood Station	9100 E Levee Rd
612	Blue Banks Flood Station	7601 Rochester
614	South Airport Flood Station (New)	95 N Richards Road
~~626~~	~~50 Highway Flood Station~~	~~3901 Blue Parkway~~
699	Kemper Flood Station	1701 W American Royal Ct

WASTEWATER PUMP STATION

FACILITY NUMBER	FACILITY NAME	FACILITY LOCATION
Priv	Swope Health Services - Private	4000 Blue Parkway
~~616~~	~~Westside Effluent Pumping Station~~	~~1501 Woodswether Road~~
617	Santa Fe Pumping Station	1200 Woodswether Rd
618	Swope Industrial Pumping Station	4300 E 75th Terr
619	North Church Estates Pumping Station	8908
620	Blue River Effluent Pump Station	7800 Front Street
622	Little Shoal Creek Lift Station	7300 N Church Dr
623	Pied Creek Pumping Station	6615 Eastside Dr
~~625~~	~~89th & Prospect Pumping Station~~	~~8720 Prospect Ave~~
627	First Creek Pumping Station	10990 N Wyandotte Ave
628	Second Creek Pumping Station	11000 NW Skyview Dr
629	Quail Run Pumping Station	8729 N Helena Dr
630	Tiffany Greens Pumping Station	6089 NW 108 TH St
633	N Bristol Pumping Station	601 Cookingham Rd
~~634~~ 640	Shoal Creek Pumping Station	11010 NW Baughman Rd
641	Tiffany Lake Pumping Station	10898 N Dalton St
642	Wildwood West Pumping Station	8727 N Winfield Ave
643	KCI Pump Station	9900 AMITY
646	Briarcliff West Sanitary Pump Station	3498 N Wyoming
647	15th & Crystal Pumping Station	7601 E Truman Rd
648	Line Creek Pumping Station	2599 NW Tullison Rd
649	Riverside Sewage Pumping Station	NE 9 Highway & Northwood
651	Blue River Pumping Station	7300 Hawthorne Rd
652	Buckeye Creek Pumping Station	5001 Birmingham Rd
~~654~~	~~71 Highway Pumping Station~~	~~8590 Blue River Rd~~
658	NEID Pumping Station	7300 Hawthorne Rd
661	Turkey Creek Pumping Station	2300 State Line
662	Riverside / Horizons Pumping Station	
663	Birchwood Pumping Station	10320 Indiana
667	12th St Pumping Station	7701 E 12th St
669	Round Grove Pumping Station	5901 Coal Mine Rd
673	Green Hills Pumping Station	
676	South Airport Pumping Station	800 Lou Holland Dr
677	Lawndale Pumping Station	5799 E 118th St
678	87th St Pumping Station	8700 Prospect
682	Lake Waukomis Pumping Station	5801 NW 78th Ter
~~683~~	~~Thornhill Pumping Station~~	~~10123 NW Old Stagecoach Rd~~
684	White Aloe Pumping Station	6510 NW Platte Hills Rd
686	Brush Creek & Prospect	4640 Prospect Ave
687	Upper Rush Creek (Weatherby Lake)	8100 Eastside Dr
688	Harlem Pumping Station	250 E Harlem St
691	Burlington Creek Pumping Station	4700 Green Hills Rd
692	83rd Street Pumping Station	8100 Blue River Rd
693	Birmingham Pumping Station	11011 Birmingham Rd
694	Mace Road Pumping Station	7500 N Mace Rd
~~695~~	~~71 Hwy Ind Park Pumping Station~~	~~14910 71 Hwy~~
696	Weatherby Lake #2	8100 Westside Dr
697	Platte Woods Pumping Station	74th & Chatan Rd

WASTEWATER TREATMENT PLANT

FACILITY NUMBER	FACILITY NAME	FACILITY LOCATION
701	Blue River Treatment Plant	7300 Hawthorne Rd
702	Blue River Secondary	7600 Front Street
710	Blue River Sludge Processing	7300 Hawthorne Rd
711	Birmingham Treatment Plant	10801 NE 28th St
712	Westside Treatment Plant	1849 Woodswether Rd
715	Todd Creek Treatment Plant	7600 NW 144th St
718	Rocky Branch Treatment Plant	500 NE 132nd St
719	Line Creek Treatment Plant	2599 NW Tullis (Future)
720	Fishing River Treatment Plant	10600 NW 118th St
721	Birmingham (Land Application)	10801 NE 28th St
~~744~~	~~KCI Industrial Park~~	~~99th St & N Amity~~
745	KCI Aircraft Deicing Fluid Treatment	Paris St between Brasila & Athens
746	Northland Mobile Homes	3500 NE 118th Ter

Figure 3-5

CITY OF KANSAS CITY, MISSOURI SEWER FACILITIES MAP PUMP STATIONS AND TREATMENT PLANTS

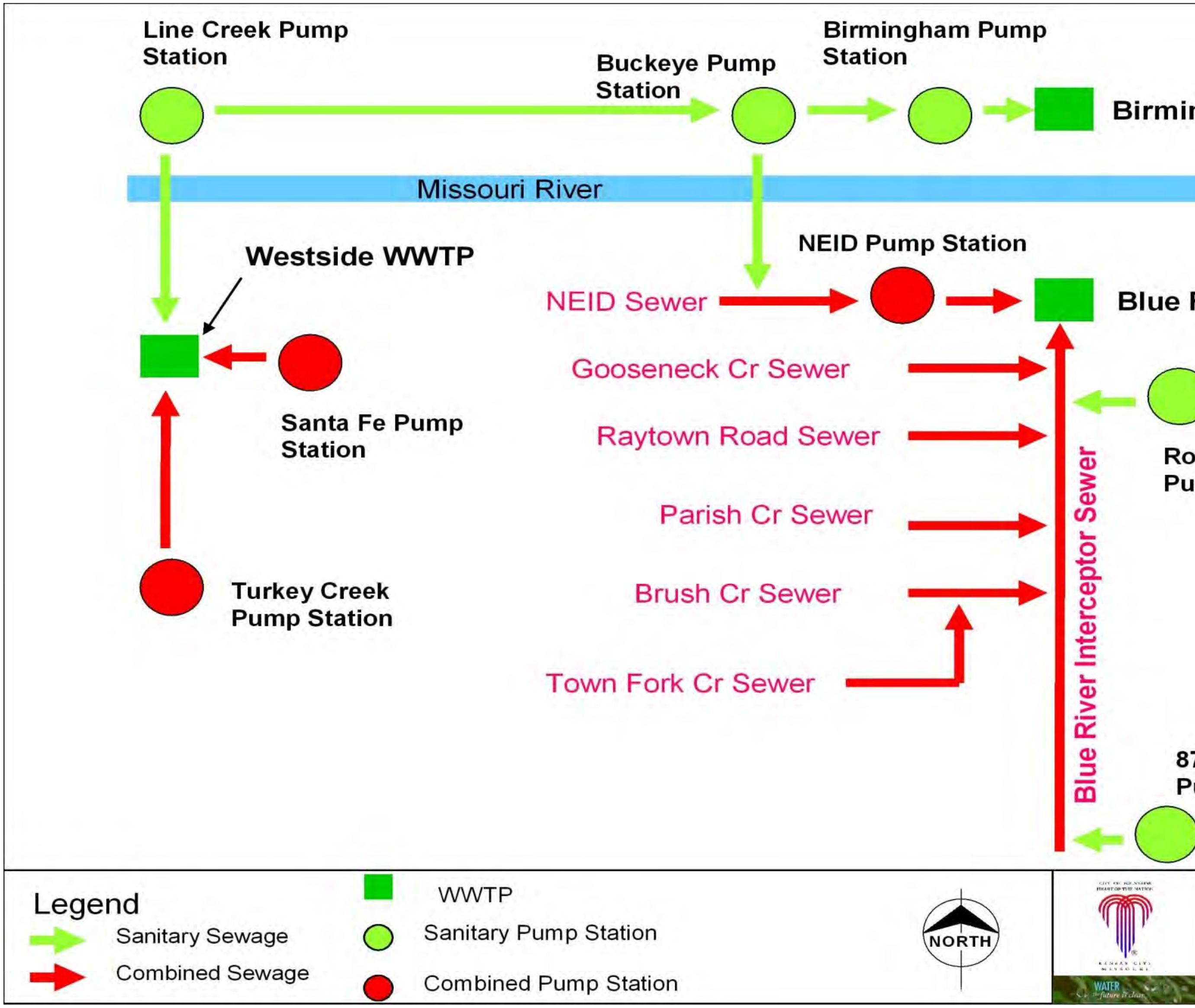


Figure 3-6

KANSAS CITY SEWER SYSTEM SCHEMATIC DIAGRAM

Table 3-4 Existing and Future Land Use

SSS Drainage Basin

	Birmhm./Shoal Creek		*Blue River Central*		*Blue River North*		*Blue River South*		*Little Blue River*		*Line Creek*		*N Watersheds*		*NW Watersheds*		*Round Grove*	
Land Use Description	Existing	Future	Existing	Future	Existing	Future	Existing	Future	Existing	Future	Existing	Future	Existing	Future	Existing	Future	Existing	Future
Single Family	17.7%	42.7%	27.8%	45.9%	16.2%	19.4%	31.2%	48.8%	25.2%	55.6%	43.0%	55.9%	8.0%	42.9%	18.2%	30.6%	40.6%	42.9%
Multifamily	0.9%	7.2%	2.6%	3.1%	0.3%	1.9%	4.8%	6.0%	1.0%	6.2%	7.0%	13.6%	0.3%	6.7%	2.1%	3.1%	3.4%	7.2%
Commercial	1.7%	8.4%	3.5%	7.2%	2.8%	3.7%	6.8%	12.3%	1.0%	3.7%	4.7%	8.4%	1.6%	10.4%	2.1%	5.2%	4.8%	12.7%
Industrial	2.4%	19.9%	0.8%	7.4%	30.5%	56.1%	3.0%	6.0%	0.6%	8.7%	0.9%	1.7%	1.0%	20.4%	0.6%	36.8%	1.6%	4.5%
Institutional	1.5%	1.7%	10.4%	0.5%	3.2%	0.5%	4.4%	2.7%	2.8%	2.8%	6.3%	3.6%	1.7%	0.2%	1.3%	1.5%	14.9%	9.5%
Transportation	4.7%	0.1%	0.4%	0.0%	4.3%	1.0%	1.4%	0.4%	6.8%	0.7%	0.4%	0.0%	16.8%	8.3%	26.7%	7.9%	1.6%	0.0%
Mass Assembly	0.7%	1.0%	1.0%	1.9%	1.7%	0.0%	1.5%	1.5%	0.7%	1.0%	1.4%	1.2%	0.3%	0.8%	0.3%	0.4%	6.1%	3.1%
Leisure Activities	7.8%	7.4%	26.5%	30.6%	1.4%	8.8%	17.0%	19.4%	15.1%	11.6%	9.5%	9.5%	1.3%	5.6%	4.8%	7.4%	7.6%	13.5%
Natural Resources	49.8%	0.1%	2.8%	0.2%	3.3%	1.3%	16.7%	0.5%	36.9%	2.3%	14.7%	0.4%	65.7%	0.3%	37.0%	0.2%	2.5%	0.0%
Unclassifiable	12.8%	11.4%	24.1%	3.1%	36.4%	7.3%	13.0%	2.3%	9.9%	7.3%	12.1%	5.7%	3.4%	4.5%	6.9%	6.9%	17.0%	6.7%

CSS Drainage Basin

	Brush Creek		*Gooseneck Creek*		*Lower Blue River*		*Middle Blue River*		*Downtown Airport*		*NEID*		*Town Fork Creek*		*Turkey Creek*	
	Existing	Future	Existing	Future	Existing	Future	Existing	Future	Existing	Future	Existing	Future	Existing	Future	Existing	Future
Single Family	53.2%	43.8%	44.3%	35.5%	38.9%	46.0%	39.5%	49.0%	0.4%	0.0%	3.5%	2.1%	60.5%	56.8%	14.8%	18.4%
Multifamily	10.0%	23.9%	6.3%	24.9%	5.1%	11.2%	4.5%	4.7%	0.5%	0.0%	1.9%	5.4%	3.7%	9.9%	10.5%	12.5%
Commercial	8.9%	11.0%	5.3%	6.3%	2.4%	2.9%	4.3%	5.5%	1.1%	0.9%	4.7%	6.4%	7.0%	9.9%	11.3%	16.9%
Industrial	1.6%	0.5%	13.1%	17.6%	14.0%	18.2%	8.6%	13.9%	2.0%	10.4%	24.9%	54.6%	1.3%	0.1%	18.0%	21.2%
Institutional	7.3%	7.5%	9.3%	3.4%	5.3%	4.2%	3.8%	2.8%	0.0%	0.0%	7.7%	2.5%	12.9%	7.0%	10.9%	11.5%
Transportation	2.0%	0.2%	4.8%	2.0%	2.2%	0.0%	2.6%	0.3%	62.2%	47.4%	15.8%	3.4%	2.1%	0.0%	8.7%	2.9%
Mass Assembly	2.5%	1.8%	2.0%	2.0%	2.0%	2.0%	1.0%	0.9%	0.1%	0.0%	0.2%	0.1%	1.8%	1.9%	2.7%	1.2%
Leisure Activities	4.7%	11.1%	3.3%	7.6%	12.1%	15.1%	16.7%	18.7%	0.0%	2.9%	21.9%	11.4%	4.6%	14.4%	9.2%	15.3%
Natural Resources	0.2%	0.1%	0.0%	0.2%	0.0%	0.4%	1.0%	0.0%	0.0%	1.7%	1.8%	1.2%	0.0%	0.0%	0.0%	0.1%
Unclassifiable	9.7%	0.0%	11.5%	0.6%	17.9%	0.0%	18.0%	4.2%	33.8%	36.6%	17.5%	13.0%	6.0%	0.0%	14.0%	0.0%

3.2.5 Water Consumption

The WSD supplies water for approximately 1 million people in the City and 24 other area communities. The Missouri River, upstream from the reach containing the combined sewer overflows (CSO) from the CSS area, provides approximately 94 percent of the source water, with the other 6 percent coming from deep wells. Water treatment plant capacity is 240 MGD, with recent average flows equivalent to 115 MGD.

3.2.6 Wastewater Treatment

The City owns and operates seven WWTPs. Significant WWTP characteristics are shown in Table 3-5. Of particular importance to planning for CSS overflow control are the Blue River and Westside WWTPs, which are the only treatment plants that receive combined sewage. These two WWTPs also receive flow from portions of the City and satellite community SSS areas.

Table 3-5 Wastewater Treatment Plants - Characteristics

Plant	Permitted Capacity (MGD*)	Average Flow Calendar Year 2006 (MGD)	5-Year Average Flow, 2002-2006 (MGD)	Process
Blue River	105.00	63.7	73.0	Trickling Filter
Westside	22.50	11.6	14.4	Activated Sludge
Birmingham	20.00	10.6	10.7	Activated Sludge
Todd Creek	3.40	1.53	1.42	Extended Aeration
Rocky Branch	2.00	1.29	1.04	Extended Aeration
Fishing River	1.00	0.67	0.60	Extended Aeration
Northland Mobile Home Park	0.09	0.05	0.06	Activated Sludge Package Plant
KCMO Totals	**153.99**	**89.44**	**101.22**	

* MGD = Million Gallons per Day

3.3 Major Watersheds

The City's CSSs overflow to three principal receiving streams: the Kansas River (tributary to the Missouri River near the City's western boundary); the Missouri River; and the Blue River (tributary to the Missouri River near the City's eastern boundary). The Brush Creek / Town Fork Creek basin is tributary to the Blue River.

Figure 3-7 shows the streams that receive CSOs from the City's system and indicates the current recreational water quality standard designated by the State of Missouri (or by the State of Kansas, for the Kansas River). The map shows the CSO area directly tributary to the Missouri River (including those areas tributary via the Kansas River). It also shows all areas tributary to the Blue River. The map

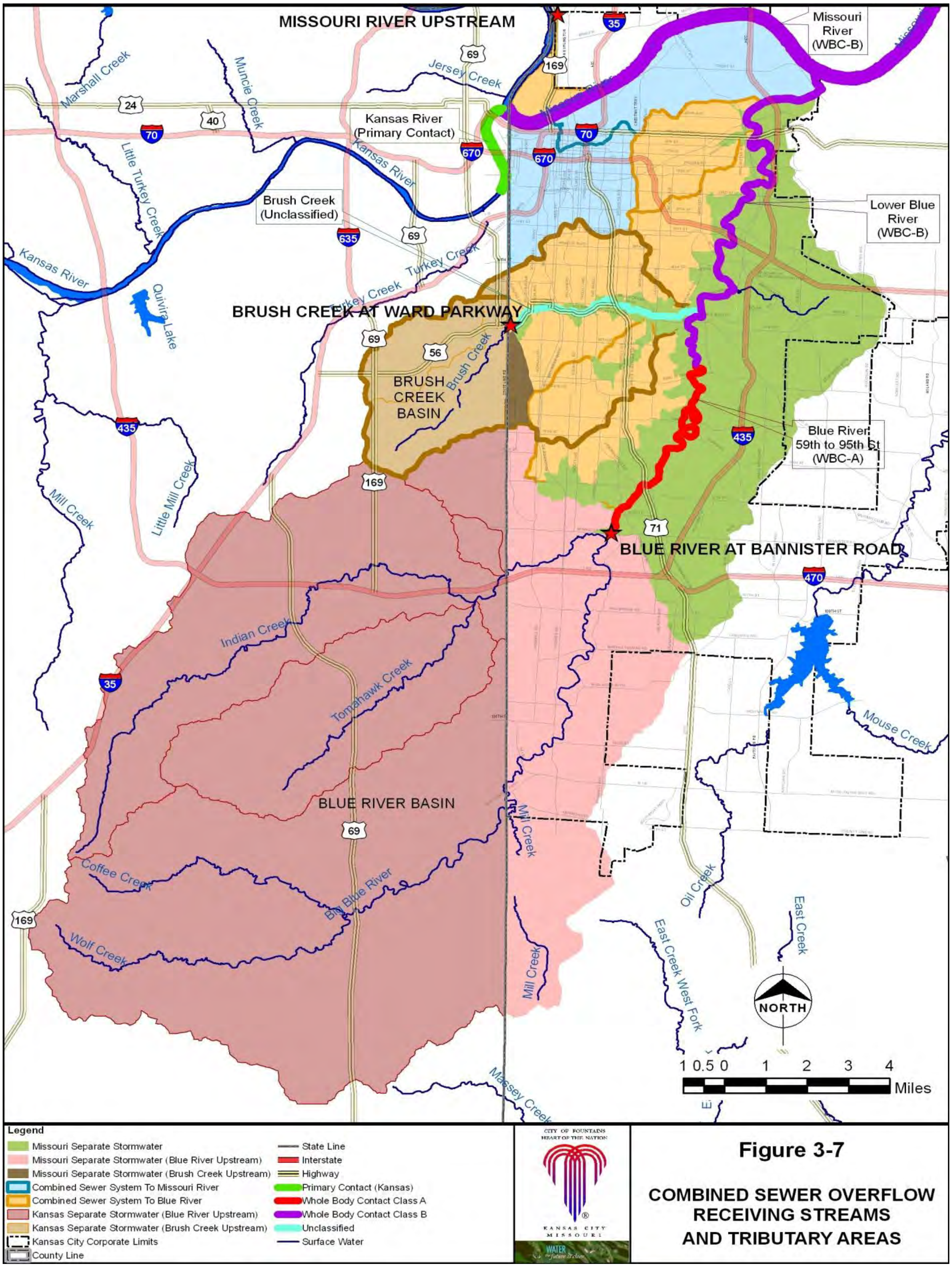


Figure 3-7

COMBINED SEWER OVERFLOW RECEIVING STREAMS AND TRIBUTARY AREAS

distinguishes between those tributary areas upstream from Kansas City's CSOs (e.g., upstream from the points marked with red stars), and areas directly tributary to those stream reaches that receive CSOs. A discussion of water quality in receiving streams and actual uses is presented in Chapter 6.

3.3.1 Missouri River

The Missouri River, which begins in Montana and receives flow from 9 upstream states (including Missouri) and a small part of Canada, has a 484,100-square-mile drainage area at the Broadway Bridge in the City. The noted area includes over 60,000 square miles tributary from the Kansas River. Mean annual flow (1958 through 2005) at the site exceeds 55,300 cubic feet per second (cfs) or 35,750 MGD. Annual flow has ranged from 34,420 cfs (22,250 MGD) in 1963, to 104,700 cfs (67,675 MGD) in 1993. All of the City's CSSs are either directly or indirectly tributary to the Missouri River. The CSSs in the Downtown Airport, Central Industrial District, and Northeast Industrial District are directly tributary to that river. The total area drained by the Missouri River at the City is approximately 8,275 times the total area served by the City's CSS. The river has a Missouri Department of Natural Resources (MDNR) classification of "Whole Body Contact – Class B."

Missouri River

3.3.2 Lower Blue River (Downstream from Brush Creek confluence)

Within the Blue River basin, areas directly tributary to stream reaches that receive CSOs include both CSS (shown in yellow, Figure 3-7) and separate stormwater systems (shown in green, Figure 3-7). Table 3-6 summarizes information regarding the 277-square-mile area tributary to various components of the Blue River.

Lower Blue River

The "Blue River at Missouri River" portion of Table 3-6 notes that 157.8 square miles of the 277 square mile tributary area (57 percent) are located in Kansas. Only 10 percent of the total tributary area is served by CSSs located in the City. Although influenced by CSOs, these percentages also illustrate that interstate and stormwater flows significantly impact the receiving water. The Lower Blue River has an MDNR classification of "Whole Body Contact – Class B. It has an average flow rate slightly exceeding 250 cfs.

Much of this section of the Lower blue River has been straightened and paved with concrete by the United States of America Corps of Engineers (USACOE) as part of its flood control efforts. Land use along this reach is primarily industrial, with numerous auto parts operations and other similar businesses. Public access is considered limited.

3.3.3 Upper Blue River (Upstream from Brush Creek confluence)

The "Blue River upstream of Brush Creek" portion of Table 3-6 notes that, at this point along the stream, 145.2 square miles of the 220 square mile tributary area (66 percent) are located in Kansas. Only 2 percent of the tributary area is served by CSS (from the Middle Blue River CSS basin). Although influenced by CSOs, these percentages also illustrate that interstate and stormwater flows significantly impact the receiving water. In addition, treated wastewater flows from WWTPs in Kansas represent a significant flow component. The USGS notes, "Downstream from WWTPs, effluent can comprise greater than 95 percent of base flow." The Upper Blue River has MDNR classifications of "Whole Body Contact – Class B" from Brush Creek upstream to 59th Street and "Whole Body – Class A" from 59th Street to 95th Street.

Upper Blue River

3.3.4 Brush Creek / Town Fork Creek

Brush Creek and Town Fork Creek are presently unclassified by MDNR, with no state-designated beneficial uses. However, Brush Creek is a highly-visible amenity associated with the major retail area in the City, known as "The Plaza." Local residents, business owners, and WSD have devoted considerable effort to improve the stream reach. Much of Town Fork Creek flows through private, residential areas, with very limited public access.

Brush Creek

Brush Creek is a tributary to the Blue River. The Brush Creek drainage basin in Missouri is served by both combined and separate sewer systems. The Brush creek drainage basin in Kansas is served by an SSS.

3.3.5 Kansas River

The tributary area to the Kansas River at De Soto, Kansas, the nearest USGS stream gauging station which is approximately 30 miles upstream from the Missouri River / Kansas River confluence, is approximately 59,756 square miles. Mean annual flow (1918 through 2005) at the site is 7,359 cfs (4,757 MGD). Annual flow has ranged from 1,148 cfs (750 MGD) in 1956, to 31,700 cfs (20,500 MGD) in 1993. The area tributary to the Kansas River at De Soto, Kansas is approximately 8,075 times the size of the Turkey Creek basin (the only City CSS basin tributary to the Kansas River). The river has a Kansas Department of Health and Environment (KDHE) classification of "Primary Contact."

Kansas River

3.4 Precipitation

On average, the City receives 36.50 inches of precipitation annually. Monthly average precipitation depths during the non-recreation season (November through March) range from 1.24 inches in January to 2.25 inches in March. By contrast, monthly average rainfall depths during the recreation season (with more restrictive water quality standards) range from 3.29 inches in April and October to 5.31 inches in June. During the summer months, the City can be affected by intense thunderstorms, which have occasionally produced flood flows that have resulted in loss of life. At the Downtown Airport, the greatest single day rainfall was 7.45 inches on August 15, 1969.

Precipitation data is available for the Kansas City, Missouri (KCMO) area from two primary sources. Continuous, long-term data is available from the National Climatic Data Center (NCDC) for the Kansas City Downtown Airport (MKC; November 1948–October 1972) and the Kansas City International Airport (MCI; November 1972–present). The combined airport data sets provide 56 continuous and complete years of hourly precipitation data with a precision of 0.01 inch. Annual precipitation totals for 1949-2004 for the historical dataset are shown in Figure 3-8. Figure 3-9 is a ranked order plot showing highest to lowest annual precipitation (from left to right) for the same data set. The solid horizontal lines on these figures represent the median annual depth for the historical dataset, and the lower and upper dotted lines represent the 25th and 75th percentile annual depths, respectively.

Figure 3-8 KCMO Airport Locations: Annual Rainfall Depth by Year

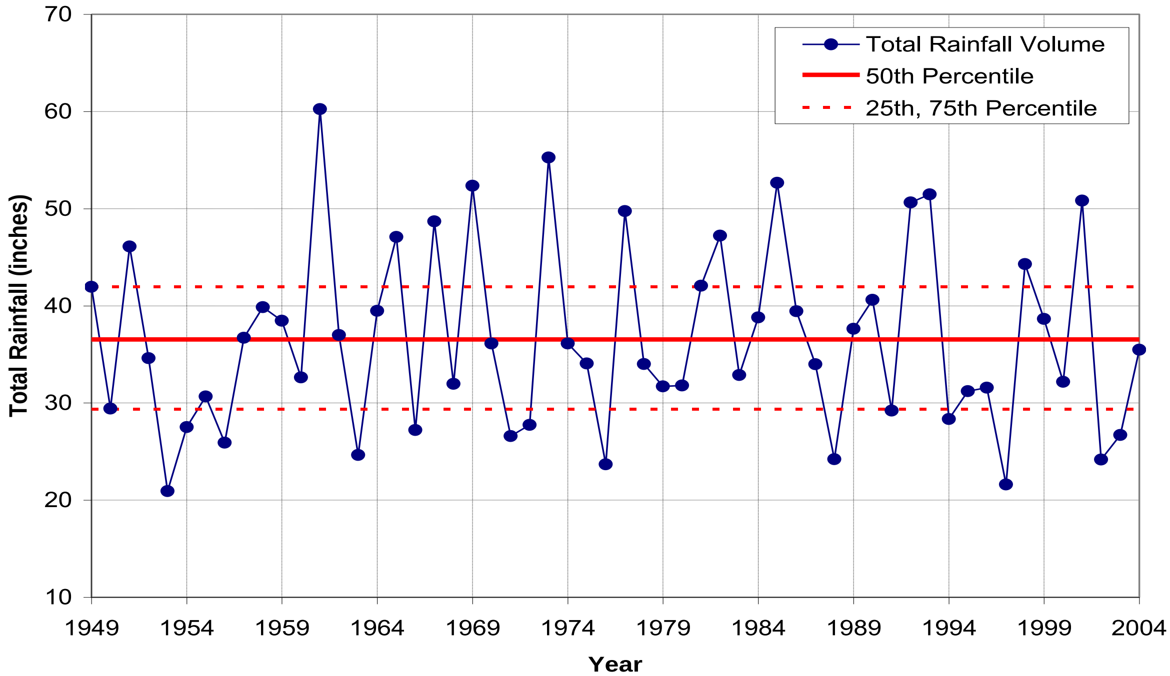
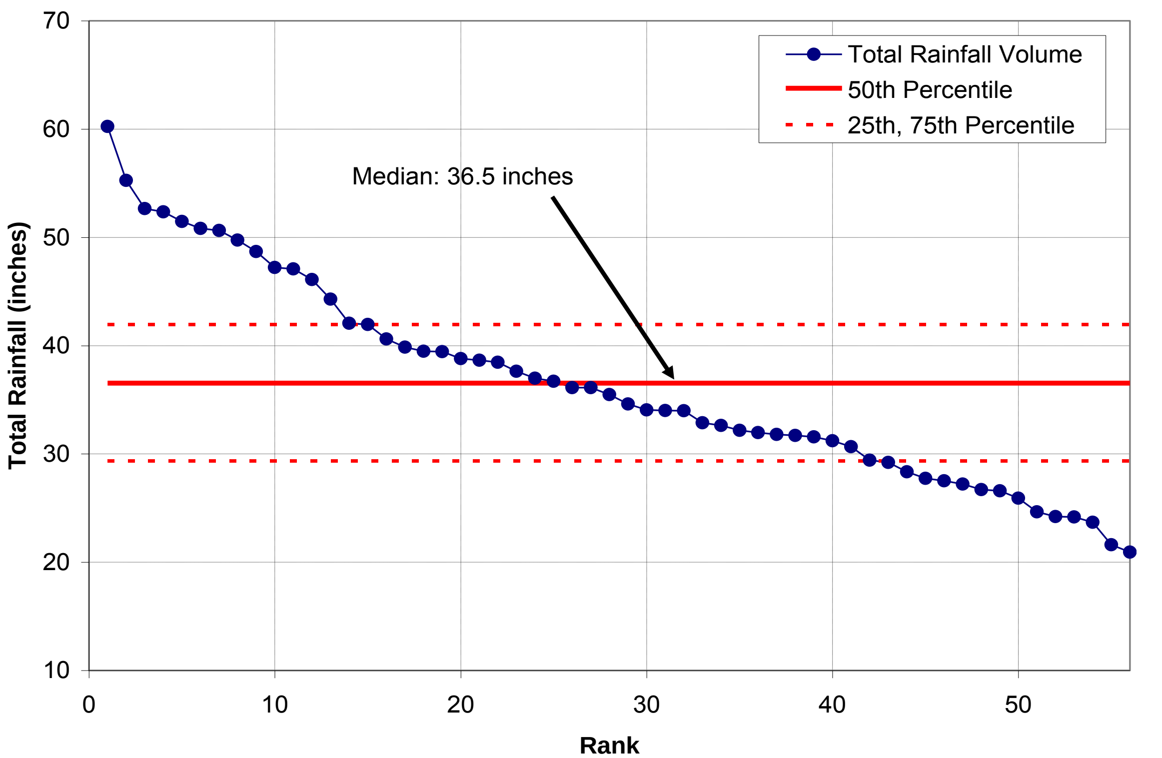


Figure 3-9 KCMO Airport Locations: Ranked Annual Rainfall Depth



For 1949-2004, annual precipitation in the KCMO area varies by nearly a factor of three, with a minimum of 20.9 inches in 1953 and a maximum of 60.3 inches in 1961.

Table 3-6 Blue River Tributary Areas

Stream Name	Location	Tributary Area Description	Tributary Area (square miles)	Percent of Tributary Area at Location
Blue River	Bannister Road	"Upstream" area west of State Line	145.2	77%
		"Upstream" area in KCMO	26.3	14%
		"Upstream" Missouri area outside KCMO	16.5	9%
		Total Tributary Area	**188**	**100%**
Blue River	Upstream of Brush Creek	"Upstream" area west of State Line	145.2	66%
		"Upstream" area in KCMO	29.4	13%
		"Upstream" Missouri area outside KCMO	16.5	7%
		Combined sewer system areas	4.1	2%
		Separate storm sewer system areas	24.9	11%
		Total Tributary Area	**220**	**100%**
Brush Creek	Ward Parkway	"Upstream" area west of State Line	11.6	95%
		"Upstream" area in KCMO	0.6	5%
		Total Tributary Area	**12.2**	**100%**
Brush Creek	Upstream of Blue River	"Upstream" area west of State Line	12.6	42%
		"Upstream" area in KCMO	1.1	4%
		Combined sewer system areas	13.8	46%
		Separate storm sewer system areas	2.6	9%
		Total Tributary Area	**30.1**	**100%**
Blue River	Downstream of Brush Creek	"Upstream" area west of State Line	157.8	63%
		"Upstream" area in KCMO	30.5	12%
		"Upstream" Missouri area outside KCMO	16.5	7%
		Combined sewer system areas	17.8	7%
		Separate storm sewer system areas	27.6	11%
		Total Tributary Area	**250**	**100%**
Blue River	At Missouri River	"Upstream" area west of State Line	157.8	57%
		"Upstream" area in KCMO	30.5	11%
		"Upstream" Missouri area outside KCMO	16.5	6%
		Combined sewer system areas	27.9	10%
		Separate storm sewer system areas	44.6	16%
		Total Tributary Area	**277**	**100%**

In addition to the historical airport data sets, recent real-time precipitation data is available for the KCMO area from the ALERT (Automated Local Evaluation in Real-Time) Flood Warning System (FWS) network, which transmits environmental data to a central computer in real-time. The FWS, which is jointly operated by Johnson County, Kansas and KCMO, is primarily intended to serve as an early flood warning system, and employs sensors throughout the Kansas City metropolitan areas. Continuous precipitation data is recorded at more than twenty sensors located within, or in close proximity to, the CSS area. The FWS data sets provide important advantages over historical precipitation data sets, including close proximity to the CSS area, the availability of multiple sensors to measure spatial distribution of precipitation, and real-time availability. Overall, there are 43 FWS rain gauges in the City; data from the remaining gauges was used in wet-weather analyses of the SSS areas.

Historical data from the airport locations and more detailed data from the FWS were analyzed to produce a set of design events. That same information, coupled with stream flow and water quality data, was used to select a "typical year" that represents the precipitation which can cause CSOs. Additional details can be found in Chapter 5.

3.5 Permits

Table 3-7 summarizes major permit conditions for the two WWTPs that receive flows from the CSS. In addition to the noted conditions, both permits state that the Kansas City WSD must assure continued compliance with "Nine Minimum Controls" technology-based requirements.

Table 3-7 NPDES Permit / Missouri State Operating Permit Summary

Item	Permits	
Permit No.	MO-0024911	MO-0024929
WWTP Facility Name	Blue River	Westside
Receiving Stream	Missouri River	Missouri River
Effective Date	12/30/2005	5/28/2004
Revised Date	No revision date applies.	11/26/2008
Expiration Date	12/29/2010	5/27/2009
Additional No. of Outfalls listed	98 (001-099)	5 (002-006)
Design Flow (MGD)	105.0	22.5
Actual Flow (MGD)	81.0	10
Design Population Equivalent	850,000	225,000
BOD^5 Weekly	60	45
BOD^5 Monthly	40	30
TSS Weekly	60	45
TSS Monthly	40	30
NH3, Daily		monitor only
NH3, Monthly		monitor only

The permits are on the MDNR website at http://www.dnr.mo.gov/env/wpp/permits/wpcpermits-issued-k-m.htm#K

3.6 Public Drinking Water Intakes

There are no public drinking water intakes in any CSO receiving waters in the City. The City's drinking water intake on the Missouri River is upstream from both the Missouri River's confluence with the Kansas River and CSO locations. The nearest downstream drinking water intake is approximately 41 miles from the City at the City of Lexington, MO.

* * * * *

4 EXISTING SYSTEMS

4.1 Data Sources

The existing sewer collection system descriptions presented in this chapter are based on Overflow Control Program (OCP) database information. The basis for the OCP database information includes City of Kansas City, Missouri (the City, KCMO) Water Services Department (WSD) records, previous consultant studies, and field activities conducted during development of the Overflow Control Plan (the Plan). Early in the planning effort, Basin Engineers prepared reports and technical memoranda describing the various major tributary areas served by the City. Figure 4-1 shows the combined and separate sewer areas, the associated Basin Engineer, satellite communities, and unincorporated areas.

The system characterization presented below may vary from the descriptions reported in the Basin Engineer publications because understanding of the existing system has undergone continued refinement since those reports were published. Also, differences in reported descriptions may be due to the use of technical judgment while characterizing the system.

Current land use data were extracted from the OPC Data Management System. The WSD provided existing land use codes and categories. To facilitate comparison, land use categories were grouped into four general land use types, including:

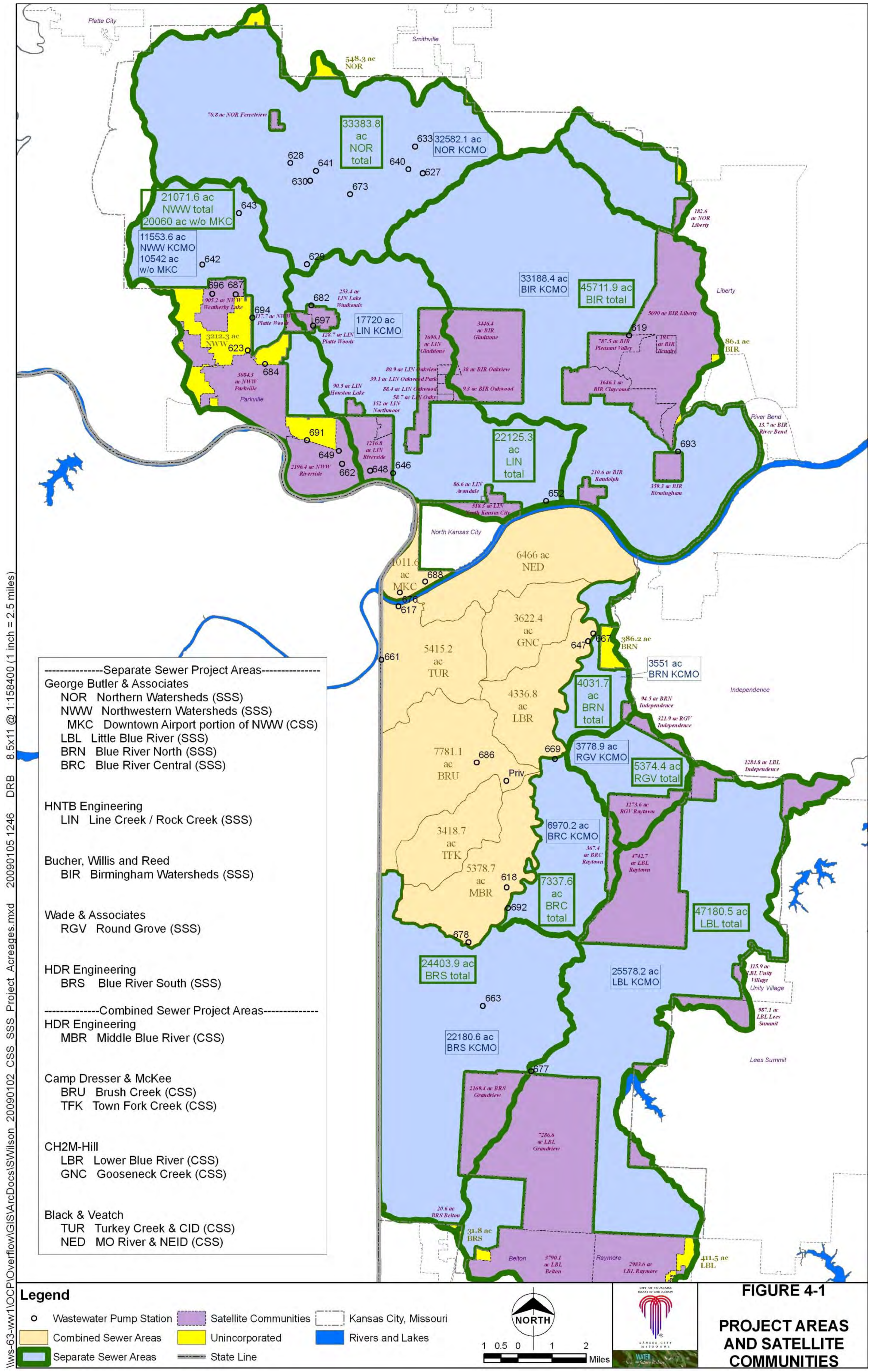
- Residential
- Commercial/Industrial
- Institutional/Transportation/Assembly
- Open

The residential land use category includes the following land use classifications:

- Single Family
- Mobile Home
- Townhouse
- Duplex
- Multifamily
- Condominium

The commercial/industrial land use category includes the following land use classifications:

- Hotel/Motel
- Commercial


--------------Separate Sewer Project Areas--------------
George Butler & Associates
NOR Northern Watersheds (SSS)
NWW Northwestern Watersheds (SSS)
MKC Downtown Airport portion of NWW (CSS)
LBL Little Blue River (SSS)
BRN Blue River North (SSS)
BRC Blue River Central (SSS)
HNTB Engineering
LIN Line Creek / Rock Creek (SSS)
Bucher, Willis and Reed
BIR Birmingham Watersheds (SSS)
Wade & Associates
RGV Round Grove (SSS)
HDR Engineering
BRS Blue River South (SSS)
-------------Combined Sewer Project Areas-------------
HDR Engineering
MBR Middle Blue River (CSS)
Camp Dresser & McKee
BRU Brush Creek (CSS)
TFK Town Fork Creek (CSS)
CH2M-Hill
LBR Lower Blue River (CSS)
GNC Gooseneck Creek (CSS)
Black & Veatch
TUR Turkey Creek & CID (CSS)
NED MO River & NEID (CSS)
Legend
Wastewater Pump Station
Satellite Communities
Kansas City, Missouri
Combined Sewer Areas
Unincorporated
Rivers and Lakes
Separate Sewer Areas
State Line
NORTH
1 0.5 0 1 2
Miles
FIGURE 4-1
PROJECT AREAS AND SATELLITE COMMUNITIES
33383.8 ac NOR total
32582.1 ac NOR KCMO
21071.6 ac NWW total 20060 ac w/o MKC
11553.6 ac NWW KCMO 10542 ac w/o MKC
17720 ac LIN KCMO
33188.4 ac BIR KCMO
45711.9 ac BIR total
22125.3 ac LIN total
6466 ac NED
1011.6 ac MKC
3622.4 ac GNC
5415.2 ac TUR
4336.8 ac LBR
7781.1 ac BRU
3418.7 ac TFK
5378.7 ac MBR
3551 ac BRN KCMO
4031.7 ac BRN total
3778.9 ac RGV KCMO
5374.4 ac RGV total
6970.2 ac BRC KCMO
7337.6 ac BRC total
47180.5 ac LBL total
25578.2 ac LBL KCMO
24403.9 ac BRS total
22180.6 ac BRS KCMO
548.3 ac NOR
86.1 ac BIR
386.2 ac BRN
31.8 ac BRS
411.5 ac LBL
3212.3 ac NWW
Platte City
Smithville
Liberty
Parkville
North Kansas City
Independence
Unity Village
Lees Summit
Belton
Raymore
River Bend
\\ws-63-ww1\OCP\Overflow\GIS\ArcDocs\SWilson 20090102 CSS SSS Project Acreages.mxd 20090105 1246 DRB 8.5x11 @ 1:158400 (1 inch = 2.5 miles)

- Office
- Heavy Industrial; Light Industrial/Storage/Distribution/Vehicle Sale/Service
- Solid Waste Management

The institutional/transportation/assembly land use category includes the following land use classifications:

- School/Outside Training Classrooms/Library
- Emergency Response
- Utilities
- Medical
- Cemetery
- Institutional
- Pedestrian Movement
- Garage
- Paved Parking/Other Paved Lots
- Driving
- Railroad
- Water-Based Movement
- Airport
- Spectator Sports
- Theater
- Convention and Exhibition
- Social or Cultural Assembly
- Church
- Museum
- Historical

The open land use category includes the areas with no designated land use as well as the areas with the following land use classifications:

- Park/Golf Course/Other Recreation
- Common Areas
- Agriculture/Horticultural
- Permanent open space/Vacant Residential and Non-Residential

Impervious area data was generally obtained from the OCP database. Individual Basin Engineers integrated these data sources to produce values representing current conditions. Impervious area percentages are used to determine, in part, the stormwater runoff that occurs during a rainfall event. Pervious areas also generate runoff, but usually in lower quantities since much of the rainfall that falls on pervious surfaces will infiltrate into the ground until the soil saturation limit is reached. Impervious areas include roads, rooftops, driveways, sidewalks, and other surfaces in the basins where stormwater does not infiltrate the ground surface.

4.2 Separate Sewer System Basins

4.2.1 Tributary to Blue River WWTP

The separate sewer system (SSS) tributary to the Blue River Wastewater Treatment Plant (WWTP) includes the Blue River basins, Blue River South basin, and portions of the Line Creek/Rock Creek basin. The Line Creek/Rock Creek basin is located north of the Missouri River, as shown in Figure 3-3. All other basins are located south of the Missouri River, as shown in Figure 3-4. All sanitary sewage generated is treated at the Blue River WWTP. The collection system in these basins also serves multiple satellite communities as shown in Table 3-3. Table 4-1 presents overall summary information for the basins tributary to the Blue River WWTP and Table 4-2 presents summary information for the individual sub-basins making up the Blue River Basins. The total service area includes the KCMO service area and, where applicable, the service area of unincorporated regions served by the system in the respective basins.

Table 4-1 Summary Information – SSS Areas Tributary to Blue River WWTP

Parameter	Blue River (1)	Blue River South	Line Creek/Rock Creek	Satellite Communities(2)	Total
Service Area – Acres					
Total	14,686	24,404	17,722	25,440	82,252
City of KCMO	14,300	22,181	17,722		54,203
Impervious Area - %					
2005 (Current)	21.1	21.3	23.9		22.1
Land Use – Current %					
Residential	24.5	31.0	39.7		32.1
Commercial/Industrial	9.3	8.5	4.5		7.4
Institutional/Transportation/Assembly	11.1	6.3	6.4		7.6
Open	55.1	54.2	49.4		52.9
Population					
2005 (Current)	25,109	57,456	58,048		140,613
SSS					
Total Footage	885,024	1,731,781	2,075,896		4,692,701
Pumping Stations					
Number	2	1	5		8
Total Capacity – MGD	63.32	0.28	70.32		133.92

(1) Includes Blue River Central, Blue River North, and Round Grove Creek – see Table 4.2 for details.

(2) See Table 3-3.

Additional detail concerning existing systems in each of the basins can be found in the following references:

- *Existing Conditions Technical Memorandum – Task 6 Blue River South Project Area;* April 2007. HDR.
- *Final Design Storm and Alternative Development Technical Memorandum – Line Creek/Rock Creek SSS Study;* May 2008. HNTB.
- *Round Grove Project Area Sanitary Sewer Evaluation Study;* June 2008. Wade & Associates.

Table 4-2 Summary Information for "Blue River" Data Provided in Table 4.1

Parameter	Blue River Central	Blue River North	Round Grove Creek	Satellite Community (1).	Total for "Blue River"
Service Area – Acres					
Total	6,970	3,937	3,779	2,057	16,743
City of KCMO	6,970	3,551	3,779		14,300
Impervious Area - %					
2005 (Current)	12.9	27.8	30.1		21.1
Land Use – Current %					
Residential	26.2	12.4	32.7		24.5
Commercial/Industrial	3.8	24.9	4.7		9.3
Institutional/ Transportation/Assembly	10.2	6.8	16.8		11.1
Open	59.8	55.9	45.7		55.1
Population					
2005 (Current)	11,278	4,282	9,549		25,109
SSS					
Total Footage	379,938	202,224	302,862		885,024
Pumping Stations					
Number	2	0	0		2
Total Capacity – MGD	63.32	0	0		63.32

(1) Includes Independence and Raytown

4.2.2 Little Blue River

The SSS tributary to the Little Blue River and the Little Blue Valley River Sewer District is shown in Figure 3-4 and the area, population, and sewer length are presented in Table 3-2. Lee's Summit is the only satellite community that contributes flow to the system, as shown in Table 3-3.

4.2.3 Tributary to Westside WWTP

The SSS tributary to the Westside WWTP includes the Northwestern Watersheds and a portion of the Line Creek basin. All basins are located north of the Missouri River, as shown in Figure 3-3. All sanitary sewage generated is treated at the Westside WWTP. The collection system also serves multiple satellite communities, as shown in Table 3-3. Table 4-3 presents overall summary information for the basins tributary to the Westside WWTP.

4.2.4 Tributary to Birmingham WWTP

The SSS tributary to the Birmingham WWTP includes the Birmingham/Shoal Creek Watershed, as shown in Figure 3-3. The collection system also serves portions of Gladstone, Claycomo, Pleasant Valley, Randolph, and Liberty, as shown in Table 3-3. Table 4-4 presents overall summary information for the basins tributary to the Birmingham WWTP.

Table 4-3 Summary Information – SSS Areas Tributary to Westside WWTP

Parameter	Northwestern Watersheds	Satellite Communities (1)	Total
Service Area – Acres			
Total	13,754	6,304	20,058
City of KCMO	10,542		10,542
Impervious Area - %			
2005 (Current)	16.4		16.4
Land Use – Current %			
Residential	16.7		16.7
Commercial/Industrial	2.2		2.2
Institutional/Transportation/Assembly	23.3		23.3
Open	57.7		57.7
Population			
2005 (Current)	15,366		15,366
SSS			
Total Footage	542,685		542,685
Pumping Stations			
Number	9		9
Total Capacity – MGD	26.38		26.38

(1) Includes Gladstone, Houston Lake, Lake Waukomis, Northmoor, Oakview, Oakwood Park, Platte Woods, Platte County RSD, Riverside, Parkville, and Weatherby Lake

Table 4-4 Summary Information – SSS Areas Tributary to Birmingham WWTP

Parameter	Birmingham/Shoal Creek	Satellite Communities (1)	Total
Service Area – Acres			
Total	33,276	12,619	45,895
City of KCMO	33,190		33,190
Impervious Area - %			
2005 (Current)	12.0		12.0
Land Use – Current %			
Residential	15.0		15.0
Commercial/Industrial	3.4		3.4
Institutional/ Transportation/Assembly	5.5		5.5
Open	76.1		76.1
Population			
2005 (Current)	39,235		39,235
SSS			
Total Footage	2,064,202		2,064,202
Pumping Stations			
Number	3		3
Total Capacity – MGD	35.22		35.22

(1) Includes Claycomo, Gladstone, Liberty, Pleasant Valley, and Randolph

4.2.5 Tributary to Various Northern WWTPs

The SSS tributary to the Fishing River, Rocky Branch, Todd Creek, and Northland Mobile Homes WWTPs is identified as the Northern Watersheds in Figure 3-3. The collection system also serves a portion of Smithville and Ferrelview, as shown in Table 3-3. Table 4-5 presents overall summary information for basins tributary to northern WWTPs.

Table 4-5 Summary Information – SSS Areas Tributary to Northern WWTPs

Parameter	Northern Watersheds	Satellite Communities (1)	Total
Service Area – Acres			
Total	33,130	169	33,299
City of KCMO	32,582		32,582
Impervious Area - %			
2005 (Current)	9.2		9.2
Land Use – Current %			
Residential	6.8		6.8
Commercial/Industrial	2.2		2.2
Institutional/ Transportation/Assembly	15.6		15.6
Open	75.4		75.4
Population			
2005 (Current)	15,900		15,900
SSS			
Total Footage	846,341		846,341
Pumping Stations			
Number	7		7
Total Capacity – MGD	8.24		8.24

(1) Includes Ferrelview and Smithville

4.3 Combined Sewer System Basins

4.3.1 Tributary to Blue River WWTP

The CSS tributary to the Blue River WWTP includes the Brush Creek, Gooseneck Creek, Lower Blue River, Middle Blue River, Northeast Industrial District, and Town Fork Creek basins. All basins are located south of the Missouri River, as shown in Figure 4-2 Table 4-6 presents overall summary information for the basins tributary to the Blue River WWTP.

Additional detail concerning existing systems in each of the basins can be found in the following references:

- *Field Reconnaissance Report, Gooseneck Creek and Lower Blue River Project Area;* CH2MHill; March 2006
- *System Characterization Technical Memorandum – Task 4.12; Gooseneck Creek and Lower Blue River Combined Sewer System;* CH2MHill; November 2006.

- *Estimate Existing Conditions and Technical Memorandum – Task A-7 Gooseneck Creek/Lower Blue River Project Area;* CH2MHIL; March 2008..
- *Field Reconnaissance Technical Memorandum – Task A-3, Middle Blue River Project Area;* HDR; April 2007.
- *Existing Conditions Technical Memorandum – Task A-7 Middle Blue River Project Area;* HDR; May 2007.
- *Estimate Existing Conditions Technical Memorandum – Task A-7 Missouri River Northeast Industrial District/Turkey Creek Project Area;* B&V; December 2007.
- *Final Estimate Existing Conditions Technical Memorandum – Brush/Town Fork Creek Project Area;* CDM; July 2007.

Table 4-6 Summary Information – CSS Areas Tributary to Blue River WWTP

Parameter	Brush Creek	Gooseneck Creek	Lower Blue R.	Middle Blue R.	NEID	Town Fork Creek	Total
Service Area – Acres							
Total	7,781	3,622	4,337	5,379	6,466	3,419	31,004
Impervious Area - %							
2005 (Current)	46.1	47.7	34.1	26.1	37.2	41.0	38.7
Land Use – Current %							
Residential	44.6	36.7	32.9	35.9	4.4	48.1	32.5
Commercial/Industrial	7.4	13.3	12.3	10.5	24.3	6.3	12.7
Institutional/Transportation/ Assembly	8.3	11.7	7.1	6.0	19.5	12.6	10.9
Open	39.7	38.3	47.7	47.6	51.8	33.0	43.9
Population							
2005 (Current)	66,267	28,615	23,865	21,338	12,828	23,919	176,832
Collection System							
Total Footage	1,459,869	692,042	592,254	746,345	427,835	579,424	4,497,769
Flow Splitters	7	9	9			23	48
Diversions	43	19	25	33	9	22	151
Outfalls	24	4	17	16	8	16	85
Pumping Stations							
Number	2	2	2	2	1	0	9
Total Capacity – MGD	0.2	298	4.76	93.22	0	0	396.18

4.3.2 Tributary to Westside WWTP

The CSS tributary to the Westside WWTP includes the Turkey Creek Basin and the Charles B. Wheeler (Downtown) Airport. The Turkey Creek Basin is located south of the Missouri River and the Downtown Airport is located north of the Missouri River, as shown in Figure 4-2. Table 4-7 presents overall summary information for the basins tributary to the Westside WWTP.

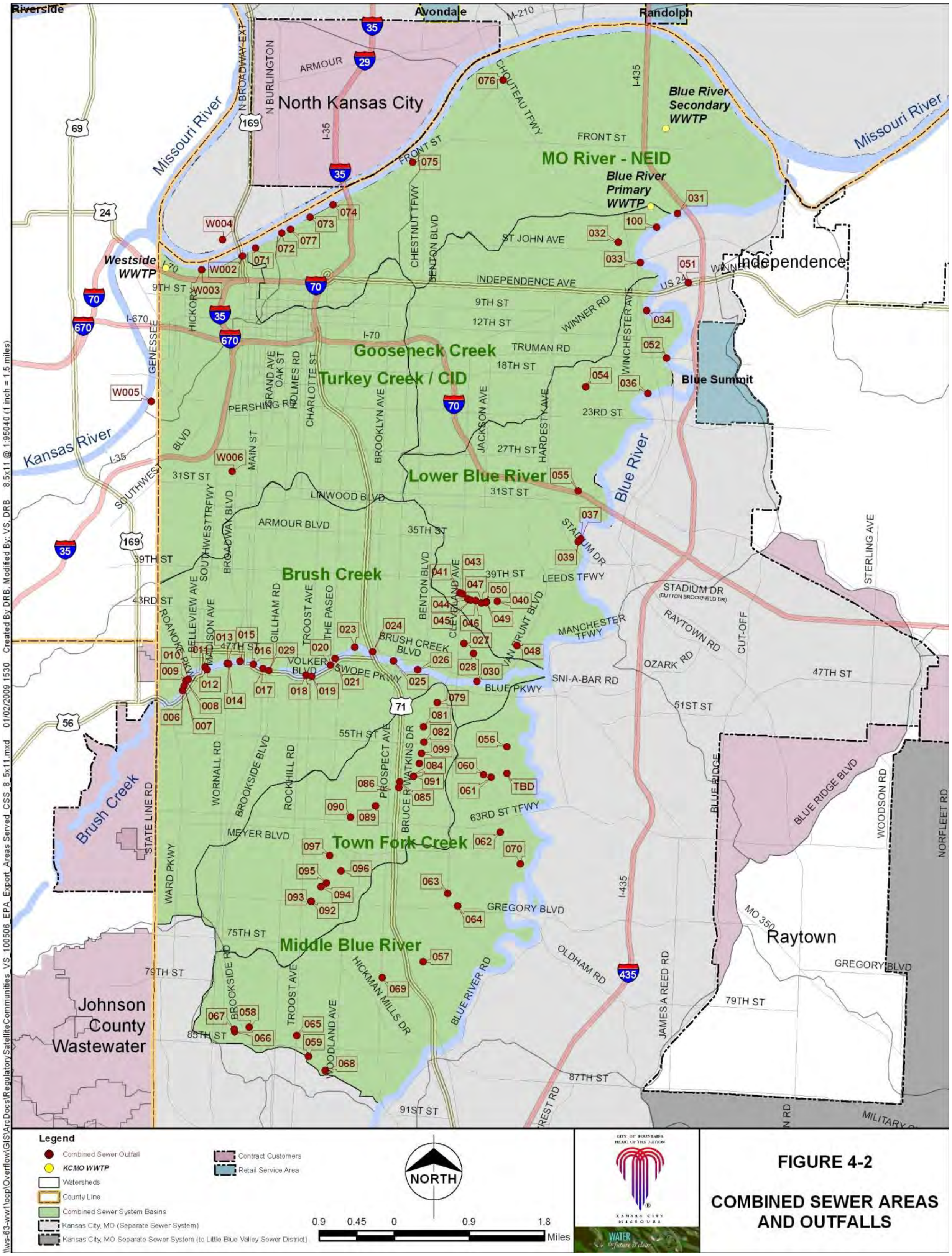


FIGURE 4-2

COMBINED SEWER AREAS AND OUTFALLS

Additional detail concerning existing systems in each of the basins can be found in the following references:

- *Estimate Existing Conditions Technical Memorandum – Task A-7 Missouri River Northeast Industrial District/Turkey Creek Project Area;* B&V; December 2007.

Table 4-7 Summary Information – CSS Areas Tributary to Westside WWTP

Parameter	Turkey Creek	Downtown Airport	Total
Service Area – Acres			
Total	5,415	1,012	6.427
Impervious Area - %			
2005 (Current)	55.7	30.9	51.8
Land Use – Current %			
Residential	15.9	0.7	13.5
Commercial/Industrial	18.4	2.7	15.9
Institutional/Transportation/Assembly	14.0	55.4	20.5
Open	51.7	41.1	50.1
Population			
2005 (Current)	25,836	115	25,951
Collection System			
Total Footage	997,746	95,673	1,093,419
Flow Splitters	12		12
Diversions	4	3	7
Outfalls	4	1	5
Pumping Stations			
Number	2	2	4
Total Capacity – MGD	16.96	3.28	20.24

4.4 Pumping Stations

The City's wastewater collection system includes 38 pump stations providing a total firm pumping capacity of approximately 620 million gallons per day (MGD). The largest station, located at the Blue River WWTP, has a total capacity of approximately 228 MGD, while the largest in-system station (87th Street) has a total capacity of approximately 90 MGD. Most of the other pump stations are relatively small, with 75 percent having a capacity less than 10 MGD (with one-third of those having a capacity less than 1 MGD). Figure 3-5 shows the location of each pump station in the system. Table 4-8 contains a summary of the key features of each station.

Table 4-8 Sanitary Sewer Pump Station Summary Information

Sanitary Sewage Pump Stations

Facility ID	Pumping Station Name	Basin and CSS or SSS	Installed Pumps and Rated Capacity (MGD)	Total Capacity (MGD)	Firm Capacity (MGD) [1]
617	Santa Fe	Turkey Creek/CID (CSS)	3 @ 14, 2 @ 2.88	5.76 [2]	2.88
618	Swope Industrial	Middle Blue River (CSS)	2 @ 1.61	3.22	1.61
619	North Church Estates	Birmingham (SSS)	2 @ .11	0.22	0.11
623	Pied Creek	Northwestern Watersheds (SSS)	2 @ 3.08, 1 @ 1.4	7.56	4.48
627	First Creek	Northern Watersheds (SSS)	2 @ .42	0.84	0.42
628	Second Creek	Northern Watersheds (SSS)	2 @ 0.75	1.50	0.75
629	Quail Run	Northern Watersheds (SSS)	2 @ 0.74	1.48	0.74
630	Tiffany Greens	Northern Watersheds (SSS)	2 @ .34	0.68	0.34
633	N Bristol	Northern Watersheds (SSS)	2 @ 1.05	2.10	1.05
640	S Bristol	Northern Watersheds (SSS)	2 @ 0.75	1.50	0.75
641	Tiffany Lake	Northern Watersheds (SSS)	2 @ 0.07	0.14	0.07
642	Wildwood West	Northwestern Watersheds (SSS)	2 @ 0.12	0.24	0.12
643	KCI	Northwestern Watersheds (SSS)	2 @ 0.35	0.70	0.35
646	Briarcliff West	Line Creek/Rock Creek (SSS)	2 @ 1.6	1.60	0.80
647	15th & Crystal	Lower Blue River (CSS)	2 @ 0.77	1.54	0.77
648	Line Creek	Line Creek/Rock Creek (SSS)	3 @ 11.6	34.86	23.20
649	Riverside Sewage	Northwestern Watersheds (SSS)	2 @ 0.84	1.68	0.84
652	Buckeye Creek	Line Creek/Rock Creek (SSS)	4 @ 7.00	21.00 [3]	14.00
661	Turkey Creek	Turkey Creek/CID (CSS)	4 @ 11.20	11.2 [4]	0.00
662	Riverside/Horizons	Northwestern Watersheds (SSS)	2 @ 2.91	5.82	2.91
663	Birchwood	Blue River South (SSS)	2 @ 0.14	0.28	0.14
667	12th St	Lower Blue River (CSS)	2 @ 1.61	3.22	1.61
669	Round Grove	Blue River Central (SSS)	2 @ 25.2, 3 @ 3.92	62.20	unknown [5]
673	Green Hills	Northern Watersheds (SSS)	2 @ 0.94	1.88	0.94
676	South Airport	Downtown Airport portion of NWW (CSS)	2 @ 1.16	2.32	1.16
677	Lawndale	Little Blue River (SSS)	2 @ 0.53	1.06	0.53
678	87th St	Middle Blue River (CSS)	4 @ 20, 4 @ 32.5	80 to 100	60 to 85 [6]
682	Lake Waukomis	Line Creek/Rock Creek (SSS)	3 @ 4.2	12.60	8.40
684	White Aloe	Northwestern Watersheds (SSS)	2 @ 1.46	2.92	1.46
686	Brush Creek & Prospect	Brush Creek (CSS)	2 @ 0.10	0.20	0.10
687	Upper Rush Creek	Northwestern Watersheds (SSS)	2 @ 3.01, 1 @ 1.47 [7]	6.00	3.00
688	Harlem	Downtown Airport portion of NWW (CSS)	2 @ 0.48	0.96	0.48
691	Burlington Creek	Northwestern Watersheds (SSS)	2 @ 1.33	2.66	1.33
692	83rd Street	Blue River Central (SSS)	2 @ 0.56	1.12	0.56
693	Birmingham	Birmingham (SSS)	2@31.1	35.00 [8]	17.50 [8]
694	Mace Road	Northwestern Watersheds (SSS)	2 @ 0.84	1.68	0.84
696	Weatherby Lake #2	Northwestern Watersheds (SSS)	2 @ 1.47	2.94	1.47
697	Platte Woods	Line Creek/Rock Creek (SSS)	2 @ 0.13	0.26	0.13

1. Capacity with largest pump out of service.
2. 14 MGD pumps are non-functional
3. One pump is non-functional
4. Three pumps non-functional.
5. Station serves two major influent lines with separate wet wells. 60" bypass is provided, but not used.
6. 4 - 32.5 MGD pumps currently not in use due to insuffcient capacity in BRIS. System curves indicate capacity is 85 MGD at low head.
7. Third pump is non-functional. Discharge line blocked.
8. Only 2 - 17.5 MGD pumps are operable

Future capital improvement projects addressing the necessary pump station improvements are included in the City's current 5-year CIP plan, as shown in Table 11-2.

4.5 Wastewater Treatment Plants (WWTPs)

Summary tributary area information and capsule process descriptions for the City's WWTPs have primarily been extracted from the "2007 Hydraulic Capacity Report" that was submitted to the Missouri Department of Natural Resources (MDNR). That report is included in the references in Appendix D. A detailed discussion related to plant performance and full-scale "stress tests" conducted on the plants that receive flow from the CSS is presented in Chapter 5.

4.5.1 Blue River WWTP

The Blue River WWTP provides secondary treatment for residential, commercial, and industrial wastewater before discharge to the Missouri River. The average daily design flows for the primary and secondary treatment facilities are 120 MGD and 105 MGD, respectively. Much of the wastewater received at the plant originates in the CSS areas located south of the Missouri River. The plant also receives flow from SSS areas both north and south of the River.

Influent flow is metered at the plant headworks using a Parshall flume. Preliminary treatment includes a rock box, bar screens, and swirl-concentrator type grit removal. Screenings from the mechanically-cleaned bar screens, rocks, and grit are hauled to a landfill for disposal. Four circular clarifiers provide primary treatment with primary sludge pumped to holding tanks prior to incineration. Secondary treatment is provided by high-rate trickling filters. Secondary sludge is treated in anaerobic digesters and land-applied.

The Blue River WWTP serves as a sludge processing center for most of the other City owned WWTPs. Primary sludge and secondary waste-activated sludge produced at the Birmingham and Westside plants are pumped via dedicated pipeline to the Blue River WWTP for processing. Biosolids from Rocky Branch, Fishing River, and Northland Mobile Home Park WWTPs are hauled by tanker trucks, on an intermittent basis, to sanitary sewers that are tributary to the Blue River WWTP.

4.5.2 Westside WWTP

The Westside WWTP is an activated sludge treatment plant with primary and secondary clarifiers. Light industrial, commercial, and residential wastewater flows are treated at this facility. The average daily design flow is 22.5 MGD. Biosolids generated at this plant are pumped to the Blue River WWTP for processing.

The plant serves part of the City's downtown area and the area immediately west of downtown along the state line. These areas are served by the CSS. The facility also serves parts of the area north of the

Missouri River, including the Downtown Airport, Harlem, and areas tributary to the Line Creek Pumping Station.

The Westside WWTP uses primary clarification, activated sludge, and final clarification to provide secondary treatment for influent wastewater.

4.5.3 Birmingham WWTP

Birmingham WWTP is an activated sludge treatment plant. Light industrial, commercial, and residential wastewater flows are treated at this facility. The average daily design flow is 20 MGD. The biosolids generated at the plant are pumped to the Blue River WWTP for processing.

The primary clarifiers and the drive mechanisms for one of the four clarifiers were recently replaced. The influent pump station was recently rehabilitated; new dry pit submersible pumps, new HVAC equipment, and new mechanically cleaned bar screens were installed. Treated effluent from the final clarifiers is discharged to the Missouri River.

4.5.4 Northern Watersheds (Fishing River, Rocky Branch, Todd Creek)

4.5.4.1 Fishing River WWTP

Fishing River WWTP provides secondary treatment for primarily domestic wastewater from portions of the Fishing River drainage basin within the City. This watershed includes the northeastern-most portion of the City.

The WWTP utilizes the extended aeration activated sludge process. It was rehabilitated in 2003 and returned to service with an average daily design flow of 1.0 MGD. Aeration diffusers, a manually-cleaned bar screen, an influent pump, and aeration blowers were installed. A two-cell lagoon is used for effluent polishing and equalization before discharging treated effluent to the Fishing River.

4.5.4.2 Rocky Branch WWTP

Rocky Branch WWTP receives domestic wastewater from Rocky Branch and First Creek Watersheds on the northern side of the City.

A new activated sludge treatment plant with an average daily design flow of 2 MGD was substantially completed in January 2006. The old treatment plant tankage was converted to an aerobic digester. Treated effluent is discharged to the Rocky Branch River.

4.5.4.3 Todd Creek WWTP

Todd Creek WWTP provides secondary treatment for a combination of domestic, commercial, and industrial wastewater from the northwest part of the City surrounding the Kansas City International (KCI)

Airport. The KCI Industrial Park WWTP was replaced with a pumping station at the end of 2004. Flows from that service area are now pumped to the Todd Creek WWTP.

The original Todd Creek WWTP was constructed in 1972-1973 and consisted of two Smith & Loveless package units, each containing contact aeration, center well clarification, and chlorine disinfection zone. The facility has been rehabilitated and expanded. It currently has an average daily design flow of 3.4 MGD.

Todd Creek WWTP is operated as an aeration-clarification wastewater treatment plant. Treated effluent from the final clarification process is discharged to Todd Creek. Biosolids are pumped to an on-site, three-cell lagoon and periodically land-applied.

4.5.4.4 Northland Mobile Home Park WWTP

The City operates a small domestic wastewater treatment plant that serves the Northland Mobile Home Park in the far upper reach of Wilkerson Creek Watershed. The average design flow is 0.09 MGD. The City plans to decommission this treatment plant and pump the wastewater to the Rocky Branch WWTP.

* * * * *

5 COLLECTION SYSTEMS AND TREATMENT FACILITIES CHARACTERIZATION

5.1 Introduction

The City of Kansas City, Missouri's (the City's) sewer system was characterized to assess the magnitude, frequency, duration, and quality of combined sewer overflows (CSO) and separate stormwater discharges to receiving waters in and around the City. Characterization was performed by:

- Monitoring and collecting rainfall data
- Collecting and compiling data on the collection systems to fill data gaps and check suspect information
- Monitoring flows in the Combined Sewer System (CSS) and the Separate Sewer System (SSS) to compile data on flow volumes, durations, and overflow rates, as applicable
- Sampling of CSOs and separate stormwater discharges
- Computer modeling of the CSS and SSS to evaluate wet-weather solution scenarios
- Evaluation of wastewater treatment plant (WWTP) wet-weather operational capacities

These activities are described below.

5.2 Rainfall Measurement and Characterization

5.2.1 Historical

Rainfall data have been collected by the City for a number of years to:

- Provide flood warnings
- Evaluate infiltration and inflow (I/I) in sanitary sewer system areas
- Prepare master plans for collection system improvements city-wide
- Conduct earlier wet weather control studies

Precipitation data are available for the City from two primary sources:

- Continuous, long-term data are available from the National Climatic Data Center (NCDC) for the Charles B. Wheeler Downtown Airport (Downtown Airport)
- The Kansas City International Airport (MCI)

Precipitation data were recorded at the Downtown Airport for the period November 1948 through October 1972, and at MCI during the period November 1972 through the present. The combined airport data sets, which are used as the basis for all historical rainfall analyses for the City, provide 56 continuous and complete years of hourly precipitation data, with a precision of 0.01 inch.

In addition to the historical airport rainfall data sets, recent real-time precipitation data are available for the Kansas City metropolitan area from the Flood Warning System (FWS). The FWS utilizes Automated Local Evaluation in Real Time (ALERT) technology to transmit environmental data to a central computer in real time. The ALERT system rainfall gauges report on a self-initiated basis, either timed or when an event is detected. An "event" for a rain gauge is defined as the tip of the rain gauge tipping bucket. Each tip indicates the measurement of one millimeter (0.03937 in.) of rainfall.

The FWS is jointly operated by Johnson County, Kansas and the City, is primarily intended to serve as an early flood warning system, and employs sensors throughout the Kansas City metropolitan area. The FWS consists of 132 sites that form a shared regional telemetry system using three single-frequency, store-and-forward radio repeaters. The system includes 441 defined sensors from 108 rain gauges, 83 water level sensors, 11 weather data stations, and 113 battery sensors.

Continuous precipitation data are presently recorded by 13 sensors located within proximity to the CSS area. Plans call for expanding the total rain sensors to 29 in 2009. These continuous data were then aggregated into discrete time intervals (e.g., 15 minutes) for various analyses. There are 43 rain gauges in the City's portion of the system; most of the rain gauges are co-located at stream level sensor sites. The City's Water Services Department (WSD) system includes three weather stations and 34 stage gauges. The location of the ALERT rain gauges in the Kansas City metropolitan area is presented in Figure 5-1.

5.2.2 Monitoring

FWS precipitation data for a limited number of sensor locations exist as far back as 1998. Consistent data acquisition for a majority of the sensors began in 1999 and 2000. The FWS precipitation data sets provide the following important advantages over the historical precipitation data set available from the airport gauges: close proximity to the CSS and SSS areas, the availability of multiple sensors to measure spatial distribution of precipitation, and real-time availability. The FWS sensors are designed to record rainfall in increments of 0.04-inch (1 mm), while the existing MCI gauge records can record rainfall in 0.01-inch increments. In the context of water quality data and modeling evaluations, the FWS data provided considerable value in terms of characterizing event precipitation and watershed response for recent years, and during the periods the WSD's Overflow Control Program (OCP) performed water quality and collection system flow monitoring (April through October, 2005).

5.2.2.1 Radar Rainfall

Rain gauges are fundamental tools for hydrologists and water resource engineers. They provide an estimate of rainfall at a point, which is then used to infer the amount of rainfall over the area surrounding

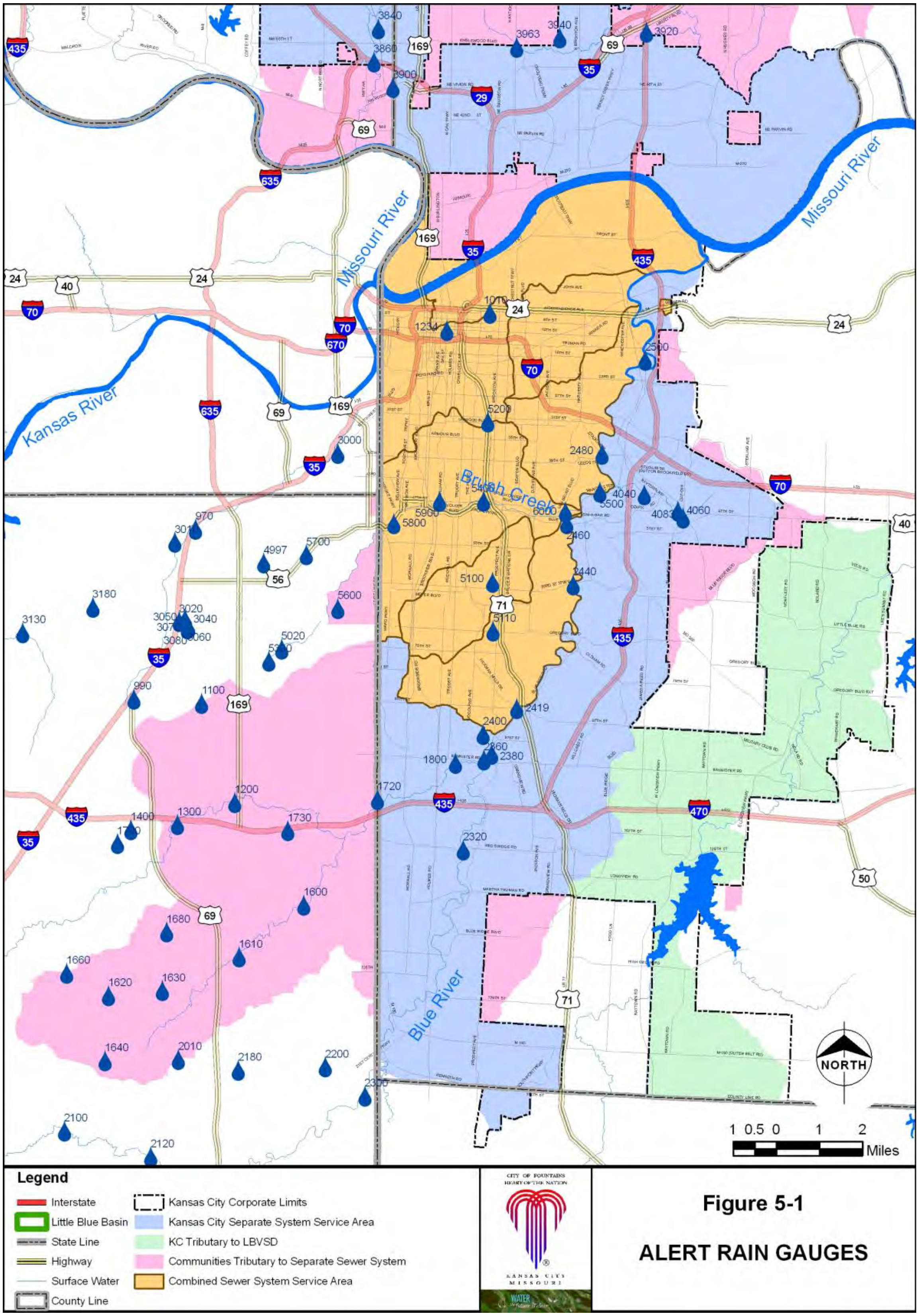


Figure 5-1

ALERT RAIN GAUGES

the gage. The success of this inference depends on how consistently rain gage observations actually represent rain falling in the area of interest.

Typically, a network of rain gauges is used to determine rainfall patterns over a watershed or other target area. The network provides a collection of point estimates, which are used to map the spatial distribution of rain. The spatial distribution of rainfall is often described by a series of contours of equal rainfall, known as isohyets, drawn through points interpolated from the rain gage observations. The shape of these contours is used to estimate the shape of the rainfall surface over a region. The rainfall contour analysis in total yields the most important datum for hydrologists: the total volume of water entering a watershed over a specified period of time. The accuracy of the estimate of total watershed input depends on how well rain gauges and the interpolation technique represent the actual rainfall topography.

The weakness in a rain gauge network's ability to define the actual rainfall surface is that rain gauges cannot provide any information about the rainfall distribution between gauges. A network of rain gauges can only resolve features of the rainfall surface larger than the characteristic distance between gauges in the network. Even then, the rainfall surface drawn from rain gauge observations is often distorted from the true rainfall distribution. Distortion of rainfall surface is especially important when analyzing the geometric properties of storms and or storm cells. Characteristic rainfall topologies are important in the development of design storms where storm size, storm shape, storm orientation, and depth-area relationships are important parameters. In addition, rain gauge network design is strongly dependent on the same storm geometries.

Radar-rainfall estimation offers hydrologists and engineers the opportunity to "see" between the gauges. With resolutions on rectilinear grids of 1-km x 1-km (1-km^2 or 0.39 mi^2), radar can resolve features on the rainfall surface in much greater detail. With radar, it is possible to more accurately estimate the actual rainfall topography. This leads directly to an improved estimate of the total watershed input, improved estimates of the timing and placement of input throughout the watershed, and a better picture of how local storm geometry impacts gauge network design.

5.2.2.2 Event Characteristics

An analysis of historical Downtown Airport and MCI precipitation data was conducted for the 1949-2004 period. Continuous hourly data with a precision of 0.01-inch were used to evaluate storm event depth, intensity, duration, and other characteristics within the historical period. In addition to the historical airport data set, available data for the FWS Paseo High School location (ALERT sensor #5400, centrally located in the CSS area near the Paseo Bridge at Brush Creek) were used to establish event characteristics within the CSS area.

In terms of identifying an event for use in precipitation data analysis and model calibration/application, a key consideration is the selection of an appropriate Inter-Event Time (IET). The IET refers to a minimum period of dry weather (i.e., characterized by no measurable rainfall) that delineates sequential storm events. Several possible IETs were used to delineate events for the historical and recent data sets, including 2, 4, 8, 12, and 24 hours. Both of the data sets used indicated consistency between the five IETs for events characterized by total depths of 0.50-inch to 0.75-inch. For total event precipitation depths greater than approximately 0.75-inch, the longer IETs tended to produce greater depths. This result was to be expected because longer IETs tend to aggregate measured precipitation into a lesser number of events with larger depths relative to shorter IETs. The average annual number of events for the various categories was consistent between the two data sets. For example, the average number of events exceeding 0.50-inch was 23 to 24 for the historical data set and was 22 for the Paseo High School data set. The similarities between the historical data set and recent FWS Paseo High School data event characteristics indicated that precipitation trends observed within the CSS during the 1999-2004 period were quite similar to long-term trends for this area. The difference in minimum recordable depth generally resulted in more observed events and higher total annual depths for the combined airport data set. However, these differences did not have a discernible impact on events that exceeded the targeted minimum capture rainfall of 0.50-inch. Events exceeding the minimum capture rainfall were expected to be the focus of the OCP and Basin Engineer modeling analyses. Overall, the comparisons for IETs of 2, 4, 8, 12, and 24 hours suggested that the selection of a particular IET would not significantly impact the range of events that needed to be evaluated by the OCP and the Basin Engineers (consulting firms tasked with the detailed analysis of individual basins).

In addition to precipitation event characteristics, sewer system analysis must consider the response time of the conveyance system in order to select an IET that allows the system to return to normal following a precipitation event. System modeling conducted by the OCP for the Blue River Interceptor Sewer (BRIS) has shown that it can take approximately six hours for flows to traverse from the Upper Blue River basin to the Blue River WWTP. This is in addition to time required for flows to travel from the individual basin sewers to the BRIS. Once the increased flow arrives at the Blue River WWTP, additional time is required for processing. These system characteristics suggested that an IET of 8 to 12 hours is appropriate to "reset" the City's CSS.

Considering the actual characteristics of the rainfall data sets and the response time of the City's CSS, a 12-hour IET was adopted for use in the rainfall analyses. It was also recommended that an IET of 12 hours be employed for any future City rainfall data analyses. In addition to the rainfall and system characteristics discussed above, information available from the Nashville, Tennessee Program effort was obtained. This additional data suggests that National Weather Bureau personnel agree that a 12-hour dry period is indicative of an atmospheric "turnover," implying that a new event begins with the next measurable rainfall. This information has not been analyzed in detail, but it provides further support for the use of a 12-hour IET.

Selection of the IET is discussed in detail in a technical memorandum titled *Design Storms for CSS Analyses*; OCP; May 2006.

5.2.2.3 Design Storms

The OCP modeling evaluation to support the development of the Overflow Control Plan (the Plan) consisted of two separate but complementary components: development and application of XP-SWMM models for the various CSS basins, interceptors, and joint use facilities; and development and application of hydrodynamic and water quality models for receiving waters, including Brush Creek and the Blue River. Due to the practical limitation on the number of simulations that could be performed with the CSS models, a set of design storms was developed to represent the range of events during a typical year.

The OCP used the hydrographs, generated by the Basin Engineers, for a set of design storm simulations to develop event hydrographs for each precipitation event within a typical year (or recreation season) for all CSS outfall locations. The design storms for use in the Plan and Basin Engineer modeling analyses were selected to meet the following objectives:

- Must permit a "knee-of-the-curve" analysis that can be used to evaluate relative benefits and costs for various modeling alternatives.
- Must be generally representative of actual events found within a typical year recreation season in order to maximize the accuracy of translation of model-predicted CSS discharge volumes for design storms into final CSS outfall hydrographs.

A set of 8 design rainfall events was developed to characterize City rainfall for a typical year. In a typical year, the City experiences 78 rainfall events. Of that total, 36 events have a depth equal to or exceeding 0.28 inch, 18 have a depth equal to or exceeding 0.52 inch, 12 have a depth equal to or exceeding 0.86 inch, 6 equal to or exceeding 1.40 inches, 4 have a depth equal to or exceeding 1.80 inches, 3 have a depth equal to or exceeding 2.00 inches, 2 have a depth equal to or exceeding 2.40 inches, and one rainfall event has a depth equal to or exceeding 2.90 inches. The response of the CSS to those design rainfall events was modeled, and the results were aggregated to estimate the overall volume of CSOs in a typical year. A total annual rainfall of 36.85 inches was reflected in that analysis, closely approximating the long-term average annual rainfall of 36.5 inches in the City.

The development of the design storms is presented in the technical memorandum, *Design Storms for CSS Analyses*; OCP; May 2006. A summary of the selected design storm events is presented in Table 5-1.

Table 5-1 Design Storms to Support Program Modeling Evaluations

Return Period[1]	Storm ID	Storm Depth (inches)	Peak Hourly Intensity (in/hr)	Storm Duration (hours)	Events Exceeding per Year[2]	Number of Events per Year[3]
0.33 month	A	0.28	0.16	6.00	36	18
0.67 month	B	0.52	0.25	8.75	18	6
1 month	C	0.86	0.38	12.25	12	6
2 months	D	1.40	0.60	16.75	6	2
3 months	E	1.80	0.73	19.75	4	1
4 months	F	2.00	0.82	21.00	3	1
6 months	G	2.40	0.95	23.75	2	1
12 months	H	2.90	1.2	26.75	1	1

[1] Based on total event depth and peak hourly intensity
[2] Total number of events per year with total depths and peak hourly intensities equal to, or exceeding, the specified design storm depth and intensity.
[3] Total number of events per year with the same, or very similar, depth/intensity/duration characteristics as the specified design storm.

5.2.2.4 Design (Typical) Year

Precipitation event characteristics were a primary consideration when selecting a design year and establishing an appropriate set of design storms for use in CSS modeling. Modeling analyses for the receiving waters represented in-stream hydraulic and water quality responses due to CSS discharges, separate stormwater discharges, and upstream watershed components. Therefore, it was important to also evaluate streamflow characteristics to determine that the design year for precipitation was not associated with an atypical year for streamflow in the receiving water bodies of interest.

Because large portions of the watersheds of the Blue River are located within the boundaries of the City, the streamflow response for these water bodies was expected to be strongly correlated to local precipitation observations.

The selection of a design year to support CSS and receiving water modeling analyses took into consideration the availability of precipitation and streamflow data sets to support modeling. Also considered were precipitation event characteristics for candidate years relative to long-term event characteristics (including full year and recreation season). In addition to these two primary considerations, annual stream flow statistics for the Blue, Missouri, and Kansas Rivers were checked for candidate years to determine that flows were reasonable with respect to average long-term, streamflow behavior.

The time period that could be considered for design-year selection was necessarily limited by the availability of precipitation and stream flow data that was required to support the CSS and receiving water models. Precipitation data were needed to simulate event-specific responses within the CSS basin models developed by the Basin Engineers, while streamflow data were needed to specify appropriate hydraulic boundary conditions for the receiving water models. The availability of key precipitation and stream flow data sets is summarized in Table 5-2.

The compilation in Table 5-2 indicates that USGS streamflow data sets for both Brush Creek locations and one Blue River location were limited to the 1999-2004 period. Local precipitation data collected via the FWS were also limited to this time period, although partial data sets for 1998 were available for a limited number of FWS sensor locations. In order to utilize the best available data to support the design-year modeling applications, it was necessary to select the design year from the six years comprising the 1999-2004 period. However, this was dependent on identification of one of those years as being characterized by appropriate precipitation event and streamflow characteristics relative to historical conditions.

As discussed previously, precipitation data were collected since December 1972 at the MCI, which is located approximately 18 miles north of the City's CSS area. This data set was valuable in terms of evaluating long-term trends in annual rainfall and event characteristics. However, there were several important advantages relative to the available data for the FWS sensors located within and around the City and the Kansas City metropolitan area as compared to the MCI airport data set, including:

- Providing significantly better representation of the depth, intensity, duration, and timing for local precipitation events
- Providing the ability to evaluate the spatial variability of each precipitation event across CSS and separate stormwater basins using multiple sensor data sets
- Providing consistency between simulated precipitation events and local streamflow response in Brush Creek, the Blue River, and other receiving water bodies

Table 5-2 Kansas City Metropolitan Area Precipitation & Streamflow Data Availability

Data set Type	Location/Description	Available Time Period[1]
Precipitation	MKC/MCI Airport	1949-2004
	Flood Warning System (Paseo High School, other CSS locations)	1999-2004
Streamflow (USGS)	Brush Creek (Ward Pkwy.)	1999-2004
	Brush Creek (Rockhill Rd.)	1999-2004
	Blue River (KCMO / 95th St.)	1940-2004
	Blue River (12th St., Stadium Dr.)	1999-2004

[1]Only years with a full 12 months of data are included in these ranges.

A review of the available FWS sensor locations and associated data indicated that the Paseo High School sensor (#5400) is centrally located within the CSS (Figure 5-1) and is also generally representative of the precipitation response at other FWS sensors located within or near the CSS area. For simplicity, the Paseo High School data set was used to support all design-year analyses. Precipitation data sets for six other FWS sensors within the CSS area were compared to the Paseo High School data set and general consistency in terms of event response across the CSS area was observed.

The design year was selected from the 1999-2004 time period because those six years provided superior coverage for precipitation and streamflow data in the Kansas City metropolitan area. These data for the years 1999-2004 were compared in terms of event characteristics related to total depth, duration, and peak intensity. Comparison of annual depths was not included because differences in the minimum capture depth for the historical and FWS precipitation measurement systems reduced the value of that metric of comparison. Selection of all event characteristics and related analyses were based on an IET of 12 hours.

Development of the design (or typical) year is described in greater detail in *Design Year for CSS Analyses;* OCP, September 2006.

5.3 Collection System

The City's sewer system is comprised of storm sewers, sanitary sewers, combined sewers, interceptor sewers, and private sewers. The CSS also includes structures that divert dry weather flow and some wet weather flow into interceptors to the treatment facilities, and it includes outfall lines and structures that discharge excess wet weather flow to receiving waters. A description of the existing data that was available for characterizing the CSS and SSS and preliminary analyses of the data follows.

5.3.1 Drawings / GIS Information / DMS

The primary data source was the WSD and its records, including previous and on-going studies and reports related to the study area. Representative sources that provided data on the existing collection system in the study area included the following:

- WSD sewer atlases (print and electronic versions) for sewer sizes and locations
- WSD Geographic Information System (GIS)
- WSD employees
- Operation and Maintenance Manual for Kansas City Missouri Combined Sewer Overflows
- Combined Sewer Overflow Inventory, Volumes 1 and 2
- Combined Sewer System Pipeline Inspections for Water Services Department Kansas City, Missouri
- Wastewater Master Plan Kansas City South of the Missouri River.

The City's GIS database generally contains information on diameter, length, material type, and ages for each sewer type (separate, storm, combined). The database lists diameters for 99 percent of the total listed sewers, with the remaining 1 percent listed as either zero or not given. A summary of the total sewer length by basin was presented previously in Table 3-1 for the CSS and Table 3-2 for the SSS.

To address issues with the varieties of data generated by the OCP that was to be accessed by multiple users, span multiple OCP phases, and integrated with the City departments, a Data Management Protocol, (DMP) and an associated Data Management System (DMS) were prepared. This data management initiative provides a foundation for data standardization and long-term availability, which will improve the OCP and WSD efficiency. This effort will also enhance the continued development of WSD's GIS and associated data systems.

The DMP provided documentation of data structures and processes used when collecting and transmitting OCP data among many contracted organizational entities. These requirements were necessary for standardization of large, yet similar datasets for OCP. The DMP identified the methods and software by which data will be created, modified, accessed and documented.

5.3.2 Field Verification

The primary intent of the field verification efforts was to collect data required to build a hydraulic model of the sewer collection system infrastructure located in the CSS and SSS basins. The field inspection efforts included the collection of data relating to diversion structures, flow splitters, and manholes. These data were used to develop the hydraulic model of the study area that has been used extensively during the ongoing project tasks to evaluate the performance of the existing system and to also identify and evaluate different improvement alternatives.

These field efforts began in April 2005 and were substantively completed in December 2005. Limited additional efforts extended into 2006. The field verification activities, initiated at different times, included several different phases of work including:

- Review of the historical data
- GPS surveying of the diversion structures, flow splitters, outfall structures, and manholes
- Inspection of diversion structures and flow splitters (confined-space-entry inspections)
- CCTV inspection and smoke testing of sewer lines to establish connectivity and identify I/I sources and pipe line defects

Field inspections involved activities representing considerable safety risks, including working on public right-of-ways and close to traffic, working in confined spaces, and other safety requirements and considerations. A Field Investigation Protocol was prepared by the OCP to provide safety guidelines and standardize procedures for public and OCP notification procedures, guidelines for inspections and data collection, data quality review standards, and requirements for data reporting format.

Historical sources provided much, but not all, of the information needed for a comprehensive hydraulic model. The model sources generally were complete for sewer assets of 30-inch and greater in diameter. Many structures on sewers between 24-inch and 30-inch diameters were missing, resulting in gaps in the model data. Other missing data included diversion structure dry-weather outlets to interceptor sewers and miscellaneous additional attribute information.

As part of Nine Minimum Controls (NMC) implementation by WSD, modifications, elimination, and re-configuration of diversion structures has taken place since the last field inspection of CSS structures in 1996. As a result, some of the historic data on diversion structures, flow splitters, and outfalls were incomplete, obsolete, or incorrect. Gaps and identified inconsistencies in the model data were reconciled through field inspections.

5.3.2.1 Manholes

Manholes for field inspection were identified based on modeling needs as follows:

- All identified diversion structures and flow splitters structures to be "internally (confined space entry) inspected."
- Those manholes required to complete connectivity of the sanitary interceptor sewer segments.
- Those manholes required to complete connectivity of the diversion structure dry weather outlet to sanitary interceptor sewer segments.
- Those manholes required to complete connectivity of the collection system upstream of diversion structures (non-interceptor) to resolve inconsistencies in hydraulic connectivity reflected in model.
- Those manholes required to resolve miscellaneous hydraulic inconsistencies with the model, such as negative drop, negative slope, excessive slope, and downstream pipe restriction.
- Those manholes on pipe assets that connect the dry weather outlets of the diversion structures to the main sanitary interceptor sewer system considered to be the most critical for inspection.

The manhole inspections included general surveying efforts, measurement of pipe diameters and invert depths, the completion of a standardized inspection form, and the generation of a digital photograph of the location and a digital photograph of the manhole interior. Most manhole inspections did not require a confined space entry and were conducted at the ground level. Incoming and outgoing pipes were identified by the direction of the sewage flow. Additional information was also obtained in order to complete the appropriate portions of standardized manhole inspection forms.

5.3.2.2 Outfalls, Diversion Structures and Flow Splitters

A diversion structure is a structure where the diversion of CSS flow to a receiving stream occurs during wet weather conditions. These structures contain at least one pipe conveying combined sanitary and stormwater flow into the structure and at least two pipes conveying flow out of the structure. One of the outlet pipes (dry weather outlet) conveys flow out of the structure to the interceptor for treatment at the Blue River WWTP or Westside WWTP; the other outlet pipe (wet weather overflow) conveys overflows from the structure to an outfall that discharges into a receiving stream. In addition to diversion structures, there are a large number of flow-splitter structures in the CSS basins. These are structures at which the CSS flows into the structure are divided into two pipes that then contribute flows to a diversion structure located downstream of the flow splitter. A schematic of a typical CSO, with the standard terminology, is presented in Figure 5-2.

An outfall structure is typically an end-of-pipe section that discharges wet weather overflow to the receiving stream. In the CSS, it was observed that there is not necessarily a one-to-one correspondence between diversion structures and outfalls. It was identified that in multiple locations the pipes were configured such that the wet weather overflow from diversion structures were combined to a single, larger pipe, which then connected to the outfall structure.

Sewer atlas sheets, plus inventory records from earlier studies, were used to construct a schematic layout of the diversion structures, major tributary combined sewer lines, and outfalls to receiving waters. This schematic was linked to sewer system GIS data files supplied by the City, and a to-scale schematic of the diversion structure system and major tributary lines from the GIS was produced. Major tributary lines missing from or incorrectly identified in the GIS were added during preparation of this analysis. Data sources used in constructing the to-scale schematic contained conflicting information that was resolved during Plan development so the schematic accurately represented the physical configuration of the CSS and SSS.

A map showing the location and corresponding City ID number of each combined sewer outfall within the CSS area is presented in Figure 5-3. The current itemized list of combined sewer outfalls is presented in Table 5-3. This table identifies the watershed, receiving stream, the three-digit identification number for each outfall as identified in the NPDES Permit / Missouri State Operating Permits, and the City's ID number.

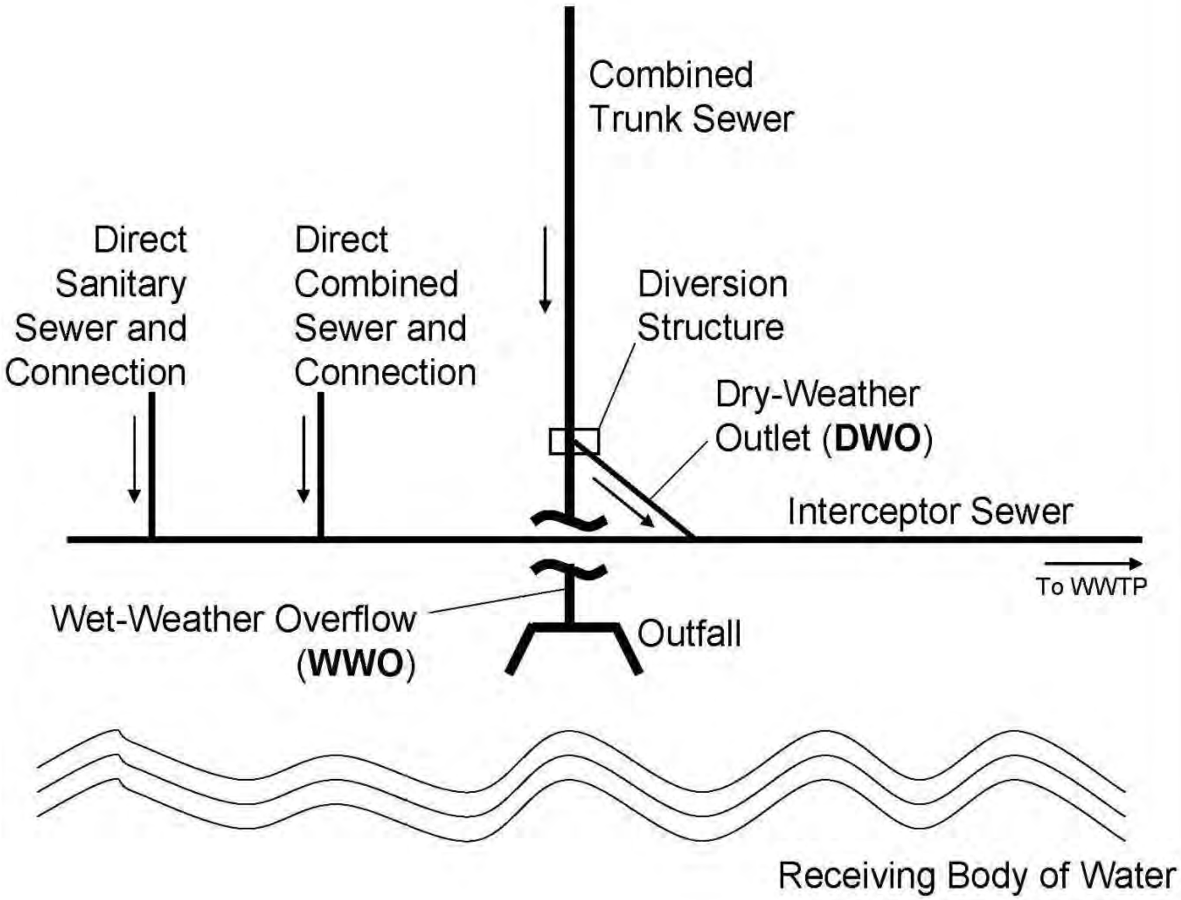


Figure 5-2
Standardized CSO Terminology

KCMO Overflow Control Program

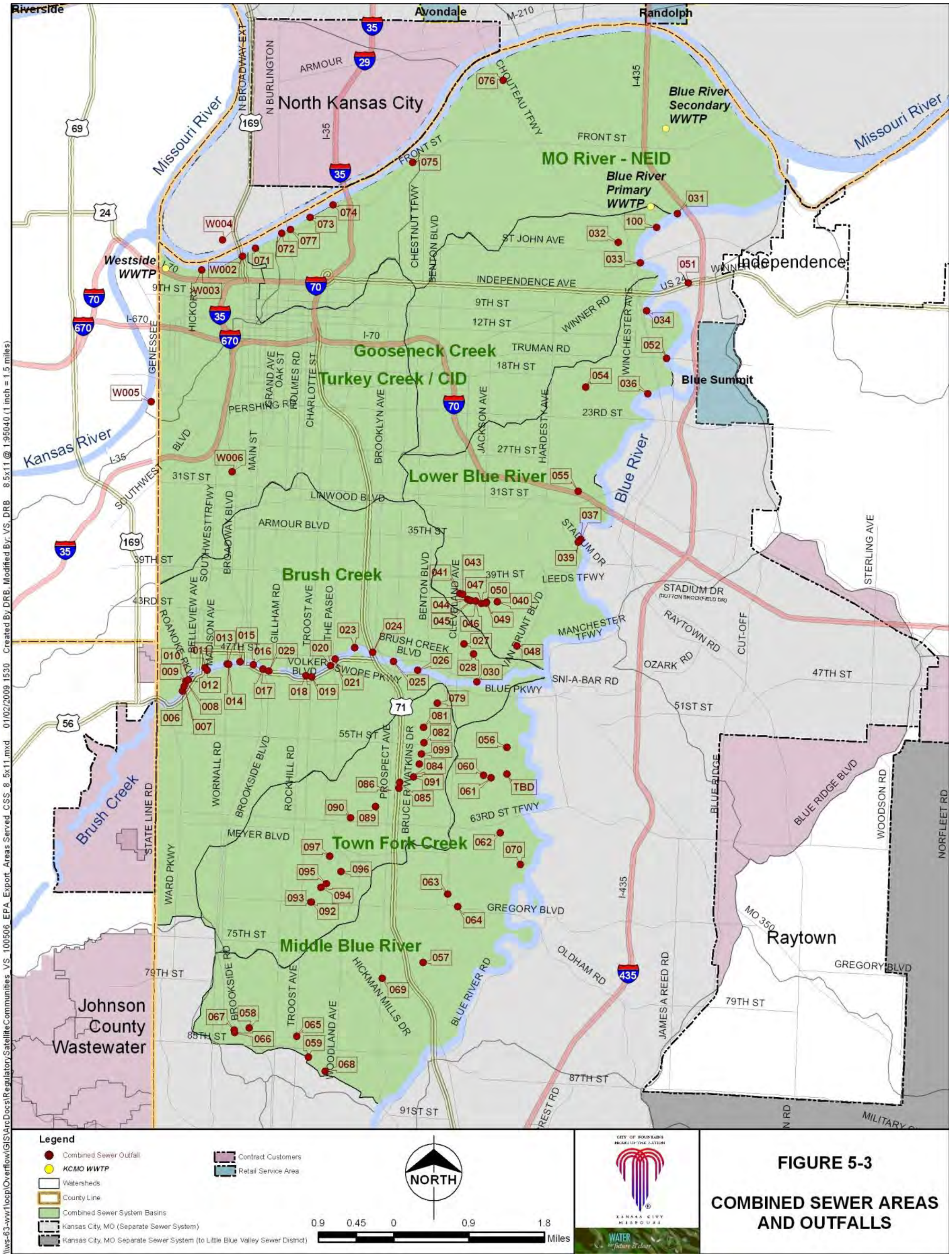


FIGURE 5-3

COMBINED SEWER AREAS AND OUTFALLS

Table 5-3 List of Active CSO Outfalls (Total = 90)			
Watershed	**Receiving Stream**	**MDNR ID Number**	**KCMO ID Number**
Missouri River	Missouri River	004	NEDFW317
Blue River	Blue River	031	LBLFB007
Blue River	Blue River	032	LBLFB008
Blue River	Blue River	033	LBLFB009
Blue River	Blue River	034	LBLFB010
Blue River	Blue River	036	LBLFB012
Blue River	Blue River	037	LBLFB013
Blue River	Blue River	039	LBLFB150
Blue River	Blue River	048	LBLFB170
Blue River	Blue River	051	LBLFB205
Blue River	Blue River	052	LBLFB206
Blue River	Blue River	054	LBLFB211
Blue River	Blue River	055	LBLFB214
Blue River	Blue River	056	MBLFB065
Blue River	Blue River	070	MBLFB300
Blue River	Blue River	100	LBLFB333
Blue River	Dyke Branch	058	MBLFB068
Blue River	Dyke Branch	059	MBLFB069
Blue River	Dyke Branch	065	MBLFB120
Blue River	Dyke Branch	066	MBLFB121
Blue River	Dyke Branch	067	MBLFB122
Blue River	Dyke Branch	068	MBLFB123
Blue River	Unnamed Tributary	040	LBLFB152
Blue River	Unnamed Tributary	041	LBLFB155
Blue River	Unnamed Tributary	043	LBLFB158
Blue River	Unnamed Tributary	044	LBLFB159
Blue River	Unnamed Tributary	045	LBLFB160
Blue River	Unnamed Tributary	046	LBLFB161
Blue River	Unnamed Tributary	047	LBLFB162
Blue River	Unnamed Tributary	049	LBLFB173
Blue River	Unnamed Tributary	050	LBLFB174
Blue River	Unnamed Tributary	057	MBLFB067
Blue River	Unnamed Tributary	060	MBLFB074
Blue River	Unnamed Tributary	061	MBLFB075
Blue River	Unnamed Tributary	062	MBLFB094
Blue River	Unnamed Tributary	063	MBLFB099
Blue River	Unnamed Tributary	064	MBLFB111
Blue River	Unnamed Tributary	069	MBLFB124
Blue River	Unnamed; Blue River	TBD	MBLFB336
Brush Creek	Brush Creek	006	BRUFB016
Brush Creek	Brush Creek	007	BRUFB017
Brush Creek	Brush Creek	008	BRUFB018
Brush Creek	Brush Creek	009	BRUFB019

Table 5-3 List of Active CSO Outfalls (Total = 90)			
Watershed	**Receiving Stream**	**MDNR ID Number**	**KCMO ID Number**
Brush Creek	Brush Creek	010	BRUFB020
Brush Creek	Brush Creek	011	BRUFB022
Brush Creek	Brush Creek	012	BRUFB024
Brush Creek	Brush Creek	013	BRUFB025
Brush Creek	Brush Creek	014	BRUFB026
Brush Creek	Brush Creek	015	BRUFB027
Brush Creek	Brush Creek	016	BRUFB028
Brush Creek	Brush Creek	017	BRUFB031
Brush Creek	Brush Creek	018	BRUFB032
Brush Creek	Brush Creek	019	BRUFB033
Brush Creek	Brush Creek	020	BRUFB037
Brush Creek	Brush Creek	021	BRUFB038
Brush Creek	Brush Creek	023	BRUFB041
Brush Creek	Brush Creek	024	BRUFB042
Brush Creek	Brush Creek	025	BRUFB043
Brush Creek	Brush Creek	026	BRUFB045
Brush Creek	Brush Creek	027	BRUFB166
Brush Creek	Brush Creek	028	BRUFB169
Brush Creek	Brush Creek	029	BRUFB199
Brush Creek	Brush Creek	030	BRUFB314
Brush Creek	Town Fork Creek	079	TFKFB046
Brush Creek	Town Fork Creek	081	TFKFB048
Brush Creek	Town Fork Creek	082	TFKFB049
Brush Creek	Town Fork Creek	083	TFKFB051
Brush Creek	Town Fork Creek	085	TFKFB056
Brush Creek	Town Fork Creek	089	TFKFB061
Brush Creek	Town Fork Creek	091	TFKFB072
Brush Creek	Town Fork Creek	099	TFKFB187
Brush Creek	Town Fork Creek	080	TFKFB057
Brush Creek	Town Fork Creek	090	TFKFB062
Brush Creek	Town Fork Creek	094	TFKFB115
Brush Creek	Unnamed Tributary	092	TFKFB113
Brush Creek	Unnamed Tributary	093	TFKFB114
Brush Creek	Unnamed Tributary	095	TFKFB116
Brush Creek	Unnamed Tributary	096	TFKFB117
Brush Creek	Unnamed Tributary	097	TFKFB118
Kansas River	Kansas River	005	TURFW005
Kansas River	Penn Valley Lake	006	TURFW006
Missouri River	Missouri River	002	NEDFW002
Missouri River	Missouri River	003	NEDFW003
NEID	Missouri River	071	NEDFB001
NEID	Missouri River	072	NEDFB002
NEID	Missouri River	073	NEDFB003

Table 5-3 List of Active CSO Outfalls (Total = 90)			
Watershed	**Receiving Stream**	**MDNR ID Number**	**KCMO ID Number**
NEID	Missouri River	074	NEDFB004
NEID	Missouri River	075	NEDFB005
NEID	Missouri River	076	NEDFB006
NEID	Missouri River	077	NEDFB130

5.3.2.3 Interceptors

Interceptors are the large diameter pipes that carry flows from the sewers to the WWTPs. The City's combined sewer interceptor network has three main branches: the Blue River Interceptor, the NEID run, and the Turkey Creek interceptor run. The first two interceptor branches flow into the Blue River WWTP and Turkey Creek interceptor flows to the Westside WWTP. The Blue River Interceptor has four further branches: Town Fork Creek Interceptor, South Brush Creek Interceptor, North Brush Creek Interceptor, and Gooseneck Creek Interceptor. It also receives flows from two SSS basins, Blue River South via 87th Street Pump Station Force Main and Round Grove Basin via the Round Grove Force Main.

The combined system network contains 45 miles of interceptor sewers, ranging from 24-inch diameter pipes to 20-foot wide arch sewers, 90 CSO outfall points, and 58 square miles of tributary area. The separated sewer system maintains 155 miles of interceptors, ranging from 24-inch to 10-foot diameter.

5.4 Flow Monitoring

The temporary flow monitoring program for the development of the Plan began in the spring of 2005. The principle goals of the temporary flow metering program were to meter flow at key locations in the CSS and SSS to determine average dry-weather base flows and to determine collection system responses to a range of wet weather events.

5.4.1 Collection System and Wastewater Flow

WSD identified seven CSS drainage areas or basins and nine SSS basins to facilitate the development of the Plan. Four SSS basins were designated as priority project areas. These areas require immediate action to correct known bypasses and/or to confirm sizing of major facilities. The five remaining SSS basins are areas without known bypasses or pending major facilities. Flow metering was performed for the CSS basins, the priority SSS basins, and three of the remaining SSS basins. Rainfall data for evaluations were obtained from NEXRAD radar rainfall monitoring and the Kansas City ALERT flood warning system, a network of 43 gauges spaced throughout the City (see Section 5.2).

5.4.2 Site Selection

During March 2005, an initial list of sites for temporary flow meter installations was developed by each Basin Engineer. The initial sites were selected to isolate flows from sub-catchments within each basin, and each basin itself. The following factors were also considered in selection of the meter locations: collection system layout, including the location of diversion structures, treatment plants, pump stations, and outfalls; connection points of basin trunk sewers to main interceptors; ease of access; and acceptable hydraulic conditions, i.e. mild slopes and straight pipe runs. After initial site selection, field inspections were performed by the flow metering contractor under contract to WSD to confirm the suitability of the initial site, or to locate appropriate alternative sites.

The inspection process and the selection of final flow meter sites occurred from March 2005 to June 2005. Unanticipated field conditions resulted in unexpected difficulties confirming acceptable sites. In several cases, field conditions encountered necessitated the search for and selection of alternative flow metering sites and the placement of additional flow meters.

It was originally planned to meter flow for four months simultaneously in all 14 basins. However, because of the difficulties encountered during the inspection and installation phases of work, the flow meters were installed and made operational on a staggered basis. In addition, selected flow meters were kept in service for longer than four months to compensate for periods of poor operation. At the height of the flow metering effort, 170 flow meters were in place as follows: 4 at WWTPs, 62 in the SSS area, and 104 in the CSS area.

The sewers that were flow metered ranged from 15 inches in diameter to a 17 ft x 19 ft double box sewer; and a variety of flow metering equipment was used to provide valid results for intermittent, highly-variable flow conditions. Flow meters were programmed to collect level and velocity data every 15 minutes. The flow meters were serviced once a week, during which data were downloaded and routine maintenance was performed.

Flow meter locations are summarized in Table 5-4. Figures showing flow meter locations for the various CSS and SSS basins and "bubble" diagrams provided in Field Reconnaissance technical memoranda, prepared by the Basin Engineers, compiled in Appendix B and Appendix C. These bubble diagrams show the schematic relationship of the flow meters and major hydraulic features within the monitored CSS and SSS basins.

Table 5-4 Summary of Flow Meter Sites

Basin	Basin Engineer	Basin Type	Number of Meter Sites	Basin Initiation Date	Basin Completion Date
Turkey Creek	Black & Veatch	CSS	11	6/11/2005	10/13/2005
NEID/MO River	Black & Veatch	CSS	11	6/25/2005	10/24/2005
Town Fork Creek	Camp, Dresser & McKee	CSS	12	5/11/2005	9/28/2005
Brush Creek	Camp, Dresser & McKee	CSS	18	5/12/2005	9/28/2005
Gooseneck Creek	CH2M Hill	CSS	19	6/9/2005	10/17/2005
Lower Blue River	CH2M Hill	CSS	11	7/2/2005	10/26/2005
Middle Blue River	HDR	CSS	22	6/24/2005	10/25/2005
Birmingham	Bucher, Willis & Ratliff	SSS	11	6/26/2005	11/15/2005
Blue River Central	George Butler Associates	SSS	6	5/13/2005	10/24/2005
Blue River North	George Butler Associates	SSS	3	5/25/2005	9/28/2005
Little Blue River	George Butler Associates	SSS	4	6/9/2005	10/11/2005
Blue River South	HDR	SSS	13	6/15/2005	11/15/2005
Line Creek/Rock Creek	HNTB	SSS	11	5/20/2005	9/28/2005
Round Grove	Wade & Associates	SSS	14	5/29/2005	10/24/2005
Westside WWTP	OCP	Wastewater Plant	1	6/3/2005	10/31/2005
Blue River WWTP	OCP	Wastewater Plant	3	6/3/2005	10/31/2005

5.4.3 Data Review and Analysis

Flow metering results were generally good; and there were sufficient periods of dry weather and rain events of a good variety during the flow metering period to allow for characterization of the CSS and SSS, and for calibration and verification of collection system computer models. The Basin Engineers independently calculated and reviewed RDII and ADWF reported by the flow-metering contractor, and OCP staff visually examined the level, velocity, and resultant flow graphs for each site to assess wet weather response.

5.4.4 Performance Information

The flow-metering contractor provided a final flow-meter data submittal in which the following metrics were calculated and summarized for each flow metering site: average daily dry-weather flow on a daily and hourly basis for weekdays and weekends, maximum dry-weather flow, average dry-weather flow scatterplots, wet weather scatterplots, rainfall derived infiltration and inflow (RDII) for SSS metering sites, and calculated CSO overflow rates and volumes.

5.5 Hydraulic Modeling

5.5.1 Modeling Platform

WSD, based on their experience and that of the consulting engineering community, selected XPSWMM as the standard modeling platform. To address compatibility issues, all modeling was performed using XPSWMM, Version 9.5. All pipes that were 24 inches in diameter or larger were modeled for the eleven basins for which detailed analyses were performed. In addition, in the seven CSS basins, all diversion structures and any pipes exiting in those structures were modeled. Flow splitters were modeled, if necessary, to describe system hydraulics and /or if encountered along pipe reaches with dimensions that required modeling. A portion of one SSS basin (Round Grove) was modeled using a routine specifically designed for extraneous flow quantification. For the Blue River South basin, the Basin Engineer used XPSWMM for modeling some smaller pipes in an effort to isolate capacity problems that may be causing basement flooding.

5.5.2 Configuration (Input Data)

Data from stormwater models developed previously as part of WSD Stormwater Program efforts or data from applicable Wastewater Master Plans were utilized in the basin models. Task efforts involved in configuring the models included collection of data from existing sources, such as WSD GIS records, WSD sewer atlas, sewer record books (plan and profile information), and historical diversion structure inspection reports. Field survey and inspection of the sewer systems were performed to fill in data gaps from existing data sources and to confirm the accuracy of existing data sources. After system characteristics data were collected, the model hydraulic networks were constructed by identifying catchments, establishing nodes and links, identifying load points (locations where flow is introduced into the hydraulic model), and establishing diversion structures and flow splitters, as applicable. Quality assurance/quality control (QA/QC) procedures used in the construction of the models typically included checking of pipe dimension changes from larger upstream dimensions to smaller downstream dimensions, profile breaks, negative slopes, unusual changes in pipe slopes, non-matching crown connections, and unusually flat slopes.

5.5.3 Connectivity

OCP conducted monthly Modeling Work Group meetings with the lead modelers from all Basin Engineers. At these meetings, information was exchanged, procedures reviewed/standardized, flow metering data reviewed, and special assignments (such as developing the approach for modeling given diversion structure types) addressed.

As of February 2006, for the CSS and SSS basins where modeling was required, the hydraulic models were complete and connectivity had been demonstrated. Connectivity for the hydraulic models was demonstrated by having the Basin Engineers run the models allowing OCP to observe the dynamic responses of inputs to load points in both a plan-view format and profile format. This provided OCP with XPSWMM tabular outputs from Table E21 (Continuity Balance) and Table E22 (Numerical Efficiency).

The XPSWMM output Table E21 indicated the total volume of flow input to the model at load points during a simulation and the total volume of flow discharged from the model at its downstream locations during a simulation. Ideally, the input and discharge volumes should be the same, and the model calculates a percent error for the simulation based on a comparison of the input and output volumes. The XPSWMM output Table E22 provides an output that indicates a judgment regarding the efficiency and stability of the model.

Errors in continuity (Table E21) ranged from -0.057 percent to 3.12 percent; the ratings for continuity error indicated in Table E22 ranged from “good” to “great” and the efficiency of the models was indicated as “excellent.” The Basin Engineers prepared memoranda to document model connectivity and these memoranda are presented in Appendices B and C.

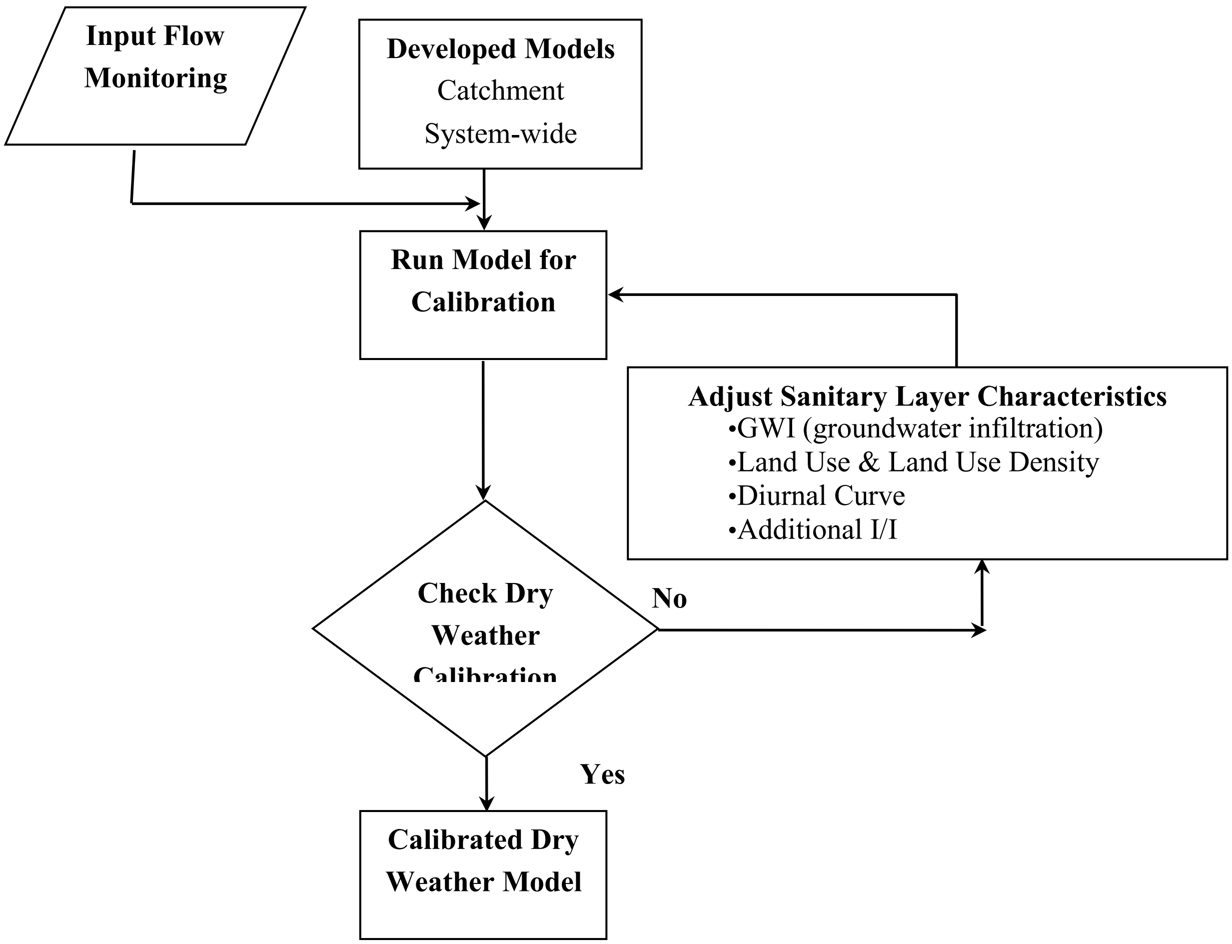
5.5.4 Calibration

5.5.4.1 Dry Weather Calibration

Model simulations were performed by the Basin Engineers and the model outputs were compared to measured dry weather flows. A weighted absolute error was calculated for the simulated period. If comparisons between simulated flows and measured flows were within +/- 20 percent for flow variations and total volume quantities, then the model was considered calibrated. Otherwise, the inputs and characteristics in the model were adjusted. This iterative process continued until acceptable model performance was achieved. The accuracy of peak dry weather flow (base wastewater flow plus additional I/I) rates was visually determined by observing the diurnal curve.

The Basin Engineers developed average dry weather flow curves for weekday and weekend flows, which in general did not differ significantly. The process that was followed for dry-weather model calibration is shown in Figure 5-4a.

Figure 5-4a: Dry Weather Catchment Model Calibration Process



5.5.4.2 Wet Weather Calibration

The process that was followed for wet weather calibration is shown in Figure 5-4b.

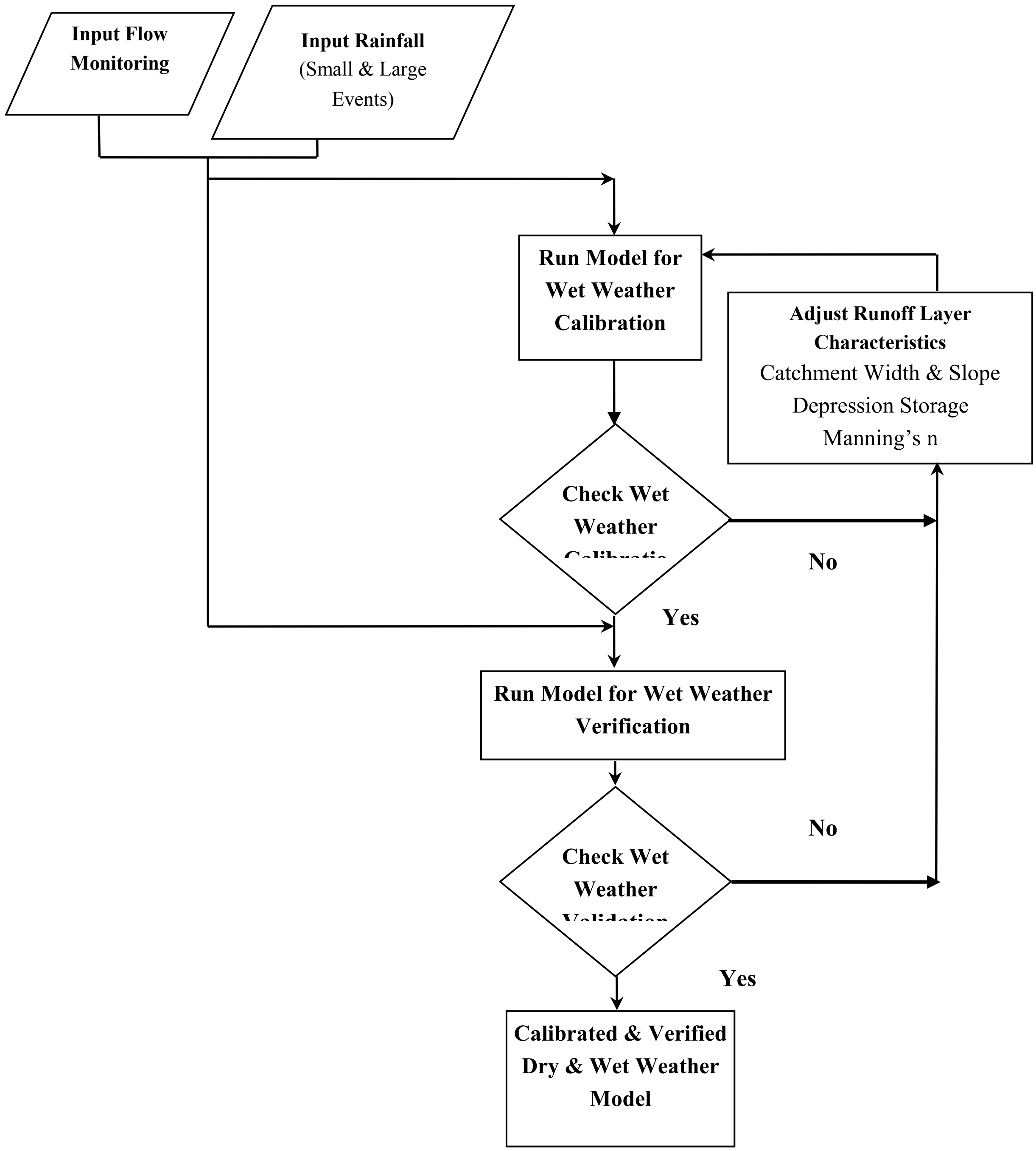
The following Hydraulics and Runoff Layer parameters were defined as part of the wet weather calibration process:

- Percent Imperviousness
- Catchment Runoff Width
- Catchment Runoff Slope
- Infiltration Coefficients
- Impervious and Pervious Depression Storage
- Catchment Overland Flow Roughness
- Collection System Manning's "n"

Based on work group meeting discussions, the general approach suggested by OCP to the Basin Engineers was to use 12 hours as a standard inter-event time for rainfall events. The following "types" of rainfall events were suggested by OCP for use in calibration: 0.5 inches, 1 to 1.25 inches, and 2 inches. However, the Basin Engineers were to evaluate rainfall in their areas to use events that best suited their specific conditions and available data in their respective basins. In addition, the Basin Engineers used their professional judgment as to whether to use radar rainfall, ALERT rain gauge data, or a combination of both data sources for calibration input parameters, given the variations sometimes observed between radar rain pixels and nearby ALERT gauges.

Model simulations were performed by the Basin Engineers and the model outputs were compared to measured wet weather flows for the selected storm events. A weighted absolute error was calculated for the simulated storm events. If comparisons between simulated flows and measured flows were within +/- 20 percent for volume and peak flow over the range of events simulated, then the model was considered calibrated. Otherwise, the inputs and characteristics in the model were adjusted. This iterative process continued until acceptable model performance was achieved. All calibration results were evaluated on a case by case basis and specific conditions were documented in detail by the Basin Engineers. The Basin Engineers prepared memoranda documenting model calibration and these memoranda are presented in Appendices B and C.

Figure 5-4b: Wet Weather Catchment Model Calibration Process



5.5.5 Verification

Once the models were calibrated to wet weather conditions, additional simulations were performed with different storm data assumed during the flow metering period to verify the models. The same criteria used for the acceptance of calibration were used to evaluate verification simulations.

As a quality control measure, simulation accuracy for the SSS basins was further checked by comparing the runoff portion of the simulation against the monitored runoff flow volumes. The runoff portion of the monitored wet weather flow was estimated by subtracting average base wastewater flow and additional I/I from the total volume for the simulation period. Using this approach, inaccuracies in simulating runoff would not be masked by accurately simulated dry-weather flows that make up the majority of the overall flow.

5.5.6 Consolidated Blue River Interceptor Sewer Model

The BRIS serves five of the seven CSS basins, and all of that part of the SSS in the Blue River basin lying south of the Missouri River. The consolidated BRIS model included the Blue River interceptor and the contributing basins, and simulated conveyance of flow to the Blue River WWTP. The analysis included in the consolidated BRIS model covered the system from Swope Park, near 67th Street, extending 8.5 miles north to the Blue River WWTP. The BRIS is a significant conduit, transporting over 80 percent of the flows received at the City's largest WWTP.

The BRIS and the contributing basins were a complex system to model, calibrate, and verify. Factors contributing to this complexity consisted of:

- Linking models from contributing sub-basins prepared by the Basin Engineers and simulating performance of the 6 overflow locations on the BRISs
- Manual operation of 3 diversion gates at the WWTP which impact upstream hydraulic profiles
- Performance characteristics of the 6 diversion chambers along the interceptor
- Potential for backflow through low-lying diversions structures within Gooseneck Creek and Lower Blue basins

Based on modeling results, it was determined that wet weather hydraulic grade lines (HGL) in the BRIS were very similar for all design storms. This was due to the self-limiting performance of the tributary area/interceptor. The 138 diversion structures in the five contributory CSS basins limit the flow quantities that can be delivered from these basins to the BRIS.

The consolidated BRIS model was used by the OCP to perform modeling simulations of city-wide and area-wide wet weather improvement scenarios to evaluate wet weather reduction efficiencies.

5.6 Collection System Water Quality

Water quality field testing was conducted in 2005 at representative receiving water locations in the City, under both dry weather and CSO conditions. From this effort, a water quality modeling framework was developed to simulate existing conditions, preliminary CSS "level of control" alternatives, and hypothetical reductions to upstream pollutant loadings where applicable in City receiving waters, and performance of final alternatives.

The primary water quality modeling objectives for City receiving waters included the following:

- Develop an understanding of water quality response over various space and time scales under existing conditions.
- Develop an understanding of pollutant sources in the watershed and their impacts on existing water quality conditions.
- Evaluate improvements to water quality under various control alternatives scenarios, which included simulating potential sewer system improvements.
- Support the review and revision of existing water quality standards.

These objectives applied to the Blue River, Brush Creek (including Town Fork Creek), Penn Valley Lake, the Missouri River, and the Kansas River. Water quality modeling tools were developed and calibrated using receiving water quality monitoring data collected by OCP, the United States Geological Survey (USGS), and the City's WSD.

See Chapter 6 for a detailed discussion of the water quality modeling efforts and receiving waters characterization.

5.6.1 Combined Sewer Overflows (CSOs)

Key findings from the water quality model application included:

- Upstream loadings of bacteria and oxygen-demanding pollutants were significant in all City water bodies.
- CSS loadings were most significant in Brush Creek.
- CSS controls that reduce the annual overflows to fewer than 12, on average, could be expected to provide negligible improvement in water quality, primarily considering *E. coli* concentrations.
- Compliance with water quality standards for *E. coli*, where applicable in the Blue River and the Missouri River, could not be attained through CSO control alone. Reductions in other watershed loadings would be needed to attain current standards.
- Compliance with the current water quality standards of Whole Body Contact Class A for the stretch of the Blue River from 95th Street to 59th Street could not be reasonably attained even with substantial reductions in upstream loadings and high levels of CSS control.

5.6.2 Storm Sewer Discharges

The following general observations were made related to the flow balance (CSS flow vs. separate stormwater runoff):

- Greater than 80 percent of the total flow volume in Blue River was derived from watershed sources upstream of the City's CSS area.
- The City's CSS discharges contributed 6 percent or less of the total flow volume to each water body, except Brush Creek (24 percent).
- Upstream flow sources were very dominant in the Missouri and Kansas Rivers, with a 0.1 percent or less contribution from the City's CSS discharges
- Stormwater discharges contributed a large majority (94 percent) of the total inflow volume to Penn Valley Lake.

The following general observations could be made related to the *E. coli* load balance:

- For the Blue River, approximately half of the load originated from upstream sources, with less than 40 percent from CSS discharges.
- For Brush Creek, over 75 percent of the loading originated from CSS discharges (including CSS discharges entering via Town Fork Creek).
- For the Missouri and Kansas Rivers, upstream sources accounted for more than 94 percent of the total loading.
- All Kansas City metropolitan CSS discharges (including Turkey Creek and all outfalls in Brush Creek, Blue River, and Penn Valley Lake) contributed just 2.5 percent of the total load to the Missouri River.
- For Penn Valley Lake, CSS and separate stormwater discharges contributed approximately equal loads.

5.7 Wastewater Treatment Plants

The City owns and operates seven WWTPs. The City's wastewater collection system also includes 38 pump stations and an additional 17 flood pumping stations provide stormwater drainage service to the City. Significant WWTP flow characteristics of these plants are presented in Table 5-5. Of particular importance to planning for CSS overflow control are the Blue River and Westside WWTPs, which are the only two that receive CSS flows.

The Blue River WWTP receives sanitary and wet weather flow, predominantly from the areas south of the Missouri River, plus a small amount of flow that is pumped across from north of Missouri River through the Buckeye Pump Station. Flows from five CSS Basins and the Blue River South, Round Grove, and Blue River Central SSS basins, are conveyed by the BRIS to the WWTP. Flows from the

NEID CSS basin and pumped flow from Buckeye Pump Station are conveyed by the NEID interceptor to the WWTP via the NEID Pump Station. Flow from the Blue River North SSS basins east of the Blue River is conveyed to the NEID Pump Station by Accessory Sewer No. 1 interceptor. Flows from the Turkey Creek and CID CSS areas are conveyed to the Westside WWTP, which also receives flow from the Line Creek SSS Pump Station.

The OCP completed capacity assessments of the Blue River and Westside WWTP for treating both wet and dry weather flows. Field stress tests were also completed to evaluate the performance of the process systems to maximize capacity utilization. Collectively, these studies included detailed reviews of plant information, design criteria, and operational data relevant to the planning issues. Activities included review of previous engineering studies and facility plans; analysis of existing data to characterize long-term, seasonal, in-plant recycle and wet weather loadings; preparation of simplified process flow sheets; review of upcoming non-CSO related capital improvements; and identification of plant site areas that could accommodate new CSO abatement facilities. Baseline conditions at the Blue River and Westside WWTPs are described below. A summary of the National Pollution Discharge Elimination System (NPDES) permit limits for each of the City's WWTPs is presented in Table 5-6.

Table 5-5 Kansas City Metropolitan Area WWTP Flow Characteristics

Plant	Permitted Capacity (MGD)	Average Flow – Calendar Year 2007 (MGD)	5-Year Average Flow, 2003-2007 (MGD)	Process
Blue River	105.00	78.1	71.8	Trickling Filter
Westside	22.50	14.1	14.1	Activated Sludge
Birmingham	20.00	13.0	11.6	Activated Sludge
Todd Creek	3.40	1.60	1.16	Extended Aeration
Rocky Branch	2.00	1.63	1.04	Extended Aeration
Fishing River	1.00	0.70	0.67	Extended Aeration
Northland Mobile Home Park	0.09	0.06	0.05	Activated Sludge Package Plant
KCMO Totals (MGD)	153.99	109.19	100.42	

5.7.1 Blue River WWTP

The Blue River WWTP includes the primary plant, built in 1964 and 1965, and the secondary plant, built in 1987. The original design capacities of the primary plant were 85 million gallons per day (MGD) for design average flow and 170 MGD for peak flow. The original design capacities of the secondary plant were 70 MGD for design average flow and 105 MGD for peak flow. The WWTP outfall discharges to the Missouri River.

Table 5-6 NPDES Permit / Missouri State Operating Permit Summary for Kansas City Metropolitan Area

Item	Permits						
Permit No.	MO-0049531	MO-0024911	MO-0048313	MO-0025011	MO-0048305	MO-0024961	MO-0024929
WWTP Facility Name	Birmingham	Blue River	Fishing River	Northland Mobile Home Park	Rocky Branch	Todd Creek	Westside
Receiving Stream	Missouri River	Missouri River	Fishing River	Wilkerson Creek, Platte River Basin	Rock Branch Creek	Todd Creek, Platte River Basin	Missouri River
Effective Date	1/26/2007	12/30/2005	12/16/2005	7/1/2005	10/13/2006	12/23/2005	5/28/2004
Revised Date	6/29/2007	(1)	4/21/2006	(1)	(1) (2)	4/21/2006	(1)
Expiration Date	1/25/2012	12/29/2010	12/15/2010	6/30/2010	10/12/2011	12/22/2010	5/27/2009
Additional No. of Outfalls listed	1	98(001-099)	0	0	1	0	5 (001-006)
Design Flow (MGD)	20.0	105.0	1	0.09	2.0	3.4	22.5
Actual Flow (MGD)	12.4	81.0	0.71	0.06	0.9	1.4	14
Design Population Equivalent	100,000	850,000	10,000	900	20,000	27,000	225,000
BOD^5 Weekly	45	60	45	45	20	10	45
BOD^5 Monthly	30	40	30	30	10	10	30
TSS Weekly	45	60	45	45	25	30	45
TSS Monthly	30	40	30	30	15	20	30
NH_3, Daily May-Oct. Nov.-April						3.7 7.5	
NH_3, Monthly May-Oct. Nov.-April						1.9 3.7	
(1) No revision date yet applies to these permits. (2) Rocky Branch will have new permit issued upon substantial completion of improvements.							

5.7.1.1 Description

The primary plant is located on Hawthorne Road immediately north of the Blue River and west of Interstate I-435. Plant facilities include a rock box and Parshall flume on the Blue River interceptor influent line, separate NEID and Blue River screen houses and pumping stations, a grit building that contains aerated grit chambers and vortex type grit removal units, and four primary clarifiers. The primary plant solids treatment facilities serve the WWTP as well as the sludge pumped from the Westside WWTP and the Birmingham WWTP. Solids handling facilities include a solids processing building (which includes the incinerators and belt filter presses), sludge holding tanks, sludge thickener basins, and anaerobic digesters. The administration building for the WWTP is located at the primary plant. A 72-inch diameter pipeline delivers primary effluent to the secondary plant.

The secondary plant facilities are located east of Interstate 435 north of Front Street. The secondary plant includes a secondary pumping station and four sets of trickling filter towers and secondary clarifiers. The pumping station includes four sets of pumps, each of which delivers flow to one of the sets of trickling filter towers and secondary clarifiers. One pump in each set of pumps can be used, if desired, to recycle trickling filter effluent back to the tricking filter. Secondary plant effluent is collected in an effluent header and conveyed to the Missouri River through a 96-inch effluent pipeline. An effluent pumping station located on the pipeline is used when the river level is too high to permit gravity flow into the river.

Stormwater collected within the plant is also received at the effluent pumping station and shares the Missouri River outfall with the treated wastewater. A pump within the effluent pumping station is dedicated to stormwater pumping during high river levels.

Secondary sludge from the final settling basins is pumped through two 10-inch force mains to sludge thickeners located at the primary plant site. Floating solids (scum) from the final clarifiers are also collected and pumped with the secondary sludge to the primary plant site.

5.7.1.2 Primary Plant Process Capacity

The capacity of the existing grit removal system limits the primary plant flows to a rated capacity of 168 MGD. However, HGL analyses determined that peak hourly flows up to 230 MGD are feasible with the existing facilities by overloading the aerated grit chambers. The effect of overloading the grit facilities is that excessive grit may be carried over to the primary basins, causing wear on the clarifier, holding tank, and digester equipment, and adding grit in the incinerators.

With all four clarifiers in service, treatment capacities total 90.8 MGD for design average flow and 182 MGD for peak hourly flow, based on Missouri Department of Natural Resources (MDNR) and Ten States Standards criteria. The effect of overloading the clarifiers up to the 230 MGD hydraulic capacity is that excessive solid and organic loads may be passed to the secondary plant, increasing loads on the trickling filters and increasing the possibility of effluent limit violations.

Since the treatment capacity is less than the hydraulic capacity, the existing primary plant capacity should be rated at 182 MGD, with the limitation that for flows over 168 MGD, excessive grit will carry over to the primary clarifiers. Flows in excess of the 182 MGD primary clarifier system may pass excessive solid and organic loads to the secondary plant.

The Maximum Month Average Daily Flow (MMAD) of 202 MGD (including recycle flows) exceeds the estimated treatment capacity of 182 MGD. The MMAD flows are experienced during periods of wet weather and these excess flows are bypassed at the headworks of the plant.

A complete summary of the capacity study is presented in the *Blue River WWTP Capacity Study*; OCP; March 2006. A 5-year summary of the Blue River WWTP operational performance is presented in Table 5-7.

Table 5-7 Blue River WWTP Operational Performance – 5-year Summary

1	Facility Name	Blue River WWTP Outfall #001					
2	Mo NPDES Permit #	MO - 0024911					
3	Reporting Period	2003	2004	2005	2006	2007	Avg
4	Design Population Equivalent	850,000					
5	Ave Daily Design Flow (MGD)	105					
6	Max Peak Flow (MGD)	204.9	141.5	124.9	138	147.8	-
7	Ave Actual Daily Flow (MGD)	70.9	72.6	74	63.7	78.1	71.8
8a	Ave Inf BOD (MG/L)	202	176	193	230	140	187
8b	Ave Inf TSS (MG/L)	195	228	337	374	208	268
8c	Ave Inf Ammonia (MG/L)	18	16	14	16	13	15
9a	Ave Eff BOD (MG/L)	44	35	20	23	17	28
9b	Ave Eff TSS (MG/L)	39	32	21	25	19	25
9c	Ave Eff Ammonia (MG/L)	16	13	12	17	14	14
10a	Removal Efficiency for BOD (%)	78	77	89	90	88	85
10b	Removal Efficiency for TSS (%)	79	83	94	93	91	90
10c	Removal Efficiency for Ammonia	14	18	17	-4	-6	8
11	Annual Rainfall	35	49	49	37	35	-
Source: WSD 2007, Hydraulic Capacity Report, Water Services Dept. KCMO, March 2008							

5.7.1.3 Secondary Plant Process Capacity

The existing secondary pumping facilities firm capacity of 140 MGD and corresponding secondary clarifier capacity of 140 MGD limit the secondary plant peak hourly flows to less than the calculated 149 MGD hydraulic capacity. Therefore, the existing secondary plant peak hourly capacity is 140 MGD with all four treatment trains in service.

Trickling filter evaluations indicated that the filters can adequately treat daily flows up to 84 MGD without recirculation of secondary clarifier solids, or 152 MGD if recirculation is practiced. The treatment capacities were calculated based on 170 MG/L primary effluent BOD. The filter capacities are sufficient to treat the AADF of 80 MGD without recirculation and the MMAD of 120 MGD by practicing recirculation.

5.7.1.4 Flow Transfer Capacity from Primary to Secondary Plants

Calculations in the hydraulic modeling indicated that 149 MGD is the limiting capacity in the pipeline between the primary and secondary plant, based on the design Hazen-Williams friction coefficient of 100 with no blending at the secondary plant. This coefficient is commonly used for WWTP evaluations. The flow capacity is directly related to the actual friction coefficient, which could be determined by field testing. The model calculated a possible flow capacity of 165 MGD, including 11 MGD blending flow if the assumed friction coefficient is improved to 120. Depending on the results of field testing, the actual pipeline capacity and the blending amount could be greater or lesser than calculated by the model.

5.7.1.5 Capacity Evaluation Summary

Desktop HGL analyses determined hydraulic capacities for the primary plant of 230 MGD and secondary plant of 140 MGD, using all four clarifiers at each plant. Modeling also determined the capacity to convey flow between the primary and secondary plants to be 149 MGD using a conservative friction coefficient for flow in the conduit connecting the plants. Unless bypassing or blending is practiced at the Primary WWTP, the 140 MGD secondary plant capacity sets the maximum allowable influent flow rate to the WWTP (excluding plant recycle flows).

The effective peak hourly treatment capacity of the primary plant is 182 MGD, based on the allowable primary clarifier surface overflow rate. Operation at higher rates may result in poor solids removal performance. Field testing would be required to determine actual performance. The effective peak hourly treatment capacity of the secondary plant is 140 MGD, based on the combination of secondary pumping, trickling filter, and clarifier criteria. There is no information to indicate that the secondary plant can be operated satisfactorily at higher rates.

A summary of the Blue River plant's baseline design and loading criteria based on the hydraulic capacity analysis is presented in Table 5-8.

Table 5-8 Blue River WWTP – Baseline Design and Loading Criteria

Treatment Process/Units	Unit Description	Capacity
Preliminary Treatment		
Rock Box	Open bottom channels with constructed fillet that allows debris to slide out to clean out wells on the sides. Typically removes grit and debris larger than 1mm at a specific gravity of 2.65	
Mechanical Bar Screens		
- NEID	3-coarse screens of 6-inch openings 3- mechanical fine screens of 1-inch openings	
- Blue River Interceptor	6 –coarse screens of 6-inch openings 4-operating mechanical fine screens of 1-inch openings	62 MGD for each channels, total four channels provide 248 MGD
Raw Sewage Pumps		
-NEID	3 – 24 MGD vertical non-clog centrifugal pumps	72 MGD (Design) 48 MGD (Firm Peak)
- Blue River	7 – 33.5 MGD pumps	234 MGD (Design) 201 MGD (Firm Peak)
Aerated Grit Chambers	Four vortex grit chambers, each with 30 MGD capacity 2 – 120' L x 24' W x 18' D Tanks with pre-aeration and grit removal for emergencies; 4 - 120' L x 24' W x 18' D tanks with older equipments needing upgrade; 24 MGD x 4 = 96 MGD with reduced removal efficiency.	120 MGD for vortex chambers 48 MGD total for 2-tanks
Primary Treatment		
Primary Clarifiers	4 – 170' dia. 8'6" D	
-Total Surface Area	90,800 SF	
- Average Flows	At 1,000 gpd / SF overflow rate	90.8 MGD
	At 1,500 gpd / SF overflow rate	136 MGD
-Peak Hourly Flow	At 2,000 gpd / SF overflow rate	181.6 MGD
Primary Sludge Pumps		
Secondary Treatment		
Secondary Treatment Pump Station	4 sets of 3 pumps total 12- Vertical, non-clog centrifugal at 17.5 MGD each	52.5 MGD (Design) for each set 35 MGD (Firm Peak) 140 MGD (Design) for the station 105 MGD (Firm Peak) for station 210 MGD Theoretical for station
Trickling Filters	4 – 150' dia. X 24' D with Plastic media filters	
- Total Surface Area	70,680 SF	
- Total Media Surface Area	50,899,600 SF	
- Avg. Hyd. Loading Rate	0.83 gpm / SF (4 towers in use)	82 MGD
- Peak Hyd. Loading Rate	1.38 gpm / SF (3 towers in use)	105 MGD
Secondary Clarifiers	4 – 160' dia. x 15' D	
-Total Surface Area	80,425 SF	
- Average Flows	750 gpd/SF	60 MGD
-Peak Hourly Flow	1,500 gpd/SF	120 MGD
- Effluent limits	Performance based	140 MGD
Effluent Pump Station	Normal flow by gravity, 96-inch outfall line	
	5 – 36 MGD effluent pumps 1- 36 MGD storm pump	180 MGD (Design) 144 MGD (Firm Peak)

5.7.1.6 Stress Tests

Stress testing was conducted at the Blue River WWTP in 2006 to determine the whole plant capacity for peak flow conditions. The test was conducted in phases, with Phases 1-4 testing the capacity of the basic unit processes, i.e., Grit System, Primary Clarifier, Trickling Filter without recirculation, and Trickling Filter with recirculation, and Phase 5 testing the whole plant capacity. From the test results, theoretical treatment process capacities were developed, as follows:

- Grit System – 236 MGD
- Primary Clarifiers – 160 MGD
- Trickling Filters (w/o recirc.) – 156 MGD
- Trickling Filters (w/o recirc.) – 140 MGD
- Secondary Clarifiers – 160 MGD

A complete summary of the stress test is presented in the *Blue River WWTP Stress Testing Report*; OCP; *September 2008.*

It is anticipated that the primary treatment capacity can be increased to a level approaching the hydraulic maximum of 230 MGD through modernization and repair of the existing facilities and operational modifications, including solids handling. WSD's Capital Improvement Program, as described in Chapter 11, includes the necessary funding for plant modernization and repair. The selected Plan (described in Chapter 12) contemplates an eventual capacity of approximately 220 MGD. If, after completion of plant modernization, the primary treatment capacity cannot be increased to 220 MGD, the capacity of the wet weather facilities described in Chapter 12 may need to be increased.

5.7.2 Westside WWTP

The Westside WWTP is located near the confluence of the Missouri and Kansas Rivers. Flows from two CSS and one SSS basins are treated at this plant. Flow from Line Creek Pump Station, which serves as the collection point for the Line Creek SSS basin, is pumped across the Missouri River to the WWTP. The CID and Turkey Creek CSS basin flows are pumped to the plant through the Santa Fe Pump Station and Turkey Creek Pump Station respectively. Two small pump stations, including the Downtown Airport Pump Station (only dry weather flows are pumped for treatment) and the Harlem Pump Station, discharge separate sanitary sewage to the Line Creek Force Main. These three force mains deliver the majority of the flow to the Westside WWTP.

Average daily flow to the Westside WWTP is approximately 14 to 17 million MGD. Current operating practice during wet weather is to limit flow to the Westside WWTP to the plant design flow of 22.5 MGD, as stated in the Missouri State Operating Permit, also known as the NPDES Permit.

5.7.2.1. Description

The facility is a conventional primary clarifier and activated sludge facility. The primary plant was constructed in 1963. The activated sludge plant was constructed in 1978. According to the 2003 Facility Plan, the plant was designed to treat influent wastewater from a combined storm and SSS at an annual average flow of 22.5 MGD and peak design flow of 50 MGD. Design loading values included an annual average biochemical oxygen demand (BOD5) of 45,000 pounds per day (ppd) and total suspended solids (TSS) of 46,900 ppd.

Force mains from the Santa Fe and Turkey Creek Pump Stations combine near the south border of the Westside WWTP. Just prior to entering the Westside WWTP influent channel, a force main from the Line Creek Pump Station and the Downtown Airport and Harlem Pump Stations intersects the influent force main. The Westside WWTP consists of two parallel treatment processes. The influent channel acts as a flow splitter between two parallel grit/pre-aeration basins. Effluent from these basins flows into two primary clarifiers. The effluent launders of the primary clarifiers are designed to split primary effluent between two dissimilar aeration basins, each of which has a dedicated secondary clarifier. Secondary effluent from both secondary clarifiers combines at an effluent structure and flows to an effluent flood pump station structure. Plant effluent flows through an outfall structure to the Missouri River. The flood pump station activates when the Missouri River is near 100-year flood stage. The plant can be split into two primary plants and two secondary plants.

5.7.2.2. Performance Information

Historical wastewater characteristics were reviewed between January 2003 and December 2007. This data showed that average influent biochemical oxygen demand (BOD5) at 190 milligrams per liter (MG/L) and total suspended solids (TSS) at 258 MG/L. Peaking factors for these two parameters were found to be approximately twice average flow. A 5-year summary of the Westside WWTP operational performance is presented in Table 5-9.

Table 5-9 Westside WWTP Operational Performance – 5-Year Summary

1	Facility Name		Westside WWWTP				
2	Mo NPDES Permit #		MO-0024929				
3	Reporting Period	2003	2004	2005	2006	2007	Avg
4	Design Population Equivalent		225,000				
5	Ave Daily Design Flow (MGD)		22.5				
6	Max Peak Flow (MGD)	19	23.4	33	43.7	39.7	-
7	Ave Actual Daily Flow (MGD)	14.7	14.6	15.5	11.6	14.1	14.1
8a	Ave Inf BOD (MG/L)	142	275	194	242	246	218
8b	Ave Inf TSS (MG/L)	258	326	292	296	346	284
8c	Ave Inf Ammonia (MG/L)	12.2	35.6	14.1	15.4	14.3	18
9a	Ave Eff BOD (MG/L)	25	18	11	8	12	14
9b	Ave Eff TSS (MG/L)	19	12	11	4	8	10
9c	Ave Eff Ammonia (MG/L)	7.8	7.4	5.6	5	5.8	6
10a	Removal Efficiency for BOD (%)	83	93	95	97	95	93

10b	Removal Efficiency for TSS (%)	86	92	96	99	98	96
10c	Removal Efficiency for Ammonia	36	79	60	68	59	60
11	Annual Rainfall	32	34	39	31	37	-
	Source: WSD 2007, Hydraulic Capacity Report, Water Services Dept. KCMO, March 2008.						

5.7.2.3. Capacity Evaluation

A complete summary of the capacity study is presented in the *Westside WWTP Capacity Study*; OCP; April 2006. The design average flow capacity of the Westside WWTP is 22.5 MGD. The design peak wet weather capacity for Westside WWTP is reported to be 50 MGD. The Westside WWTP has not been operated to its peak wet weather design capacity of 50 MGD for several reasons:

- The NPDES permit states the plant design flow is 22.5 MGD. Operation to those criteria shows operation that is consistent with the NPDES permit.
- Attempts to increase wet weather flow from Turkey Creek and Santa Fe Pump Stations has resulted in grit inundation at these pump stations.
- The NPDES permit allows wet weather discharges from diversion structures at Turkey Creek and Santa Fe Pump Stations; doing so does not violate the NPDES permit.
- The Westside WWTP is able to meet permitted discharge requirements without washout of micro organisms from the aeration basins when keeping wet weather flows at or below 22.5 MGD.

The Turkey Creek and Santa Fe Pump Stations both have diversion structures, which are identified in the NPDES permit for activation during wet weather flow. Historical operating experience at the Santa Fe and Turkey Creek Pump Stations has shown that much more flow passes through the permitted CSOs than can be transported and treated at the Westside WWTP. In practice, the Turkey Creek Pump Station generally is maintained in operation at average flow capacity during dry and wet weather events. Excess wet weather flow at the Turkey Creek Pump Station is discharged through the associated permitted CSO diversion structure to the Kansas River.

The Santa Fe Pump Station is operated at or above average flow conditions to prevent street backups. Excess wet weather flow at the Santa Fe Pump Station passes through the Santa Fe Flood Pump Station and is discharged through the permitted CSO diversion structure to the Missouri River. This practice minimizes grit inundation in the pump stations and provides capacity at the Westside WWTP for minimizing SSOs from the Line Creek Pump Station.

The current evaluated peak flow capacity of the plant is approximately 51 MGD in both the primary and secondary treatment processes if mixed liquor suspended solids (MLSS) in the aeration basins is maintained at or below 2,380 MG/L. Primary clarifier weir length is the evaluated hydraulic parameter that limits flow through the primary process. The capacity of the secondary treatment process will vary depending on MLSS concentration in the aeration basins, as this parameter bears directly on surface loading rate of the secondary clarifiers.

The potential capacity of the primary clarifiers could increase to 70 MGD if inboard launders were added to prevent the weirs from flooding. Adding inboard launders at the primary clarifiers would reduce the weir loading rate, which could result in improved primary effluent quality. The improved primary clarifier hydraulics would facilitate treatment of up to 70 MGD with primary treatment, bypass of 19 MGD of primary effluent in accordance with CSO Long Term Control Plan minimum treatment standards, and treatment of up to 51 MGD of secondary effluent. Flooding conditions impose another restriction. Firm effluent flood pump station capacity is limited to approximately 51 MGD. All effluent flood pumps would be required to pump 70 MGD during the 100-year wet weather event.
A summary of the Westside plant baseline design and loading criteria is presented in Table 5-10.

Table 5-10 Westside WWTP – Baseline Design and Loading Criteria

Treatment Process/Units	**Unit Description**	**Capacity**
Preliminary Treatment		
Aerated Grit Chambers	2 – rectangular tanks	51 MGD Design Peak
Primary Treatment		
Primary Clarifiers	2 – 125' dia. x 10' D circular tanks	
-Total Surface Area	24,544 SF	
- Average Flows	At 611 gpd / SF overflow rate	15 MGD
	At 1000 gpd / SF overflow rate	?MGD
-Peak Hourly Flow	At 2,000 gpd / SF overflow rate	50 MGD
Secondary Treatment		
Secondary Treatment Aeration Basins	2 – basins	MGD (Design) for each Basin MGD (Firm Peak) MGD (Design) total MGD (Firm Peak) total
Secondary Clarifiers	2 – 125' dia. x 10' D	
-Total Surface Area	24,544 SF	
- Average Flows	750 gpd/SF	18.5 MGD
-Peak Hourly Flow	1,500 gpd/SF	37 MGD
- Effluent limits	2300 MG/L MLSS	51 MGD
Effluent Pump Station	Normal flow by gravity, 60-inch outfall line	
	MGD effluent pumps	60 MGD (Design) 40 MGD (Firm Peak)

5.7.2.4. Stress Tests

Stress testing was conducted in the field for the Westside WWTP facility to determine the peak hydraulic and treatment capacity of the plant and the pump stations that serve it. The phased testing included flow tests at each of the 3 pumping stations (Turkey Creek, Sante Fe, and Line Creek), primary treatment unit testing, secondary treatment testing, and finally, a whole plant test.

The stress test results were presented in technical memorandum titled *Westside WWTP Stress Test Report;* OCP; December 2007. A brief summary of the stress test findings includes the following:

- Pumping Stations. The three (3) pumping stations (Turkey Creek, Sante Fe, Line Creek) can deliver a combined flow of 53 MGD to the plant. While the force mains share a common force for a short distance prior to discharge at the WWTP headworks, this hydraulic interaction has minimal impact on the continuous pumping capacity of the three stations – and in particular the Line Creek station.
- Primary Treatment. The two primary clarifiers in service have a hydraulic capacity of 48 MGD, before weir submergence, while effluent quality deteriorates at flows greater then 42 MGD.
- Secondary Treatment. The capacity for acceptable treatment performance from the two final clarifiers is 40 MGD, based on limiting excessive solids carryover. It may be possible to increase the flow to 45 MGD for short periods without violating the TSS permit limits (45 mg/L weekly average; 30mg/L monthly average).
- Whole Plant. The overall plant capacity is limited to the 40 MGD performance capacity of the secondary clarifiers. At the same time, primary treatment capacity is not appreciably higher (42-48 MGD). Therefore, treating and discharging excess (bypass) primary flow is not considered a viable alternative for the existing Westside WWTP system.

5.7.3 Birmingham WWTP

The Birmingham WWTP is a conventional activated sludge system that includes the following components: two aerated grit chambers , two primary clarifiers, two aeration basins, two final clarifiers, an effluent pump station, and sludge pumping facilities (sludge transfer pump station and irrigation pumping station). Final effluent discharge to the Missouri River normally flows by gravity, but when the river level prevents gravity flow, the effluent pump station is used. Primary sludge and waste activated sludge (WAS) are pumped to the Blue River WWTP. Raw wastewater transferred to the Birmingham WWTP is received from the Birmingham Pump Station, located approximately two miles north of the WWTP. Flows from Birmingham SSS basin flow to the Birmingham Pump Station and is pumped to the WWTP. There is also a force main connection from Buckeye Pumping Station to Birmingham WWTP, but this is not operated.

Performance parameters of the Birmingham WWTP from 2003 through 2007 are summarized in Table 5-11.

Table 5-11 Birmingham WWTP Operational Performance Summary

	Facility Name	Birmingham WWTP					
	Mo NPDES Permit #	MO - 0049531					
	Reporting Period	2003	2004	2005	2006	2007	Avg
	Design Population Equivalent	100,000					
	Ave Daily Design Flow (MGD)	20					
	Max Peak Flow (MGD)	19.5	24.4	31.9	22.8	32.5	
	Ave Actual Daily Flow (MGD)	9.4	12.4	12.4	10.6	13	11.6
	Ave Inf BOD (MG/L)	226	172	245	313	299	251
	Ave Inf TSS (MG/L)	184	313	413	591	486	362
	Ave Inf Ammonia (MG/L)	29	27	20	23	20	24
	Ave Eff BOD (MG/L)	29	27	20	11.4	22.1	21
	Ave Eff TSS (MG/L)	15	17	12	6.5	11.2	11
	Ave Eff Ammonia (MG/L)	14	14	14	16	13	14
	Removal Efficiency for BOD (%)	87	87	92	96	93	91
	Removal Efficiency for TSS (%)	92	94	97	99	98	96
	Removal Efficiency for Ammonia	52	48	30	30	41	39
	Annual Rainfall (inches)	33	44	39	29	33	
Source: WSD 2007, Hydraulic Capacity Report, Water Services Dept. KCMO, March 2008							

5.7.4 Additional Northern WWTPs

There are four additional smaller WWTPs north of the Missouri River that the City operates: Fishing River, Rocky Branch, Todd Creek, and KC Northland Mobile. A summary of the design capacity and performance for each of these WWTPs for 2007 is presented in Table 5-12.

Table 5-12 Additional Northland WWTP Operational Performance Summary for 2007

	Facility Name	**Fishing River**	**Rocky Branch**	**Todd Creek**	**Northland Mobile**
	Design Population Equivalent	10,000	20,000	27,000	900
	Ave Daily Design Flow (MGD)	1.00	2.00	3.40	0.09
	Max Peak Flow (MGD)	2.46	9.49	3.34	0.21
	Ave Actual Daily Flow (MGD)	0.70	1.63	1.60	0.06
	Ave Inf BOD (MG/L)	334	237	208	215
	Ave Inf TSS (MG/L)	580	424	353	206
	Ave Inf Ammonia (MG/L)	31	23	25	33
	Ave Eff BOD (MG/L)	5	4	3	7.2
	Ave Eff TSS (MG/L)	8	5	5	9
	Ave Eff Ammonia (MG/L)	2.1	0.4	0.44	1.3
	Removal Efficiency for BOD (%)	98	98%	99%	96%
	Removal Efficiency for TSS (%)	99%	99%	99%	97%
	Removal Efficiency for Ammonia	93%	98%	98%	96%
	Annual Rainfall (inches)	40	38	40	40

5.8 Collection System Existing Conditions

5.8.1 Combined Sewer System

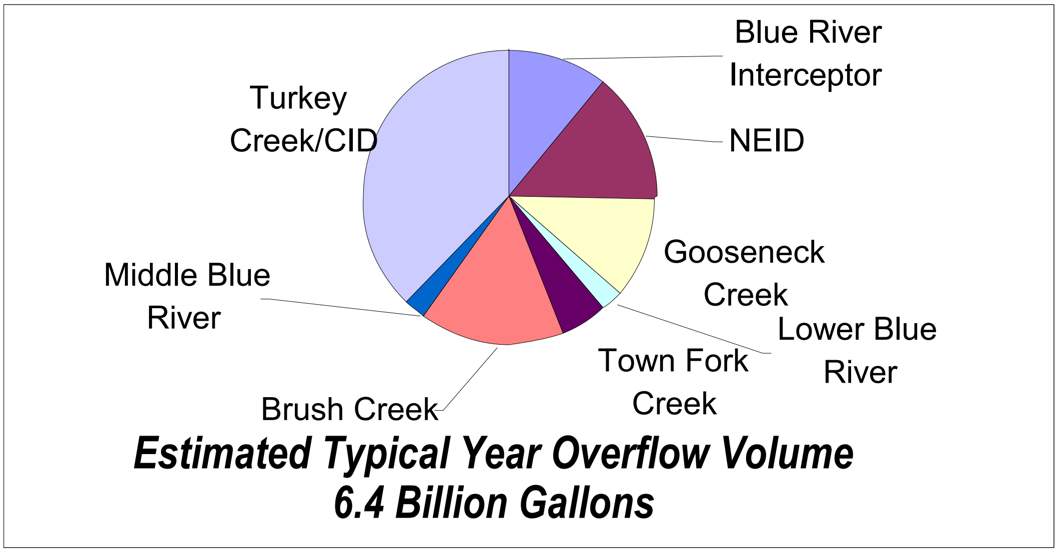
Using computer models based on the wastewater flow meter and rainfall data, current CSS performance was established, as presented in Table 5-13. A set of eight design rainfall events was developed to characterize the City's rainfall for a typical year, as presented previously in Table 5-1. The response of the CSS to those design rainfall events was modeled and the results were aggregated to estimate the overall volume of CSOs in a typical year. A total annual rainfall of 36.85 inches is reflected in that analysis, closely approximating the long-term average annual rainfall of 36.5 inches in the City.

Table 5-13 Combined Sewer System Performance in Typical Year

Basin	Typical Year Wet Weather Flow (billion gallons)	Existing Overflow Volume (billion gallons)	Capture of Wet Weather Flow (%)
MISSOURI RIVER CSS BASINS			
Downtown Airport	Data not Available		
Turkey Creek/Central Industrial District	2.99	2.66	11%
Northeast Industrial District	1.12	0.89	21%
Subtotal, Missouri River Basins	**4.11**	**3.55**	**14%**
BLUE RIVER CSS BASINS			
Town Fork Creek	0.88	0.34	61%
Brush Creek	1.83	1.46	20%
Subtotal, Brush Creek CSS Basins	**2.71**	**1.80**	**34%**
Gooseneck Creek	1.02	0.68	34%
Lower Blue River	0.62	0.21	66%
Middle Blue River	0.62	0.15	76%
Subtotal, All Blue River CSS Basins	**4.97**	**2.83**	**43%**
SSS Wet Weather from 87th Street	2.07	N/A	N/A
SSS Wet Weather from Round Grove	0.50	N/A	N/A
Subtotal, SSS Inflows to BRIS	**2.56**	N/A	N/A
CITY-WIDE TOTALS	***11.64***	***6.38***	***45%***

Figure 5-5 illustrates the overflow volume from each of the seven principal CSS basins and the Blue River Interceptor Sewer. Although the annual total of 6.4 billion gallons is significant, during a typical year, the current system captures 48 percent of the wet weather flow. There are 158 diversion structures that can overflow to the receiving streams through 90 outfalls.

Figure 5-5 Combined Sewer Overflows in Typical Year



5.8.2 Separate Sewer System

The service area of SSSs tributary to the City's WWTP (including satellite communities) is approximately 312 square miles. An additional 36 square miles of sewer service area is tributary to the Little Blue Valley Sewer District. For planning purposes, the area within the City's SSS was divided into nine principal basins, as presented previously in Figure 3-3 and Figure 3-4, for the north side and the south side of the Missouri River, respectively. Four of these basins (Line Creek/Rock Creek, Birmingham/Shoal Creek, Round Grove Creek, and Blue River South) were studied in more detail than the other five, as they directly impact the performance of facilities also serving the CSS or are more likely candidates for priority rehabilitation activities due to the age the sewer system.

The existing SSS performance was estimated for the Line Creek/Rock Creek, Birmingham/Shoal Creek, Round Grove Creek, and Blue River South basins using flow meter data and computer models. Approximately half of the annual flow in the SSS is actual wastewater generated by residential/commercial/industrial sources. Increased flows during wet weather – I/I – represent the remaining half.

Peak flows from these four basins during heavy rainfall events can approach ten times the average daily dry weather flow, indicative of high amounts of I/I in the SSS. There is only one constructed Sanitary Sewer Overflow (SSO) in the separated sanitary sewer system, located immediately upstream of the Line Creek pumping station.

Flows from the satellite community SSS that are tributary to the City's sewer system were included in the system analysis.

Presented in Table 5-14 is the estimated annual overflow volume based on the hydraulic model results of the 5-year 24-hour design storm for the four basins with the most significant I/I contribution (Line Creek/Rock Creek, Birmingham/Shoal Creek, Round Grove Creek, and Blue River South). The total estimated overflow volume is approximately 190 million gallons.

Table 5-14 Modeled Sanitary Sewer Overflow Volume 5-year, 24-hour rainfall event

Separate Sewer Basin	Volume (MG)
Line Creek/Rock Creek	43.54
Birmingham/Shoal Creek	51.58
Round Grove	5.18
Blue River South	63.49
Total Uncontrolled Overflow Volume	**163.79**
Line Creek (Constructed Bypass)	26.45
Total Bypass Volume (Controlled + Uncontrolled)	**190.24**

* * * * *

6 RECEIVING WATERS CHARACTERIZATION

6.1 Introduction

The receiving waters impacted by discharges from the City of Kansas City, Missouri (the City) combined sewer system (CSS) include Brush Creek (including Town Fork Creek), the Blue River, Penn Valley Lake, the Missouri River, and the Kansas River. Figure 6-1 is a map of the current recreational water quality standard designated by the State of Missouri for all local receiving waters in Missouri, or by the State of Kansas for the Kansas River. Key features of the receiving waters are summarized as follows:

Brush Creek:

- Drainage area is approximately 30 square miles and fully developed; the upper one-third of the watershed area is in Kansas.
- Lower four miles has been hydraulically modified from free-flowing reaches to a series of impoundments, including Lake of the Enshriners.
- Receives urban stormwater runoff and SSO discharges from communities in Kansas, as well as, CSS discharges in the City, both directly and via Town Fork Creek.
- Tributary to the Blue River.

Blue River:

- Receives discharge from three wastewater treatment plants (WWTP) located within portions of the watershed upstream of the Kansas-Missouri state line. Receives rural and urban stormwater runoff from the City and communities in Kansas.
- Receives City CSS discharges directly and indirectly via Brush Creek and other minor tributaries.
- Tributary to the Missouri River with a total drainage area of approximately 270 square miles.

Penn Valley Lake:

- Inflow derived primarily from the City CSS discharges via the culvertized OK Creek.
- Total lake volume is approximately 200 million gallons (based on an estimated average depth of 6 feet).
- Outflow routed to the Turkey Creek sewer.

Kansas River:

- Receives wet weather discharges from Kansas City, Kansas along its lower six miles.
- Receives wet weather discharges from the Turkey Creek watershed within the City CSS, approximately two miles upstream of the Missouri River confluence.
- Tributary to the Missouri River with a total drainage area of approximately 60,000 square miles, nearly all of which lies within the State of Kansas.

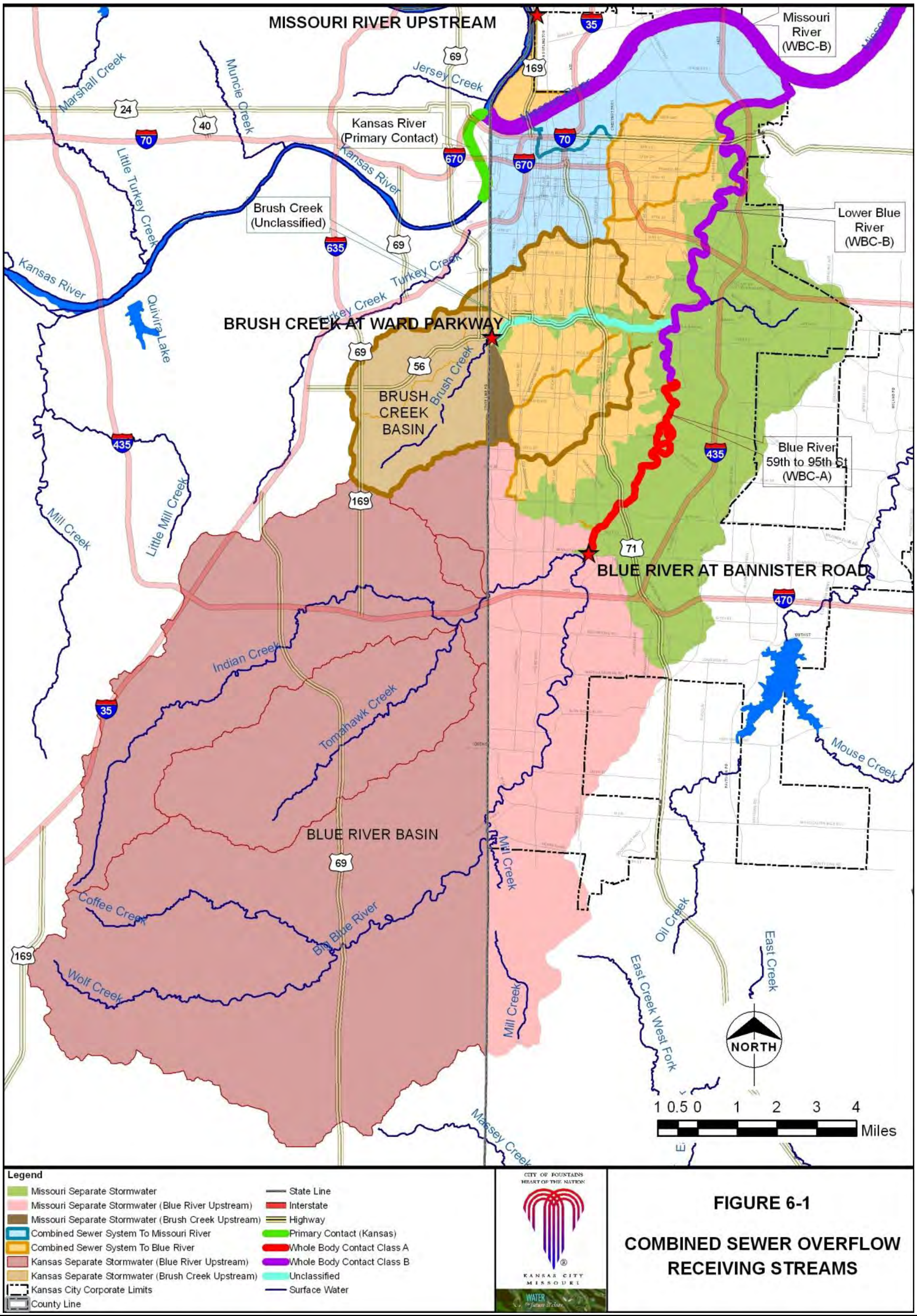


FIGURE 6-1

COMBINED SEWER OVERFLOW RECEIVING STREAMS

<u>Missouri River</u>:

- Six reservoirs located within Montana, North Dakota, and South Dakota regulate flow and effect water quality conditions downstream.
- The Kansas City, Kansas Kaw Point WWTP and the City's Blue River and Westside WWTPs discharge to the Missouri River downstream of the Kansas River confluence.
- Receives overflow from nine City CSS discharge locations during wet weather.
- Tributary to the Mississippi River with a drainage area of approximately 484,000 square miles near the City.

Identification of the applicable water quality standards for the receiving waters, a summary of the available water quality monitoring data, a description of the models developed to support the Overflow Control Plan (the Plan), and the results of the model simulation of existing conditions in the receiving waters follow.

6.2 Applicable Water Quality Standards

One of the primary goals of combined sewer overflow (CSO) control is maintenance of designated beneficial water uses of receiving waters through attainment of appropriate water quality standards. Water quality standards established by the Missouri Department of Natural Resources (MDNR) are provided in *Title 10 of the Missouri Code of State Regulations, Division 20, Chapter 7.031, Water Quality Standards* (10 CSR 20-7.031). Applicable beneficial uses and water quality standards for the Kansas River are established by the Kansas Department of Health and Environment (KDHE) and are defined in the *Kansas Surface Water Standards* (K.A.R. 28-16-28b through 28-16-28g).

Water quality data and modeling analyses discussed below identified *Escherichia coli* (*E. coli*) as the primary pollutant of concern in City CSS receiving waters. In addition, water quality conditions and compliance for dissolved oxygen (DO) have been evaluated.

6.2.1 Missouri Water Quality Standards

The applicable numeric criteria for *E. coli* for a particular receiving water reach are determined by the beneficial use(s) associated with that reach as assigned by the MDNR. Beneficial uses related to *E. coli* standards include Whole Body Contact – Class A (WBC-A) and Class B (WBC-B), and Secondary Contact Recreation (SCR). The numeric criterion for DO is associated with the protection of aquatic life (AQL) use. A summary of the numeric criteria associated with these beneficial uses is provided in Table 6-1.

Table 6-1 Missouri Beneficial Uses & Numeric Criteria for *E. coli* and Dissolved Oxygen

Beneficial Use Description	*E. coli* (#/100ml) [1]	Dissolved Oxygen (mg/l)
Whole Body Contact Class "A" (WBC-A) [1]	126	--
Whole Body Contact Class "B" (WBC-B)[1]	206[2]	--
Secondary Contact Recreation (SCR) [1]	1,134	--
Protection of Aquatic Life (AQL)	--	5

[1] Numeric criteria apply to a geometric mean computed for the recreation season (April 1 – October 31).
[2] The numeric criterion of 206 for WBC-B is anticipated to replace the existing criterion of 548 as a result of USEPA disapproval of the 548 criterion and approval by the Missouri Clean Water Commission in November 2008 for emergency rulemaking by the MDNR to revise the criterion to 206.

The numeric criteria for *E. coli* represent geometric mean (or "geomean") values not to be exceeded for the recreation season period (April 1 – October 31) each year. The DO standard of 5 mg/l represents a minimum concentration to protect aquatic species.

Table 6-2 provides a summary of which beneficial uses included in Table 6-1 apply to a given City CSS receiving water reach.

Table 6-2 Classifications and Key Designated Uses for KCMO CSS Receiving Waters in Missouri

Receiving Water	Beneficial Use Classification?	WBC-A	WBC-B	SCR	AQL
Blue River (Bannister to 59th St.)	Yes	X		X	X
Blue River (59th St. to mouth)	Yes		X	X	X
Missouri River	Yes		X	X	X
Brush Creek (state line to mouth)	No				
Penn Valley Lake	No				

6.2.2 Kansas Water Quality Standards

The beneficial uses of the Kansas River that are relevant to bacteria and DO levels include Primary Contact Recreation (PCR) – Class B, as well as AQL. The numeric criteria for these beneficial uses are summarized in Table 6-3.

Table 6-3 Kansas Beneficial Uses & Numeric Criteria for Bacteria and Dissolved Oxygen

Beneficial Use Description	*E. coli* (#/100ml)	Dissolved Oxygen (mg/l)
Primary Contact Recreation (Class B)	262	--
Protection of Aquatic Life (AQL)	--	5

The numeric criterion for *E. coli* in Table 6-3 represents a 30-day geomean value not to be exceeded during the recreation season (April 1- October 31). The DO standard represents a minimum concentration to protect aquatic life.

6.2.3 Impaired Waters Listings and Total Maximum Daily Loads

The Blue River is included on the 2006 and proposed 2008 State of Missouri 303(d) list of impaired waters for *E. coli*. Development of a Total Maximum Daily Load (TMDL) has not been scheduled.

TMDLs have been developed and approved for the Missouri River (November 3, 2006) for Chlordane and polychlorinated biphenyl (PCBs); and for the Blue River (November 19, 2001) for Chlordane. The TMDLs called for natural attenuation and did not require any reductions for CSS dischargers in the wasteload allocation.

The Kansas River segment that receives CSS dischargers from the City's Turkey Creek outfall is included on the State of Kansas 2008 303(d) list for impaired waters based on total phosphorus, total suspended solids, and lead. TMDLs for this segment of the Kansas River have been developed for total suspended solids (approved January 26, 2000), chlordane (approved January 26, 2000), nutrients and oxygen demand (approved January 26, 2000), and *E. coli* (revised November 19, 2007). The City's Turkey Creek CSS discharge is not identified for a reduction in loading for any of these parameters in the wasteload allocations for any of the TMDLs.

6.2.4 Actual Uses

An evaluation of the water quality in the City's receiving streams needs to consider not only current state-designated uses, but also how the community values and uses those streams. The community's actual receiving waters uses were assessed in 2006 using two methods:

- Site visits, including public interviews
- Public surveys

Field crews visited several sites along each receiving water during the recreation season on a monthly basis from April through October and recorded observed water and/or surrounding area uses. When on-site, they also interviewed members of the public concerning their use or observed use of the waters. A public survey was also conducted by mail and telephone. Over 5,400 households throughout the City participated in the survey.

Results from the field and public surveys generally showed that all receiving waters within the City were perceived as recreational sources, but that hiking, walking, bird watching, and other shore-oriented activities were the most common. The Missouri River was the only City CSO receiving water that was frequently used for in-water recreational purposes, such as boating and fishing. Penn Valley Lake was also frequented for fishing. The other CSO receiving waters were valued as places to hike or walk, but were not used for in-water recreational purposes.

6.2.4.1 Brush Creek

Public access to Brush Creek is available along much of its reach. Brush Creek Park and Blue Banks Park are adjacent to the lower portion of the creek and provide walkways, overlooks, benches, and other areas for public access. There are no public swimming areas in Brush Creek. During field surveys at four sites along Brush Creek, wading was observed once. The waders were from a University of Missouri class that was studying field sampling for water quality. Four people interviewed during site visits reported their belief that swimming has never occurred in Brush Creek. The public survey revealed that residents in the Brush Creek basin view the most common activity near or in lakes and streams in the City to be hiking/walking and that 64 percent of residents participated in activities such as hiking, walking, picnicking or fishing in or around Brush Creek.

6.2.4.2 Blue River

For this evaluation, the Blue River within the City was divided into three sections:

- Lower Blue River, from 59th Street to the mouth
- Middle Blue River, from Bannister Road downstream to 59th Street
- Upper Blue River, from the state line to Bannister Road

Public access to the lower Blue River is limited because much of the area is industrial and/or private property. The stream banks have been channelized and are quite steep in some areas, which further limit public access to the water. Riverside parks provide opportunities for people to access the river in this section, but there are no public swimming areas. Field surveys throughout the recreation season at four sites along the lower Blue River revealed no concurrent uses, although footpaths, fishing tackle, bait remnants, and garbage were present. Public survey results from this basin suggested that hiking/walking was the most common activity near water bodies in the City. Thirty-four percent of lower Blue River residents surveyed participated in the identified activities.

Public access to the middle Blue River is available at several locations along Blue River Parkway and in Swope Park; however, stream banks are steep in some areas. Field surveys at three sites in this section revealed no uses. Some evidence of shoreline visitors included footpaths, fishing tackle, and garbage present along the river. Field interviews revealed that boating and wading happens infrequently in this area. The results of the public survey revealed that hiking/walking was the most common activity near the City's streams, yet only 30 percent of respondents reported conducting any activities near the middle Blue River.

The upper Blue River is accessible to the public in several locations along Blue River Parkway, but no uses were observed at three sites during field visits. Foot paths/prints, fishing tackle, and litter were present, implying that people may use the river for fishing and hiking. The public survey respondents in this basin revealed that hiking/walking was the most common activity at streams in the City and 41 percent reported conducting recreational activities near the upper Blue River.

6.2.4.3 Penn Valley Lake

Penn Valley Lake is easily accessible, as it is in a City park. The lake is also stocked with fish by the Missouri Department of Conservation and this draws residents to the lake. Fishing was observed during two of four site visits. No other activities were observed at the lake. In five interviews, recreational users reported that swimming never occurred in Penn Valley Lake, but that fishing was common. This water body was not specifically targeted for the public survey.

6.2.4.4 Town Fork Creek

Although much of Town Fork Creek flows through private residential areas, public access to the creek is available at a number of parks. However, no residents were observed using the creek or surrounding areas during field visits to four sites. This basin was not specifically targeted for the public survey.

6.2.4.5 Missouri River

Public access is available at one riverside park and one boat launch area along the Missouri River in the City. Much of the area is industrial and/or private property, limiting public access. Five potential recreation sites were visited along the Missouri River during the recreation season. Uses observed included boating and fishing on multiple visits at a few of the sites. Interviews at these sites revealed that other water-related activities such as wading, swimming, and jet skiing or water skiing occur infrequently. This basin was not specifically targeted for the public survey.

6.2.4.6 Kansas River

The Kansas River was not surveyed by field or public survey methods. There are no known public swimming beaches in these waters and public access is limited due to surrounding industrial land uses and flood control structures.

6.2.5 Sensitive Areas

The CSO Policy also states that sensitive areas are to be determined by the National Pollution Discharge Elimination System (NPDES) permitting authority in coordination with state and federal agencies. For the

City, the NPDES permitting authority is the MDNR. The CSO Policy indicates that sensitive areas may include the following:

- Waters designated as Outstanding National Resource Waters (ONRW)
- National Marine Sanctuaries
- Shellfish beds
- Waters with primary contact recreation
- Waters with threatened or endangered species and their habitat
- Public drinking water intakes and their designated protected areas

None of the City's CSO receiving streams is considered to be a sensitive area when evaluated based on the guidance contained in the CSO Policy. A complete discussion of an assessment of sensitive areas in the receiving waters is documented in the following memorandum:

Assessment of Sensitive Areas in the Kansas City, Missouri (KCMO) Combined Sewer Overflow (CSO) Receiving Waters; LimnoTech February 26, 2008.

A summary of the sensitive areas assessment is presented below.

6.2.5.1 Outstanding National Resource Waters (ONRW)

The MDNR is responsible for ONRW designations for receiving waters. No ONRWs have been designated in the CSO receiving waters in or around KCMO.

6.2.5.2 National Marine Sanctuaries

National Marine Sanctuaries (NMS) are designated by the U.S. Secretary of Commerce. No NMS have been designated within the KCMO CSO receiving waters.

6.2.5.3 Shellfish Beds

There are no known commercial shellfish beds nor is shellfish harvest for consumption by private individuals known to occur within the KCMO CSO receiving waters.

6.2.5.4 Waters with Primary Contact Recreation

All classified water bodies in Missouri are designated for whole body contact recreation unless otherwise designated through a Use Attainability Analysis (UAA). However, while there are CSO receiving waters designated for primary contact recreation, there are no known public or private swimming areas within those receiving waters. During separate surveys at 25 sites along those receiving waters in July, August, and September 2006, field crews did not observe any primary contact recreation. In interviews with local residents at these sites, the majority of interviewees reported that swimming never occurs in the Missouri River, while three residents noted that swimming occurred in the Missouri River at a maximum of one time per month. All interviewees reported that swimming never occurs in the other CSO receiving waters.

There are no plans for construction of public swimming facilities along these waterways. Nearly all interviewees viewed fishing as the prominent recreational activity. The absence of public swimming areas, apparent minimal use of the waters for swimming, and physical risks, especially during and following wet weather events due to debris and current velocity in these streams, do not support the consideration of the City's receiving waters as sensitive areas.

6.2.5.5 Waters with Threatened or Endangered Species and Their Habitat

Federal wildlife agencies identified and verified one federally-listed aquatic species in the vicinity of the City's CSO receiving waters. The State of Missouri did not identify any state-listed threatened and endangered species within those receiving waters, while seven threatened or endangered aquatic species were identified by the State of Kansas.

The pallid sturgeon is a federally endangered, large-river fish that was last noted in the Kansas City area in the Missouri River in 1979. Recovery of the pallid sturgeon is not expected to be dependent on the presence or control of CSOs.

The City's Turkey Creek CSS basin discharges to the Kansas River very near its downstream end and confluence with the Missouri River. The State of Kansas list of species and their critical habitat in the Kansas River and/or Missouri River include the chestnut lamprey (threatened), flathead chub (threatened), sicklefin chub (endangered), silver chub (endangered), silverband shiner (threatened), sturgeon chub (threatened), and the western silvery minnow (threatened). Limited information is available on the habitats and water quality requirements of these species. The emphasis of recovery efforts for these species is on habitat and flow improvements and demonstrates that these are the critical factors currently limiting species recovery.

The presence or control of CSOs is not likely to affect water quality conditions that may impact the recovery of these species due to the intermittent nature of the CSOs, and the insignificant flow contribution of the City's CSOs to the annual flow of receiving waters (0.1 percent to Kansas River, 0.02 percent to Missouri River). The primary pollutant of concern in the City's CSOs (bacteria) has no known impact on the aquatic species of concern. In addition, as CSOs occur only during wet weather events when receiving waters experience higher in-stream flows, the potential influence of other possible pollutants of concern in the CSOs is minimized.

6.2.5.6 Public Drinking Water Intakes and Their Designated Protected Areas

There are no public drinking water intakes in any CSO receiving waters in the City. The City's drinking water intake on the Missouri River is upstream of both its confluence with the Kansas River and the CSO locations. The nearest downstream drinking water intake is approximately 41 miles from the City at the City of Lexington. The State of Missouri defines priority areas for source water protection for large watersheds, such as the Missouri River, as a 5-mile radius upstream of the intake. Effective treatment of incoming water at the Lexington Plant has not been impacted by variations in water quality in the

Missouri River that could potentially be linked to CSOs from the City. The Missouri River is not a sensitive area due to drinking water intakes.

The closest public drinking water wells that may be under direct influence of the Missouri River are included in the well field for the City of Independence, which is located approximately 6 miles downstream from the most downstream CSO in the City. The wells do not draw water directly from the Missouri River, and bacterial contamination has not been a problem. Physical processes and disinfection chemicals are used to remove any bacteria or other harmful organisms that may be present. A susceptibility determination conducted by the MDNR as part of the Source Water Inventory Project (SWIP) evaluated the susceptibility of the City of Independence wells to contamination. Based on available data, the determination was made that the wells are not susceptible. The susceptibility analyses consider whether contaminants have been detected in the well water, well construction deficiencies, geology and depth, and contaminants in source water. Public wells along the Missouri River located further downstream are far less likely to be impacted by CSOs. Susceptibility determinations for the two public drinking water well fields located downstream of the Independence well field (Tri-County Water Authority and KC Water Services) indicate that the wells are not susceptible to contamination.

For these reasons, the Missouri River should not be considered a sensitive area due to public drinking water intakes and wells.

6.3 Receiving Water Quality Monitoring

Extensive water quality monitoring has been conducted to characterize the receiving waters and support the development of the Plan. Water quality sampling and analysis has been conducted and continues to be conducted by the City through a number of coordinated programs:

- The City has conducted routine bi-weekly sampling and analysis at 10 key locations in the receiving waters, beginning in 2005. This effort continues to be on-going.
- The City has supported hydrologic and water quality monitoring being conducted by the United States Geological Survey (USGS) in the Blue River and Brush Creek basins. This program has been on-going since 1996 and includes stream flow gauging, and baseline and wet weather event water quality monitoring. The City has also supported special studies by the USGS, including monitoring of the Kansas and Missouri Rivers and biological monitoring in receiving waters.
- In 2005 City conducted intensive water quality monitoring of combined sewer overflows, stormwater discharges and receiving water conditions. In-situ measurements of water quality were conducted as well as the collection of approximately 500 samples during 4 wet weather events at 17 receiving water locations, 9 combined sewer outfalls, and 6 separate stormwater discharge locations. Samples were analyzed for approximately 30 water quality parameters, totaling nearly 13,000 analytical results.

The monitoring activities have all been conducted in accordance with quality assurance plans and data validation reviews. The data were used to assess existing conditions, including spatial and temporal trends, and to develop and calibrate the water quality models of the receiving waters. A complete discussion of the water quality monitoring data is documented in the following report:

Draft OCP Water Quality Data Report; LimnoTech; May 2006.

The Overflow Control Program (OCP) water quality monitoring program included 36 parameters for laboratory analysis and 5 field measurement parameters. Parameters for laboratory analysis such as: total suspended solids, total dissolved solids, volatile suspended solids, turbidity, fecal coliform, *E. coli,* BOD_5, $CBOD_{20}$, total phosphorus, ammonia nitrogen, nitrate + nitrite, total Kjeldahl nitrogen, dissolved phosphorus, hardness, cadmium, chromium, copper, lead, nickel, zinc, and chlorophyll *a*. Field parameters measured included temperature, conductivity, pH, DO, and turbidity.

The key findings from the water quality monitoring included:

- Water quality conditions in the receiving streams are typical of what is found in other urban settings and CSS communities across the country.
- The primary pollutants of concern are pathogens as measured by *E. coli*. Dissolved oxygen levels are also a concern in Brush Creek pools.
- Pollutant sources throughout the watershed contribute to water quality concerns. These sources include not only CSOs in the City, but also separate stormwater runoff in the City, stormwater runoff from upstream watersheds, WWTP discharges, and potential wet weather overflows or bypasses in areas upstream of the City.

The monitoring results and data analysis for *E. coli* and DO are summarized in the following sections.

6.3.1 *Escherichia* coliform bacteria (*E. coli*)

A total of 599 *E. coli* samples were collected and analyzed. Data were segregated into wet and dry categories to distinguish between impacts that are attributable to sources that are active in wet weather, such as CSS discharges, and other sources that may be active during dry weather or during all conditions. Table 6-4 and Figure 6-2 summarize the receiving water data for *E. coli*. In Figure 6-2, the box and whiskers plots represent the following values: median values are represented by a dash within the box, the box ends identify the 25th and 75th percentile values, and the whiskers identify the 5th and 95th percentile values.

Wet weather concentrations of *E. coli* tend to be higher than dry weather concentrations in all of the receiving waters. The median wet weather concentrations in the Blue River, Brush Creek, and Town Fork Creek tend to be two to three times the order of magnitude of the corresponding median dry weather concentrations. Figure 6-2 suggests that wet weather sources are impacting all of the monitored receiving waters in the City, although dry weather concentrations are also elevated relative to the WBC-A and WBC-B, criteria of 126 cfu/100 ml and 206 cfu/100ml, respectively.

Figure 6-2 *E. coli* Data Summary

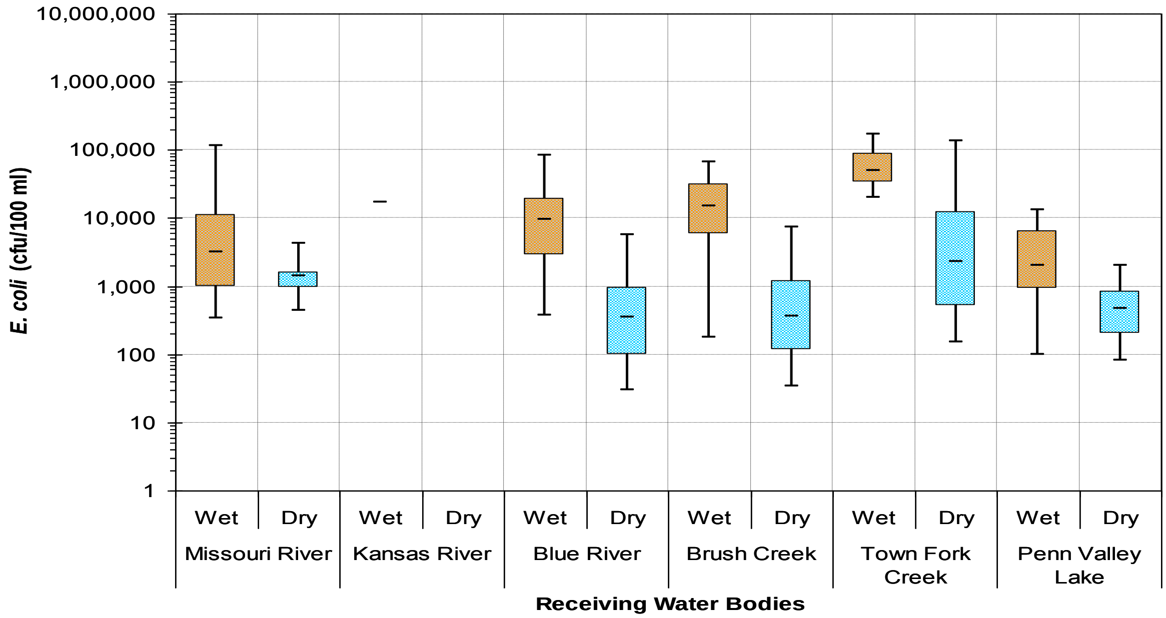


Table 6-4 *E. coli* Data Summary

Receiving Water Body	Precip Condition	OCP Event Data (April-July, 2005)			USGS Baseflow/Event Data (Aug. 2004 – Aug. 2005)			USGS Baseflow/Event Data (Jan. 1998 – June 2004)		
		Count	ND	Range[1]	Count	ND	Range[1]	Count	ND	Range[1]
Blue River	Dry	24	0	21-79,145	22	0	61-4,800	57	2	16-10,000
	Wet	112	0	271-325,000	12	0	690-23,500	22	0	80-32,000
	All Data	***136***	***0***	***21-325,000***	***34***	***0***	***61-23,500***	***79***	***2***	***16-32,000***
Brush Creek	Dry	21	0	42-44,050	23	0	5-9,700	50	3	2-11,000
	Wet	98	2	11-236,700	11	0	150-71,000	16	0	13-160,000
	All Data	***119***	***2***	***11-236,700***	***34***	***0***	***5-71,000***	***66***	***3***	***2-160,000***
Town Fork Creek	Dry	3	0	84-410,000	2	0	165-3,600			
	Wet	14	0	14,100-168,000	4	0	33,000-220,000			
	All Data	***17***	***0***	***84-410,000***	***6***	***0***	***165-220,000***			
Penn Valley Lake	Dry	3	0	623-905	1	0	4000			
	Wet	14	0	371-13,250	2	0	7,600-14,000			
	All Data	***17***	***0***	***371-13,250***	***3***	***0***	***4,000-14,000***			
Kansas River	Dry									
	Wet				3	0	1,800-20,000			
	All Data				***3***	***0***	***1,800-20,000***			
Missouri River	Dry									
	Wet				20	0	330-200,000			
	All Data				***20***	***0***	***330-200,000***			

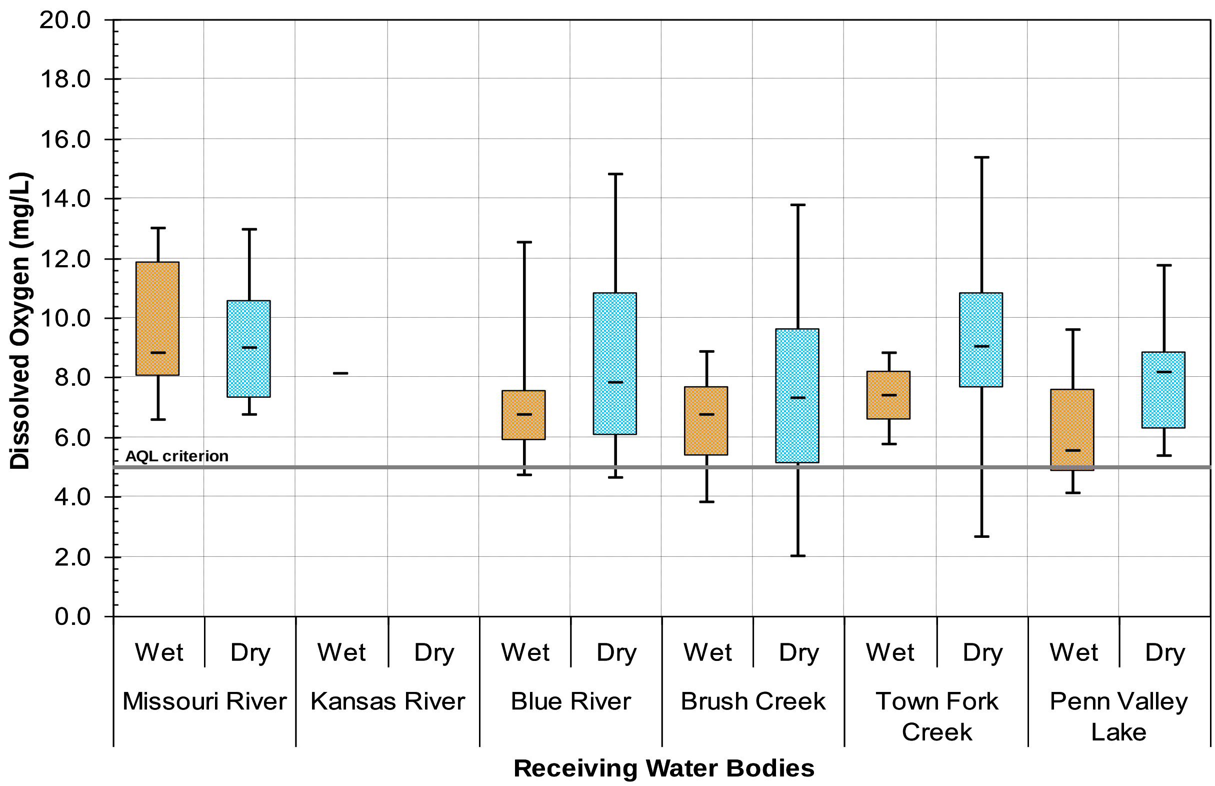
1 All values in colonies per 100 mL.

6.3.2 Dissolved Oxygen

A total of 657 DO measurements were analyzed. Data were segregated into wet and dry categories to evaluate differences for in-stream DO conditions during periods when wet weather sources, such as CSS discharges, are active and when these sources are not active. Figure 6-3 illustrates the range of observed dry and wet weather concentrations in each receiving water. In Figure 6-3, the box and whiskers plots represent the following values: median values are represented by a dash within the box, the box ends identify the 25th and 75th percentile values, and the whiskers identify the 5th and 95th percentile values.

Median dry weather concentrations tend to be higher than wet weather concentrations in all of the receiving waters. Seventy-fifth percentile values generally meet the criterion of 5 mg/l, while some 95th percentile values fall below the criteria.

Figure 6-3 Dissolved Oxygen Data Summary



6.4 Receiving Water Modeling Approach

Comprehensive water quality model simulation tools were developed to assess water quality under existing conditions and evaluate the benefit of potential CSS and watershed improvements. Memoranda and reports documenting the details of model development, calibration, and application include:

Integration of Water Quality Data into the OCP Receiving Water Quality Modeling Framework. Draft Technical Memorandum; OCP; June 7, 2006.

Hydraulic & Water Quality Model Calibration for KCMO Receiving Waters; LimnoTech; August 2007.

Hydraulic & Water Quality Model Application for KCMO Receiving Waters: Existing Conditions and Preliminary CSS "Level of Control" Alternative; LimnoTech; February 2008.

The model domain includes the primary water bodies receiving City CSS discharges, including:

- Blue River - Bannister Road to the mouth (approximately 20 miles)
- Brush Creek - State Line Road to the mouth (approximately 5 miles)
- Penn Valley Lake
- Kansas River – DeSoto, Kansas to the mouth (approximately 30 miles)
- Missouri River – from the City drinking water intake (located upstream from the Kansas River confluence) to Waverly, Missouri (approximately 70 miles)

Several models were utilized to complete the receiving water analysis. A linked hydraulic – water quality modeling framework was selected to represent the City's CSS-impacted receiving water bodies. The Full Equations (FEQ) model developed by the USGS was selected as the hydraulic component. The Water Quality Simulation Model – Version 5 (WASP5) model developed by the USEPA was selected as the water quality model component. The Missouri River was also simulated with a two-dimensional (2D) modeling framework, utilizing the USEPA-supported Environmental Fluid Dynamics Code (EFDC) model to simulate both hydrodynamic and water quality behavior. The selected modeling framework provided the necessary scope and flexibility to produce realistic and reliable simulations of hydraulic and water quality conditions in the receiving waters.

Based on the outcome of the OCP, USGS, and WSD data collection efforts and comparison of the data to water quality standards, *E. coli* and DO were identified as key parameters for simulation within the model. The model also simulated carbonaceous biochemical oxygen demand (CBOD) and nitrogen compounds that impact oxygen resources (organic nitrogen and ammonia). However, existing data indicated that DO is not a concern in the Missouri River, and therefore DO and related parameters were not included in the Missouri River model domain.

Pollutants (bacteria and oxygen demanding material) in the receiving waters move with the flowing water, settle, and die off or decay. Processes included in the model include CBOD and bacteria decay and settling, nitrification, reaeration, photosynthesis and respiration (P&R), and sediment oxygen demand (SOD).

The development and calibration of the hydraulic and water quality components of the modeling are discussed below.

6.4.1 Calibration and Verification Period

The models were calibrated to dry and wet weather in-stream data collected during the April through July 2005 timeframe. The characteristics of the wet weather events used in the calibration and verification of the model are summarized in Table 6-5 below.

Table 6-5 Calibration and Verification Wet Weather Event Characteristics

OCP Event Date (ID)	Total Precipitation (inches)			Peak Upstream Flow (cfs)	
	Blue River	Brush Creek	Penn Valley Lake	Blue River	Brush Creek
May 12-14, 2005 (WW-03)	1.68	2.27	2.60	3,360	730
June 3-5, 2005 (WW-05)	3.61	4.00	3.35	15,400	1,260
July 26-28, 2005 (WW-10)	0.89	1.15	0.75	1,220	867

The WW-03 (May 12-14) and WW-10 (July 26-28) water quality sampling data sets were selected for use in calibrating the water quality model. The WW-05 (June 3-5, 2005) event data was selected for use in verifying the calibration.

6.4.2 Calibration Inputs

Inflows to the hydraulic component of the water quality model for the calibration/verification period were determined as follows:

- Upstream inflows were established using USGS 15-minute streamflow estimates.
- CSS discharge hydrographs were based directly on CSS model predictions developed by the Basin Engineers.
- Separate stormwater hydrographs for non-CSS areas tributary to the Blue River and Brush Creek were established using an application of the Hydrologic Simulation Program – FORTRAN (HSPF) model for impervious areas in the individual sub-basins.
- WWTP discharge rates were period-based on daily monitoring data, where available, or the average design flow specified in each treatment WWTP's permit.

Where available, water quality monitoring data were used to represent the upstream boundary concentrations. Data-based regressions were also developed to estimate pollutant concentrations at the upstream locations, as functions of streamflow for periods not covered by the monitoring programs.

CSS and separate stormwater concentrations were developed from the 2005 OCP wet weather monitoring data sets. WWTP concentrations were developed on available effluent monitoring data and literature value estimates. Table 6-6 shows the concentrations applied to each source in the receiving water simulations.

Table 6-6 Summary of Concentrations Simulated for Each Source

Source Type	*E. coli* (#/100ml)	CBODu (mg/l)
Upstream (varies daily and by stream)	19 - 88,000	5 - 15.6
CSS	214,000	34
Separate Stormwater	44,000 (first flush) 13,000 (remainder of discharge)	40 (first flush) 20 (remainder of discharge)
Blue River WWTP (final effluent)	25,000 (literature value required due to limited availability of effluent data)	66.3
Westside WWTP (final effluent)		42.4
Birmingham WWTP (final effluent)		44.3
KAW Point WWTP (final effluent)		26.5

6.4.3 Calibration Results

An example of the evaluation of quantitative calibration metrics and a visual assessment of the temporal and spatial trends in the calibration are provided in Table 6-7 below. A complete discussion of the calibration is documented in the following report:

Hydraulic & Water Quality Model Calibration for KCMO Receiving Waters; LimnoTech; August 2007.

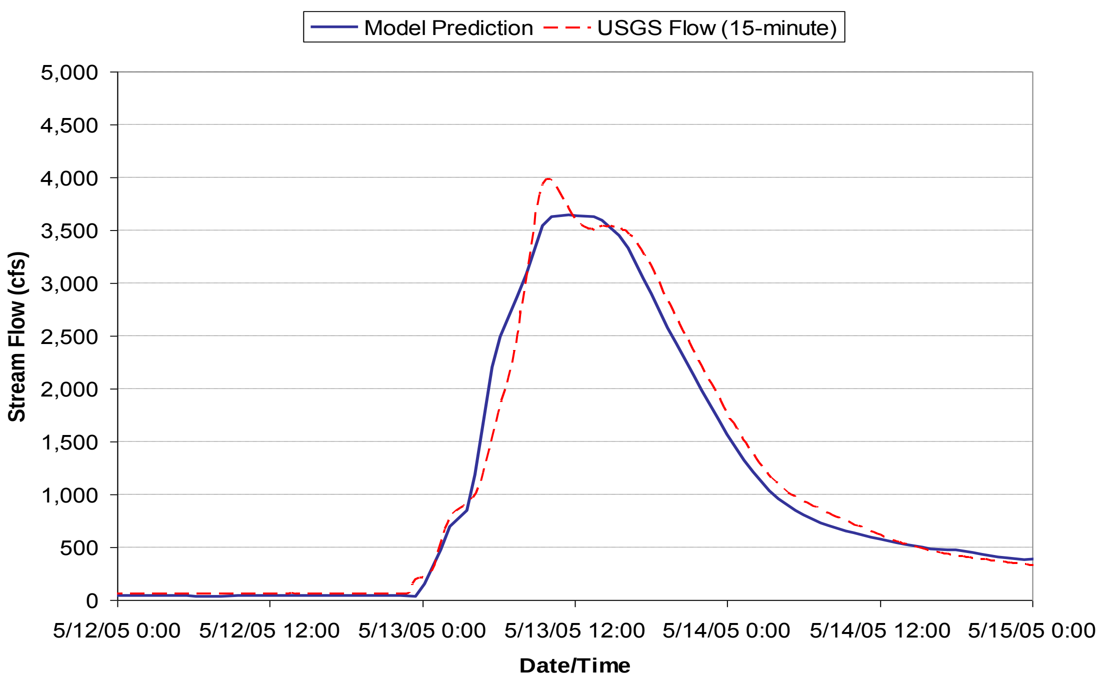
USGS flow data available at Stadium Boulevard (ID: 06893578) were used to calibrate the overall flow balance for the Blue River and Brush Creek. Adjustments were made to the timing and magnitude of separate stormwater inflows to optimize the calibration fit at Stadium Boulevard. The model is well calibrated, with discharge volume for both calibration events predicted within 5 percent of the USGS observed volume at this gauge location (Table 6-7).

Table 6-7 Blue River Discharge Volume Comparison at Stadium Boulevard for Calibration Events

OCP Event Date (ID)	Date/Time Range	Observed Volume (ft^3)	Predicted Volume (ft^3)	% Difference
May 12-14, 2005 (WW-03)	5/12/05 23:00 – 5/14/05 14:30	2.66E+8	2.59E+8	-2.6%
July 26-28, 2005 (WW-10)	7/26/05 17:30 – 7/27/05 15:00	3.73E+7	3.87E+7	+3.8%

A comparison between the flows at Stadium Boulevard predicted by the model and the USGS flow data for the May 12-14, 2005 event is provided in Figure 6-4. The timing and magnitude of simulated peak flow compares well with the USGS data. These results confirm that the model is accurately simulating flows in the system.

Figure 6-4 Model-Data Flow Comparison at Stadium Boulevard for May 12-14, 2005 Event



Bacteria calibration involved adjusting model coefficients for die-off and settling within reasonable ranges to achieve a good fit to the receiving water data. Die-off and settling rates determine the slope of the decline in bacteria concentrations over time when plotting bacteria concentration versus time. In the calibrated model, *E. coli* die off at a maximum rate of 1 day.

CSS discharges are expected to carry larger, faster-settling particles than separate stormwater and upstream flows. A settling rate of 4 meter/day was used to represent more rapidly settling CSS bacteria and associated particles. Lower bacteria settling rates were used for separate stormwater (0.5 meter/day) and upstream sources (0.1 meter/day).

DO calibration utilized measurements of CBOD and ammonia in source waters and receiving waters in support of modeling of these constituents and included calibration of CBOD decay and nitrification rates. Also, reaeration was modeled using standardized formulations that depend on velocity and depth information (available from the hydraulic model) and wind data (from the Kansas City International Airport). Photosynthesis and respiration parameters were estimated by approximating the diurnal swing evident in the continuous DO data collected by the USGS in Brush Creek (at Rockhill Road) and Blue River (at 95th Street). SOD was generally the final parameter adjusted to provide a good fit to the receiving water DO measurements.

Table 6-8 summarizes all of the calibrated water quality model coefficients and shows typical values for the model coefficients. The calibrated coefficients are consistent with typical values. This set of calibrated parameters was used for existing condition and control alternative simulations.

Table 6-8 Calibrated Water Quality Model Parameters

Parameter	Rate	Units	Typical Value	Source[1]
Bacteria die-off				
Bacteria die-off rate at 20ºC	1	day^{-1}	0.25 - 2.5	A
Half-saturation constant for bacteria die-off	500	#/100 mL	Not available	
Temperature coefficient for bacteria die-off	1.08		1.07 - 1.09	A
CBOD deoxygenation				
CBOD deoxygenation rates at 20ºC:				
Upstream loads	0.2	day^{-1}	0.1 - 0.5	B
Combined sewer loads	0.5	day^{-1}		
Stormwater loads	0.3	day^{-1}		
Half-saturation constant for CBOD deoxygenation - oxygen limitation	2	mg/L	Not available	
Temperature coefficient for CBOD deoxygenation	1.047		1.02 - 1.09	B
Sediment oxygen demand				
Sediment oxygen demand at 20ºC:				
Blue River, Brush Creek, and Penn Valley Lake	5	$g/m^2/day$	0.2 - 10	B
Kansas River and Missouri River	2	$g/m^2/day$		
Half-saturation constant for SOD - oxygen limitation	1.4	mg/L	1.4	A
Temperature coefficients for sediment oxygen demand:				
Lake of the Enshriners	1.02[2]		1.04 - 1.13	B
All other locations	1.047			
Nitrification				
Nitrification rate at 20ºC	0.2	day^{-1}	0.1 - 0.5	B
Half-saturation constant for nitrification - oxygen limitation	1	mg/L	Not available	
Temperature coefficient for nitrification	1.08		1.05 - 1.1	B
Photosynthesis and Respiration				
Saturated phytoplankton growth rate at 20ºC	3	day^{-1}	1.5 - 3	B
Temperature coefficient for phytoplankton growth rate	1.066		1.066	B
Phytoplankton respiration rate at 20ºC	0.25	day^{-1}	0.05 - 0.25	B
Temperature coefficient for phytoplankton respiration	1.08		1.08	B
Saturation light intensity	500	ly/day	250 - 500	B
Settling				
Settling rates for solids and particulate-bound material:				
Upstream bacteria, upstream CBOD, and organic nitrogen	0.1	m/day	0.1 - 30[3]	C
Combined sewer bacteria and combined sewer CBOD	4	m/day		
Stormwater bacteria and stormwater CBOD	0.5	m/day		
Particulate-bound fractions:				
Upstream bacteria	0.25		Not available	
Combined sewer bacteria	0.75		Not available	
Stormwater bacteria	0.5		Not available	
Upstream CBOD	-		Not available	
Combined sewer CBOD	0.5		Not available	
Stormwater CBOD	0.25		Not available	
Organic nitrogen	0.5		Not available	

[1] Sources:
A. USEPA, 1985
B. Thomann and Mueller, 1987
C. Chapra, 1997

[2] Temperature input for Brush Creek is based on shallow waters at Rockhill Rd. A low SOD temperature correction factor is used for LOE to account for more consistent temperatures near the bed in these deeper waters.

[3] Range of settling rates is for organinc solids, clays, and silts.

Water quality model calibration included both visual comparisons and quantitative metric reviews that evaluated model "goodness of fit" to monitoring data. Median absolute relative error (MARE) was selected as the primary quantitative metric because it is readily understood and commonly used to evaluate the predictive capabilities of water quality models. The MARE is calculated as the median (i.e., 50^{th} percentile) value of the absolute relative errors computed for a set of model-predicted versus measured data pairs. By evaluating absolute errors, this statistic considers all differences between model and measured data without offsetting positive and negative errors. As a result, the MARE provides a meaningful representation of the goodness of fit, but does not provide information about model bias (whether or not the model typically over- or under-predicts the data). Bias is evaluated through the visual comparisons that follow of model results versus measured data. These plots do not reveal a consistent over- or under-prediction. The absolute relative error is computed for a given model-data pair as:

$$ARE = 100 * \left(\frac{|C_{data} - C_{model}|}{C_{data}} \right) \qquad (1)$$

where:

ARE = absolute relative error (percent);
C_{data} = concentration obtained from data; and
C_{model} = concentration predicted by model.

Data pairs were established by pairing each data point with the model prediction closest to that data value within a specified window centered on the date/time of field sampling. For bacteria, a +/- 3 hour window was used because the timing of peak wet weather bacteria concentrations is strongly dependent on the timing of upstream, CSS, and other loads. A window of +/-1 hour was used for DO because this constituent demonstrates diurnal behavior and is not as strongly influenced by the precise timing of oxygen demand loadings. MARE metrics were calculated for the two calibration events, the combination of calibration events, and the verification event. A summary of the MARE metrics for the combination of calibration events is provided in Table 6-9 for *E. coli* and DO.

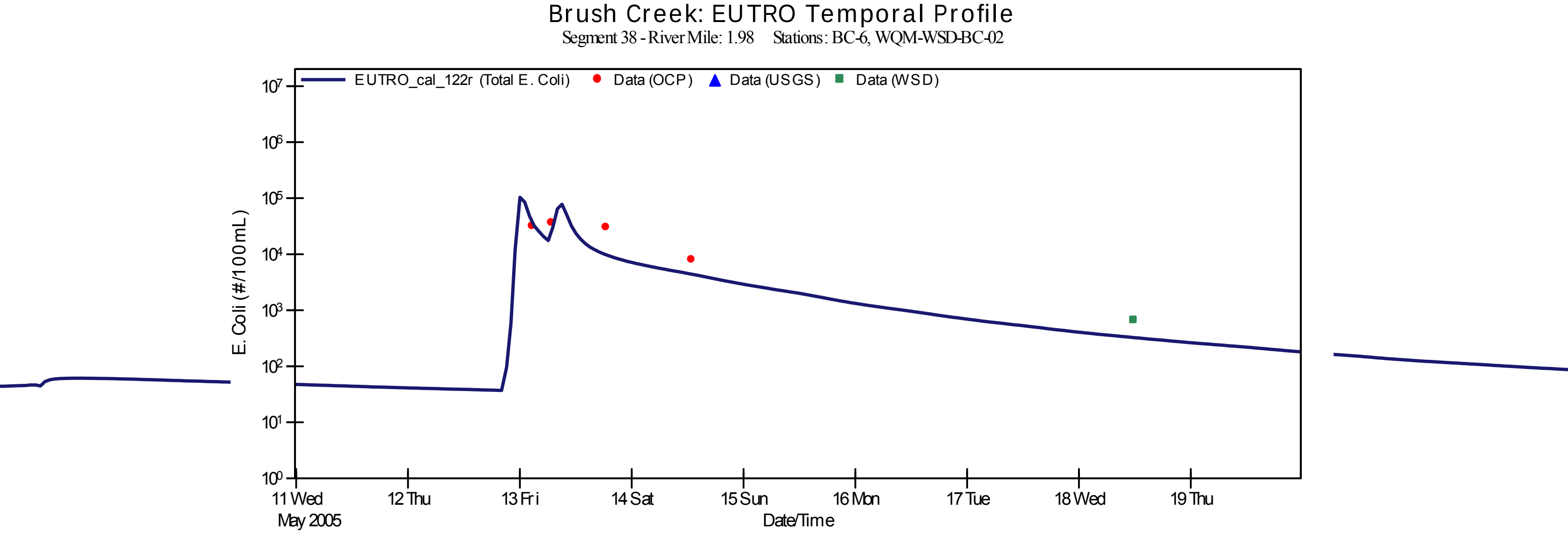
Table 6-9 Water Quality Model Calibration Metrics

Receiving Water	Location Description	Median Relative Error		No. of Data Points	
		E. coli	DO	E. coli	DO
Blue River	Hickman Mills Dr.	4.6%	5.1%	*8*	*9*
	Gregory Blvd.	30.9%	4.3%	*10*	*9*
	Blue Pkwy.	30.5%	14.5%	*9*	*9*
	Stadium Dr.	43.7%	5.7%	*10*	*9*
	23rd St.	29.7%	7.9%	*9*	*9*
	12th St.	30.0%	15.5%	*9*	*9*
	RR bridge - I-435	50.0%	8.0%	*10*	*8*
Brush Creek	Ward Pkwy. Rockwell Lane	27.3%	8.1%	*21*	*18*
	Broadway St.	88.4%	3.5%	*9*	*9*
	Rockhill Rd.	58.7%	7.2%	*13*	*7*
	Prospect Ave.	43.7%	20.1%	*10*	*10*
	Elmwood Ave.	26.7%	23.1%	*10*	*9*
Penn Valley Lake	PVL outlet	53.9%	10.4%	*10*	*10*

The MARE values calculated for *E. coli* range from 4.6% to 88.4%; however, a majority (10 of 13) of the values fall within the 20%-50% range. When evaluating these metrics for bacteria, it is important to consider uncertainty in the data sets as well. The membrane filtration method for analyzing *E. coli* colony counts has a 95^{th} percentile confidence interval of approximately +/- 20-50%. The MARE metrics calculated for DO tend to fall in the 5% to 20% range. Based on previous modeling studies performed for other cities and utilities, and in the context of data uncertainties and the inevitable variability in concentrations within water bodies, the calibration is considered to be very good.

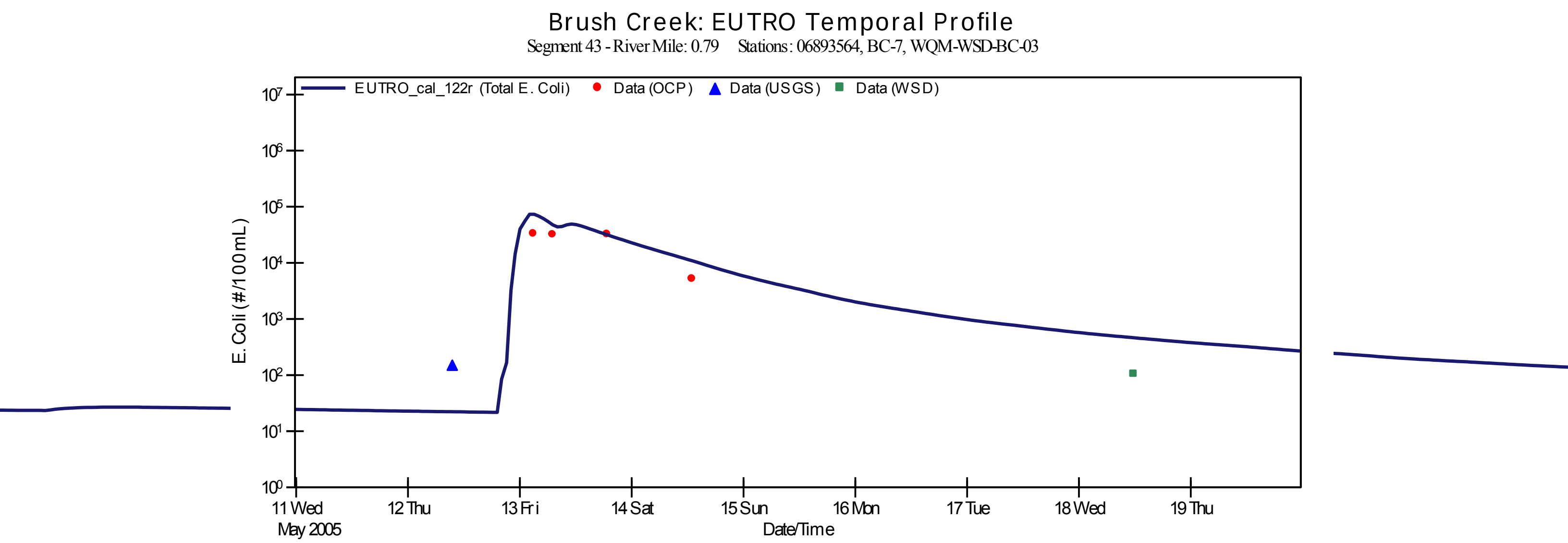
Figures 6-5 and 6-6 show the May 12-14, 2005, model calibration results for Brush Creek *E. coli* at Prospect Avenue and Elmwood Avenue. The May 2005 event had a bimodal rainfall distribution with the highest intensity rainfall occurring near 12 AM on May 13 and a secondary rainfall peak intensity occurring at 8 AM on May 13. These two distinct peaks are evident in the model results at Prospect Avenue (Figure 6-5), with peak concentrations resulting from CSS loads. The USGS measurements and the first two rounds of OCP sampling support the magnitude and timing of the peak model concentrations. The third and fourth rounds of OCP sampling, as well as the WSD measurement on May 18, provide a good indication of the decline from peak concentrations.

Figure 6-5 Brush Creek *E. coli* at Prospect Avenue – May 12-14, 2005 Calibration Event.



The response to wet weather loadings is not as sharp at Elmwood Avenue (Figure 6-6) as for upstream locations. Due to the larger volume and longer residence time in Lake of the Enshriners, bacteria concentrations increase and decrease more gradually.

Figure 6-6 Brush Creek *E. coli* at Elmwood Avenue – May 12-14, 2005 Calibration Event.



Figures 6-7 and 6-8 show the July 26-28, 2005,model calibration results for Blue River *E. coli* at Blue Parkway (River mile (RM)11.4) and upstream of I-435 (RM 2.2). Rainfall during the July 2005 event occurred on July 26th, beginning after 12 PM, with peak intensity occurring around 6 PM and ending by midnight. The model accurately represents the peak and subsequent decline in *E. coli* concentrations at both locations.

Figure 6-7 Blue River *E. coli* at Blue Parkway – July 26-28, 2005 Calibration Event.

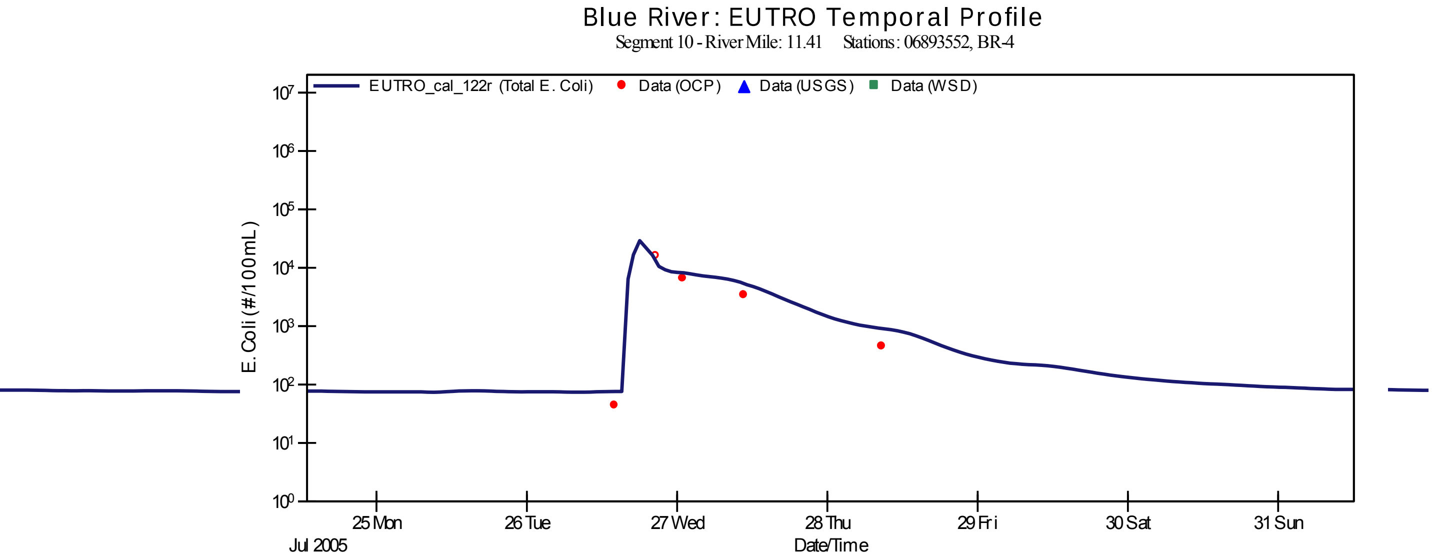
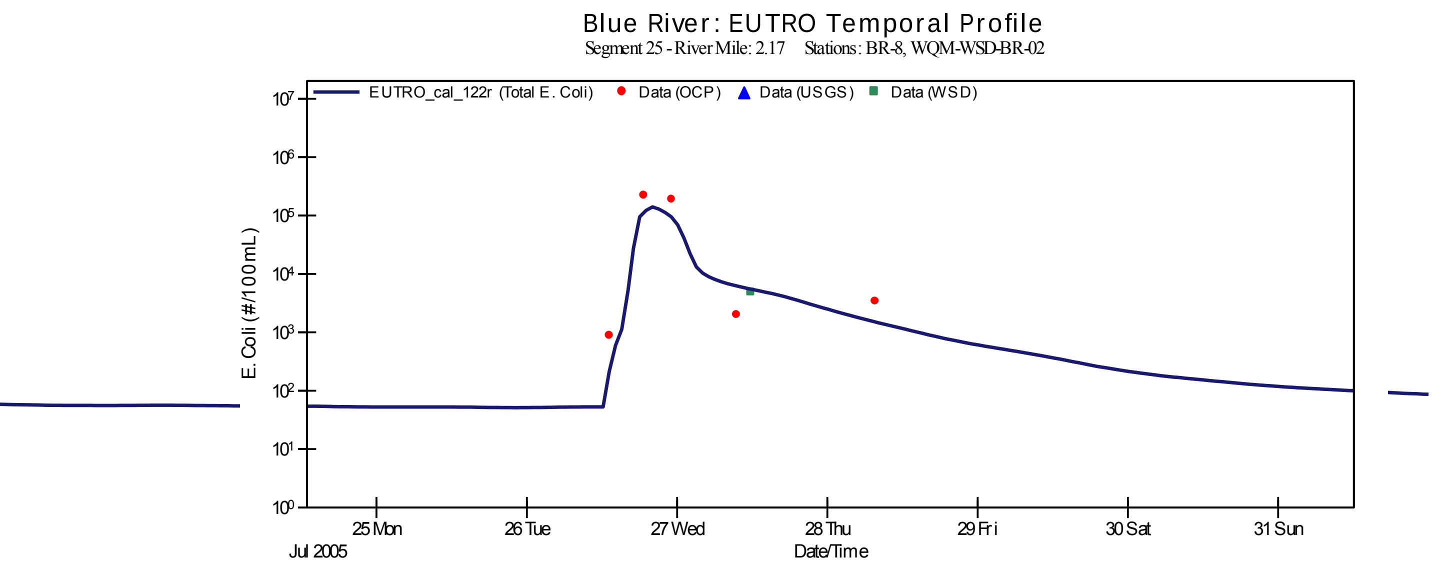


Figure 6-8 Blue River *E. coli* Upstream of I-435 – July 26-28, 2005 Calibration Event.



Overall, the models adequately reproduce observed concentrations of key constituents, including *E. coli* and DO. Calibration and verification results are summarized as follows:

- The hydraulic model accurately simulates the overall flow balance and timing of peak wet weather flows. The simulated Blue River discharge volume at Stadium Boulevard for the calibration events is within 5 percent of the observed discharge volume. For Brush Creek, the simulated pool stage in Lake of the Enshriners closely matches observed data at Elmwood Avenue.

- Based on model comparisons to USGS stage and velocity data, the hydraulic models accurately simulate hydrodynamic behavior in the Missouri River between the City and Waverly, Missouri.
- The water quality model accurately reproduces *E. coli* and DO data based on evaluation of quantitative metrics, as well as temporal and spatial trends. Median absolute relative errors for model-predicted *E. coli* generally fall within the 25 percent to 50 percent range, which represents a good fit for bacteria calibration.

6.5 Design Storm and Design Year

A comprehensive analysis of the City's rainfall and streamflow historical data was conducted to assess typical conditions in the CSS area. This analysis was used to identify a set of design storms and a "design-year" recreation season to support the CSS and receiving water modeling efforts. The selection of the design storms and design year and discussion of the approach are documented in the following reports:

Design Storms for CSS Areas; OCP; May 2006.
Design Year for CSS Analyses; OCP; September 2006.

The design-year analysis involved comparing local rainfall and streamflow data for individual years to historical averages. Based on this analysis, a modified version of the 2001 recreation season (April-October) was selected as the design-year recreation season for application in the existing conditions water quality simulation. Eight design storms were selected to represent the range of rainfall events for a typical year in the City's CSS area based on an analysis of event frequency. The eight selected design storms were substituted for actual 2001 events with similar characteristics.

Design-year flows and pollutant loads were developed for upstream watersheds, the City's CSS and separate stormwater discharges, and the City's WWTP discharges. The concentrations of simulated water quality parameters used for these sources were the same as those used during model calibration. Upstream boundary conditions for the design-year recreation season were based on an assessment of available monitoring data. Discussion of the specific approach used to establish flows, loads, and upstream boundary conditions for the design year is presented in *Hydraulic & Water Quality Model Application for KCMO Receiving Waters: Existing Conditions and Preliminary CSS "Level of Control" Alternatives;* LimnoTech; February 2008.

6.6 Model Simulation of Existing Conditions

The calibrated models were applied to simulate existing conditions for the design-year recreation season. The kinetic coefficients and parameters established as part of the water quality model calibration were maintained for simulation of existing conditions. The results of the existing conditions simulation were processed on an hourly basis for *E. coli* and DO. The results of the continuous, design-year simulation were compared to water quality standards to establish baseline conditions in the system.

6.6.1 Summary of Flow & Load Balances

The overall flow volume balance for the existing conditions simulation is summarized in Table 6-10 for each of the City's receiving water bodies. The following general observations can be made related to the flow balance:

- Greater than 80 percent of the total flow volume in the Blue River is derived from watershed sources upstream of Bannister Road or from Brush Creek.
- Direct City CSS discharges contribute 6 percent or less of the total flow volume to each water body except Brush Creek (24 percent).
- Upstream flow sources are very dominant in the Missouri and Kansas Rivers, with a 0.1 percent or less contribution from City CSS discharges.
- Stormwater discharges contribute a large majority (94 percent) of the total inflow volume to Penn Valley Lake.

Table 6-10 Flow Balance Summary for Existing Conditions Simulation

Receiving Water Body	Upstream and Tributary	Combined Sewer System[1]	Separate Stormwater[2]	WWTP[3]
Blue River	82%	4%	14%	--
Brush Creek	60%	24%	16%	--
Penn Valley Lake	--	6%	94%	--
Missouri River	99.62%	0.05%	--	0.33%
Kansas River	99.9%	0.1%	--	--

[1]Includes only direct City CSS discharges to the water body, based on XP-SWMM results provided by the Basin Engineers.
[2]Separate stormwater was not estimated or included in the water quality model for the Missouri and Kansas Rivers.
[3]Includes only City WWTPs (Blue River, Westside, Birmingham); WWTP discharges for other municipalities are included in the "upstream" category.

A summary of the *E. coli* loading balance for the existing conditions simulation is provided in Table 6-11. The following general observations can be made related to the *E. coli* load balance:

- For the Blue River, only 17 percent of the load originates from direct CSS discharges, with 76 percent from upstream and Brush Creek sources. Of the 76 percent, 47 percent comes from sources upstream of Bannister Road.
- For Brush Creek, over 75 percent of the load originates from CSS discharges (including CSS discharges entering via Town Fork Creek).
- For the Missouri and Kansas Rivers, upstream and tributary sources account for 96 percent of the total loading. Of this 96 percent, 94 percent is from upstream sources in the Missouri and Kansas Rivers.
- All City CSS discharges (including Turkey Creek and all outfalls in Brush Creek, Blue River, and Penn Valley Lake) contribute less than 3 percent of the total load to the Missouri River.
- For Penn Valley Lake, CSS and separate stormwater discharges contribute approximately equal loads.

Table 6-11 *E. coli* Loading Summary for Existing Conditions Simulation

Receiving Water Body	Upstream and Tributary	Combined Sewer System	Separate Stormwater	WWTP
Blue River	76%	17%	7%	--
Brush Creek	20%	76%	4%	--
Penn Valley Lake	--	49%	51%	--
Missouri River	96%	1%	--	3%
Kansas River	94%	6%	--	--

6.6.2 Evaluation of Water Quality Compliance

The model-predicted concentrations for *E. coli* and DO were compared against numeric criteria to evaluate compliance with water quality standards. Although these comparisons can be made at any location within the simulated stream reaches, the analysis was based on a set of key locations defined by OCP for each receiving water body. The key locations were selected to provide a representative set of model results that reflect the impacts from upstream sources and for the various City CSS basins, as delineated by OCP. The set of key locations are listed in Table 6-12 and displayed geographically in Figure 6-9.

Table 6-12 Key Locations Selected for Water Quality Compliance Evaluation

Receiving Water Body	Key Location Description	Key Location ID	River Mile
Blue River	Bannister Road	KL-BR1	20.1
	Upstream of Brush Creek	KL-BR2	10.7
	Downstream of Brush Creek	KL-BR3	10.0
	Mouth at Missouri River	KL-BR4	0.2
Brush Creek	Ward Parkway	KL-BC1	5.0
	Upstream of Lake of the Enshriners (LOE)	KL-BC2	1.7
	Downstream of Lake of the Enshriners (LOE)	KL-BC3	0.4
Penn Valley Lake	Penn Valley Lake outlet	KL-PV1	0.0
Missouri River	Upstream of Kansas River	KL-MR1	359
	Downstream of Kansas River	KL-MR2	357
	Upstream of Blue River	KL-MR3	348
	Downstream of Blue River	KL-MR4	347
	Waverly, Missouri	KL-MR5	286
Kansas River	Upstream of Turkey Creek CSS discharge	KL-KR1	3.0
	Downstream of Turkey Creek CSS discharge	KL-KR2	1.0

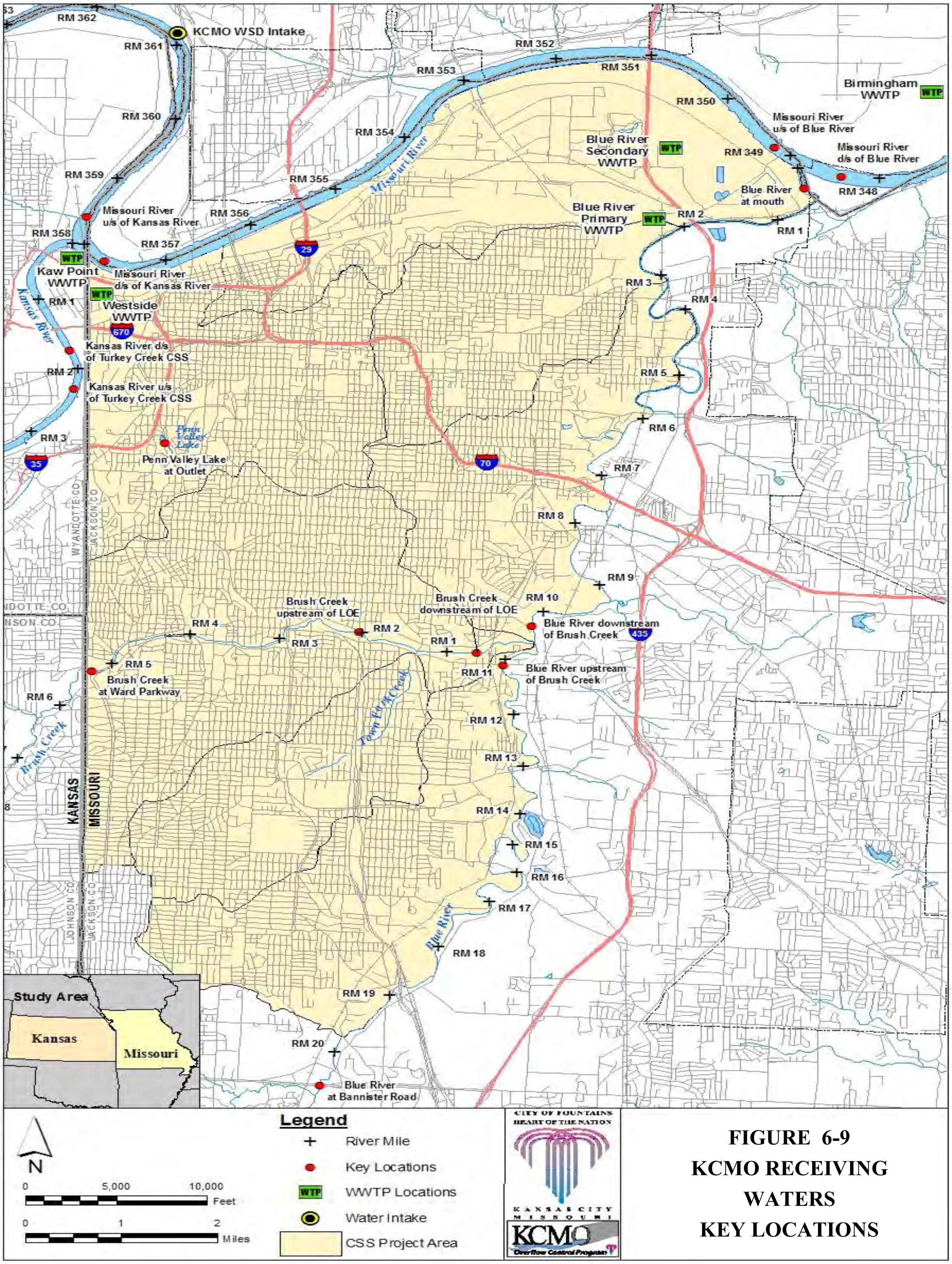


FIGURE 6-9
KCMO RECEIVING WATERS
KEY LOCATIONS

The evaluation of model simulation results for existing conditions during a typical recreation season in the context of water quality standards for *E. coli* and DO follow.

6.6.2.1 *E. coli* Comparison

For *E. coli* bacteria, the numeric criteria used for this analysis represented the recreation season geomean criterion associated with the most stringent beneficial use for each key location. The *E. coli* geomean comparison is provided in Table 6-13 for each key location. The model simulation of existing conditions indicates that *E. coli* concentrations in the receiving waters, both upstream and within the CSS impacted reaches, do not comply with the numeric criteria for a typical recreation season.

Table 6-13 *E. coli* Geomean Comparison for Existing Conditions at Key Locations

Water Body	Key Location Description	Geomean Criterion[1]	Recreation Season Geomean Predicted
Blue River	Bannister Road	126	619
	Upstream of Brush Creek	206	571
	Downstream of Brush Creek		595
	Mouth at Missouri River		740
Brush Creek	Ward Parkway	n/a	782
	Upstream of Lake of the Enshriners		426
	Downstream of Lake of the Enshriners		413
Penn Valley Lake	Penn Valley Lake outlet	n/a	140
Missouri River	Upstream of Kansas River	206	638
	Downstream of Kansas River		811
	Upstream of Blue River		860
	Downstream of Blue River		876
	Waverly, Missouri		588
Kansas River	Upstream of Turkey Creek CSO	262	506
	Downstream of Turkey Creek CSO		567

[1]Represents the numeric criterion for the most stringent beneficial use: 126 for WBC Class A, 206 for WBC Class B, and 262 for the Kansas PCR Class B use. A “n/a” entry indicates that the water body is currently unclassified and numeric criteria do not apply.

6.6.2.2 Dissolved Oxygen Comparison

For DO, water bodies classified for the AQL beneficial use are subject to a minimum criterion of 5 mg/l. Model hourly predictions of DO were compared to this criterion. Table 6-14 presents the percentage of recreation season hours that are below the 5 mg/l criterion for the key locations in the Blue River, Brush

Creek, and Penn Valley Lake. DO was not simulated for the Missouri River or the Kansas River because data indicated that DO is typically above 5 mg/l in the vicinity of the City.

Table 6-14 Dissolved Oxygen Comparison for Key Receiving Water Locations

Water Body	Key Location Description	River Mile	% of Hours Below Criterion (5 mg/l)
Blue River	Bannister Road	20.1	0.0%
	Upstream of Brush Creek	10.7	0.1%
	Downstream of Brush Creek	10.0	0.2%
	Mouth at Missouri River	0.2	34.8%
Brush Creek	Ward Parkway	5.0	0.1%
	Upstream of Lake of the Enshriners	1.7	12.5%
	Downstream of Lake of the Enshriners	0.4	33.8%
Penn Valley Lake	Penn Valley Lake outlet	0.0	4.1%

The results in Table 6-14 suggest that occasional low DO levels are very likely not a problem in the Blue River, except near its confluence with the Missouri River where DO levels are predicted to below 5 mg/l approximately 34 percent of the time. Because very few DO concentration data are available between I-435 and the confluence, this finding of low DO is based on model results that could not be verified by data. Upstream of the confluence area, DO levels are maintained by a combination of: (1) sufficient reaeration due to fast-flowing reaches and (2) low hydraulic residence time. Near the confluence, however, backwater from the Missouri River frequently results in a pooling of Blue River water during dry weather conditions. This minimizes the flow velocity, as well as the reaeration rate, and increases the hydraulic residence time substantially (i.e., stagnation effect). As a result, the water quality model predicts that oxidation of CBOD and ammonia loadings, as well as the exertion of sediment oxygen demand, cause a decline in DO concentrations in this area.

Within Brush Creek, DO levels at Ward Parkway and in the free-flowing reach extending to Roanoke Parkway are generally maintained above 5 mg/l. However, depressed DO levels may occur in the various pool areas. For example, Lake of the Enshriners, which is the largest pool on Brush Creek, experiences DO levels below 5 mg/l approximately 35 percent of the time, typically following wet weather events.

* * * * *

7 CSO CONTROL TECHNOLOGIES

7.1 Introduction

Various wet weather control technologies and practices, other control technologies, and combined sewer overflow (CSO) and separate sewer overflow (SSO) mitigation capabilities were considered during development of this Overflow Control Plan (the Plan). Technologies and practices considered are described in this chapter. Screening and selection of technologies for basin-specific alternatives are discussed in chapter 8.

Municipalities use a wide variety of technologies and operating practices to:

- maintain existing infrastructure
- minimize unnecessary waste and flow entering the sewer system
- increase wet weather flow capture and treatment in the combined sewer system (CSS)
- reduce the impact of any subsequent discharges on the environment and human health

Most technologies and operating practices are designed to reduce, not eliminate, pollutant discharge and attendant impacts since it is generally not feasible to eliminate all discharges. Numerous technologies and operational practices have been used to reduce CSO and SSO volume, frequency, and environmental impacts. Technology performance and cost-effectiveness are often related to site-specific factors, including:

- Current sewer system condition
- Wet weather flow characteristics (e.g., peak flow rate, flow volume, concentration of key pollutants, frequency and duration of wet weather events)
- Hydraulic and pollutant loading to a particular facility
- Climate, including seasonal variations in temperature and rainfall patterns
- Implementation requirements (e.g., land or space constraints, surrounding neighborhood, noise, disruption, etc.)
- Maintenance requirements

7.2 Nine Minimum Controls Considerations

Nine Minimum Controls (NMC) considerations are identified in the United States Environmental Protection Agency's (USEPA) CSO Control Policy as:

> ". . . the minimum technology-based controls that can be used to address CSO problems without extensive engineering studies or significant construction costs, prior to the implementation of long-term control measures."

NMC activities are described in the USEPA's 1995 publication entitled "Combined Sewer Overflows – Guidance for Nine Minimum Controls."

In 1996, the City submitted the required NMC Plan to the Missouri Department of Natural Resources (MDNR). Annual NMC activity summaries have been submitted in the first quarter of each subsequent year. The most recent annual report was submitted in March 2008. In October 2008, the City submitted a Capacity, Management, Operations, and Maintenance Plan (CMOM) and an NMC Plan to the MDNR and the USEPA. The NMC Plan describes the City's actions that have or will be implemented, and serves as the City's documentation of compliance required by the CSO Control Policy.

7.3 Source Controls

Source controls generally involve the removal of deposits from sewers, street surfaces, paved areas, highways, parks, and other areas before these deposits are carried into and conveyed into the sewer system by storm run-off. These deposits consist largely of sand, silt, and inorganic particulates, and contain low quantities of organics (biochemical oxygen demand or BOD) in comparison to domestic sewage. Source controls also include methods and activities to reduce sewer flows with the goal of reducing the magnitude, frequency, and duration of CSOs and SSOs.

7.3.1 Street Sweeping

Streets are continuously subject to dust, dirt, and leaves blown by the wind or tracked by vehicles, and other debris generated by human activity. Street sweeping can be an effective means of reducing the accumulation of debris, including food and beverage containers, paper and plastic bags, leaves, and sand/dirt. Common methods of street sweeping are manual, mechanical, and vacuum sweepers; and street flushing. Street sweeping uses machines available from several commercial sources. City personnel typically operate these machines over pre-programmed routes, often at night to avoid traffic congestion and/or parked cars. The overall effectiveness of a street sweeping program is a function of the frequency of sweeping, the size of particles collected, climatic conditions, and parking regulations. Street sweeping can be conducted by the City on a year-round basis.

Depending on the circumstances, street sweeping can remove up to approximately 20 cubic yards of material from City streets per curb mile swept. Removal of the debris also reduces the potential for clogged sewer lines and may lessen the amount of dry and wet weather overflow events caused by clogs in the system.

Street sweeping is primarily effective in gathering solids, thereby impacting aesthetics and receiving water solids. Street sweeping also contributes to improved water quality by reducing nutrient, BOD, bacterial, and metal loads delivered to the CSS. However, street sweeping is not effective at reducing the magnitude, frequency, or duration of CSOs; and it is not effective for the reduction of fecal coli forms and *E. coli* that originate primarily from sewage.

7.3.2 Construction Site Erosion Control

Construction sites involve activities that accelerate erosion. Removing vegetative cover, compacting and excavating soil, changing natural drainage patterns, and increasing the amount of impermeable surfaces all speed up erosion. This accelerated erosion can have significant effects on the CSS and the separate sewer system (SSS). Excessive runoff reduces system capacity and results in more overflows. Blocked catch basins result from additional sediment and lead to inefficient operation of the collection systems. Disturbances to natural habitat and aquatic life occur from increased sediment in receiving waters. Turbidity, nutrients, metals, and other toxic substances adversely affect receiving waters as well.

Construction site erosion control can substantially decrease erosion from construction sites, reduce solids concentrations in CSOs, and reduce sewer cleaning operations and maintenance (O&M) costs. Many methods are available for different situations that can significantly reduce the pollution from these sites. For effective construction site erosion control, planning prior to disruption is necessary. Construction planning should include a focus on preserving existing vegetation, retaining sediment on-site, and identifying post construction environmental remediation activities.

The effectiveness of erosion control depends on the methods chosen. It is important to slow and spread the flow of stormwater runoff when possible and to retain and preserve as much existing vegetation as possible. Silt fences, filter fabrics, and straw wattles can efficiently control sediment from construction slopes. Several options for sediment traps in drainageways include rock check dams, woodchip-filled bags, hay bales, and small stilling ponds. Streets can be protected from sediment at construction site entrances by using geo-textile fabrics and three-inch rock. Wheel washes can be used in cases where the construction site is large or in situations where additional sediment warrants.

Many options for construction site erosion control not only help control sediment but also add aesthetic value to the site. Environmentally oriented landscaping, mulching, and seeding aid in erosion control and improve appearance.

7.3.3 Catch Basin Cleaning

Catch basins accumulate debris, sediment, and floatables from natural sources, as well as from human activity. This accumulation can result in clogging, localized flooding, reduced hydraulic capacity, and increased risk of damage to downstream pumping equipment. Regularly scheduled catch basin cleaning helps prevent buildup in the catch basins and helps maintain the performance of the collection system. Methods for catch basin cleaning include manual cleaning, vacuum cleaning, and cleaning with other mechanical equipment.

Catch basin cleaning is applicable throughout the CSS and can improve collection system performance, as well as, reduce localized flooding and pollutant loads. Regularly scheduled catch basin cleaning prevents potential blockages and the resulting reduced capacity and downstream damage. Catch basin cleaning allows the basins to maintain sediment trapping ability, thereby contributing to the reduction of sediment delivered to the CSS. However, catch basin cleaning is generally not considered effective for the reduction of fecal coli forms and *E. coli* that originate from sewage.

7.3.4 Garbage Disposal Ban

Eliminating or restricting the use of garbage disposals decreases the amount of solids and pollutants in the CSS. Eliminating garbage disposals can also reduce the buildup of solids. Use of garbage disposals in the City is fairly common and widespread. It is generally assumed that there would be little public support for elimination of this common household convenience, and that enforcement would be difficult and unpopular. Therefore, a garbage disposal ban is not a viable alternative for the City.

7.3.5 On-site Domestic Wastewater Storage/Treatment

The ability of on-site, domestic wastewater systems to remove settleable solids, floatable grease and scum, nutrients, and pathogens from wastewater discharges defines the importance of those systems in protecting human health and environmental resources. Typically, an on-site system consists of a septic tank and a soil absorption field. These conventional systems remove the majority of settleable and floatable material, as well as promote partial digestion of retained organic material. Conventional system effluent is traditionally discharged to some media absorption field such as soil or sand for further treatment through biological processes, absorption, filtration, and infiltration into underlying soils. Newer or “alternative” on-site domestic wastewater technologies are more complex than conventional systems and incorporate pumps, recirculation piping, aeration, and other features that require ongoing or periodic monitoring and maintenance.

When conventional systems are installed in areas with the appropriate soils and hydraulic capacities; are designed to treat the incoming waste load to meet public health, ground water, and surface water performance standards; are installed properly; and maintained appropriately, they work well. These criteria, however, are often not met. Only about one-third of the land area in the United States has soils suited for conventional subsurface soil absorption fields.

There is essentially no opportunity to employ on-site treatment systems in a fully-developed urban area such as the City because space requirements for septic tank and drain field installation preclude such systems.

7.3.6 Combined Sewer Flushing

Solids deposited in sewers during dry weather can be a major component of CSO pollution loads during storm events. Accumulated sediments can result in a loss of conveyance and storage capacity, leading to local flooding and odor or corrosion problems. Periodically flushing sewers during dry weather helps prevent this buildup and sends the settled materials to the wastewater treatment plant (WWTP). Minimizing sediment accumulation contributes to optimizing collection system performance, and decreasing pollution of receiving waters.

Sewer flushing consists of introducing water into the collection system at selected key locations over a short time period. This can be accomplished by using hydrant water or other sources and installation of control structures, such as sluice gates or inflatable dams, in the collection system to allow use of water within the collection system.

Sewer system flushing reduces the sediment buildup in the collection system, and therefore decreases CSO pollution loads. When performed manually, sewer flushing is labor intensive and is applicable to relatively limited sewer reaches. Cleansing efficiency of combined sewer flushing depends on flush volume, flush discharge rate, sewer slope, sewer length, sewer flow rate, and sewer diameter Sewer flushing is generally not viable as a stand-alone alternative that can be used to achieve substantial CSO reduction.

7.3.7 Infiltration and Inflow Reduction

The reduction of the amount of infiltration and inflow (I/I) in the CSS can contribute to reductions in the magnitude, frequency, and duration of CSOs and decrease the frequency and severity of SSOs from the SSS. Infiltration is groundwater that enters the collection system through defective pipe joints; cracked or broken pipes, manhole walls, and connections; and other similar sources. Inflow is water that enters the collection system from sources such as roof leaders, cross connections from storm sewers, catch basins, manhole covers, surface runoff, and other similar sources.

Excessive I/I increases the average and peak flows in the collection system resulting in increased wet weather overflows, and higher O&M costs. Existing systems should be extensively investigated to determine the extent and location of infiltration. Reduction of inflow waters can be accomplished after sources of such flows and alternate methods of removal have been identified. I/I sources can be determined with methods such as televising, smoke testing, flow monitoring, house-to-house inspections, and other field investigations.

I/I reduction will generally have a greater impact on reducing wet weather overflows in SSS areas than in CSS areas; however, rehabilitation of aging sewer lines to remove I/I sources may result in restoration of system capacity and help to reduce basement backups in areas with smaller sewer lines.

7.3.8 Upland Stormwater Storage

Storing stormwater in upland areas temporarily during peak wet weather flows contributes to reductions in the magnitude, frequency, and duration of CSO discharges. There are several different methods for upland stormwater storage, including the construction of detention ponds. Detention ponds in upland areas can store stormwater runoff temporarily, delaying its introduction into the collection system, and thereby helping to attenuate peak weather flows in the collection system. The detention facilities drain to the collection system when peak wet weather flows subside. Another method for stormwater storage is the use of pervious areas to allow for infiltration and attenuation of peak flows. Capture of stormwater flow in pervious areas not only helps attenuate peak wet weather flow in the collection system, but also reduces runoff volume through infiltration into the soil.

Upland stormwater storage structures, such as detention ponds, have been used widely for many years. Applicability is very dependent on availability of land and/or existing ponds. Upland stormwater storage structures not only can help control the quantity of flow in the system, but they can also help improve the quality of water when it is discharged into the system. Suspended solids, metals, and dissolved nutrients can all be reduced through the use of such facilities.

7.3.9 Stormwater Sumps

Stormwater sumps are below ground structures that collect and store the "first flush" of stormwater during rain events. The collection basin of a stormwater sump is deeper than the invert of the pipe leaving the structure. Water ponds in the sump until it reaches the pipe invert. Water retained by the sump will either infiltrate into the ground or evaporate and never enter the combined sewer. Removing this stormwater from the CSS reduces overflows. Although sumps are generally designed and operated for flood control, they may also help treat stormwater and improve its quality.

Stormwater sumps are widely used in urban watersheds and are built and operated by cities and industries. Stormwater sumps can significantly reduce inflow in areas where the underlying soils are moderately to highly permeable and the water table is well below the ground surface. If stormwater remains in stormwater sumps for an extended time some sediment, BOD, nutrients, and metals are removed. There is normally little change in groundwater contamination with stormwater sumps.

Use of stormwater sumps for CSO control in the City was considered unlikely due to the fact that the native soils typically have low permeability rates.

7.3.10 Sewer Separation

Sewer separation converts a CSS into an independent SSS and storm sewer system. After sewer separation, sanitary wastewater is conveyed to the existing WWTP through sanitary sewers; stormwater is conveyed and discharged directly into receiving waters through dedicated storm sewers.

Sewer separation can essentially eliminate CSOs, but the separated stormwater still delivers a pollutant load to the receiving waters. Human fecal matter, pathogens, bacteria, BOD, and associated floatables are generally contained in the SSS, while untreated stormwater conveys potentially more heavy metals, sediments, and nutrients to receiving waters. Separated stormwater also conveys fecal matter, pathogens, and bacteria from non-human sources such as dogs, geese, and other wildlife to receiving waters.

Sewer separation can be performed at various levels of "completion" as follows:

- Downspout Disconnection: disconnection of downspouts (roof leaders, see Section 7.3.12) and diversion to pervious areas.
- Partial Separation: sewer separation occurs in the streets or sewer easements through the construction of a new SSS, in which case the existing collection system would function as a storm sewer after the completion of construction; or the construction of a new storm sewer system, in which case the existing collection system would function as an SSS after the completion of construction. Each approach has its advantages and disadvantages. If a new SSS is constructed, it is necessary to disconnect all house connections from the existing sewer, and reconnect with the new sewer; and it may actually be necessary to construct new SSS for each side of the street or right-of-way, if the existing sewer conflicts with the routing of house connections and hydraulic requirements. If a new storm sewer is constructed, it is necessary to disconnect all curb inlets and catch basins from the existing sewer and reconnect with the new sewer. The use of an existing CSS for sanitary flow only is also a disadvantage in that flow conditions will not be optimal, and the periodic flushing caused by wet weather flow will no longer occur. The approach taken for sewer separation must be carefully evaluated to be suitable and cost-effective for the drainage area under consideration.
- Complete Sewer Separation: Partial separation in streets or right-of-way plus downspout disconnection plus removal of private sources of stormwater runoff and inflow, including disconnection of foundation drains and sump pumps.

Costs, benefits, the level of community disruption, and utilities relocations for sewer separation depend on the level and extent of sewer separation. Sewer separation is more appropriate when most sewers are already separated, siting constraints and costs prohibit using other CSO control technologies, receiving stream uses prohibit other types of CSO controls, other CSO strategies are not publicly acceptable, additional infrastructure improvements such as street paving are required independent of sewer system modifications, the CSS is undersized, elimination of CSOs is desired, and/or other CSO measures are not able to achieve the community's goals. Complete separation can be performed on a system-wide basis or in targeted areas, or partial separation can be used in conjunction with other CSO controls.

7.3.11 Stream Diversion

In some cases, small streams that have previously been routed into combined sewers carry stormwater surface runoff that reduces capacity of the CSS and contributes to overflows. Rerouting these streams and their corresponding surface runoff to pervious areas, receiving streams, or to areas that have separate storm sewers can have a major impact on the sewer capacity. Stream diversion is considered unlikely in the City for CSO control because major areas with separate storm sewers do not exist in the CSS area and there are few, if any, non-CSO receiving streams.

7.3.12 Roof Leader Disconnection

Disconnection of roof leaders is a relatively simple and low-cost technique for reducing inflow. It is generally most effective in residential areas where houses are detached, yards are sufficiently large to accommodate increased overland flow, and soils have relatively high infiltration rates. In order for a roof leader disconnection program to be successful, the public must be educated about the benefits of disconnection and methods for implementing the program. This can be time-consuming and may require some type of rebate program or other incentive for compliance. Communities that have experimented with voluntary disconnection programs found that approximately 20 percent of property owners are willing to participate. In addition, because the effect per individual roof leader is small, this program must be implemented with broad participation across entire neighborhoods in order for there to be a discernible reduction in sewer system flow.

Roof leader disconnection is considered a viable method to aid in the reduction of CSOs, basement backups, and SSOs in the City.

7.3.13 Best Management Practices

Stormwater is the water that runs off surfaces such as rooftops, paved streets, highways, driveways, and parking lots. Stormwater can also come from hard grassy surfaces such as lawns, playgrounds, athletic fields, and gravel roads. Better stormwater management helps to reduce flows to the collection system and to reduce pollution loads. Best Management Practices involve strategic application of site design principles, construction techniques to prevent sediments and other pollutants from entering surface or ground water, source controls, and treatment of runoff to reduce pollutants.

Best Management Practices help control nonpoint source pollution using nonstructural and/or structural techniques to intercept surface runoff from developed areas and filter and treat this runoff, and then discharge it at a controlled rate. Activities such as increasing permeable paving surfaces; allowing thick vegetation (or buffer strips) to grow alongside waterways to filter and slow runoff; and planting more trees, shrubs, and groundcover; all minimize stormwater runoff.

Plants, trees, shrubs, and groundcover absorb many times more rainwater than grass lawns and they do not require fertilizer. Limiting harmful materials such as oil, pesticides, fertilizers, nutrients, and sediments through stormwater management provides positive impacts to area streams, rivers, and other surface water.

7.3.14 Green Solutions

Green solutions are practices and site-design techniques that store, infiltrate, evaporate, or detain stormwater runoff and in so doing, control the timing and volume of stormwater discharges from impervious surfaces (e.g., streets, building roofs, and parking lots) to the sewer system. Another benefit of green solutions is they also improve stormwater quality. Controlling the timing and volume of stormwater discharges can be an important component of a program to control CSOs.

Examples of green solutions include:

- Porous Pavement – Porous pavement is an infiltration system in which stormwater runoff infiltrates through or is stored below a permeable layer of pavement or other stabilized permeable surface. The use of porous pavement reduces or eliminates impervious surfaces, thus reducing the volume of storm water runoff and peak discharge volume generated by a site.
- Green Roofs – Green roofs use rooftop vegetation and underlying soil to intercept storm water, delay runoff peak, and reduce runoff discharge rates and volume. Their use can lead to reductions in the volume or occurrence of CSOs.
- Bio-retention – Bio-retention (rain garden) is a soil and plant-based stormwater management practice used to filter and infiltrate runoff from impervious areas such as streets, parking lots, and rooftops. Bio-retention systems are essentially plant-based filters designed to mimic the infiltrative properties of naturally vegetated areas, reducing runoff rates and volumes.
- Rain Barrels – A rainwater collection system consisting of a barrel, typically 50 to 60 gallons, is placed at the end of a roof leader, and used to capture and store runoff from rooftops for later use.
- Constructed Wetlands – Engineered and constructed wetlands or marshes are designed to store stormwater runoff and use natural processes to improve water quality. Constructed wetlands can be used to attenuate peak stormwater flows to the CSS or to discharge treated stormwater to receiving waters. Although constructed wetlands can provide significant storage volume and a measure of water quality treatment, they require substantially larger area than equivalent, standard treatment facilities.
- Vegetated Buffers – Vegetated buffers consist of a strip of vegetation located around sensitive areas and receiving waters, designed to provide infiltration and attenuate peak stormwater flows.
- Streetscapes – Streetscapes can be modified to capture and attenuate stormwater flows. Streets can be modified by adding swales, bio-filters, infiltration basins, porous pavement, and other “green” features.
- Water Conservation – Water conservation is the efficient use of water in a manner that extends water supplies, conserves energy, and reduces water and wastewater treatment expenditures. Reducing water use can decrease the total volume of domestic sewage conveyed by a sewer system, which can increase conveyance and treatment capacity during periods of wet weather and potentially reduce the magnitude, frequency, and volume of CSOs and SSOs. Water can be

conserved in a number of ways, including use of water-efficient fixtures and appliances, rainfall capture, water reuses, and use of waterless technologies.

7.3.15 Industrial Pretreatment

Industries generate and contribute large amounts of industrial wastewater to CSSs. The pollutants from industries can disrupt the normal operating procedures of WWTPs. The development of, and adherence to, pretreatment requirements reduces the amount of industrial wastes in CSOs and allows the collection system to operate more efficiently. The WSD's Industrial Waste program encourages pollution prevention, as well as waste pretreatment. As noted in WSD's NMC Plan, most restaurants and many industries are inspected each year.

Monitoring the amount and characteristics of industrial wastes is necessary to implement the appropriate pretreatment requirements uniformly. Providing broad programs of incentives and publicly recognizing successes can also increase industrial pretreatment. Metals such as lead, mercury, chromium, and cadmium that cannot be broken down naturally or in normal treatment, are handled in industrial pretreatment. Toxic organics such as pesticides, dioxins, and solvents are also pretreated before released to the CSS.

7.4 Collection System Controls

Collection system controls can be accomplished through a number of similar and potentially simultaneous activities to optimize use of the sewer system. Diversion structure consolidation, along with static, variable, and/or real-time flow control measures, can optimize CSS performance. These techniques minimize both overflow frequency and volume by consolidating, adjusting, and distributing flows to the interceptor sewers to maximize conveyance and retention. Improvements can range from minor weir modifications to installation of completely automated systems (diversion structures, back flow [river flooding] prevention gates, monitoring, and real-time control [RTC] devices). Specific control measures are described below.

7.4.1 In-Line Storage

In-line storage (ILS) uses the capacity of existing pipes in the CSS to temporarily store wet weather flows caused by rain events. After rain events, stored combined sewage is released for conveyance to a treatment facility. Generally, using the existing sewer system makes ILS an attractive alternative to off-line storage systems such as storage tanks and tunnels. However, depending on the sewer slope and dimensions and the slope of incoming pipes, ILS could be undesirable in certain locations because raising the hydraulic gradeline could result in basement back-ups and street flooding.

ILS is generally accomplished through the use of static flow control devices or structures, or adjustable devices or structures. ILS has the advantages of using existing facilities, requiring small amounts of land, and being effective for small localized rain events. The disadvantages of ILS are that it increases the potential for sewer and basement back-ups; it has the potential to cause nuisance odors; and unless the sewers are large and on a shallow slope, it typically will be less effective for capturing large volumes of combined sewage.

7.4.1.1 Static Flow Control

Static flow control involves measures or structures that have no moving parts and, once constructed, are not readily adjusted. These measures or structures include fixed weirs, restricted outlets, swirl concentrators, and vortex valves. Static flow control involves retaining and controlling overflow volumes and quality.

Static flow control devices are widely applicable for CSO control and are typically used for the diversion of flows to CSO treatment facilities, to control flow out of various storage facilities, and to replace less reliable mechanical regulators. The advantages of the various static flow control measures vary. For vortex valves, the discharge opening is larger than other standard openings with the same discharge rate; therefore, limiting the risk of blockage. Since static flow regulating devices are not adjustable, they do not respond to variations in local flow conditions.

7.4.1.2 Variable Flow Control

Variable flow control devices include inflatable dams, tilting plate regulators, reverse tainter gates, and other motor or hydraulically operated gates. Variable flow control can involve using such devices to limit flows to the interceptor and use existing capacity of trunk sewers to temporarily store combined sewage during rainfall events, while still conveying the maximum dry weather capacity. When not in use, the devices allow flows to proceed normally, but during rain events the devices can be used to optimize system storage and reduce overflows. For example, inflatable dams can be used to restrict flow in an outfall conduit or combined sewer trunk; inflatable dams can also be installed upstream to create in-system storage.

When maintained and inspected regularly, variable flow control systems can be effective in helping regulate flow. When effective in limiting CSO events, pollutants discharged to the environment, such as turbidity, harmful nutrients, and metals, are reduced. Since variable flow control devices are adjustable, they can respond to variations in local flow.

7.4.2 Real-Time Flow Control

Real-time flow control (RTC) is a form of variable flow control in which an integrated system consisting of flow sensors, mechanically adjustable flow control facilities (gates and pumps), and a SCADA (Supervisory Control and Data Acquisition) system. RTC is used to make operating decisions to maximize collection system storage, treatment, and transport capacities in a coordinated fashion on an area-wide basis. By redirecting flows to underutilized parts of the sewer network, the capacity of the sewer system is increased and the magnitude, frequency, and duration of CSOs can be reduced. RTC can also decrease the need for and capacity requirements of expensive underground storage tanks and tunnels. As with any plan for improving in-line storage, for RTC to be most effective, a CSS should have relatively flat slopes with upstream storage and downstream interceptor capacity.

Computer models associated with the RTC systems allow an evaluation of expected system response to control commands before execution. Localized RTC are used to maximize storage in sub-basins and prevent flooding; system-side controls are used to coordinate operation of sub-area controls to achieve system-wide control objectives.

7.4.3 Diversion Structure Consolidation

Diversion structure consolidation is the process of eliminating overflow structures through consolidation of piping. Diversion structure consolidation can reduce the complexity of the CSS by reducing the number of outfalls through which CSOs are discharged, and in some cases, diversion structures are removed. Consolidation is most applicable to groups of diversion or flow-regulating structures that are relatively close together and is far less applicable to structures that are scattered or separated by large distances.

Consolidation can be accomplished by combining existing outfall conduits and routing them to a single outfall pipe or new diversion structure. It can also be achieved by combining pipes upstream of existing diversion structures and routing them to a new master diversion structure through a new, larger-diameter sewer.

Based upon national experience, diversion structure consolidation can reduce CSO overflow loads to the environment by up to 30 percent. Consolidation typically results in lower maintenance costs, easier and better monitoring of CSO events, and fewer overflow events during smaller rain events.

7.5 Storage

Storage is an alternative in which combined sewage that would otherwise overflow to receiving waters is collected and stored during wet weather events, and then it is conveyed to treatment facilities during or after the rain event. Storage is often the best method for reducing or eliminating large volumes of CSOs caused by wet weather events. In addition to minimizing water quality impacts and attenuating peak flows, CSO storage facilities can eliminate or reduce sewer back-ups, reduce capacity requirements for treatment facilities, and improve efficiency and effluent quality at treatment facilities. Major storage concerns include managing flows to and from the retention facilities, preventing combined sewage from becoming septic, and removing accumulated solids and floatables. Specific types of storage facilities are described below.

7.5.1 Earthen Basins

Earthen basins can provide an effective means for CSO storage. The basins are typically shallow in depth, ranging from four to 12 feet; are uncovered; and include some type of synthetic liner to prevent exfiltration. Earthen basins are generally used away from populated areas and where open land is readily available. Major advantages of this alternative include low capital and O&M costs and simple operation. Disadvantages include the large land requirements not normally available in urban areas, adverse aesthetic impacts, and the need for odor control.

7.5.2 Concrete Tanks

Concrete tanks, the most commonly used type of storage facility, can be constructed either above ground or underground, with or without covered tops. When the tanks are equipped with a sludge removal and collection mechanism, they can be used as a sedimentation basin.

Concrete tanks have the advantages of being relatively simple to operate and maintain, and having dual capabilities for storage and sedimentation. Though limitations include the requirement of moderate amounts of land, storage tanks can be an attractive component in a larger CSO abatement program in which several methods are used. Covered basins are widely used and provide better odor control and safety conditions than uncovered basins. Screens and disinfection equipment are sometimes added to those storage facilities designed to discharge directly to receiving waters.

Concrete tanks have broad applicability and can be adapted to many different site-specific conditions by changing the basin size (volume), layout, proximity to the ground surface, type (inlet or outlet), and, where required, disinfection facilities. They are particularly applicable in areas where land is readily available and the disruption due to construction will be minimal. The adaptability of these storage facilities has led to their use throughout the country. The flexibility of the basin design makes concrete tanks practical in most areas, including for the City.

7.5.3 Storage Conduits

Storage conduits utilize storage in series with the sewer. In-line storage can be developed in two ways: (1) construction of oversized conduits to provide storage capacity or (2) construction of a flow regulator to optimize storage capacity in existing conduits. The new oversized conduits are designed to allow dry weather flow to pass through, while wet weather flows are restricted, causing the oversized conduit to fill. A flow regulator on an existing conduit functions under the same principle, with the existing conduit providing the storage volume.

The applicability of in-line storage, particularly the use of existing conduits for storage, is very site-specific, depending on existing conduit sizes and the risk of flooding due to an elevated hydraulic grade line.

Storage is often the best measure for attenuating peak CSS flows caused by wet weather events. In-line facilities capture and store portions of the excess combined sewage that would otherwise overflow. The major concerns include managing flows to and from the conduits, preventing the combined sewage from becoming septic, and removing accumulated solids and floatables.

7.5.4 Storage Tunnels

Storage tunnels capture and store portions of excess combine sewage that would otherwise be diverted to receiving waters during wet weather events. Stored flows are then typically pumped back to the CSS during periods of dry weather for conveyance to treatment facilities. This technology provides storage and conveyance of wet weather flows in large tunnels constructed deep beneath the ground surface. Tunnels can provide large storage volumes with minimal disturbance to the ground surface and subsurface utilities and infrastructure. Flows are conveyed to the tunnel through dropshafts. Pumping facilities are typically required at the downstream end to convey the stored combined sewage to a treatment facility.

Deep tunnel storage is especially applicable to areas of dense development that would involve large excavation or land acquisition costs. In addition to minimizing water quality impacts and attenuating peak flows, large storage tunnels can eliminate or reduce sewer back-ups, reduce treatment facility capacity requirements, and improve existing efficiency and effluent quality at treatment facilities. Major operational concerns include managing flows to and from the tunnel, preventing the combined sewage from becoming septic and removing accumulated solids and floatables.

Tunnels are primarily implemented as controls in CSSs, but have had some application in SSSs. As their name implies, deep tunnels are typically located 100-400 feet below ground. Tunnel diameters usually range from 10 to50 feet, and can be several miles in length. Construction usually requires large tunnel boring machines. Most deep tunnels are built in hard rock, but some have been built in unconsolidated material. Lining the tunnel with concrete or other impermeable material to prevent infiltration and exfiltration is required in unconsolidated material, and is recommended for hard rock. Stored flow is typically conveyed from deep tunnels to a treatment facility during and after wet weather events, as capacity becomes available.

Tunnels have been used as part of CSO control plans in large cities, including Chicago, Cleveland, Portland, and Milwaukee, and are considered to be suitable for use in the City.

7.6 Physical/Chemical Treatment

Physical processes were some of the earliest methods to remove solids from wastewater, usually by passing wastewater through screens to remove debris and solids. In addition, solids that are heavier than water will settle out from wastewater by gravity. Particles with entrapped air float to the top of water and can also be removed. These physical processes are employed in many modern WWTPs today.

Chemicals can be used to create changes in pollutants that increase the removal of these new forms by physical processes. Simple chemicals such as alum, lime, or iron salts can be added to wastewater to cause certain pollutants, such as phosphorus, to floc, or bunch together, into large, heavier masses, which can be removed faster through physical processes. Over the past 30 years, the chemical industry has developed synthetic inert chemicals, known as polymers, to further improve the physical separation step in wastewater treatment. Polymers are often used at the later stages of treatment to improve the settling of excess microbiological growth or bio-solids.

Specific physical/chemical treatment technologies are described below.

7.6.1 Swirl Concentrators

Swirl concentrators are devices that impart a swirling motion to the incoming combined sewage stream, thereby separating solids. Solids are concentrated and removed through an under-drain while the treated effluent passes over a weir and exits the concentrator. The swirl concentrator can also function to regulate flow by restricting the discharge from the device. Each swirl concentrator may have different dimensions and may include various configurations of baffles and pipe arrangements to maximize removal of suspended solids. Grit and some primary solids are caught in the boundary layer of the tank wall and fall into a pit in the tank floor for vacuum or pump removal after a rain event. Flow exits the tank through a pipeline extending to the center of the tank. Screening is sometimes added at the discharge point to exclude floatables from the effluent.

If solids and floatables removal is desired and there is adequate hydraulic head available, the swirl concentrator is applicable. Swirl concentrators can be sized for minimal grit and screenings removal with high surface loading rates; or surface loading rates can be lowered such that primary sedimentation quality effluent may be achievable. The detention time in the concentrator can be used to contribute to contact time for disinfection processes. In more sophisticated designs, or where on-site solids handing and treatment are available, grit and solids can be withdrawn to a solids handling pump station. There, the material can be de-gritted and sent to thickeners, treatment, dewatering, and/or transported to a remote solids handling facility.

Proper operation and good performance of a swirl concentrator is very dependent upon the rate of flow at the site. Swirl concentrators can operate without moving parts and entirely by gravity, given proper site and hydraulic conditions. The major advantages of swirl concentrators are a high overflow rate with a small footprint and passive operation without moving parts. However, the reported performance data indicates that solids removal by swirls concentrators can be inconsistent.

7.6.2 Vortex Separators

Vortex separators are devices based on the swirl concentrator concept and use the vortex principle to move settleable solids to the bottom center of a circular chamber. The settled solids are continuously removed from the bottom at a low rate. Spacing in the internal components of the vortex separators can limit the upward size of particles entering the device. Wastewater enters the circular vortex separator on a tangent imparting a swirl to the contents. A motorized paddlewheel maintains organics in suspension while baffles help create a boundary layer wherein grit is trapped and routed to a sump for subsequent removal via pumping. Surface loading rates vary widely and pretreatment for screenings and large particle removal is required. Organics and screenings removals are minimal.

Proper operation and performance of vortex separators is very dependent upon the rate of flow of the combined sewage at the site. Vortex separators are typically optimized for fine grit removal ahead of pumps, tanks, and mechanical equipment that might otherwise be damaged from fine sands, but they can also be very effective in the removal of large suspended solids. For certain flow rates, removal of suspended solids can be up to 50 percent; and performance can be enhanced with the addition of dissolved air floatation.

7.6.3 Primary Sedimentation

Primary sedimentation devices include clarifiers and sedimentation basins or tanks. Primary sedimentation basins produce clarified effluent by relying on low, relative flow rates (low velocities) to allow time for suspended solids to settle out by gravity before treated water is discharged. Primary sedimentation is a common and accepted unit operation for wastewater treatment. Off-line storage facilities, such as storage tanks, can function as primary sedimentation facilities and provide a measure of treatment during periods when flows exceed storage capacity. Settled solids must be removed and collected, requiring significant maintenance.

The performance of primary sedimentation facilities can be enhanced by the use of chemical additives such as lime, alum, ferric chloride, and polymers. The detention time provided by primary sedimentation facilities can also contribute to contact time for disinfection processes.

7.6.4 Flocculation/Sedimentation

Primary sedimentation with chemical addition results in flocculation, and improved removal of suspended solids. The addition of chemicals helps form particles known as floc. These particles form by suspended solids attaching to the chemicals that are added to the basin. The particles coalesce, become larger, and settle out more quickly from the water column, thereby increasing removal efficiency.

7.6.5 Dissolved Air Flotation (DAF)

Dissolved Air Flotation (DAF) removes solids from wastewater by introducing fine air bubbles into the waste stream. The dissolved air bubbles float to the surface and attach to small particulate solids. The collected solids are then skimmed off of the surface of the wastewater. DAF is useful for the removal of light solids that are difficult to settle, and operate at higher hydraulic loadings with shorter detention times than for conventional primary sedimentation This results in a greatly-reduced facility footprint when compared to conventional sedimentation facilities. In addition, oil and grease are more readily removed by DAF than by primary sedimentation. Removal rates for suspended solids of up to approximately 43 percent have been reported.

7.6.6 Dissolved Air Flotation (DAF) with Polymer Addition

This process is the same as dissolved air flotation, except that chemicals (polymer and ferric chloride) are added to enhance solids removal. Chemical addition results in more efficient removals than achieved just through DAF, but with increased costs because of the chemical (polymer) addition. DAF with polymers can be used in the same applications as can DAF alone. Removal rates for suspended solids of up to approximately 71 percent have been reported.

7.6.7 High-Rate Filtration (HRF)

The high-rate filtration process involves using filters composed of various layers of sand and anthracite coal to filter the wastewater. As an example, a two-layer bed may consist of a layer of coarse anthracite particles on top of a finer bed of sand. As the wastewater passes through the layers of anthracite and sand, particles suspended in the wastewater then attach to the coal and sand particles. Filters are periodically backwashed to remove accumulated solids.

High-rate filtration removes most of the moderate size suspended solids in the water. To remove some of the smaller suspended solids, chemicals must be added to make the particles larger. High-rate filtration facilities typically have a much smaller footprint than conventional sedimentation facilities. High-rate filtration is effective for the removal of suspended solids, but a disadvantage is that the large volumes of backwash water and solids require further treatment.

7.6.8 Flocculation/High-Rate Filtration

This process is the same as high-rate filtration, with the addition of chemical coagulants. The added chemicals begin forming particles known as floc, composed of the chemical and solids removed from the wastewater. The floc tends to remove smaller particles that cannot be removed by the conventional high-rate filtration. As the floc gets larger by accumulating suspended solids, it is removed from the wastewater by the filter materials.

This process is applicable to areas requiring the removal of smaller suspended solids. Flocculation/high-rate filtration does a reliable job of removing many of the smaller suspended solids that filtration would not. Flocculation/high-rate filtration facilities also have a much smaller footprint than conventional sedimentation facilities and remove more solids than other high-rate filtration processes.

7.6.9 Ballasted Flocculation

The ballasted flocculation system (High-Rate, Physical-Chemical Treatment) is a chemical process for enhanced reduction of suspended solids and biochemical oxidation demand (BOD). Fundamentally, the process is very similar to conventional coagulation, flocculation, and sedimentation systems used in water treatment plants.

A coagulant is used to destabilize suspended materials entering the process and a flocculation-aiding polymer is added to aggregate solids into larger masses. The resulting floc is removed by settling. The ballasted flocculation system enhances this process by adding microsand (fine sand similar to silica powder) as seed for developing high-density floc, which is ballasted by the relatively high-density microsand and more easily removed by settling. The benefit of the ballasted flocculation process is the ability to achieve good solids removal performance at a very, high-surface overflow rate. The process can be rapidly started and optimized even with variations in flow and water quality.

De-gritting may be incorporated as part of the process in the coagulation stage; and a disinfection facility can be added to treat the effluent of the process. The compact size of ballasted flocculation units makes them particularly attractive for retrofit and high-rate applications. This technology has been applied both within traditional treatment trains and as overflow treatment for peak wet weather flows.

The two major manufacturers of high-rate, physical-chemical treatment systems are Infilco Degremont, Inc., and US Filter. Infilco Degremont manufactures the DensaDeg process. This process requires upstream screening and uses settled solids from the system in the flocculation process. In the United States, a number of DensaDeg pilot facilities have been operated in recent years, and removal rates for suspended solids of 80 to 95 percent can be expected, depending on overflow rates and chemical dosages. The DensaDeg process takes approximately 30 minutes to reach optimal operation from start-up time.

US Filter manufactures the Actiflo process, which uses a fine sand as part of the coagulation and flocculation processes. Upstream screening is necessary, but the process can tolerate the presence of grit. In the United States, there have been a number of pilot tests of the Actiflo system for CSO application. Removal rates for suspended solids range from 80 to 95 percent depending on overflow rates and chemical dosages. The Actiflo process is reported to take approximately 15 minutes to reach optimal removal rates after start-up.

7.6.10 Biological Treatment

Biological treatment utilizes naturally occurring bacteria to stabilize dissolved organic matter and remove non-settleable colloidal solids Typical biological processes include activated sludge, trickling filtration, and rotating biological contactors.

Biological treatment is usually preceded by physical processes such as screening, grit removal, and primary sedimentation to remove debris and heavy solids. At WWTPs, biological treatment removal rates are typically 70 to 95 percent for both biochemical oxygen demand and suspended solids. However, because CSOs occur intermittently, with highly variable flows, the use of biological treatment for remote, end-of-pipe facilities generally is not practical. This is because biological processes perform poorly when treating rapidly-fluctuating flows and shock loads. In order to be viable for CSO treatment, biological treatment facilities would require upstream storage/detention and primary treatment facilities. Therefore, use of biological processes is generally limited to facilities integrated with or as part of dry-weather treatment facilities.

7.6.11 Disinfection

Disinfection is a process to kill and control the level of pathogenic microorganisms in discharges to receiving waters. In conventional WWTPs, disinfection is typically performed using chlorine gas or sodium hypochlorite. Contact time for the process varies based on the necessary kill rate, but a minimum of 15 minutes at peak flow is a common design criterion. Disinfection capability has been included in many CSO abatement facilities in the United States. Disinfection of combined sewage usually involves one of three processes: chlorination/dechlorination, ultraviolet radiation, or ozonation. Other oxidizing agents that can be used as a substitute for chlorine include chlorine dioxide and peracetic acid. At appropriate dosages and contact times, disinfection systems can remove most total coli form bacteria. However, to be cost-effective, disinfection should generally be applied after solids are removed from the CSS. Critical criteria associated with selecting the most effective disinfection technology include: effectiveness, public safety, aquatic toxicity, applicability to low quality effluent, required contact time, permit limits, and cost. Disinfection generally must be used in coordination with other primary removal treatment technologies to be effective. Chlorination and dechlorination, ultraviolet disinfection and ozonation are discussed in more detail below.

7.6.11.1 Chlorination/Dechlorination

Chlorination has been used since 1855 to disinfect wastewater and is the most common disinfection technology. It is widely applied because chlorine is available in several forms, is relatively inexpensive, and is effective against bacteria. Although disinfection is intended to protect human health, chlorination can create serious issues for communities, operators, and aquatic ecosystems. Chlorination results in high chlorine concentrations in the effluent that can deliver toxic by-products and unused chlorine to receiving waters. Due to more strict regulations, dechlorination of the effluent is often necessary. Dechlorination typically involves adding sodium bisulfite to the treated effluent after the chlorine has had sufficient contact time with the wastewater. Dechlorination typically adds approximately 30 percent to the cost of chlorination.

7.6.11.2 Ultraviolet Disinfection

Ultraviolet (UV) disinfection involves rendering bacteria inert and therefore incapable of reproducing through the use of ultraviolet radiation generated by lamps. Ultraviolet disinfection is commonly used to disinfect wastewater and drinking water. Its safety and other advantages make it potentially useful for disinfecting CSOs. UV systems can result in nearly complete reduction of pathogens, have no disinfection by-products, and do not involve the use of dangerous chemicals. Because UV depends on light penetration, it has limited ability to treat combined sewage unless the majority of the suspended solids are removed prior to disinfection. Ultraviolet disinfection effectiveness tends to decrease at total suspended solids (TSS) concentrations above 150 mg/l. In addition, grease and solids can foul the lamps, thereby reducing effectiveness. Further, some form of flow equalization may be needed to handle peak rates.

7.6.11.3 Ozonation

Ozone is a strong oxidizing gas that can be used to disinfect wastewater. Its use in CSO treatment facilities for wastewater disinfection is relatively new in the United States and there are few facilities currently using ozone for disinfection. This can be potentially attributed to high initial capital costs and power costs associated with ozone generation equipment. Ozone is equal or superior to chlorine in "killing" power, but unlike chlorine, it does not cause the formation of halogenated organics. Ozone disinfection is similar in most respects to chlorine disinfection. The major difference is that ozone is unstable, so it must be generated on site. Dosage is approximately 1 to 10 mg/l with contact times of 15 minutes or less, depending upon wastewater characteristics.

7.6.12 Solids and Floatables Control

Floatables control technologies are designed to reduce or eliminate the floating, visible, solid waste and debris often present in CSO discharges. Floatables control technologies can include screens, netting, baffles, containment booms, skimmer vessels, and catch basin modifications. These technologies are discussed in more detail below.

7.6.12.1 Screening

Screens are an effective and economically-efficient method of removing solids and floatables from CSO discharges. The amount and size of the solids and floatables collected is a function of the screen type and its corresponding opening size. Screens are typically constructed of parallel steel bars or wire mesh, grating, or perforated plate having slot sizes ranging from 0.1 inches to 6 inches in width. Coarse screens are typically constructed of parallel vertical bars and are cleaned manually or by an electrically- or hydraulically-driven raking mechanism.

Trash racks are types of coarse screens designed to remove only very large objects from the flow stream. Fine screens typically follow coarse screening equipment and provide the next level of physical treatment in removing solids with slotted openings ranging in size from 0.01 inches to 0.5 inches. Fine screens are typically made of stainless steel and solids are normally discharged by gravity or washing. A mechanical fine screen can be a rotary screen in which a drum rotates allowing liquids to pass through but trapping solids. Self-cleaning screens include chain driven, climber type rake, and catenary screens.

Screening is widely used to limit solids and floatables at WWTPs. Screening is also used at CSO facilities across the country. Screens that are large in size and self-cleaning are most effective for removing solids and floatables control. The removal efficiency is a function of the screen opening size and solids size.

7.6.12.2 Netting Systems

Netting systems are designed to reduce or eliminate the amount of visible solid waste that is often discharged to receiving streams during CSO events. These systems are end-of-pipe systems that utilize the passive energy of the effluent stream to push floatables into nets or modular disposable mesh bags. Sites that are considered for these types of installations should be accessible by roads capable of easily accommodating medium-sized trucks and maintenance crews. In addition, the site topography should allow for using a crane to install and remove nets. The system should also be located in water with depth of at least 3 feet, in an area clear of rocks and debris, away from heavily navigated waterways, and away from areas with strong currents or heavy wave action. Nets are effective at removing floatables and solids but must be inspected and serviced frequently.

7.6.12.3 Other Floatables Control Technologies

Baffles are simple plates typically installed in diversion structures that extend from the top of the structure to below the crest of a weir in the structure. Catch basin modifications can include hoods, submerged outlets, and vortex valves. Containment booms float on the water surface and can trap oil, grease, and other items floating on the water surface. Similarly, skimmer vessels are boats specifically designed to pick up floating debris using booms.

The effectiveness of baffles typically depends on the design of the diversion structure. Containment boom efficiency can range from 60 to 90 percent, depending on receiving water velocity and CSO flows. Hooded catch basins can retain approximately 85% of the litter delivered to them, versus 30% in un-hooded basins. Continued effectiveness depends on an adequate catch basin cleaning program.

* * * * *

8 IDENTIFICATION AND EVALUATION OF TECHNOLOGIES – BASIN-SPECIFIC ALTERNATIVES

8.1 Introduction

The Overflow Control Plan (the Plan) was developed by the City of Kansas City, Missouri (the City) Water Services Department (WSD) Overflow Control Program (OCP). In creating the Plan, the OCP initially developed basin-specific alternative. Physical characteristics, measured flow/quality data, mathematical model runs, preliminary system capacity allocations (such as interceptor sewer conveyance) and available technologies were considered for each combined sewer basin. This major first step in alternatives development also acknowledged and considered input from the various citizen panels. Subsequent activities modified the initial basin-specific recommendations in order to take full advantage of system-wide characteristics and to meet varying water quality requirements (see chapter 10).

The initial basin-specific alternatives are contained in the alternatives analysis technical memoranda prepared by engineers responsible for basin-specific planning. The OCP provided guidance and coordination (as needed) during alternatives development. The technical memoranda can be found in Appendices B and C.

8.2 Technology Screening Worksheets

As described in Chapter 7, many wet weather control technologies have been developed and applied in communities across the country. These technologies can address both combined sewer overflow (CSO) and separate sewer overflow (SSO) issues.

The OCP provided a technology screening worksheet template, which:

- Listed (vertically) all the technologies described in Chapter 7, along with certain the Nine Minimum Controls (NMC; identified in the United States Environmental Protection Agency's (USEPA) CSO Control Policy) and particular City concerns (public education and voluntary property buyouts).
- Provided adjacent columns for quantitative or qualitative values or comments: as follows (see Table 8-1 for application guidance and components for quantitative scores related to Performance, Neighborhood Impact, Safety and Implementation/Operation):
    - Eliminate (Yes or No)
    - Utility (H, M, L)
    - Cost ($$$, $$, $)
    - Performance Score
    - Neighborhood Impact Score
    - Safety Score

- Implementation/Operation Score
- Total Score
- Consider for Widespread Use
- Consider for Localized Use
- Consider for Interim Use
- Eliminate from Further Consideration
- Comments

The template and associated guidance provided a standardized approach for evaluating and screening potential wet weather solution technologies.

As part of the public input process, Basin Coordinating Committees were organized to educate and plan at the basin level. Four planning meetings, plus an open house, were held for each of eleven basins, totaling nearly 60 basin public input and planning meetings (see chapter 9). Over 200 participants were involved in these planning meetings, which were held in 2006 and 2007. These planning meetings helped develop the "weighting factors" for each criterion. These weighting factors provided a means for quantifying public priorities. Table 8-2 summarizes the relative importance that was assigned by the coordinating committees to the various considerations identified.

Significant findings from the Basin Coordinating Committee process include:

- Citizens' desires varied by basin
- Citizens are more interested in sewer back-ups and flooding than overflows
- Citizens are concerned about how to pay for improvements
- Public education is working – more people know they live in a watershed and that stormwater runoff is a principal contributor of pollutants in the City's streams, lakes, and rivers

Input from the community suggests that the top five public concerns related to overflow control are:

1. Frequency of untreated discharges
2. Runoff volume
3. Human health & safety
4. Street flooding and damage to structures
5. Protection of environmental resources

Table 8-1 - OCP Guidance for Screening and Ranking of Technologies

OBJECTIVE: Determine preferred technologies from the available control technologies identified.

The screening process, which is done in a matrix format, involves:

1. Defining a set of screening criteria for the technologies
2. Applying a "scoring" system to each technology
3. Focusing on preferred technologies based on scoring results.

Control Technology Screening Criteria

Category	Criteria
Performance Factors *The technology will reduce:*	Water-in-basement Street flooding and damage to structures Combined Sewer Overflow volume Runoff volume Frequency of untreated discharges Wet weather flows in system Overflow suspended solids Overflow bacteria Overflow floatables/trash
Neighborhood Impacts *The technology will address and/or minimize:*	Construction period disruptions Protection of historical and cultural resources Protection of environmental resources Implementation impacts (noise, odor, truck traffic, siting, aesthetics, etc.) Multiple objectives (open space creation, recreational opportunities, etc.)
Safety *The technology is compatible with:*	Human health & safety Flora & fauna safety
Implementation and Operation Factors *The technology will:*	Enhance Nine Minimum Controls Utilize proven technology/reliability Provide flexibility (possibility of future expansion) Minimize land requirements Address constructability Be simple to operate and maintain Shorten implementation time

Table 8-1 - OCP Guidance for Screening and Ranking of Technologies (Cont)

Scoring Systems:

The initial screening of technologies is done on a qualitative basis. The scoring for each criterion is:

4 = very good/positive   3 = good/positive   2 = OK/neutral

1 = poor/adverse   0 = very poor/adverse

Weighting factors for each criterion:

Consist of four categories and will be set with Basin Coordinating Committee input:

VI = very important   D = desirable

I = important   N = neutral/not important

Numeric values of 1 to 4 are assigned to each category (4 = very important) for scoring.

Composite Scores for each category:

An average composite score is calculated for each category.

Process for scoring:

1. In the Evaluation Matrix, set weighting factors for each criterion with input from Basin Coordinating Committees.
2. Basin Engineers score each technology for each criterion.
3. If a technology has a "fatal flaw", place "X" in "eliminate" column.
4. Qualitatively assign "high", "medium", or "low" for the technology's overall perceived utility. Utility is used as a way to distinguish more desirable technologies from others that may score the same or lower. It overrides the numeric scores.
5. Qualitatively assign a "high", "medium", or "low" for the overall cost of the technology represented as "$$$", "$$", or "$", including consideration of capital and operation and maintenance.
6. Transfer utility assignments and scores to the Screening Summary worksheet. Place an "X" in the column most appropriate for use of that technology (consider for widespread, localized, interim use).
7. Upon further discussion, a technology can be eliminated from further consideration within the second worksheet. This elimination can be based on low scoring from the Evaluation Matrix or lack of likely applications.

Comments on specific technologies should be recorded during use of both the Evaluation Matrix and the Screening Summary using the reference numbers in each worksheet.

Technologies with higher relative scores, higher assigned utilities, and those considered for widespread use should be given priority for incorporation into the preliminary control alternatives.

Table 8-2 Basin Coordinating Committee Preferences, Using Weighting Factors by OCP

	Panel Members Ranking of Factor at Left					
	Very Important	**Important**	**Desirable**	**Neutral/Not Important**		
Weighting Factor =	4	3	2	1	**Total Score ***	**Relative Importance**
Performance Factors						
Reduces water-in-basement	3	10	11	1	65	13
Reduces street flooding and damage to structures	17	7	5	1	100	4
Reduces Combined Sewer Overflow (CSO) volume	14	11	0	0	89	6
Reduces runoff volume	19	7	4	4	109	2
Reduces frequency of untreated discharges	18	9	6	0	111	1
Reduces wet weather flows in system	0	12	9	1	55	20
Reduces suspended solids	4	8	7	6	60	15
Reduces bacteria	13	10	1	4	88	7
Reduces floatables/trash	1	7	12	8	57	19
Neighborhood Impacts						
Construction period disruptions	1	4	11	20	58	18
Protection of historical & cultural resources	8	10	7	7	83	9
Protection of environmental resources	16	7	4	0	93	5
Implementation impacts	7	4	11	6	68	12
Multiple objectives	12	7	5	9	88	8
Safety						
Human health & safety	17	12	0	0	104	3
Flora & fauna safety	9	4	10	5	73	11
Implementation and Operation Factors						
Enhances Nine Minimum Controls	3	7	7	12	59	17
Proven technology/ reliability	3	11	13	3	74	10
Flexibility	1	4	6	9	37	23
Land requirements	2	3	10	8	45	22
Constructability	5	5	8	9	60	16
Simplicity of Operation and Maintenance	0	11	9	10	61	14
Implementation time	0	5	13	13	54	21

* The total score is computed by multiplying the number of panel members by the weighting factor shown for the various ranking categories.

8.3 Control Technologies

A matrix was created using that listed potential improvements in the following major categories (see Table 8-3 for complete listing of individual technologies):

- Source Controls: Actions, such as street sweeping, sewer flushing, etc., that primarily impact wet and/or dry weather flow quality.
- Low-Impact Development-Retrofit Technologies: "green solutions," that are relatively low-cost, primarily on-site facilities (such as rain gardens, rain barrels, etc.) and help reduce runoff quantities that must be accommodated by the sewer system.
- Inflow Reduction Technologies: Activities, such as sewer system inflow and infiltration (I/I) removal projects, sewer separation, etc., that are intended to reduce flow quantities that must be conveyed by the piping network.
- Sewer System Optimization Technologies: Activities that maximize the use and capabilities of the existing sewer system and include diversion structure consolidation and a wide variety of in-sewer control approaches.
- Storage Technologies: Utilization of in- or off-line facilities that detain wet weather flows until sewer system capacity is restored and/or auxiliary treatment facilities can be utilized.
- Treatment Technologies: Treatment technologies (physical, chemical, and/or biological) that can be utilized to treat the wet weather flows, dependent on desired water quality goal, influent wet weather flows characteristics, available land, cost, and other considerations.
  - Physical / Chemical Treatment: Physical processes that screen debris, separate/settle solids, and/or apply high-rate processes for wet weather flow treatment. For the technologies considered, a chlorination/dechlorination system using sodium hypochlorite and sodium bisulfite solutions was included for disinfecting the effluent.
  - Biological Treatment: Existing biological treatment plants were tested (full scale) to establish wet weather treatment capabilities. Process expansions were considered to accommodate flows that can be conveyed to the plants (conveyance capacity typically exceeding currently available treatment capacity).

8.4 Control Technologies Evaluation Matrix

The Control Technologies Evaluation Matrix worksheets brought together the technologies (described in Chapter 7 and summarized above), screening criteria (shown in Table 8-1), public input regarding criteria weighting factors (shown in Table 8-2), and basin-specific knowledge in order to eliminate unworkable technologies and concentrate on those technologies with the greatest potential. Table 8-3 summarizes numerical scores for each basin for each control technology. Scores were normalized within each basin by dividing the score for each technology by the largest score given to any technology within the respective basin. This provided a measure of the relative applicability and/or sequence in which various actions might be best applied. For example, for the Middle Blue River Basin, the "Sewer Separation" technology received the largest score, at 25.8. Scores for other technologies were divided by this value and converted to percentages to illustrate their relative applicability. Other technologies receiving high ratings included "Rain Gardens" (91 percent of the maximum score), and "Rain Barrels" (90 percent of the maximum score), illustrating the perceived benefit associated with "green solutions". Three of the basins had "Pollution Prevention/Public Education" as the highest scoring activity, one basin had "Storage Conduits" as the highest scoring activity, and two others had "Storage Tunnels" as the highest scoring activity. These values were tempered with qualitative assessments related to cost, utility, and applicability to the specific area. Generally, this preliminary screening suggested that there is a preference for reducing the problem (education, removing extraneous flows, "green solutions") before proceeding to sewer separation and/or storage.

The Control Technologies Evaluation Matrix provided a generalized approach for evaluating the wide variety of wet weather solution technologies currently available. The evaluation and the applied rankings resulted in higher scores for those technologies which are low impact and inexpensive. While many technologies with the higher scores (i.e., public education, street sweeping, etc.) are useful, they would need to be coupled with other technologies in order to provide wet weather flow reductions sufficient to handle larger runoff events.

Table 8-3 shows technologies suggested for elimination for the various basins. In some instances, elimination was recommended not because a technology was inappropriate, but rather because it was considered as an integral part of other WSD functions. For example, "Pollution Prevention/Public Education" was noted for elimination (Elim) in two basins, not because it is unworkable or ineffective, but rather because those actions would logically fall within the NMC category.

Table 8-3 Screening Summary by Basin

	Middle Blue River Basin		Town Fork Creek		Brush Creek		Lower Blue River		Gooseneck Creek Basin		NEID Basin		Turkey Creek Basin	
Control Technology	Total Score	Tech score as % of max tech score	Total Score	Tech score as % of max tech score	Total Score	Tech score as % of max tech score	Total Score	Tech score as % of max tech score	Total Score	Tech score as % of max tech score	Total Score	Tech score as % of max tech score	Total Score	Tech score as % of max tech score
Source Controls														
Street Sweeping	22.0	85%	19.5	99%	23.0	95%	16.6	85%	22.6	90%	32.8	82%	26.9	74%
Construction Site Erosion Control	21.1	82%	19.3	99%	22.9	94%	16.5	84%	22.5	89%	29.8	75%	24.2	66%
Catch Basin Cleaning	22.2	86%	18.2	93%	22.1	91%	15.8	81%	21.6	86%	32.3	81%	27.0	74%
Industrial Pretreatment	19.2	74%	18.5	95%	22.3	92%	16.0	82%	21.8	87%	22.1	Elimin	19.7	Elimin
Ban Garbage Disposals	20.3	Elimin	0.0	Elimin	0.0	Elimin	13.9	Elimin	18.0	Elimin	0.0	Elimin	0.0	Elimin
Onsite Domestic WW Storage	11.7	Elimin	0.0	Elimin	0.0	Elimin	17.3	Elimin	22.5	Elimin	0.0	Elimin	0.0	Elimin
Sewer Flushing	21.1	82%	18.1	93%	22.0	91%	15.0	Elimin	20.9	Elimin	31.7	80%	26.8	74%
Pollution Prevention/Public Education	15.4	60%	19.6	100%	24.2	100%	17.8	91%	25.2	100%	27.4	Elimin	24.3	Elimin
Construction erosion and sediment control	18.9	73%	17.5	89%	21.3	88%	14.0	72%	18.9	75%	30.2	Elimin	24.7	Elimin
Catch basin maintenance	18.4	71%	17.7	90%	21.6	89%	14.6	75%	19.7	78%	31.6	79%	26.0	71%
Catch basin water quality BMPs	18.1	70%	18.5	94%	22.0	91%	13.6	Elimin	17.9	Elimin	31.6	79%	25.7	70%
Commercial/residential pre-treatment	16.6	65%	13.5	69%	16.0	66%	12.3	63%	15.6	62%	22.2	Elimin	19.1	Elimin
Stormwater detention/retention	20.3	79%	15.6	80%	17.7	73%	16.4	84%	19.6	78%	32.2	81%	27.1	74%
Disconnection of impervious areas	21.0	81%	13.1	67%	15.7	65%	19.3	99%	23.5	93%	23.7	60%	20.3	Elimin
Low-Impact Development-Retrofit														
Rain Gardens	23.6	91%	16.9	86%	20.6	85%	17.0	87%	20.2	80%	34.8	87%	31.1	85%
Stormwater Wetlands	20.0	77%	16.1	82%	19.4	80%	16.0	82%	18.4	73%	32.9	83%	28.6	79%
Rain Barrels	23.2	90%	18.2	93%	21.5	89%	17.6	90%	22.5	89%	33.8	85%	29.9	82%
Swales	21.1	82%	16.2	83%	19.6	81%	13.3	Elimin	17.6	Elimin	34.6	87%	29.9	82%
Bioretention	20.5	79%	16.1	82%	19.4	80%	12.9	Elimin	17.3	Elimin	35.0	88%	30.9	85%
Porous Pavement	21.1	82%	14.9	76%	17.7	73%	13.0	Elimin	17.0	Elimin	31.2	78%	27.6	76%
Vegetated Buffers	20.9	81%	15.1	77%	18.3	76%	14.3	Elimin	19.5	Elimin	34.5	Elimin	29.6	Elimin
Rooftop Greening	19.8	77%	13.8	71%	16.4	68%	13.2	Elimin	17.8	Elimin	33.3	Elimin	30.7	Elimin
Infiltration Trenches	21.9	85%	14.7	75%	17.4	72%	12.5	Elimin	16.5	Elimin	32.2	81%	27.9	76%
Level Spreader	20.8	81%	12.7	65%	15.4	64%	14.1	Elimin	19.2	Elimin	28.5	Elimin	24.6	Elimin
Curb, gutter, and sidewalk removal	7.9	30%	13.5	69%	15.4	64%	13.5	Elimin	17.9	Elimin	22.0	Elimin	18.8	Elimin
Voluntary buyouts	0.0	0%	14.5	74%	17.3	71%	14.4	74%	17.7	70%	33.7	85%	30.6	84%
Inflow Reduction														
Upland Stormwater Storage	21.6	84%	15.6	80%	17.7	73%	16.0	82%	19.0	75%	32.2	81%	27.1	74%
Stormwater Sumps	20.3	79%	13.3	68%	16.1	66%	14.7	Elimin	18.1	Elimin		Elimin		0%
Stream Diversion	15.9	61%	14.2	73%	16.7	69%	10.1	52%	11.1	44%	22.3	Elimin	21.1	Elimin
Sewer Separation	25.8	100%	15.6	79%	18.4	76%	12.3	63%	14.1	56%	25.9	65%	22.2	61%
Sewer System Optimization														
Diversion Structure Consolidation	14.6	56%	14.6	74%	17.3	72%	14.7	75%	20.4	81%	30.2	76%	25.9	71%
I/I Abatement	17.7	69%	16.3	83%	19.7	81%	13.4	Elimin	18.1	Elimin	23.6	59%	21.0	58%
Static Flow Control	18.0	70%	14.6	75%	17.4	72%	17.4	89%	24.2	96%	36.2	Elimin	31.8	87%
Variable Flow Control	18.5	72%	14.8	76%	17.6	72%	17.3	Elimin	23.2	Elimin	30.9	Elimin	26.6	73%
Real-Time Flow Control	19.0	74%	15.0	77%	17.8	73%	17.3	89%	23.2	92%	31.8	Elimin	29.5	81%
Storage														
Earthen Basins	15.5	60%	13.1	67%	14.8	61%	17.1	Elimin	18.2	Elimin	29.4	Elimin	25.9	Elimin
Open Concrete Tanks	15.3	Elimin	13.4	68%	15.1	62%	17.2	Elimin	18.5	Elimin	31.8	Elimin	28.3	Elimin
Closed Concrete Tanks	15.3	59%	14.5	74%	16.9	70%	18.1	93%	20.2	80%	32.6	82%	28.9	79%
Storage Conduits	15.3	59%	13.8	71%	16.0	66%	19.5	100%	23.4	93%	29.2	73%	25.8	71%
Storage Tunnels	16.8	65%	16.8	86%	19.5	81%	19.4	99%	23.1	92%	39.8	100%	36.5	100%
Physical / Chemical Treatment (all options include chlorination / dechlorination)														
Swirl Concentrator	14.4	56%	15.4	79%	17.5	72%	15.0	77%	17.5	69%	27.9	70%	22.9	63%
Vortex Separator	14.4	56%	15.4	79%	17.5	72%	15.0	77%	17.5	69%	27.9	Elimin	22.9	Elimin
Netting Systems	12.6	49%	15.4	79%	17.5	72%	13.2	Elimin	17.4	Elimin	27.6	Elimin	22.9	Elimin
Floatables Control	14.4	56%	15.4	79%	17.5	72%	13.2	Elimin	17.4	Elimin	27.2	68%	22.3	61%
Coarse Screening	14.0	54%	15.4	79%	17.5	72%	13.4	69%	16.9	67%	26.8	67%	22.2	61%
Fine screening	14.4	56%	14.5	74%	16.7	69%	14.6	75%	17.9	71%	27.5	69%	22.8	62%
Primary Sedimentation	11.6	Elimin	14.1	72%	16.2	67%	14.6	75%	17.9	71%	29.4	74%	23.9	Elimin
Flocculation / Sedimentation	11.7	Elimin	14.7	75%	16.9	70%	14.4	74%	17.6	70%	30.1	76%	24.1	Elimin
Dissolved Air Flotation (DAF)	12.2	Elimin	15.7	80%	17.8	74%	14.4	74%	17.6	70%	31.3	Elimin	25.9	Elimin
DAF with Polymer Addition	12.2	Elimin	15.7	80%	17.8	74%	14.4	74%	17.6	70%	32.1	Elimin	26.2	Elimin
High Rate Filtration (HRF)	12.2	47%	15.7	80%	17.8	74%	14.4	74%	17.6	70%	32.1	Elimin	26.2	Elimin
Flocculation/HRF	12.2	47%	15.7	80%	17.8	74%	14.4	74%	17.6	70%	32.1	Elimin	26.2	Elimin
Ballasted flocculation	12.2	47%	15.7	80%	17.8	74%	14.4	74%	17.6	70%	32.7	82%	27.0	74%
Biological Treatment														
West Side and Blue River Plants	13.5	52%	0.0	0%	0.0	0%	16.0	Elimin	20.2	Elimin	17.4	44%	25.1	69%
Wetlands Treatment	12.3	48%	0.0	Elimin	0.0	Elimin	15.6	80%	17.5	69%	0	Elimin	0.0	Elimin

A few technologies were eliminated from further consideration due to regulatory concerns, implementation issues, or aesthetics. These are presented in Table 8-4. More detailed analyses and evaluation of the individual technologies and discussions on appropriate use in respective study basins are documented in the Basin Engineers' Task 8–Preliminary Improvement Scenarios' Technical Memorandum provided in Appendix C.

Table 8-4 Technologies Eliminated from Further Consideration

Technology	Rationale for Elimination
Ban Garbage Disposals	Implementation and enforcement difficulty – engineers for all basins suggest elimination
Onsite Domestic WW Storage	Contradicts MDNR regulation for new construction – engineers for all basins suggest elimination
Earthen Storage Basins	Not desired for CSOs due to aesthetics and safety
Open Concrete Storage Tanks	Not desired for CSOs due to aesthetics and safety
Wetlands Treatment for CSO	Aesthetics and large land area requirements are problematic
Stormwater Sumps	Not desired due to regulatory issues elsewhere in the country

8.5 Preliminary Basin-Specific Alternatives in the CSS

Considering the relative ranking and applicability of CSO control technologies noted above, a set of preliminary improvement alternatives was developed for each basin in the CSS. Table 8-5 summarizes the preliminary improvement alternatives considered viable for each basin. The integration of basin-specific alternatives to form city-wide alternatives is discussed in Chapter 10.

Table 8-5 Basin-Specific Alternative Improvement Scenarios for CSO Basins

	Turkey Creek Basin			**NEID Basin**		**Gooseneck & Lower Blue Basins**				**Brush & Town Fork Creek Basins**			**Middle Blue River Basin**		
Control Technology	Alt 1	Alt 2	Alt 3	Alt 1	Alt 2	Alt 1	Alt 2	Alt 3	Alt 4	Alt 1	Alt 2	Alt 3	Alt 1	Alt 2	Alt 3
Source Controls															
Street Sweeping															
Construction Site Erosion Control															
Catch Basin Cleaning															
Industrial Pretreatment															
Ban Garbage Disposals															
Onsite Domestic WW Storage															
Sewer Flushing															
Pollution Prevention/Public Education															
Post construction erosion and sediment control															
Catch basin maintenance															
Catch basin water quality BMPs															
Commercial/residential pre-treatment															
Stormwater detention/retention	X	X	X												
Disconnection of impervious areas						X	X	X	X						
Others…															

Table 8-5 Basin-Specific Alternative Improvement Scenarios for CSO Basins

	Turkey Creek Basin			NEID Basin		Gooseneck & Lower Blue Basins				Brush & Town Fork Creek Basins			Middle Blue River Basin		
Control Technology	Alt 1	Alt 2	Alt 3	Alt 1	Alt 2	Alt 1	Alt 2	Alt 3	Alt 4	Alt 1	Alt 2	Alt 3	Alt 1	Alt 2	Alt 3
Low-Impact Development-Retrofit															
Rain Gardens						X	X	X	X	X	X	X	X	X	X
Stormwater Wetlands										X	X	X	X	X	X
Rain Barrels						X	X	X	X	X	X	X	X	X	X
Swales						X	X	X	X	X	X	X	X	X	X
Bioretention	X	X	X			X	X	X	X	X	X	X	X		
Porous Pavement															
Vegetated Buffers										X	X	X			
Rooftop Greening															
Infiltration Trenches															
Level Spreader															
Curb, gutter, and sidewalk removal															
Voluntary buyouts															
Others…															
Inflow Reduction															
Upland Stormwater Storage															
Stormwater Sumps															
Stream Diversion															
Sewer Separation	X	X	X			X	X	X	X	X	X	X	X		
Others…															
Sewer System Optimization															
Diversion Structure	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

Table 8-5 Basin-Specific Alternative Improvement Scenarios for CSO Basins

	Turkey Creek Basin			**NEID Basin**		**Gooseneck & Lower Blue Basins**				**Brush & Town Fork Creek Basins**			**Middle Blue River Basin**		
Control Technology	Alt 1	Alt 2	Alt 3	Alt 1	Alt 2	Alt 1	Alt 2	Alt 3	Alt 4	Alt 1	Alt 2	Alt 3	Alt 1	Alt 2	Alt 3
Consolidation															
I/I Abatement													X		
Static Flow Control						X	X	X	X						
Variable Flow Control	X	X	X							X	X	X			
Real-Time Flow Control						X	X	X	X	X	X	X			
Others…															
Storage															
Earthen Basins															
Open Concrete Tanks															
Closed Concrete Tanks						X	X	X	X	X	X	X	X	X	
Storage Conduits						X	X	X	X				X	X	
Storage Tunnels	X	X	X	X	X	X	X	X	X	X	X	X			
Others…															
Physical / Chemical Treatment (all options include chlorination / dechlorination)															
Swirl Concentrator															
Vortex Separator															
Netting Systems															
Floatables Control	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Coarse Screening										X	X	X			
Fine screening															
Primary Sedimentation															
Flocculation /															

Table 8-5 Basin-Specific Alternative Improvement Scenarios for CSO Basins

	Turkey Creek Basin			**NEID Basin**		**Gooseneck & Lower Blue Basins**				**Brush & Town Fork Creek Basins**			**Middle Blue River Basin**		
Control Technology	Alt 1	Alt 2	Alt 3	Alt 1	Alt 2	Alt 1	Alt 2	Alt 3	Alt 4	Alt 1	Alt 2	Alt 3	Alt 1	Alt 2	Alt 3
Sedimentation															
Dissolved Air Flotation (DAF)															
DAF with Polymer Addition															
High Rate Filtration (HRF)															
Flocculation/HRF															
Ballasted flocculation	X	X	X	X	X					X	X	X			X
Others…															
Biological Treatment															
West Side and Blue River Plants	X	X	X	X	X	X	X	X	X						
Wetlands Treatment															
Others…															

Technology eliminated from consideration in alternatives development
Technology included in the Alternatives Developed

8.6 Separate Sewer Systems Technologies

This section describes technologies available for abating SSOs in the City. SSOs occur in every collection system under both dry weather and wet weather conditions. SSOs are discharges of untreated wastewater from separate sewer system (SSS) components such as manholes, pumping stations, and constructed outfalls. Sewage backups into basements may also occur.

SSOs may occur wherever the total flow is greater than the capacity of a sewer line, pumping station, or treatment plant. Typically, excessive flows result from stormwater entering the system during wet weather through a variety of defects or illegal connections. SSOs may also be caused by a loss of sewer capacity due to blockages from root growth into the sewers, debris accumulation, structural failures, grease, or other causes. Abating SSOs in a system typically requires locating and removing infiltration and inflow (I/I) from the system, adding capacity to the system, or both.

I/I occurs on both private and public properties. The sewer customer owns and is responsible for private sector facilities, including the building connection line outside the public right-of-way and any sources in or around the building. The City owns the public sector facilities and is responsible for I/I in these facilities, which include the public sewers and the portion of the building connections located within the right-of-way. In addition, the City maintains building connections up to the building for commercial and industrial customers, and for multi-family (more than two) residential dwellings.

Numerous I/I studies and Sewer System Evaluation Surveys (SSES) were performed nationwide under the USEPA's Construction Grants program in the 1970s. Many of these studies recommended removal of I/I sources through replacement and rehabilitation projects and estimated I/I reduction percentages based on the estimated flows through each source. In general, the estimated I/I reduction levels were not achieved. In a study prepared for the USEPA, Conklin (1981) reported that many rehabilitation programs predicted 60 to 90 percent I/I removal, but achieved only zero and 30 percent removal.

The City has completed 18 comprehensive I/I studies in high-priority drainage basins. Based on these studies, public sector I/I sources have been addressed in a series of major manhole rehabilitation projects, and capacity improvements have been made by completing several important relief sewers. To date, rehabilitation projects have concentrated on manhole rehabilitation rather than sewer line repairs. Concerns relative to spending public money on private property have precluded the completion of recommended private sector repairs. The amount of I/I actually removed through the manhole rehabilitation projects is not yet known. I/I reduction levels expected after completing all cost-effective rehabilitation projects ranged from 5 to 45 percent.

Nashville, Tennessee's Overflow Abatement Program has successfully removed about 50 percent of total I/I volume in the areas studied to-date. The Nashville program includes flow monitoring to prioritize sub-basins, performing comprehensive CCTV inspections in the high I/I sub-basins, and complete rehabilitation of the defective sewer lines and laterals. Nashville has found that the rehabilitation is required for about 15 to 20 percent of the total sewer length, thereby removing about 8 to 10 mg/year per 1,000 feet rehabilitated.

Proposed strategies for the SSS are to: (1) reduce I/I where cost-effective using a similar approach adopted by Nashville, Tennessee, (2) provide a combination of wet weather storage and treatment to address remaining wet weather inflows, and (3) accommodate population growth. Table 8-6 summarizes the system improvements expected to be included in the Plan in each of the SSS basins following completion of the basin-specific alternatives analyses.

Table 8-6 Separate Sanitary Sewer System Technologies Considered

Basin	Control Plan Components							
	Reduce Inflow & Infiltration	Expand Primary & Secondary Treatment Capacity	Tunnel for Storage & Conveyance of Wet Weather Flow	Relief Sewers	Expand Capacity of Major Pumping Station	Construct Tank Storage for Wet Weather Flows	High Rate Treatment for Wet Weather Flows	Other Collection System Improvements
Northern Watersheds	√	√		√				√
Line Creek/Rock Creek & Northwestern	√		√	√				√
Birmingham/Shoal Creek	√	√	√		√		√	
Blue River North & Blue River Central	√							√
Round Grove	√			√				√
Blue River South	√			√		√		√
Little Blue River Tributaries	√							√

* * * * *

9 PUBLIC PARTICIPATION

9.1 Introduction

The Overflow Control Plan (the Plan) developed by the Water Services Department (WSD) Overflow Control Program (OCP) involved an extensive public participation program. The public participation program was designed to educate and involve the public in the City of Kansas City, Missouri's (the City, KCMO) long-term planning process to develop ways to control overflows from the City's wastewater collection and treatment system. The primary goal was to secure public support for the recommended Plan as it was developed and for its subsequent implementation. A significant amount of public participation documentation and materials are included in Appendix E.

The public participation program evolved into one component of the Wet Weather Solutions Public Participation Program. The Wet Weather Solutions Program involved the OCP, in addition to the KC-One stormwater program, and the Waterways Program within the WSD. The activities of these programs, all of which concerned the impacts of wet weather, were coordinated within the Wet Weather Solutions Program to create a consolidated public participation effort.

Public participation efforts were organized to provide the citizens of Kansas City with a comprehensive and consolidated opportunity to participate in the development of solutions for all wet weather issues facing the City. A cornerstone of the public participation effort was an intense effort with the Community Panel, a citizen task force appointed by the Mayor of Kansas City, coupled with efforts to engage and educate the public at large.

9.2 Community Panel

The Wet Weather Community Panel (the Community Panel) was formed in 2003 to build an informed group of stakeholders, to foster a constructive interchange among the various interests, and to access technical assistance and input. The initial phase of the Community Panel was primarily educational. The focus shifted half-way through the meeting process to move into the input and deliberation phase.

The Community Panel met approximately 45 times since 2003, including monthly meetings during 2007 and 2008. Subcommittees were formed to discuss in more detail wet weather-related policies, including Guiding Principles, Public Participation, Sewer Back-up Program, Goals and Objectives, and Green Solutions.

9.2.1 Composition and Mission

The Community Panel's membership was formally defined by City Council Resolution 030764 adopted on July 10, 2003. The membership was designed to reflect a balance of interests. The Community Panel members initially represented the following groups:

- Local technical specialists (such as scientists, engineers, financial, and public health experts)
- Mid-America Regional Council representative (metropolitan planning organization for Kansas City)
- Environmental Groups (such as Sierra Club, Watershed Associations, Kansas City Missouri Environmental Management Commission)
- Citizens (from Neighborhood Groups, and past major community initiatives)
- Business Interests (such as Chambers of Commerce, Business Associations, Industrial Districts/Councils)
- Council District representatives (one from each of the six Kansas City, MO council districts)

Community Panel membership was expanded in early-2006 to include developers, major property owners, major rate-payers, recreation interests, and other interested persons.

The mission and responsibilities of the Community Panel included:

- Provide a city-wide view from the stakeholder perspective
- Provide input into the Guiding Principles, a document to guide program development and implementation based upon community values
- Provide input into goals, objectives and performance indicators for the Wet Weather Solutions Program
- Provide input into development of evaluation criteria
- Advise Community Panel and staff on public participation
- Provide linkage and reporting between the Basin Coordinating Committees and other projects in the City
- Assist the Community Panel and staff with stakeholder outreach activities
    - Participate in road-show presentations along with a Community Panel member
    - Provide informational outreach to local media, politicians, governmental organizations (USEPA, MDNR, MDC, KDHE) and other associations

9.2.2 Additional Community Panel Input

The Community Panel completed many tasks through 2008. Accomplishments included:

- Establishment of Guiding Principles for the Panel by the Guiding Principles Subcommittee
- Establishment of Wet Weather Solutions Program Goals and Objectives
- Endorsement of the Wet Weather Solutions Program Public Participation Plan
- Establishment of priority factors for evaluation of basin plans
- Determination of evaluation criteria for basin plans

- Discussion of potential strategies, service levels, and performance measures
- Discussion of potential technologies for each basin
- Development of an interim Sewer Back-Up Program by the Sewer Back-up Program Subcommittee
- Development of a Green Solutions Position Paper
- Endorsement of the Stormwater Policies created by the KC-One stormwater program
- Endorsement of the City Planning and Development Department's Stream Buffer Ordinance

In May 2007, members of the Community Panel made a workshop presentation titled, "Storm Inform 2007" to the new Mayor, City Manager, and new City Council. The purpose of the workshop was to inform the Kansas City community's elected and appointed leaders of the Wet Weather Solutions Program, its impact on the City, and the involvement of the community in the planning to address these issues.

9.2.3 Guiding Principles Committee

Ten Guiding Principles for the Wet Weather Solutions Program were developed by the Guiding Principles committee. The principles were officially adopted by the Community Panel at its February 2006 meeting. The Guiding Principles state that:

"Through strong creative leadership and a stewardship ethic, the Wet Weather Solutions Program will take action to manage the City's water resources in a sustainable way."

- Leadership:
  - Communicative: use plain language so that information and discussions are immediately understood by all participants in the process.
  - Participatory: Citizens will have a meaningful say in actions that affect their lives and spend their tax dollars/user fees.
  - Collaborative: Stakeholders are partners in each aspect of the decision-making, including the development of alternatives and identification of preferred solutions.
  - Accountable: Stakeholders and the Community Panel are accountable in their respective roles for successful program development and implementation while the City Council is the ultimate decision-maker and is accountable to the citizens it represents.
- Transparent: Strive for openness in all actions so that the public and other stakeholders have confidence that outcomes are rational in light of all identified interests and inputs. Stewardship:
  - Comprehensive: Consider all sources of problems and solutions so that strategies account for the interrelationship of water, land use, air quality, and human communities within a watershed

- Beneficial: Prefer options that create multiple benefits for the community, environment, and regional economy so that the legacy of the Program is a stronger, more appealing, and more prosperous community
- Fiscally responsible: Manage the community's resources with a long-term view, pursuing fairness in the distribution of the economic benefits and burdens

- Take Action:
  - Innovative: Innovate while developing the program – let experience inform future plans
  - Progressive: Actively seek out existing projects that can demonstrate quick progress

The Guiding Principles are now distributed at each Community Panel meeting to reinforce and remind the members what the principles are as they work to address wet weather-related issues.

9.2.4 Public Participation Committee

The purpose of the Public Participation Committee was to provide input into a Public Participation Plan document. The committee members were charged with making sure the Public Participation Plan approach was heading in the right direction, that elements were not missing, and that groups or individuals were being reached. This committee also led the recruitment of new Panelists in late-2005 through early-2006.

9.2.5 Sewer Back-up Program Committee

The Water-in-Basement, or Sewer Back-up Program Committee, began meeting in October 2005. The purpose of this committee was to provide input into the development of a Sewer Back-up Program. The committee worked with WSD to draft a program policy document that was completed in January 2006. After the Sewer Back-up Program Committee and WSD reviewed the draft document, the committee reconvened in August 2006. The committee then presented its information at the September 2006 Community Panel meeting.

9.2.6 Goals and Objectives Committee

This Goals and Objectives Committee was convened in April 2006 to help the Community Panel with refinement of the Program's Goals and Objectives of the Wet Weather Solutions Program. The committee, with the help of the Community Panel attending various meetings, participated in the development of Goals and Objectives for the Wet Weather Solutions Program. The goals were officially adopted by the entire Community Panel at its May 2006 meeting. That guidance stated that the Wet Weather Solutions Program would be structured to accomplish three primary goals:

- Minimize loss of life and injury, and reduce property damage due to flooding
- Improve water quality
- Maximize economic, social, and environmental benefits

Specific objectives were defined for each goal:

- Goal: Minimize loss of life and injury and reduce property damage due to flooding:
  - Warn the public of the dangers of high water
  - Provide passable roads during flooding
  - Reduce flood damage to structures
  - Protect public infrastructure from flood damage
- Goal: Improve water quality:
  - Protect streams and natural resources
  - Reduce pollution in streams, lakes and rivers
  - Meet or exceed all applicable regulations
- Goal: Maximize economic, social and environmental benefits:
  - Create and sustain recreational opportunities
  - Support economic development and sustainable growth
  - Optimize infrastructure investment
  - Enhance natural habitats

9.2.7 Green Solutions Committee

This committee began to meet in January 2007 as a result of increased interest in the City's potential for green solutions as part of city-wide wet weather solutions scenarios. Over several meetings, the committee created a position paper. At the July 2007 Community Panel meeting, Panelists adopted its "Green Solutions Position Paper" and approved a motion to forward that paper to the City Council, with a request for Council endorsement.

As defined by the Panel, "Green solutions are strategies that result in on-the-ground projects which are specifically designed to reduce stormwater runoff, reduce water pollution, create recreational amenities, and protect our natural resources through the use of 'green infrastructure' (also referred to as 'natural systems') such as rain gardens, bio-retention facilities, stream restoration, stream buffers, and other scientifically proven methods." The purpose of the position paper was to advocate for adoption of a formal policy by the City, that recognized water as a vital and valuable natural resource, and that integrated the protection of water into every component of the City's comprehensive wet weather solutions plan. The paper outlined four specific implementation strategies and recommended a series of specific action steps to be taken under each implementation strategy.

The strategies presented in the position paper were structured to:

- Educate and engage the public. Create community and regional partnerships.

- Enact regulations and create enforcement programs that protect natural resources. Eliminate any ordinance provision or enforcement practice that discourages the use of green, multi-purpose solutions.
- Create incentives to integrate green solutions into the community.
- Invest public dollars in green, multi-benefit solutions.

The committee presented the position paper to the City Council in July 2007. The subcommittee's action resulted in unanimous support for a city-wide council resolution on green solutions. The resolution was introduced at the July 26, 2007 Legislative Session of the Kansas City, Missouri City Council. The resolution was approved by unanimous vote of the City Council on August 9, 2007.

> *"RESOLUTION - Establishing the policy of the City to integrate green solutions protective of water in our City planning and development processes, particularly in our comprehensive Wet Weather Solutions Program; directing the City Manager to submit a plan within 90 days for implementing the strategies set out in the Green Solutions Position Paper created by the City's Wet Weather Community Panel; and directing the City Manager to incorporate green solutions, when possible, in the City's conceptual long-term control plan for sewer overflows."*

9.3 Basin Coordinating Committees

In June 2006, twelve Basin Coordinating Committees (BCCs) were organized throughout the City to educate the public and assist with wet-weather solutions planning at the basin level. To increase meeting attendance, mid-way through the meeting process, two committees were combined. Four planning meetings, plus an open house (Wet Weather Fair), were held for each of eleven BCCs, totaling fifty-seven basin public meetings. Twenty-four of these meetings took place in 2006 and 33 meetings took place in 2007. Over 200 participants were involved in the basin planning meetings, and over 400 participants attended the Wet Weather Fairs.

9.3.1 Composition and Mission

Members of the Basin Coordinating Committees included Community Panelists, local and regional government representatives, community representatives from neighborhood associations or other interested organizations, and representatives from City departments.

The BCC members contributed their knowledge of wet weather problems, helped define the problems, gave feedback on possible strategies, and helped with outreach to the community. The BCC members also:

- Provided a geographically-based view from the stakeholder perspective of the problems, causes, and possible solutions

- Provided input into the weighting of evaluation criteria for their respective basin
- Made a recommendation regarding the strategies selected
- Advised the Community Panel and staff on public participation in their respective basin
- Assisted the Community Panel and WSD with outreach activities in their respective basin

9.3.2 Basin Coordinating Committee Input

As part of the Basin Coordinating Committee meeting process, eleven Wet Weather Fairs (Fairs) were conducted in April and May of 2007. The "come-and-go" open house Fairs displayed to attendees the potential solutions in their respective basins, as well as various activities property owners can do themselves to help with the issues. Fair attendees were given a comment card and brief survey to obtain additional information.

Significant input from the Basin Coordinating Committee process included:

- Citizens' desires varied by basin.
- Citizens are most interested in sewer back-ups and flooding – not wet-weather overflows.
- Citizens are concerned about how to pay for improvements.
- Public Education is working – more people know they live in a watershed and that stormwater runoff is a principal contributor of pollutants in the City's streams, lakes, and rivers.

9.4 Outreach / Education

9.4.1 Website / Information, Voicemail, & Email Address

The WSD Wet Weather Solutions Program created a website in 2004 to highlight the planning process, problems, and projects in both the OCP and the KC-One stormwater program. In 2005, several meetings took place with WSD public relations staff and OCP to discuss objectives of the website. In late-2005, a new web address was acquired for easier navigation: www.kcmo.org/wetweather. The website continued to be updated to include Community Panel meeting dates, agendas, meeting materials and meeting notes. In the summer of 2007, Basin Coordinating Committee meeting information was also added to the website. There were approximately 40 pages of information on the website, not including specific meeting pages. In late-2008, additional information on the KC-One stormwater program was added to the website.

A Wet Weather Solutions Program information voicemail (816-513-0124) was set up in May 2006. The voicemail was monitored regularly and requests for information were responded to in a timely manner. Citizens and interested persons left messages with questions on topics, such as public meeting information and how to obtain and install a rain barrel. An email address (KC-OCPInfo@kcmo.org) was also created for the same purpose. Both the voicemail and email address had little traffic. However, many of the individuals that have utilized these resources found them to be beneficial. Additionally, the voicemail number and email address were published on all documents that were distributed to the public, including the Citizen Action Kit.

9.4.2 Citizen Action Kit

A Citizen Action Kit was developed to inform residents about the activities of the WSD and OCP and to educate citizens about what actions they could take. The idea was to build a partnership between WSD and citizens while working toward a common set of goals. Some of the flyers were developed internally, while other flyers were obtained from the Mid-America Regional Council. The contents of the kit included:

- Overflow Control Program Handout
- Stormwater Program Handout
- Waterways Program Handout
- Autumn Watershed Tip Handout – Facts about Stream Corridors
- Summer Watershed Tip Handout – The Facts about Pet Waste
- Spring Watershed Tip Handout – The Facts about Lawn Chemicals
- Winter Watershed Tip Handout – What is Sediment Pollution
- Sewer Back-ups and Overflows- What you Can Do
- Backwater Valves- Can They Help Prevent Sewer Back-ups?
- How to Build Your Own Rain Garden
- Rain Garden Guide
- How Citizens Can Help (added in March 2007)
- How to Disconnect Your Sump Pump (added in March 2007)
- How to Install a Rain Barrel (added in March 2007)
- Disconnect or Redirect Your Downspout (Mid-America Regional Council)
- Conserve Water with Rain Barrels (Mid-America Regional Council)
- Know Your Watershed (Mid-America Regional Council)
- Know Your Roots (Mid-America Regional Council)
- Wet Weather Solutions Program Overview

9.4.3 Style Guide

A Style Guide and accompanying CD were also developed to create a consistent look for documents and graphic materials. Contents of the Style Guide were approved and distributed to the Community Panel and program consultants in the fall of 2006.

9.4.4 Wet Weather Video

Two videos were created for the Wet Weather Solutions Program so that an overview of the program could be shared at public meetings. The first video premiered at an orientation session for the new Community Panelists in January 2006. Additional revisions were made based on comments received. The video was finalized in July 2006. In August 2006, the video was converted to DVD format and was distributed to neighborhood groups, the Wet Weather Community Panel and consultants, and various interested citizens. The video was updated in January 2008 to include details on the Conceptual Control Plan and other plans for the Wet Weather Solutions Program.

9.4.5 Road-Show Presentations

The Wet Weather Solutions Program staff began to make presentations in 2006 to neighborhood groups, professional organizations, and various City departments. These road-show presentations included a presentation of the Wet Weather Video and a PowerPoint presentation with details on wet weather-related information. Over 2,000 persons attended the road-show presentations.

9.4.6 Rain Gardens Initiative

The 10,000 Rain Gardens campaign was started in the fall of 2005. It was a metropolitan area plan to improve water quality by establishing this low-impact development technique as a standard Best Management Practices (BMP) for City departments, property owners, businesses, and developers. A rain garden is a shallow basin filled with native plants that captures runoff and filters it, thereby reducing water pollution and stream degradation. The goal of the initiative was to actively engage homeowners, churches, businesses, non-profit groups, and schools to voluntarily reduce wet weather problems. Citizens were encouraged to register their rain garden on the 10,000 Rain Gardens website (www.rainkc.com). In 2007, the initiative was expanded to include several professional and public workshops that helped to expand public knowledge and training.

From 2005 to early 2007, a total of 62 rain garden presentations were given with an average attendance of 15 people per presentation. An electronic newsletter is distributed to nearly 1,100 persons per quarter and the website has had an average of 2,500 visits per week. Past ad campaigns have resulted in the number of weekly website visits more than tripling. Two media campaigns, in spring/fall 2006 and spring 2007, reached participants through television commercials, newspaper inserts, radio commercials, and television appearances. The campaigns were estimated to have reached over 1 million people in 2006 and over 3 million people in 2007. As of July 1, 2008, there were 303 rain gardens throughout the region registered on the www.rainkc.com website, 116 of which are in the City.

9.4.7 Summary Report of Findings from Qualitative and Quantitative Research

In the summer of 2005, stakeholder interviews were conducted with 16 community leaders to gauge understanding of water quality issues and overflow events. From the interviews, OCP obtained key stakeholders' views on issues and challenges, and suggestions on gaining funding support from the public. Interview results were compiled into a report and completed in November 2005.

In addition, information and research was gathered on other combined sewer systems (CSS)/separate sewer systems (SSS) communities throughout the nation. The information provided insight on how other communities have designed their public participation and education processes. This interview process included discussion of education and participation techniques, key messaging, possible public polling, and whether the community was under a consent decree.

Work on the first public opinion survey started in November 2005 and continued into 2006. A draft survey was administered during the September 2005 Community Panel meeting, where Panel members took the survey and provided feedback. This feedback was taken into consideration when making survey revisions. The survey was finalized in December 2005. ETC Institute conducted the survey in late-January and February 2006. The survey was mailed to 1,200 households in each of the 12 designated basins, totaling 14,400 households. Follow-up phone calls were made soon after distribution of the survey to maximize the response rate. A total of 5,430 surveys was received, with more than 400 received from within each of the twelve basin areas. The survey results were statistically significant with a confidence level of 95 percent and a precision of at least ± 1.5 percent. The report summarizing the survey results was completed in June 2006. The report included overall City data, as well as data divided within the twelve basins throughout the City. All survey responses were coded to keep track of the surveys received by basin area.

The following is a listing of key results from the 2006 Wet Weather Solutions Program public opinion survey:

- 92 percent of those surveyed indicated that they value natural resources.
- 77 percent of those surveyed thought that the quality of local streams affects property values.
- 43 percent of those surveyed understood that stormwater runoff contributes the most to pollution in lakes, rivers, and streams.
- 87 percent of those surveyed thought it was important to improve water quality in streams in the City.
- 85 percent of those surveyed thought it was important to make improvements that would minimize sewer overflows into creeks and streams during heavy rains. However, most of those individuals were not willing to support substantial tax or utility rate fees (the majority said they would be willing to pay an 1/8th of cent sales tax and up to $5 more per month in utility fees for both sewers and stormwater).
- Most residents said they would be willing to change their behavior and take actions on their property to reduce stormwater runoff to improve water quality.

Work on the second public opinion survey began in November 2007 and continued into January 2008. The intent of this survey was to follow-up on several key questions asked in the 2006 survey, as well as to ask respondents to answer questions related to funding of capital improvements. ETC Institute again administered the survey, which was conducted in late-January 2008. The four-page survey was mailed to a stratified random sample of households in the City. The sample was designed to ensure the completion of at least 200 households in each of the six council districts, as opposed to the twelve designated basins targeted in the 2006 survey. A total of 1,318 survey responses were received giving the survey statistical significance with a 95 percent level of confidence and a precision of at least ± 2.7 percent. Some of the key results from the 2008 survey include:

- 76 percent of the residents surveyed thought City leaders should place a very high or high priority on maintaining and protecting streams.
- 90 percent of those residents surveyed indicated that they value natural resources.
- 86 percent of those surveyed thought that it is was important to improve the quality of streams in Kansas City.
- 82 percent of those surveyed thought that it is was important to make improvements to minimize sewer overflows into creeks and streams during heavy rains.
- 41 percent understood that stormwater runoff contributes the most to pollution in lakes, rivers, and streams.
- 62 percent of residents indicated they would support an increase of $5 a month per household to fund improvements to the City's sanitary sewer system to reduce damage from flooding and to help protect the water quality in the City's lakes and streams.

9.4.8 Newsletters, E-blasts, and Fact Sheets

Throughout the public participation process, many articles on various topics were published in existing city publications such as *Waterlines* and *Connections*. Since 2005, 25 articles have been published in Waterlines. Topics of those articles included:

- How to disconnect a downspout
- What is a rain barrel
- 10,000 Rain Garden campaign information
- Basin Coordinating Committee Meeting information
- Wet Weather Fair invitation
- General overview of the Wet Weather Solutions Program
- General overview of the Overflow Control Program
- Combined Sewer Overflow signage

Additionally, electronic e-blasts sharing information regarding wet weather issues have been distributed over 50 times to approximately 500 people that are on the Wet Weather Solutions Program distribution list.

9.4.9 Miscellaneous Meetings and Outreach

- *United States Geological Survey (USGS) water quality monitoring study press conference*: A press conference to present results of the monitoring study was held. The study was conducted by the USGS, in cooperation with the City WSD, and was based upon six years of monitoring data on water quality in the Blue River Basin.. The study report included analysis of nutrients, common household chemicals and personal care products, pesticides, pharmaceuticals, bacteria and bacteria sources, and aquatic organisms in streams in the Kansas City metropolitan area. This study characterized the water quality of receiving streams, provided a better understanding of the myriad of factors that influence water quality in the Blue River Basin, and provided scientific data to assist in the Plan development.
- *World Water Quality Monitoring Day*: Approximately 60 people attended World Water Quality Monitoring Day, on October 18, 2006. Speakers included representatives from the Blue River Watershed Association, the WSD, the USGS, Missouri Department of Natural Resources (MDNR) and the United States Environmental Protection Agency (USEPA). Participants at the World Water Monitoring Day broke into smaller groups and discussed and proposed recommendations as to what should be done in the region to improve water quality. The recommendations were considered by the OCP and were presented to the Community Panel.

9.4.10 Media

Throughout the program development, articles were written in various local publications such as *The Kansas City Star* and *The Wednesday*. In addition, press releases were written on occasion to prompt media interest.

The Community Panel staff members also appeared on the local access (Channel 2) television station's *Talk of the Town* program in a number of episodes. The episodes featured a general background on sewer overflows and the Wet Weather Solutions Program, as well as information on the Wet Weather Community Panel and the Wet Weather Fairs.

Channel 2 also produced several informational videos that were periodically shown on the station. The video segments included Disconnecting Your Downspouts and How to Construct a Rain Garden. The Community Panel also participated occasionally in program development for the WSD-produced program, *On Tap*.

9.4.11 T.R.U.E. Blue Program & Community Stewardship Activities

Beginning in November 2007, the Blue River Watershed Association (BRWA) helped to extend the public education outreach to school children. The T.R.U.E. (Teaching Rivers in an Urban Environment) Blue Program focused specifically on schools in the Blue River watershed to provide an activity-based, watershed literacy program for K-12 students. The T.R.U.E. Blue Program was designed to train and equip teachers and students to establish school-based stream teams to monitor water quality at their local stream. Participants learned about the detrimental effects of pollution on urban rivers and streams, and then performed hands-on activities to assess water quality. From November 2007 to November 2008, over 70 classes at 19 schools were involved in the education and implementation of the T.R.U.E. Blue Program. Over 100 adult volunteers helped nearly 1,400 students during the year.

In addition, several presentations were made to local businesses, educating employees about the T.R.U.E. Blue Program, as well as providing an opportunity to recruit volunteers for the implementation program.

Education efforts also were extended to neighborhood associations. BRWA was also tasked with identifying and recruiting neighborhood associations within the Blue River watershed to complete a stewardship activity. Organizations were encouraged to become engaged in stewardship activities designed to protect and restore the watershed through the reduction of stormwater runoff, and through other innovative approaches to water quality degradation issues. Some potential activities included water quality monitoring of local streams, trash pickups, and installation of green solutions, such as rain gardens.

BRWA staff met with larger neighborhood organizations to solicit interest from neighborhood association representatives. The staff then met with interested groups and helped the groups identify a stewardship project that they would like to implement. The following neighborhood associations became involved:

- Linden Hills neighborhood (located south of Bannister Rd., north of I-435, east of Holmes Rd., west of Blue River Rd.): Participated in Blue River Rescue Event on April 5, 2008; group plans to install a rain garden; group participated in Household Hazardous Waste event in August 2008.
- Santa Fe Hills Homes Association (located south of 85th St., north of 89th St., east of Wornall Rd., west of Holmes Rd.): Received presentation on water quality issues and water quality improvement projects.
- Washington Wheatly Neighborhood Association (located south of 18th St., north of 27th St., east of Paseo, west of I-70): Met with neighborhood representatives about conducting a water quality workshop. BRWA also worked with the UMKC School of Architecture, Urban Planning and Design in this neighborhood to develop a Green Block Project, as well as to plant a rain garden at Wheatly Elementary School (2415 Agnes Avenue).

- Marlborough Neighborhood Association: Met with neighborhood representatives to discuss planting rain gardens.

Additionally, a presentation was made to the 2nd Friday organization where several neighborhood association representatives were in attendance. The purpose of the presentation was to educate neighborhood representatives on water quality issues and to solicit groups for stewardship activities.

9.5 Public Comment on Draft Long-Term Control Plan

A 30-day public comment period was initiated on May 8, 2008, for the Draft Control Plan Summary, following its presentation to the City Council (see chapter 10). During the 30-day period, three Town Hall meetings were held across the City on May 15th, May 22nd, and May 28th. An informal meeting was also held north of the river on May 27th. At the Town Hall meetings, attendees were given a brief summary of the draft Plan. Attendees were then allowed to provide comments and ask questions. Approximately 90 people attended the four meetings. A feedback form was distributed at the meetings that helped to provide additional feedback that may have not been discussed during the comment and question portion of the meetings.

Persons could also provide public comment by responding to an informal survey located on the Wet Weather Solutions Program website homepage where the Draft Control Plan Summary was posted. Persons could also mail or email comments to the OCP.

9.6 Green Integration Collaborative Team

The WSD established an independent peer review team, Green Integration Collaborative Team, (GICT) to investigate how the Plan could be modified to cost effectively incorporate more green solutions. The GICT consisted of representatives from Mid-America Regional Council, BNIM Architects, Low Impact Development Center Inc., Conservation Design Forum, Tetra Tech, and Burns & McDonnell.

Over several months, the GICT worked to develop its recommendations. The GICT gave two reports to the City Council's EPA Response Team (October 20, 2008 and November 17, 2008) and also held a Stakeholder Forum on November 18, 2008 to present the recommendations to the public.

The independent GICT held a Stakeholder Forum on November 18, 2008 at Union Station to provide an opportunity for the public to hear the recommended green solutions improvements to the Plan. Several outreach techniques were used to invite the public to this forum. Those techniques included:

- Emailed an invitation to over 500 people on the Wet Weather Solutions Program distribution dist (included USEPA staff, MDNR staff, previous participants of Wet Weather Solutions Program meetings, Wet Weather Community Panelists, etc.).

- Emailed an invitation to 200 neighborhood leaders.
- Mailed a postcard invitation to 175 neighborhood leaders.
- Posted Stakeholder Forum information on the homepage of the WSD website.
- Posted a banner on Channel 2 with the Stakeholder Forum information.
- Posted Stakeholder Forum information on the homepage of the City's website.
- Advertised Stakeholder Forum information in Kansas City Call, Kansas City Globe, KC Hispanic News, and Dos Mundos (information was translated into Spanish for Dos Mundos).
- Posted a notice in the Kansas City Star's Press Release Central.
- Posted a Public Meeting Notice in the Kansas City Star.

Over 120 people attended the Stakeholder Forum where the independent GICT gave a PowerPoint presentation on its recommendations and where attendees had the opportunity to vote on related questions by using a clicker voting remote.

9.7 Water Services Utility Funding Task Force

In January 2008, a group of individuals was appointed by the Mayor to help integrate community values into forming a funding strategy for the City's water, wastewater, and stormwater facilities. As part of the Financial Capability Study, the Water Services Utility Funding Task Force (the Funding Task Force) met over 14 times to develop guiding principles for the creation of user charges and fees that are fair, equitable, and sufficient to meet revenue requirements. The Funding Task Force also provided guidance on how to fund the Plan.

The Funding Task Force supplied written recommendations for funding the Plan (wastewater), water, and stormwater utilities to the Mayor and City Council for their consideration.

9.7.1 Composition and Mission

The Funding Task Force membership was defined by Council resolution 071205 adopted on November 8, 2007. The membership was designed to reflect a balance of interests, including:

- One to two members of the City Council
- One to two current or past members of the Public Improvements Advisory Committee (PIAC)
- One to two members of the Wet Weather Community Panel
- One to two members of the financial community
- One member of the community acquainted with local poverty issues
- One member of the community acquainted with development issues
- One member of the community with a background in demographics and social sciences
- One representative from the Greater Kansas City Chamber of Commerce
- One representative from the industrial community

- Three community representatives

While the Funding Task Force membership was designed to reflect a balance of interests, the members were encouraged to think about all sides of the issues discussed.

The mission and responsibilities of the Funding Task Force included:

- Provide a city-wide view from a stakeholder perspective
- Develop an understanding of funding issues and provide constructive feedback on issues papers
- Develop criteria for evaluating funding options
- Develop a Customer Assistance Program recommendation for the Mayor and City Council
- Develop funding guidance recommendation for the Mayor and City Council
- Advise OCP and Water Services Department staff on public participation and stakeholder outreach activities

9.7.2 Funding Task Force Input

At the first several meetings, the Funding Task Force became familiar with the current funding methods used by the WSD, the City budget, economic trends of the City, and the revenue requirements for the Plan. Once the initial education was complete, the Funding Task Force began deliberating issues and providing direction on recommended policies. The Funding Task Force:

- Evaluated a wide variety of funding methods (taxes, user charges, special assessments, system development charges, etc.).
- Completed a policy survey.
- Worked with the business community to develop stormwater program incentives to reduce the quantity of water entering the system and improve water quality.
- Evaluated options for a customer assistance program.
- Discussed best management and financial practices, ratemaking methodology, and cost of service.

9.7.3 Public Hearings

In March, April, and June 2008, the Funding Task Force held five public hearings in locations throughout the City. Residents and business leaders provided input at the hearings. The public hearing in June was planned specifically for the industrial and business community.

9.7.4 Guiding Principles

The Funding Task Force established twelve Guiding Principles for decision making. Potential revenue sources and customer assistance program options were evaluated against those Guiding Principles. The following are the Guiding Principles and policy statements developed by the Funding Task Force:

- Equity: Costs should be directly linked to the use of the service. Rates and charges should recover the full cost of services used.
- Ability to Pay: Fairness is important in structuring utility rates and funding. As costs escalate, the ability to pay by low income households should be considered. The City should reduce the high burden of increased rates on low-income households through a program that allows these households to pay less for service than other households more able to pay. The City should reduce the high burden of increased rates on low-income households through a program that helps lower the usage and therefore lowers the utility bill.
- Growth Pays for Growth: The full capital cost of services provided should be recovered from new development projects. Existing ratepayers should <u>not</u> fund the extension of service to new developments.
- Revenue Stability: Cash flow should be predictable and lack extreme variations. The rate structure and funding strategy should produce predictable cash flow.
- Conservation: The efficient use of resources should be encouraged.
- Prioritize: The City cannot meet all the financial needs identified. Strategic financial investments should be made to accomplish community priorities and where the value gained from the investment made is high.
- Economic competitiveness: Decisions regarding funding strategy, rate structure, and rate levels should be made in light of the City's need to attract and retain businesses, citizens, and customers.
- Administrative Ease: The cost of administration should be minimized and uncomplicated processes should be used.
- Public Acceptance: The public should feel that the rate structure and funding program is fair. Customers should be confident that utility bills accurately reflect usage. The WSD should make changes necessary to improve efficiencies and customer service.
- Simplicity: Citizens should understand how charges and fees are determined.
- Education: The City should provide easy-to-understand information regarding the rate structure and conservation to enable customers to make informed decisions on usage and other actions.
- Funding Source Efficiency: The fee, charge, or tax on an activity should correspond or relate to the activity benefited.

9.8 Future Public Participation

Public participation will continue to play a vital role in the implementation phase of the Plan as described in Chapter 12. WSD will continue to contact groups about road-show presentations and presentation updates will be given to groups who have had presentations in the past. Newsletters, E-blasts, and fact sheets will continue to be distributed to the distribution list and other existing publications.

* * * * *

10 INTEGRATION OF BASIN ALTERNATIVES AND DEVELOPMENT OF CITY-WIDE OVERFLOW CONTROL PLAN

10.1 Introduction

The City of Kansas City, Missouri's (the City) wastewater collection and treatment system serves a large geographic area that includes both the combined sewer system (CSS) and separate sewer system (SSS). The pipe networks are interconnected at numerous locations and dynamically interact during both dry and wet weather. Improvements and changes to the SSS directly impact facilities serving the CSS. For that reason, the City's Overflow Control Plan (the Plan) addresses the City's entire system. The Plan was developed by the City's Water Services Department (WSD) Overflow Control Program (OCP).

Following its evaluation of technologies and development of a preliminary range of improvements on a basin-specific basis, as described Chapter 8, OCP proceeded with the development, evaluation, and selection of project alternatives that resulted in the selected Plan described in Chapter 12. The major tasks required to complete the Plan included:

- Initial development and evaluation of city-wide alternatives
- Preparation of a Conceptual Control Plan (CCP)
- Further evaluation and refinement of a preliminary control plan (PCP)
- Development of a summary of the draft Plan for additional public input and comment
- Additional modification of the draft Plan summary in response to public input and comment

10.2 Initial Development and Evaluation of City-wide Alternatives

Numerous wastewater system facilities that serve more than one basin are classified as "system-wide" or "city-wide" facilities. Principal city-wide facilities include:

- The Blue River and Westside Wastewater Treatment Plants (WWTP). Wastewater collected from approximately one-fifth of the SSS north of the Missouri River is sent to these WWTPs. These WWTPs also serve all of the CSS and the bulk of the SSS basins south of the Missouri River. The only area south of the Missouri River not served by these WWTPs generally lies east of Blue Ridge Boulevard, and is tributary to the Little Blue Valley Sewer District.
- The Blue River Interceptor Sewer. This carries flows from 70 percent of the CSS and wastewater from over 60 percent of the total SSS service area south of the Missouri River to the Blue River WWTP.
- The Northeast Industrial District (NEID) Interceptor Sewer and Pumping Station. These facilities convey flows from approximately seven square miles of CSS service area and wastewater from SSS areas, both north and south of the Missouri River, to the Blue River WWTP.

The process followed during initial development of city-wide alternatives was to:

- Develop and evaluate basin-specific alternatives for each principal basin (seven CSS basins and nine SSS basins). These alternatives did not necessarily consider impacts on interconnected parts of the system. In the CSS service area, it was necessary to consider a range of performance, i.e., level of control, during this development and evaluation process. Overall, 175 basin alternatives were developed. These alternatives were defined and briefly summarized in Chapter 8.
- Combine the basin-specific alternatives into a range of alternatives for larger areas, generally arranged to conform to WWTP service areas. In total, 192 functional area alternatives were developed. Those functional area alternatives were then evaluated and combined into multiple compatible configurations to form an initial suite of city-wide alternatives.
- Consider and evaluate the impact of changing larger areas' boundaries (e.g., modifying system interconnections by changing the areas tributary to the various WWTPs), modifying capacity allocations for city-wide facilities, and making adjustments to optimize basin-specific alternatives based on city-wide cost and performance. A total of 27 city-wide alternatives were eventually defined.

The results of that initial development of city-wide alternatives were summarized in the following report:

> *Preliminary City-Wide Wet-Weather Solution Alternatives for Consideration by Kansas City Missouri Water Services Department:* OCP; May, 2007.

Evaluation of those city-wide alternatives led to the following principal conclusions concerning the SSS:

- Generalized analysis (based on widespread use of the "Nashville" approach) in the Line Creek/Rock Creek, Birmingham/Shoal Creek, and Blue River South "priority" basins led to the preliminary conclusion that an overall reduction of approximately 30 percent in infiltration and inflow (I/I) is achievable and would be cost-effective in the City. The result of that generalized analysis was confirmed by the results of a detailed sanitary sewer evaluation study in the Round Grove "priority" basin, which projected an I/I reduction of 29 percent. The actual results of I/I reduction efforts can typically vary markedly from projections. An overall reduction of 30 percent at the basin scale is considered reasonably attainable.
- Continuing to pump wastewater (dry weather flows) from the Northwestern and Line Creek/Rock Creek basins to the Westside and Blue River WWTPs represents the least cost alternative when considering wastewater system improvements throughout the City.
- Additional treatment capacity should be provided in those basins north of the Missouri River for both wet weather flows and future increases in dry weather flows associated with increasing population in these developing basins.

- The most cost-effective method of providing treatment for wet weather flows from the Northwestern and Line Creek/Rock Creek basins is to construct a tunnel (for both conveyance and storage) from the Line Creek Pumping Station to the Birmingham WWTP and from the Birmingham WWTP to the Birmingham Pump Station. High rate treatment would also be provided at the Birmingham WWTP to treat flow stored in the new tunnels.
- The present capacity of the Round Grove Pumping Station is adequate, but it is necessary to extend a second force main from that station to take advantage of its full capacity.
- Storage for wet weather flows is needed at or upstream of the 87th Street Pumping Station. Additional storage may be needed in the future as flows tributary to that pumping station increase and the population in the area grows.

The range of capital costs for SSS improvements was estimated at $1.0 to $1.5 billion (in June, 2006 dollars; Engineering News Record Construction Cost Index = 8500). The development and evaluation of structural alternatives for combined sewer overflow (CSO) control focused on identifying the least-costly combination of conventional control technologies capable of meeting varying levels of CSO control, without direct consideration of the benefits (or costs) of green solutions and other source controls. Those alternatives were developed on the assumption that a uniform level of control (expressed as remaining number of overflow events in a typical year, following plan completion) would be developed for all outfalls in the CSS. Figures 10-1 through 10-3 summarize the results of those preliminary analyses.

Figure 10-1 Overflow Volume vs. Overflow Event Frequency

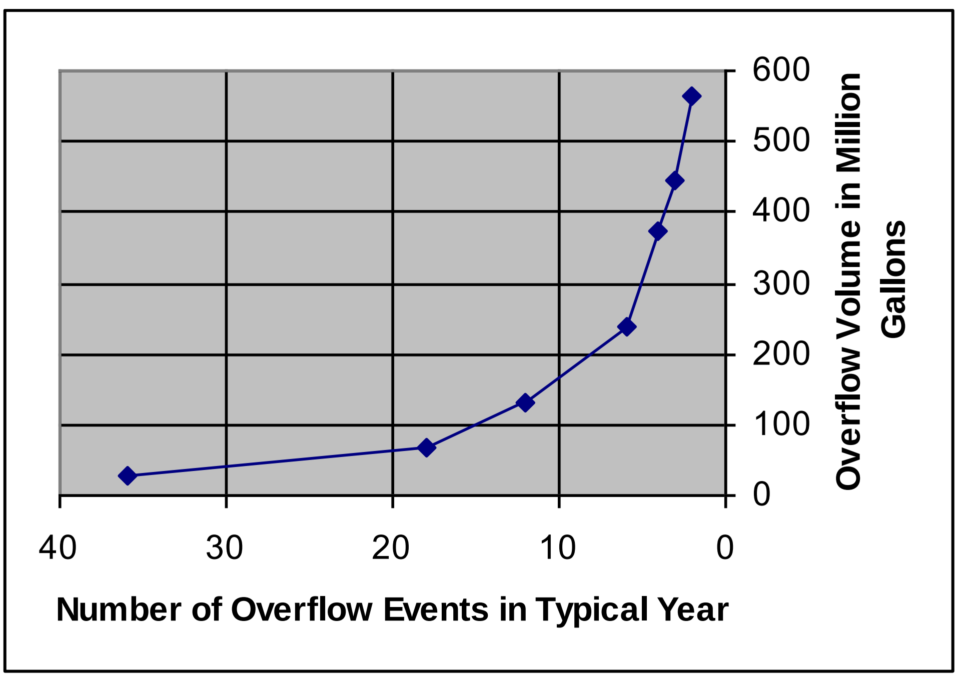


Figure 10-2 Estimated Capital Cost vs. Frequency of Remaining Overflows

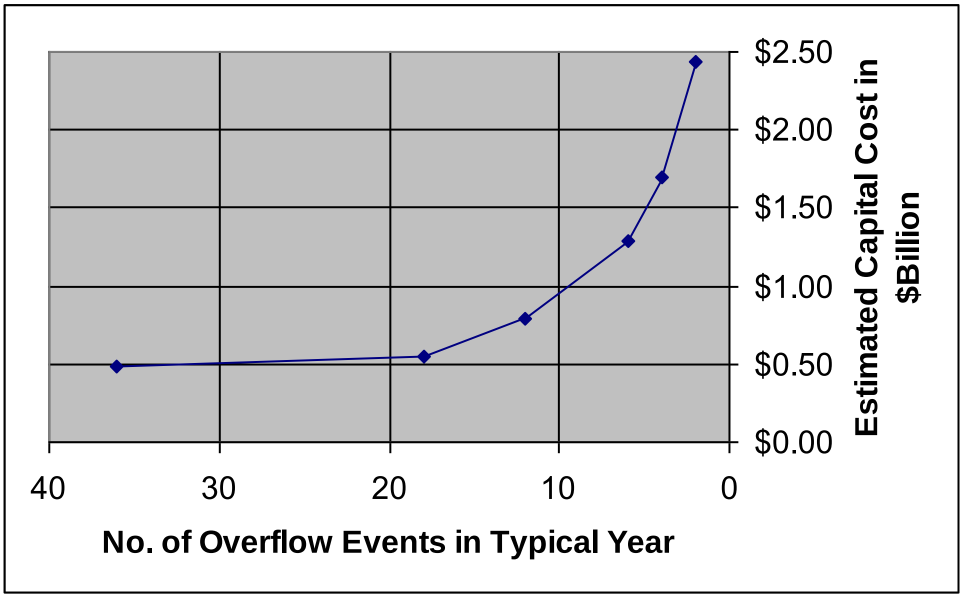
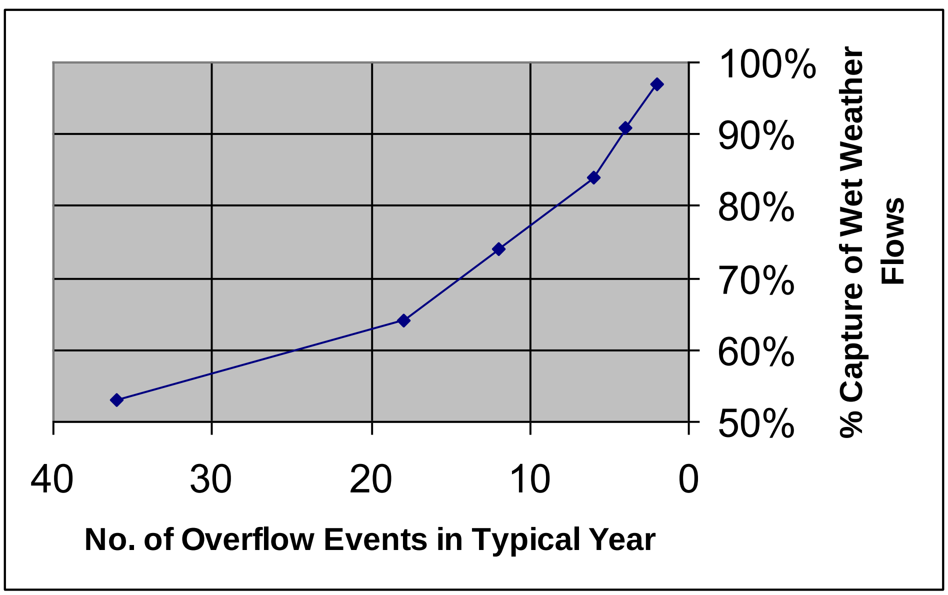


Figure 10-3 Estimated % Capture of Wet Weather Flows vs. Frequency of Remaining Overflows



Estimated capital costs summarized in Figure 10-2 are expressed in 2006 dollars (Engineering News Record Construction Cost Index = 8500).

Evaluation of those city-wide alternatives led to the following principal conclusions concerning the CSS:

- Green solutions and source controls can have a significant impact on the size and cost of conventional structural controls for CSOs; however, it was not presently possible to reliably predict that impact given the uncertainty in both the extent of green solutions that can be implemented and the schedule by which they can be placed in service. Nonetheless, targeted wet weather flow capture percentages are expected to result from a combination of conventional structural controls and an aggressive, city-wide implementation of green solutions and source controls.
- CSO controls that reduce the annual overflows to fewer than 12 in a typical year can be expected to provide negligible additional improvement in compliance with water quality standards, primarily considering *E. coli* concentrations. Reductions in other watershed loadings (e.g., from upstream watersheds and from SSS stormwater areas) are needed to attain current standards.
- Compliance with the current water quality standards of Whole Body Contact Class A for the reach of the Blue River from 95th Street to 59th Street cannot be attained even with substantial reductions in upstream loadings and high levels of CSO control.
- Significant reductions in bacteria from upstream sources would be needed to attain compliance with water quality standards of Whole Body Contact Class B for the receiving streams analyzed, regardless of the level of CSO control provided.
- City-wide estimated costs for CSO control would increase disproportionately to the benefit for controls that reduce the annual overflows to fewer than 12 in a typical year, i.e., there are significantly diminishing returns on investments above those necessary to limit overflows to fewer than 12 events in a typical year.

City-wide alternatives were then further modified by considering projected water quality improvements within the City's receiving waters. Compatibility with a collaborative public participation process that included input from the Wet Weather Community Panel was also considered. Where cost-effective, dedicated CSO abatement facilities were configured to help relieve street flooding and basement backups, as well as complement likely future stormwater management projects.

A preliminary city-wide integrated wet-weather control plan was then developed from the modified city-wide alternatives. This plan was identified as the *Conceptual Control Plan (CCP)*; OCP; September 2007. The CCP was submitted to the United States Environmental Protection Agency (USEPA) and the State of Missouri Department of Natural Resources (MDNR), collectively referred to as "the agencies," on September 20, 2007.

10.3 Preparation of a Conceptual Control Plan (CCP)

The CCP was an interim report to the agencies providing the approach being taken and the status of the Plan development. It provided the agencies an opportunity to comment on the approach being taken by OCP prior to completing the Plan.

Although the Plan was expected to address stormwater management in the CSS, KC-One (the City's stormwater management plan) is to instead provide recommendations to address stormwater issues throughout the City. The Plan is intended to complement KC-One to achieve three primary goals defined by the Wet Weather Community Panel:

- Minimize loss of life & injury
- Reduce property damage due to flooding
- Improve water quality while maximizing economic, social, and environmental benefits

It was concluded that achieving those goals and meeting regulatory requirements will require more than simply decreasing the frequency and volume of overflows from the City's CSS and SSS. A watershed approach is needed, coupling overflow control with forward-looking stormwater management with a community-wide emphasis on protecting water quality and reducing runoff. Green solutions, stormwater Best Management Practices, and conventional source reduction techniques all had to play significant and early roles in an adaptive program structured to achieve those many objectives at an appropriate cost.

The Conceptual Control Plan was structured to:

- Reduce the problem before solving it, by getting as much stormwater as practicable out of the CSS and SSS (this would be accomplished through widespread implementation of both green solutions and conventional source controls early in Plan implementation).
- Address flood protection needs while reducing CSOs.
- Provide a platform to facilitate implementation of a comprehensive green solutions initiative.
- Engage the entire metropolitan community in a comprehensive effort to improve the City's urban lakes, streams, and rivers.
- Maximize use of the existing system through improved operation and maintenance, coupled with an appropriate level of investment in continuing repair and replacement of system components as they age.
- Establish an adaptive approach to long-term plans for structural solutions so that they can be modified to reflect the results and benefits of early efforts, i.e., effects of green solutions and conventional source controls on the response of the CSS to rainfall events.

In the Conceptual Control Plan, it was anticipated that the Plan components would fall into one of three principal categories:

- Actions that are programmatic in nature
- Actions targeted primarily to address overflows in the SSS
- Actions targeted primarily to reduce overflows in the CSS

Programmatic actions were expected to include:

- Green Solutions: The City would adopt the philosophy of "every drop counts," meaning it was important to reduce stormwater entering the system wherever practicable. This would be accomplished through changing the way the community develops and redevelops, educating citizens regarding steps they could take to reduce the amount of stormwater entering the sewer system, enabling citizens to take those steps, incorporating green infrastructure in the design of public infrastructure, and making targeted public investments in green infrastructure demonstration projects.
- Watershed Management: Development and implementation of a Watershed Management Plan for the Blue River and its tributaries. This would address all four primary sources of pollution in the streams that receive CSOs: stormwater runoff from upstream sources, stormwater runoff from both SSS areas adjacent to the streams and in the CSS areas, effluent from WWTPs, and untreated wastewater in CSOs.
- Reduction of Inflows from Private Property: An aggressive approach to the reduction of inflows from private property through disconnection of downspouts, sump pumps, and other sources of stormwater inflows to the sewer system.
- Plan Adaptability: An emphasis on monitoring, evaluation, and adaptation through which the design, construction, and operation of remaining Plan components would be adjusted throughout Plan implementation.
- Interim Sewer Back-Up Program: A program structured to assist customers experiencing back-ups related to a lack of system capacity until Plan measures are fully implemented.
- Water Quality Standards Amendment: Seeking to amend water quality standards only where necessary to make them achievable.

Proposed strategies in the SSS were to: (1) reduce I/I, where cost-effective, (2) provide a combination of wet weather storage and treatment to address remaining wet weather inflows, and (3) accommodate population growth.

Proposed strategies in the CSS were developed in concert with the Wet Weather Community Panel, and included:

- Placing a higher emphasis on control of CSOs in the Blue River basin than on areas that discharge directly to the Kansas and Missouri Rivers.
- Entering into a process to modify the current water quality standard for bacteria applicable to the Blue River between 59th Street and 95th Street, and to establish interim wet weather standards.
- Placing a higher investment emphasis and implementation priority on those outfalls where improved flood protection and storm drainage service can result from the implementation of CSOs controls.
- Placing lesser emphasis on reducing the frequency of overflows at outfalls that discharge relatively low volumes, in favor of focusing on reducing the quantity of overflow at larger contributing outfalls.

In the CCP, it was estimated that the overall capital cost for all elements of the Plan (other than the programmatic components, for which cost estimates were not yet available) would range from $2.4 billion to $3.0 billion (in June 2006 dollars). The estimate was composed of:

- Between $1.0 and $1.25 billion for improvements in the SSS
- Between $1.2 and $1.5 billion for improvements in the CSS basins
- Between $160 and $240 million for improvements at the Blue River and Westside WWTPs

It was recognized in the CCP that implementation of the Plan would also substantially increase annual expenditures for operation and maintenance.

In the CCP, it was anticipated that achieving the targeted performance in the CSS by basin would result in a capture of roughly 75 percent of the wet weather flows in those basins that discharge directly to the Kansas and Missouri Rivers, and roughly 83 percent in those basins that are tributary to the Blue River (including consideration of remaining overflows from the Blue River Interceptor Sewer), resulting in a capture of approximately 80 percent of the total wet weather flows in the CSS.

It was further anticipated in the CCP that a period of 25 years or more would be needed to complete implementation of the Plan: (1) without imposing an undue burden on the community, and (2) to maximize the benefits of green solutions.

10.4 Further Evaluation and Refinement of the CCP

The projected performance of the facilities identified in the CCP was initially evaluated using basin models and discrete design storms. Updated capital cost estimates for the CSO controls outlined in the CCP were prepared; those updated capital cost estimates aggregated to $2.8 billion (in 2008 dollars, Engineering News Record Construction Cost Index = 9180). Consolidated area-wide models that used existing basin models were developed to perform continuous simulation modeling (CSM) of the facilities identified in the CCP for the recreation season. Detailed modeling results for discrete design storms and for CSM were in reasonable agreement. Results indicated that the overall capture of wet weather inflows projected in the CCP would be exceeded if facilities described in the CCP were constructed.

Concurrent with the additional technical evaluation of the CCP, a preliminary Financial Capability Assessment (FCA) was performed for WSD by a team led by the Economics Center for Education & Research of the University of Cincinnati's College of Business. A draft document was submitted to USEPA and MDNR in January 2008 (for additional discussion, see Chapter 11). That analysis was based on an estimated capital cost of $2.6 billion for the Plan. The FCA summarized the City's financial capability to fund the controls outlined in the CCP. It was concluded that a capital program based on the facilities identified in the CCP, with construction over a 25-year implementation period, would result in a heavy burden on WSD's rate payers, and would exceed the City's financial capability.

Considering revised projections of CCP facilities performance and cost, CSM results, and the draft FCA findings, work continued to identify an affordable city-wide plan that would meet regulatory requirements and address the community's goals and objectives. A series of seven additional alternatives for controlling CSOs were developed. Each alternative represented an incremental modification to CSO control facilities in which the capacity of those controls was reduced, and associated capital costs and wet weather performance levels were estimated. SSS control plan elements were the same in each alternative, but were reduced from those anticipated in the CCP to:

- Eliminate components associated with growth (i.e., WWTP expansions)
- Limit planned I/I reduction efforts to those basins and sub-basins where such work was expected to be cost-effective.

The incremental reduction in CSO control performance for each alternative was computed based on a CSM analysis for the typical year recreation season. The incremental reductions in the nature and cost of CSS controls were sequential in nature (i.e., Increment 1 would be the first reduction, followed by Increment 2, etc.); each increment built upon the previous increment(s). Increment sequencing was determined based on guidance provided by the Wet Weather Community Panel. Figure 10-4 presents an overall summary of this incremental analysis (*Updated Estimates of Capital Cost vs. Capture of CSO Volume;* OCP; March 2008), and identifies, based on that incremental analysis, the basic level of performance and cost of the updated Plan. All costs shown in Figure 10-4 are in 2008 dollars (Engineering News Record Construction Cost Index = 9180).

A summary of the changes to the CSO components of the CCP under the various increments summarized in Figure 10-4 are presented in Table 10-1. The base case presented in Table 10-1 and Figure 10-4 is composed of the facilities contemplated in the CCP, expanded to include an "express sewer" for conveyance of SSS flows from the 87th Street and Round Grove Pumping Stations to the Blue River

WWTP. For that base case, the estimated capital cost of the Plan was $2.9 billion (in 2008 dollars). The estimated capture of typical year wet weather flows originating in the CSS was 92 percent.

The recommended update to the CCP was developed to support the CSS improvement strategies recommended by the Wet Weather Community Panel. Emphasis was placed on retaining overflow control components that would contribute to reduced bacteria loads in the Blue River and its tributaries. However, as a result of the need to reduce the overall cost of the Plan, in the interest of affordability, many of the flood damage reduction and storm drainage benefits associated with the CCP were eliminated.

Figure 10-4 Summary of Incremental Analysis

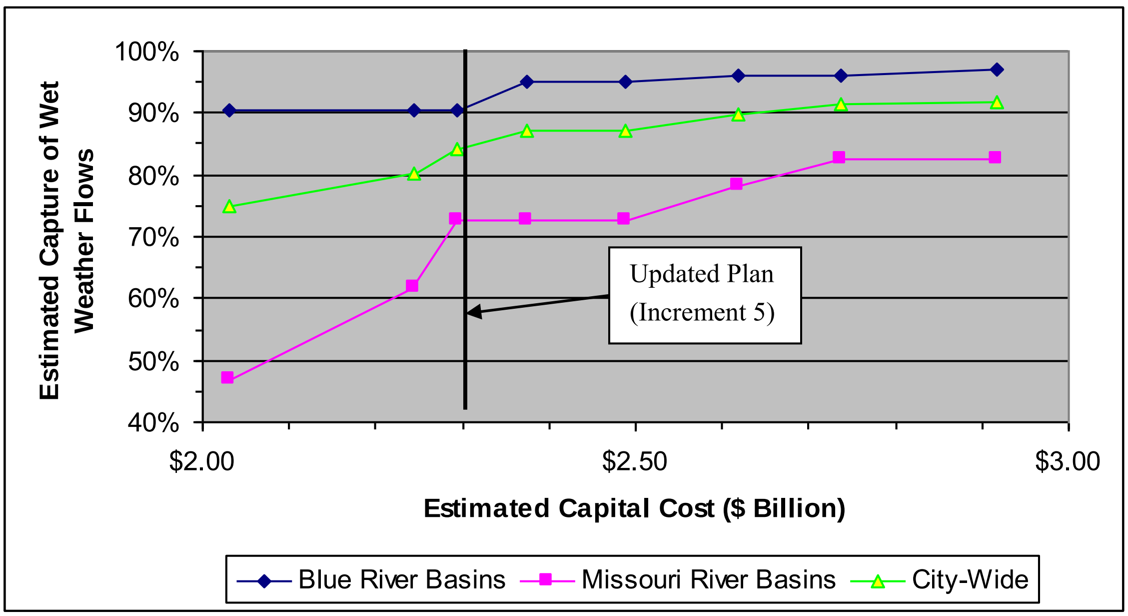


Table 10-1 Increments Considered in Update of Conceptual Control Plan

Description	Summary of Changes to Combined Sewer Controls Contemplated in Conceptual Control Plan
Base Case	Facilities contemplated in Conceptual Control Plan, with addition of "Express Sewer" from 87th Street Pumping Station to Blue River WWTP.
Increment 1	Shorten Town Fork Creek tunnel; eliminate Gillham tunnel; reduce diameter of remaining Brush Creek, Town Fork Creek, and Gooseneck Creek tunnels; eliminate tank storage in Lower Blue River basin; separate sewers in Brookside sub-basin of Brush Creek basin.
Increment 2	Eliminate South Bank tunnel in Northeast Industrial District.
Increment 3	Shorten OK Creek tunnel; eliminate Westport tunnel.
Increment 4	Replace "Express Sewer" with High Rate Treatment facility at confluence of Brush Creek and Blue River; modify proposed wet weather treatment facilities at Blue River WWTP.
Increment 5 **(Recommended)**	Eliminate Gooseneck Creek tunnel (retain in-line storage in existing arch).
Increment 6	Reduce diameter of remaining OK Creek tunnel.
Increment 7	Eliminate remaining OK Creek tunnel (retain in-line storage in existing culvert, new Turkey Creek pump station and force main).

Table 10-2 presents a summary of the estimated capital cost and CSO control performance of the update to the CCP, prepared in March, 2008. The updated capital cost estimate for the Plan (in 2008 dollars) was reduced from \$2.9 billion to \$2.3 billion; the overall capture of typical year wet weather flows originating in the CSS was reduced from 92 percent to 85 percent. With consideration of SSS flows from the 87th Street and Round Grove Pumping Stations (both of which discharge to the Blue River Interceptor Sewer in the CSS), the capture of all wet weather flows in the CSS upon Plan completion was estimated at 88 percent.

Table 10-2 Summary of Estimated Cost and Performance, Updated CCP

Basin	Typical Year Wet Weather Flow (billion gallons)	Existing Overflow Volume (billion gallons)	Future Overflow Volume (billion gallons)	Plan Complete Capture of Wet Weather Flow (%)	Estimated Capital Cost ($Million)
MISSOURI RIVER CSS BASINS					
Downtown Airport					$17.28
Turkey Creek	2.703	2.526	0.508	81%	$209.00
Central Industrial District	0.284	0.130	0.066	77%	$1.04
Northeast Industrial District	1.119	0.704	0.466	58%	$3.73
Subtotal, Missouri River Basins	**4.106**	**3.360**	**1.040**	**75%**	**$231.04**
BLUE RIVER CSS BASINS					
Town Fork Creek	0.880	0.301	0.023	97%	$306.91
Brush Creek	1.830	0.954	0.031	98%	$281.71
Subtotal, Brush Creek CSS Basins	**2.710**	**1.255**	**0.054**	**98%**	**$588.62**
Gooseneck Creek	1.019	1.298	0.225	N/A	$5.40
Lower Blue River	0.622	0.208	0.033	N/A	$24.52
Middle Blue River	0.623	0.149	0.027	96%	$90.99
Subtotal, All Blue River CSS Basins	**4.974**	**2.910**	**0.339**	**93%**	**$709.52**
Blue River WWTP HRT	N/A	N/A	N/A	N/A	$63.10
Blue River WWTP Solids Handling	N/A	N/A	N/A	N/A	$141.37
Westside WWTP HRT	N/A	N/A	N/A	N/A	$46.01
CITY-WIDE TOTALS Without SSS Inflows to BRIS	***9.08***	***6.27***	***1.38***	***85%***	***$1,191.05***
SSS Wet Weather from 87th Street	2.065	N/A	N/A	N/A	N/A
SSS Wet Weather from Round Grove	0.499	N/A	N/A	N/A	N/A
Subtotal, SSS Inflows to BRIS	**2.564**	N/A	N/A	N/A	N/A
CITY-WIDE TOTALS With SSS Inflows to BRIS	***11.64***	***6.27***	***1.38***	***88%***	***$1,191.05***
Blue River Basins Capture with SSS Inflows to BRIS				***96%***	
Programmatic Components					***$29.00***
Neighborhood Sewers in CSS Basins					***$126.21***
Estimated Capital Cost for SSS Basins					***$947.44***
Estimated Total Capital Cost for Overflow Control Plan					***$2,293.70***

Capital cost estimates reflected in Table 10-2 were based on inspection and adjustment of estimates prepared by the various Basin Engineers for facilities contemplated in the original CCP, and required confirmation by the Basin Engineers.

10.5 Draft Control Plan Summary and Public Review and Comment

A draft *Overflow Control Plan, Control Plan Summary;* OCP; May 2008 (draft Plan) was presented to the City Council on May 8, 2008. That May 8 presentation initiated a 30-day public review and comment period, which ended on June 6, 2008. Four "Town Hall" meetings were jointly conducted by the WSD and the Wet Weather Community Panel (on May 15, May 22, May 27, and May 28, 2008) to present the draft Plan to the public at-large and solicit their comments. Comments received at the Town Hall meetings and on-line at the City's website can be found at

http://www.kcmo.org/water/KCWetWeatherCityNav/images/PDFs/Comments_061108.pdf

Additional written comments and statements were received from the City's Environmental Management Commission (memorandum to Mayor Funkhouser and Members of the City Council dated May 20, 2008); the Wet Weather Community Panel (resolution dated June 12, 2008); and a May 28, 2008 letter to the City Manager from eight members of the City Council.

Concurrent with the public review and comment period, the Basin Engineers developed final planning estimates of the capital and incremental operations and maintenance costs for the draft Plan.

Comments received during the public review and comment period were considered in subsequent modifications of the draft Plan. Most significantly, at the direction of the City Council, the WSD commissioned an independent review of the draft Plan to identify opportunities to further integrate and increase reliance on green solutions and green infrastructure.

10.6 Modification of draft Plan in Response to Public Review and Comment

A number of adjustments were made to the draft Plan in consideration of comments received during the public review and comment period. Those adjustments resulted from a combination of continued technical evaluation of the potential for combined "gray-green" approaches to CSO control; final estimates of capital and incremental operations and maintenance cost provided by the Basin Engineers; and recommendations made by the independent review team. Each of those adjustments is reflected in the selected Plan described in detail in Chapter 12.

10.6.1 Results of Review for Potential "Gray-Green" Infrastructure

The various CSO control components described in the Draft Control Plan Summary were reviewed to identify cost-effective opportunities to increase early investment in green infrastructure and reduce subsequent reliance on conventional structural controls. A series of preliminary analyses were conducted to assess the potential cost impact that would result from modification of the CSO control components identified in the draft Plan to incorporate a combination of gray and green technologies. The results of those analyses are presented in the following OCP technical memoranda:

(1) *Gray-Green Alternatives for OK Creek*; OCP; May 30, 2008. This memorandum addresses approximately 4,770 acres in the Turkey Creek basin tributary to a proposed CSO storage tunnel along the original alignment of OK Creek.
(2) *Gray-Green Alternatives for Brush & Town Fork Creeks*; OCP; June 10, 2008. This memorandum addresses just less than 7,000 acres in the Brush Creek and Town Fork Creek basins tributary to a proposed CSO storage tunnel system paralleling those two creeks.
(3) *Green Alternatives for Outfalls 059 and 069*; OCP; June 10, 2008. This memorandum addresses approximately 744 acres in the Middle Blue River basin tributary to two proposed CSO storage tanks.

(4) Green Alternatives for Outfalls 092-097; OCP; June 24, 2008. This memorandum addresses approximately 367 acres in the Town Fork Creek basin tributary to six different outfalls in the vicinity of the Forest Hills cemetery.

In the absence of detailed modeling, certain simplifying assumptions were necessary in the conduct of those preliminary analyses. A key assumption made was that the volume of storage in green solutions would result in an equal reduction in the volume of storage in the gray components of the current plan. That is an aggressive assumption that can only be tested through detailed modeling. Any change to that assumption that would result from more detailed modeling would be expected to result in the need for additional "green" storage. A second assumption made was that each million gallons of green storage would result in a reduction of 0.5 MGD in the capacity of downstream pumping stations and treatment facilities. This would be due to the combined effects of evaporation and infiltration at the green storage facilities. This assumption also can only be tested through detailed modeling. Changes to that assumption that would result from detailed modeling could either increase or reduce the change in capital cost for gray components.

Green storage technologies considered in the preliminary analyses included:

- Catch basin retrofits in road and street rights-of-way
- Curb extension swales
- Street trees
- Replacement of sidewalks in road and street rights-of-way with permeable pavement
- Replacement of pavement outside of road and street rights-of-way with permeable pavement
- Conversion of roof areas to green roofs
- Stormwater planters

Other technologies are possible. The purpose of the preliminary analyses was not to select technologies for any given basin or specific location, but to develop representative estimates of the capital cost potentially associated with green storage.

The following is a summary of principal conclusions reached in those preliminary analyses:

- From references (1) and (2) above, it was concluded that, in general, the overall capital cost (considering both public and potential private investment) of integrated gray and green alternatives for CSO control could be expected to exceed the capital cost for gray-only control. However, it was also concluded that, with sufficient private investment, public investment could be reduced with integrated gray and green alternatives.

- In reference (3) above, it was concluded that it could be cost-effective to completely replace the proposed storage tanks at Outfalls 059 and 069 in the Middle Blue River basin with distributed green storage in their tributary areas.
- In reference (4) above, it was concluded that it would not be cost-effective to eliminate consolidation piping between Outfall 097 and the BTFC tunnel by constructing distributed green storage in the areas tributary to Outfalls 092-097. It was further concluded that an investment in green storage could reduce the frequency and volume of CSOs to Forest Hills Cemetery, although at an increase in the overall cost of the CSO control program.

Given those principal conclusions, two CSO tanks in the Middle Blue River basin upstream of Outfalls 059 and 069 included in the draft Plan have been replaced in the selected Plan with green storage distributed throughout the 744 acres tributary to those outfalls.

10.6.2 Updated Cost Estimates

Updated estimates of the capital and incremental operations and maintenance cost of the Plan components included in the May, 2008, Draft Control Plan Summary were prepared by the Basin Engineers. The net effects of those updated estimates (all estimates expressed in 2008 dollars) were to:

- Increase the estimated capital cost of the Plan from $2.3 to $2.4 billion
- Increase the incremental operations and maintenance cost from $30 million per year to $33 million per year.

10.6.3 Additional Changes Recommended by Independent Review Team

The following additional changes and adjustments to the draft Plan were recommended by the independent review team commissioned by the WSD, and are reflected in the selected Plan described in Chapter 12:

- Approach: An adaptive management approach has been incorporated throughout the Plan. This approach enables the City to minimize risk and uncertainty associated with the performance, acceptability, and cost of the various plan components. The Plan is founded upon a holistic, watershed perspective to CSOs, which will result in more comprehensive, cost-effective solutions that involve watershed stakeholders from various jurisdictions throughout the planning and management process. In addition to regulatory reviews of the Plan scheduled to occur every five years, intermediate, internal program reviews at the mid-point of each 5-year cycle are incorporated into the Plan and will focus on the direction of the Plan and its benefits to the rate payers and citizens of the City.
- Green Infrastructure Pilots and Partnerships: The Plan includes $28 million to develop large scale, green infrastructure pilots and partnerships in the CSS basins. Pilot projects will focus on

incorporating and evaluating green infrastructure as part of the proposed basin specific solutions. Green infrastructure partnerships will concentrate on creating private sector participation in both the pilots and final basin solutions.

- Rain Gardens and Downspout Disconnects: The City's award winning "10,000 Rain Gardens" campaign will be expanded as part of the comprehensive solution to downspout disconnects and green infrastructure development on private land. Funding in the amount of $5 million is estimated for this effort.
- Green Collar Jobs and Workforce Development: The City's $2.4 billion investment in its sewer infrastructure presents significant opportunities for local businesses and residents. The Plan will fund $5 million to work with job creation and work force development organizations in the development and implementation of training programs, including a green collar jobs program.
- Blue River Watershed Management Plan: Funding for the City to develop a Blue River Watershed Management Plan with Johnson County, Kansas and other stakeholders has been increased to $2 million. This plan will represent a bi-state, comprehensive effort to identify watershed solutions to water quality improvement needs and facilitate reduced structural controls within the selected Plan.
- Enhanced Model Development: In order to better understand how the system will respond to green infrastructure and structural solutions, detailed monitoring and modeling activities will be required. Funding for these activities has been defined in the amount of one percent of Plan costs, equating to $24 million over the life of the Plan. The results of this extensive monitoring and modeling effort will not only be important to the City, but will also provide invaluable information about green solutions implementation opportunities nationwide.
- Public Education and Outreach: The City will engage neighborhood associations, businesses, civic groups, non-profit entities, universities, and citizens in a public dialogue designed to educate and inform the community about the Plan as implementation progresses, and to seek input and involvement from all sectors of the community. Funded at $12 million, this initiative will allow for ongoing education and input from impacted neighborhoods and from the community at large throughout the life of the Plan.
- Institutional Strategies: Implementation of pilot projects will provide opportunities for the City to assess and recommend revisions to a host of planning and design processes nested within the City's current institutional structure. Recommendations may include revisions to the City's development code, engineering and design standards and specifications, and standard operating procedures for a range of City functions. City processes and project implementation strategies will be evaluated to see if new approaches for communications between departments, citizens and neighborhoods can be provided. City staff, at all levels, will undergo appropriate training on new approaches and technologies to best serve the citizens of the City.

The last of the above changes (Institutional Strategies) is beyond the direct control of the WSD. Its contribution to the overall success of the selected Plan will be determined by the long-term commitment of the City as a whole to the development and implementation of green infrastructure as an integral component of efforts to improve water quality in Kansas City's lakes, streams, and rivers.

* * * * *

.

11 FINANCIAL CAPABILITY AND IMPLEMENTATION SCHEDULE

11.1 Introduction

The United States Environmental Protection Agency's (USEPA) Combined Sewer Overflow (CSO) Control Policy (40 CFR Part 122) requires that permittees include all pertinent information in the overflow control plan necessary to develop the construction and financing schedule for implementation of overflow controls. As provided in that CSO Control Policy, schedules for implementation of the overflow controls may be phased based on the relative importance of adverse impacts upon water quality standards and designated uses, on priority projects identified in the overflow control plan, and on the permittee's financial capability.

The Policy provides that construction phasing should consider:

- Eliminating overflows that discharge to sensitive areas as the highest priority;
- Ambient water quality designated use impairment;
- The permittee's financial capability including consideration of such factors as:
  - Median household income
  - Total annual wastewater and overflow control costs per household, as a percent of median household income
  - Overall net debt as a percent of full market property value
  - Property tax revenues as a percent of full market property value
  - Property tax collection rate
  - Unemployment
  - Bond rating
  - Local socio-economic conditions
- Grant and loan availability
- Previous and current residential, commercial, and industrial sewer user fees and rate structures
- Other viable funding mechanisms and sources of financing.

As indicated in Chapter 12, the estimated capital cost for the selected Plan is $2.4 billion (in 2008 dollars). However, the wastewater utility's current capital improvements program includes an additional $0.5 billion in other needs that must also be considered when finalizing funding and an implementation schedule for the Plan.

This Chapter provides a summary of the various analyses and projections prepared to assess possible funding and Kansas City's (the City) financial capability to implement an Overflow Control Plan, including their impact on possible implementation schedules for the selected Plan (which is described in Chapter 12).

11.2 Funding Mechanisms and Sources of Financing

A Water Services Utility Funding Task Force (Funding Task Force) comprised of community leaders was appointed by City Mayor Mark Funkhouser in January 2008 to help integrate community values into a funding strategy for the City's water, sewer, and stormwater utilities. Additional detail on the Task Force and its deliberations is presented in Chapter 9 and Appendix E.

Principal recommendations from the Funding Task Force to the City Council that directly affect possible implementation schedules for the selected Plan include:

- Funding of the Plan should be primarily accomplished through increased sewer rates, unless other funding mechanisms become available.
- City Council should support future voter-authorized debt to utilize a blend of pay-as-you-go and revenue bonds, with approximately 50 percent cash financed and 50 percent debt financed.
- Other funding mechanisms should be explored throughout the life of the Plan, including operational efficiencies, use of sales tax, and the pursuit of state and federal grants.

These recommendations were subsequently accepted through a resolution of the City Council at its December 11, 2008 meeting.

While the Task Force strongly supported aggressively pursuing state and federal monies for the City's Wet Weather Solutions Program (which includes the Plan), little such funding has been available. However, there is some indication that federal grant funding (or grant equivalents) may become available through federal economic recovery/stimulus legislation.

Accordingly, the Water Services Department (WSD) has briefed the City's congressional delegation so that advantage can be taken of any opportunity for federal grant funding that may present itself. WSD has also entered into discussions with the Kansas City District, U.S. Army Corps of Engineers (KCDCOE) to identify possible federal interest in elements of the Plan. Projects were identified that could potentially be eligible for inclusion in any economic stimulus package that may be adopted by the federal government in the near future.

11.3 Financial Capability

The City's financial capability to implement overflow controls was analyzed throughout development of this Plan. Key milestones in that continuing analysis are summarized below.

11.3.1 Preliminary Financial Capability Assessment

Following publication of the *Conceptual Control Plan*, (CCP); OCP, September 2007, WSD contracted for an assessment of the City's financial capability to implement the preliminary recommendations of the CCP. That assessment is documented in the following technical memorandum:

> *Preliminary Financial Capability Assessment;* Economics Center for Education & Research, College of Business, University of Cincinnati; January 2008.

The estimated capital cost of the overflow controls outlined in the CCP was between $2.4 and $3.0 billion (June, 2006 dollars). The CCP suggested an implementation period of 25 years or longer would be necessary to complete implementation of the conceptual Plan without imposing an undue burden on the community and to maximize the benefit of green solutions.

The preliminary Financial Capability Assessment (FCA) was structured to assess the impact of the CCP on the City's rate payers in accordance with guidance developed by USEPA in 1997, entitled *CSO Guidance for Financial Capability Assessment and Schedule Development.* This guidance has not been promulgated as a rule or regulation and is not a legally binding requirement. Due to dissatisfaction with the guidance, legislation is pending before Congress to force USEPA to update and revise this guidance.

The FCA was developed assuming a capital cost of $2.6 billion and an implementation period of 25 years. Completion of the preliminary FCA also required initial projections to factor in inflation, construction cost increases, financing costs, and other key factors.

The principal conclusion of the preliminary FCA was that the CCP, with an approximate capital cost of $2.6 billion implemented over a 25-year period, would impose a very heavy burden on sewer ratepayers in the City's retail service area. The guidance looks at two factors: (1) residential indicator, which assesses the impact of the Plan on residential ratepayers and (2) financial indicator, which assesses the City's overall ability to fund the Plan.

Considering only the residential indicator (cost per household for future sewer service as a percentage of median household income [MHI]) criterion of the Guidance, the preliminary FCA further concluded that:

- A capital investment of $2.14 billion would put the sewer billing rates for all residential users at 2.0 percent of MHI for the retail service area, on the borderline of the "medium" and "heavy" burden categories
- When the second criterion in the guidance (the Financial Indicator) is considered, even the $2.14 billion level of investment would put the City in the "heavy" burden category for households in the retail service area and, accordingly, may not be affordable.

Continued financial analyses subsequent to completion of the preliminary FCA revisited each of the principal assumptions and projections underlying the preliminary FCA. Significant adjustments were made to those assumptions and projections in parallel with updated estimates of Plan performance and costs.

11.3.2 Modifications to Conceptual Control Plan

Chapter 10 describes the process followed in modification of the CCP leading to the selected Plan, presented in detail in Chapter 12. The estimated capital cost of the Plan is approximately $2.4 billion in 2008 dollars (Engineering News Record Construction Cost Index of 9180), equivalent to $2.2 billion in June, 2006 dollars (Engineering News Record Construction Cost Index = 8500). Additional operations and maintenance costs for the selected Plan are estimated to aggregate to $33 million per year in 2008 dollars.

11.3.3 Base Case Financial Projections for Overflow Control Plan

All assumptions and projections made in preparation of the preliminary FCA were revisited in a detailed financial analysis documented in:

Financial Analysis Summary, Base Case (Debt Financing); OCP; September 2008.

That analysis was developed assuming that the entire Plan and wastewater utility operations were funded from user rates. Revenue bonds (with debt service paid from user rates) were used in the analysis to accelerate completion of major components of the Plan. An implementation period of not less than 25 years was recommended to:

- Maintain future user fees within the range established under the USEPA's guidelines for assessment of affordability; those guidelines generally consider user rates approaching two percent of median household income as imposing a heavy burden on ratepayers.
- Provide the maximum opportunity for the city-wide implementation of green solutions to avoid or reduce the eventual cost of larger, more conventional structural controls.
- Cap annual rate increases at 13 percent, the maximum level deemed attainable.

The analysis considered not only the projected costs directly associated with the selected Plan, but also the necessary increases in wastewater utility revenues required to properly operate, maintain, repair, and replace the wastewater collection and treatment system during and after completion of the Plan.

An upper limit on residential user fees equal to 1.7 percent of the City's median household income was established for the analysis. That limit was based upon consideration of the USEPA's guidance, along with various economic factors specific to the City.

The analysis at this stage did not consider the impact of other recent and potential future regulatory changes on wastewater utility costs. Examples of such regulatory changes include:

- Disinfection of wastewater treatment plant effluent (expected to be a requirement in the City's upcoming National Pollutant Discharge Elimination System [NPDES] permit renewals).
- More restrictive limits on ammonia levels in treatment plant effluent (now under discussion between WSD and the Missouri Department of Natural Resources in connection with NPDES permit renewals for the Westside and Blue River wastewater treatment plants).
- Possible new future limits on nutrients (primarily phosphorous and nitrogen) in wastewater treatment plant (WWTP) effluents resulting from ongoing regulatory agency analysis of an expanding hypoxic zone in the Gulf of Mexico. Future regulatory requirements are uncertain, but could be very costly to meet.

Projected annual expenditures for the selected Plan were developed through an iterative analysis considering:

- Necessary design and construction schedules for individual components of the Plan.
- Logical sequencing of the various components.
- The influence of available revenues on annual expenditure limits.
- Early investment in green infrastructure and repair of the existing system, with larger structural controls, particularly those for which design requirements can be impacted by early inflow reduction efforts, constructed later in the overall schedule.

Additional factors considered in that financial analysis included:

- Provisions for growth
- Projected inflation and construction cost escalation rates
- Revenue sources and revenue growth
- Expenditures other than Plan capital cost, such as:
  - Additional funding for repair and replacement of the existing system
  - Additional funding for enhanced operation, maintenance, and management of the existing system
  - Increased operations and maintenance costs upon completion of Plan components
- Use of revenue bonds and resulting debt service payments
- Financial operating criteria

The upper limit on residential user fees in the analysis (1.7 percent of MHI) was developed based on all residential households in the City's retail service area, including both single-family residential accounts and households billed under commercial accounts (such as for apartment buildings and multiplex housing units). Future user rates for single-family residential accounts (which typically use more water than households in commercial accounts) were projected at 1.9 percent of the City's MHI. Further significant increases in future user fees would result in sewer billings for single family residential accounts clearly exceeding the Residential Index criterion in USEPA's guidance and place an unreasonably heavy burden on the City's rate payers.

The base case financial projections did not directly consider WSD's current capital improvements program, which includes a substantial backlog of identified system maintenance needs.

11.4 Other Wastewater Utility Capital Needs

An initial assessment of the potential capital cost for reasonably foreseeable regulatory changes (including disinfection at all WWTPs and potential ammonia reduction requirements at the Blue River WWTP) is presented in Table 11-1.

Table 11-1 Estimated Capital Cost of Other Regulatory Changes

Treatment Plant	Action	Est. Capital Cost ($ Million)	Completion Date
Rocky Branch	Disinfection	$2.2	10/11/2011
Birmingham	Disinfection	$15.2	01/24/2012
Blue River	New Ammonia Limits	$77.0 (Note 3)	(Note 2)
Blue River	Disinfection	$60.0	12/31/2013
Westside	Disinfection	$13.2	12/31/2013
Fishing River	Disinfection	$2.2	12/31/2013
Northland Mobile	N/A (Note 1)		
Todd Creek	Disinfection	$2.2	12/31/2013
Initial Assessment of Total Capital Cost		**$172 Million**	

Notes:

1. Northland Mobile Home Park WWTP to be removed from service.
2. Final nature of necessary improvements and completion schedule highly uncertain.
3. Based on nitrifying activated sludge after trickling filters.
4. All estimated capital costs are in 2008 dollars and are highly conceptual in nature.

The data listed in Table 11-1 excludes the longer-term potential for future limits on nutrient levels in WWTP effluents. Future costs for nutrient control at the City's WWTPs are highly uncertain, but could range from $250 million to $750 million.

An initial compilation of current estimates of capital cost for other system needs, taken from the WSD's current capital improvements program listing for Fiscal Years 2010-2014, is presented in Table 11-2.

Other reasonably foreseeable wastewater utility capital needs over the next five years, not directly considered in financial capability assessments prepared for the Plan, aggregate to $593 million (summation of estimated costs listed in Tables 11-1 and 11-2). That total includes a total of $90 million for collection system expansion and increased capacity at certain of the WWTPs intended to accommodate system growth. As financial projections and

Table 11-2 Other Wastewater Utility 5-Year Capital Improvement Needs

Nature of Capital Improvement	Estimated Capital Cost (2008 $ Million)
Collection System Repair, Reconstruction and Replacement	$61
Collection System Expansion	41
Infill Assessment Sewers (Septic Tank Elimination)	15
Collection System Investigations & Water Quality Monitoring	3
Repair, Replacement and Reconstruction at Existing Wastewater Treatment Plants	83
Increase Capacity at Wastewater Treatment Plants (Fishing River, Todd Creek, Rocky Branch)	43
Pumping Stations & Force Main Repair, Reconstruction and Replacement (Includes SCADA)	49
Administrative & Maintenance Facility Repair, Reconstruction and Replacement	94
Economic Development and System Relocations	8
Asset Management, Security Enhancements, Planning and Administrative Costs	24
Total	**$421**

capability assessments prepared for the Plan did not consider an expanded ratepayer base resulting from possible system growth, the estimated costs of $90 million directly associated with system growth was excluded from further consideration. Any final implementation schedule developed for the Plan must recognize the near-term need for approximately $500 million in other capital improvements, in addition to the Plan's estimated capital cost of $2.4 billion. The funding options described below address all identified revenue needs.

11.5 Funding Options and Range of Possible Plan Implementation Schedules

Implementation of the Plan will be controlled by the availability of funds to construct, operate, and maintain the proposed facilities. Projecting the availability of funds literally decades into the future introduced a number of uncertainties, including but not limited to the following key considerations:

- Voters' willingness to approve the issuance of revenue bonds.
- Financial market health and the cost of capital.
- The degree to which construction cost escalation parallels general rates of price inflation.
- The extent to which other sources of funding, such as federal and state grants or cost-sharing, become available.
- The degree to which growth in the City's median household income parallels general rates of price inflation.
- Future changes in the general economic health and posture of the City
- Gains or losses in service area population over time.
- Future regulatory changes that might compete with the Plan for available funds, or further increase performance objectives.

The above uncertainties are in addition to those inherent in the basic planning process (such as accuracy of cost estimates and actual vs. modeled facility performance).

A number of financial projections were prepared to evaluate the overall time required for completion of the Plan. Four such projections are presented below. The following assumptions were common to each of those projections:

- The principal source of funding is wastewater utility user rates.
- Eventual user rates are capped at a given percentage of median household income.
- User rates increase at not less than 10 percent per year above general price inflation until that cap is reached, and parallel to general price inflation rates thereafter.
- The real (after inflation) cost of capital is generally 2.6 percent per year.
- The maturity of any new revenue bonds would be 30 years.
- The estimated total capital cost of necessary wastewater utility improvement (in 2008 dollars) is \$2.9 billion (\$2.4 billion for the Plan, \$0.5 billion for other capital needs).

11.5.1 Alternative No. 1 (Base Case)

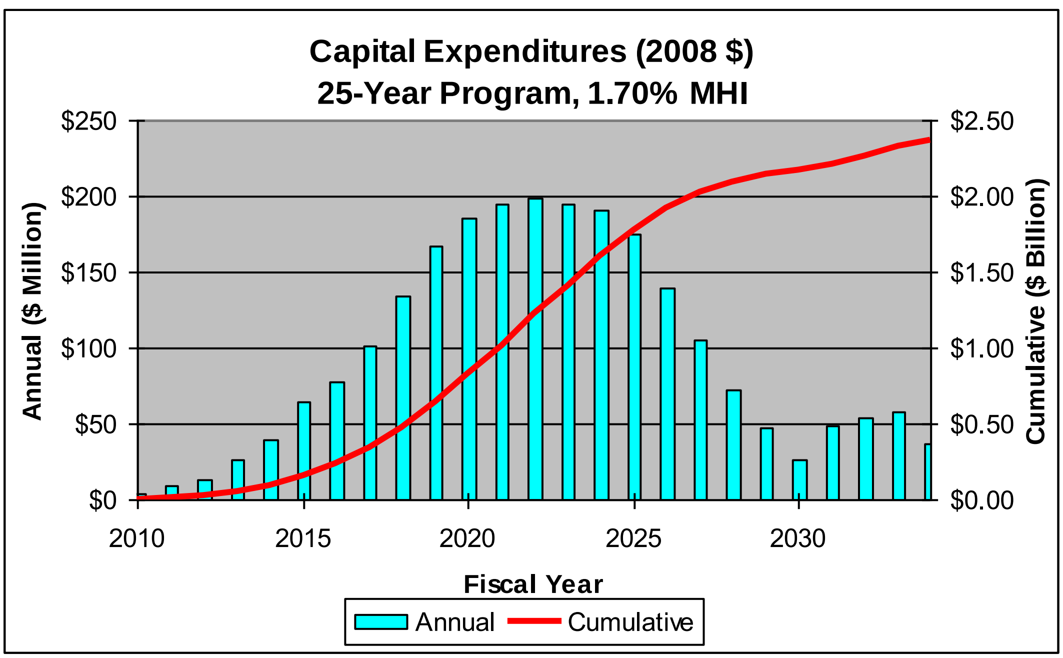
The possible implementation schedule presented in Chapter 12 was developed in concert with the base case financial analysis (\$2.4 billion in 2008 dollars implemented over 25 years) described above. The availability of funds for the Plan capital improvements resulting from that analysis is summarized in Figure 11-1. Significant assumptions in that analysis included:

- Sewer billing rates for all residential users capped at 1.7 percent of the MHI for the retail service area (reached in Fiscal Year 2023).
- The City's electorate approves the issuance of additional revenue bonds for the Plan, with the first such issuance in Fiscal Year 2013 (total new bond issuance of $2.83 billion over the life of the Plan, in future dollars). Roughly one-half the capital cost of the Plan would be financed through those additional revenue bonds, with the other half funded from cash.

The second of the above assumptions may be overly optimistic, as the City's voters would be asked to approve a major bond issue while being advised that their sewer billing rates would continue to significantly increase each year for another decade.

Under this very aggressive projection, a total of 25 years would be needed to complete construction of all components of the Plan. However, even this aggressive projection does not consider the additional $500 million in other wastewater utility capital needs discussed previously. Thus, the City either needs to find $500 million (2008 dollars) in revenues from other sources (such as State or federal grants) to maintain the overall 25-year completion schedule or the schedule must be extended. Alternatives 2 through 4, described below, develop estimates of the longer schedule necessary to fund the additional $500 million, assuming that no federal or State grant funds are forthcoming.

Figure 11-1 Capital Expenditure Projections, Alternative 1



11.5.2 Alternative No. 2

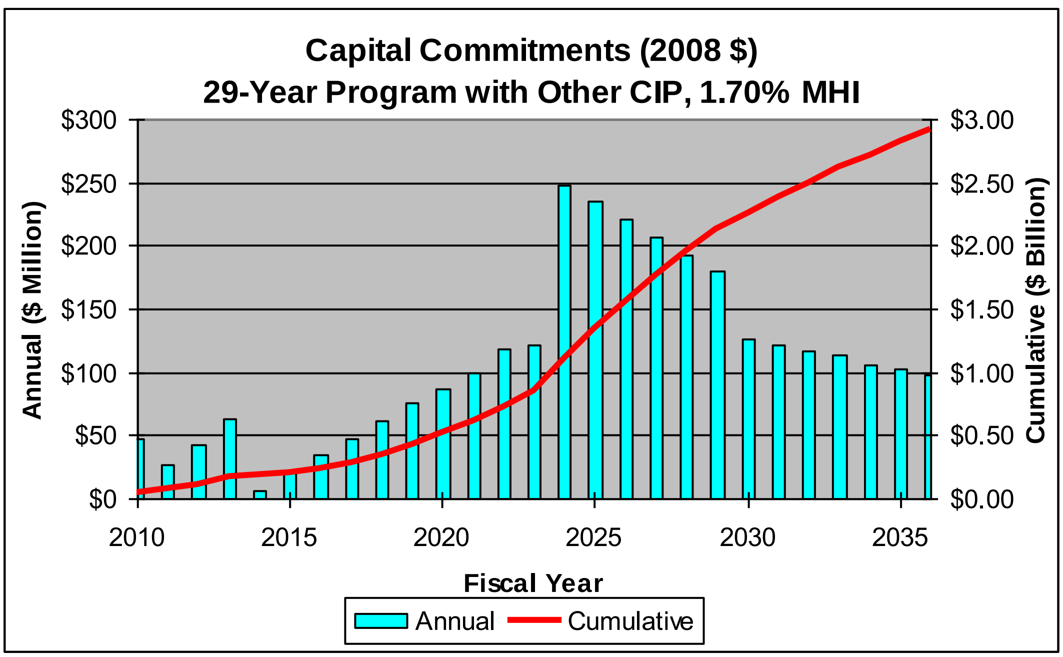
This financial projection was made on the principal assumption that no other significant source of funding is found, and that it would be necessary to fund $2.9 billion in capital improvements ($2.4 billion for the Plan and $0.5 billion for other capital needs) from user rates and bonds. Other significant assumptions included in this projection include:

- Sewer billing rates for all residential users capped at 1.7 percent of the MHI for the retail service area (reached in Fiscal Year 2023).
- The City's electorate approves the issuance of additional revenue bonds for the Plan, with the first such issuance in Fiscal Year 2023 (total new bond issuance of $2.91 billion over the life of the Plan, in future dollars).

Under this projection, the need for additional bonds would be taken to the City's voters at a point in time when the maximum real (e.g., after inflation) sewer billing rates had been reached, potentially increasing the possibility of voter approval.

The availability of funds for capital improvements (both for the Plan and for other capital improvement needs) resulting from this projection is summarized in Figure 11-2.

Figure 11-2 Capital Expenditure Projections, Alternative 2



Under this projection, a total of 27 years would be needed to generate sufficient funds to contract for construction of all components of the Plan and the additional $500 million in other wastewater utility capital needs discussed previously. Some additional time would be required for completion of all construction, leading to an overall completion schedule of approximately 29 years.

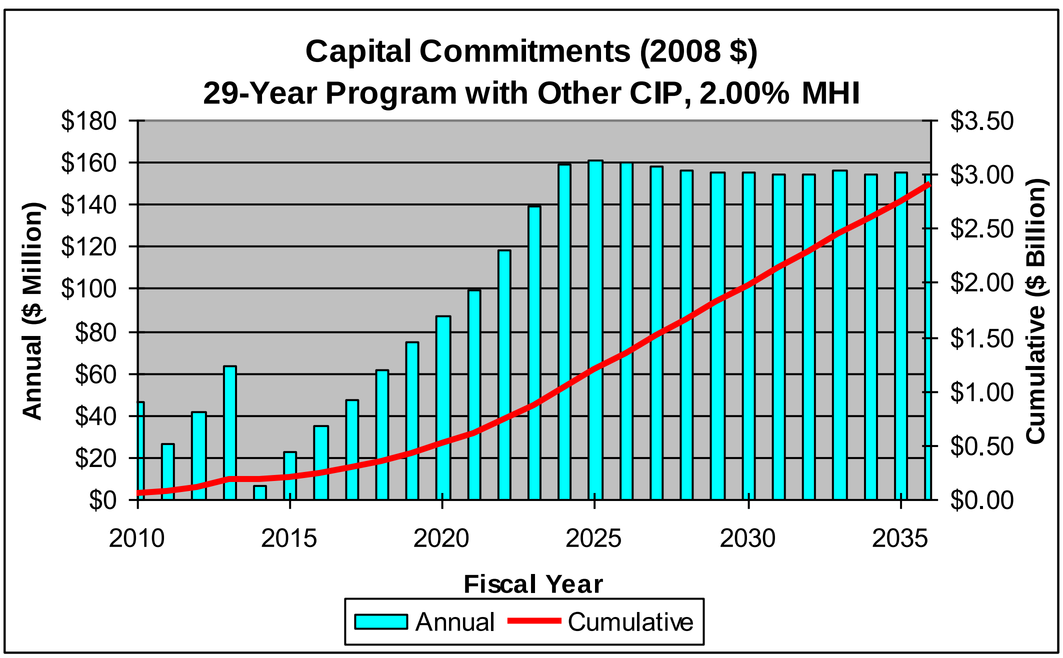
11.5.3 Alternative No. 3

This financial projection was made on the principal assumption that no other significant source of funding is found, and that it would be necessary to fund $2.9 billion in capital improvements from user rates. Other significant assumptions in this projection include:

- Sewer billing rates for all residential users capped at 2.0 percent of the MHI for the retail service area (reached in Fiscal Year 2024). Rates through Fiscal Year 2022 would be equal to those considered in Alternative No. 2.
- No issuance of additional revenue bonds for the Plan, i.e., voter denial of any proposed bond authorization.

In essence, this projection could be considered as the choice given voters when authorization of additional bonds is proposed. The availability of funds for capital improvements (both for the Plan and for other capital improvement needs) resulting from that analysis is summarized in Figure 11-3.

Figure 11-3 Capital Expenditure Projections, Alternative 3



Under this projection, a total of 27 years would be needed to generate sufficient funds to contract for construction of all components of the Plan and the additional $500 million in other wastewater utility capital needs discussed previously. Some additional time would be required for completion of all construction, leading to an overall completion schedule of approximately 29 years.

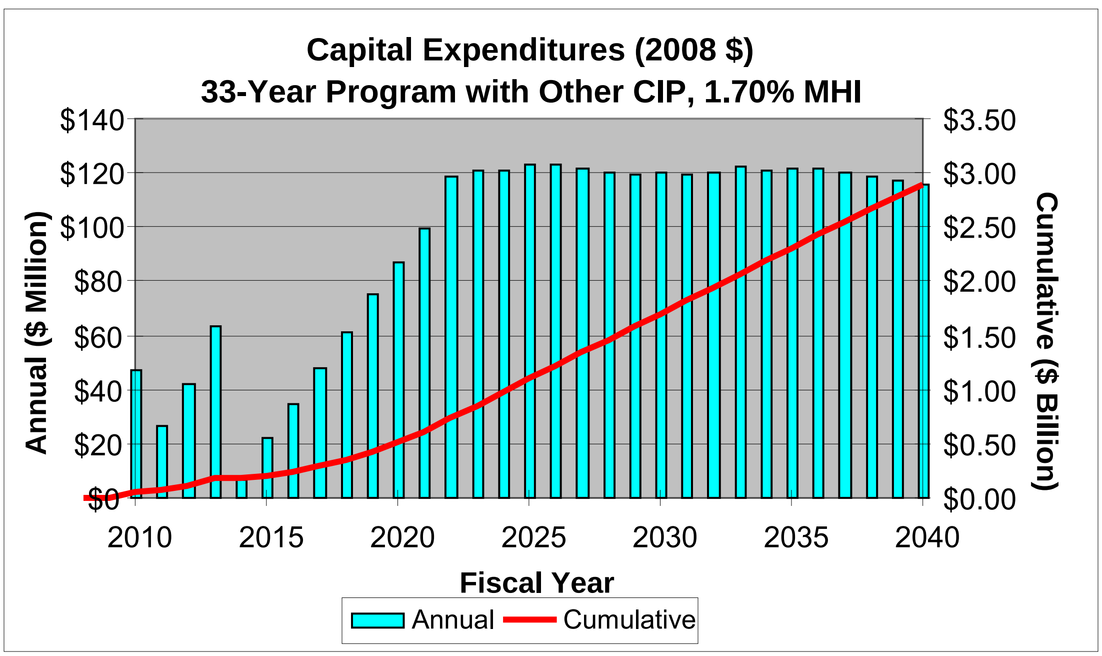
11.5.4 Alternative No. 4

This financial projection was made on the principal assumption that no other significant source of funding is found, and that it would be necessary to fund $2.9 billion in capital improvements from user rates. Other significant assumptions in this projection include:

- Sewer billing rates for all residential users capped at 1.7 percent of the MHI for the retail service area (reached in Fiscal Year 2023). Rates through Fiscal Year 2023 and beyond would be equal to those considered in Alternative No. 2.
- No issuance of additional revenue bonds for the Plan.

The availability of funds for capital improvements (both for the Overflow Control Plan and for other capital improvement needs) resulting from that analysis is summarized in Figure 11-4.

Figure 11-4 Capital Expenditure Projections, Alternative 4



Under this projection, a total of 31 years would be needed to generate sufficient funds to contract for construction of all components of the Plan and the additional $500 million in other wastewater utility capital needs discussed earlier in this Chapter. Some additional time would be required for completion of all construction, leading to an overall completion schedule of approximately 33 years.

11.6 Conclusion

The financial projections discussed above suggest that between 25 and 33 years will be needed to fund and implement the Plan while completing other presently identified wastewater utility capital needs. This conclusion is reached without consideration of other scheduling factors, such as the need to maximize the use and benefit of green solutions and integration with other City/regional/State/Federal projects. As discussed in Chapter 12, these other scheduling factors provide additional compelling support for this range of implementation schedules. Each of those projections is predicated upon acceptance of a heavy financial burden by the City and its ratepayers. Achieving an overall completion at the lower end of that range (consistent with the preliminary schedule presented in Chapter 12, which considers constructability and phasing) will require the identification of additional revenues, other than those from presently projected user rate increases, sufficient to comply with other new regulatory requirements and other wastewater utility capital improvement needs.

The funding analysis and financial projections, as presented above, were based on estimates, forecasts, projections, and schedules relating to costs, quantities, and pricing of construction, operations and maintenance costs, and future sewer rates. Actual results may vary significantly from these current projections. Therefore, these projections should be revisited from time to time throughout implementation of the Plan. At a minimum, the analysis (including all underlying assumptions) should be updated at five-year intervals concurrent with the overall Plan reviews recommended in Chapter 12.

* * * * *

12 SELECTED PLAN

12.1 Overview

The plan selected by the City of Kansas City, Missouri (the City; KCMO) for decreasing the frequency, volume, and duration of overflows from its combined sewer system (CSS) and separate sanitary sewer systems (SSS) is described herein. While this selected Overflow Control Plan (the Plan) refers to stormwater management in the combined sewer system, KC-One (Kansas City's stormwater management plan) will provide recommendations to address stormwater issues throughout the City. The Plan is designed to work in concert with KC-One to achieve the primary goals defined by the Wet Weather Community Panel (the Community Panel):

- Minimize loss of life & injury
- Reduce property damage due to flooding
- Improve water quality while maximizing economic, social, and environmental benefits

The Community Panel further defined specific objectives for each of those goals (see Chapter 9). Achieving those goals and meeting regulatory requirements will require more than simply decreasing the frequency, volume, and duration of overflows from the City's CSS and SSS. A watershed approach is needed, coupling overflow control with forward-looking stormwater management and a community-wide emphasis on protecting water quality and reducing runoff. Green solutions, stormwater Best Management Practices, and conventional source reduction techniques will all play significant and early roles in an adaptive program structured to achieve those objectives at an appropriate cost.

The Plan is premised on an adaptive management approach in which design, management, and monitoring are integrated to systematically test assumptions, learn from results, and adapt future plans throughout implementation. The adaptive management framework will be applied to the Plan on various levels. Adaptive management will be part of the overall programmatic approach, and will also be specifically applied at the basin and project level. Data gathered throughout project implementation will provide opportunities for feedback that subsequently will provide for informed decision-making at the basin level and, ultimately, City-wide.

The Plan is structured to:

- Reduce the problem before trying to solve it by preventing as much stormwater as practicable from entering the CSS and SSS. This will be accomplished through implementation of both green solutions and conventional source controls early in the Plan implementation.
- Address flood protection needs, where practical, while reducing combined sewer overflows (CSO).

- Provide a programmatic platform to facilitate implementation of a comprehensive green solutions initiative across the City.
- Engage the entire metropolitan community in a comprehensive effort to improve water quality in the City's lakes, streams and rivers.
- Maximize use of the existing collection and treatment systems.
- Establish an adaptive approach to long-term plans for structural solutions so they can be modified to reflect the results and benefits of early efforts (green solutions and conventional source controls) on the responses of both the CSS and SSSs to rainfall events.

The Plan will:

- Eliminate, or capture for treatment, approximately 88 percent of the existing (2007) wet-weather flows in the CSS during a typical year.
- Reduce typical-year CSO volume from 6.4 billion gallons to approximately 1.4 billion gallons.
- Reduce infiltration and inflow (I/I) in the SSS.
- Provide adequate capacity to store, transport, and treat remaining wet-weather flows (as predicted by modeling) in the SSS during a 5-year, 24-hour rainfall event.
- Reduce the frequency and severity of basement backups throughout the City.
- Cost approximately $2.4 billion (in 2008 dollars).
- Increase annual costs for operation and maintenance of the sewage collection and treatment system by approximately $33 million per year (in 2008 dollars).

Improved operation and maintenance and an appropriate level of investment in repair and replacement of system components are also needed to overcome deferred maintenance. Costs for those efforts to restore and preserve the integrity of the City's wastewater collection and treatment assets have been considered in developing an appropriate level of investment for the Plan.

12.2 Blue River Watershed Management Plan

The City's water quality monitoring data revealed that streams receiving CSO generally meet current water quality standards for most pollutant parameters. However, CSO receiving streams do not meet current state standards for bacteria. There are four primary sources of pollution in the streams that receive CSOs: stormwater runoff from upstream sources, stormwater runoff from both SSS areas adjacent to the streams and in the CSS areas, effluent from wastewater treatment plants (WWTP), and untreated wastewater in CSOs. If the City's CSOs are reduced (or even eliminated), water quality would still not meet state bacteria standards in the Missouri River and part of the Blue River. Attainment of appropriate water quality standards in the Blue River requires that substantial reductions for each of the primary sources of pollution be achieved. A watershed approach is clearly needed to deliver meaningful improvements in water quality.

The Plan includes a commitment to the preparation of a watershed management plan (WMP) for the entire Blue River Basin. Strategies will be developed that acknowledge the interrelationship of water, land use, and human communities within the watershed. Resultant projects should produce multiple benefits.

The Blue River originates at the confluence of Wolf Creek and Coffee Creek and flows 41 river miles through the Kansas City metropolitan area to the Missouri River. Approximately 60 percent of the 270-square mile watershed is located in Kansas and the remaining 40 percent is in Missouri. Within the two states, the watershed covers parts of four counties, 13 local governments and 11 school districts. The major tributaries to the Blue River are Brush, Indian, Tomahawk, Wolf, and Coffee Creeks. Since problems and solutions cross political boundaries, the City will work with neighboring watershed communities to develop this WMP.

The WMP is intended to be multi-jurisdictional, bi-state, cost-effective, collaborative, and comprehensive. The WMP will include goals, objectives, and specific strategies, and an implementation plan. During implementation, progress will be monitored and WMP adjustments made to ensure real improvement in water quality directed toward eventual compliance with water quality standards.

An outline of the potential steps and the process that will be followed when preparing the Blue River WMP can be found in the United States Environmental Protection Agency's (USEPA) Handbook for Developing Watershed Plans to Restore and Protect Our Waters at:

http://www.epa.gov/nps/watershed_handbook/pdf/handbook.pdf.

The City has successfully participated in other watershed initiatives such as the Brush Creek Feasibility Study, the Blue River Feasibility Study, and the Upper Blue River Watershed Initiative. The City will build on its watershed accomplishments toward the goal of making the Blue River WMP a success and model for future watershed planning in the region.

12.3 Monitor, Evaluate and Adapt

A critical aspect of adaptive management is the ability to measure and evaluate programmatic and project activities, which requires the identification of performance indicators, or measures of success. As the Plan moves forward, performance indicators that relate to overall Plan development and implementation will be formulated to measure Plan success in reducing sewer overflows and maximizing social, economic, and environmental opportunities for the Kansas City community. Additionally, specific performance indicators will be devised to evaluate success at both the project and basin levels.

One of the first activities in the Plan will be to install flow meters and level sensors in both the CSS and SSS. Those meters and sensors will be monitored to:

- Measure flows to the SSS from the more significant satellite communities, i.e., Johnson County Wastewater District, North Kansas City, Liberty, Gladstone, and Raytown.
- Install level sensors at all diversion structures and flow meters at more significant diversion structures in the CSS.
- Develop long-term information describing sewer system response to rainfall.
- Assess the impact of green solutions and I/I reduction efforts on the response of the sewer system to rainfall events.
- Confirm the impact of incremental system improvements on that response.

The results of the monitoring will be evaluated through computer modeling of the sewer system and will lead to adjustments in the design, construction, and operation of remaining components throughout implementation of the Plan.

The Plan also includes recommendations for an expanded water quality monitoring plan (WQMP) for the City's lakes, streams, and rivers. This WQMP will develop the information necessary to document progress toward attainment of water quality standards, and to assist in development of the Blue River Watershed Management Plan.

Additional detail on the WQMP and a post-construction monitoring plan (PCMP) for the sewer system itself is included in Chapter 13.

Adjustments to the design, construction, and operation of the entire Plan will result from an evaluation of progress to-date, including, but not limited to, the results of the ongoing monitoring efforts. That evaluation is expected to be a continuous effort throughout the Plan implementation period. Formal updates and revisions to the Plan will be conducted on five-year intervals and submitted to the regulatory agencies (including the Missouri Department of Natural Resources [MDNR]) for concurrence. In addition, intermediate, internal Plan reviews focusing on the direction of the Plan and its benefits to the rate payers and citizens of the City will be conducted at the midpoint of each 5-year cycle

12.4 City-Wide Program of Green Solutions

Kansas Citians desire solutions to wet-weather problems that produce multiple benefits. Creative partnerships, focused land conservation and restoration, community education, regulations, and sustainable infrastructure projects are all necessary to achieve multiple benefits**.** These solutions are critical if the City is to succeed in protecting water as a valuable resource. Every decision should be viewed as an opportunity to incorporate a green-solutions approach. The City has adopted an "every drop counts" philosophy, meaning it is important to reduce stormwater entering the system wherever practicable. This will be accomplished through changing the way the community develops and redevelops its sewer and stormwater infrastructure, educating citizens regarding steps they can take to reduce the amount of stormwater entering the sewer system, enabling citizens to take those steps, incorporating green infrastructure in the design of public infrastructure, and making targeted public investments in green infrastructure projects early in the Plan implementation.

The Plan is just one element of a comprehensive approach to systematically incorporate low impact development strategies, tools, and practices that focus on maintaining the natural hydrologic cycle to achieve program goals. An example of this strategy is the City's recent adoption of a stream setback ordinance in August 2008. Other public policy initiatives expected to enhance the effectiveness of the Plan include:

- Integration with other City and regional efforts: The Plan will complement, and be integrated with, other city and regional programs related to integrated water resource management, climate protection, land use, community development, parks and trails, air quality, and transportation.
- Development of regulations for public and private property: A review of the full city development code to support broad low impact development strategies will be performed to formulate proposed code revisions to be submitted to the City Council for its review and approval.
- Review of stormwater engineering criteria, standards, and specifications for new and redevelopment projects: Existing standards applied to public and private projects alike will be reviewed to ensure that low impact development benefits are maximized through state-of-the-art stormwater management practices.
- Expansion of urban and community forestry program: Expanded urban forestry programs will achieve multiple benefits, such as improved air and water quality, reduced energy use and urban heat islands, and restored habitat and biodiversity.
- Definition of new standard operating procedures: City operations and maintenance (O&M) practices will be guided by new procedures to capitalize on the many opportunities to implement more distributed, green infrastructure solutions, and to ensure the long-term effectiveness of these practices.

Elements of the Plan directed toward promoting and enhancing the City's overall program of green solutions include:

- Dedicated funding for public education and outreach: Active citizen participation will be critical to the overall success of the Plan. To facilitate this participation, the City will partner with neighborhood associations to develop a public education and outreach program that helps inform citizens of the problem and their role in the solution. Creating successful individual projects is also highly reliant on positive citizen participation. Throughout the life of the Plan, public education and outreach will also focus on informing citizens about proposed project designs, schedules, and progress towards completion. Funding for public education and outreach has been estimated at approximately 0.5 percent of the Plan's capital costs, equating to $12 million in 2008 dollars, to be spent over the life of the Plan.

- An enhanced "10,000 Rain Gardens" and downspout disconnection program: Since 2005, the City's award-winning "10,000 Rain Gardens" campaign has focused on educating homeowners on the positive effects of rain gardens. As a part of the Plan, the campaign's focus will be expanded to include an aggressive rain garden establishment program along with a new downspout disconnection program. Funding for this program is estimated at $5 million in 2008 dollars. The initiative, which will incentivize citizens to disconnect their downspouts, will also include assistance and information related to helping homeowners and businesses manage and hold water on their own property.
- Funding for job creation and work force development initiatives related to specific program objectives, including "green collar" jobs: Preparing the Kansas City community for the work required in the Plan is critical to its success. Funding for the Plan includes $5 million (in 2008 dollars) to be utilized in job creation and work force development initiative related to Plan objectives. The City will work with job training and work force development organizations to develop a green collar jobs program related to green infrastructure and sustainable projects proposed in the Plan.
- Enhanced technical models, complemented by a "triple bottom line" evaluation framework, including specified social, economic, and environmental metrics: CSS models developed for the Plan analyze performance characteristics in pipes 24 inches in diameter and larger. In order to evaluate the potential impact of green infrastructure solutions, these models will need to be extended further up the drainage basins. Technical models will be complemented by a triple bottom line evaluation framework including well specified social, economic, and environmental metrics. Once system models and related evaluation frameworks are developed, adjustments to the design, construction, and operation of remaining components will be analyzed throughout implementation of the Plan. Funding for the enhanced monitoring and modeling activities has been estimated at 1 percent of the Plan's capital costs, equating to $24 million over the life of the Plan.
- Substantial funding for green infrastructure pilot projects and partnerships in the CSS basins: The Plan includes $28 million (in 2008 dollars) dedicated to developing green infrastructure pilot projects and partnerships in the CSS basins. Large scale pilot projects will be used to gather the information required to effectively implement green infrastructure on a broad scale while simultaneously constructing a portion of the basin-specific solution. Green infrastructure partnerships will focus on creating private sector participation in the pilots and proposed basin solutions.

- The first pilot project will be implemented in the Middle Blue River Basin, upstream of CSO 069. In this pilot project, distributed green solutions will be provided throughout a 100-acre area of the neighborhood. The area is primarily residential, but does include commercial businesses. In addition to gaining valuable information about the effectiveness of green infrastructure in controlling CSOs, this initial pilot project will evaluate alternatives to achieve additional plan objectives, including:

- Effectiveness of green infrastructure as a systematic solution
- Codes and ordinances in conflict with green infrastructure utilization
- Socio-economic benefits/changes
- Construction techniques and costs on a wide-scale programmatic level
- Development of preliminary design standards for the City
- Maintenance approaches and costs
- Public/private partnership opportunities
- Community interaction and support of green infrastructure practices

This 100-acre pilot project is in a 744-acre area of the Middle Blue River Basin where distributed green storage will be relied on as the principal means of CSO control.

In some sub-watersheds, separation of the CSS is recommended. The sewer separation will largely eliminate CSOs from those sub-watersheds. However, stormwater runoff during low to moderate rainfall events (presently captured and treated) would then be discharged to receiving streams. Where practicable, stormwater treatment using green infrastructure will be installed in and/or downstream of the newly separated areas.

The Plan includes sewer separation for 2,220 acres in nine different CSS sub-basins south of the Missouri River, and at the Charles B. Wheeler Municipal (Downtown) Airport. Project cost estimates and descriptions presented herein were developed in anticipation that stormwater treatment facilities will be constructed downstream from SSS areas at six locations. These stormwater treatment facilities would use green infrastructure (such as wet retention basins) to improve water quality. Sites include:

- South of 17th & Topping (Lower Blue River Basin), serving 40 acres of newly-separated storm sewers.
- At 41st & Jackson (Lower Blue River Basin), serving 200 acres of newly-separated storm sewers.
- West of Town Fork Creek near 53rd & Waldron (Town Fork Creek Basin), serving 138 acres of newly-separated storm sewers.

- East of Town Fork Creek near 55th & College (Town Fork Creek Basin), serving 59 acres of newly-separated storm sewers.
- Upstream of George Washington Lake in Penn Valley Lake (Turkey Creek Basin), serving 66 acres of newly-separated storm sewers.
- Just north of 85th Street near Brookside Road (Middle Blue River Basin), serving 270 acres of newly-separated storm sewers.

12.4.1 Additional Focus Areas for Green Solutions

The construction of green infrastructure and development of sustainable water management practices will be beneficial throughout the City, including all areas served by the CSS. Figure 12-1 shows the locations of green solutions projects (described above) included in the Plan.

Figure 12-1 also identifies specific areas in the CSS in which green infrastructure and sustainable water management practices implemented by the City and community at large can provide the greatest benefit in meeting the overall Plan objectives. These are in addition to those areas specifically included in the Plan, The areas of special focus for the City and the community include:

- Areas for which no or minimal conventional structural controls are proposed.
- Areas in which widespread implementation of green solutions by the community at large offer the greatest opportunities for reducing the size and cost of conventional structural controls included in the Plan.
- Areas for which it would be particularly desirable to further reduce the projected overflow activation frequency following completion of recommended controls.
- Areas in which sewer separation is proposed but where no Water Services Department (WSD) investment in treating the separate stormwater runoff has been included in the Plan.

In those special focus areas (more specifically described below), WSD will provide technical assistance to the public sector and other City departments in identification and implementation of green solutions. An inventory of completed green solutions projects will be maintained, and changes in the response of the CSS to rainfall events over time will be monitored and evaluated. Periodic updates to the Plan will include assessment of the performance of green solutions in those areas, and reflect that performance in planning for remaining Plan elements.

The overall objective of the CSO controls in this Plan, when coupled with the demonstrated beneficial impacts of green solutions in these focus areas, will remain the elimination, or capture for treatment, of approximately 88 percent of the existing wet-weather flows in the CSS.

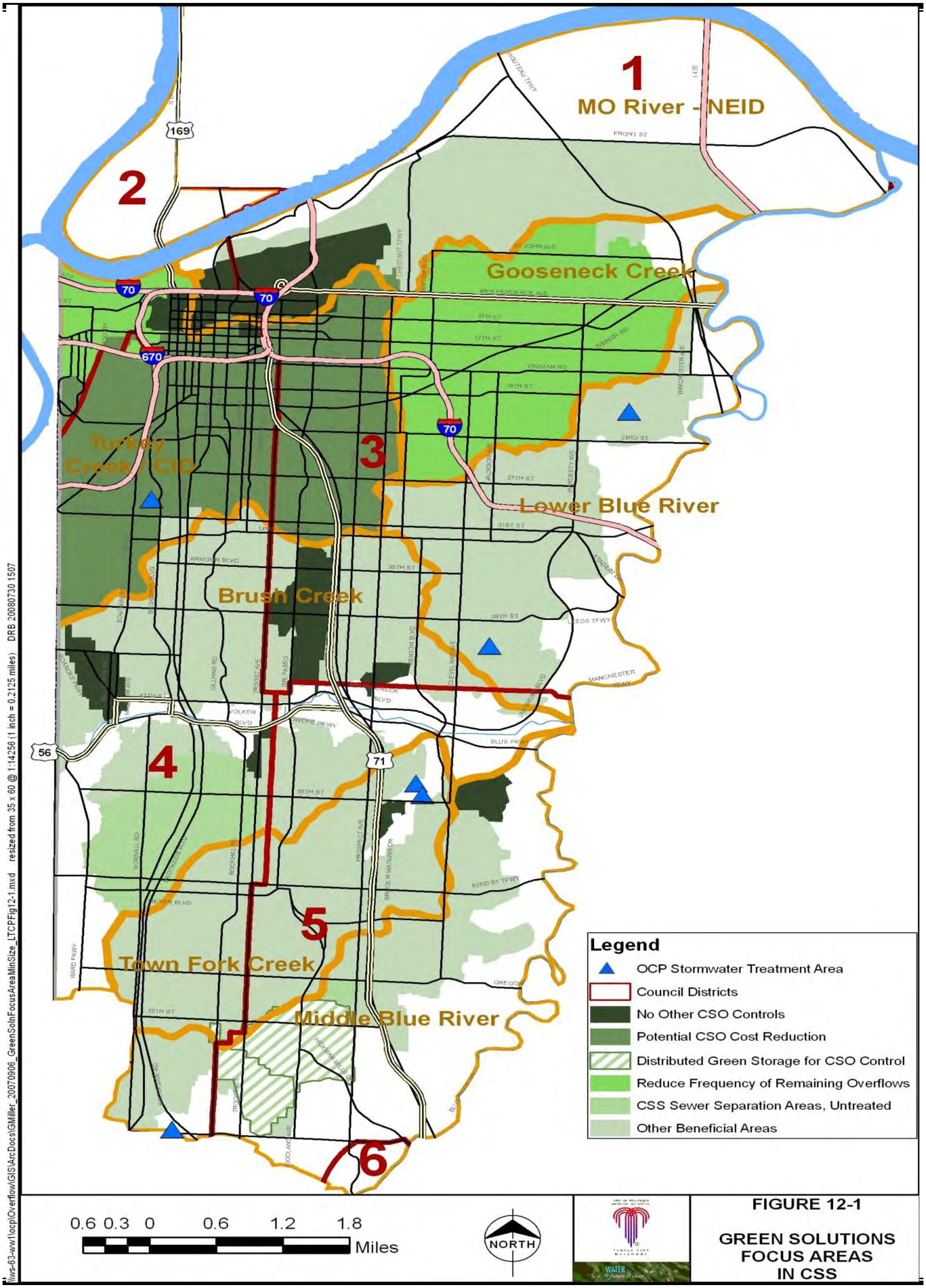


FIGURE 12-1

GREEN SOLUTIONS FOCUS AREAS IN CSS

12.4.2 Areas with No or Limited Structural CSO Controls

The Plan includes minimal conventional structural controls for overflows from 1,720 acres of the CSS (approximately five percent of the CSS service area south of the Missouri River). In the following areas, green solutions constructed by the private sector or as part of public infrastructure projects can contribute to reductions in CSO frequency and volume:

- 874 acres tributary to seven outfalls to the Missouri River: Under existing conditions, it is estimated that those seven outfalls would discharge a total of 620 million gallons (MG) to the Missouri River in a typical year (10 percent of the city-wide overflow volume under existing conditions). Using conventional structural controls to reduce overflow frequency at those outfalls from the present total of 36 or more events per year to a total of 12 or fewer would require an investment of approximately $110 million. This investment would reduce bacteria loads in the Missouri River by less than one-half of one percent. Clearly, such a structural investment would not return any meaningful public benefit. Those seven outfalls include:

    - Outfall W002 (Broadway) in the Central Industrial District (CID).
    - Outfalls 071 (Delaware), 072 (Main Street), 073 (Gillis), 074 (Lydia), 075 (Prospect), and 077 (Holmes) in the Northeast Industrial District (NEID).

- 134 acres tributary to one outfall (Outfall 056) in the Middle Blue River Basin: Existing overflow volumes at this outfall will be reduced due to the influence of other planned hydraulic grade line controls in the Blue River Sewer at this outfall; the remaining activation frequency is estimated at 12 times in a typical year. Under existing conditions, this outfall contributes less than 0.2 percent of the total bacteria load in the Blue River upstream from Brush Creek. Further reductions in activation frequency would require sewer separation in tributary areas, at an estimated capital cost of $7.5 million.
- 33 acres tributary to two outfalls (Outfalls 084 and 099) on the west side of Town Fork Creek east of Bruce R. Watkins Drive: Overflows from these outfalls contribute approximately 3.5 percent of the total annual overflow volume to Town Fork Creek.
- 675 acres tributary to four outfalls (Outfalls 011, 019, 023, and 025) to Brush Creek: The total estimated typical-year overflow volumes from these outfalls following plan completion is less than 16 MG (1 percent of the existing typical-year overflow volume from the Brush Creek Basin).

12.4.3 Areas Identified for Special Focus in Reducing Future Structural Controls

The Plan and preliminary implementation schedule are structured to permit a reasonable and workable time frame for widespread implementation and performance verification of green solutions. Satisfactory performance can permit reductions in the size and cost of planned structural controls throughout the CSS.

Particular emphasis in promoting publicly- and privately-constructed green solutions is recommended in 4,690 acres in the Turkey Creek Basin.

12.4.4 Areas Beneficial for Reducing Future Activation Frequency

The following two outfalls are prime candidates for further reductions in activation frequency through the implementation of green solutions in their tributary areas:

- 3,270 acres in the Gooseneck Creek Basin tributary to Outfall 033: Proposed structural controls at that outfall are expected to reduce overflow frequency from more than 36 events in a typical year to approximately 12, and to reduce typical-year overflow volumes from 676 MG to approximately 238 MG.
- 575 acres in the CID tributary to outfall W003 (Santa Fe Pumping Station): Proposed structural controls at that outfall are expected to reduce overflow frequency from more than 12 events in a typical year to approximately 7, and to reduce overflow typical-year overflow volume from 95 MG to approximately 43 MG.

12.4.5 Additional Areas Identified for Improved Water Quality in Sewer Separation Areas

In two areas totaling 1,190 acres, sewer separation is recommended, but no suitable stormwater treatment alternatives have been identified. In those areas (1,140 acres of the Brookside sub-basin in the Brush Creek Basin and 50 acres southwest of Gregory and Prospect in the Middle Blue River Basin), green solutions distributed throughout the sub-basins can be beneficial in improving the quality of stormwater runoff prior to its discharge to receiving streams. Detailed planning and design for each of those sub-basins should evaluate and incorporate distributed green solutions throughout the sub-basins wherever practicable and cost-effective.

12.5 Separate Sanitary Sewer System Improvements

The overall objective of improvements in the SSS basins is to substantially eliminate overflows. Recommended strategies are to:

- Reduce I/I by rehabilitating the existing system where cost-effective
- Provide a combination of wet-weather storage and treatment to address the remaining excess flow

As a practical matter, the complete elimination of sanitary sewer overflows (SSO) is not possible. There is a need to select a specific design storm under which the proposed improvement would cost-effectively eliminate overflows. For the Plan, the proposed design storm in the SSS basins is a rainfall event having a duration of 24 hours and a depth that would be equaled or exceeded, on average, once every five years. This design storm would result in a rainfall depth of 4.68 inches.

Design for a heavier rainfall (e.g., less frequent rainfall event) would further increase the cost of the controls. In the Blue River South Basin alone (which includes 12 percent of the area served by the City's SSS), providing controls capable of eliminating overflows for a rainfall event having an average frequency of once every ten years would increase the capital cost of the Plan by $57 million to $94 million (for additional details, see *Alternatives Development and Evaluation TM-10 yr Design Storm Final;* HDR; April 2008.). The additional capital costs to provide controls capable of eliminating overflows for a rainfall event having an average frequency of once every ten years in the priority sanitary sewer basins located north of the river (Birmingham, Line Creek and Rock Creek) would be approximately $78 million. The necessary additional capital improvements would include additional capacity for deep-storage tunnels, screening, and a deep-tunnel pump station, as well as additional I/I rehabilitation, relief sewers, and pump station upgrades (for additional details, see *Final 10-Yr Design Storm Modeling and Cost Estimation Technical Memorandum;* HNTB; July 2008.). Increasing the design rainfall event in the SSS above that recommended in this Plan is considered not feasible, as the additional costs would either exceed the City's financial capabilities or would require a commensurate reduction in the cost (and performance) of CSO controls.

12.5.1 North of the Missouri River

Plan improvements for the SSS located north of the Missouri River include:

1. I/I reduction
2. Construction of Birmingham Pump Station upgrades
3. Construction of approximately 62,000 linear feet of 11-foot diameter deep-storage tunnel
4. Construction of a 30-million gallons per day (MGD) tunnel dewatering pump station
5. Construction of approximately 12,000 linear feet of 24-inch force main
6. Construction of a temporary 30-MGD High-Rate Treatment (HRT) facility near the Line Creek Pump Station
7. Construction of relief sewers at various locations

The general locations of the plan improvements are shown in Figure 12-2. Additional improvement details in the priority SSS basins north of the Missouri River are presented in the *Birmingham Project Area Final Alternatives Development and Evaluation Technical Memorandum;* BWR*;* August 2008 and the *Design Storm and Alternative Development Technical Memorandum;* HNTB; May 2008 for the Line Creek/Rock Creek project area. Additional information on wet-weather flows in the Northern watersheds (including the upper reaches of the Birmingham/Shoal Creek Basin) is included in *Remainder of the Separate Sanitary Sewer System Project Area;* GBA; October 2007

Cost effective I/I reduction is a key component of the plan. Varying target levels of reduction are planned for each SSS watershed located north of the river.

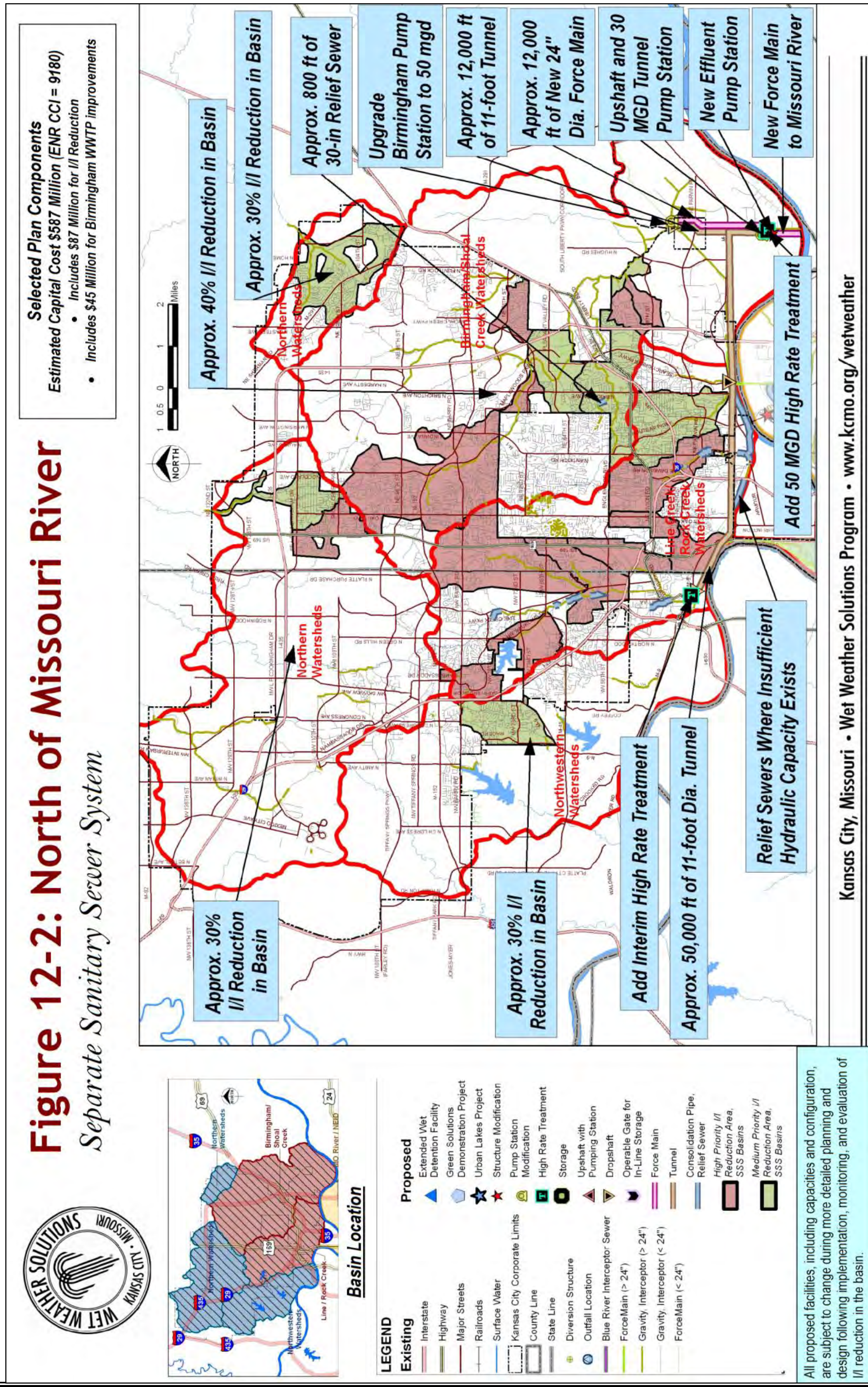


Figure 12-2: North of Missouri River
Separate Sanitary Sewer System

Watershed target reduction levels reflect flow-study results indicating existing levels of I/I. The watersheds targeted for I/I reduction and the target levels of reduction include:

- Northern Watersheds 30- percent reduction
- Northwestern Watersheds 30- percent reduction
- Line Creek/Rock Creek Watersheds 35- percent reduction
- Birmingham/Shoal Creek Watersheds 40- percent reduction

Target levels of reduction are applied to predicted peak flows at the lower end of the system during the design rainfall event. In some instances, additional relief sewer and pumping capacity will also be needed to deliver wet-weather flows in the collection system to proposed new storage and conveyance systems leading to the City's WWTPs.

Wet-weather flows from the Line Creek/Rock Creek and Northwestern Basins will be transported through a new conveyance and storage tunnel to the Birmingham WWTP. That tunnel system will also temporarily store excess wet-weather flows from the Birmingham/Shoal Creek Basin. The North Bank Tunnel System is expected to include approximately 62,000 feet of 11-foot diameter tunnel and a 30-MGD pumping station at the Birmingham WWTP for dewatering the tunnel. The North Bank Tunnel System is sized for projected wastewater flows after full development of its tributary areas.

A constructed SSO exists in the Line Creek/Rock Creek Basin, just upstream from the Line Creek Pumping Station. The North Bank Tunnel System will eventually eliminate this constructed SSO; however, tunnel construction will not begin until I/I reduction work in the basin nears completion. An evaluation of alternatives for addressing this SSO is presented in *Line Creek Interim Alternatives*; OCP; August 2008.

Based on that evaluation, an interim 30-MGD HRT facility will be constructed near the Line Creek Pumping Station early in the Plan implementation. The temporary facility will also serve as a large-scale, pilot program providing design data for a permanent facility to be constructed later in the Plan implementation. The interim facility will also provide O&M information, and it will provide increased confidence in the ability of any permanent HRT facility to meet permit requirements.

The Plan includes construction of a new 50-MGD HRT facility at the Birmingham WWTP to address peak wet-weather inflows. Discharges from this HRT facility will be blended with flows from the secondary clarifiers for discharge to the Missouri River. Additional detail on this facility is included in *Joint Use Facilities Expansion Capabilities;* OCP; September 2008. The final design capacity and regulatory requirements for this facility will be evaluated in future Plan updates. This evaluation and any updates will be based on performance data from the interim HRT at the Line Creek site and the actual performance of I/I reduction measures.

It is anticipated that the HRT/disinfection facility will meet permit requirements for biochemical oxygen demand and total suspended solids concentrations in the blended effluent from the Birmingham WWTP. Complying with percentage reduction requirements found in Missouri's secondary treatment standards may be problematic, due principally to reduced plant influent concentrations. The HRT/disinfection facility will include grit removal, fine screening, high-rate clarification, and disinfection. Final effluent will discharge to the effluent pump station. The existing pump station consists of two 40-MGD pumps and space for an additional pump. A new 50-MGD pump will be installed in the available space to handle the combined projected WWTP effluent and wet-weather treatment effluent.

Estimated capital and additional annual O&M costs for SSS Plan improvements north of the Missouri River are shown in Table 12-1, in 2008 dollars (ENR CCI 9180). The estimated capital cost is $587 million. The estimated additional annual O&M cost of the improvements is $5 million.

Table 12-1 North of the Missouri River Sanitary Sewer System Improvement Costs

Improvement	Capital Cost (million $)	Annual O&M Cost (million $)
I/I reduction	$86.94	
Construct temporary HRT-Line Creek	37.16	$0.05
Construct 50 MGD HRT/disinfection/force main at Birmingham WWTP	44.64	$2.27
Approx. 50,000 LF 11-foot diameter tunnel-North Bank	238.29	0.64
Relief sewers-Line Creek	13.38	
Relief sewers-Birmingham	0.22	
Upgrade Birmingham pump station to 50 MGD	24.36	0.88
Approx. 12,000 LF of 11-foot diameter tunnel-Birmingham	64.25	0.25
Upshaft and 30 MGD tunnel pump station-Birmingham	73.99	0.89
Approx. 12,000 LF of 24-inch diameter force main-Birmingham	4.06	0.02
Total	**$587.30**	**$5.00**

*all costs in 2008 dollars (ENR 9180)

12.5.2 South of the Missouri River

Plan improvements for the SSS located south of the Missouri River include:

1. I/I reduction.
2. Construction of relief sewers, where necessary.
3. Construction of a 68-MG storage tank at the 87th Street Pump Station.

4. Construction of a 24-inch force main from Round Grove Pump Station to the Blue River Interceptor Sewer (parallel existing force main).
5. Increase the firm pumping capacity at the Round Grove Pump Station by 12 MGD.

The general locations of Plan improvements south of the Missouri River are shown in Figure 12-3. Priority SSS basins south of the Missouri River include the Blue River South and Round Grove Basins. Additional improvement details in the Blue River South Basin are presented in *Alternative Development, Evaluation, Facilities Siting, Constructability, and Operability Technical Memorandum;* HDR; April 2008. Additional information for the Round Grove Basin is presented in *Round Grove Project Area Sanitary Sewer Evaluation Study*; WAI; June 2008. Additional information on wet-weather flows in the Little Blue River, Blue River North, and Blue River Central Basins is included in *Remainder of the Separate Sanitary Sewer System Project Area;* GBA; October 2007.

Cost effective I/I reduction is a key component of the plan for the SSS located south of the Missouri River. Varying target levels of reduction are planned for each sanitary sewer watershed in this area. Watershed target reduction levels reflect flow study results indicating existing levels of I/I. The watersheds and target I/I removal levels (applied to rainfall-derived I/I) are as follows:

• Little Blue River	30- percent reduction
• Blue River South	45- percent reduction
• Blue River Central	30- percent reduction
• Blue River North	30- percent reduction
• Round Grove	29- percent reduction

Target levels of reduction are applied to predicted peak flows at the lower end of the system during the design rainfall event. It is presently anticipated that a total storage volume of 68 MG will be provided to store excess I/I from the Blue River South Basin (including flows from Johnson County Wastewater District) at the 87th Street Pumping Station. That estimated storage volume was developed considering wastewater flows expected in the Year 2030, following completion of recommended I/I reduction work in the Blue River South Basin. Additional information on flows reaching the 87th Street Pumping Station is presented in *Wet Weather Flow Rates and Volumes at 87th Street Pumping Station;* OCP; February 2008.

At present, Johnson County Wastewater District has wet-weather facilities at its Tomahawk WWTP. Those facilities can reduce the peak flow to the City's system at 103rd and State Line Road by up to 40-MGD. If Johnson County Wastewater District elects to discontinue operation of those wet-weather facilities, the required volume of tank storage at the 87th Street Pumping Station would increase to 82 MG. Alternatively, Johnson County Wastewater District may elect to provide its own storage at or near the Tomahawk WWTP, thereby reducing the required storage volume at the 87th Street Pumping Station.

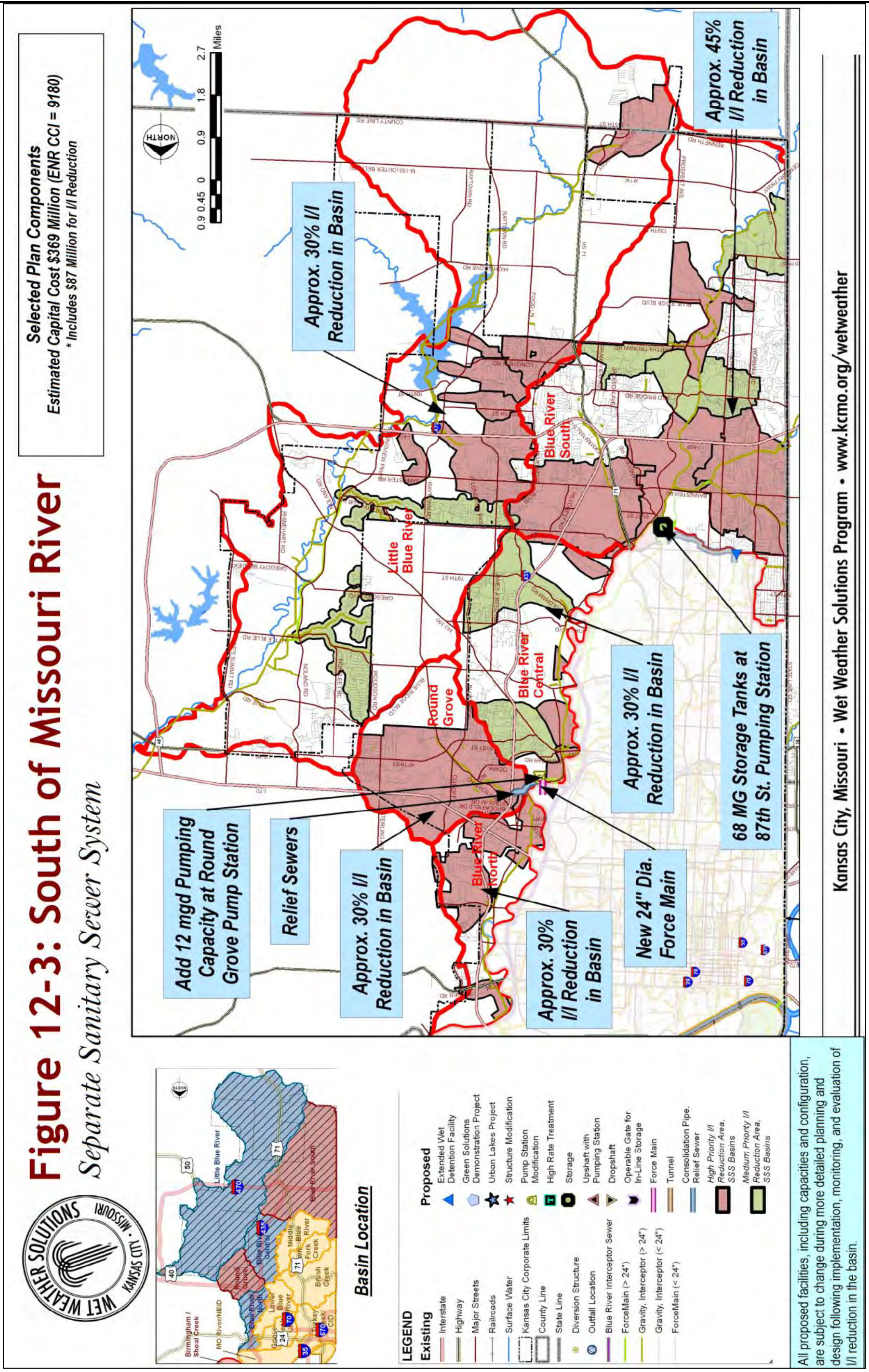


Figure 12-3: South of Missouri River
Separate Sanitary Sewer System

Final selection of the required storage capacity at the 87th Street Pumping Station will depend on the results of contractual discussions between WSD and Johnson County Wastewater District.

Estimated capital and additional annual O&M costs for SSS Plan improvements south of the Missouri River are shown in Table 12-2, in 2008 dollars (ENR CCI 9180). The capital cost is $369 million. The estimated additional annual O&M cost of the improvements is $1.1 million.

Table 12-2 South of the Missouri River Sanitary Sewer System Improvement Costs

Improvement	Capital Cost (million $)	Annual O&M Cost (million $)
I/I reduction	$87.25	
68-MG storage tanks at 87th Street Pump Station	268.99	$1.13
24-inch diameter Round Grove force main	1.62	
Additional 12-MGD pumping capacity at Round Grove Pump Station	11.34	
Total	**$369.20**	**$1.13**

*all costs in 2008 dollars (ENR 9180)

12.6 Combined Sewer System Improvements

Improvements in the CSS basins will address the goals established by the Community Panel, meet regulatory requirements, and provide multiple benefits with judicious investment of public dollars for infrastructure improvements.

Core strategies followed in selection of improvements include:

- Emphasize control of CSOs in the Blue River Basins (Middle Blue, Town Fork Creek, Brush Creek, Lower Blue River and Gooseneck Creek) and expend less effort on basins that drain directly to the Kansas and Missouri Rivers (Turkey Creek, CID, and NEID). Approximately 3 percent of the bacteria in the Missouri River just downstream from the river’s confluence with the Blue River is associated with the City's CSOs. Funds expended to address this relatively small source of bacteria to the Missouri River could be better spent to address water quality in streams that are more directly influenced by the City's actions and have more influence on the City’s residents, such as the Blue River and its tributaries.
- Place a higher investment emphasis and priority on those outfalls where improved flood protection and storm drainage service can result from implementation of CSO control.
- Place a lower investment emphasis on reducing the frequency and volume of CSOs at outfalls that discharge relatively low volumes, in favor of focusing on reducing the quantity of overflow at larger contributing outfalls.

- Repair and rehabilitate small diameter (equal to or less than 12 inches) sewers to reduce the quantity of flow entering the system and to improve service by reducing the frequency and severity of basement backups. Approximately 60 percent of the total sewer length in the CSS will be addressed by this strategy, at an estimated capital cost (in 2008 dollars) of $174 million.

Descriptions of the presently anticipated nature, configuration, capacity, and cost of overflow controls in the CSS follow. All planned facilities, including capacities and configurations, are subject to change during more detailed planning and design, following implementation, monitoring, and evaluation of green solutions and source controls in the CSS.

12.6.1 Brush Creek Basin

The general locations of the Brush Creek Basin improvements are shown in Figure 12-4. Additional improvement details are located in the *Final Development of Preliminary Improvement Scenarios Technical Memorandum.* CDM. June 2008. The Brush Creek Basin improvements consist of:

1. Construction of approximately 20,600 linear feet of 16-foot diameter deep tunnel.
2. Construction of a 45-MGD deep-tunnel pump station.
3. Construction of a 200-MGD HRT/disinfection facility at the confluence of Brush Creek and the Blue River.
4. Construction of approximately 9,200 linear feet of consolidation piping ranging from 24-inches to 96-inches in diameter.
5. Construction of approximately 350 linear feet of relief sewer 24 inches in diameter.
6. Construction of approximately 2,800 linear feet of storm sewer 72 inches in diameter.
7. Combined sewer separation in approximately 1,140 acres of the Brookside sub-basin.
8. Various baseline improvements.
9. Basin-wide small-sewer rehabilitation.

The deep-storage tunnel will provide approximately 31 MG of storage capacity. The tunnel site is along Brush Creek from Brookside Boulevard to an area near the confluence of Brush Creek and the Blue River. A deep-tunnel pump station located near the Blue River will dewater the tunnel. The firm capacity of the pump station is 45-MGD. The pump station will convey flow from storage to a proposed 200-MGD HRT/disinfection treatment process. Treated effluent will discharge to the Blue River.

The HRT/disinfection facility will receive flow from both the deep-tunnel pumping station and up to 150-MGD of excess wet-weather gravity flow diverted from the BRIS. The purpose of the diversion is to provide hydraulic grade line relief for Blue River Interceptor Sewer (BRIS) flow.

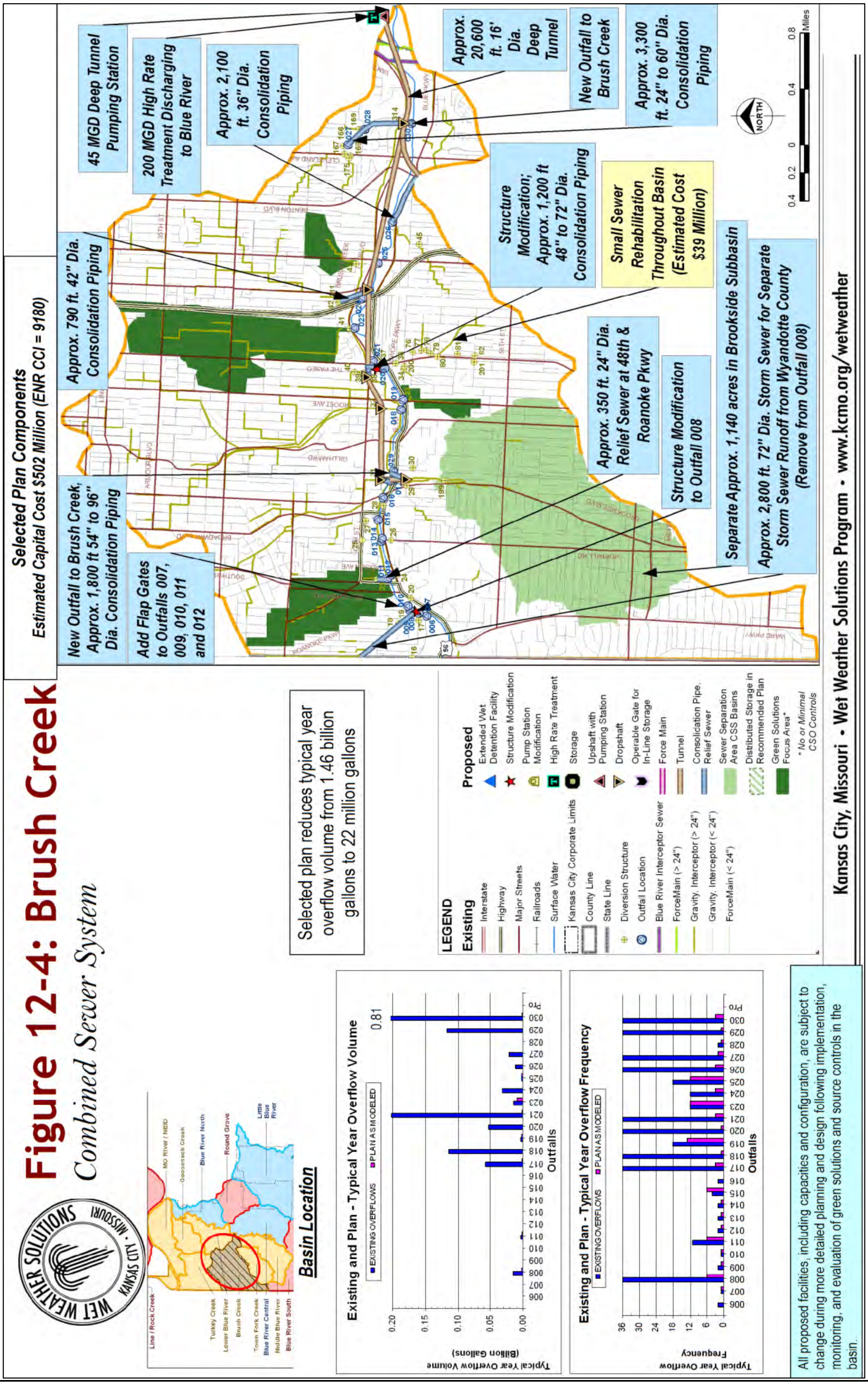


Figure 12-4: Brush Creek
Combined Sewer System
WET WEATHER SOLUTIONS
KANSAS CITY · MISSOURI
Basin Location
Line / Rock Creek
MO River / NEID
Gooseneck Creek
Blue River North
Turkey Creek
Lower Blue River
Brush Creek
Round Grove
Town Fork Creek
Blue River Central
Middle Blue River
Blue River South
Little Blue River
Existing and Plan - Typical Year Overflow Volume
EXISTING OVERFLOWS
PLAN AS MODELED
0.81
Typical Year Overflow Volume (Billion Gallons)
Outfalls
Existing and Plan - Typical Year Overflow Frequency
Typical Year Overflow Frequency
Selected plan reduces typical year overflow volume from 1.46 billion gallons to 22 million gallons
LEGEND
Existing
Interstate
Highway
Major Streets
Railroads
Surface Water
Kansas City Corporate Limits
County Line
State Line
Diversion Structure
Outfall Location
Blue River Interceptor Sewer
ForceMain (> 24")
Gravity, Interceptor (> 24")
Gravity, Interceptor (< 24")
ForceMain (< 24")
Proposed
Extended Wet Detention Facility
Structure Modification
Pump Station Modification
High Rate Treatment
Storage
Upshaft with Pumping Station
Dropshaft
Operable Gate for In-Line Storage
Force Main
Tunnel
Consolidation Pipe, Relief Sewer
Sewer Separation Area CSS Basins
Distributed Storage in Recommended Plan
Green Solutions Focus Area*
* No or Minimal CSO Controls
All proposed facilities, including capacities and configuration, are subject to change during more detailed planning and design following implementation, monitoring, and evaluation of green solutions and source controls in the basin.
Selected Plan Components
Estimated Capital Cost $502 Million (ENR CCI = 9180)
New Outfall to Brush Creek, Approx. 1,800 ft 54" to 96" Dia. Consolidation Piping
Add Flap Gates to Outfalls 007, 009, 010, 011 and 012
Approx. 790 ft. 42" Dia. Consolidation Piping
45 MGD Deep Tunnel Pumping Station
200 MGD High Rate Treatment Discharging to Blue River
Approx. 2,100 ft. 36" Dia. Consolidation Piping
Structure Modification; Approx. 1,200 ft 48" to 72" Dia. Consolidation Piping
Approx. 20,600 ft. 16' Dia. Deep Tunnel
New Outfall to Brush Creek
Approx. 350 ft. 24" Dia. Relief Sewer at 48th & Roanoke Pkwy
Small Sewer Rehabilitation Throughout Basin (Estimated Cost $39 Million)
Approx. 3,300 ft. 24" to 60" Dia. Consolidation Piping
Structure Modification to Outfall 008
Separate Approx. 1,140 acres in Brookside Subbasin
Approx. 2,800 ft. 72" Dia. Storm Sewer for Separate Storm Sewer Runoff from Wyandotte County (Remove from Outfall 008)
NORTH
Miles
Kansas City, Missouri • Wet Weather Solutions Program • www.kcmo.org/wetweather

Various baseline improvements include measures to assure that the current collection system operates at its maximum capacity. The basin baseline improvements include sediment, debris, and blockage removal; and flap gate installation. Flap gates will be installed at five Brush Creek outfalls. Backflow conditions occur at these outfalls due to high water surface elevations in Brush Creek that occur during wet weather.

Estimated capital and additional annual O&M costs for CSS Plan improvements in the Brush Creek Basin are shown in Table 12-3, in 2008 dollars (ENR CCI 9180). The estimated capital cost is approximately $502 million. The estimated additional annual O&M cost of the improvements is approximately $7.4 million.

Table 12-3 Brush Creek Basin Improvement Costs

Improvement	Capital Cost (million $)	Annual O&M Cost (million $)
Approximately 20,600 LF 16-foot diameter deep tunnel	$210.90	$2.00
45-MGD deep tunnel pump station	63.28	0.94
200-MGD HRT facility discharging to Blue River	165.80	4.50
Approximately 3,300 LF of 24 to 60-inch diameter consolidation piping	5.76	
Approximately 2,100 LF of 36-inch diameter consolidation piping	1.86	
Approximately 790 LF of 42-inch diameter consolidation piping	1.51	
Approximately 1,200 LF of 48 to 72-inch diameter consolidation piping	1.58	
Approximately 350 LF of 24-inch relief sewer at 48th & Roanoke Parkway	0.20	
Approximately 2,800 LF of 72-inch storm sewer	5.41	
New outfall to Brush Ck/1800 LF of 54 to 96-inch diameter consolidation piping	3.67	
Baseline improvements	2.53	
Small sewer rehabilitation throughout basin	39.00	
Total	**$501.51**	**$7.44**

*all costs in 2008 dollars (ENR 9180)

Multiple continuous model runs for the recreational season were conducted to evaluate the basin-wide effect of the improvements. Modeling indicated that the improvements will reduce the typical-year overflow volume in the basin by 98 percent. The projected overflow volume will decrease from the existing level of 1.46 billion gallons, to 22 MG in a typical year. The modeled typical-year overflow frequency for all basin outfalls decreased by 80 percent,, from a total of 415 or more events to a total of 82 events. The modeled range of annual overflow frequency for individual outfalls varied from 0 events to 13 events. Table 12-4 summarizes the modeling results, by outfall, for the Brush Creek Basin plan.

Table 12-4 Brush Creek Modeled Plan Effectiveness

Outfall	**EXISTING OVERFLOWS**		**PLAN AS MODELED**	
MDNR Outfall ID	Typical Year Annual Overflow Volume (MG)	Typical Year Annual Overflow Frequency	Estimated Recreation Season Overflow Volume (MG)	Estimated Recreation Season Overflow
006	0.00	≥2	0.00	0
007	0.07	≥1	0.03	1
008	15.67	≥36	1.98	6
009	Included with 008	≥2	0.09	1
010	0.17	≥1	0.01	1
011	3.73	≥11	0.66	6
012	0.04	≥2	0.04	1
013	0.26	≥2	0.14	1
014	0.14	≥2	0.06	1
015	0.44	≥4	0.24	6
016	0.00	≥2	0.00	0
017	57.90	≥36	0.71	3
018	113.44	≥36	0.26	1
019	3.05	≥18	2.09	13
020	52.27	≥36	0.37	1
021	201.07	≥36	1.63	3
023	14.19	≥12	9.68	12
024	31.80	≥12	0.37	3
025	2.74	≥18	1.97	12
026	12.20	≥36	0.07	3
027	21.90	≥36	0.34	2
028	0.31	≥2	0.04	1
029	116.35	≥36	0.14	1
030	807.77	≥36	1.03	3
Total	**1,455.51**	**≥415**	**21.96**	**82**

12.6.2 Gooseneck Creek Basin

The general locations of the Gooseneck Creek Basin improvements are shown in Figure 12-5. Additional improvement details are located in the *Technical Memorandum for Task 8-Preliminary Improvement Scenarios Gooseneck Creek and Lower Blue River Study Area;* CH2M Hill; July 2008. The Gooseneck Creek Basin improvements consist of:

1. Installation of an automated gate in the existing Gooseneck Arch Sewer
2. Construction of a 4-MGD pump station.
3. Basin-wide small-sewer rehabilitation

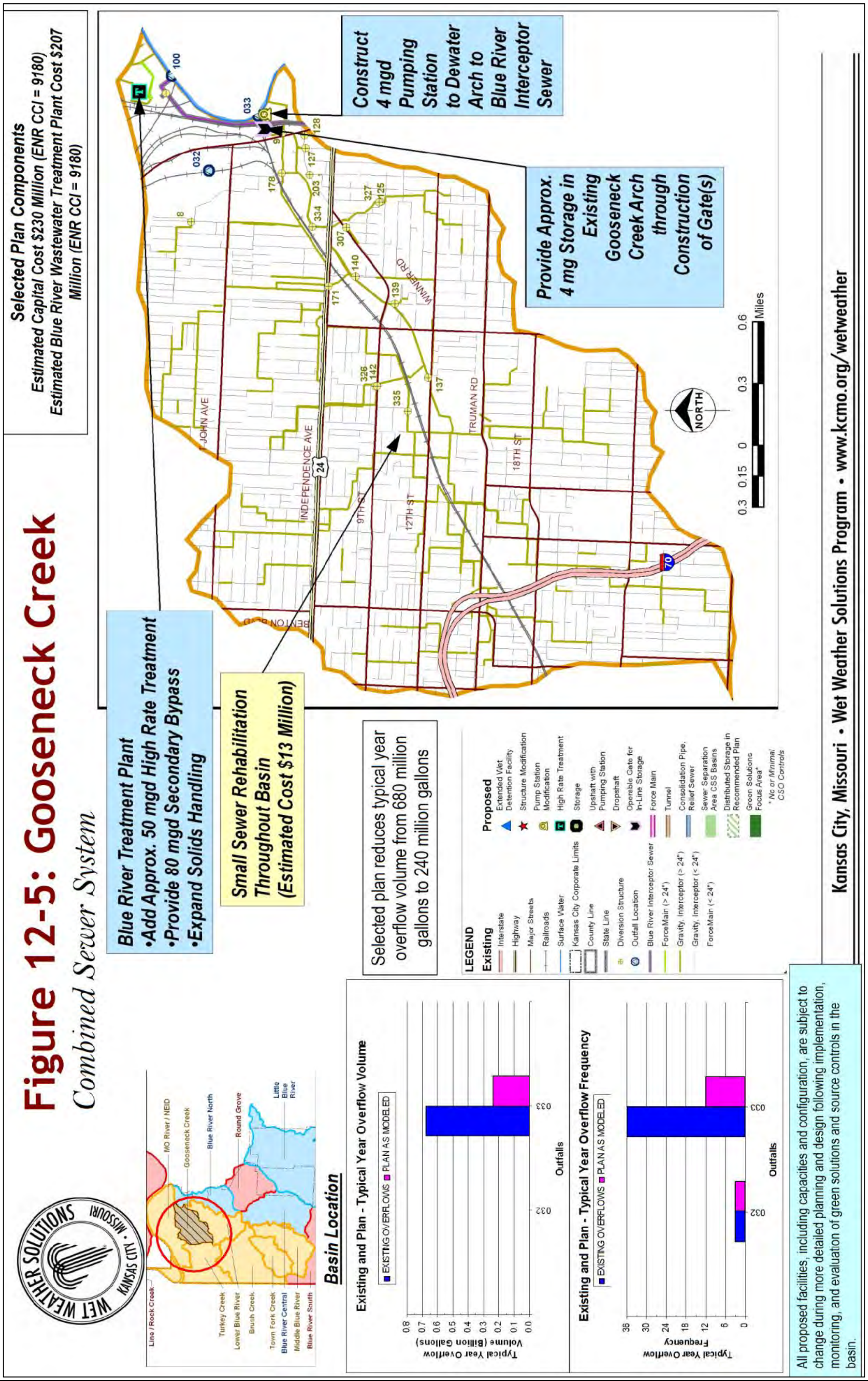


Figure 12-5: Gooseneck Creek
Combined Sewer System
Selected Plan Components
Estimated Capital Cost $230 Million (ENR CCI = 9180)
Estimated Blue River Wastewater Treatment Plant Cost $207 Million (ENR CCI = 9180)
Blue River Treatment Plant
•Add Approx. 50 mgd High Rate Treatment
•Provide 80 mgd Secondary Bypass
•Expand Solids Handling
Small Sewer Rehabilitation Throughout Basin (Estimated Cost $13 Million)
Provide Approx. 4 mg Storage in Existing Gooseneck Creek Arch through Construction of Gate(s)
Construct 4 mgd Pumping Station to Dewater Arch to Blue River Interceptor Sewer
Selected plan reduces typical year overflow volume from 680 million gallons to 240 million gallons
Basin Location
Existing and Plan - Typical Year Overflow Volume
Existing and Plan - Typical Year Overflow Frequency
Outfalls
All proposed facilities, including capacities and configuration, are subject to change during more detailed planning and design following implementation, monitoring, and evaluation of green solutions and source controls in the basin.
Kansas City, Missouri • Wet Weather Solutions Program • www.kcmo.org/wetweather

The purpose of the automated gate installation is to reduce overflow at Outfall 033. The gate will be installed at the downstream end of the Gooseneck Arch Sewer at Manhole S024-813. The gate will permit up to approximately 4 MG of storage in the arch sewer. A 4-MGD pump station will be located near Manhole S024-813 to convey in-line storage to the BRIS. The adjustable gate will allow volumes surpassing storage and pumping capacities to overflow to the Blue River at Outfall 033.

Multiple continuous model runs for the recreational season were conducted to evaluate the basin-wide effect of the improvements. Modeling indicated the improvements will reduce the typical-year overflow volume in the basin by 65 percent. The overflow volume will decrease from the existing level of 676 MG to approximately 238 MG for a typical year. The modeled typical-year overflow frequency for all the basin outfalls decreased by 62 percent, from a total of 39 or more events, to an approximate total of 15 events. The modeled range of annual overflow frequency for individual outfalls varied from 3 events to 12 events. Table 12-5 summarizes the modeling results, by outfall, for the Gooseneck Creek Basin plan. In the model, a minor increase was projected in overflow volume at Outfall 032 following plan implementation. This projected increase in overflow volume is attributable to boundary condition changes in the continuous simulation model and is considered within the level of accuracy of the modeling projections.

Table 12-5 Gooseneck Creek Modeled Plan Effectiveness

Outfall	**EXISTING OVERFLOWS**		**PLAN AS MODELED**	
MDNR Outfall ID	Typical Year Annual Overflow Volume (MG)	Typical Year Annual Overflow Frequency	Estimated Recreation Season Overflow Volume (MG)	Estimated Recreation Season Overflow
032	0.08	≥3	0.36	3
033	676.38	≥36	238.11	12
Total	**676.46**	**≥39**	**238.48**	**15**

Estimated capital and additional annual O&M costs for CSS Plan improvements in the Gooseneck Creek Basin are shown in Table 12-6, in 2008 dollars (ENR CCI 9180). The estimated capital cost is approximately $23 million. The estimated additional annual O&M cost of the improvements is approximately $0.1 million.

Table 12-6 Gooseneck Creek Basin Improvement Costs

Improvement	**Construction Cost (million $)**	**Annual O&M Cost (million $)**
Construct 4-MGD pump station	$2.54	$0.09
Approximately 4-MG storage in existing gooseneck arch using gates	$7.71	$0.04
Small sewer rehabilitation throughout basin	$13.00	
Total	**$23.25**	**$0.13**

*all costs in 2008 dollars (ENR 9180)

12.6.3 Lower Blue River Basin

The general locations of the Lower Blue River Basin improvements are shown in Figure 12-6. Additional improvement details are located in the *Technical Memorandum for Task 8-Preliminary Improvement Scenarios Gooseneck Creek and Lower Blue River Study Area;* CH2M Hill; July 2008. The Lower Blue River Basin improvements consist of:

1. Either increase the capacity of the 15th Street Pump Station or provide sewer separation in its upstream drainage basin.
2. Construction of approximately 3,500 linear feet of relief sewer 54 inches in diameter, downstream of the intersection of Hardesty Avenue and 31st Street.
3. Construction of approximately 3,400 linear feet of relief sewer 48 inches in diameter, downstream of the intersection of Vineyard and Lawn Street.
4. Construction of approximately 1,500 linear feet of relief sewer 24 inches in diameter, south of 45th Street, between Chelsea Avenue and Van Brunt Boulevard.
5. Sewer separation in approximately 225 acres near 40th & Monroe, elimination of 9 outfalls, and use of green infrastructure to control stormwater runoff.
6. Sewer separation in approximately 35 acres near 17th & Topping, elimination of 1 outfall, and use of green infrastructure to control stormwater runoff.
7. Basin-wide small-sewer rehabilitation.

Multiple continuous model runs for the recreational season were conducted to evaluate the basin-wide effect of the improvements. Modeling projected that the improvements will reduce the typical-year overflow volume in the basin by 64 percent. The overflow volume will be reduced from the existing level of 211 MG to approximately 76 MG for a typical year. The modeled typical-year overflow frequency for all the basin outfalls decreased by 82 percent, from a cumulative total of 271 or more events to an approximate total of 50 events. The modeled range of annual overflow frequency for individual outfalls varied from 0 events to 12 events. Table 12-7 summarizes the modeling results, by outfall, for the Lower Blue River Basin plan.

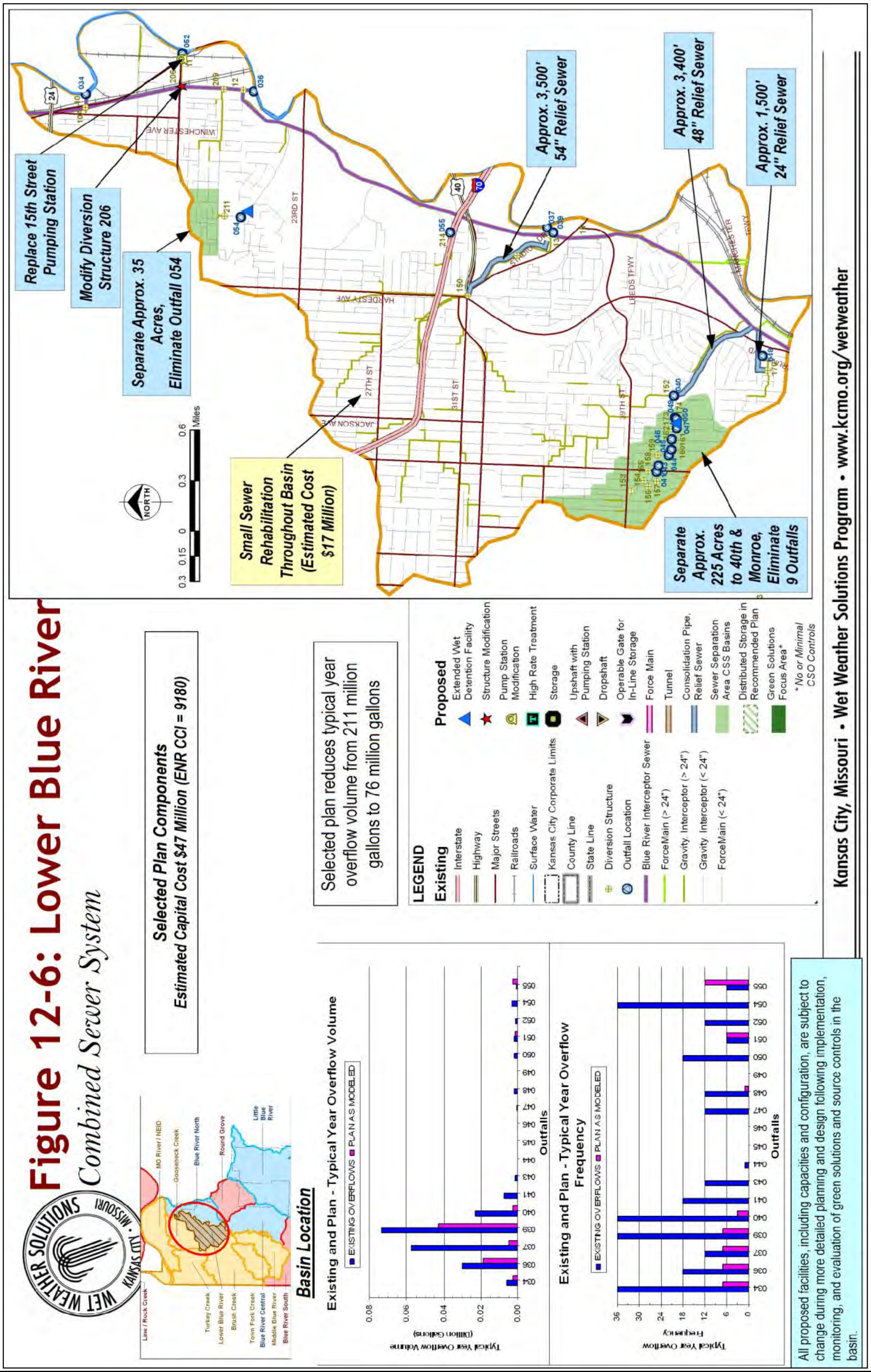


Figure 12-6: Lower Blue River
Combined Sewer System
Selected Plan Components
Estimated Capital Cost $47 Million (ENR CCI = 9180)
Selected plan reduces typical year overflow volume from 211 million gallons to 76 million gallons
Basin Location
Existing and Plan - Typical Year Overflow Volume
EXISTING OVERFLOWS
PLAN AS MODELED
Typical Year Overflow Volume (Billion Gallons)
Outfalls
Existing and Plan - Typical Year Overflow Frequency
Typical Year Overflow Frequency
Replace 15th Street Pumping Station
Modify Diversion Structure 206
Separate Approx. 35 Acres, Eliminate Outfall 054
Small Sewer Rehabilitation Throughout Basin (Estimated Cost $17 Million)
Approx. 3,500' 54" Relief Sewer
Approx. 3,400' 48" Relief Sewer
Approx. 1,500' 24" Relief Sewer
Separate Approx. 225 Acres to 40th & Monroe, Eliminate 9 Outfalls
NORTH
Miles
LEGEND
Existing
Interstate
Highway
Major Streets
Railroads
Surface Water
Kansas City Corporate Limits
County Line
State Line
Diversion Structure
Outfall Location
Blue River Interceptor Sewer
ForceMain (> 24")
Gravity Interceptor (> 24")
Gravity Interceptor (< 24")
ForceMain (< 24")
Proposed
Extended Wet Detention Facility
Structure Modification
Pump Station Modification
High Rate Treatment
Storage
Upshaft with Pumping Station
Dropshaft
Operable Gate for In-Line Storage
Force Main
Tunnel
Consolidation Pipe, Relief Sewer
Sewer Separation Area CSS Basins
Distributed Storage in Recommended Plan
Green Solutions Focus Area*
*No or Minimal CSO Controls
All proposed facilities, including capacities and configuration, are subject to change during more detailed planning and design following implementation, monitoring, and evaluation of green solutions and source controls in the basin.
Kansas City, Missouri • Wet Weather Solutions Program • www.kcmo.org/wetweather

Table 12-7 Lower Blue River Modeled Plan Effectiveness

Outfall	EXISTING OVERFLOWS		PLAN AS MODELED	
MDNR Outfall ID	Typical Year Annual Overflow Volume (MG)	Typical Year Annual Overflow Frequency	Estimated Recreation Season Overflow Volume (MG)	Estimated Recreation Season Overflow Activations
034	5.97	≥36	2.44	7
036	30.17	≥18	18.68	7
037	57.44	≥12	5.03	7
039	73.63	≥36	42.76	7
040	22.80	≥36	2.72	3
041	7.51	≥18	0.00	0
043	1.40	≥12	0.00	0
044	0.02	≥1	0.00	0
045	0.00	0	0.00	0
046	0.00	0	0.00	0
047	0.52	≥12	0.00	0
048	1.85	≥12	0.02	1
049	0.00	0	0.00	0
050	1.84	≥18	0.00	0
051	2.02	≥6	1.68	6
052	1.03	≥12	0.00	0
054	3.56	≥36	0.00	0
055	0.75	≥6	2.82	12
Total	**210.51**	**≥271**	**76.16**	**50**

Estimated capital and additional annual O&M costs for CSS Plan improvements in the Lower Blue River Basin are shown in Table 12-8, in 2008 dollars (ENR CCI 9180). The estimated capital cost is approximately $47 million. Little or no additional annual O&M expense is expected in this Basin.

Table 12-8 Lower Blue River Basin Improvement Costs

Improvement	**Capital Cost (million $)**	**Annual O&M Cost (million $)**
Replace 15th Street Pump Station	$3.00	
Approximately 3,500 LF of 54-inch diameter relief sewer	2.60	
Approximately 3,400 LF of 48-inch diameter relief sewer	2.60	
Approximately 1,500 LF of 24-inch diameter relief sewer	0.73	
Separate approx. 225 acres to 40th & Monroe, eliminate 9 outfalls	17.49	
Separate approximately 35 acres, eliminate outfall 054	3.22	
Small sewer rehabilitation throughout basin	17.00	
Total	**$46.65**	**$0.00**
*all costs in 2008 dollars (ENR 9180)		

12.6.4 Middle Blue River Basin

The general locations of the Middle Blue River Basin improvements are shown in Figure 12-7. Additional details for those improvements (other than controls for Outfalls 059 and 069) are located in the *Development of Preliminary Improvement Scenarios – Combined Sewer System Basins Technical Memorandum-Final MBR Task 8;* HDR; May 2008. The continued development of CSO controls for Outfalls 059 and 069 is discussed in Chapter 10 and detailed in *Green Alternatives for Outfalls 059 and 069*; OCP; June 2008. The Middle Blue River Basin improvement plan consists of:

1. Construction of approximately 9,400 linear feet of relief sewer 30 and 36-inches in diameter.
2. Sewer separation in approximately 270 acres, elimination of one outfall.
3. Sewer separation in approximately 50 acres, elimination of one diversion structure.
4. Construction of distributed storage using green infrastructure in the 475 acres basin tributary to Outfall 069.
5. Construction of distributed storage using green infrastructure in the 269 acres basin tributary to Outfall 059.
6. Construction of approximately 12,000 linear feet of consolidation piping 12 to 36 inches in diameter and elimination of 14 diversion structures.
7. Raise manhole rim elevations and make structural modifications.
8. Basin-wide small-sewer rehabilitation.

Original planning for the Middle Blue River Basin included two underground storage tanks, one each near Outfall 059 and Outfall 069, and associated pumping equipment to store and transfer approximately 3.5 MG of overflow from diversion structures upstream of those outfalls. As a result of the continued alternatives analysis, these tanks have been replaced with distributed storage using green infrastructure throughout the 744 acres tributary to these outfalls. The 100-acre pilot project discussed previously is included in the area tributary to Outfall 069 and forms a part of the planned overflow controls associated with that outfall.

The relief sewer project will replace existing lines with larger-diameter pipes. The purpose of this project is to mitigate surcharging and overflows and to correct significant system deficiencies identified by hydraulic modeling. This project assumes open-cut construction to install approximately 9,400 linear feet of sewer pipe. The project also includes replacement of 21 manholes and raising the rim elevations of 4 manholes.

The sewer separation projects will eliminate CSOs at their respective outfalls. Sanitary flow will be conveyed to treatment and storm flow will be conveyed to the receiving stream. The projects include construction of new sanitary sewer pipes and manholes. The existing CSS will remain in place to serve as the storm sewer servicing the respective areas. Both separation projects include I/I rehabilitation for the existing collection system.

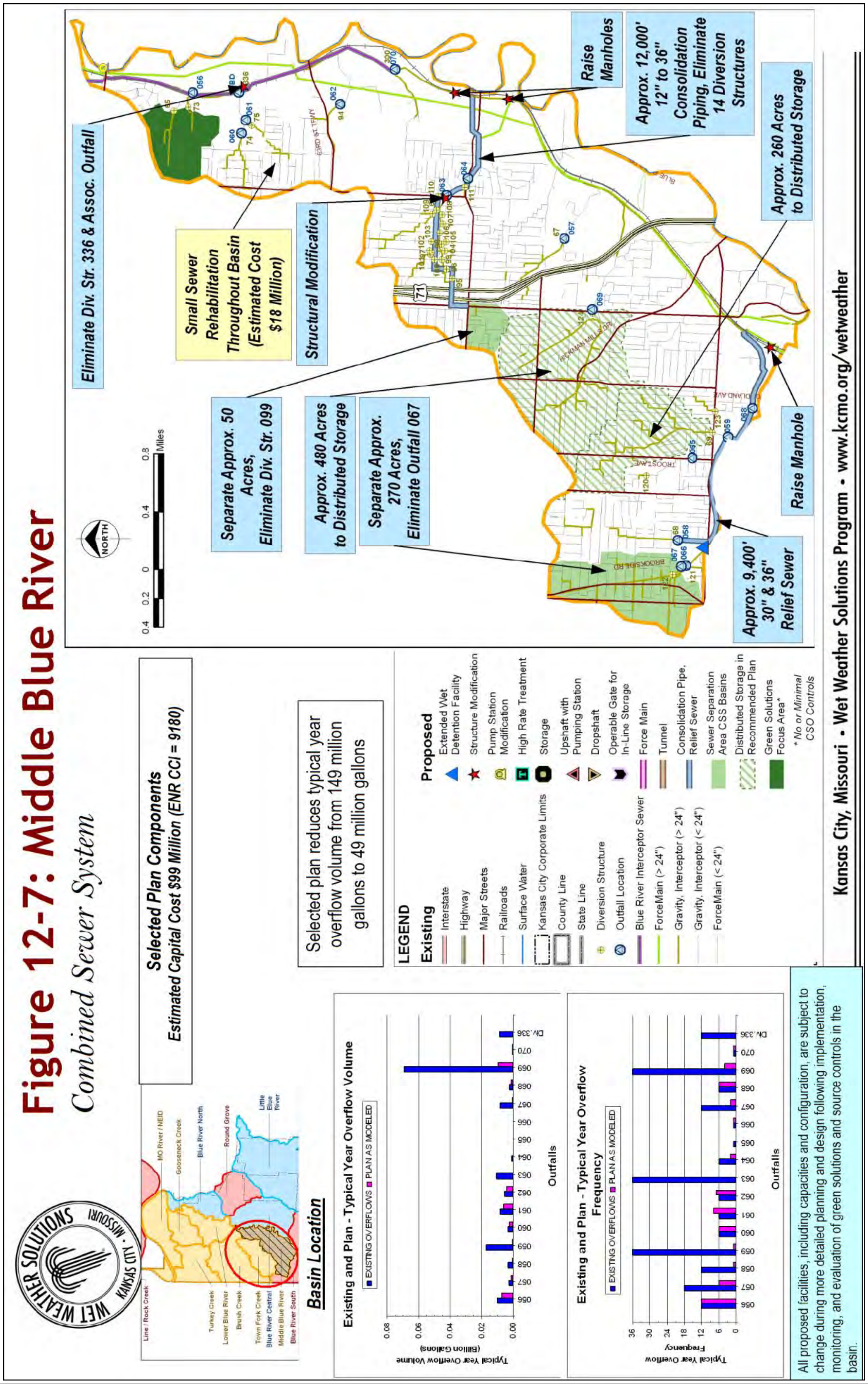


Figure 12-7: Middle Blue River
Combined Sewer System
Selected Plan Components
Estimated Capital Cost $99 Million (ENR CCI = 9180)
Selected plan reduces typical year overflow volume from 149 million gallons to 49 million gallons
Basin Location
Existing and Plan - Typical Year Overflow Volume
Existing and Plan - Typical Year Overflow Frequency
EXISTING OVERFLOWS
PLAN AS MODELED
Outfalls
Eliminate Div. Str. 336 & Assoc. Outfall
Small Sewer Rehabilitation Throughout Basin (Estimated Cost $18 Million)
Structural Modification
Raise Manholes
Approx. 12,000' 12" to 36" Consolidation Piping, Eliminate 14 Diversion Structures
Approx. 260 Acres to Distributed Storage
Separate Approx. 50 Acres, Eliminate Div. Str. 099
Approx. 480 Acres to Distributed Storage
Separate Approx. 270 Acres, Eliminate Outfall 067
Raise Manhole
Approx. 9,400' 30" & 36" Relief Sewer
LEGEND
Existing
Proposed
Kansas City, Missouri • Wet Weather Solutions Program • www.kcmo.org/wetweather
All proposed facilities, including capacities and configuration, are subject to change during more detailed planning and design following implementation, monitoring, and evaluation of green solutions and source controls in the basin.

Estimated capital and additional annual O&M costs for CSS improvements in the Middle Blue River Basin are shown in Table 12-9, in 2008 dollars (ENR CCI 9180). The estimated capital cost is approximately $99 million. The estimated additional annual O&M cost of the improvements is $2.0 million.

Table 12-9 Middle Blue River Basin Improvement Costs

Improvement	Capital Cost (million $)	Annual O&M Cost (million $)
Approximately 9,400 LF of 30 and 36-inch relief sewer	$5.51	
Separate approximately 270 acres, eliminate outfall 067	25.05	
Separate approximately 50 acres, eliminate diversion structure 099	4.32	
Distributed green storage upstream of Outfalls 059 and 069	40.00	$2.00
Approximately 12,000 LF of 12 to 36-inch diameter consolidation piping/ eliminate 14 diversion structures	6.08	
Small sewer rehabilitation throughout basin	18.00	
Raise manholes/structural modification	0.07	
Total	**$99.02**	**$2.00**

*all costs in 2008 dollars (ENR 9180)

There were uncertainties associated with the aggregate performance of multiple, widely-distributed, green storage facilities on overflow volumes at the lower end of the system. The resulting total capital budget of $46 million for green solutions upstream of Outfalls 059 and 069 was approximately 30 percent greater than the conceptual cost estimate. The 100-acre pilot project discussed previously will help answer questions concerning the aggregate performance. The capital budget for that pilot project is $6 million, which is included in the overall Plan budget of $28 million for pilot projects and partnerships in the CSS also discussed previously. The estimated capital cost for distributed storage shown in Table 12-9 ($40 million) is for completion of the remaining green storage projects upstream of Outfalls 059 and 069.

Multiple continuous model runs for the recreational season were conducted to evaluate the basin-wide effect of the improvements. Modeling indicated that the improvements will reduce the typical-year overflow volume in the basin by 67 percent. The overflow volume will be reduced from the existing level of 149 MG to approximately 49 MG for a typical year. The modeled typical-year overflow frequency for all the basin outfalls decreased by 69 percent, from a cumulative total of 207 or more events to an approximate total of 64 events. The modeled range of annual overflow frequency for individual outfalls varied from 0 events to 12 events. Table 12-10 summarizes the modeling results, by outfall, for the Middle Blue River Basin plan.

Table 12-10 Middle Blue River Modeled Plan Effectiveness

Outfall	EXISTING OVERFLOWS		PLAN AS MODELED	
MDNR Outfall ID	Typical Year Annual Overflow Volume (MG)	Typical Year Annual Overflow Frequency	Estimated Recreation Season Overflow Volume (MG)	Estimated Recreation Season Overflow Activations
056	9.67	>12	7.03	12
057	2.61	>18	1.46	6
058	3.23	>12	0.32	1
059	17.11	>36	6.79	6
060	3.08	>6	2.23	6
061	8.09	>6	5.87	8
062	5.40	>6	3.94	7
063	10.19	>36	0.00	0
064	1.06	>6	0.15	2
065	0.02	>1	0.00	0
066	0.07	>1	0.03	1
067	8.17	>12	0.27	2
068	2.10	>6	1.56	6
069	69.38	>36	19.50	6
070	0.48	>1	0.31	1
Manholes	8.40	>12	0.00	0
Total	**149.06**	**≥207**	**49.45**	**64**

12.6.5 Northeast Industrial District Basin

The general locations of the NEID Basin improvements are shown in Figure 12-8. Additional improvement details are located in the *Missouri River Northeast Industrial District/Turkey Creek Project Area Preliminary Improvement Scenarios Technical Memorandum;* Black and Veatch; July 2008. The basin improvements consist of:

1. Sewer separation in approximately 260 acres
2. Basin-wide small-sewer rehabilitation

The main project included in the NEID Basin plan is separation of approximately 260 acres of CSS. Sewer separation will eliminate Outfall 076. This project includes construction of an estimated 13,500 linear feet of new sanitary sewer lines ranging in size from 8- to 12-inches in diameter. Multiple continuous model runs for the recreational season were conducted to evaluate the basin-wide effect of the improvements. Modeling indicated that the improvements will reduce the typical-year overflow volume in the basin by 48 percent. The overflow volume will be reduced from the existing level of 886 MG to approximately 462 MG for a typical year. The modeled typical-year overflow frequency for all the basin outfalls decreased by 19 percent, from a cumulative total of 240 or more events to an approximate total of 194 events. The modeled range of annual overflow frequency for individual outfalls varied from 0 events to 34 events. Table 12-11 summarizes the modeling results, by outfall, for the NEID Basin plan.

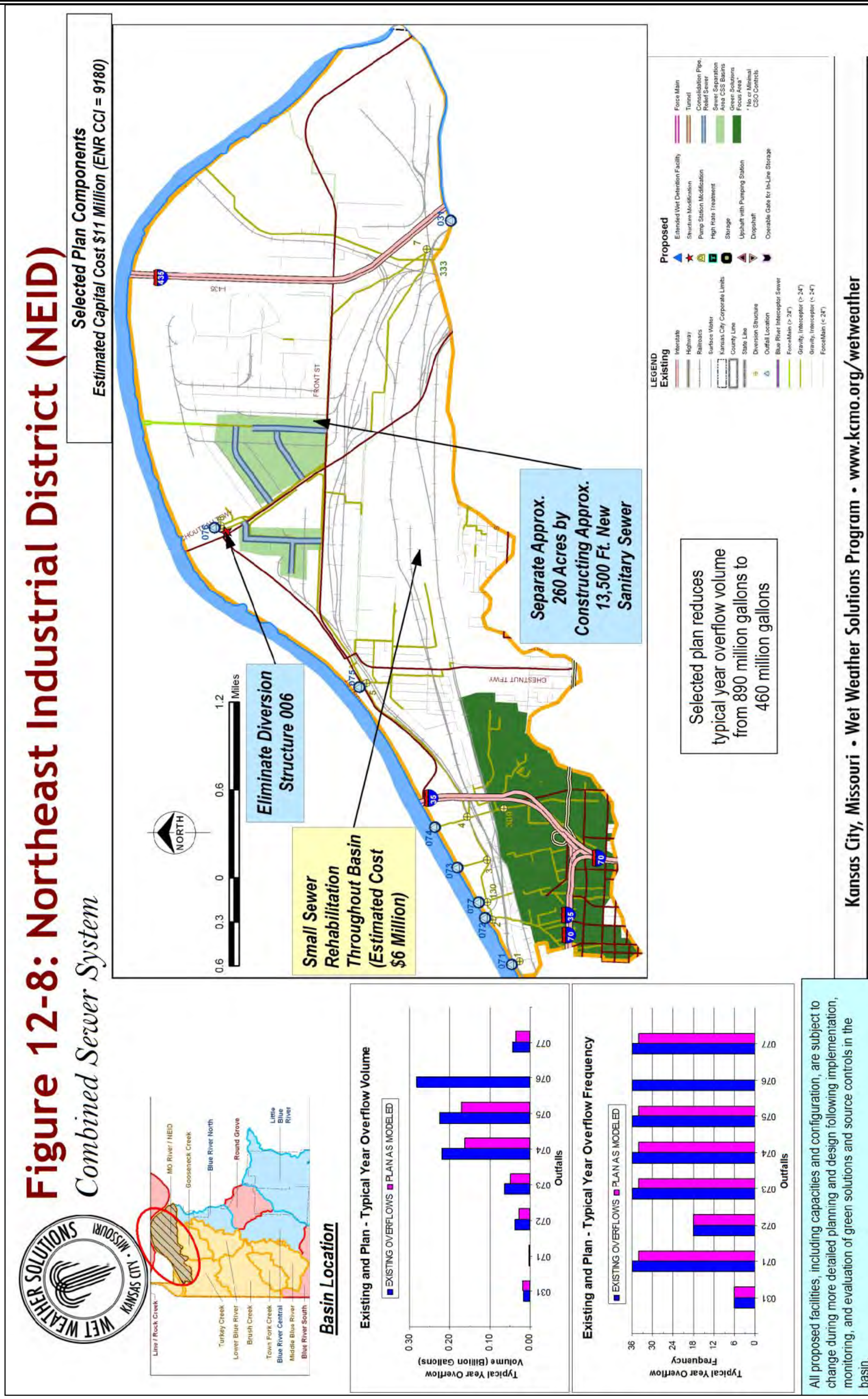


Figure 12-8: Northeast Industrial District (NEID)
Combined Sewer System
Selected Plan Components
Estimated Capital Cost $11 Million (ENR CCI = 9180)
Basin Location
Line / Rock Creek
MO River / NEID
Gooseneck Creek
Blue River North
Turkey Creek
Lower Blue River
Round Grove
Brush Creek
Town Fork Creek
Blue River Central
Little Blue River
Middle Blue River
Blue River South
Eliminate Diversion Structure 006
Small Sewer Rehabilitation Throughout Basin (Estimated Cost $6 Million)
Separate Approx. 260 Acres by Constructing Approx. 13,500 Ft. New Sanitary Sewer
Selected plan reduces typical year overflow volume from 890 million gallons to 460 million gallons
Existing and Plan - Typical Year Overflow Volume
EXISTING OVERFLOWS
PLAN AS MODELED
Typical Year Overflow Volume (Billion Gallons)
Outfalls
Existing and Plan - Typical Year Overflow Frequency
Typical Year Overflow Frequency
All proposed facilities, including capacities and configuration, are subject to change during more detailed planning and design following implementation, monitoring, and evaluation of green solutions and source controls in the basin.
LEGEND
Existing
Proposed
Kansas City, Missouri • Wet Weather Solutions Program • www.kcmo.org/wetweather

Table 12-11 Northeast Industrial District Modeled Plan Effectiveness

Outfall	EXISTING OVERFLOWS		PLAN AS MODELED	
MDNR Outfall ID	Typical Year Annual Overflow Volume (MG)	Typical Year Annual Overflow Frequency	Estimated Recreation Season Overflow Volume (MG)	Estimated Recreation Season Overflow Activations
031	17.20	≥6	18.28	6
071	2.37	≥36	1.79	34
072	35.52	≥18	26.22	18
073	63.78	≥36	47.79	34
074	219.28	≥36	163.13	34
075	224.76	≥36	171.15	34
076	280.99	≥36	0	0
077	42.50	≥36	33.46	34
Total	**886.40**	**≥240**	**461.82**	**194**

Estimated capital and additional annual O&M costs for CSS Plan improvements in the NEID Basin are shown in Table 12-12, in 2008 dollars (ENR CCI 9180). The estimated capital cost is approximately $11 million. Little or no additional annual O&M expense is expected in this basin.

Table 12-12 Northeast Industrial District Basin Improvement Costs

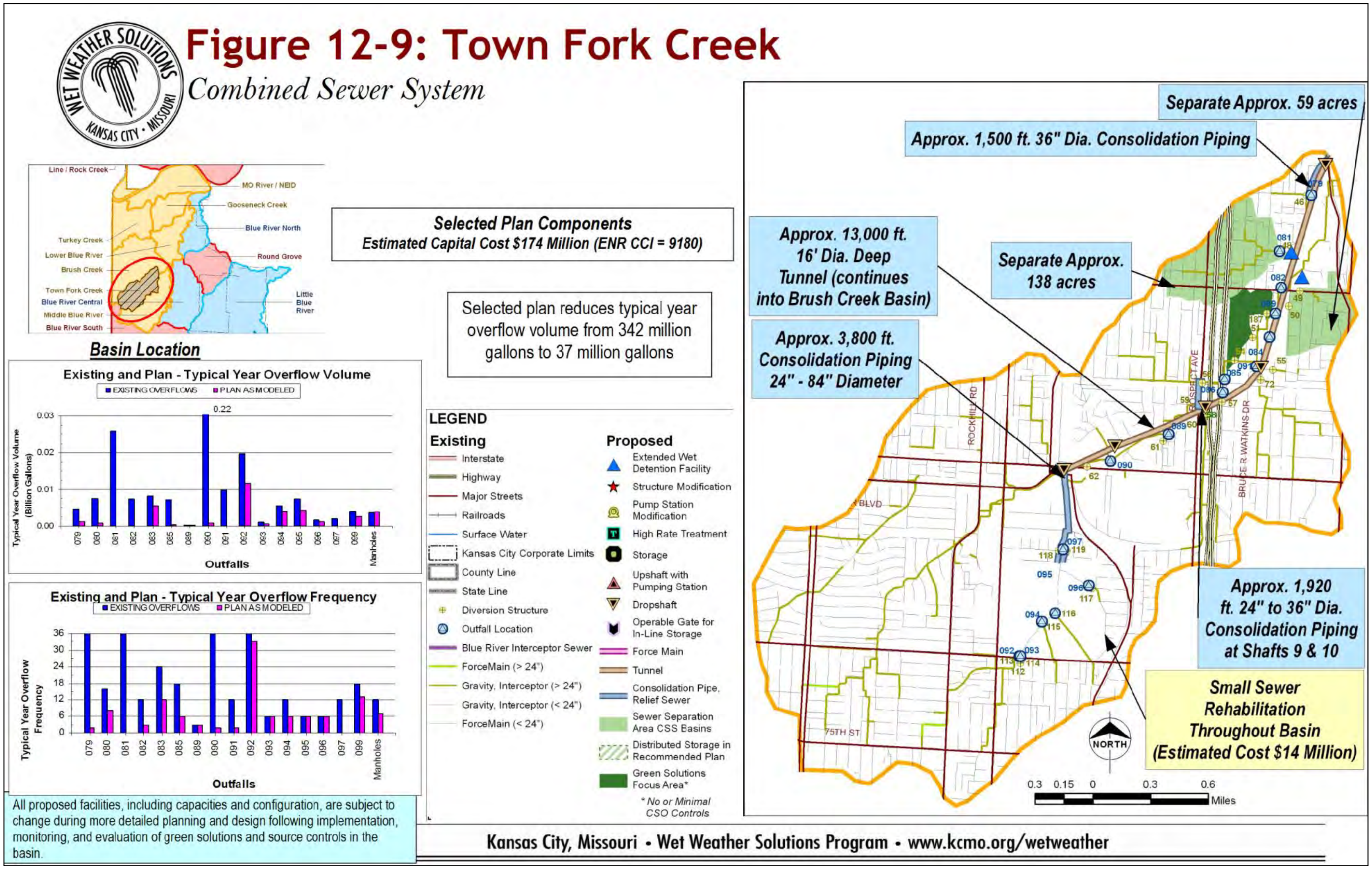
Improvement	**Capital Cost (million $)**	**Annual O&M Cost (million $)**
Separate approximately 260 acres/eliminate diversion structure	$5.19	
Small sewer rehabilitation throughout basin	6.00	
Total	**$11.19**	**$0.00**

*all costs in 2008 dollars (ENR 9180)

12.6.6 Town Fork Creek Basin

The general locations of the Town Fork Creek Basin improvements are shown in Figure 12-9. Additional improvement details are presented in the *Final Development of Preliminary Improvement Scenarios Technical Memorandum; CDM;*. June 2008. The basin improvements generally consist of:

1. Construction of approximately 13,000 linear feet of 16-foot diameter deep tunnel.
2. Placement of approximately 7,200 linear feet of consolidation piping ranging from 24 inches to 84 inches in diameter.
3. Sewer separation in approximately 200 acres, with green solutions for controlling stormwater runoff.
4. Various baseline improvements.
5. Basin-wide, small-sewer rehabilitation.



WET WEATHER SOLUTIONS
KANSAS CITY • MISSOURI
Figure 12-9: Town Fork Creek
Combined Sewer System
Line / Rock Creek
MO River / NEID
Gooseneck Creek
Blue River North
Turkey Creek
Lower Blue River
Round Grove
Brush Creek
Town Fork Creek
Blue River Central
Middle Blue River
Blue River South
Little Blue River
Basin Location
Selected Plan Components
Estimated Capital Cost $174 Million (ENR CCI = 9180)
Selected plan reduces typical year overflow volume from 342 million gallons to 37 million gallons
Existing and Plan - Typical Year Overflow Volume
EXISTING OVERFLOWS
PLAN AS MODELED
Typical Year Overflow Volume (Billion Gallons)
0.22
Outfalls
Existing and Plan - Typical Year Overflow Frequency
Typical Year Overflow Frequency
Manholes
LEGEND
Existing
Interstate
Highway
Major Streets
Railroads
Surface Water
Kansas City Corporate Limits
County Line
State Line
Diversion Structure
Outfall Location
Blue River Interceptor Sewer
ForceMain (> 24")
Gravity, Interceptor (> 24")
Gravity, Interceptor (< 24")
ForceMain (< 24")
Proposed
Extended Wet Detention Facility
Structure Modification
Pump Station Modification
High Rate Treatment
Storage
Upshaft with Pumping Station
Dropshaft
Operable Gate for In-Line Storage
Force Main
Tunnel
Consolidation Pipe, Relief Sewer
Sewer Separation Area CSS Basins
Distributed Storage in Recommended Plan
Green Solutions Focus Area*
* No or Minimal CSO Controls
Separate Approx. 59 acres
Approx. 1,500 ft. 36" Dia. Consolidation Piping
Approx. 13,000 ft. 16' Dia. Deep Tunnel (continues into Brush Creek Basin)
Separate Approx. 138 acres
Approx. 3,800 ft. Consolidation Piping 24" - 84" Diameter
Approx. 1,920 ft. 24" to 36" Dia. Consolidation Piping at Shafts 9 & 10
Small Sewer Rehabilitation Throughout Basin (Estimated Cost $14 Million)
PROSPECT AVE
BRUCE R WATKINS DR
ROCKHILL RD
75TH ST
NORTH
Miles
All proposed facilities, including capacities and configuration, are subject to change during more detailed planning and design following implementation, monitoring, and evaluation of green solutions and source controls in the basin.
Kansas City, Missouri • Wet Weather Solutions Program • www.kcmo.org/wetweather

The 16-foot diameter deep-storage tunnel will provide approximately 19 MG of storage capacity. The tunnel will connect to the Brush Creek deep-storage tunnel near Diversion Structure 314. Stored flow will be treated at an HRT/disinfection facility and the effluent will discharge to the Blue River (see section 12.4.1 for discussion of HRT/disinfection facility).

In addition to providing storage for CSOs, the Town Fork Creek deep-storage tunnel will be designed to function as a conveyance conduit during heavy rainfall events, reducing peak-flow rates and flood damage along Town Fork Creek. Under KC-One, the City is contemplating completion of an urban channel restoration along Town Fork Creek, which will be made possible by the in-channel, flow reductions associated with the tunnel.

Sewer separation is recommended in two areas of the Town Fork Creek Basin. The larger area is approximately 138 acres and is located west of Outfall 081. The smaller area is approximately 59 acres and is generally located east of Outfall 082.

Consolidation piping is recommended in three areas. The purpose of these projects is to re-route wet-weather flows, which would normally overflow to receiving streams, to deep-tunnel, drop shafts.

Various baseline improvements include measures to assure the current collection system operates at its maximum capacity. The baseline improvements include sediment, debris, and blockage removal; and diversion structure clogged-grate removal (plugged grated inlets covering dry-weather outlet pipes should either be removed or maintained more frequently).

Multiple, continuous model runs for the recreational season were conducted to evaluate the basin-wide effect of the improvements. Modeling suggested that the improvements decreased the typical-year overflow volume in the basin by 89 percent. The overflow volume decreased from the existing level of 341 MG to approximately 37 MG for a typical year. The modeled typical-year overflow frequency for all the basin outfalls decreased by 62 percent, from a cumulative total of 301 or more events to an approximate total of 115 events. The modeled range of annual overflow frequency for individual outfalls varied from 0 events to 33 events. Table 12-13 summarizes the modeling results, by outfall, for the Town Fork Creek Basin plan.

Outfalls 092-096 are each located upstream of proposed consolidation piping extending from the deep-storage tunnel to Forest Hill Cemetery. These outfalls discharge to an open-channel system in the cemetery. Up to the capacity of the consolidation piping, overflows from those outfalls will be reintroduced to the CSS and controlled by the consolidation piping.

Table 12-13 Town Fork Creek Modeled Plan Effectiveness

Outfall	**EXISTING OVERFLOWS**		**PLAN AS MODELED**	
MDNR Outfall ID	Typical Year Annual Overflow Volume (MG)	Typical Year Annual Overflow Frequency	Estimated Recreation Season Overflow Volume (MG)	Estimated Recreation Season Overflow Activations
079	4.70	≥36	1.30	2
080	7.61	≥16	0.77	8
081	25.88	≥36	0.00	0
082	7.44	≥12	0.02	3
083	8.12	≥24	5.42	12
085	7.12	≥18	0.44	6
089	0.30	≥3	0.22	3
090	224.70	≥36	0.75	2
091	9.84	≥12	0.07	2
092	19.88	≥36	11.54	33
093	1.00	≥6	0.56	6
094	5.57	≥12	3.98	6
095	7.39	≥6	4.23	6
096	1.63	≥6	1.22	6
097	1.96	≥12	0.00	0
099	4.17	≥18	2.67	13
Manholes	3.68	≥12	3.83	7
Total	**340.99**	**>301**	**37.02**	**115**

Estimated capital and additional annual O&M costs for CSS Plan improvements in the Town Fork Creek Basin are shown in Table 12-14, in 2008 dollars (ENR CCI 9180). The estimated capital cost is approximately $174 million. The estimated additional annual O&M cost of the improvements is approximately $1.2 million.

Table 12-14 Town Fork Creek Basin Improvement Costs

Improvement	**Capital Cost (million $)**	**Annual O&M Cost (million $)**
Approximately 13,000 LF of 16-foot diameter deep tunnel	$123.89	$1.23
Approximately 3,800 LF of 24 to 84-inch diameter consolidation piping	8.82	
Approximately 1,920 LF of 24 to 36-inch diameter consolidation piping	4.57	
Approximately 1,500 LF of 36-inch diameter consolidation piping	2.46	
Separate approximately 59 acres	5.75	
Separate approximately 138 acres	12.00	
Baseline improvements	2.53	
Small sewer rehabilitation throughout basin	14.00	
Total	**$174.02**	**$1.23**

*all costs in 2008 dollars (ENR 9180)

12.6.7 Turkey Creek Basin

The general locations of the Turkey Creek Basin improvements are shown in Figure 12-10. Additional improvement details are presented in the *Missouri River Northeast Industrial District/Turkey Creek Project Area Preliminary Improvement Scenarios Technical Memorandum;* Black and Veatch; July 2008. The basin improvements generally consist of:

1. Sewer separation in approximately 66 acres.
2. Construction of approximately 10,600 linear feet of 48-inch force main.
3. Replacement of gates at the Santa Fe Pumping Station and institution of real-time gate control to take advantage of additional system storage made available in ongoing CID storm drainage improvements.
4. Construction of approximately 7,500 linear feet of 26-foot diameter deep-storage tunnel.
5. Construction of a 30-MGD deep-tunnel pump station.
6. Upgrade the Turkey Creek Pump Station capacity to 30 MGD.
7. Construction of in-line storage gates for real-time control of depths in the OK Creek sewer to take advantage of available system storage.
8. Basin-wide small-sewer rehabilitation

The major control component of the basin improvement plan is the deep-storage tunnel. The tunnel will be located over 200 feet deep and will have a storage capacity of approximately 30 MG. The preliminary tunnel alignment would begin just south of the Turkey Creek Pump Station and terminate near West 22nd Street and Grand Avenue. The majority of the preliminary alignment is within the Kansas City Terminal Railway Company right-of-way, and generally parallels the OK Creek sewer.

The deep-storage tunnel will, in addition to providing storage for CSOs, be designed to function as a conveyance conduit during infrequent rainfall events, reducing peak-flow rates and flood damage in the basin. A double box culvert will be constructed as a relief sewer to convey wet-weather flows that exceed the tunnel's storage capacity to a new outfall at the Kansas River.

A 30-MGD pump station, working shaft, and ancillary facilities will be constructed to dewater the deep tunnel within 48 hours. The deep-tunnel pump station will be located at the existing Turkey Creek Pump Station site. Flow will be pumped to the Westside WWTP through a new 48-inch force main that will replace the existing force main from the Turkey Creek Pumping Station.

The existing Turkey Creek Pumping Station will be reconstructed (firm capacity of 30 MGD) and will draw from the OK Creek sewer just upstream of the in-line storage gates. The in-line gates will provide up to 20 MG of storage in the OK Creek sewer. An additional one million gallons of system storage will be made available upon completion of the ongoing CID storm drainage improvements and institution of real-time control of in-line gates at the Santa Fe Pumping Station.

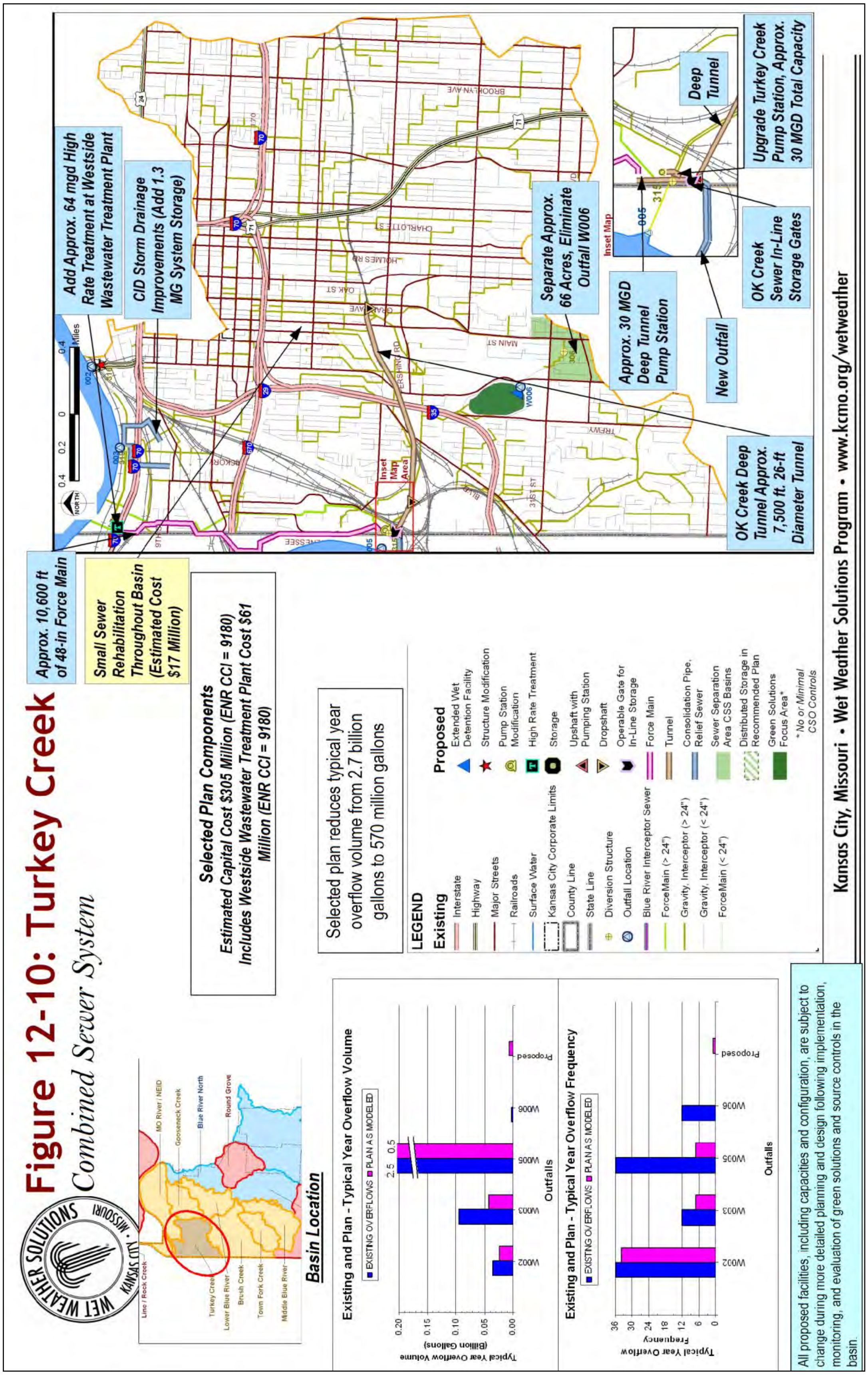


Figure 12-10: Turkey Creek
Combined Sewer System
Basin Location
Approx. 10,600 ft of 48-in Force Main
Small Sewer Rehabilitation Throughout Basin (Estimated Cost $17 Million)
Selected Plan Components
Estimated Capital Cost $305 Million (ENR CCI = 9180)
Includes Westside Wastewater Treatment Plant Cost $61 Million (ENR CCI = 9180)
Selected plan reduces typical year overflow volume from 2.7 billion gallons to 570 million gallons
Add Approx. 64 mgd High Rate Treatment at Westside Wastewater Treatment Plant
CID Storm Drainage Improvements (Add 1.3 MG System Storage)
Separate Approx. 66 Acres, Eliminate Outfall W006
Approx. 30 MGD Deep Tunnel Pump Station
New Outfall
OK Creek Sewer In-Line Storage Gates
Upgrade Turkey Creek Pump Station, Approx. 30 MGD Total Capacity
Deep Tunnel
OK Creek Deep Tunnel Approx. 7,500 ft. 26-ft Diameter Tunnel
Inset Map
Inset Map Area
LEGEND
Existing
Interstate
Highway
Major Streets
Railroads
Surface Water
Kansas City Corporate Limits
County Line
State Line
Diversion Structure
Outfall Location
Blue River Interceptor Sewer
ForceMain (> 24")
Gravity, Interceptor (> 24")
Gravity, Interceptor (< 24")
ForceMain (< 24")
Proposed
Extended Wet Detention Facility
Structure Modification
Pump Station Modification
High Rate Treatment
Storage
Upshaft with Pumping Station
Dropshaft
Operable Gate for In-Line Storage
Force Main
Tunnel
Consolidation Pipe, Relief Sewer
Sewer Separation Area CSS Basins
Distributed Storage in Recommended Plan
Green Solutions Focus Area*
* No or Minimal CSO Controls
Existing and Plan - Typical Year Overflow Volume
EXISTING OVERFLOWS
PLAN AS MODELED
Typical Year Overflow Volume (Billion Gallons)
Outfalls
W002
W003
W005
W006
Proposed
Existing and Plan - Typical Year Overflow Frequency
Typical Year Overflow Frequency
Kansas City, Missouri • Wet Weather Solutions Program • www.kcmo.org/wetweather
All proposed facilities, including capacities and configuration, are subject to change during more detailed planning and design following implementation, monitoring, and evaluation of green solutions and source controls in the basin.

The sewer separation project is in the area of 31st Street and Broadway, upstream of George Washington Lake in Penn Valley Park. This project will eliminate Outfall W006. Following separation, only stormwater will discharge to the lake. This project includes use of green infrastructure to control stormwater runoff reaching George Washington Lake inflows.

Multiple continuous model runs for the recreational season were conducted to evaluate the basin-wide effect of the planned improvements. Modeling indicated that the improvements will reduce the typical-year overflow volume in the basin by 78 percent. The overflow volume will be reduced from the existing level of 2,659 MG to approximately 574 MG for a typical year. The modeled typical-year overflow frequency for all the basin outfalls decreased by 49 percent, from a cumulative total of 96 or more events to an approximate total of 49 events. The modeled range of annual overflow frequency for individual outfalls varied from 0 events to 34 events. Table 12-15 summarizes the modeling results, by outfall, for the Turkey Creek Basin plan. Outfall W002 is located along Broadway Avenue and discharges to the Missouri River.

Table 12-15 Turkey Creek Modeled Plan Effectiveness

Outfall	**EXISTING OVERFLOWS**		**PLAN AS MODELED**	
MDNR Outfall ID	Typical Year Annual Overflow Volume (MG)	Typical Year Annual Overflow Frequency	Estimated Recreation Season Overflow Volume (MG)	Estimated Recreation Season Overflow Activations
W002	35.30	≥36	22.8	34
W003	95.00	≥12	42.9	7
W005	2,525.90	≥36	501.4	7
W006	2.80	≥12	0	0
NA*			6.46	1
Total	**2,659.00**	**>96**	**573.56**	**49**

*New Outfall from Turkey Creek Tunnel

Estimated capital and additional annual O&M costs for CSS Plan improvements in the Turkey Creek Basin are shown in Table 12-16, in 2008 dollars (ENR CCI 9180). The estimated capital cost is approximately $244 million. The estimated additional annual O&M cost of the improvements is approximately $1.8 million.

Table 12-16 Turkey Creek Basin Improvement Costs

Improvement	Capital Cost (million $)	Annual O&M Cost (million $)
Separate approximately 66 acres/eliminate outfall 006	$9.47	
Approx. 10,600 LF of 48-inch diameter Turkey Creek PS force main	13.25	
CID storm drainage improvements	2.19	
Construct approximately 7,500 LF of 26-foot diameter deep-tunnel	122.59	$0.24
Construct approximately 30-MGD deep tunnel pump station	63.57	0.93
Upgrade Turkey Creek Pump Station to 30-MGD capacity	11.42	0.58
OK Creek sewer in-line storage gates	4.50	0.02
Small sewer rehabilitation throughout basin	17.00	
Total	**$243.99**	**$1.77**

*all costs in 2008 dollars (ENR 9180)

12.6.8 Blue River Interceptor Sewer (BRIS)

The BRIS is the principal means of delivering flow to the Blue River WWTP from the Gooseneck Creek, Lower Blue River, Brush Creek, Town Fork Creek, and Middle Blue River Basins in the CSS. It also carries flow discharged from the Blue River South, Round Grove, and Blue River Central Basins in the SSS.

Wastewater from the Blue River South Basin flows by gravity to the 87th Street Pumping Station and is discharged directly through a 72-inch diameter force main extending from that pumping station to the BRIS, just north of the confluence of Brush Creek and the Blue River. The Blue River Interceptor Sewer carries flow from the CSS in the Middle Blue River, Town Fork Creek and Brush Creek Basins. The Round Grove Pumping Station drains the SSS in the Blue River Central and Round Grove Creek Basins. The Round Grove Pumping Station also discharges to the BRIS. The BRIS then extends northerly to the Blue River WWTP, picking up additional CSS discharges from the Lower Blue River and Gooseneck Creek Basins, prior to its downstream terminus at the headworks of the Blue River WWTP.

Estimated overflows from the SSS upstream of the BRIS, during the typical-year, total 29.1 MG. The maximum single-event rainfall depth in the typical year is 2.9 inches. During a 5-year, 24-hour rainfall event (4.68-inch rainfall depth), existing SSOs upstream of the 87th Street and Round Grove Pumping Stations are estimated to total 68.7 MG. That overflow volume would be captured for treatment upon completion of the Plan.

An analysis of the extent to which those SSS flows would remain in the system and be conveyed to the Blue River WWTP for treatment is included in *Blue River Basin Separate Sanitary Sewer System Flows to Blue River Interceptor and WWTP;* OCP; October 2008. Total overflows from the BRIS (excluding CSS overflows that do not enter the BRIS) at and upstream of the Blue River WWTP, during a 5-year, 24-hour rainfall event, following completion of the Plan, are estimated to total less than 4 MG. Untreated CSOs to the Blue River and its tributaries during that same event are estimated to exceed 1.4 billion gallons following completion of the Plan.

The potential for extending the force main from the 87th Street Pumping Station to the Blue River WWTP for paralleling the existing BRIS downstream of Brush Creek was evaluated in *BRIS & 87th Street Force Main Expansion Capabilities;* OCP; August 2007. Either of those potential improvements would be intended to provide a means for removing SSS flows from the BRIS and carrying those flows directly to the Blue River WWTP. Either method was projected to result in a high capital cost, with little beneficial impact on typical-year overflows from or along the BRIS.

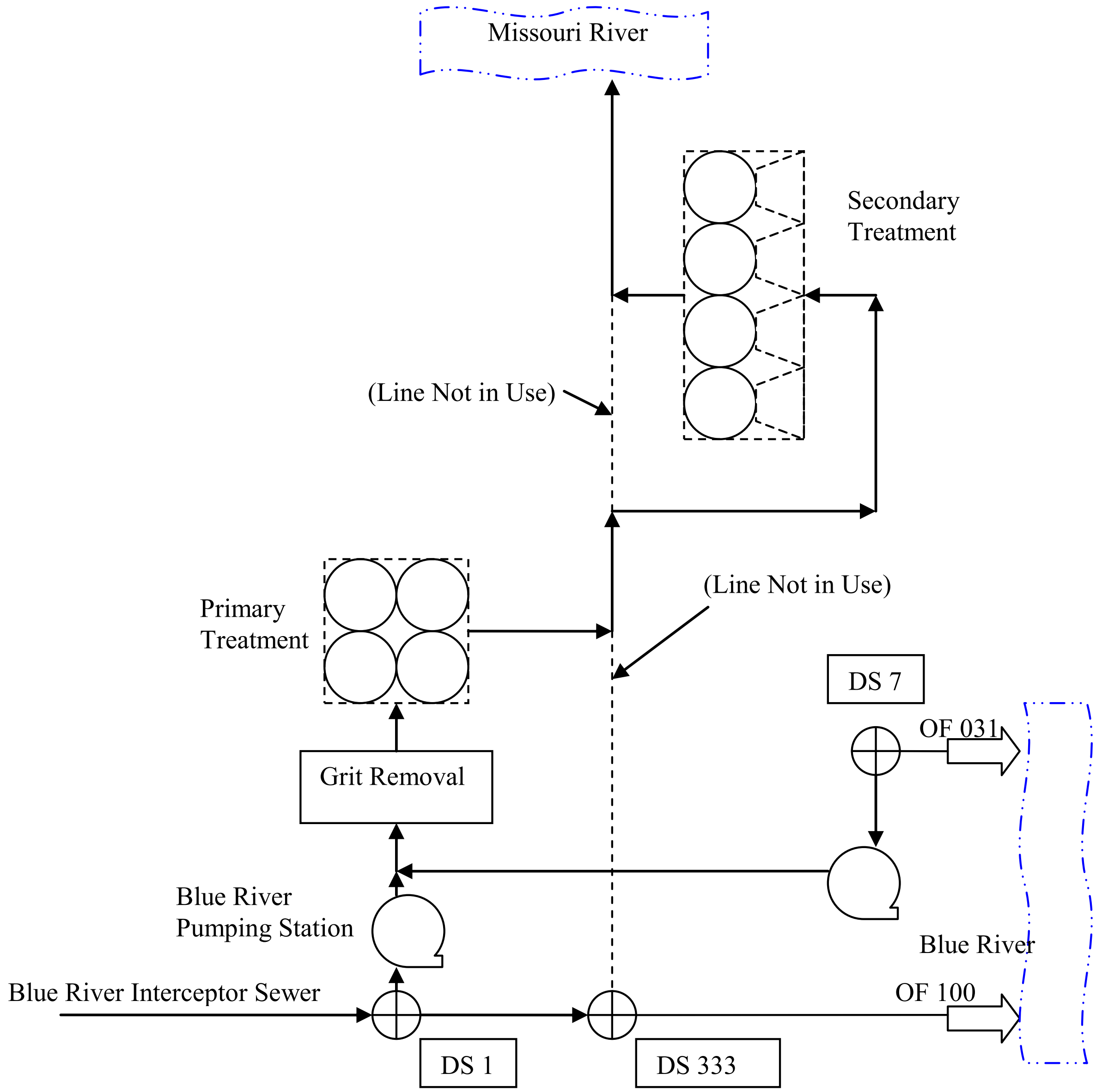
12.6.9 Blue River WWTP

A simplified flow schematic for the Blue River WWTP is presented in Figure 12-11. Plan improvements at the Blue River WWTP include:

1. Modifications for diversion of up to 80 MGD of primary-plant effluent directly to disinfection facilities for treatment and discharge to the Blue River during wet-weather events, which cause flows to exceed the 140-MGD secondary treatment capacity.
2. Construction of a 50-MGD HRT/disinfection facility for treatment of wet-weather flow.
3. Expansion of solids handling facilities to accommodate additional loading from all proposed HRT/disinfection facilities.

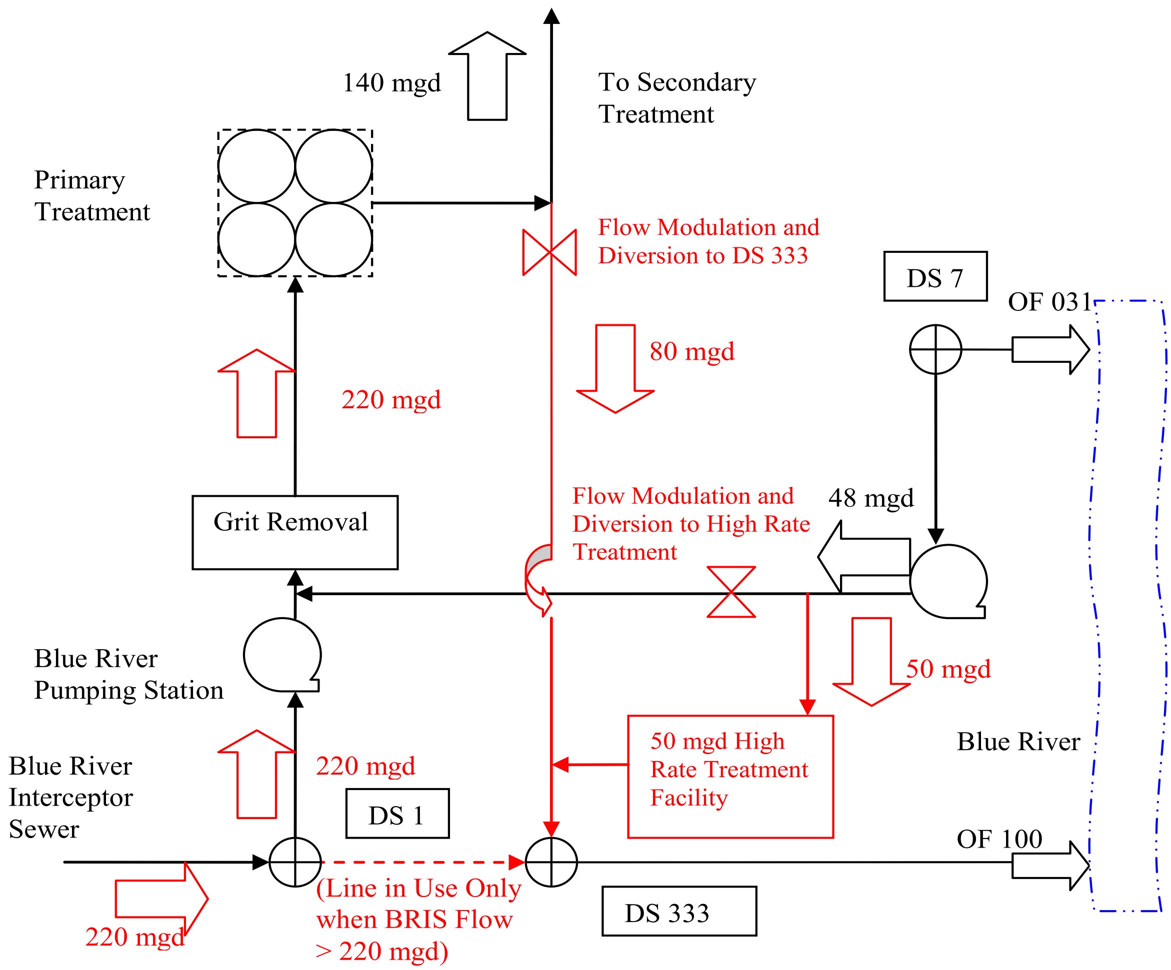
Figure 12-12 is a simplified flow schematic of the primary plant following addition of the secondary bypass and HRT facilities. Disinfecting and discharging 80 MGD of primary-plant effluent maximizes use of the primary-plant treatment capacity. Currently, the treatment capacity of the primary plant (220 MGD) exceeds the treatment capacity of the secondary plant (140 MGD). This modification will result in primary treatment and disinfection of up to 80 MGD of wet-weather flows bypassing the secondary treatment plant.

Figure 12-11 Existing Blue River WWTP Flow Schematic



Construction of the HRT/disinfection facility, in addition to that secondary bypass, will enable full utilization of the primary-plant influent sewer capacity (maximum capacity without overflow of 220 MGD from the BRIS and firm pumping capacity of 48 MGD from the NEID Pump Station). Flow in excess of primary-clarifier capacity will divert from the primary-clarifier influent line to the new facility. The HRT facility will include fine screening, high rate clarification, and disinfection. Planned Blue River WWTP improvements are expected to eliminate any typical-year overflow from the primary-plant Outfall 100. Additional improvement details are located in the *Joint Use Facilities Expansion Capabilities Technical Memorandum;* OCP; September 2008.

Figure 12-12 Future Blue River Primary WWTP Flow Schematic



The existing Blue River solids handling facility consists of dissolved air flotations (DAF), anaerobic digesters, belt filter presses (BFPs), and incinerators. Combined primary and secondary sludge from both Birmingham and Westside WWTPs are presently combined with secondary sludge from Blue River WWTP. Sludge from each of the HRT facilities included in this Plan (three facilities south of the Missouri River and one at the Birmingham WWTP) will be directed through the primary clarifiers at the Blue River WWTP to remove the heavier solids.

The necessary additional solids handling components are presently expected to include:

1. Three primary DAF units
2. Three belt filter presses
3. Three incinerators
4. Two digester DAF units
5. Seven anaerobic digesters

Estimated capital and additional annual O&M costs for presently anticipated improvements at the Blue River WWTP are shown in Table 12-14, in 2008 dollars (ENR CCI 9180). The estimated capital cost is approximately $207 million. The estimated additional annual O&M cost of the improvements is approximately $9.3 million, the majority of which is for expanded solids handling.

Table 12-17 Blue River WWTP Improvement Costs

Improvement	Construction Cost (million $)	Annual O&M Cost (million $)
50-MGD HRT/disinfection at Blue River WWTP	$45.93	$2.28
Expand solids handling at Blue River WWTP	$161.03	$7.04
Total	**$206.96**	**$9.32**

*all costs in 2008 dollars (ENR 9180)

12.6.10 Westside WWTP

Plan improvements at the Westside WWTP include construction of a 64-MGD, HRT/disinfection facility. Wet-weather flows exceeding primary- and secondary-treatment capacity will be diverted from the WWTP influent for HRT. The diversion will occur from influent piping downstream of the junction of the Santa Fe and Turkey Creek force mains. All dry weather flows and up to 40 MGD of wet-weather influent will be treated by the existing Westside WWTP.

Automated flow control valves and flow meters placed on both the WWTP influent line downstream of the intercept point and on the wet-weather treatment train force main will be connected to the WWTP control system. Control logic will divert influent flows above 40 MGD to the HRT/disinfection facility.

The HRT facility includes grit removal, fine screening, high rate clarification, and disinfection. HRT facility effluent will combine with WWTP effluent. Final effluent will continue to discharge to the Missouri River. A new effluent pump station will discharge at a firm capacity of 104 MGD during high river stages. Additional improvement details are presented in the *Joint Use Facilities Expansion Capabilities Technical Memorandum;* OCP; September 2008.

Estimated capital and additional annual O&M costs for presently anticipated improvements at the Westside WWTP are shown in Table 12-14, in 2008 dollars (ENR CCI 9180). The estimated capital cost is approximately $61 million. The estimated additional annual O&M cost of the improvements is approximately $1.8 million.

Table 12-18 Westside WWTP Improvement Costs

Improvement	Capital Cost (million $)	Annual O&M Cost (million $)
Construct 64 mgd HRT/disinfection at Westside WWTP	$61.42	$1.81
Total	**$61.42**	**$1.81**

*all costs in 2008 dollars (ENR 9180)

It is anticipated that improvements at the Westside WWTP will be constructed in two phases. The first phase (HRT/disinfection facility capacity of 32 MGD and all planned grit removal and fine screening) would be constructed after reconstruction of the Turkey Creek Pumping Station and installation of in-line storage gates in the OK Creek sewer. Completion of the second phase would be needed concurrent with completion of the deep-storage tunnel and associated pumping station in the Turkey Creek Basin.

12.6.11 Summary of Plan Improvements in the CSS Basins

Table 12-19 summarizes the modeled performance and estimated costs of the CSO controls by basin.

The Plan for the CSS is structured to eliminate, or capture for treatment, approximately 88 percent of the total wet-weather flow in the City's CSS. That removal will result from a combination of green solutions and source controls with conventional structural controls at or upstream of combined sewer outfalls. The portion of capture attributable to green solutions and source controls will be determined in the future, as such solutions are implemented, monitored, and analyzed. The estimated total cost for the CSS Plan is approximately $1.4 billion.

Table 12-19 Performance and Cost Summary for Recommended CSO Controls by Basin

Basin	Typical Year Wet Weather Flow (billion gallons)	Existing Overflow Volume (billion gallons)	Plan Complete Overflow Volume (billion gallons)	Plan Complete Capture of Wet Weather Flow (%)	Estimated Capital Cost ($Million)
MISSOURI RIVER CSS BASINS					
Downtown Airport	Data not Available				$17.28
Turkey Creek/Central Industrial District	2.987	2.659	0.574	81%	$226.99
Northeast Industrial District	1.119	0.886	0.462	59%	$5.19
Subtotal, Missouri River Basins	**4.105**	**3.545**	**1.035**	**75%**	**$249.47**
BLUE RIVER CSS BASINS					
Town Fork Creek	0.880	0.341	0.037	96%	$160.02
Brush Creek	1.830	1.456	0.022	99%	$462.51
Subtotal, Brush Creek CSS Basins	**2.710**	**1.797**	**0.059**	**98%**	**$622.53**
Gooseneck Creek	1.019	0.676	0.238	N/A	$10.25
Lower Blue River	0.622	0.211	0.076	N/A	$29.65
Middle Blue River	0.623	0.149	0.049	92%	$81.02
Subtotal, All Blue River CSS Basins	**4.974**	**2.832**	**0.423**	**91%**	**$743.46**
Blue River WWTP HRT	N/A	N/A	N/A	N/A	$45.93
Blue River WWTP Solids Handling	N/A	N/A	N/A	N/A	$161.03
Westside WWTP HRT	N/A	N/A	N/A	N/A	$61.42
SSS Wet Weather from 87th Street	2.065	N/A	N/A	N/A	N/A
SSS Wet Weather from Round Grove	0.499	N/A	N/A	N/A	N/A
Subtotal, SSS Inflows to BRIS	**2.564**	N/A	N/A	N/A	N/A
CITY-WIDE TOTALS	***11.64***	***6.38***	***1.46***	***88%***	***$1,261.31***
Blue River Basins Capture				***94%***	
Neighborhood Sewers in CSS Basins					***$124.00***
Estimated Total Capital Cost for Combined Sewer System Basins					***$1,385.31***

12.7 Summary of Estimated Plan Costs

Table 12-20 presents a summary of the estimated capital and additional annual O&M costs for the Plan. The table categorizes programmatic, SSS, and CSS improvement costs. All costs are expressed in mid-2008 dollars (ENR CCI 9180). The estimated capital cost for individual Plan components shown in Table 12-20 vary slightly from those presented in previous tables herein. Approximately 1.5 percent of the capital cost estimates in the earlier tables were for public outreach and education (0.5 percent) and enhanced modeling and monitoring (1.0 percent), which are separately reported as defined Plan expenditures in Table 12-20. The estimated overall capital cost for the Plan is approximately $2.4 billion, in 2008 dollars (ENR Construction Cost Index = 9180). The estimated additional O&M costs for plan elements total approximately $33 million per year.

Cost opinions and projections prepared for the Plan are based principally on standardized cost guidance developed from review of actual and/or estimated costs from other similar planning efforts documented in *Basis of Cost Manual*; OCP; January 2007. As indicated in that reference, the cost for individual components and types of projects can vary significantly for any given project type or capacity.

Table 12-20 Summary of Estimated Plan Costs

Project Description	Estimated Capital Cost ($Million)	Additional O&M Cost ($Million/Yr)	Project Type
Programmatic Elements			
Public Education and Outreach	$12.00	$0.00	Program Initiatives
Enhanced Monitoring and Modeling	24.00	1.00	Program Initiatives
Green Collar Jobs and Workforce Development	5.00	0.00	Program Initiatives
Rain Gardens and Downspout Disconnects	5.00	0.00	Program Initiatives
Blue River Watershed Management Plan	2.00	0.00	Program Initiatives
Subtotal, Programmatic Elements	**$48.00**	**$1.00**	**All**
Separate Sanitary Sewer System			
Round Grove Pumping Station Second Force Main	$1.60	$0.02	Increase System Capacity
Line Creek Temporary High Rate Treatment	36.61	0.53	Increase System Capacity
I/I Reduction (basins south of Mo. River)	85.99	0.00	System Rehabilitation
I/I Reduction (basins north of Mo. River)	85.66	0.00	System Rehabilitation
Upgrade Birmingham Pump Station	24.00	0.88	Increase System Capacity
Birmingham Force Main	4.00	0.02	Increase System Capacity
87th Street Pump Station Storage	265.04	1.13	Storage Projects
North Bank Tunnel System & Pumping Station	370.99	1.78	Storage Projects
Birmingham WWTP High Rate Treatment	43.98	2.26	Increase System Capacity
Round Grove Pumping Station & Relief Sewers	11.17	0.03	Increase System Capacity
Line/Rock Creek Relief Sewers	13.18	0.00	Increase System Capacity
Shoal Creek Relief Sewers	0.22	0.00	Increase System Capacity
Subtotal, Separate Sanitary Sewer System	**$942.44**	**$6.65**	**All**
Combined Sewer System			
Green Infrastructure Pilots and Partnerships	$28.00	$1.40	Green Infrastructure
Neighborhood Sewers Rehabilitation	122.18	0.00	System Rehabilitation
Operable Gates in OK Creek Culvert	4.43	0.02	Storage Projects
Turkey Creek Pumping Station & Force Main	24.31	0.58	Increase System Capacity
Separation at Milwaukee/Chouteau Outfall	5.11	0.00	Separation Projects
CID In-Line Storage	2.16	0.01	Storage Projects
Brush Creek Tunnel and Pump Station	270.15	2.94	Storage Projects
200-mgd High Rate Treatment for Brush Creek	163.36	4.50	Increase System Capacity
Town Fork Tunnel	122.07	1.23	Storage Projects
High Rate Treatment at Blue River WWTP	45.25	2.28	Increase System Capacity
Blue River WWTP Solids Handling	158.66	7.04	Increase System Capacity
Sewer Separation, 53rd & Waldron	11.82	0.09	Separation Projects
Sewer Separation, 55th & College	5.67	0.04	Separation Projects
OK Creek Tunnel & Pump Station	183.42	1.17	Storage Projects
High Rate Treatment at Westside WWTP	60.52	1.81	Increase System Capacity
Sewer Separation, 84th & Brookside	24.68	0.09	Separation Projects
Consolidation Piping, Gregory & Cleveland	5.43	0.06	Outfall Consolidation Piping
Sewer Separation, Gregory & Prospect	4.26	0.00	Separation Projects
Sewer Separation, 40th & Monroe	17.24	0.00	Separation Projects
Sewer Separation, 17th & Topping	3.17	0.00	Separation Projects
Gooseneck Creek In-Line Storage	10.10	0.13	Storage Projects
Distributed Storage, Outfalls 059 and 069	40.00	2.00	Green Infrastructure
Sewer Separation, 31st & Broadway	9.33	0.00	Separation Projects
Town Fork Creek Basin Consolidation Piping	15.62	0.00	Outfall Consolidation Piping
Sewer Separation, 47th & State Line	5.33	0.00	Separation Projects
Sewer Separation, Downtown Airport	17.03	0.04	Separation Projects
Brush Creek Basin Consolidation Piping	14.37	0.00	Outfall Consolidation Piping
Relief Sewers in Lower Blue River Basin	8.80	0.00	Increase System Capacity
Relief Sewers in Middle Blue River Basin	5.43	0.00	Increase System Capacity
Other Small Existing System Improvements	5.05	0.00	Increase System Capacity
Subtotal, Combined Sewer System	**$1,392.93**	**$25.44**	**All**
TOTAL ESTIMATED COST	**$2,383.37**	**$33.09**	

Detailed estimates of project cost will be prepared as a normal part of the design process, as individual projects are implemented, and records maintained of final constructed costs for each project are compared to the budget estimates (adjusted for inflation and construction cost escalation) contained herein.

Cost opinions and projections prepared by WSD and its engineering consultants relating to construction costs and schedules, O&M costs, equipment characteristics and performance, and operating results are based on their experience, qualifications, and judgment as design professionals. Since neither WSD nor its engineering consultants has control over weather, cost and availability of labor, material and equipment, labor productivity, construction contractors' procedures and methods, unavoidable delays, construction contractors' methods of determining prices, economic conditions, competitive bidding or market conditions, and other factors affecting such cost opinions or projections, WSD and its engineering consultants do not guarantee that actual rates, costs, performance, schedules, and related items will not vary from cost opinions and projections prepared for the Plan.

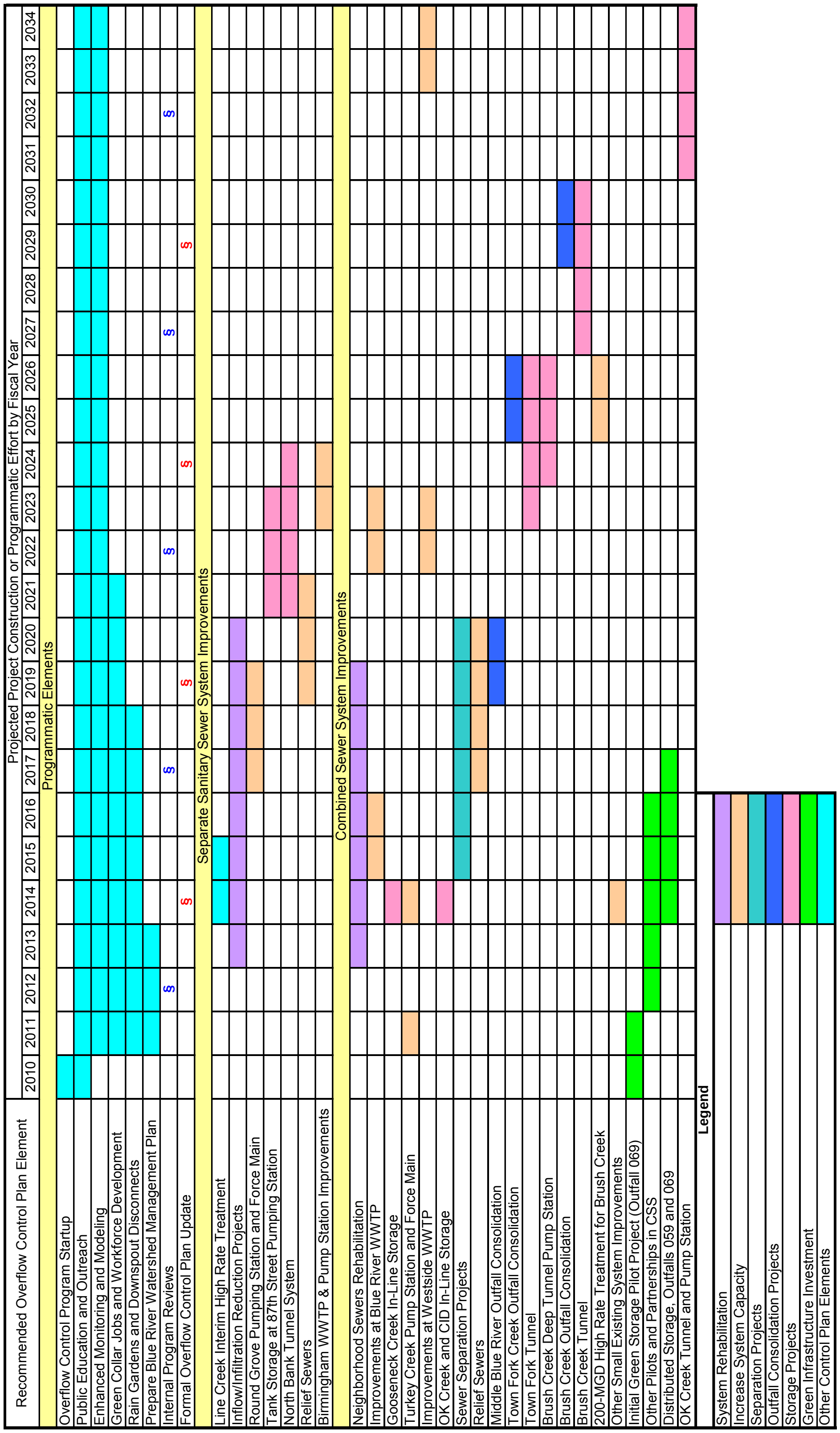
12.8 Preliminary Implementation Schedule

A preliminary construction schedule for major Plan components is summarized in Figure 12-13. Plan improvements will be completed in the shortest practicable time consistent with the City's financial capability and other factors. Additional discussion of the City's financial capability, available revenues, and other necessary wastewater utility expenditures, and their impact on possible Plan implementation schedules, is included in Chapter 11. Implementation of the Plan will be primarily controlled by the availability of funds to construct, operate, and maintain the proposed facilities. Projecting the availability of funds literally decades into the future introduces a number of uncertainties, including but not limited to:

- Voters' willingness to approve the issuance of revenue bonds.
- Financial market health and the cost of capital.
- The degree to which construction cost escalation parallels general rates of price inflation.
- The extent to which other sources of funding, such as federal and state grants or cost-sharing, become available.
- The degree to which growth in the City's median household income parallels general rates of price inflation.
- Future changes in the general economic health and posture of the City.
- Gains or losses in service area population over time.
- Future regulatory changes requiring projects that might compete with the Plan for available funds, or further increase performance objectives and/or requirements.

The above uncertainties are in addition to those inherent in the basic planning process (such as accuracy of cost estimates, as discussed above, and actual vs. modeled facility performance).

Figure 12-13 Preliminary Implementation Schedule



The financial projections discussed in Chapter 11 suggest that between 25 and 33 years will be needed to complete construction of the Plan and other presently identified wastewater utility capital needs. Each of those projections is predicated upon acceptance of a heavy financial burden by the City and its ratepayers. Achieving an overall completion at the lower end of that range (consistent with the preliminary schedule presented in Figure 12-13) is expected to require the identification of additional revenues (other than those from presently projected user rate increases considered in those projections) sufficient to comply with other new regulatory requirements and other wastewater utility capital improvement needs.

WSD revenues must significantly increase prior to any commitment for construction of major structural controls. The preliminary schedule shown in Figure 12-13 emphasizes completion of less expensive plan elements while revenues are increased over time. For both the SSS and the CSS, the proposed construction sequence provides the minimum time frame for completion and evaluation of source reduction efforts, including green solutions, prior to final design and construction of major structural components.

In the SSS, approximately one-half of the proposed I/I reduction efforts will be complete prior to the initiation of design on the major structural components (principally the North Bank Tunnel system and tank storage at the 87th Street Pump Station). Completing that much I/I rehabilitation is expected to be adequate to confirm the extent to which the completed work meets expectations for overall removal of stormwater from the system. That information will permit an informed adjustment to remaining I/I reduction work and/or principal structural controls necessary to attain the design objective.

In the CSS, completion of major structural components is scheduled to closely follow completion of major SSS Plan components. The neighborhood sewer improvements in the CSS, sewer separation projects, and relief sewers are scheduled concurrent with major planned expenditures in the SSS. The preliminary schedule provides an opportunity to incorporate the monitored and evaluated results of those efforts and parallel green solutions (and other source controls) into the final design and construction of major CSO controls.

12.9 Compliance with Water Quality Standards in CSO Receiving Streams

Water quality modeling tools were developed and calibrated using receiving water quality monitoring data collected by WSD, its Overflow Control Program (OCP), and the United States Geological Survey (USGS). The one-dimensional modeling framework addresses major KCMO waters that receive CSS discharges and utilizes the USGS “Full Equations” (FEQ) model for its hydraulic component and the USEPA “Water Quality Simulation Program-Version 5” (WASP5) model for its water quality component. Calibration of the hydraulic and water quality modeling tools for the Blue River, Brush Creek, Penn Valley Lake, and Missouri River is discussed in Chapter 6. Chapter 6 also discusses application of the modeling tools to simulate existing conditions.

The level of CSO control represented by the Plan was simulated with the water quality models and was compared to a simulation of the existing conditions. The model application simulates the expected loadings from a number of sources, including: upstream, CSS, separate stormwater, WWTPs, and wet-weather, HRT facilities.

For simulations of the Plan, existing upstream loadings were based on data at the upstream boundaries of the models. CSS loadings for the final alternative were based on XP-SWMM model results for each outfall and for HRTs in the CSS. Hydrographs for separate stormwater areas located in the Blue River and Brush Creek Basins were developed based on the Hydrologic Simulation Program – FORTRAN (HSPF) watershed model. The modeling includes a “first flush” effect for the first hour of separate stormwater discharges. The inclusion of a first flush for separate stormwater was based on an assessment of the monitoring results showing the concentrations in the first hour of stormwater flow are significantly higher than those in subsequent hours. Daily average and wet-weather loadings from WWTPs were developed for the Westside, Blue River, and Birmingham WWTPs, as well as the Kansas City, Kansas KAW Point WWTP. The concentrations of simulated water quality parameters used for the CSS, separate stormwater, and WWTP sources were the same as those used during model calibration and simulation of existing conditions. Simulations of the Plan were also conducted representing disinfection of WWTP, wet-weather bypass, and HRT effluents, assuming *E. coli* concentrations of 126 #/100ml in the disinfected discharge. A disinfected effluent *E. coli* concentration of 126 #/100ml was chosen as it is within the expected range of the performance of disinfection technologies and it results in compliance with the most stringent in-stream criterion at the end-of-pipe.

Those “Plan complete” water quality analyses are discussed in more detail in *Receiving Water Quality Modeling of LTCP Final Alternative*; OCP; January 2009. The results of those analyses for *E. coli* concentrations are summarized in Table 12-21.

Reductions in the *E. coli* geomean concentration during a typical-year recreation season are predicted upon completion of the Plan at most downstream locations, without disinfection of HRT and WWTP effluent. The only exceptions are the Blue River location at the mouth of the Missouri River and Penn Valley Lake. The Blue River location at the mouth is predicted to have an increase in the geomean from 740 to 780 #/100 ml. This is a result of increased transport of CSS flow to the Blue River WWTP and wet-weather discharges into the Blue River through the secondary bypass and HRT. Given the planned disinfection of the secondary bypass and HRT facilities, the mouth of the Blue River is predicted to experience a decrease to 597 #/100ml. Penn Valley Lake is expected to have an increase from 140 to 165 #/100ml. This is due to more frequent and greater volume of separate stormwater runoff to Penn Valley Lake as a result of separation of the sewer system in that area. The impact of that separation may be lessened or potentially eliminated with implementation of green solutions in and/or downstream of the newly separated area.

Table 12-21 *E. coli* Geomean Comparison at Key Locations

Water Body	Key Location Description	Geomean Criterion[1] (#/100ml)	Geomean Predicted for Existing Conditions	Geomean Predicted for Final Alternative	Geomean Predicted for Final Alternative with Disinfection	Geomean Predicted for Final Alternative with Disinfection and Reduction in Upstream Loads
Blue River	Bannister Road	126	619	619	619	143
	Upstream of Brush Creek	206	571	569	569	157
	Downstream of Brush Creek		595	591	559	162
	Mouth at Missouri River		740	780	597	236
Brush Creek	Ward Parkway	n/a	782	782	782	243
	Upstream of Lake of the Enshriners		426	382	382	233
	Downstream of Lake of the Enshriners		413	329	327	258
Penn Valley Lake	Penn Valley Lake outlet	n/a	140	165	165	165
Missouri River	Upstream of Kansas River	206	638	638	638	205
	Downstream of Kansas River		811	804	724	302
	Upstream of Blue River		860	844	675	371
	Downstream of Blue River		876	859	674	384
	Waverly, MO		588	583	425	308
Kansas River	Upstream of Turkey Creek CSS discharge	262	506	506	506	152
	Downstream of Turkey Creek CSS discharge		567	487	487	155

[1]Represents the numeric criterion for the most stringent beneficial use: 126 for WBC Class A, 206 for WBC Class B, and 262 for the Kansas PCR Class B use. An "n/a" entry indicates that the water body is currently unclassified and therefore is not subject to the Missouri standards.

Applying disinfection to the WWTP and HRT effluents is expected to reduce *E. coli* concentrations in the Blue River downstream of Brush Creek (geomean of 559 #/100ml) and at the mouth (geomean of 597 #/100ml). Disinfection is also predicted to reduce *E. coli* concentrations in the Missouri River. Disinfection of HRT effluent is included in the Plan. Disinfection of WWTP effluent is the subject of additional regulatory requirements promulgated by MDNR (see Chapter 11).

The geomean concentrations at the upstream boundary are shown to be a significant impact. The Plan was simulated to examine the water quality benefits of the final alternative if upstream *E. coli* loads were reduced to a level that would meet the applicable criteria. These results are shown in the far right column of Table 12-21. Based on the modeling results, reductions in bacteria concentrations at upstream boundaries would have a significant impact on *E. coli* geomeans in the receiving waters.

The USEPA's CSO Control Policy offers two approaches ("Presumptive" and "Demonstration") for development and implementation of an overflow control plan, each with an overall objective to meet water quality standards and protect existing and designated uses.

For the Missouri River, the Plan is based on the Presumptive approach, which requires (as one possible criterion) the elimination, or capture for treatment, of no less than 85 percent, by volume, of the combined sewage collected in the CSS during precipitation events on a system-wide, annual average basis. The Plan design to capture approximately 88 percent clearly meets this criterion.

For the Blue River, the Plan is based on the Demonstration approach. Analyses prepared for this Plan show that:

- Current water quality standards for bacteria in the Blue River cannot be met, even if CSOs are completely eliminated, as a result of bacteria loading from sources upstream of the CSS, and in separate stormwater runoff reaching the CSO receiving streams.
- Overflows remaining after implementation of the Plan will not prevent the attainment of water quality standards in the Blue River.
- The Plan will achieve the maximum pollution reduction benefits reasonably attainable for the Blue River.
- CSO controls in the Blue River Basin are structured and will be designed to allow cost-effective expansion if additional controls are subsequently determined to be necessary to meet water quality standards, including protection of designated uses.

Reduction of bacteria loads in the Blue River from sources upstream of the CSS and in separate stormwater runoff is expected to be one objective of the Blue River Watershed Management Plan.

* * * * *

13 POST CONSTRUCTION MONITORING PLAN

The post-construction monitoring plan (PCMP) describes current plans to monitor and measure the effectiveness of the Overflow Control Plan (the Plan) through the collection of flow and pollutant parameter data throughout Plan implementation before, during, and after completion of individual Plan components.

13.1 Introduction

The PCMP will provide the data necessary to assess and document the extent to which the performance measures identified in the selected Plan (see Chapter 12) are being met. The PCMP will also evaluate any improvements in receiving water quality that result from Plan implementation.

The PCMP includes features to enable the City's Water Services Department (WSD) to:

- Measure the effectiveness of green solutions projects in the combined sewer system (CSS).
- Measure the effectiveness of infiltration and inflow (I/I) reduction efforts, including private inflow source reduction projects in the separate sanitary sewer (SSS) area.
- Measure the performance of the High-Rate Treatment (HRT) facilities in treating wet weather flows
- Measure the effectiveness small-sewer rehabilitation projects in the CSS.
- Measure the effectiveness of the overall Plan in meeting wet weather management objectives.
- Update and enhance collection system and receiving water computer models with a view toward improving and optimizing facilities operations, and enhancing design criteria for subsequent major facilities, consistent with the adaptive management process central to the Plan.
- Provide information to educate the public on the need for implementation of wet weather solutions, and the progress made in achieving program objectives.

The PCMP will be the mechanism by which data will be collected to assess and document the performance of the Plan as implementation proceeds, and will provide necessary information for the adaptive management of Plan implementation based on results observed and other lessons learned.

Previous chapters documented that decreasing the volume, frequency, and duration of CSOs and SSOs alone would not result in achievement of the goals and objectives of the Wet Weather Solutions Program, or the applicable regulatory requirements. This outcome was projected because the quality of water in the receiving waters within the City is greatly affected by the flow volume and bacterial levels in discharges from upstream sources. CSOs from the City contribute only approximately 3 percent of the total *E. coli* bacteria in the Missouri River immediately downstream from its confluence with the Blue River. CSOs from the City contribute approximately 39 percent of the total *E. coli* bacteria in the Blue River; therefore, approximately 61 percent of the total *E. coli* bacteria in the Blue River are attributable to sources other than the City's CSOs. Water quality modeling to date reveals that compliance with current State of Missouri water quality standards would require substantial reductions in bacteria loads originating from upstream sources and areas within the City not served by the CSS, in addition to implementation of the Plan.

The Plan further indicates that a watershed approach is needed, and includes a commitment to the preparation of the Blue River Watershed Management Plan described in Chapter 12. A watershed approach will blend together wet weather overflow control measures with management practices and programmatic initiatives designed to control stormwater runoff from SSS areas in and upstream of the City tributary to the Blue River. Programmatic initiatives would include continued review and possible revisions of City standards and policies to require and encourage development practices having lower impacts on stormwater generation and water quality, greater sustainability, and greater emphasis on use of green features.

The general approach of the PCMP will be to perform monitoring and sampling throughout Plan implementation at many of the monitoring stations identified and used during the development of the Plan, and at additional selected locations to compile the data necessary to support the development of a watershed management plan. The use of these locations will enable comparison of post-construction conditions with baseline conditions determined during the development of the Plan.

Short-term monitoring of approximately one- to two-years' duration before and after project completion and activation will be performed to measure and evaluate the performance of green solutions, programmatic elements, and sewer system improvements for the reduction of wet weather flow volumes and peak flow rates. Green solutions will include demonstration projects and green solutions in support of sewer separation projects. Programmatic elements will include private inflow source reduction. Sewer system improvements include I/I reduction projects in the SSS basins, relief sewer construction in the SSS basins, small-sewer rehabilitation projects in the CSS basins, and sewer separation projects in the CSS basins.

Long-term monitoring of the performance of major constructed facilities will be initiated upon the substantial completion of construction and activation of such facilities. Major constructed facilities include pumping station improvements, wet weather storage tanks and conveyance/storage tunnels, expansions and upgrades of existing wastewater treatment plants (WWTP), and new high-rate treatment facilities planned for the CSS basins. Long-term monitoring of water quality in the receiving streams will be performed in accordance with the Water Quality Monitoring Plan (WQMP) described below.

Given the dynamic nature of assessment of water quality standards and evolution of regulations, during the course of the PCMP the data collected will be periodically evaluated for the extent to which it serves

WSD's needs for documentation of Plan performance and adaptive management of remaining Plan components. Based on such evaluations WSD will propose modifications of the PCMP to the regulatory agencies, and will make such modifications to the PCMP as have been accepted by the regulatory agencies. Modifications may include addition, elimination, or relocation of monitoring stations; addition or elimination of pollutant parameters; modification of data collection techniques; and modification of data evaluation methods.

13.2 Water Quality Monitoring Plan (WQMP)

Monitoring locations for receiving waters will include sites used during the development of the Plan, standing WSD water quality sampling sites, and three additional sites on Indian Creek, Blue River, and Mill Creek. Table 13-1 provides a summary of site identification number, receiving water, and reasons for the selection of the monitoring site. Figure 13-1 shows the monitoring locations.

The monitoring plan will focus on water quality parameters related to potential concerns from CSO discharges and upstream pollutant sources as follows:

- Human illness from exposure to human pathogens, as measured by indicator bacteria, notably *E. coli*
- Support of aquatic life as measured by dissolved oxygen concentrations
- Aesthetics as measured by observations of floatables, debris, odor, and nuisance algal blooms

The major objectives of the monitoring plan are:

- Characterization of existing water quality conditions prior to the development and implementation of wet weather controls as part of the Plan.
- Measurement of changes in water quality during and after implementation of wet weather controls.
- Measurement and documentation of parameters related to the potential for recreational use of the waters and compliance with applicable water quality standards.

Field measurements and collection of water quality samples will be conducted at the recommended sites on a bi-weekly basis throughout the April 1 – October 31 recreation season. Monitoring will be conducted at approximately the same time of day, on the same day of the week, at each location, to obtain an appropriate representation of storm event and non-event conditions. Monitoring will not be delayed because of weather except for safety reasons. The monitoring frequency will provide data sufficient to calculate a geometric mean *E. coli* concentration over the recreation season for comparison to water quality standards and for tracking long-term trends.

Field measurements recorded at each site will consist of temperature, pH, conductivity, and dissolved oxygen. Field observations will be recorded for floating debris, submerged debris, algal growth, odor, and recreational use. Samples will be collected and analyzed for *E. coli*, and total suspended solids. Monitoring activities will be conducted in accordance with the OCP's Quality Assurance Project Plan (*OCP Water Quality Monitoring Quality Assurance Project Plan*; LimnoTech; April 14, 2005).

Table 13-1 Receiving Water Monitoring Locations

Site Identifier	Location Description	Rationale for Selection
BC-1	Brush Creek at Belinder St., KS	Characterize upstream water quality
BC-2	Brush Creek at Ward Parkway	Characterize water quality at state line
BC-3	Brush Creek at Rockwell Lane	Characterize impact of CSO and storm water loads
BC-4	Brush Creek at Broadway Street	Characterize impact of CSO and storm water loads
BC-5	Brush Creek at Rockhill Road	Characterize impact of CSO and storm water loads
BC-6	Brush Creek at Prospect Avenue	Characterize impact of CSO and storm water loads
BC-7	Brush Creek at Elmwood Avenue	Characterize cumulative impacts to Brush Creek
TF-1	Town Fork Creek at 51st Street	Characterize loads from Town Fork Creek
BR-1	Blue River at Bannister Road	Characterize conditions upstream of all Kansas City, Missouri CSOs
BR-2	Blue River at Hickman Mills Dr.	Characterize impact of CSO, storm water, and small tributary loads to Blue River
BR-3	Blue River at Gregory Blvd	Characterize impact of CSO, storm water, and small tributary loads to Blue River
BR-4	Blue River at Blue Parkway	Characterize impact of CSO, storm water, and small tributary loads to Blue River upstream of Brush Creek
BR-5	Blue River at Stadium Drive	Characterize impact of CSO, storm water, and small tributary loads to Blue River
BR-6	Blue River at 23rd Street	Characterize impact of CSO, storm water, and small tributary loads to Blue River
BR-7	Blue River at 12th Street	Characterize impact of CSO, storm water, and small tributary loads to Blue River
BR-8	Blue River at train bridge upstream of I-435	Characterize cumulative impacts to Blue River
BR-9	Blue River south of Kenneth Drive, and west of Missouri-Kansas border	Characterize pollutant loads from Johnson County, KS
PV-1	Penn Valley Lake at outlet	Characterize conditions in Penn Valley Lake
MC-1	Mill Creek south of Kenneth Drive, and north of border between Jackson County and Cass County	Characterize Mill Creek pollutant loads tributary to the Blue River
IC-1	Indian Creek north of US Highway 435 in the vicinity of 103rd Street, and west of Missouri-Kansas border	Characterize pollutant loads from Johnson County, KS

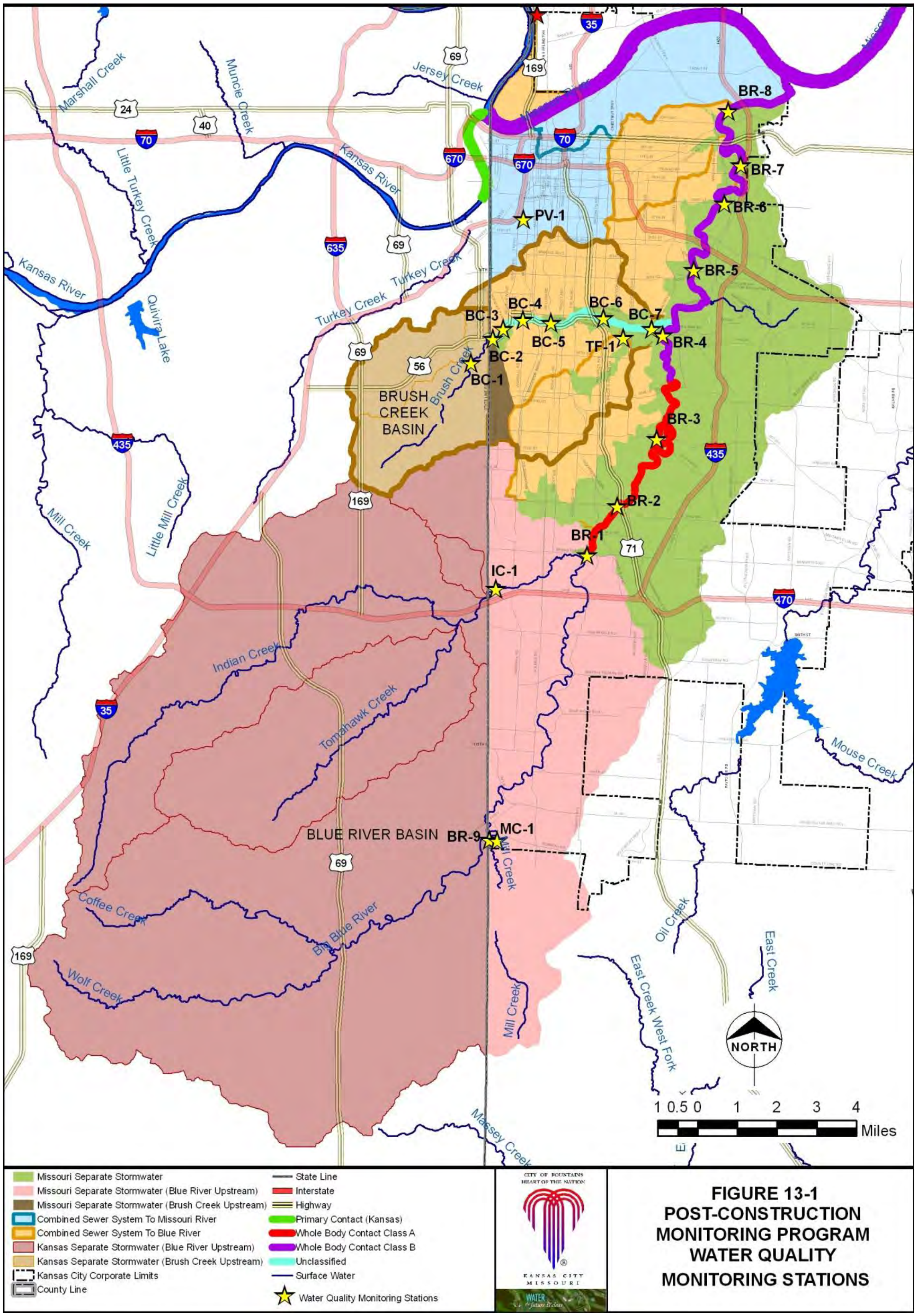


FIGURE 13-1
POST-CONSTRUCTION
MONITORING PROGRAM
WATER QUALITY
MONITORING STATIONS

13.3 PCMP for CSO Controls and Major Wet Weather Facilities

The following sections describe the PCMP for CSO controls and major wet weather facilities included in the Plan; estimated costs for these actions (as well as expanded receiving stream monitoring described above) are included in the overall estimates of Plan costs presented in Chapter 12. This PCMP will augment WSD's existing (and, in some cases, expanded) wastewater system monitoring.

13.3.1 Evaluation of Effectiveness of Green Solutions

Monitoring of green solutions will be performed to evaluate their effectiveness in reducing wet weather overflows in the CSS. Specific details for monitoring of green solutions will be developed in conjunction with the planning and implementation of individual projects. This monitoring is expected to be highly project-specific and relatively short term in nature.

13.3.2 Effectiveness of Sewer System Improvements and Small-Sewer Rehabilitation Projects

Flow metering will be performed as part of sewer system improvements and small-sewer rehabilitation projects to evaluate flow reduction effectiveness. Sewer system improvements and small-sewer rehabilitation projects consist of I/I reduction in the SSS area, private inflow source reduction, and sewer separation and small-sewer rehabilitation projects in the CSS area.

Specific details for monitoring programs will be developed as part of the planning for sewer system improvements and small-sewer rehabilitation projects. This monitoring is expected to be highly project-specific and relatively short term in nature.

13.3.3 Line Creek High-Rate Treatment Facility

The operation and performance of the interim 30-MGD, HRT pilot facility to be located at the constructed SSO near the Line Creek Pumping Station will be monitored. This interim facility will reduce discharges from this constructed SSO during the early stages of the wet weather program. The HRT will also serve as a large-scale pilot facility. In this capacity, the HRT will enable WSD to gain experience in operating and maintaining an HRT facility, and operating and performance data will be collected. The collected operating and performance data will be used to support the design of permanent HRT facilities planned for construction at the Birmingham WWTP, the Brush Creek and Town Fork Creek basins, and the Blue River WWTP.

A detailed sampling plan to guide this effort will be prepared as the specific features of the HRT become better known during subsequent design efforts.

13.3.4 CSS, CSO Outfalls, and Major Wet Weather Facilities

Data collected through flow monitoring of selected CSO outfalls, selected collection system locations, and major wet weather facilities, such as pumping station improvements, in-line storage facilities, storage tanks, and conveyance/storage tunnels, will enable determination of the level of control achieved as Plan implementation progresses and will also support:

- Characterization of sewer flow data for evaluation of long-term collection system performance.
- Collection of information on overflows at critical CSS diversion structures.
- Collection of additional data, such as discharge rates at new pumping facilities and gate positions at the Blue River WWTP, which would assist in optimizing sewer system operations.
- Development of a database of flow data for use in future design efforts related to controlling both CSS and SSS overflows.
- Enhanced operation and maintenance actions to further control wet weather discharges and National Pollutant Discharge Elimination System (NPDES) permit compliance.

Table 13-2 presents the initially planned suite of flow monitoring locations for selected CSO outfalls and CSS collection system locations. The monitoring locations were selected with an emphasis on the CSS areas for evaluation of sewer system improvements, facilities performance, system operational characteristics, and dry-weather flows in the CSS areas. No reduction or relocation of sites listed in Table 13-2 will be made without prior consultation with MDNR and the USEPA.

Flow monitoring of the selected CSO outfalls and collection system locations listed in Table 13-2 will be performed throughout Plan implementation. Monitoring of each major constructed wet weather facility will commence upon the substantial completion of construction and activation of that facility.
A detailed monitoring plan for each of the following major wet weather facilities will be prepared approximately one year prior to the substantial completion of construction and activation of that facility:

- In the CSS:
  - Secondary bypass at Blue River WWTP.
  - HRT facility at Blue River WWTP.
  - HRT facility at the confluence of Brush Creek and the Blue River.
  - Deep tunnel pumping station at the lower end of the Brush Creek/Town Fork Creek CSO storage tunnel.
  - New outfall to Brush Creek at the intersection of the Brush Creek and Town Fork CSO storage tunnels (near existing CSO 030).
  - Deep tunnel pumping station at the lower end of the OK Creek CSO storage tunnel.
  - New outfall to the Kansas River at the lower end of the OK Creek CSO storage tunnel.
  - Reconstructed Turkey Creek Pumping Station.
  - In-line storage gates at the lower end of the existing OK Creek sewer.
  - In-line storage gates at the Santa Fe Pumping Station (CID storm sewers);

- In-line storage gates and new pumping station at the lower end of the Gooseneck Creek arch.

Table 13-2 CSS Flow Metering Sites

Project Area	Area Type	Site ID or Other Designation	Conduit Dimensions [inches or as shown]	Manhole Number	Comment
Middle Blue River					
Middle Blue River	CSS	BR056	15	S097-061	Measurement of flow to Blue River
Middle Blue River	CSS	BR059	6' x 6' box	S147-011	Measurement of Overflow
Middle Blue River	CSS	BR061	48	S097-005	Measurement of Overflow
Middle Blue River	CSS	BR062	12 dry weather line; 54 wet weather line	S106-032 (dry weather line); S106-034 (wet weather line)	Measurement of dry-weather line; and wet weather flow
Middle Blue River	CSS	BR063	60	To be determined	Measurement of Overflow
Middle Blue River	CSS	BR064	2' - 3" x 4' - 0" overflow	S122-206	Measurement of overflow
Middle Blue River	CSS	BR066	24 overflow	S148-039	Measurement of Overflow
Middle Blue River	CSS	BR067	96	S148-051	Measurement of Overflow
Middle Blue River	CSS	BR069	5' - 8" x 5' - 8" DB	S128-356	Measurement of Overflow
Brush Creek					
Brush Creek	CSS	BR008	72	S078-174	Stormwater separation
Brush Creek	CSS	BR026	48	S082-010	Provides Q from all Town Fork prior to discharge into BRIS.
Brush Creek	CSS	BR030	78	S082-053	Represents a large portion of the Brush Creek basin before discharge to the Blue River Interceptor Sewer (BRIS)
Brush Creek	CSS	BR017	88	S079-219	Diversion structure located in vicinity of Plaza,
Brush Creek	CSS	BR018	12'x6'	S079-640	Diversion structure located in vicinity of Plaza.
Brush Creek	CSS	BR021	24	S080-620	Diversion structure located in vicinity of Plaza.
Town Fork Creek					
Town Fork Creek	CSS	BR090	7' - 3" x 10' - 6" DB	S104-351	Major outfall
Town Fork Creek	CSS	BR090	36	S104-264	Represents a large portion of the Town Fork Creek basin.
Lower Blue River					
Lower Blue River	CSS	BR036	60	S048-800	Overflow at BRIS
Lower Blue River	CSS	BR037	24	S059-009	Overflow at BRIS
Lower Blue River	CSS	BR039	24	S059-001	Overflow to combined sewer outfall
Lower Blue River	CSS	BR040	72	S073-037	Overflow to Parrish Creek
Lower Blue River	CSS	BR054	30	S048-058	Downstream of sewer separation area
Lower Blue River	CSS	BR034	102	S035-431	At lower end of Basin within the BRIS
Lower Blue River	CSS	BR039	36	S058-077	Tributary area into BRIS at the midpoint of this basin.
Lower Blue River	CSS	BR037	96x98 egg	S082-166	At mid-point of BRIS from several upstream CSS basins.
Lower Blue River	CSS	BR055	33	S059-030	Overflow to Blue River
Lower Blue River	CSS	BR036	60	S048-120	BRIS overflow
Gooseneck Creek					
Gooseneck Creek	CSS	BR032	39 to 48	S024-209	Overflow to Blue River
Gooseneck Creek	CSS	BR033	64	S024-091	CSS Interceptors
Gooseneck Creek	CSS	BR033	NA	S024-087	BRIS overflow

(Cont'd. next page)

Table 13-2 (Cont'd) CSS Flow Metering Sites

Project Area	Area Type	Site ID or Other Designation	Conduit Dimensions [inches or as shown]	Manhole Number	Comment
Turkey Creek					
Turkey Creek/CID	CSS	W005	15'-8" x 15'	S053-127	CSS Interceptors
Turkey Creek/CID	CSS	W005	15'-8" x 15'	S053-127	CSS Interceptors
Turkey Creek/CID	CSS	W005	18' H x 17' W	S053-018Sa	Turkey Creek Pump Station overflow.
Turkey Creek/CID	CSS	W005	18' H x 17' W	S053-018Sa	Turkey Creek Pump Station overflow.
Turkey Creek/CID	CSS	W003	60	S029-811	Westside WWTP outfall
Turkey Creek/CID	CSS	W003	120	S029-820	Santa Fe Pump Station overflow
Turkey Creek/CID	CSS	W002	48	S029-058	Broadway Avenue outfall
Turkey Creek/CID	CSS	W006	24	S055-290	Upstream of Penn Valley Lake
NEID					
NEID	CSS	BR071	18	S028-035	Delaware St. outfall
NEID	CSS	BR072	78	S028-302	Main St. outfall
NEID	CSS	BR073	42	S028-954	Gillis Avenue outfall
NEID	CSS	BR074	72	S027-860	Lydia Avenue outfall
NEID	CSS	BR075	84	S009-017	Prospect Avenue pump station outfall
NEID	CSS	BR076	6' H x 8' W	S006-801	Milwaukee/Choteau outfall
NEID	CSS	BR077	52	S028-955	Holmes Avenue outfall
NEID	CSS	BR100	102 x 114 Horseshoe	S024-807	One of the bypasses at the Blue River WWTP influent box. Install at 1/3 points
NEID	CSS	BR031	42	S023-844	Near Blue River WWTP, overflow to Blue River

- In the SSS:
  - Storage tanks at the 87th Street Pumping Station.
  - Collection system and diverted flows at each downshaft to the North Bank Tunnel System.
  - Deep tunnel pumping station at the downstream end of the North Bank Tunnel System.
  - HRT facility at the Birmingham WWTP.

13.4 Other WSD Monitoring

The PCMP for CSO controls and other major wet weather facilities will augment WSD's existing wastewater system monitoring. In some cases, an expansion of the existing monitoring system is planned. Costs for expansion of the existing monitoring system is included in WSD's capital improvements program briefly summarized in Chapter 11; in some cases (as for metering flows received from satellite communities) costs may be recovered from or metering performed by the satellite communities under the terms of interjurisdictional agreements with those communities.

13.4.1 Satellite Communities

Flow meter data collected from satellite communities that contribute substantial discharges to the City's wastewater collection systems will be used in the assessment of the performance of the Plan and specific Plan elements, particularly I/I reduction initiatives and sewer system improvements in SSS basins.

At present, the majority of wastewater flows received from the following satellite communities is metered.

- City of North Kansas City, Missouri.
- City of Liberty, Missouri.
- Johnson County, Kansas Wastewater.

In addition, the majority of flows discharged from the City's collection system to the Little Blue Valley Sewer District (LBVSD) are metered by LBVSD. That meter data will also be used to assess performance of I/I reduction efforts in the SSS.

The existing interjurisdictional metering program will continue in the future. Adjustments or additions to flow meter locations will be negotiated with the various satellite communities at the time of contract renewal. It is anticipated that interjurisdictional meters will be added at:

- Significant points of inflow from the City of Gladstone. Gladstone discharges to the City's collection system at 32 locations. It is anticipated that meters will be added at not less than three of the more significant discharge points.
- The principal point of discharge from the City of Raytown to the City's collection system in the Round Grove Creek basin.
- In the Shoal Creek interceptor upstream and downstream of the City of Pleasant Valley.

13.4.2 Supervisory Control and Data Acquisition (SCADA)

The wastewater utility capital improvement program includes expansion and enhancement of the wastewater SCADA system. That expansion will emphasize control and data acquisition at the various existing pumping stations and at the WWTPs.

13.4.3 Flow Metering at Pumping Stations

The wastewater utility capital improvements program includes addition or significant improvement of flow metering capabilities at the following major pumping stations, all of which will provide key data for the long-term assessment of Plan and overall system performance:

- 87^{th} Street Pumping Station (discharges to the BRIS).
- Round Grove Pumping Station (discharges to the BRIS).
- Santa Fe Pumping Station (discharges to the Westside WWTP).
- NEID Pumping Station (discharges to the Blue River WWTP).
- Line Creek Pumping Station (discharges to both the Westside WWTP and the Hillside Bond Sewer in the Line Creek/Rock Creek basin).

- Buckeye Creek Pumping Station (discharges to the NEID interceptor).
- Birmingham Pumping Station (discharges to Birmingham WWTP).

13.5 Rainfall Monitoring

Rainfall monitoring is an essential component of the PCMP. Detailed analysis of precipitation data is necessary to fully evaluate performance of the Plan and specific project elements. Precipitation data of interest consist of total rainfall depth, duration, intensity, and event distribution.

Rainfall data will be compiled and analyzed as part of the PCMP. The source of rainfall data will be the City's ALERT flood warning system (FWS), which presently consists of 44 rain gauges spaced throughout the WSD service area. During the development, calibration, and verification of collection system computer models, WSD demonstrated that the ALERT FWS provides sufficient data in terms of quantity and quality for the purposes of a monitoring program. Rainfall data collected by the ALERT FWS will be used for analysis in connection with other post-construction, monitoring data.

13.6 Data Management

As part of the Plan, WSD has developed a Data Management System (DMS) and associated protocols for the storage, management, retrieval, and analysis of all data of importance in assessment of the performance of the City's collection system.

13.7 Quality Control

Quality control and quality assurance procedures and protocols prepared as part of the development of the Plan will continue to be used for the implementation of the PCMP. The relevant documents are:

- *Appendix A of Administration Manual;* OCP; 2005
- *Water Quality Monitoring Quality Assurance Project Plan*; OCP; April 14, 2005.

13.8 Analysis and Progress Reporting

Data from the PCMP will be used to evaluate the performance and effectiveness of the Plan and its various specific elements. That data will also be used to assess water quality in the receiving waters in and around the City by comparing newly collected information to baseline conditions prior to Plan implementation. Finally, the data from the PCMP will be used in the collection system and receiving water models to project post-construction conditions at locations not scheduled for monitoring under the PCMP.

The results and progress of the PCMP will be reported to the regulatory agencies in the OCP Annual Report. This progress report will include a summary of CSS basin performance to-date, consisting of:

- Status of Plan implementation.

- CSO and collection system sampling and flow monitoring data.
- Rainfall data.
- Receiving water monitoring results.
- Flow monitoring and sampling results for green solutions, programmatic elements, sewer system improvements, and pilot facilities.
- Flow monitoring and sampling results for major constructed facilities.
- Re-evaluation of collection system and receiving water computer models to confirm continued acceptable calibration. Necessary model modifications, re-calibration, and re-verification will be indicated and documented.
- Identification and documentation of deficiencies and performance limitations.
- Identification and documentation of proposed corrective measures.
- Plan of action for upcoming year.

* * * * *

14 FINAL PLAN

14.1 Overview

On January 30, 2009, the City of Kansas City, Missouri (the City; KCMO) completed its Overflow Control Plan (the Plan) and submitted the Plan to the United States Environmental Protection Agency (USEPA) and the Missouri Department of Natural Resources (MDNR). Subsequent to submittal of the Plan, the City, acting principally through its Water Services and Law Departments, continued negotiations with the USEPA and MDNR for the development of a Consent Decree under which the Plan would be implemented. Those negotiations were successfully concluded in April, 2010. On May 18, 2010 the United States submitted the proposed Consent Decree for lodging with the United States District Court for the Western District of Missouri, Western Division, styled as Civil Action No. 4:10-cv-0497-GAF.

On Sept. 27, 2010, following a public comment and review period, the Federal Court approved and entered the Consent Decree, a full copy of which may be found at the following website:

http://www.kcmo.org/idc/groups/public/documents/waterservices/consentdecree.pdf

The Court's order caps a multi-year effort by the City to obtain regulatory approval for a Long Term Control Plan (Plan) to control sewer overflows that is the right Plan for Kansas City. The Consent Decree describes the overflow control measures and performance criteria that must be implemented and achieved, respectively, for decreasing the frequency, volume, and duration of overflows from the City's combined sewer system (CSS) and separate sanitary sewer system (SSS).

The primary emphasis of the Consent Decree negotiations was on establishing an implementation schedule that completed all agreed-upon improvements at the earliest practicable date consistent with Kansas City's financial capability while retaining the original Plan's focus on reducing the problem before trying to finally solve it. While the majority of the technical components of the Plan (and their intended performance) were confirmed in the negotiations, certain modifications were made. This Chapter 14 summarizes Plan components reflected in the Consent Decree, which in some instances vary from those presented in Chapter 12 "Selected Plan", and as such represents the "Final Plan" to which the City is committed.

Significant changes from the Chapter 12 "Selected Plan" for this "Final Plan" include:

- In the SSS:
  - Elimination of the Interim High Rate Treatment (HRT) facility in the Line Creek/Rock Creek basin of the SSS; and

   - Phased implementation of storage at the 87th Street Pumping Station, with early completion of pumping station rehabilitation and an initial 20 million gallons (mg) of storage.
- In the CSS:
   - Additional structural controls at selected small outfalls in the Brush Creek, Town Fork Creek and Lower Blue River basins to reduce the frequency of "typical year" overflows;
   - Gooseneck Creek Basin and it two outfalls were combined into other CSS basins.
      - The extent of the Northeast Industrial District Basin was redefined to include the area tributary to Outfall 033 (Gooseneck Creek arch);
      - The extent of the Lower Blue River Basin was redefined to include the area tributary to Outfall 032 (a part of the Gooseneck Creek Basin as it was originally defined);
   - At the Westside Wastewater Treatment Plant (WWTP), the Selected Plan included an increased hydraulic capacity of 64 million gallons per day (mgd) through addition of HRT and disinfection facilities in two phases of approximately equal capacity. The Final Plan contemplates that the initial increase in hydraulic capacity at Westside (from 40 mgd to approximately 70 mgd) will be accomplished through structural and operational modifications directed at restoring the WWTP to its originally intended capacity. If the capacity increase cannot be realized, it will be necessary to submit a No Feasible Alternative analysis (reference 40 C.F.R. § 122.41(m)) to the agencies no later than the end of 2016. The final expansion (32 mgd HRT with disinfection) will not require a No Feasible Alternative submittal as the regulatory agencies concluded that the information submitted during negotiations was sufficient.

During the course of the negotiations, the regulatory agencies concluded that the information presented in the Plan, coupled with supplemented information developed and submitted during the negotiations, was sufficient to determine that no feasible alternative to the addition of HRT and diversion of primary treatment effluent to disinfection and discharge at the Blue River WWTP exists, and that the requirements of 40 C.F.R. § 122.41(m) had been met thereby.

However, the agencies could not reach a similar conclusion with respect to the planned addition of HRT at the Birmingham (SSS) WWTP. The City is required to submit a "no feasible alternative" analysis pursuant to 40 C.F.R. § 122.41(m) not less than one year prior to the proposed start date of that project. The resultant submittal date for the Birmingham WWTP is no later than the end of 2022.

In addition to implementation of this Overflow Control Plan, Section VII of the Consent Decree commits the City to implementation of additional sewer system remedial measures and programs. These additional sewer system remedial measures and programs are listed below, together with the specific location in the

Consent Decree in which they are more fully defined, but are not otherwise addressed in this Chapter 14 "Final Plan":

- Nine Minimum Controls (NMCs) Plan in the CSS, more fully described in Appendix B of the Consent Decree;
- Capacity, Management, Operation and Maintenance (CMOM) Plan, more fully described in Appendix C of the Consent Decree;
- Supplemental Environmental Project (SEP) Plan that includes the implementation of a Sewer Connection and Septic Tank Closure Program, more fully described in Appendix E of the Consent Decree; and
- Implementation of Disinfection Technology at each of the City's existing WWTPs, the schedule for which is more fully described in Appendix F of the Consent Decree.

The Consent Decree requirement for implementation of disinfection technology at the City's existing WWTPs represents a substantial investment, both in capital cost (approximately $100million at the time the Consent Decree was negotiated) and for ongoing operations and maintenance (approximately $1.7 million per year in 2008 dollars), that directly impacted and limited available funding for the Overflow Control Plan, particularly in its early years.

The Plan includes an adaptive management approach in which design, management, and monitoring are integrated to systematically test assumptions, learn from results, and adapt control measures throughout implementation. The adaptive management framework will be applied to the Plan on various levels. Adaptive management will be part of the overall programmatic approach, and will also be specifically applied at the basin and project levels. Data gathered throughout project implementation will provide opportunities for feedback that subsequently will provide for informed decision-making at the basin level and, ultimately, City-wide.

The Plan is structured to:

- Reduce the problem before trying to solve it by preventing as much stormwater as practicable from entering the CSS and SSS. This will be accomplished through implementation of both green solutions and conventional source controls early in the Plan implementation.
- Address flood protection needs, where practical, while reducing combined sewer overflows (CSO).
- Provide a programmatic platform to facilitate implementation of a comprehensive green solutions initiative across the City.
- Maximize use of the existing collection and treatment systems.

- Establish an adaptive approach to long-term plans for structural solutions so they can be modified to reflect the results and benefits of early efforts (green solutions and conventional source controls) on the responses of both the CSS and SSSs to rainfall events.

The Plan will:

- Reduce typical-year CSO volume from 6.4 billion gallons to approximately 1.4 billion gallons.
- Reduce infiltration and inflow (I/I) in the SSS.
- Provide adequate capacity to store, transport, and treat remaining wet-weather flows (as predicted by modeling) in the SSS.
- Reduce the frequency and severity of basement backups throughout the City.
- Cost approximately $2.5 billion (in 2008 dollars).
- Increase annual costs for operation and maintenance of the sewage collection and treatment system by approximately $31 million per year (in 2008 dollars).

14.2 Blue River Watershed Management Plan

The City's water quality monitoring data revealed that streams receiving CSO generally meet current water quality standards for most pollutant parameters. However, CSO receiving streams do not meet current state standards for bacteria. There are four primary sources of pollution in the streams that receive CSOs: stormwater runoff from upstream sources, stormwater runoff from both SSS areas adjacent to the streams and in the CSS areas, effluent from wastewater treatment plants (WWTP), and untreated wastewater in CSOs. Water quality would not meet state bacteria standards in the Missouri River and in a portion of the Blue River even if the City's CSOs are reduced (or even eliminated). Attainment of appropriate water quality standards in the Blue River requires that substantial reductions for each of the primary sources of pollution be achieved. A watershed approach is clearly needed to deliver meaningful improvements in water quality.

Although not required by the Consent Decree, the Plan includes the preparation of a watershed management plan (WMP) for the entire Blue River Basin. Strategies will be developed that acknowledge the interrelationship of water, land use, and human communities within the watershed. Resultant projects should produce multiple benefits.

The Blue River originates at the confluence of Wolf Creek and Coffee Creek and flows 41 river miles through the Kansas City metropolitan area to the Missouri River. Approximately 60 percent of the 270-square mile watershed is located in Kansas and the remaining 40 percent is in Missouri. Within the two states, the watershed covers parts of four counties, 13 local governments and 11 school districts. The major tributaries to the Blue River are Brush, Indian, Tomahawk, Wolf, and Coffee Creeks. Since problems and solutions cross political boundaries, the City will work with neighboring watershed communities to develop this WMP.

The WMP is intended to be multi-jurisdictional, bi-state, cost-effective, collaborative, and comprehensive. The WMP will include goals, objectives, and specific strategies, and an implementation plan. During implementation, progress will be monitored and WMP adjustments made to ensure real improvement in water quality directed toward eventual compliance with water quality standards.

An outline of the potential steps and the process that may be followed when preparing the Blue River WMP can be found in the United States Environmental Protection Agency's (USEPA) Handbook for Developing Watershed Plans to Restore and Protect Our Waters at:

http://www.epa.gov/nps/watershed_handbook/pdf/handbook.pdf.

The City has successfully participated in other watershed initiatives such as the Brush Creek Feasibility Study, the Blue River Feasibility Study, and the Upper Blue River Watershed Initiative. The City will build on its watershed accomplishments toward the goal of making the Blue River WMP a success and model for future watershed planning in the region.

14.3 Monitor, Evaluate and Adapt

A critical aspect of adaptive management is the ability to measure and evaluate programmatic and project activities against the Plan's approved performance criteria. As the Plan is implemented, compliance with performance criteria will be measured to evaluate success at both the project and basin levels. Minimum requirements for the Post Construction Monitoring Program (PCMP) are included in Appendix D of the Consent Decree.

The Plan includes installation of flow meters and level sensors in both the CSS and SSS to obtain baseline information before project design begins and to assess compliance with performance criteria upon completion of Plan components. Meters and sensors will be monitored to:

- Measure flows to the SSS from the more significant satellite communities, i.e., Johnson County Wastewater District, North Kansas City, Liberty, Gladstone, and Raytown.
- Update and enhance collection system computer models.
- Measure the effectiveness of infiltration and inflow ("I/I") reduction efforts, including private inflow source reduction projects in the separate sanitary sewer ("SSS") area.
- Measure the effectiveness of green solutions projects in the combined sewer system ("CSS").
- Measure the effectiveness of the control measures.
- Determine the number of activation events at CSO outfalls.

- Provide information to educate the public on the need for implementation of wet weather solutions, and the progress made in achieving program objectives.

The City is required to begin flow metering in the CSS at some of the locations identified in Table 2 of Appendix D to the Consent Decree on April 1, 2011. No reduction or relocation of the sites listed in Table 2 can be made without prior written approval of the USEPA.

Short-term flow monitoring of approximately one to two years' duration before and after project completion and activation will be performed to measure and evaluate the performance of green solutions, programmatic elements, and sewer system improvements for the reduction of wet weather flow volumes and peak flow rates. Green solutions will include demonstration projects in the CSS for reducing overflows and green infrastructure for reducing the impact of stormwater runoff in sewer separation project areas. Programmatic elements will include private inflow source reduction. Sewer system improvements include I/I reduction projects in the SSS basins, relief sewer construction in the SSS basins, and sewer separation projects in the CSS basins.

Long-term monitoring of the performance of major wet weather facilities will be initiated within six months of the completion of construction and activation of such facilities (e.g., Achievement of Full Operation). Major wet weather facilities include pumping station improvements, wet weather storage tanks and conveyance/storage tunnels, expansions and upgrades of existing WWTPs, and HRT facilities. Appendix D of the Consent Decree includes a listing of the major wet weather facilities included in the Plan for which such monitoring is required. Appendix A of the Consent Decree identifies specific dates by which post-construction monitoring plans must be submitted to the USEPA (approximately one year prior to the scheduled substantial completion of construction of each major constructed wet weather facility).

The wastewater utility capital improvements program includes additional or significant improvement of flow metering capabilities at the following major pumping stations, all of which will provide key data for the long-term assessment of the performance criteria and overall system compliance with the performance measures:

- 87th Street Pumping Station (discharges to the BRIS).
- Round Grove Pumping Station (discharges to the BRIS).
- Santa Fe Pumping Station (discharges to the Westside WWTP).
- NEID Pumping Station (discharges to the Blue River WWTP).
- Line Creek Pumping Station (discharges to both the Westside WWTP and the Hillside Bond Sewer in the Line Creek/Rock Creek basin).
- Buckeye Creek Pumping Station (discharges to the NEID interceptor).

- Birmingham Pumping Station (discharges to Birmingham WWTP).

The Plan also includes a Water Quality Monitoring Plan (WQMP) for the City's lakes, streams, and rivers. This WQMP will develop the information necessary to document progress toward attainment of water quality standards. A WQMP was prepared and submitted prior to the December 31, 2010 deadline, and it will be updated as needed. Monitoring locations for receiving waters include certain sites used during the development of the Plan, existing WSD water quality sampling sites, and one additional site on each of the following water bodies; Indian Creek, Blue River, and Mill Creek. Data collected by the U.S. Geological Survey, Missouri Department of Natural Resources ("MDNR"), or Kansas Department of Health and Environment ("KDHE") may be utilized for this monitoring.

The monitoring plan focuses on water quality parameters related to potential concerns from combined sewer overflows ("CSO") discharges and upstream pollutant sources as follows:

- Indicator bacteria, notably E. coli;
- Dissolved oxygen concentrations; and
- Aesthetics as measured by observations of floatables, debris, odor, and nuisance algal blooms.

The major objectives of the monitoring plan are:

- Further characterization of baseline water quality conditions prior to the development and implementation of the control measures set forth in the Plan.
- Measurement of changes, if any, in water quality during and after implementation of the control measures set forth in the Plan.

The WQMP will, at a minimum, be structured to permit an assessment of the impact of CSOs remaining after completion of the control measures in each basin on the water quality in that basin's receiving stream.

Field measurements and collection of water quality samples will be conducted on a bi-weekly basis throughout the April 1 – October 31 recreation season. Monitoring must begin April 1, 2011, and will be conducted at approximately the same time of day, on the same day of the week, at each location, to obtain an appropriate representation of storm event and non-event conditions. Monitoring will not be delayed because of weather, except for safety reasons. The monitoring frequency will provide data sufficient to calculate a geometric mean E. coli concentration consistent with applicable water quality standards and for tracking long term trends.

Data from the flow monitoring and WQMP will be used to update and improve calibration and verification of the City's collection system models. The updated collection system models will be used to demonstrate compliance with the performance criteria established in Appendix A of the Consent Decree (both the Percent Capture of Wet Weather flows and activation frequency where specified) using the same design storms and design typical year hyetograph used in development of the Plan. For the purpose of demonstrating compliance, the "Plan-complete" activation frequency at individual outfalls is subject to the tolerances defined in Appendix D of the Consent Decree.

The results and progress of the flow and water quality monitoring will be reported to the EPA in an Annual Report and as set forth in Section IX of the Consent Decree.

Adaptation and adjustments to the design, construction, and operation of the entire Plan will result from an evaluation of progress to-date, including, but not limited to, the results of the ongoing monitoring efforts. That evaluation is expected to be an on-going effort throughout the Plan implementation period. The City may request that the CSO and SSO Control Measures set forth in the Plan be revised if it can demonstrate that the requested revision (1) reflects good engineering practice and (2) will continue to achieve the percent capture of wet weather flows and performance criteria as those terms are used in Appendix A of the Consent Decree. The manner in which EPA will review and approve or deny such requests depends upon the extent to which the City proposes to revise a control measure and how the control measure is characterized in Appendix A.

1. If the City seeks to revise a control measure that utilizes the term "approximately" to indicate how compliance will be measured AND the proposed revision represents a 20 percent or less reduction of what is called for in the control measure, the City's request shall be submitted pursuant to, and be governed by the procedures of Section VI of the Consent Decree;
2. If the City seeks to revise a control measure that does not include the term "approximately" as a compliance measurement OR seeks a greater than 20 percent reduction in a control measure that does utilize the term "approximately" as a compliance measure, the requested revision shall be submitted as a proposed Modification pursuant to Section XXV of the Consent Decree.

If EPA approves the request, the Consent Decree will be modified in accordance with the provisions of Section XXV. If EPA denies the request the City may, within thirty (30) days of the denial, appeal the decision to the Director, Water, Wetlands, and Pesticides Division, EPA, whose decision will be final. Simultaneously with any request for modification, the City will provide to EPA all documentation necessary to support the request for modification, including all information relevant to the criteria set forth above.

14.4 City-Wide Program of Green Solutions

Kansas City citizens desire solutions to wet-weather problems that produce multiple benefits. Creative partnerships, focused land conservation and restoration, community education, regulations, and sustainable infrastructure projects are all necessary to achieve multiple benefits**.** These solutions are critical if the City is to succeed in protecting water as a valuable resource. Every decision should be viewed as an opportunity to incorporate a green-solutions approach. The City has adopted an “every drop counts” philosophy, meaning it is important to reduce stormwater entering the system wherever practicable. This will be accomplished through changing the way the community develops and redevelops its sewer and stormwater infrastructure, educating citizens regarding steps they can take to reduce the amount of stormwater entering the sewer system, enabling citizens to take those steps, incorporating green infrastructure in the design of public infrastructure, and making targeted public investments in green infrastructure projects early in the Plan implementation.

Elements of the Plan directed toward promoting utilization of green solutions include:

- Dedicated funding for public education and outreach: Active citizen participation will be critical to the overall success of the Plan. To facilitate this participation, the City will partner with neighborhood associations to develop a public education and outreach program that helps inform citizens of the problem and their role in the solution. Creating successful individual projects is also highly reliant on positive citizen participation. Throughout the life of the Plan, public education and outreach will also focus on informing citizens about proposed project designs, schedules, and progress towards completion.
- A rain gardens and downspout disconnection program: The City’s award-winning “10,000 Rain Gardens” campaign has focused on educating homeowners on the positive effects of rain gardens. The Plan will include a rain garden program along with a new downspout disconnection program. Funding for this program is estimated at $5 million in 2008 dollars. The initiative, which will incentivize citizens to disconnect their downspouts, will also include assistance and information related to helping homeowners and businesses manage and hold water on their own property.
- Funding for job creation and work force development initiatives related to specific program objectives, including “green collar” jobs: Preparing the Kansas City community for the work required in the Plan is critical to its success. Funding for the Plan includes $5 million (in 2008 dollars) to be utilized in job creation and work force development initiative related to Plan objectives. The City will work with job training and work force development organizations to develop a green collar jobs program related to green infrastructure and sustainable projects proposed in the Plan.
- Enhanced technical models, complemented by a “triple bottom line” evaluation framework, including specified social, economic, and environmental metrics: CSS models developed for the Plan analyze performance characteristics in pipes 24 inches in diameter and larger. In order to evaluate the potential impact of green infrastructure solutions, these models will need to be extended further up the drainage basins. Technical models will be complemented by a triple bottom line evaluation framework including well specified social, economic, and environmental

metrics. Once system models and related evaluation frameworks are developed, adjustments to the design, construction, and operation of remaining components will be analyzed throughout implementation of the Plan.

- Green infrastructure pilot projects in the CSS basins: The Plan includes $28 million (in 2008 dollars) dedicated to development of green infrastructure pilot projects in the CSS basins. Large scale pilot projects will be used to gather the information required to effectively implement green infrastructure on a broad scale while simultaneously constructing a portion of the basin-specific solution. Green infrastructure pilot projects will be also constructed in certain basins to achieve a significantly higher level of control downstream of the project area.

  The first pilot project will be implemented in the Middle Blue River Basin, upstream of CSO 069. In this pilot project, distributed green solutions will be provided throughout a 100-acre area of the neighborhood. In addition to gaining valuable information about the effectiveness of green infrastructure in controlling CSOs, this initial pilot project will evaluate alternatives to achieve additional plan objectives, including:

  - Effectiveness of green infrastructure as a systematic solution
  - Codes and ordinances in conflict with green infrastructure utilization
  - Socio-economic benefits/changes
  - Construction techniques and costs on a wide-scale programmatic level
  - Development of preliminary design standards for the City
  - Maintenance approaches and costs
  - Public/private partnership opportunities
  - Community interaction and support of green infrastructure practices

  No later than 365 days after completion of the Middle Blue River Pilot Project, the City is required to submit to EPA, for review and comment, a final report on the Middle Blue River 100-acre green infrastructure pilot project. The report will include:

  - A detailed description of the activities and work performed as part of the pilot project, including specific information about type, number, and location of green infrastructure technologies included in the pilot project;
  - An evaluation of the effectiveness, implementability, and cost of the green infrastructure technologies included in the pilot project; this evaluation shall include a description of any barriers to green infrastructure implementation encountered by the City during the pilot project, community reaction to and support for green infrastructure, and evaluation of socio-economic benefits from use of green infrastructure in the pilot project;

- o A plan, based on the results of the pilot project, for implementation of green infrastructure across the remaining 644-acres upstream of combined sewer outfalls BR059 and BR069 in the Middle Ble River Basin.;
- o A plan, based upon the results of the pilot project, for implementation of green infrastructure potentially throughout the CSS.

The City intends to use an adaptive management approach in order to extensively utilize green infrastructure as appropriate to reduce or replace gray control measures included herein, provided that any green measures proposed provide the same or greater level of control as those gray control measures to be reduced or replaced.

Upon determination by the City to incorporate green infrastructure as an alternative measure to achieve the Performance Criteria set forth in the Consent Decree, the City must submit to EPA a conceptual proposal for review and approval. If EPA approves the conceptual proposal, the City will submit to EPA a detailed Green Infrastructure Project Proposal. This proposal will be consistent with the Consent Decree and shall at a minimum include the following:

- The performance levels expected to be achieved with the implementation of the Green Infrastructure Project, utilizing the information and models that the City used in developing the Plan, and any monitoring information used in formulating the proposal; along with a demonstration of the long term effectiveness and performance expected to be achieved with implementation of the project;
- A description of the work required to implement the Green Infrastructure Project and a schedule for completion of this work and implementation of the Project that is consistent with the Consent Decree and the date set forth herein in for completion of construction and full implementation of all remedial and control measures; and
- A description of any post-construction monitoring and modeling to be performed, in addition to that set forth in the Consent Decree or any previously approved Supplemental Remedial Measures Plan, that is necessary to determine whether the performance criteria will be met upon completion and implementation of the Green Infrastructure Project.

The City will provide for public participation in the development of any Green Infrastructure roject.

In the event that the City implements an approved Green Infrastructure Project Proposal that fails to meet the performance criteria set forth herein, the City may propose, within 180 days after submittal of the applicable post-construction monitoring report documenting said failure, additional control measures designed to achieve the performance criteria, or in the alternative, where the City has fundamentally met the performance criteria, the City may, within sixty (60) days after its failure to meet the performance criteria, petition EPA for a change in the performance criteria. After consideration of any such request by the City, EPA's decision will be final. In the event that EPA disapproves the City's request for a change in the performance criteria, the City may propose additional control measures.

14.5 Separate Sanitary Sewer System Improvements

The overall objective of improvements in the SSS basins is to substantially eliminate overflows. Recommended strategies are to:

- Reduce I/I by rehabilitating the existing system where cost-effective
- Provide a combination of wet-weather storage and treatment to address the remaining excess flow

As a practical matter, the complete elimination of sanitary sewer overflows (SSO) is not possible. There is a need to select a specific design storm under which the proposed improvement would cost-effectively eliminate overflows. For development of the control measures contained in the Plan, the design storm in the SSS basins is a rainfall event having a duration of 24 hours and a depth that would be equaled or exceeded, on average, once every five years. This design storm would result in a rainfall depth of 4.68 inches. Increasing the design rainfall event in the SSS above the 5-year event was considered not feasible, as the additional costs would either exceed the City's financial capabilities or would require a commensurate reduction in the cost (and performance) of CSO controls.

14.5.1 North of the Missouri River

Overflow control measures contained in the Plan for the SSS located north of the Missouri River include:

- I/I reduction
- Construction of Birmingham Pump Station upgrades
- Construction of approximately 62,000 linear feet of 11-foot diameter deep-storage tunnel
- Construction of a 30-million gallons per day (MGD) tunnel dewatering pump station
- Construction of 50 MGD High Rate Treatment facility at the Birmingham WWTP
- Construction of approximately 12,000 linear feet of 24-inch force main
- Construction of relief sewers at various locations

The general locations of the SSO control measures are shown in Figure 14-1.

Cost effective I/I reduction is a key component of the plan. Varying target levels of reduction are planned for each SSS watershed located north of the river.

Watershed target reduction levels reflect flow-study results indicating existing levels of I/I. The watersheds targeted for I/I reduction and the target levels of reduction include:

- Northern Watersheds 30- percent reduction
- Northwestern Watersheds 30- percent reduction
- Line Creek/Rock Creek Watersheds 35- percent reduction
- Birmingham/Shoal Creek Watersheds 40- percent reduction

Target levels of reduction are applied to predicted peak flows at the lower end of the system during the design rainfall event. In some instances, additional relief sewers and pumping capacity will also be

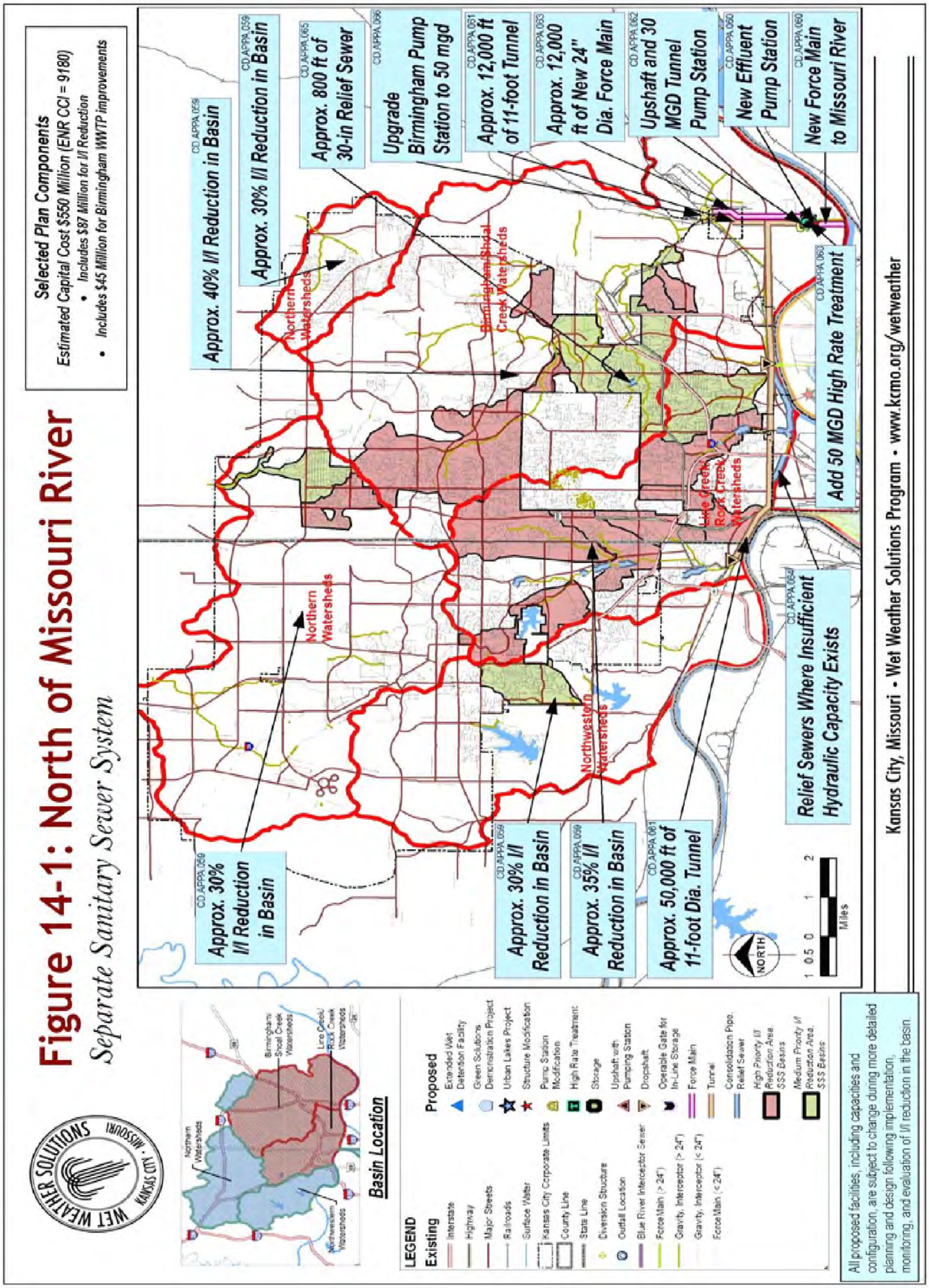


Figure 14-1: North of Missouri River
Separate Sanitary Sewer System
Selected Plan Components
Estimated Capital Cost $550 Million (ENR CCI = 9180)
Includes $87 Million for I/I Reduction
Includes $45 Million for Birmingham WWTP improvements
Approx. 30% I/I Reduction in Basin
Approx. 40% I/I Reduction in Basin
Approx. 30% I/I Reduction in Basin
Approx. 800 ft of 30-in Relief Sewer
Upgrade Birmingham Pump Station to 50 mgd
Approx. 12,000 ft of 11-foot Tunnel
Approx. 12,000 ft of New 24" Dia. Force Main
Upshaft and 30 MGD Tunnel Pump Station
New Effluent Pump Station
New Force Main to Missouri River
Add 50 MGD High Rate Treatment
Relief Sewers Where Insufficient Hydraulic Capacity Exists
Approx. 30% I/I Reduction in Basin
Approx. 35% I/I Reduction in Basin
Approx. 50,000 ft of 11-foot Dia. Tunnel
Northern Watersheds
Northwestern Watersheds
Birmingham/Shoal Creek Watersheds
Line Creek/Rock Creek Watersheds
Miles
NORTH
Basin Location
LEGEND
Existing
Interstate
Highway
Major Streets
Railroads
Surface Water
Kansas City Corporate Limits
County Line
State Line
Diversion Structure
Outfall Location
Blue River Interceptor Sewer
Force Main (> 24")
Gravity, Interceptor (> 24")
Gravity, Interceptor (< 24")
Force Main (< 24")
Proposed
Extended Wet Detention Facility
Green Solutions Demonstration Project
Urban Lakes Project
Structure Modification
Pump Station Modification
High Rate Treatment
Storage
Upshaft with Pumping Station
Dropshaft
Operable Gate for In-Line Storage
Force Main
Tunnel
Consolidation Pipe, Relief Sewer
High Priority I/I Reduction Area, SSS Basins
Medium Priority I/I Reduction Area, SSS Basins
All proposed facilities, including capacities and configuration, are subject to change during more detailed planning and design following implementation, monitoring, and evaluation of I/I reduction in the basin.
Kansas City, Missouri • Wet Weather Solutions Program • www.kcmo.org/wetweather

needed to deliver wet-weather flows in the collection system to proposed new storage and conveyance systems leading to the City's WWTPs. The target reductions are not independent performance measures. The capacity and configuration of the control measures will be adjusted as necessary to conform to the design goal of eliminating SSOs.

Wet weather flows from the Line Creek/Rock Creek and Northwestern Basins will be transported through a new conveyance and storage tunnel to the Birmingham WWTP. That tunnel system will also temporarily store excess wet-weather flows from the Birmingham/Shoal Creek Basin. The North Bank Tunnel System is expected to include approximately 62,000 feet of 11-foot diameter tunnel and a 30-MGD pumping station at the Birmingham WWTP for dewatering the tunnel. The North Bank Tunnel System will have a storage capacity of approximately 44 MG and is sized for projected wastewater flows after full development of its tributary areas.

A constructed SSO exists in the Line Creek/Rock Creek Basin, just upstream from the Line Creek Pumping Station. The North Bank Tunnel System will eventually eliminate this constructed SSO; however, tunnel construction will not begin until I/I reduction work in the basin nears completion.

The Plan includes construction of a new 50-MGD HRT facility at the Birmingham WWTP to address peak wet-weather inflows. Discharges from this HRT facility will be blended with flows from the secondary clarifiers for discharge to the Missouri River. Additional detail on this facility is included in *Joint Use Facilities Expansion Capabilities;* OCP; September 2008. The final design capacity and regulatory requirements for this facility will be evaluated in future Plan updates. This evaluation and any updates will be based on current industry performance data and the effectiveness of I/I reduction measures.

It is anticipated that the HRT/disinfection facility will meet permit requirements for biochemical oxygen demand and total suspended solids concentrations in the blended effluent from the Birmingham WWTP. Complying with percentage reduction requirements found in Missouri's secondary treatment standards may be problematic, due principally to reduced plant influent concentrations. The HRT/disinfection facility will include grit removal, fine screening, high-rate clarification, and disinfection. Final effluent will discharge to the effluent pump station. The existing pump station consists of two 40-MGD pumps and space for an additional pump. A new 50-MGD pump will be installed in the available space to handle the combined projected WWTP effluent and wet-weather treatment effluent.

Although it is the City's intention to utilize HRT/disinfection for treatment of excess flows, the Consent Decree requires the City to prepare and submit a no-feasible alternative analysis pursuant to 40 C.F.R. § 122.41(m) by 04-30-2020 prior to implementation of this control measure.

Estimated capital and additional annual O&M costs for SSS improvements north of the Missouri River required by the Consent Decree are shown in Table 12-1, in 2008 dollars (ENR CCI 9180). The estimated capital cost is $550 million. The estimated additional annual O&M cost of the improvements is $5 million.

Table 14-1 North of the Missouri River Sanitary Sewer System Improvement Costs

Task Number	Task Name	Capital Cost (million $)	Annual O&M Cost (million $)
CD.APPA.059.01	I/I Reduction: Northern Basins	$11.32	
CD.APPA.059.02	I/I Reduction: Line Creek/Rock Creek Basin	37.26	
CD.APPA.059.03	I/I Reduction: Birmingham/Shoal Creek	38.76	
CD.APPA.060	WWTP Upgrade: Birmingham WWTP Capacity Expansion	44.64	2.27
CD.APPA.061	Deep Tunnel Storage: N. of Missouri River	302.56	0.89
CD.APPA.062	Deep Tunnel Pump Station: N. of Missouri River	74.00	0.89
CD.APPA.063	Pump Station Force Main: N. of Missouri River	4.06	0.02
CD.APPA.064	Relief Sewer: Line Creek	13.38	
CD.APPA.065	Relief Sewer: Birmingham	0.22	
CD.APPA.066	Pump Station Upgrade: Birmingham	24.13	0.88
Total		**$550.33**	**$4.95**

*all costs in 2008 dollars (ENR 9180)

14.5.2 South of the Missouri River

Plan improvements and control measures for the SSS located south of the Missouri River include:

- I/I reduction.
- Construction of relief sewers.
- Rehabilitation of the 87th Street Pump Station and construction of 68-MG of storage in two phases.
- Construction of a 24-inch force main from Round Grove Pump Station to the Blue River Interceptor Sewer (parallel existing force main).
- Increasing the firm pumping capacity at the Round Grove Pump Station by 12 MGD.

The general locations of Plan improvements south of the Missouri River are shown in Figure 14-2.

Priority SSS basins south of the Missouri River include the Blue River South and Round Grove Basins. Additional improvement details in the Blue River South Basin are presented in *Alternative Development, Evaluation, Facilities Siting, Constructability, and Operability Technical Memorandum;* HDR; April 2008. Additional information for the Round Grove Basin is presented in *Round Grove Project Area*

Sanitary Sewer Evaluation Study; WAI; June 2008. Additional information on wet-weather flows in the Little Blue River, Blue River North, and Blue River Central Basins is included in *Remainder of the Separate Sanitary Sewer System Project Area;* GBA; October 2007.

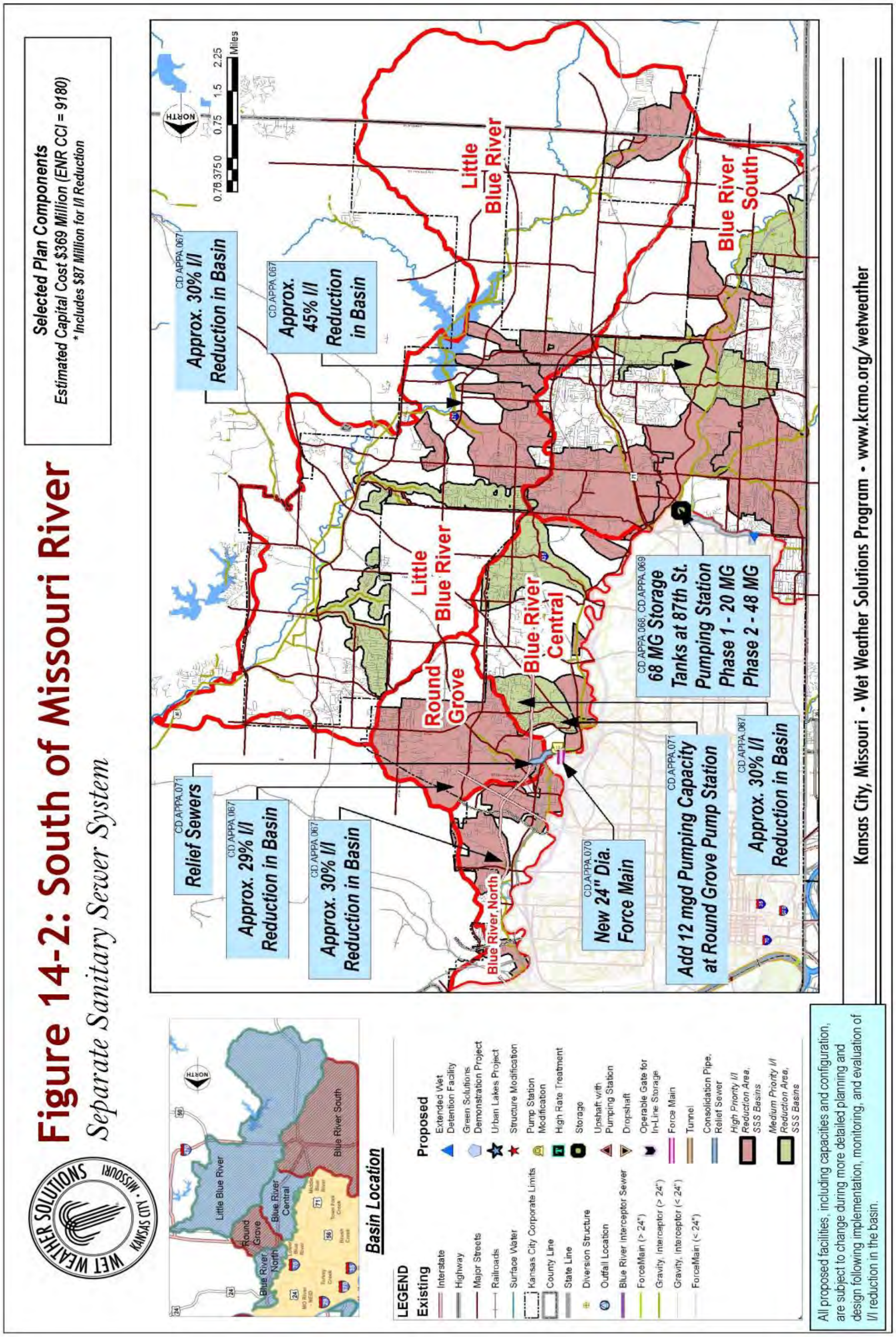


Figure 14-2: South of Missouri River
Separate Sanitary Sewer System
Selected Plan Components
Estimated Capital Cost $369 Million (ENR CCI = 9180)
* Includes $87 Million for I/I Reduction
Relief Sewers
Approx. 29% I/I Reduction in Basin
Approx. 30% I/I Reduction in Basin
Approx. 30% I/I Reduction in Basin
Approx. 45% I/I Reduction in Basin
New 24" Dia. Force Main
Add 12 mgd Pumping Capacity at Round Grove Pump Station
Approx. 30% I/I Reduction in Basin
68 MG Storage Tanks at 87th St. Pumping Station
Phase 1 - 20 MG
Phase 2 - 48 MG
Little Blue River
Blue River South
Blue River Central
Round Grove
Blue River North
Basin Location
LEGEND
Existing
Proposed
All proposed facilities, including capacities and configuration, are subject to change during more detailed planning and design following implementation, monitoring, and evaluation of I/I reduction in the basin.
Kansas City, Missouri • Wet Weather Solutions Program • www.kcmo.org/wetweather

Cost effective I/I reduction is a key component of the plan for the SSS located south of the Missouri River. Varying target levels of reduction are planned for each sanitary sewer watershed in this area. Watershed target reduction levels reflect flow study results indicating existing levels of I/I. The watersheds and target I/I removal levels (applied to rainfall-derived I/I) are as follows:

- Little Blue River 30- percent reduction
- Blue River South 45- percent reduction
- Blue River Central 30- percent reduction
- Blue River North 30- percent reduction
- Round Grove 29- percent reduction

Target levels of reduction are applied to predicted peak flows at the lower end of the system during the design rainfall event. The target reductions are not independent performance measures. The capacity and configuration of planned control measures will be adjusted as necessary to conform to the design goal of eliminating SSOs.

It is presently anticipated that a total storage volume of 68 MG will be provided to store excess I/I from the Blue River South Basin (including flows from Johnson County Wastewater District) at the 87th Street Pumping Station. That estimated storage volume was developed considering wastewater flows expected in the Year 2030, following completion of recommended I/I reduction work in the Blue River South Basin. Additional information on flows reaching the 87th Street Pumping Station is presented in *Wet Weather Flow Rates and Volumes at 87th Street Pumping Station;* OCP; February 2008.

The Consent Decree requires construction of the 68 MG storage facility in two phases. The first phase includes construction of approximately 20 MG of storage at 87th Street Pumping Station, and rehabilitation and modification of existing pumps and equipment necessary to support wet weather pumping to storage tanks concurrent with operation of duty pumps. The first phase must be operational by 12-31-2016. Construction of the remaining storage, yielding a combined total capacity presently estimated at 68 MG, are required to completed in a second phase no later than 12-31-2024. The total storage volume at the 87th Street Pumping Station may be increased or reduced consistent with the results of the I/I reduction program in the Blue River South Basin and updated projections of inflows to the Blue River South Basin from Johnson County Wastewater.

At present, Johnson County Wastewater District has wet-weather facilities at its Tomahawk WWTP. Those facilities can reduce the peak flow to the City's system at 103rd and State Line Road by up to 40-MGD. If Johnson County Wastewater District elects to discontinue operation of those wet-weather facilities, the required volume of tank storage at the 87th Street Pumping Station would increase to 82

MG. Alternatively, Johnson County Wastewater District may elect to provide its own storage at or near the Tomahawk WWTP, thereby reducing the required storage volume at the 87th Street Pumping Station.

Estimated capital and additional annual O&M costs for SSS Plan improvements south of the Missouri River as required by the Consent Decree are shown in Table 14-2, in 2008 dollars (ENR CCI 9180). The capital cost is $369 million. The estimated additional annual O&M cost of the improvements is $1.1 million.

Table 14-2 South of the Missouri River Sanitary Sewer System Improvement Costs

Task Number	Task Name	Capital Cost (million $)	Annual O&M Cost (million $)
CD.APPA.067.01	I/I Reduction: Little Blue River Basin	$23.18	
CD.APPA.067.02	I/I Reduction: Blue River South Basin	38.10	
CD.APPA.067.03	I/I Reduction: Blue River Central Basin	15.13	
CD.APPA.067.04	I/I Reduction: Blue River North Basin	5.94	
CD.APPA.067.05	I/I Reduction: Round Grove Creek	4.91	
CD.APPA.068.01	Storage: 87th Street Pumping Station (Phase 1) Storage Tank	91.31	
CD.APPA.068.02	Storage: 87th Street Pumping Station (Phase 1) Pump Station Upgrade	9.28	1.13
CD.APPA.069	Storage: 87th Street Pumping Station (Phase 2)	168.42	
CD.APPA.070	Pump Station Force Main: Round Grove	1.63	
CD.APPA.071	Pump Station Upgrade: Round Grove	11.34	0.03
Total		**$369.24**	**$1.13**

*all costs in 2008 dollars (ENR 9180)

14.6 Combined Sewer System Improvements

CSO control measures to be implemented in the CSS basins, as described herein, will address the goals established by the Wet Weather Community Panel, meet regulatory requirements, and provide multiple benefits with judicious investment of public dollars for infrastructure improvements.

Core strategies employed in the selection of control measures included:

- Emphasize control of CSOs in the Blue River Basins (Middle Blue, Town Fork Creek, Brush Creek, and Lower Blue River) and expend less effort on basins that drain directly to the Kansas and Missouri Rivers (Turkey Creek and NEID). Approximately 3 percent of the bacteria in the Missouri River just downstream from its confluence with the Blue River is associated with the City's CSOs. Funds expended to address this relatively small source of bacteria to the Missouri River could be better spent to address water quality in streams that are more directly influenced by the City's actions and have more influence on the City's residents, such as the Blue River and its tributaries.

- Placement of higher investment emphasis and priority on those outfalls where improved flood protection and storm drainage service could result from implementation of CSO control.
- Repair and rehabilitate small diameter (equal to or less than 12 inches) sewers to reduce the quantity of flow entering the system and to improve service by reducing the frequency and severity of basement backups. Approximately 60 percent of the total sewer length in the CSS will be addressed by this strategy, at an estimated capital cost (in 2008 dollars) of $124 million.

Upon completion of the CSO control measures, the City will be required to meet the performance criteria specified in Appendix A of the Consent Decree. The City must demonstrate compliance with both the percent capture of wet weather flows and performance criteria utilizing the collection system hydraulic model described in Chapter 5 of the Plan and the post construction flow monitoring data. The City must calibrate the collection system hydraulic model to at least the same degree of calibration as was achieved during the Plan development. Upon calibration of the collection system hydraulic model, a continuous simulation of the model must be run inputting the "typical year" design storms used to develop the Plan in place of the actual storms experienced during the post construction monitoring period.

For the purpose of demonstrating compliance, the percent capture of wet weather flows and the maximum volume of CSO discharges included in the CSO control measures defined in Appendix A of the Consent Decree will be met if the continuous typical year simulations using the calibrated post-construction hydraulic model demonstrate the specified basins in the "typical year" do not exceed the maximum volumes listed.

The performance criteria relative to the number of Typical Year overflow events will be met if the continuous "typical year" simulations using the calibrated post-construction hydraulic model demonstrate the collection system discharges will not exceed the number of "typical year" overflow events listed in Appendix A, subject to the tolerance defined in Appendix D of the Consent Decree.

The City will be responsible for achieving the percent capture requirement and performance criteria specified in Appendix A of the Consent Decree. Compliance with individual control measures will not constitute a defense to a failure to achieve the percent capture requirements and activation frequency performance criteria and will not relieve the City of the obligation to submit plans proposing additional control measures pursuant to Section VII.A.1.c of the Consent Decree.

Descriptions of the control measures to be implemented in the CSS and performance criteria to be met follow. All planned facilities, including capacities and configurations, are subject to change during more detailed planning and design, following implementation, monitoring, and evaluation of green solutions and source controls in the CSS.

14.6.1 Brush Creek Basin

The general locations of the Brush Creek Basin improvements are shown in Figure 14-3. Additional improvement details are located in the *Final Development of Preliminary Improvement Scenarios Technical Memorandum;* CDM; June 2008. The Brush Creek Basin improvements consist of:

- Construction of approximately 20,600 linear feet of 16-foot diameter deep tunnel with a capacity of approximately 31 MG.
- Construction of a 45-MGD deep-tunnel pump station.
- Construction of a 200-MGD HRT/disinfection facility at the confluence of Brush Creek and the Blue River.
- Construction of approximately 790 linear feet of approximately 42-inch diameter consolidation piping downstream of Diversion Structure 42 (Outfall 024). This improvement was incorrectly described in the Consent Decree as 1200 linear feet of approximately 72-inch diameter consolidation piping. Construction of approximately 1,200 linear feet of 48" to 72" consolidation piping (Outfalls 20 and 21). This improvement was not included in the Consent Decree, but is necessary to meet performance goals.
- Construction of approximately 350 linear feet of relief sewer 24 inches in diameter (vicinity 48th and Roanoke Parkway).
- Construction of approximately 2,100 linear feet of approximately 36-inch diameter consolidation piping diverting flows from Outfall 026.
- Construction of approximately 3,300 linear feet of approximately 24-inch to 60-inch diameter consolidation piping diverting flows from Outfalls 027 and 028.
- Construction of approximately 2,800 linear feet of storm sewer 72 inches in diameter.
- Combined sewer separation in approximately 1,140 acres of the Brookside sub-basin.
- Construction of approximately 1,800 linear feet of 54" to 96" consolidation piping (new outfall). This improvement was not included in the Consent Decree, but is necessary to meet performance goals.
- Various baseline improvements.
- Basin-wide small-sewer rehabilitation.
- Construction of approximately 1,150 linear feet of consolidation piping at Outfall 019. This improvement wasadded during Consent Decree negotiations and is further described in *Brush Creek Basin Combined Sewer System Outfall MDNR019; OCP; May 2009.*
- Construct new diversion structure and approximately 1,640 linear feet of consolidation piping; add flap gate at Outfall 023. This improvement wasadded during Consent Decree negotiations

and is further described in *Brush Creek Basin Combined Sewer System Outfall MDNR023; OCP; May 2009*.

- Construct new diversion structure and approximately 950 linear feet of consolidation piping; add flap gate at Outfall 025. This improvement wasadded during Consent Decree negotiations and is further described in *Brush Creek Basin Combined Sewer System Outfall MDNR025; OCP; May 2009*.

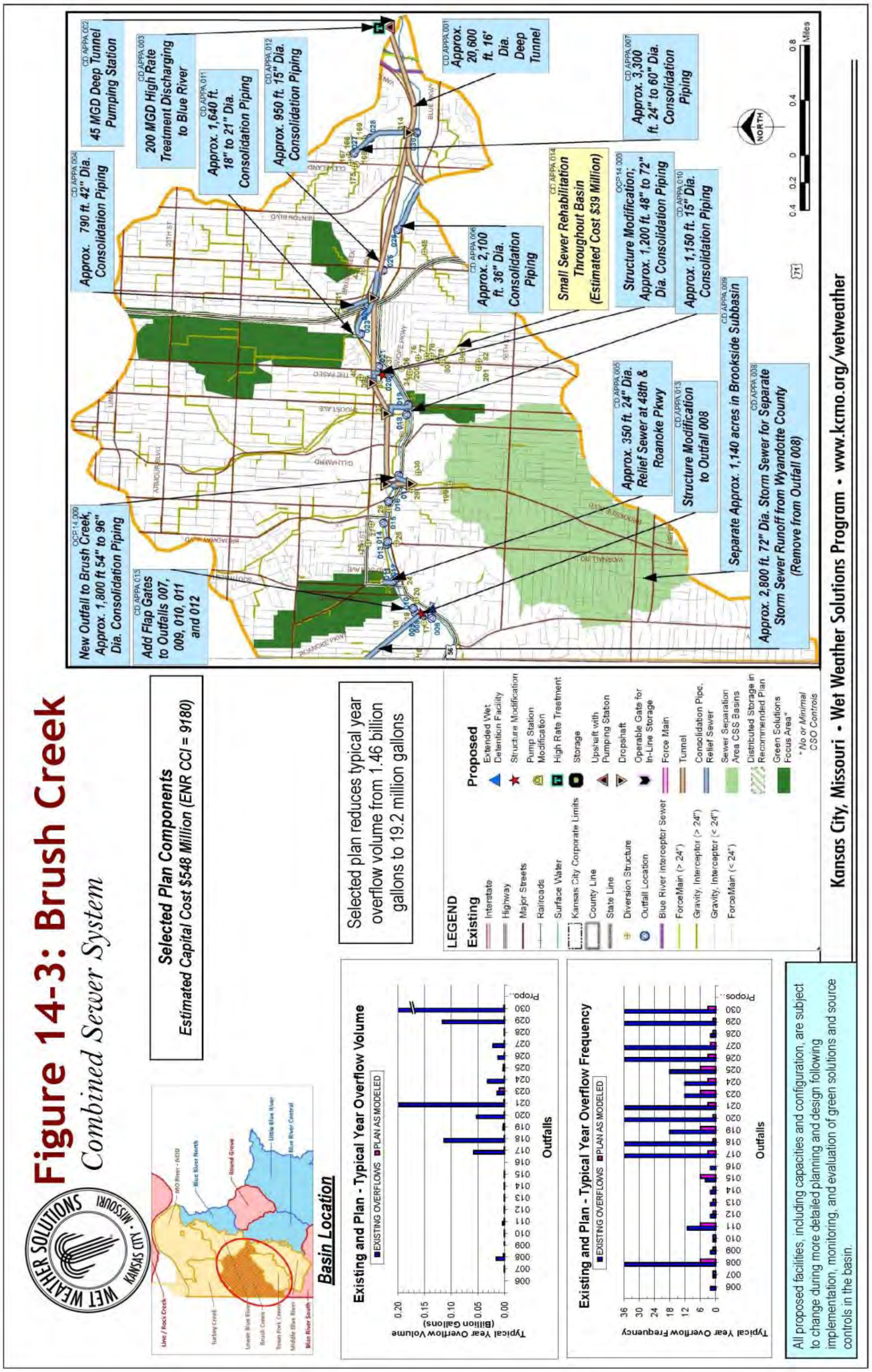


Figure 14-3: Brush Creek
Combined Sewer System
Basin Location
Selected Plan Components
Estimated Capital Cost $548 Million (ENR CCI = 9180)
Selected plan reduces typical year overflow volume from 1.46 billion gallons to 19.2 million gallons
Existing and Plan - Typical Year Overflow Volume
Existing and Plan - Typical Year Overflow Frequency
Outfalls
LEGEND
Existing
Proposed
New Outfall to Brush Creek, Approx. 1,800 ft 54" to 96" Dia. Consolidation Piping
Add Flap Gates to Outfalls 007, 009, 010, 011 and 012
Approx. 790 ft. 42" Dia. Consolidation Piping
200 MGD High Rate Treatment Discharging to Blue River
45 MGD Deep Tunnel Pumping Station
Approx. 1,640 ft. 18" to 21" Dia. Consolidation Piping
Approx. 950 ft. 15" Dia. Consolidation Piping
Approx. 20,600 ft. 16' Dia. Deep Tunnel
Approx. 2,100 ft. 36" Dia. Consolidation Piping
Small Sewer Rehabilitation Throughout Basin (Estimated Cost $39 Million)
Structure Modification; Approx. 1,200 ft. 48" to 72" Dia. Consolidation Piping
Approx. 3,300 ft. 24" to 60" Dia. Consolidation Piping
Approx. 1,150 ft. 15" Dia. Consolidation Piping
Approx. 350 ft. 24" Dia. Relief Sewer at 48th & Roanoke Pkwy
Structure Modification to Outfall 008
Separate Approx. 1,140 acres in Brookside Subbasin
Approx. 2,800 ft. 72" Dia. Storm Sewer for Separate Storm Sewer Runoff from Wyandotte County (Remove from Outfall 008)
All proposed facilities, including capacities and configuration, are subject to change during more detailed planning and design following implementation, monitoring, and evaluation of green solutions and source controls in the basin.
Kansas City, Missouri • Wet Weather Solutions Program • www.kcmo.org/wetweather

The deep-storage tunnel will provide approximately 31 MG of storage capacity. Taken together with the tunnel in the Town Fork Creek Basin described later in this chapter, the total storage provided must be 50MG. The tunnel site is along Brush Creek from Brookside Boulevard to an area near the confluence of Brush Creek and the Blue River. A deep-tunnel pump station located near the Blue River will dewater the tunnel. The firm capacity of the pump station is 45-MGD. The pump station will convey flow from storage to a proposed 200-MGD HRT/disinfection treatment process. Treated effluent will discharge to the Blue River.

The HRT/disinfection facility will receive flow from both the deep-tunnel pumping station and up to 150-MGD of excess wet-weather gravity flow diverted from the BRIS. The purpose of the diversion is to provide hydraulic grade line relief for Blue River Interceptor Sewer (BRIS) flow.

Various baseline improvements include measures to assure that the current collection system operates at its maximum capacity. The basin baseline improvements include sediment, debris, and blockage removal; and flap gate installation. Flap gates will be installed at five Brush Creek outfalls. Backflow conditions occur at these outfalls due to high water surface elevations in Brush Creek that occur during wet weather.

Estimated capital and additional annual O&M costs for CSS Plan improvements in the Brush Creek Basin as required by the Consent Decree are shown in Table 14-3. The estimated capital cost is approximately $548 million and additional annual O&M cost of the improvements is approximately $7.4 million.

Upon completion of the control measures, the typical-year overflow volume from the Brush Creek Basin is projected to decrease from the existing level of 1.46 billion gallons, to 19.2 MG. The performance criteria defined in Appendix A of the Consent Decree will be met if the modeled typical-year overflow volume from the Brush Creek and Town Fork Creek basins combined does not exceed 59 million gallons and the modeled number of typical year overflow events at any given outfall do not exceed the values listed in Table 14-4, subject to the tolerance defined in Appendix D of the Consent Decree. For certain outfalls, the Plan projects a lower activation frequency than that required by Appendix A of the Consent Decree. In those instances, the lower activation frequency remains the current planning objective, but can be relaxed during more detailed planning and design to the extent that the maximum overflow volume as defined above is not exceeded. Table 14-4 summarizes the current modeling results, by outfall, for the Brush Creek Basin plan.

Table 14-3 Brush Creek Basin Improvement Costs

Task Number	Task Name	Capital Cost* (million $)	Annual O&M Cost (million $)
CD.APPA.001	Deep Tunnel Storage: Brush Creek	$210.89	$2.00
CD.APPA.002	Deep Tunnel Pump Station: Brush Creek	63.28	0.94
CD.APPA.003	Wet-weather Treatment Facility: Brush Creek	165.78	4.50
CD.APPA.004	Wet-weather Flow Rerouting: Outfall 024	1.50	
CD.APPA.005	Relief Sewer: 48th and Roanoke	0.20	
CD.APPA.006	Wet-weather Flow Rerouting: Outfall 026	1.86	
CD.APPA.007	Wet-weather Flow Rerouting: Outfalls 027/028	5.75	
CD.APPA.008	Wet-weather Flow Rerouting: Wyan. County to Brush Creek	5.41	
CD.APPA.009	Sewer Separation: Brookside	45.89	
CD.APPA.010	Sewer Pipe Consolidation: Outfall 019	0.39	
CD.APPA.011	Diversion Structure and Consolidation Piping: Outfall 023	0.48	
CD.APPA.012	Diversion Structure and Consolidation Piping: Outfall 025	0.20	
CD.APPA.013	Baseline Improvements: Brush Creek	2.53	
CD.APPA.014	Small Sewer Rehabilitation: Brush Creek	39.00	
OCP.14.008	Sewer Pipe Consolidation: Outfall 020	1.58	
OCP.14.009	Outfall and Consolidation Piping: Brush Creek	3.67	
Total		**$548.42**	**$7.44**

*all costs in 2008 dollars (ENR 9180)

Table 14-4 Brush Creek Modeled Plan Effectiveness

Outfall	**EXISTING OVERFLOWS**		**PLAN AS MODELED**		**CONSENT DECREE**
MDNR Outfall ID	Typical Year Annual Overflow Volume (MG)	Typical Year Annual Overflow Frequency	Estimated Recreation Season Overflow Volume (MG)	Estimated Recreation Season Overflow Activations	Max. Typical Year Activation Frequency for Compliance
006	0.00	≥2	0.00	0	6
007	0.07	≥1	0.03	1	6
008	15.67	≥36	1.98	6	6
009	Included with 008	≥2	0.09	1	6
010	0.17	≥1	0.01	1	6
011	3.73	≥11	0.66	6	6
012	0.04	≥2	0.04	1	6
013	0.26	≥2	0.14	1	6
014	0.14	≥2	0.06	1	6
015	0.44	≥4	0.24	6	6
016	0.00	≥2	0.00	0	6
017	57.90	≥36	0.71	3	6
018	113.44	≥36	0.26	1	6
019	3.05	≥18	1.39	6	6
020	52.27	≥36	0.37	1	6
021	201.07	≥36	1.63	3	6
023	14.19	≥12	8.01	6	6
024	31.80	≥12	0.37	3	6
025	2.74	≥18	1.55	6	6
026	12.20	≥36	0.07	3	6
027	21.90	≥36	0.34	2	6
028	0.31	≥2	0.04	1	6
029	116.35	≥36	0.14	1	6
030	807.77	≥36	1.03	3	6
Total	**1,455.51**	**≥415**	**19.17**	**63**	

14.6.2 Lower Blue River Basin

The general locations of the Lower Blue River Basin CSO control measures are shown in Figure 14-4. Additional control measure details are located in the *Technical Memorandum for Task 8-Preliminary Improvement Scenarios Gooseneck Creek and Lower Blue River Study Area;* CH2M Hill; July 2008. The Lower Blue River Basin control measures consist of:

- Either increase the capacity of the 15th Street Pump Station to 6.5 MGD or provide sewer separation in its upstream drainage basin to eliminate typical year wet weather flows exceeding the station's current capacity.

- Construction of approximately 3,500 linear feet of relief sewer 54 inches in diameter, downstream of the intersection of Hardesty Avenue and 31st Street.
- Construction of approximately 3,400 linear feet of relief sewer 48 inches in diameter, downstream of the intersection of Vineyard and Lawn Street.
- Construction of approximately 1,500 linear feet of relief sewer 24 inches in diameter, south of 45th Street, between Chelsea Avenue and Van Brunt Boulevard.
- Sewer separation in approximately 225 acres near 40th & Monroe and elimination of 9 outfalls.
- Sewer separation in approximately 35 acres near 17th & Topping, elimination of outfall 054.
- Installation of approximately 660 linear feet of approximately 18-inch diameter dry weather line to reduce frequency of typical year overflows at Outfall 055. This improvementadded during Consent Decree negotiations and is further described in *Lower Blue River Basin Combined Sewer System Outfall MDNR055; OCP; May 2009*.
- Basin-wide small-sewer rehabilitation.

Upon completion of the control measures, the typical-year overflow volume from the Lower Blue River Basin is projected to decrease from the existing level of 210.6 MG to 76.5 MG (those values are inclusive of overflows at Outfall 032). The performance criteria defined in Appendix A of the Consent Decree will be met if the modeled overflow from the Lower Blue River and Middle Blue River basins combined (including overflows from the Blue River Interceptor Sewer, or BRIS) does not exceed 125 million gallons and the modeled number of typical year overflow events at any given outfall do not exceed the values listed in Table 14-5, subject to the tolerance defined in Appendix D of the Consent Decree. For certain outfalls, the Plan projects a lower activation frequency than that required by Appendix A of the Consent Decree. In those instances, the lower activation frequency remains the current planning objective, but can be relaxed during more detailed planning and design to the extent that the maximum overflow volume as defined above is not exceeded.

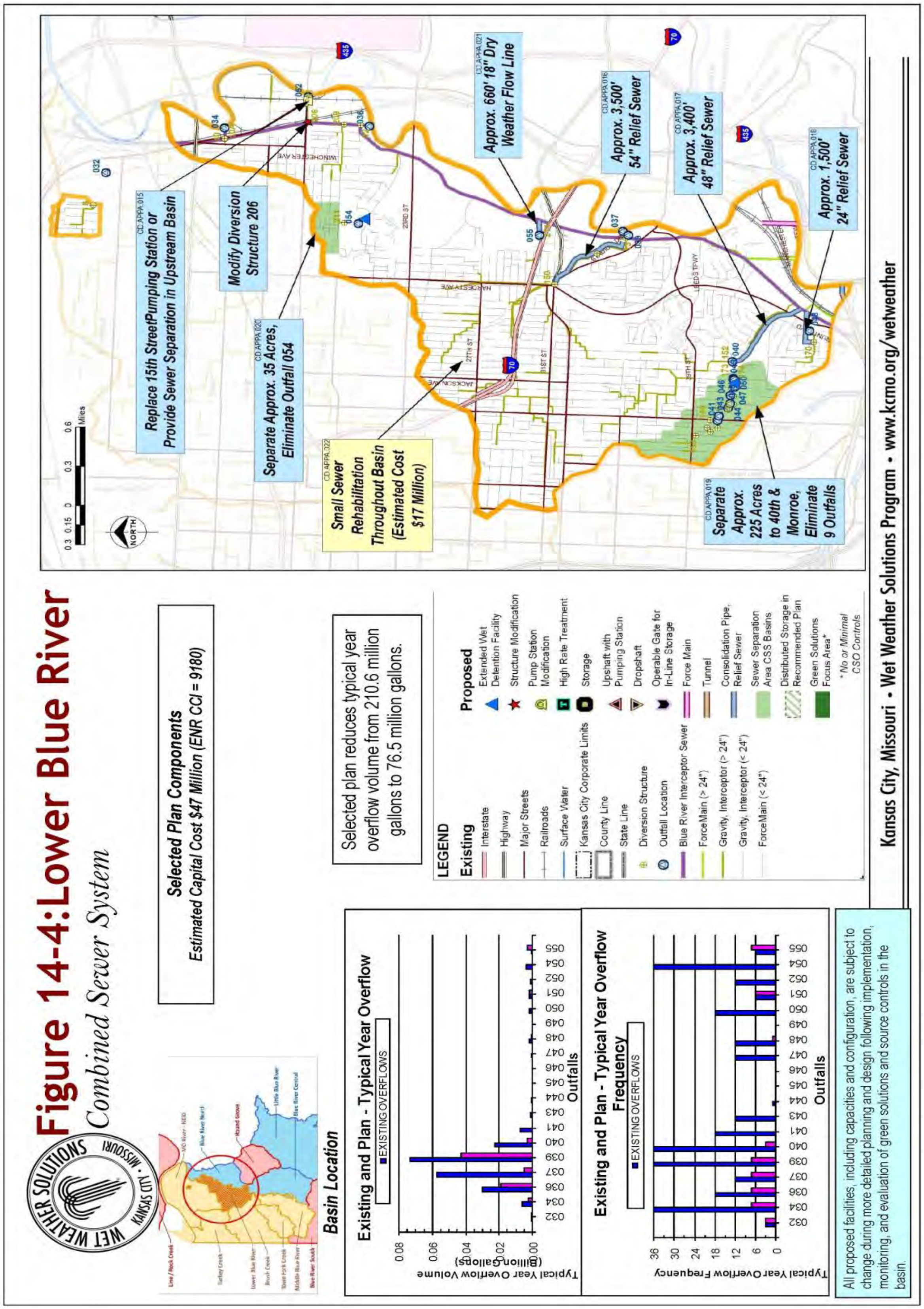


Figure 14-4:Lower Blue River
Combined Sewer System
Basin Location
Selected Plan Components
Estimated Capital Cost $47 Million (ENR CCI = 9180)
Selected plan reduces typical year overflow volume from 210.6 million gallons to 76.5 million gallons.
Existing and Plan - Typical Year Overflow
EXISTING OVERFLOWS
Typical Year Overflow Volume (Billion Gallons)
Outfalls
Existing and Plan - Typical Year Overflow Frequency
Typical Year Overflow Frequency
All proposed facilities, including capacities and configuration, are subject to change during more detailed planning and design following implementation, monitoring, and evaluation of green solutions and source controls in the basin.
LEGEND
Existing
Interstate
Highway
Major Streets
Railroads
Surface Water
Kansas City Corporate Limits
County Line
State Line
Diversion Structure
Outfall Location
Blue River Interceptor Sewer
Force Main (> 24")
Gravity, Interceptor (> 24")
Gravity, Interceptor (< 24")
Force Main (< 24")
Proposed
Extended Wet Detention Facility
Structure Modification
Pump Station Modification
High Rate Treatment
Storage
Upshaft with Pumping Station
Dropshaft
Operable Gate for In-Line Storage
Force Main
Tunnel
Consolidation Pipe, Relief Sewer
Sewer Separation Area CSS Basins
Distributed Storage in Recommended Plan
Green Solutions Focus Area*
* No or Minimal CSO Controls
Replace 15th StreetPumping Station or Provide Sewer Separation in Upstream Basin
Modify Diversion Structure 206
Separate Approx. 35 Acres, Eliminate Outfall 054
Small Sewer Rehabilitation Throughout Basin (Estimated Cost $17 Million)
Approx. 660' 18" Dry Weather Flow Line
Approx. 3,500' 54" Relief Sewer
Approx. 3,400' 48" Relief Sewer
Approx. 1,500' 24" Relief Sewer
Separate Approx. 225 Acres to 40th & Monroe, Eliminate 9 Outfalls
Kansas City, Missouri • Wet Weather Solutions Program • www.kcmo.org/wetweather

Table 14-5 summarizes the current modeling results, by outfall, for the Lower Blue River Basin plan. In the model, a minor increase was projected in overflow volume at Outfall 032 following plan implementation. This projected increase in overflow volume is attributable to boundary condition changes in the continuous simulation model and is considered within the level of accuracy of the modeling projections.

Table 14-5 Lower Blue River Modeled Plan Effectiveness

Outfall	**EXISTING OVERFLOWS**		**PLAN AS MODELED**		**CONSENT DECREE**
MDNR Outfall ID	Typical Year Annual Overflow Volume (MG)	Typical Year Annual Overflow Frequency	Estimated Recreation Season Overflow Volume (MG)	Estimated Recreation Season Overflow Activations	Max. Typical Year Activation Frequency for Compliance
032	0.08	≥3	0.36	3	7
034	5.97	≥36	2.44	7	7
036	30.17	≥18	18.68	7	7
037	57.44	≥12	5.03	7	7
039	73.63	≥36	42.76	7	7
040	22.80	≥36	2.72	3	7
041	7.51	≥18	0.00	0	0
043	1.40	≥12	0.00	0	0
044	0.02	≥1	0.00	0	0
045	0.00	0	0.00	0	0
046	0.00	0	0.00	0	0
047	0.52	≥12	0.00	0	0
048	1.85	≥12	0.02	1	7
049	0.00	0	0.00	0	0
050	1.84	≥18	0.00	0	0
051	2.02	≥6	1.68	6	7
052	1.03	≥12	0.00	0	7
054	3.56	≥36	0.00	0	0
055	0.75	≥6	2.82	7	7
Total	**210.59**	**≥274**	**76.52**	**48**	

Estimated capital and additional annual O&M costs for CSS Plan improvements in the Lower Blue River Basin are shown in Table 14-6, in 2008 dollars (ENR CCI 9180). The estimated capital cost is approximately $47 million. Little or no additional annual O&M expense is expected in this Basin.

Table 14-6 Lower Blue River Basin Improvement Costs

Task Number	Task Name	Capital Cost (million $)	Annual O&M Cost (million $)
CD.APPA.015	Pump Station Upgrade: 15th Street	$3.00	
CD.APPA.016	Relief Sewer: Hardesty Ave and 31st Street	2.59	
CD.APPA.017	Relief Sewer: Vineyard and Lawn Street	2.59	
CD.APPA.018	Relief Sewer: 45th Street	0.73	
CD.APPA.019	Sewer Separation: 40th and Monroe	17.50	
CD.APPA.020	Sewer separation: Outfall 054	3.28	
CD.APPA.021	Dry Weather Sewer Line: Outfall 055	0.20	
CD.APPA.022	Small Sewer Rehabilitation: Lower Blue River	17.00	
Total		**$46.89**	**$0.00**

*all costs in 2008 dollars (ENR 9180)

14.6.3 Middle Blue River Basin

The general locations of the Middle Blue River Basin improvements are shown in Figure 14-5. Additional details for those improvements (other than controls for Outfalls 059 and 069) are located in the *Development of Preliminary Improvement Scenarios – Combined Sewer System Basins Technical Memorandum-Final MBR Task 8;* HDR; May 2008. The continued development of CSO controls for Outfalls 059 and 069 is discussed in Chapter 10 and detailed in *Green Alternatives for Outfalls 059 and 069;* OCP; June 2008. The Middle Blue River Basin improvement plan consists of:

- Construction of approximately 9,400 linear feet of relief sewer 30 and 36-inches in diameter.
- Sewer separation in approximately 270 acres, elimination of one outfall.
- Sewer separation in approximately 50 acres, elimination of one diversion structure.
- Construction of distributed storage using green infrastructure in the 475 acres basin tributary to Outfall 069.
- Construction of distributed storage using green infrastructure in the 269 acres basin tributary to Outfall 059.
- Construction of approximately 12,000 linear feet of consolidation piping 12 to 36 inches in diameter and elimination of 14 diversion structures.
- Construction of approximately 1,200 linear feet of 18-inch dry weather line to reduce the frequency of typical year overflows at Outfall 056. This improvement wasadded during Consent

Decree negotiations and is further described in *Middle Blue River Basin Combined Sewer System Outfall MDNR056; OCP; May 2009*.

- Raise manhole rim elevations and make structural modifications.
- Basin-wide small-sewer rehabilitation.

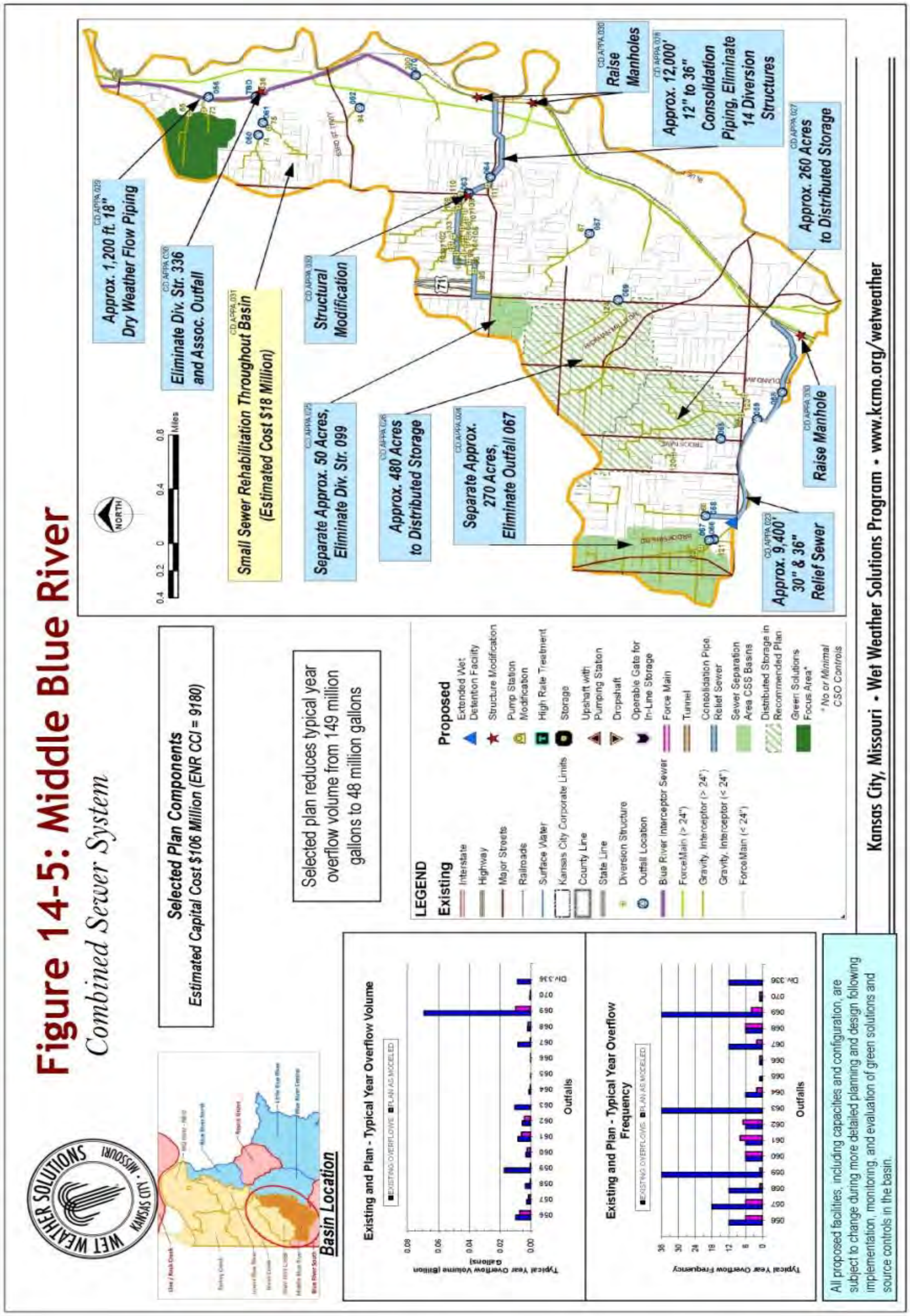


Figure 14-5: Middle Blue River
Combined Sewer System
Selected Plan Components
Estimated Capital Cost $106 Million (ENR CCI = 9180)
Selected plan reduces typical year overflow volume from 149 million gallons to 48 million gallons
Basin Location
Existing and Plan - Typical Year Overflow Volume
Existing and Plan - Typical Year Overflow Frequency
Outfalls
LEGEND
Existing
Interstate
Highway
Major Streets
Railroads
Surface Water
Kansas City Corporate Limits
County Line
State Line
Diversion Structure
Outfall Location
Blue River Interceptor Sewer
ForceMain (> 24")
Gravity, Interceptor (> 24")
Gravity, Interceptor (< 24")
ForceMain (< 24")
Proposed
Extended Wet Detention Facility
Structure Modification
Pump Station Modification
High Rate Treatment
Storage
Upshaft with Pumping Station
Dropshaft
Operable Gate for In-Line Storage
Force Main
Tunnel
Consolidation Pipe, Relief Sewer
Sewer Separation Area CSS Basins
Distributed Storage in Recommended Plan
Green Solutions Focus Area*
* No or Minimal CSO Controls
Approx. 1,200 ft. 18" Dry Weather Flow Piping
Eliminate Div. Str. 336 and Assoc. Outfall
Small Sewer Rehabilitation Throughout Basin (Estimated Cost $18 Million)
Structural Modification
Separate Approx. 50 Acres, Eliminate Div. Str. 099
Approx. 480 Acres to Distributed Storage
Separate Approx. 270 Acres, Eliminate Outfall 067
Approx. 9,400' 30" & 36" Relief Sewer
Raise Manhole
Approx. 260 Acres to Distributed Storage
Approx. 12,000' 12" to 36" Consolidation Piping, Eliminate 14 Diversion Structures
Raise Manholes
All proposed facilities, including capacities and configuration, are subject to change during more detailed planning and design following implementation, monitoring, and evaluation of green solutions and source controls in the basin.
Kansas City, Missouri • Wet Weather Solutions Program • www.kcmo.org/wetweather

The 100-acre pilot project discussed previously is included in the area tributary to Outfall 069 and forms a part of the planned overflow controls associated with that outfall.

The relief sewer project will replace existing lines with larger-diameter pipes. The purpose of this project is to mitigate surcharging and overflows and to correct significant system deficiencies identified by hydraulic modeling. This project assumes open-cut construction to install approximately 9,400 linear feet of sewer pipe. The project also includes replacement of 21 manholes and raising the rim elevations of 4 manholes.

The sewer separation projects are intended to eliminate CSOs at their respective outfalls. Sanitary flow will be conveyed to treatment and storm flow will be conveyed to the receiving stream. The projects include construction of new sanitary sewer pipes and manholes. The existing CSS will remain in place to serve as the storm sewer servicing the respective areas. Both separation projects include I/I rehabilitation for the existing collection system.

Estimated capital and additional annual O&M costs for CSS improvements in the Middle Blue River Basin are shown in Table 14-7, in 2008 dollars (ENR CCI 9180). The estimated capital cost is approximately $106 million. The estimated additional annual O&M cost of the improvements is $2.4 million.

Table 14-7 Middle Blue River Basin Improvement Costs

Task Number	**Task Name**	**Capital Cost (million $)**	**Annual O&M Cost (million $)**
CD.APPA.023	Relief Sewer: Diversion Structure 068 to Blue River Sewer	$5.52	
CD.APPA.024	Sewer Separation: Outfall 067	25.08	0.09
CD.APPA.025	Sewer Separation: Outfall 099	4.42	
CD.APPA.026.01	Distributed Storage: MBRB Green Infrastructure Pilot	6.09	$0.30
CD.APPA.026.02	Distributed Storage: Remaining Area Tributary to Outfall 069	28.20	1.30
CD.APPA.027	Distributed Storage: Outfall 059	11.80	0.70
CD.APPA.028	Sewer Pipe Consolidation: Outfall 063	6.08	.06
CD.APPA.029	Dry Weather Sewer Line: Outfall 056	0.30	
CD.APPA.030	Manhole Modifications: Middle Blue River	0.08	
CD.APPA.031	Small Sewer Rehabilitation: Middle Blue River	18.00	2.30
Total		**$105.57**	**$2.45**

*all costs in 2008 dollars (ENR 9180)

There were uncertainties associated with the aggregate performance of multiple, widely-distributed, green storage facilities on overflow volumes at the lower end of the system. The resulting total capital budget of

$46 million for green solutions upstream of Outfalls 059 and 069 was approximately 30 percent greater than the conceptual cost estimate. The 100-acre pilot project discussed previously will help answer questions concerning the aggregate performance. The capital budget for that pilot project is $6 million, which is included in the overall Plan budget of $28 million for pilot projects in the CSS also discussed previously. The estimated capital cost for distributed storage shown in Table 14-6 ($40 million) is for completion of the remaining green storage projects in the 644 acres upstream of Outfalls 059 and 069 not addressed by the pilot project.

Upon completion of the control measures, the typical-year overflow volume from the Middle Blue River Basin is projected to decrease from the existing level of 149 MG, to 48 MG. The performance criteria defined in Appendix A of the of the Consent Decree will be met if the modeled typical year overflow volume from the Lower Blue River and Middle Blue River basins combined (including overflows from the Blue River Interceptor Sewer, or BRIS) does not exceed 125 million gallons and the modeled number of typical year overflow events at any given outfall do not exceed the values listed in Table 14-8, subject to the tolerance defined in Appendix D of the Consent Decree. For certain outfalls, the Plan projects a lower activation frequency than that required by Appendix A of the Consent Decree. In those instances, the lower activation frequency remains the current planning objective, but can be relaxed during more detailed planning and design to the extent the maximum overflow volume as defined above is not exceeded.

Table 14-8 summarizes the current modeling results, by outfall, for the Middle Blue River Basin plan.

Table 14-8 Middle Blue River Modeled Plan Effectiveness

Outfall	**EXISTING OVERFLOWS**		**PLAN AS MODELED**		**CONSENT DECREE**
MDNR Outfall ID	Typical Year Annual Overflow Volume (MG)	Typical Year Annual Overflow Frequency	Estimated Recreation Season Overflow Volume (MG)	Estimated Recreation Season Overflow Activations	Typical Year Activation Frequency
056	9.67	≥12	5.68	6	7
057	2.61	≥18	1.46	6	7
058	3.23	≥12	0.32	1	7
059	17.11	≥36	6.79	6	7
060	3.08	≥6	2.23	6	7
061	8.09	≥6	5.87	8	7
062	5.40	≥6	3.94	7	7
063	10.19	≥36	0.00	0	0
064	1.06	≥6	0.15	2	7
065	0.02	≥1	0.00	0	7
066	0.07	≥1	0.03	1	7
067	8.17	≥12	0.27	2	7
068	2.10	≥6	1.56	6	7
069	69.38	≥36	19.50	6	7
070	0.48	≥1	0.31	1	7
Manholes	8.40	≥12	0.00	0	
Total	**149.06**	**≥207**	**48.10**	**58**	

14.6.4 Northeast Industrial District Basin

The general locations of the NEID Basin CSO control measures or improvements are shown in Figure 14-6. Additional improvement details are located in the *Technical Memorandum for Task 8-Preliminary Improvement Scenarios Gooseneck Creek and Lower Blue River Study Area;* CH2M Hill; July 2008. and *Missouri River Northeast Industrial District/Turkey Creek Project Area Preliminary Improvement Scenarios Technical Memorandum;* Black and Veatch; July 2008. The basin improvements consist of:

- Sewer separation in approximately 260 acres
- Green infrastructure pilot project(s) to achieve a significantly higher level of CSO control downstream of the project area
- Installation of an automated gate in the existing Gooseneck Arch Sewer
- Construction of a 4-MGD pump station
- Basin-wide small-sewer rehabilitation

The above improvements include those at and upstream of Outfall 033 which were combined with the NEID improvements during Consent Decree negotiations.

The main projects in the Plan for this basin include separation of approximately 260 acres of CSS to eliminate Outfall 076 and installation of an automated gate and pump station to reduce overflow at Outfall 033. The sewer separation project includes construction of an estimated 13,500 linear feet of new sanitary sewer lines ranging in size from 8- to 12-inches in diameter. The gate will be installed at the downstream end of the Gooseneck Arch Sewer at Manhole S024-813. The gate will permit up to approximately 4 MG of storage in the arch sewer. A 4-MGD pump station will be located near Manhole S024-813 to convey in-line storage to the BRIS. The adjustable gate will allow volumes surpassing storage and pumping capacities to overflow to the Blue River at Outfall 033.

The green solutions pilot projects have not been identified and will be determined after further study. Costs associated with pilot projects are included in the overall Plan budget of $28 million for pilot projects in the CSS discussed previously.

The control measures for the Northeast Industrial District Basin must, acting in combination with the Brush Creek Basin HRT facility, reduce the modeled typical year wet weather overflow volume from the existing volume of 1.56 billion gallons to not more than 700 MG. Although the Consent Decree does not include performance criteria for overflow frequency, the modeled typical-year overflow frequency for all the basin outfalls decreased by 14 percent when compared to existing conditions, from a cumulative total of 276 or more events to an approximate total of 206 events. The modeled range of annual overflow frequency for individual outfalls varied from 6 events to 34 events (typical year overflows at Outfall 076 will be eliminated as a result of the upstream sewer separation and associated elimination of Diversion Structure 006). Table 14-9 summarizes the current modeling results, by outfall, for the NEID Basin plan.

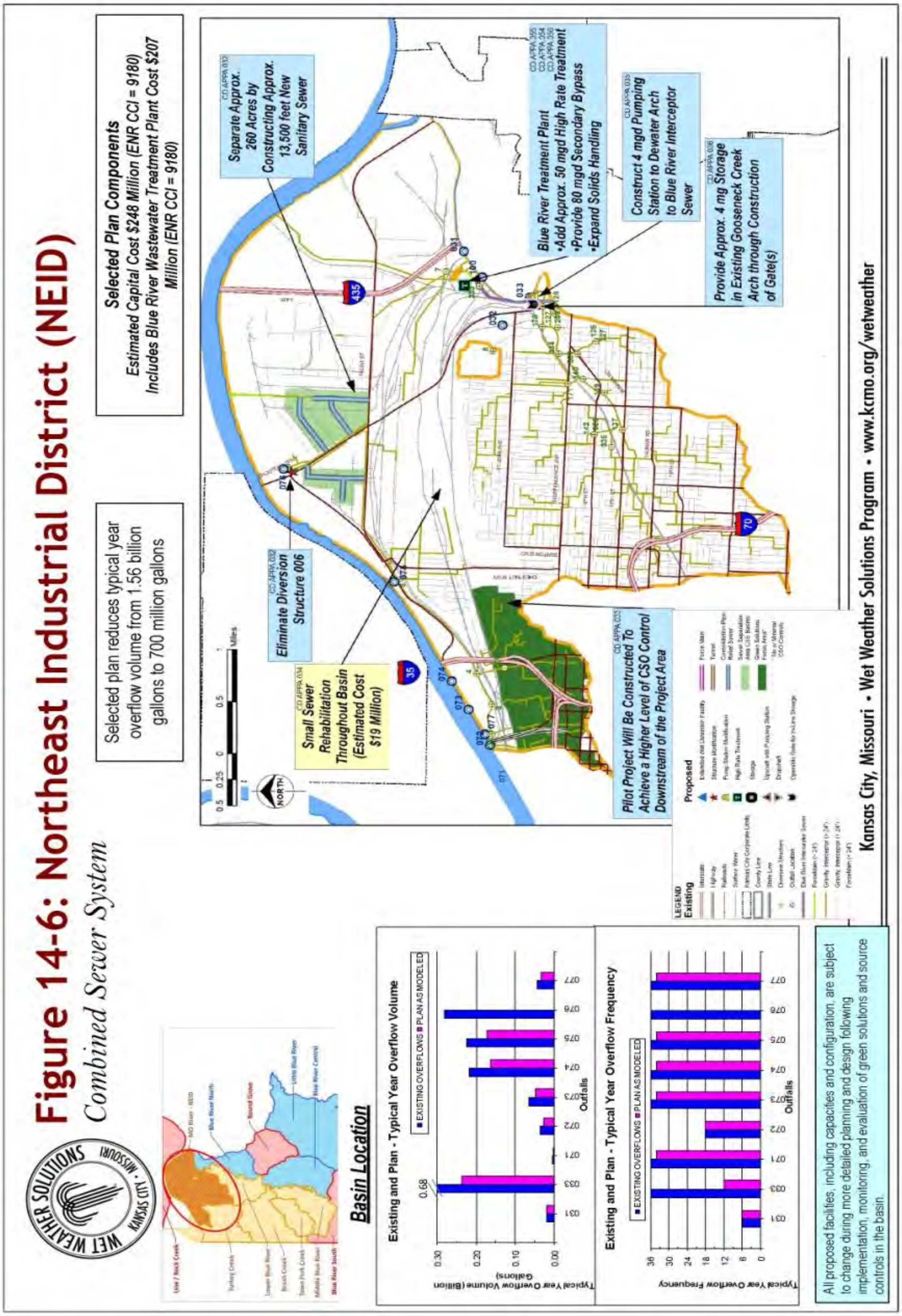


Figure 14-6: Northeast Industrial District (NEID)
Combined Sewer System
Selected plan reduces typical year overflow volume from 1.56 billion gallons to 700 million gallons
Selected Plan Components
Estimated Capital Cost $248 Million (ENR CCI = 9180)
Includes Blue River Wastewater Treatment Plant Cost $207 Million (ENR CCI = 9180)
Basin Location
Existing and Plan - Typical Year Overflow Volume
EXISTING OVERFLOWS PLAN AS MODELED
0.68
Typical Year Overflow Volume (Billion Gallons)
Outfalls
Existing and Plan - Typical Year Overflow Frequency
Typical Year Overflow Frequency
031 033 071 072 073 074 075 076 077
Eliminate Diversion Structure 006
Small Sewer Rehabilitation Throughout Basin (Estimated Cost $19 Million)
Separate Approx. 260 Acres by Constructing Approx. 13,500 feet New Sanitary Sewer
Blue River Treatment Plant
•Add Approx. 50 mgd High Rate Treatment
•Provide 80 mgd Secondary Bypass
•Expand Solids Handling
Construct 4 mgd Pumping Station to Dewater Arch to Blue River Interceptor Sewer
Provide Approx. 4 mg Storage in Existing Gooseneck Creek Arch through Construction of Gate(s)
Pilot Project Will Be Constructed To Achieve a Higher Level of CSO Control Downstream of the Project Area
LEGEND
Existing
Proposed
Miles
NORTH
All proposed facilities, including capacities and configuration, are subject to change during more detailed planning and design following implementation, monitoring, and evaluation of green solutions and source controls in the basin.
Kansas City, Missouri • Wet Weather Solutions Program • www.kcmo.org/wetweather

Table 14-9 Northeast Industrial District Modeled Plan Effectiveness

Outfall	**EXISTING OVERFLOWS**		**PLAN AS MODELED**	
MDNR Outfall ID	Typical Year Annual Overflow Volume (MG)	Typical Year Annual Overflow Frequency	Estimated Recreation Season Overflow Volume (MG)	Estimated Recreation Season Overflow Activations
031	17.20	≥6	18.28	6
033	676.38	≥36	238.11	12
071	2.37	≥36	1.79	34
072	35.52	≥18	26.22	18
073	63.78	≥36	47.79	34
074	219.28	≥36	163.13	34
075	224.76	≥36	171.15	34
076	280.99	≥36	0	0
077	42.50	≥36	33.46	34
Total	**1,562.78**	**≥240**	**699.93**	**206**

Estimated capital and additional annual O&M costs for CSS Plan improvements in the NEID Basin are shown in Table 14-10, in 2008 dollars (ENR CCI 9180). The estimated capital cost is approximately $41.90 million. O&M expense is expected in total $0.50M in this basin.

Table 14-10 Northeast Industrial District Basin Improvement Costs

Task Number	**Task Name**	**Construction Cost (million $)**	**Annual O&M Cost (million $)**
CD.APPA.032	Sewer Separation: Diversion Structure 006	$5.19	
CD.APPA.033	Green Infrastructure Pilot: Northeast Industrial District	7.44	$0.37
CD.APPA.034	Small Sewer Rehabilitation: Northeast Industrial District	19.00	
CD.APPA.035	Pump Station: Gooseneck Arch Sewer	2.55	$0.09
CD.APPA.036	In-Line Storage: Gooseneck Arch Sewer Gate	7.72	0.04
Total		**$41.90**	**$0.50**

*all costs in 2008 dollars (ENR 9180)

14.6.5 Town Fork Creek Basin

The general locations of the Town Fork Creek Basin CSO control measures or improvements are shown in Figure 14-7. Additional improvement details are presented in the *Final Development of Preliminary Improvement Scenarios Technical Memorandum; CDM;* June 2008. The basin control measures generally consist of:

- Construction of approximately 13,000 linear feet of 16-foot diameter deep tunnel with an approximate storage capacity of approximately 19 MG

- Placement of approximately 3,800 linear feet of 24 to 84-inch diameter consolidation piping near and downstream of Outfall 097
- Placement of approximately 1,100 linear feet of approximately 36 inch diameter consolidation piping downstream of Diversion Structure 46 (Outfall 079)
- Placement of approximately 1,920 LF of 24 to 36-inch diameter consolidation piping
- Sewer separation in approximately 200 acres, with green solutions for controlling stormwater runoff
- Construct new diversion structure and approximately 450 linear feet of consolidation piping; add flap gate at Outfall 083. This improvement was added during Consent Decree negotiations and is, further described in *Town Fork Creek Basin Combined Sewer System Outfall MDNR083; OCP; May 2009*.
- Construct new diversion structure and approximately 300 linear feet of consolidation piping; add flap gate at Outfall 099. This improvement was added during Consent Decree negotiations and is further described in *Town Fork Creek Basin Combined Sewer System Outfall MDNR099; OCP; May 2009*.
- Various baseline improvements
- Basin-wide, small-sewer rehabilitation

The 16-foot diameter deep-storage tunnel will provide approximately 19 MG of storage capacity. Taken together with the tunnel in the Brush Creek Basin described previous in this chapter, the total storage provided must be 50 MG. The tunnel will connect to the Brush Creek deep-storage tunnel near Diversion Structure 314. Stored flow will be treated at an HRT/disinfection facility and the effluent will discharge to the Blue River (see section 14.5.1 for discussion of HRT/disinfection facility).

Sewer separation will take place in two areas of the Town Fork Creek Basin. The larger area is approximately 138 acres and is located west of Outfall 081. The smaller area is approximately 59 acres and is generally located east of Outfall 082.

Consolidation piping will be installed in five areas. The purpose of these projects is to re-route wet-weather flows the deep-tunnel drop shafts in order to reduce or eliminate overflows at existing outfalls.

Various baseline improvements include measures to assure the current collection system operates at its maximum capacity. The baseline improvements include sediment, debris, and blockage removal; and diversion structure clogged-grate removal (plugged grated inlets covering dry-weather outlet pipes should either be removed or maintained more frequently).

Upon completion of the control measures, the typical-year overflow volume from the Town Fork Creek Basin is projected to decrease from the existing level of 341 million gallons, to 33.6 million gallons. The performance criteria defined in Appendix A of the Consent Decree will be met if the modeled typical-year overflow from the Brush Creek and Town Fork Creek basins combined does not exceed 59 million

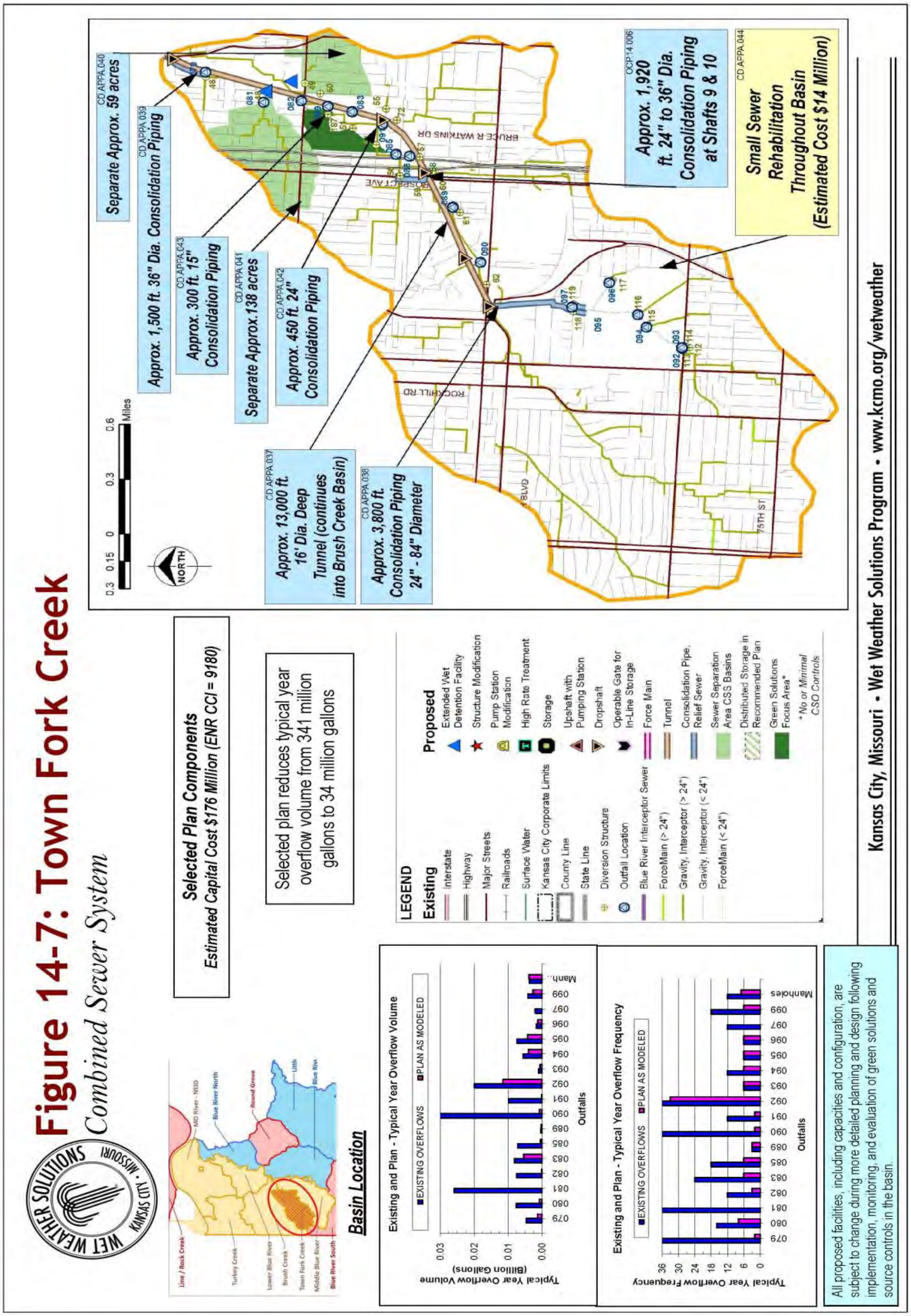


Figure 14-7: Town Fork Creek
Combined Sewer System
Selected Plan Components
Estimated Capital Cost $176 Million (ENR CCI = 9180)
Selected plan reduces typical year overflow volume from 341 million gallons to 34 million gallons
Basin Location
Approx. 1,500 ft. 36" Dia. Consolidation Piping
Separate Approx. 59 acres
Approx. 300 ft. 15" Consolidation Piping
Separate Approx. 138 acres
Approx. 450 ft. 24" Consolidation Piping
Approx. 13,000 ft. 16' Dia. Deep Tunnel (continues into Brush Creek Basin)
Approx. 3,800 ft. Consolidation Piping 24" - 84" Diameter
Approx. 1,920 ft. 24" to 36" Dia. Consolidation Piping at Shafts 9 & 10
Small Sewer Rehabilitation Throughout Basin (Estimated Cost $14 Million)
LEGEND
Existing
Proposed
Existing and Plan - Typical Year Overflow Volume
Existing and Plan - Typical Year Overflow Frequency
EXISTING OVERFLOWS
PLAN AS MODELED
Outfalls
All proposed facilities, including capacities and configuration, are subject to change during more detailed planning and design following implementation, monitoring, and evaluation of green solutions and source controls in the basin.
Kansas City, Missouri • Wet Weather Solutions Program • www.kcmo.org/wetweather

gallons and the modeled number of overflow events at any given outfall do not exceed the values listed in Table 14-11.. For certain outfalls, the Plan projects a lower activation frequency than that required by Appendix A of the Consent Decree. In those instances, the lower activation frequency remains the current planning objective, but can be relaxed during more detailed planning and design to the extent the maximum overflow volume as defined above is not exceeded.

Outfalls 092-096 are each located upstream of proposed consolidation piping extending from the deep-storage tunnel to Forest Hill Cemetery. These outfalls discharge to an open-channel system in the cemetery. All typical year overflows those outfalls will be re-captured and controlled by the downstream consolidation piping.

Table 14-11 summarizes the current modeling results, by outfall, for the Town Fork Creek Basin plan.

Table 14-11 Town Fork Creek Modeled Plan Effectiveness

Outfall	**EXISTING OVERFLOWS**		**PLAN AS MODELED**		**CONSENT DECREE**
MDNR Outfall ID	Typical Year Annual Overflow Volume (MG)	Typical Year Annual Overflow Frequency	Estimated Recreation Season Overflow Volume (MG)	Estimated Recreation Season Overflow	Max. Typical Year Activation Frequency for
079	4.70	≥36	1.30	2	7
080	7.61	≥16	0.77	8	7
081	25.88	≥36	0.00	0	0
082	7.44	≥12	0.02	3	7
083	8.12	≥24	3.30	6	7
085	7.12	≥18	0.44	6	7
089	0.30	≥3	0.22	3	7
090	224.70	≥36	0.75	2	7
091	9.84	≥12	0.07	2	7
092	19.88	≥36	11.54	33	N/A
093	1.00	≥6	0.56	6	7
094	5.57	≥12	3.98	6	7
095	7.39	≥6	4.23	6	7
096	1.63	≥6	1.22	6	7
097	1.96	≥12	0.00	0	0
099	4.17	≥18	1.36	6	7
Manholes	3.68	≥12	3.83	7	7
Total	**340.99**	**≥301**	**33.60**	**102**	

Estimated capital and additional annual O&M costs for CSS Plan improvements in the Town Fork Creek Basin are shown in Table 14-12, in 2008 dollars (ENR CCI 9180). The estimated capital cost is approximately $176 million. The estimated additional annual O&M cost of the improvements is approximately $1.2 million.

Table 14-12 Town Fork Creek Basin Improvement Costs

Task Number	Task Name	Construction Cost (million $)	Annual O&M Cost (million $)
CD.APPA.037	Deep Tunnel Storage: Town Fork Creek	$123.88	$1.23
CD.APPA.038	Sewer Pipe Consolidation: Outfall 097	$8.83	
CD.APPA.039	Sewer Pipe Consolidation: Outfall 079	$2.50	
CD.APPA.040	Sewer Separation: Outfall 082	$5.75	
CD.APPA.041	Sewer Separation: Outfall 081	$12.00	
CD.APPA.042	Diversion Structure and Consolidation Piping: Outfall 083	$0.20	
CD.APPA.043	Diversion Structure and Consolidation Piping: Outfall 099	$1.77	
CD.APPA.044	Small Sewer Rehabilitation: Town Fork Creek	$14.00	
OCP.14.006	Sewer Pipe Consolidation: Diversion Structure 056	$4.56	
OCP.14.007	Baseline Improvements: Town Fork Creek	$2.53	
Total		**$176.02**	**$1.23**

*all costs in 2008 dollars (ENR 9180)

14.6.6 Turkey Creek Basin/Central Industrial District (CID) Basins

The general locations of the Turkey Creek/CID Basins CSO control measures or improvements are shown in Figure 14-8. Additional improvement details are presented in the *Missouri River Northeast Industrial District/Turkey Creek Project Area Preliminary Improvement Scenarios Technical Memorandum;* Black and Veatch; July 2008. The basin control measures generally consist of:

- Sewer separation in approximately 66 acres
- Construction of approximately 10,600 linear feet of 48-inch force main
- Central Industrial District Storm Drainage Improvements- replacement of gates at the Santa Fe Pumping Station and institution of real-time gate control
- Construction of approximately 7,500 linear feet of 26-foot diameter deep-storage tunnel with a capacity of approximately 30 MG
- Construction of a 30-MGD deep-tunnel pump station
- Upgrade the Turkey Creek Pump Station capacity to 30 MGD
- Construction of in-line storage gates for real-time control of depths in the OK Creek sewer to take advantage of available system storage
- Basin-wide small-sewer rehabilitation
- Green infrastructure pilot project(s) in the CID to achieve a significantly higher level of CSO control downstream of the project area

The major control component of the basin improvement plan is the deep-storage tunnel. The tunnel will be located over 200 feet deep and will have a storage capacity of 30 MG. The preliminary tunnel

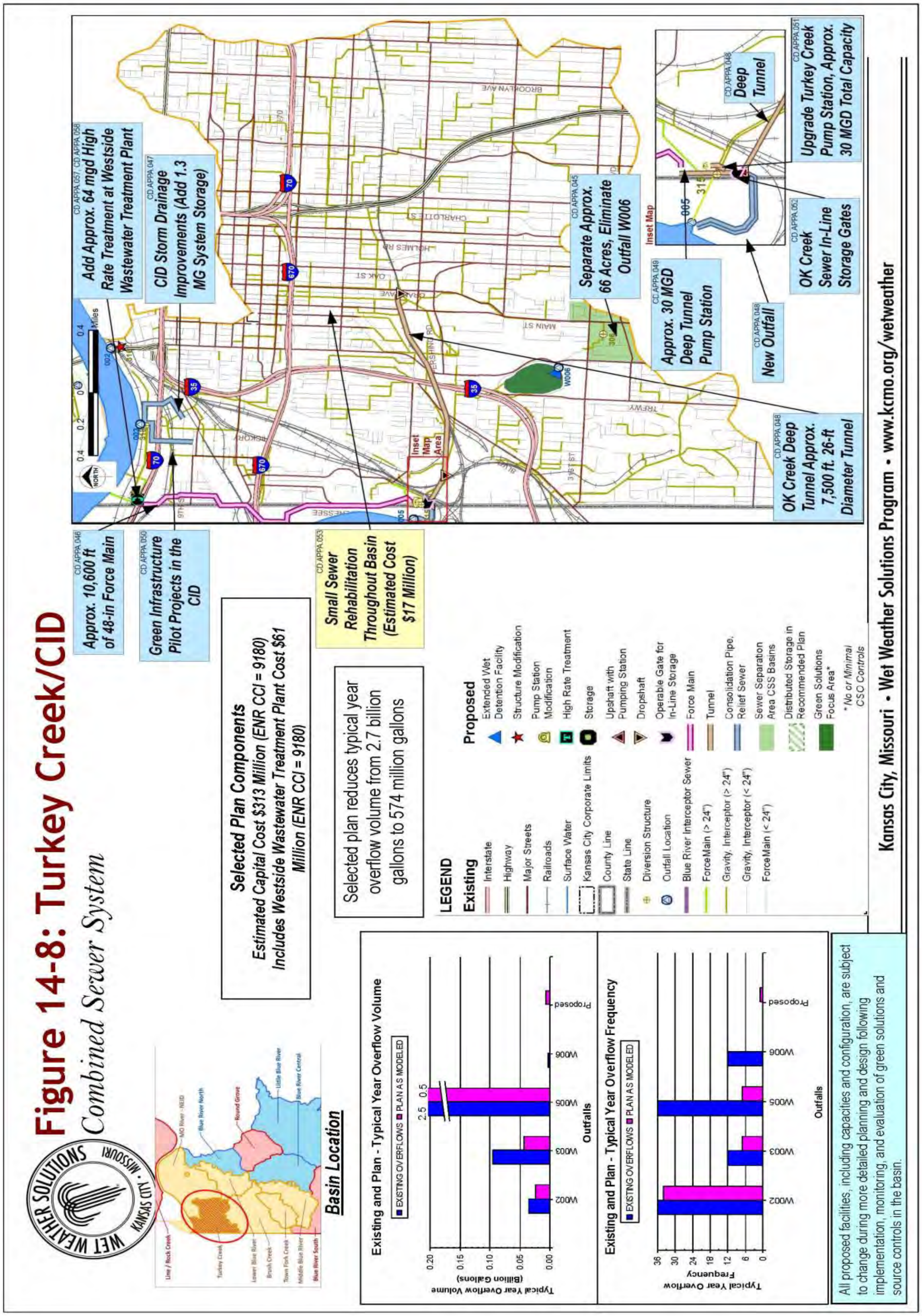


Figure 14-8: Turkey Creek/CID
Combined Sewer System
WET WEATHER SOLUTIONS KANSAS CITY, MISSOURI
Basin Location
Existing and Plan - Typical Year Overflow Volume
EXISTING OVERFLOWS PLAN AS MODELED
Typical Year Overflow Volume (Billion Gallons)
Outfalls
W002 W003 W005 W006 Proposed
Existing and Plan - Typical Year Overflow Frequency
Typical Year Overflow Frequency
Selected Plan Components
Estimated Capital Cost $313 Million (ENR CCI = 9180)
Includes Westside Wastewater Treatment Plant Cost $61 Million (ENR CCI = 9180)
Selected plan reduces typical year overflow volume from 2.7 billion gallons to 574 million gallons
Approx. 10,600 ft of 48-in Force Main
Green Infrastructure Pilot Projects in the CID
Small Sewer Rehabilitation Throughout Basin (Estimated Cost $17 Million)
Add Approx. 64 mgd High Rate Treatment at Westside Wastewater Treatment Plant
CID Storm Drainage Improvements (Add 1.3 MG System Storage)
Separate Approx. 66 Acres, Eliminate Outfall W006
Approx. 30 MGD Deep Tunnel Pump Station
New Outfall
OK Creek Sewer In-Line Storage Gates
Upgrade Turkey Creek Pump Station, Approx. 30 MGD Total Capacity
Deep Tunnel
OK Creek Deep Tunnel Approx. 7,500 ft. 26-ft Diameter Tunnel
Inset Map
LEGEND
Existing
Interstate
Highway
Major Streets
Railroads
Surface Water
Kansas City Corporate Limits
County Line
State Line
Diversion Structure
Outfall Location
Blue River Interceptor Sewer
ForceMain (> 24")
Gravity, Interceptor (> 24")
Gravity, Interceptor (< 24")
ForceMain (< 24")
Proposed
Extended Wet Detention Facility
Structure Modification
Pump Station Modification
High Rate Treatment
Storage
Upshaft with Pumping Station
Dropshaft
Operable Gate for In-Line Storage
Force Main
Tunnel
Consolidation Pipe, Relief Sewer
Sewer Separation Area CSS Basins
Distributed Storage in Recommended Plan
Green Solutions Focus Area*
* No or Minimal CSO Controls
All proposed facilities, including capacities and configuration, are subject to change during more detailed planning and design following implementation, monitoring, and evaluation of green solutions and source controls in the basin.
Kansas City, Missouri • Wet Weather Solutions Program • www.kcmo.org/wetweather

alignment would begin just south of the Turkey Creek Pump Station and terminate near West 22nd Street and Grand Avenue. The majority of the preliminary alignment is within the Kansas City Terminal Railway Company right-of-way, and generally parallels the OK Creek sewer.

The deep-storage tunnel will, in addition to providing storage for CSOs, be designed to function as a conveyance conduit during infrequent rainfall events, reducing peak-flow rates and flood damage in the basin. A double box culvert will be constructed as a relief sewer to convey wet-weather flows that exceed the tunnel's storage capacity to a new outfall at the Kansas River.

A 30-MGD pump station, working shaft, and ancillary facilities will be constructed to dewater the deep tunnel within 48 hours. The deep-tunnel pump station will be located at the existing Turkey Creek Pump Station site. Flow will be pumped to the Westside WWTP through a new 48-inch force main that will replace the existing force main from the Turkey Creek Pumping Station.

The existing Turkey Creek Pumping Station will be reconstructed (firm capacity of 30 MGD) and will draw from the OK Creek sewer just upstream of the in-line storage gates. The in-line gates are expected to provide up to 20 MG of storage in the OK Creek sewer. An additional one million gallons of system storage is expected to be made available upon completion of the ongoing CID storm drainage improvements and institution of real-time control of in-line gates at the Santa Fe Pumping Station.

The sewer separation project is in the area of 31st Street and Broadway, upstream of George Washington Lake in Penn Valley Park. This project will eliminate Outfall W006. Following separation, only stormwater will discharge to the lake. This project includes use of green infrastructure to control stormwater runoff reaching George Washington Lake inflows.

Green solutions pilot projects in the basin have not been identified and will be determined after further study. Costs associated with pilot projects are included in the overall Plan budget of $28 million for pilot projects in the CSS discussed previously.

The control measures must reduce the typical year wet weather overflow volume from the existing volume of 2.66 billion gallons to not more than 574 MG. The Consent Decree does not include performance criteria for overflow frequency except for Outfall 005 (max. 7 overflows in a typical year). The modeled typical year overflow frequency for all outfalls decreased by 49 percent from existing conditions, from a cumulative total of 96 or more events to an approximate total of 49 events. The modeled range of annual overflow frequency for individual outfalls varied from 0 events to 34 events. Table 14-13 summarizes the modeling results, by outfall, for the Turkey Creek/CID Basin plan. Outfall W002 is located along Broadway Avenue and discharges to the Missouri River.

Table 14-13 Turkey Creek/CID Modeled Plan Effectiveness

Outfall	EXISTING OVERFLOWS		PLAN AS MODELED	
MDNR Outfall ID	Typical Year Annual Overflow Volume (MG)	Typical Year Annual Overflow Frequency	Estimated Recreation Season Overflow Volume (MG)	Estimated Recreation Season Overflow Activations
W002	35.30	≥36	22.8	34
W003	95.00	≥12	42.9	7
W005	2,525.90	≥36	501.4	7
W006	2.80	≥12	0	0
NA*			6.46	1
Total	**2,659.00**	**>96**	**573.56**	**49**

*New Outfall from Turkey Creek Tunnel

Estimated capital and additional annual O&M costs for CSS Plan improvements in the Turkey Creek Basin are shown in Table 14-14, in 2008 dollars (ENR CCI 9180). The estimated capital cost is approximately $252 million. The estimated additional annual O&M cost of the improvements is approximately $2.2 million.

Table 14-14 Turkey Creek Basin Improvement Costs

Task Number	**Task Name**	**Capital Cost (million $)**	**Annual O&M Cost (million $)**
CD.APPA.045	Sewer Separation: 31st Street and Broadway	$9.47	
CD.APPA.046	Pump Station Force Main: Turkey Creek/Central Industrial District	13.25	
CD.APPA.047	Storm Drainage Improvements: Turkey Creek/Central Industrial District	2.19	$.01
CD.APPA.048	Deep Tunnel Storage: Turkey Creek/Central Industrial District	122.59	0.24
CD.APPA.049	Deep Tunnel Pump Station: Turkey Creek/Central Industrial District	63.58	0.93
CD.APPA.050	Green Infrastructure Pilot: Turkey Creek/Central Industrial District	$7.44	0.37
CD.APPA.051	Pump Station Upgrade: Turkey Creek	11.59	0.58
CD.APPA.052	In-Line Storage: OK Creek Gates	4.50	0.02
CD.APPA.053	Small Sewer Rehabilitation: Turkey Creek/Central Industrial District	17.00	
Total		**$251.61**	**$2.15**

*all costs in 2008 dollars (ENR 9180)

14.6.7 Blue River Interceptor Sewer (BRIS)

The BRIS is the principal means of delivering flow to the Blue River WWTP from the Gooseneck Creek, Lower Blue River, Brush Creek, Town Fork Creek, and Middle Blue River Basins in the CSS. It also carries flow discharged from the Blue River South, Round Grove, and Blue River Central Basins in the SSS.

Wastewater from the Blue River South Basin flows by gravity to the 87th Street Pumping Station and is discharged directly through a 72-inch diameter force main extending from that pumping station to the BRIS, just north of the confluence of Brush Creek and the Blue River. The Blue River Interceptor Sewer carries flow from the CSS in the Middle Blue River, Town Fork Creek and Brush Creek Basins. The Round Grove Pumping Station drains the SSS in the Blue River Central and Round Grove Creek Basins. The Round Grove Pumping Station also discharges to the BRIS. The BRIS then extends northerly to the Blue River WWTP, picking up additional CSS discharges from the Lower Blue River and Gooseneck Creek Basins, prior to its downstream terminus at the headworks of the Blue River WWTP.

Overflows from the CSS and SSS basins served by the BRIS are controlled by the measures that must be implemented in the basins and the Consent Decree does not contain any additional control measures for the BRIS.

14.6.8 Blue River WWTP

A simplified flow schematic for the Blue River WWTP is presented in Figure 14-9. Plan control measures or improvements at the Blue River WWTP include:

- Modifications for diversion of up to 80 MGD of primary-plant effluent directly to disinfection facilities for treatment and discharge to the Blue River during wet-weather events, which cause flows to exceed the 140-MGD secondary treatment capacity
- Construction of a 50-MGD HRT/disinfection facility for treatment of wet-weather flow
- Expansion of solids handling facilities to accommodate additional loading from all proposed upgrades to the WWTP

Figure 14-10 is a simplified flow schematic of the primary plant following addition of the secondary bypass and HRT facilities. Disinfecting and discharging 80 MGD of primary-plant effluent maximizes use of the primary-plant treatment capacity. Currently, the treatment capacity of the primary plant (220 MGD) exceeds the treatment capacity of the secondary plant (140 MGD). This modification will result in primary treatment and disinfection of up to 80 MGD of wet-weather flows bypassing the secondary treatment plant.

Construction of the HRT/disinfection facility, in addition to that secondary bypass, will enable full utilization of the primary-plant influent sewer capacity (maximum capacity without overflow of 220 MGD from the BRIS and firm pumping capacity of 48 MGD from the NEID Pump Station). Flow in excess of primary-clarifier capacity will divert from the primary-clarifier influent line to the new facility.

The HRT facility will include fine screening, high rate clarification, and disinfection. Planned Blue River WWTP improvements are expected to eliminate any typical-year overflow from the primary-plant Outfall 100. Additional improvement details are located in the *Joint Use Facilities Expansion Capabilities Technical Memorandum;* OCP; September 2008.

Figure 14-9 Existing Blue River WWTP Flow Schematic

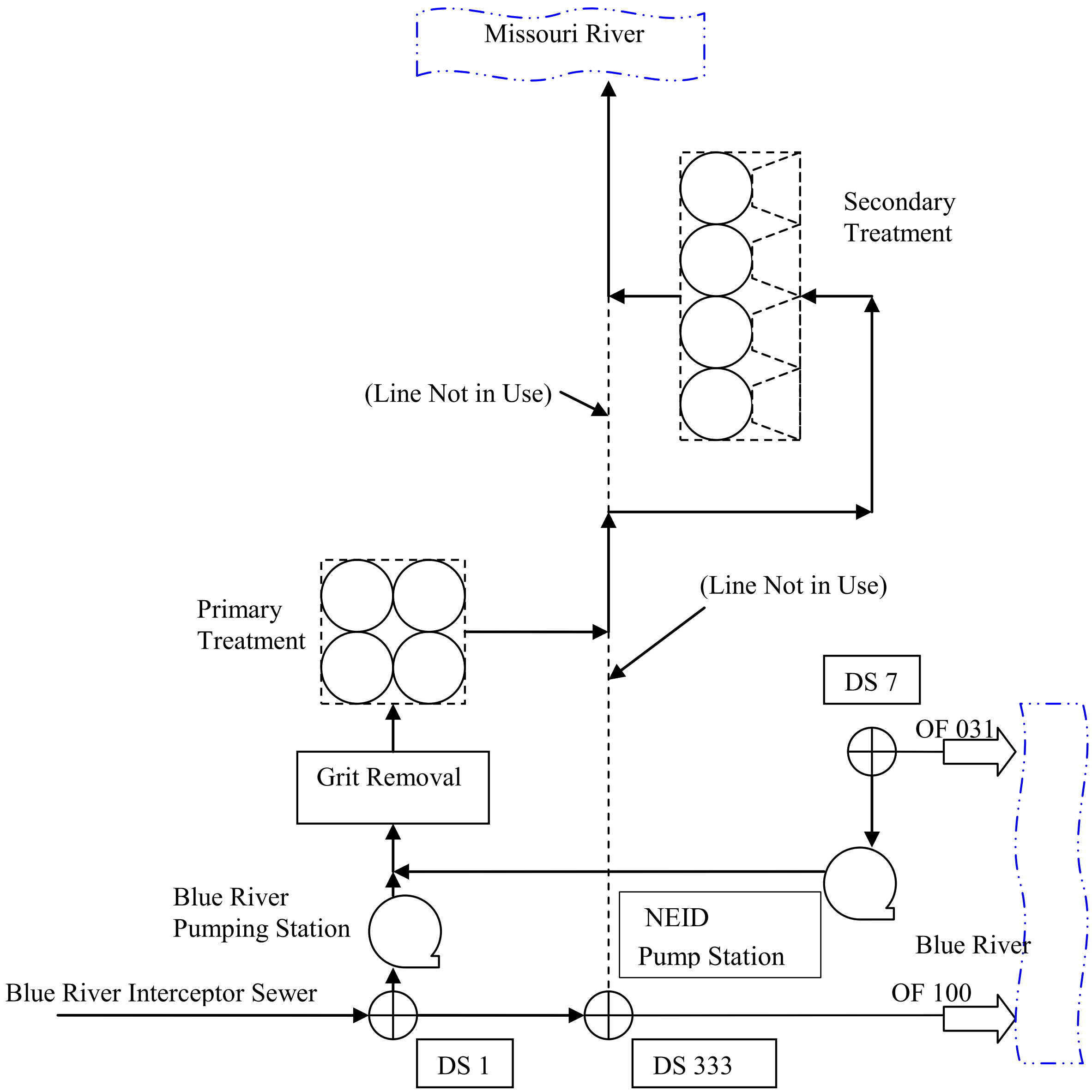
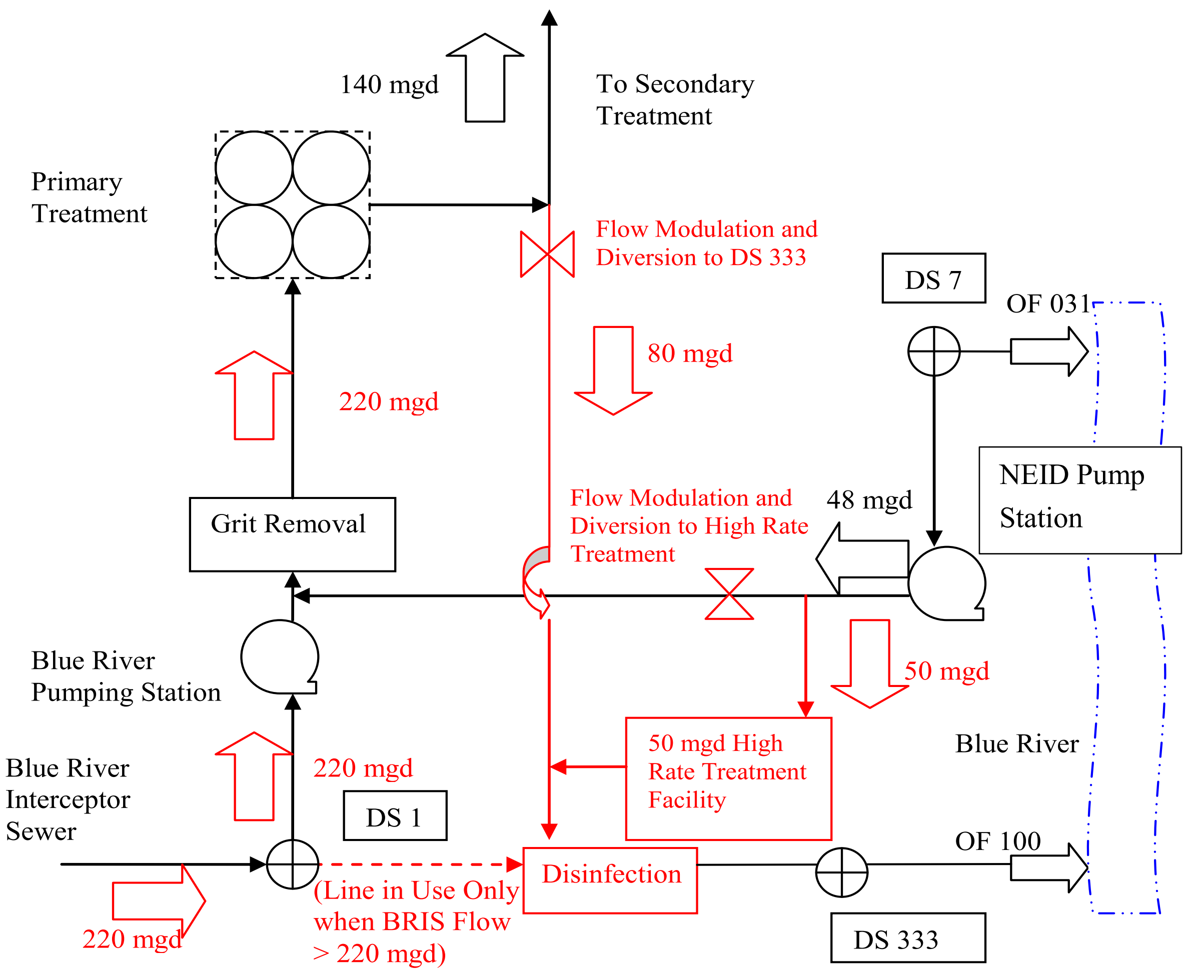


Figure 14-10 Future Blue River Primary WWTP Flow Schematic



The existing Blue River solids handling facility consists of dissolved air flotation (DAF), anaerobic digesters, belt filter presses (BFPs), and incinerators. Combined primary and secondary sludge from both Birmingham and Westside WWTPs are presently combined with secondary sludge from Blue River WWTP. Sludge from each of the HRT facilities included in the Plan (three facilities south of the Missouri

River and one at the Birmingham WWTP) will be directed through the primary clarifiers at the Blue River WWTP to remove the heavier solids.

The necessary additional solids handling components are presently expected to include:

6. Three primary DAF units
7. Three belt filter presses
8. Three incinerators
9. Two digester DAF units
10. Seven anaerobic digesters

Estimated capital and additional annual O&M costs for presently anticipated improvements at the Blue River WWTP are shown in Table 14-15, in 2008 dollars (ENR CCI 9180). The estimated capital cost is approximately $207 million. The estimated additional annual O&M cost of the improvements is approximately $9.3 million, the majority of which is for expanded solids handling.

Table 14-15 Blue River WWTP Improvement Costs

Task Number	**Task Name**	**Construction Cost (million $)**	**Annual O&M Cost (million $)**
CD.APPA.054	WWTP Upgrade: Blue River WWTP Flow Diversion	$3.05	
CD.APPA.055	Wet-weather Treatment Facility: Blue River WWTP	42.89	$2.28
CD.APPA.056	WWTP Upgrade: Blue River WWTP Solids Handling	161.05	7.04
Total		**$206.99**	**$9.32**

*all costs in 2008 dollars (ENR 9180)

During Consent Decree negotiations the City submitted a memorandum titled *Combined Sewer System Blue River WWTP; OCP; July 2009* that described the required plant improvements and associated costs to provide additional peak flow treatment. This memorandum was prepared at the request of Region VII of the USEPA to further evaluate the feasibility of expanding treatment capacity at the Blue River WWTP in lieu of providing bypass of primary effluent and high rate treatment to augment plant capacity as was proposed by the City and described above.

During Consent Decree negotiations, the City documented that expansion of treatment capacity at the Blue River WWTP in lieu of the facilities in described the Plan would require new primary and secondary facilities having a peak hour capacity of 140 mgd and an average daily flow of 46 mgd. The estimated capital cost of expanding treatment capacity is approximately $400 million, compared to a capital cost for the selected Plan improvements of $45 million to as much as $85 million (should it not eventually prove possible to increase peak flows through the existing primary plant to as much as 220 mgd).

The City also noted that should future regulations eventually require nutrient removal to levels recommended by an EPA scientific advisory group as necessary to address hypoxia in the Gulf of Mexico, the future capital cost for complying with those effluent limits could increase the cost of the additional treatment facilities by roughly $212 million should the expansion of secondary treatment described in the memorandum be implemented.

In aggregate, the capital cost (in 2008 dollars) for capacity-related improvements at the Blue River WWTP was estimated to increase by $315-$355 million compared to costs for the planned HRT facilities.

Following its review of the July, 2009 memorandum, the USEPA indicated during the Consent Decree negotiations that the analysis constituted an acceptable No Feasible Alternative analysis for the Blue River WWTP under 40 C.F.R. § 122.41(m).

14.6.9 Westside WWTP

Required Plan improvements at the Westside WWTP include providing 30 to 32 MGD of peak treatment capacity through modification of existing treatment facilities (Phase 1 of improvements at Westside WWTP) and a 32-MGD, HRT/disinfection facility (Phase 2 of improvements at Westside WWTP). A 64-MGD HRT/disinfection facility (constructed in two phases, each having a capacity of 32 mgd) will be needed if is determined that providing additional peak treatment capacity as presently intended during Phase 1 is infeasible. The Consent Decree requires the City to prepare and submit a no-feasible alternative analysis pursuant to 40 C.F.R. § 122.41(m) one year prior to implementation of the first phase of this control measure if it is determined that an expansion of peak treatment capacity is impracticable (e.g., by 2016), requiring the substitution of an initial 32 mgd HRT in lieu of that expansion.

During Consent Decree negotiations the City submitted a memorandum titled *Combined Sewer System Westside WWTP; OCP; July 2009* that described the required plant improvements and associated costs to provide additional peak flow treatment. This memorandum was prepared at the request of Region VII of the USEPA to further evaluate the feasibility of expanding treatment capacity at the Westside River WWTP in lieu of providing high rate treatment to augment plant capacity.

The City documented that expansion of treatment capacity at the Westside WWTP in lieu of the facilities proposed in the Plan would require new primary and secondary facilities having a peak hour capacity of 40 mgd and an average daily flow of 13.9 mgd. The estimated capital cost of the treatment capacity expansion facilities, together with associated changes in the upstream collection system, would be approximately $173.2 million, as compared to a capital cost for the submitted Plan improvements of $61.4 million.

The City also noted that should future regulations eventually require nutrient removal to levels recommended by an EPA scientific advisory group as necessary to address hypoxia in the Gulf of Mexico, the future capital cost for complying with those effluent limits could be increased by roughly $77 million should the expansion of treatment capacity contemplated in this analysis be implemented.

The City documented that although it was feasible to implement additional measures, the estimated capital cost (in 2008 dollars) for capacity-related improvements at and upstream of the Westside WWTP could be expected to increase by $112 million should the selected Plan be modified to replace the recommended high rate treatment facilities with expanded conventional primary and secondary treatment capacity. The overall increase in capital cost (again in 2008 dollars) could eventually reach $189 million should nitrogen removal to levels as low as 3 mg/l be required at some future point in time.

Following its review of the July, 2009 memorandum, the USEPA indicated during the Consent Decree negotiations that the analysis for the second 32 MGD HRT facility at the Westside WWTP constituted an acceptable No Feasible Alternative analysis under 40 C.F.R. § 122.41(m).

Improvements at the Westside WWTP will be constructed in two phases. The first phase (increase in treatment capacity or HRT/disinfection facility capacity of 32 MGD and all planned grit removal and fine screening) would be constructed after reconstruction of the Turkey Creek Pumping Station and installation of in-line storage gates in the OK Creek sewer. Completion of the second phase would be needed concurrent with completion of the deep-storage tunnel and associated pumping station in the Turkey Creek Basin.

Wet-weather flows exceeding primary- and secondary-treatment capacity will be diverted from the WWTP influent for HRT. The diversion will occur from influent piping downstream of the junction of the Santa Fe and Turkey Creek force mains. All dry weather flows and up to 40 MGD of wet-weather influent will be treated by the existing Westside WWTP until completion of Phase 1. Upon completion of Phase 1, the peak flow treatment capacity at Westside is expected to increase to 70-72 mgd.

Automated flow control valves and flow meters placed on both the WWTP influent line downstream of the intercept point and on the wet-weather treatment train force main will be connected to the WWTP control system. Control logic will divert influent flows above the peak flow treatment capacity of the primary and secondary facilities to the HRT/disinfection facility.

The HRT facility includes grit removal, fine screening, high rate clarification, and disinfection. HRT facility effluent will combine with WWTP effluent. Final effluent will continue to discharge to the Missouri River. A new effluent pump station will discharge at a firm capacity of 104 MGD during high river stages. Additional improvement details are presented in the *Joint Use Facilities Expansion Capabilities Technical Memorandum;* OCP; September 2008.

Estimated capital and additional annual O&M costs for presently anticipated improvements at the Westside WWTP are shown in Table 14-16, in 2008 dollars (ENR CCI 9180). The estimated capital cost is approximately $61.4 million. The estimated additional annual O&M cost of the improvements is approximately $1.8 million.

Table 14-16 Westside WWTP Improvement Costs

Task Number	Task Name	Construction Cost (million $)	Annual O&M Cost (million $)
CD.APPA.057	WWTP Upgrade: Westside WWTP Capacity Expansion	$36.05	$0.91
CD.APPA.058	Wet-weather Treatment Facility: Westside WWTP	25.38	0.90
Total		**$61.43**	**$1.81**

*all costs in 2008 dollars (ENR 9180)

14.6.10 Summary of Plan Improvements in the CSS Basins

Table 14-17 summarizes the modeled performance and estimated costs of the CSO controls by basin.

The Plan for the CSS is structured to eliminate, or capture for treatment, approximately 88 percent of the total wet-weather flow in the City's CSS. That removal will result from a combination of green solutions and source controls with conventional structural controls at or upstream of combined sewer outfalls. The portion of capture attributable to green solutions and source controls will be determined in the future, as such solutions are implemented, monitored, and analyzed. The estimated total cost for the CSS Plan is approximately $1.4 billion.

Table 14-17 Performance and Cost Summary for Recommended CSO Controls by Basin

Basin	Typical Year Wet Weather Flow (billion gallons)	Existing Overflow Volume (billion gallons)	Plan Complete Overflow Volume (billion gallons)	Plan Complete Capture of Wet Weather Flow (%)	Estimated Capital Cost ($Million)
MISSOURI RIVER CSS BASINS					
Turkey Creek/Central Industrial District	2.987	2.659	0.574	81%	$234.61
Northeast Industrial District	2.138	1.563	0.700	67%	$22.90
Subtotal, Missouri River Basins	**5.125**	**4.222**	**1.274**	**75%**	**$257.51**
BLUE RIVER CSS BASINS					
Town Fork Creek	0.880	0.341	0.034	96%	$162.02
Brush Creek	1.830	1.456	0.019	99%	$509.42
Subtotal, Brush Creek CSS Basins	**2.710**	**1.797**	**0.053**	**98%**	**$671.44**
Lower Blue River	0.622	0.211	0.076	88%	$29.89
Middle Blue River	0.623	0.149	0.048	92%	$87.57
Subtotal, All Blue River CSS Basins	**3.955**	**2.156**	**0.177**	**96%**	**$788.90**
Blue River WWTP HRT	N/A	N/A	N/A	N/A	$42.89
Blue River WWTP Flow Diversion	N/A	N/A	N/A	N/A	$3.05
Blue River WWTP Solids Handling	N/A	N/A	N/A	N/A	$161.05
Westside WWTP Phase 1	N/A	N/A	N/A	N/A	$36.05
Westside WWTP Phase 2	N/A	N/A	N/A	N/A	$25.38
SSS Wet Weather from 87th Street	2.065	N/A	N/A	N/A	N/A
SSS Wet Weather from Round Grove	0.499	N/A	N/A	N/A	N/A
Subtotal, SSS Inflows to BRIS	**2.564**	N/A	N/A	N/A	N/A
CITY-WIDE TOTALS	***11.64***	***6.38***	***1.45***	***88%***	***$1,314.83***
Blue River Basins Capture				***97%***	
Neighborhood Sewers in CSS Basins					***$124.00***
Estimated Total Capital Cost for Combined Sewer System Basins					***$1,438.83***

14.7 Summary of Estimated Plan Costs

Table 14-18 presents a summary of the estimated capital and additional annual O&M costs for the Plan. The table categorizes programmatic, SSS, and CSS improvement costs. All costs are expressed in mid-2008 dollars (ENR CCI 9180). The estimated overall capital cost for the Plan is approximately $2.47 billion, in 2008 dollars (ENR Construction Cost Index = 9180). The estimated additional O&M costs for plan elements total approximately $31 million per year.

Cost opinions and projections prepared for the Plan were based principally on standardized cost guidance developed from review of actual and/or estimated costs from other similar planning efforts documented in *Basis of Cost Manual*; OCP; January 2007. As indicated in that reference, the cost for individual components and types of projects can vary significantly for any given project type or capacity.

Table 14-18 Summary of Estimated Plan Costs

Task Number	Task Name	Estimated Capital Cost ($M)	Additional O&M Cost ($M/Yr)
Programmatic Elements			
CD.APPE.001	SEP	$1.60	
OCP.14.001	Green Collar Jobs & Workforce Development	$5.00	
OCP.14.002	Green Infrastructure Pilot: Additional Pilots	$7.44	$0.37
OCP.14.003	Rain Gardens and Downspout Disconnect	$5.00	
OCP.14.004	Blue River Watershed Management Plan	$2.00	
OCP.14.005	Program Management (Initial)	$5.00	
Subtotals		**$26.04**	**$0.37**
Separate Sanitary Sewer System			
CD.APPA.059.01	I/I Reduction: Northern Basins	$11.32	
CD.APPA.059.02	I/I Reduction: Line Creek/Rock Creek Basin	$37.26	
CD.APPA.059.03	I/I Reduction: Birmingham/Shoal Creek	$38.76	
CD.APPA.060	WWTP Upgrade: Birmingham WWTP Capacity Expansion	$44.64	$2.27
CD.APPA.061	Deep Tunnel Storage: N. of Missouri River	$302.56	$0.89
CD.APPA.062	Deep Tunnel Pump Station: N. of Missouri River	$74.00	$0.89
CD.APPA.063	Pump Station Force Main: N. of Missouri River	$4.06	$0.02
CD.APPA.064	Relief Sewer: Line Creek	$13.38	
CD.APPA.065	Relief Sewer: Birmingham	$0.22	
CD.APPA.066	Pump Station Upgrade: Birmingham	$24.13	$0.88
CD.APPA.067.01	I/I Reduction: Little Blue River Basin	$23.18	
CD.APPA.067.02	I/I Reduction: Blue River South Basin	$38.10	

CD.APPA.067.03	I/I Reduction: Blue River Central Basin	$15.13	
CD.APPA.067.04	I/I Reduction: Blue River North Basin	$5.94	
CD.APPA.067.05	I/I Reduction: Round Grove Creek	$4.91	
CD.APPA.068.01	Storage: 87th Street Pumping Station (Phase 1) Storage Tank	$91.31	$0.75
CD.APPA.068.02	Storage: 87th Street Pumping Station (Phase 1) Pump Station Upgrade	$9.28	.
CD.APPA.069	Storage: 87th Street Pumping Station (Phase 2)	$168.42	$0.38
CD.APPA.070	Pump Station Force Main: Round Grove	$1.63	
CD.APPA.071	Pump Station Upgrade: Round Grove	$11.34	$0.03
Subtotals		**$919.57**	**$6.11**
Combined Sewer System			
CD.APPA.001	Deep Tunnel Storage: Brush Creek	$210.89	$2.00
CD.APPA.002	Deep Tunnel Pump Station: Brush Creek	$63.28	$0.94
CD.APPA.003	Wet-weather Treatment Facility: Brush Creek	$165.78	$4.50
CD.APPA.004	Wet-weather Flow Rerouting: Outfall 024	$1.50	
CD.APPA.005	Relief Sewer: 48th and Roanoke	$0.20	
CD.APPA.006	Wet-weather Flow Rerouting: Outfall 026	$1.86	
CD.APPA.007	Wet-weather Flow Rerouting: Outfalls 027/028	$5.75	
CD.APPA.008	Wet-weather Flow Rerouting: Wyandotte County to Brush Creek	$5.41	
CD.APPA.009	Sewer Separation: Brookside	$45.89	
CD.APPA.010	Sewer Pipe Consolidation: Outfall 019	$0.39	
CD.APPA.011	Diversion Structure and Consolidation Piping: Outfall 023	$0.48	
CD.APPA.012	Diversion Structure and Consolidation Piping: Outfall 025	$0.20	
CD.APPA.013	Baseline Improvements: Brush Creek	$2.53	
CD.APPA.014	Small Sewer Rehabilitation: Brush Creek	$39.00	
OCP.14.008	Sewer Pipe Consolidation: Outfall 020	$1.58	
OCP.14.009	Outfall and Consolidation Piping: Brush Creek	$3.67	
CD.APPA.015	Pump Station Upgrade: 15th Street	$3.00	
CD.APPA.016	Relief Sewer: Hardesty Ave and 31st Street	$2.59	
CD.APPA.017	Relief Sewer: Vineyard and Lawn Street	$2.59	
CD.APPA.018	Relief Sewer: 45th Street	$0.73	
CD.APPA.019	Sewer Separation: 40th and Monroe	$17.50	
CD.APPA.020	Sewer separation: Outfall 054	$3.28	
CD.APPA.021	Dry Weather Sewer Line: Outfall 055	$0.20	

CD.APPA.022	Small Sewer Rehabilitation: Lower Blue River	$17.00	
CD.APPA.023	Relief Sewer: Diversion Struc. 068 to Blue River Sewer	$5.52	
CD.APPA.024	Sewer Separation: Outfall 067	$25.08	$0.09
CD.APPA.025	Sewer Separation: Outfall 099	$4.42	
CD.APPA.026.01	Distributed Storage: MBRB Green Infrastructure Pilot	$6.09	$0.30
CD.APPA.026.02	Distributed Storage: Remaining Area Tributary to Outfall 069	$28.20	$1.30
CD.APPA.027	Distributed Storage: Outfall 059	$11.80	$0.70
CD.APPA.028	Sewer Pipe Consolidation: Outfall 063	$6.08	$0.06
CD.APPA.029	Dry Weather Sewer Line: Outfall 056	$0.30	
CD.APPA.030	Manhole Modifications: Middle Blue River	$0.08	
CD.APPA.031	Small Sewer Rehabilitation: Middle Blue River	$18.00	
CD.APPA.032	Sewer Separation: Diversion Structure 006	$5.19	
CD.APPA.033	Green Infrastructure Pilot: Northeast Industrial District	$7.44	$0.37
CD.APPA.034	Small Sewer Rehabilitation: Northeast Industrial District	$19.00	
CD.APPA.035	Pump Station: Gooseneck Arch Sewer	$2.55	$0.09
CD.APPA.036	In-Line Storage: Gooseneck Arch Sewer Gate	$7.72	$0.04
CD.APPA.037	Deep Tunnel Storage: Town Fork Creek	$123.88	$1.23
CD.APPA.038	Sewer Pipe Consolidation: Outfall 097	$8.83	
CD.APPA.039	Sewer Pipe Consolidation: Outfall 079	$2.50	
CD.APPA.040	Sewer Separation: Outfall 082	$5.75	
CD.APPA.041	Sewer Separation: Outfall 081	$12.00	
CD.APPA.042	Diversion Structure and Consolidation Piping: Outfall 083	$0.20	
CD.APPA.043	Diversion Structure and Consolidation Piping: Outfall 099	$1.77	
CD.APPA.044	Small Sewer Rehabilitation: Town Fork Creek	$14.00	
OCP.14.006	Sewer Pipe Consolidation: Diversion Structure 056	$4.56	
OCP.14.007	Baseline Improvements: Town Fork Creek	$2.53	
CD.APPA.045	Sewer Separation: 31st Street and Broadway	$9.47	
CD.APPA.046	Pump Station Force Main: Turkey Creek/Central Industrial District	$13.25	
CD.APPA.047	Storm Drainage Improvements: Turkey Creek/Central Industrial District	$2.19	$0.01
CD.APPA.048	Deep Tunnel Storage: Turkey Creek/Central Industrial District	$122.59	$0.24
CD.APPA.049	Deep Tunnel Pump Station: Turkey Creek/Central Industrial District	$63.58	$0.93
CD.APPA.050	Green Infrastructure Pilot: Turkey Creek/Central Industrial District	$7.44	$0.37

CD.APPA.051	Pump Station Upgrade: Turkey Creek	$11.59	$0.58
CD.APPA.052	In-Line Storage: OK Creek Gates	$4.50	$0.02
CD.APPA.053	Small Sewer Rehabilitation: Turkey Creek/Central Industrial District	$17.00	
CD.APPA.054	WWTP Upgrade: Blue River WWTP Flow Diversion	$3.05	
CD.APPA.055	Wet-weather Treatment Facility: Blue River WWTP	$42.89	$2.28
CD.APPA.056	WWTP Upgrade: Blue River WWTP Solids Handling	$161.05	$7.04
CD.APPA.057	WWTP Upgrade: Westside WWTP Capacity Expansion	$36.05	$0.91
CD.APPA.058	Wet-weather Treatment Facility: Westside WWTP	$25.38	$0.90
Subtotals		**$1,438.82**	**$24.90**
Disinfection at WWTPs			
CD.APPF.001	Disinfection: Rocky Branch WWTP	$2.41	
CD.APPF.002	Disinfection: Birmingham WWTP	$7.22	
CD.APPF.003	Disinfection: Blue River WWTP	$42.75	
CD.APPF.004	Disinfection: Fishing River WWTP	$19.69	
CD.APPF.005	Disinfection: Todd Creek WWTP	$5.70	
CD.APPF.006	Disinfection: Westside WWTP	$11.87	
CD.APPF.007	Disinfection: Northland Mobile	$1.67	
Subtotals		**$91.31**	**$0.00**
TOTAL ESTIMATED CAPITAL COST		**$2,475.74**	**$31.38**

The costs summarized in Table 14-17 do not include:

- The cost for sewer separation at the Charles B. Wheeler downtown (Municipal) airport ($17 million). The existing combined sewer system at the Downtown Airport is owned and operated by Kansas City's Aviation Department, and has its own National Pollutant Discharge Elimination System (NPDES) permit. While sewer separation at the Downtown Airport is not addressed in the Consent Decree, it is nonetheless a part of Kansas City's plan to improve water quality in Kansas City's lakes, streams and rivers.

Detailed estimates of project cost will be prepared as a normal part of the design process, as individual projects are implemented, and records maintained of final constructed costs for each project are compared to the budget estimates (adjusted for inflation and construction cost escalation) contained herein.

Cost opinions and projections prepared by WSD and its engineering consultants relating to construction costs and schedules, O&M costs, equipment characteristics and performance, and operating results are based on their experience, qualifications, and judgment as design professionals. Since neither WSD nor its engineering consultants has control over weather, cost and availability of labor, material and equipment, labor productivity, construction contractors' procedures and methods, unavoidable delays, construction contractors' methods of determining prices, economic conditions, competitive bidding or market conditions, and other factors affecting such cost opinions or projections, WSD and its engineering consultants do not guarantee that actual rates, costs, performance, schedules, and related items will not vary from cost opinions and projections prepared for the Plan.

14.8 Implementation Schedule

The implementation schedule for major Plan components as defined in the Consent Decree is summarized in Figure 14-11, which includes annual estimates of Plan capital expenditures in 2008 dollars (Engineering News Record Construction Cost Index of 9180). The City must implement the CSO Control Measures described herein and must comply with the Project Start Dates, Date of Achievement of Full Operation, Date of Post-Construction Monitoring Plan Submission, and Critical Milestones for each control measure as defined in Appendix A of the Consent Decree. Figure 14-11 does not include sewer separation in approximately 1,140 acres of the Brookside subbasin. This sewer separation project is the subject of a previously planned and ongoing WSD capital improvements program. Appendix A of the Consent Decree requires this separation project to be fully complete no later than the end of 2032. Given the impact of costs for the addition of disinfection technology at the City's WWTPs on funds available in the early years of Plan implementation, those projects are shown on Figure 14-11.

In the SSS, the I/I reduction efforts will not be complete prior to the initiation of design on the major structural components (principally the North Bank Tunnel system and the second phase of tank storage at the 87th Street Pump Station). The I/I rehabilitation completed by that time is expected to be adequate to confirm the extent to which the completed work will meet the requirementsfor overall removal of stormwater from the system. That information will permit an informed adjustment to remaining I/I reduction work and/or principal structural controls necessary to attain the performance criteria.

In the CSS, the neighborhood sewer improvements, sewer separation projects, and relief sewers are scheduled concurrent with major planned expenditures in the SSS. The preliminary schedule provides an opportunity to incorporate the monitored and evaluated results of these improvement efforts, parallel green solutions, and other source controls into the final design and construction of major CSO controls such as tunnels and HRT facilities.

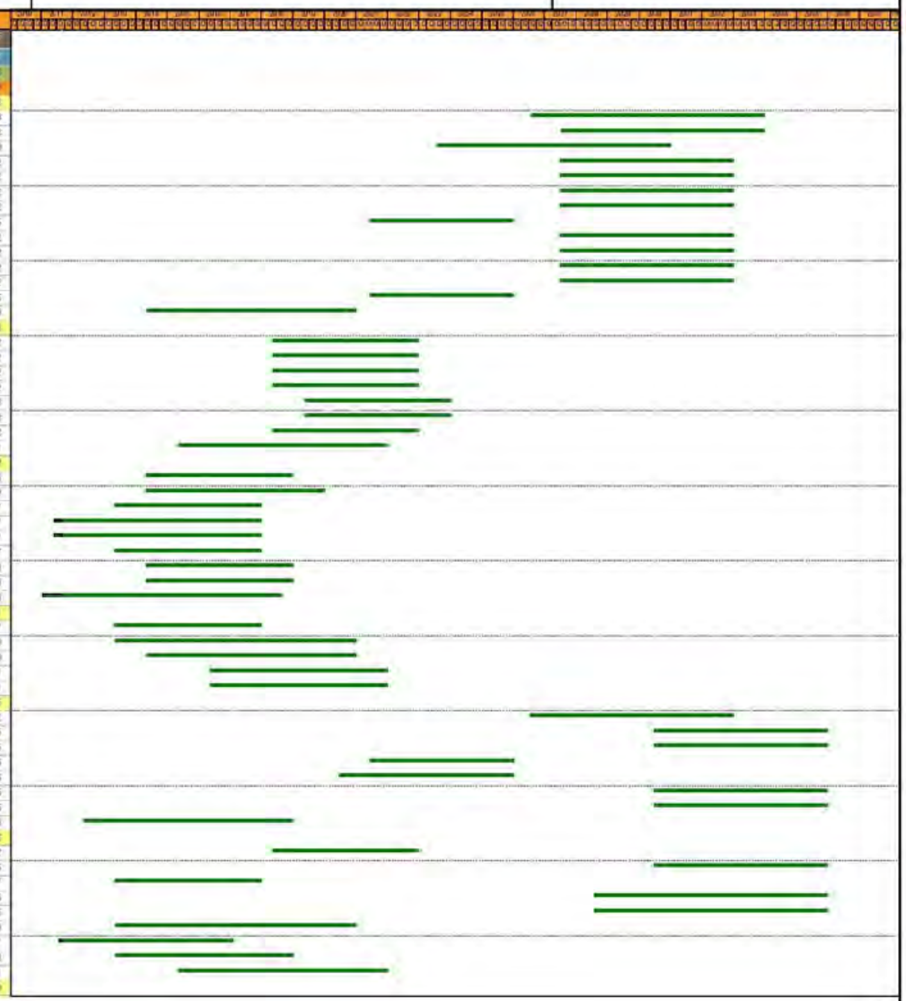
Kansas City's Overflow

OCP.IP.021 - Program Schedule
Data Date: 31-Aug-11

TASK filter: Summary Bars Only

21-Oct-11 14:04
1 of 2

KCMO Overflow Control Program		5294d	20-Dec-10 A	31-Dec-35
Consent Decree		5294d	20-Dec-10 A	31-Dec-35
Performance Measures		5294d	20-Dec-10 A	31-Dec-35
Combined Sewer Overflows		5294d	17-Jan-11 A	31-Dec-35
Brush Creek Basin		5067d	15-May-14	30-Dec-33
CD.APPA.001	Construct 31 Million Gallons of Deep Tunnel Storage	1933d	05-Aug-26	30-Dec-33
CD.APPA.002	Construct 45 MGD Deep Tunnel Pump Station	1683d	21-Jul-27	30-Dec-33
CD.APPA.003	Construct 200 MGD HRT/Disinfection Facity at Confluence of Brush Creek & Blue River	1933d	04-Aug-23	31-Dec-30
CD.APPA.004	Construct 1200 LF of 72" Piping Downstream of Diversion Structure 42	1433d	07-Jul-27	31-Dec-32
CD.APPA.005	Construct 350 LF of Relief Sewer	1433d	07-Jul-27	31-Dec-32
CD.APPA.006	Construct 2100 LF of 36" Piping Downstream of Outfall 026	1433d	07-Jul-27	31-Dec-32
CD.APPA.007	Construct 3300 LF of 60" Piping Diverting Flows from Outfalls 027 and 028	1433d	07-Jul-27	31-Dec-32
CD.APPA.008	Construct 2800 LF of 72" Storm Sewer	1183d	21-Jun-21	31-Dec-25
CD.APPA.009	Separate 1140 LF of Combined Sewer in Brookside sub-basin	1433d	07-Jul-27	31-Dec-32
CD.APPA.010	Construct 1150 LF of Consolidation Piping	1433d	07-Jul-27	31-Dec-32
CD.APPA.011	Construct Diversion Structure & 1630 LF of Piping with Flap Gate at Outfall 023	1433d	07-Jul-27	31-Dec-32
CD.APPA.012	Construct Diversion Structure & 950 LF of Piping with Flap Gate at Outfall 025	1433d	07-Jul-27	31-Dec-32
CD.APPA.013	Install Flap Gates at Outfalls 007, 009, 010, 011, 012	1183d	21-Jun-21	31-Dec-25
CD.APPA.014	Repair Small Diameter Sewers	1676d	15-May-14	31-Dec-20
Lower Blue River Basin		2203d	18-May-15	29-Dec-23
CD.APPA.015	Increase 15th St. Pump Station Capacity or Separate Sewers	1183d	18-May-18	30-Dec-22
CD.APPA.016	Construct 3500 LF of 54" Relief Sewer	1183d	18-May-18	30-Dec-22
CD.APPA.017	Construct 3400 LF of 48" Relief Sewer	1183d	18-May-18	30-Dec-22
CD.APPA.018	Construct 1500 LF of 24" Relief Sewer	1183d	18-May-18	30-Dec-22
CD.APPA.019	Separate 225 acres at 40th & Monroe	1183d	30-May-19	29-Dec-23
CD.APPA.020	Separate 35 Acres in the Upstream Drainage Area to Outfall 054	1183d	30-May-19	29-Dec-23
CD.APPA.021	Construct 660 LF of 18" Dry Weather Line	1183d	18-May-18	30-Dec-22
CD.APPA.022	Repair Small Diameter Sewers	1683d	18-May-15	31-Dec-21
Middle Blue River Basin		2128d	17-Jan-11 A	31-Dec-19
CD.APPA.023	Construct 9400 LF of Relief Sewer from DS 68 to Blue River Sewer	1176d	06-May-14	31-Dec-18
CD.APPA.024	Separate Sewer in 270 Acres in Upstream Drainage Area to Outfall 067	1426d	09-May-14	31-Dec-19
CD.APPA.025	Separate Sewer in 50 Acres in Upstream Drainage Area to DS 099	1176d	06-May-13	29-Dec-17
CD.APPA.026	Construct Distributed Storage in 475 Acres Tributary to Outfall 069	1600d	30-May-11 A	29-Dec-17
CD.APPA.027	Construct Distributed Storage in 289 Acres Tributary to Outfall 059	1426d	30-May-11 A	29-Dec-17
CD.APPA.028	Construct 12000 LF of Consolidation Piping	1176d	06-May-13	29-Dec-17
CD.APPA.029	Construct 1200 LF of 16" Dry Weather Line	1176d	06-May-14	31-Dec-18
CD.APPA.030	Raise Manhole Rim Elevations	1176d	06-May-14	31-Dec-18
CD.APPA.031	Repair Small Diameter Sewers	1637d	17-Jan-11 A	13-Aug-18
Northeast Industrial District Basin		2197d	06-May-13	31-Dec-21
CD.APPA.032	Separate Sewer in 260 Acres at Diversion Structure 006	1176d	06-May-13	29-Dec-17
CD.APPA.033	Construct Green Infrastructure Projects at NEIDB	1926d	20-May-13	31-Dec-20
CD.APPA.034	Repair Small Diameter Sewers	1676d	15-May-14	31-Dec-20
CD.APPA.035	Construct 4 MGD Pump Station	1433d	12-May-16	31-Dec-21
CD.APPA.036	Construct Automated Gate in Gooseneck Arch Sewer	1433d	12-May-16	31-Dec-21
Town Fork Creek Basin		8095d	14-May-12	31-Dec-35
CD.APPA.037	Construct 19 Million Gallons of Deep Tunnel Storage Near DS 314	1683d	22-Jul-26	31-Dec-32
CD.APPA.038	Construct 3800 LF of Piping Near Outfall 097	1433d	04-Jul-30	31-Dec-35
CD.APPA.039	Construct 1100 LF of 36" piping Downstream of DS 46 (Outfall 079)	1433d	04-Jul-30	31-Dec-35
CD.APPA.040	Separate Sewer in 59 Acres Tributary to Outfall 082	1183d	21-Jun-21	31-Dec-25
CD.APPA.041	Separate Sewer in 138 Acres Tributary to Outfall 081	1433d	26-Jun-20	31-Dec-25
CD.APPA.042	Construct Diversion Structure & 450 LF of Piping & Flap Gate at Outfall 083	1433d	04-Jul-30	31-Dec-35
CD.APPA.043	Construct Diversion Structure & 300 LF of Piping & Flap Gate at Outfall 099	1433d	04-Jul-30	31-Dec-35
CD.APPA.044	Repair Small Diameter Sewers	1676d	14-May-12	31-Dec-18
Turkey Creek / Central Industrial District Basins		5294d	01-Aug-11 A	31-Dec-35
CD.APPA.045	Separate Sewer in 66 Acres at 31st & Broadway	1183d	18-May-18	30-Dec-22
CD.APPA.046	Construct 10800 LF of 48" Force Main	1433d	04-Jul-30	31-Dec-35
CD.APPA.047	Central Industrial Storm Drain Improvements	1176d	06-May-13	29-Dec-17
CD.APPA.048	Construct 30 Million Gallons of Deep Tunnel Storage	1933d	03-Aug-28	31-Dec-35
CD.APPA.049	Construct 30 MGD Deep Tunnel Pump Station	1933d	03-Aug-28	31-Dec-35
CD.APPA.050	Construct Green Infrastructure Projects	1926d	20-May-13	31-Dec-20
CD.APPA.051	Upgrade the Turkey Creek Pump Station to 30 MGD	1387d	01-Aug-11 A	25-Jan-17
CD.APPA.052	Construct OK Creek In-line Storage Gates	1426d	09-May-13	31-Dec-18
CD.APPA.053	Repair Small Diameter Sewers	1683d	18-May-15	31-Dec-21
Blue River WWTP		1933d	04-Aug-23	31-Dec-30



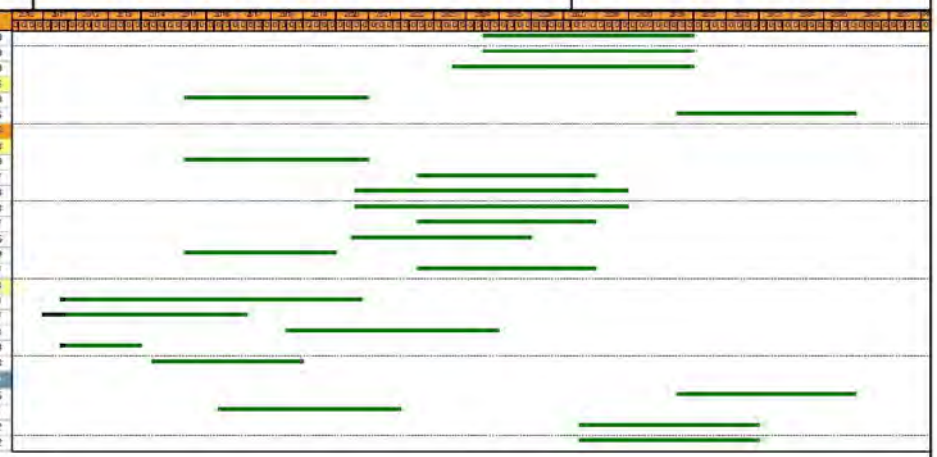
Kansas City's Overflow

OCP.IP.021 - Program Schedule
Data Date: 31-Aug-11

TASK filter: Summary Bars Only

21-Oct-11 14:04
2 of 2

CD.APPA.054	Construct Diversion of 80 MGD Effluent to Disinfection Facility	1683d	19-Jul-24	31-Dec-30
CD.APPA.055	Construct 50 MGD Wet Weather Treatment Facility with Disinfection	1683d	19-Jul-24	31-Dec-30
CD.APPA.056	Construct Modifications to Solids Handling Facility	1933d	04-Aug-23	31-Dec-30
Westside WWTP		5338d	12-May-15	31-Dec-35
CD.APPA.057	Construct 30-32 MGD Peak Treatment Enhancement	1426d	12-May-15	31-Dec-20
CD.APPA.058	Construct 32 MGD HRT Disinfection Facility	1433d	04-Jul-30	31-Dec-35
[illegible]		4469d	20-Dec-10 A	29-Dec-28
North of Missouri River		3516d	06-May-15	29-Dec-28
CD.APPA.059	Infiltration & Inflow Reduction	1426d	12-May-15	31-Dec-20
CD.APPA.060	Upgrade the Birmingham WWTP for Peak Wet Weather Flow	1433d	06-Jul-22	31-Dec-27
CD.APPA.061	Construct North bank of Birmingham Deep Tunnels	2183d	12-Aug-20	29-Dec-28
CD.APPA.062	Construct Upshaft and 30 MGD Tunnel Pump Station	2183d	12-Aug-20	29-Dec-28
CD.APPA.063	Construct 12000 LF of 24" Force Main	1433d	06-Jul-22	31-Dec-27
CD.APPA.064	Construct Relief Sewers- Line Creek	1433d	26-Jun-20	31-Dec-25
CD.APPA.065	Construct Relief Sewers- Birmingham	1176d	06-May-15	31-Dec-19
CD.APPA.066	Upgrade Birmingham Pump Station to 50 MGD	1433d	06-Jul-22	31-Dec-27
South of Missouri River		3425d	20-Dec-10 A	31-Dec-24
CD.APPA.067	Infiltration & Inflow Reduction	1426d	15-Jul-11 A	20-Oct-20
CD.APPA.068	Construct 20 Million Gallon Storage Tank at 87th St. Pump Station	1487d	20-Dec-10 A	28-Mar-17
CD.APPA.069	Construct 68 Million Gallon Storage Tank at 87th St. Pump Station	1683d	20-Jun-18	31-Dec-24
CD.APPA.070	Construct 24" Round Grove Force Main	1137d	13-Jul-11 A	31-Dec-13
CD.APPA.071	Construct Increase in Pumping Capacity of Round Grove Pump Station by 12 MGD	1176d	06-May-14	31-Dec-18
Chapter 14		5094d	12-May-16	31-Dec-35
OCP.14.006	Sewer Pipe Consolidation: Diversion Structure 056	1433d	04-Jul-30	31-Dec-35
OCP.14.007	Baseline Improvements: Town Fork Creek	1433d	12-May-16	31-Dec-21
OCP.14.008	Sewer Pipe Consolidation: Outfall 020	1433d	07-Jul-27	31-Dec-32
OCP.14.009	Outfall and Consolidation Piping: Brush Creek	1433d	07-Jul-27	31-Dec-32



* * * * *