# Executive Summary

## 1. Purpose

The purpose of this report is to present the results of a comprehensive wastewater master planning evaluation of the City of Lawrence wastewater system. The recommended improvements plan presented herein will serve as a master plan basis for the design, construction, and financing of facilities to meet anticipated regulatory requirements, residential and commercial growth, and system reliability needs for the design year of 2025. Implementation of the recommended improvements will provide an adequate and dependable wastewater system for the City of Lawrence through the year 2025.

## 2. Study Area and Scope

The Study Area for this investigation and report is shown in Figure I-1. The boundaries of the Study Area were delineated by the City of Lawrence Planning Department. The boundaries are as follows:

- Existing City Limits: City Limits of the City of Lawrence as of year 2000.
- Study Area Limits: The anticipated extent of the year 2025 Urban Growth Area (UGA) as established by the City for the *2025 Transportation Plan.*

The study period for this master plan investigation is from year 2000 through the year 2025. Detailed evaluations of the wastewater system were conducted for the design years 2000, 2010, and 2025.

The Principle elements of the study include the following:

- Review regulatory discharge limits for the Wakarusa River. Determine service area and wastewater flows for a possible wastewater treatment plant located at the Wakarusa River.
- Conduct wastewater treatment plant (WWTP) and collection system analysis to determine feasibility of expanding the Kansas River WWTP or implementing a new Wakarusa River WWTP.
- Review flow metering and rainfall monitoring data provided by the City to determine system flow characteristics.
- Create a trunk sewer inventory for modeling based on existing GIS data provided by the City.

- Develop and calibrate a HydroWorks computer model of the Lawrence sewer system using the trunk sewer inventory.
- Analyze the sewer system for current conditions.
- Define and evaluate alternatives to serve future growth as projected by the Lawrence-Douglas County Planning Office. Create hydraulic models for design years 2010 and 2025.
- Define and evaluate collection system alternatives to serve ultimate build-out conditions for the City of Lawrence.
- Recommend improvements for the collection system facilities and update the wastewater collection system improvements plan.

## 3. Population and Wastewater Flows

Estimated year 2000 and projected wastewater service population used for this report are summarized in Table ES-1. Population projections were developed by the Lawrence-Douglas County Metropolitan Planning Office.

**Table ES-1**
**Wastewater Service Population**

| Year | Population | Population Growth | |
|---|---|---|---|
| | | Persons | % (Annual) |
| 2000 | 80,098[1] | | |
| 2010 | 99,600[2] | 19,502 | 2.2 |
| 2025 | 149,278[3] | 49,678 | 2.7 |
| 2050 | 244,906[4] | 95,628 | 2.0 |

(1) U.S. Census Bureau population for City of Lawrence, Kansas
(2) Based on spatial analysis of population by TAZ provided by Lawrence-Douglas County Metropolitan Planning Office within assumed year 2010 retail water service limits and excluding population within wholesale water districts
(3) Projection by Lawrence-Douglas County Metropolitan Planning Office for UGA
(4) Projection developed for this report based on 2% per year growth rate from 2025 through 2050

The relative range of population growth by wastewater subbasin area is shown on Figures I-3 and I-4. Figure I-3 shows the difference in population from year 2000 to year 2010 and Figure I-4 shows the difference in population from year 2010 to 2025. As shown on these figures, the largest amount of population growth is projected in west Lawrence and south of the Wakarusa River.

The current annual average capacity of the Kansas River Wastewater Treatment Plant is 12.5 million gallons per day (mgd). The year 2025 annual average wastewater flow projected for two wastewater treatment plant (WWTP) scenarios is summarized as follows:

Scenario 1 - All Flow to Existing Kansas River WWTP

- Kansas River WWTP – 18.8 mgd

Scenario 2 - Flow to Wakarusa River and Kansas River WWTP's

- Wakarusa River WWTP – 6.9 mgd
- Kansas River WWTP – 11.9 mgd

## 4. Wastewater Collection and Treatment Alternatives

An evaluation was conducted to compare wastewater collection and treatment alternatives, based on wastewater treatment plant location, and recommend the best collection and treatment configuration for final basis of the Wastewater Master Plan. Three wastewater treatment plant (WWTP) locations were considered to determine the recommended wastewater system configuration. The evaluation was based on design year 2025 population and land use projections and includes all projected wastewater flows for the study area. Treatment systems were based on anticipated future regulatory requirements obtained from the Kansas Department of Health and Environment (KDHE).

Alternative 1, shown in Figure II-1, consists of routing all wastewater flow for the study area to the existing Kansas River WWTP. The existing WWTP would need to be upgraded and expanded to a capacity of 18.8 mgd. Alternative 2, shown in Figure II-2, is based on dividing the study area and conveying part of the flow to the existing Kansas River WWTP and the remaining flow to a proposed Wakarusa River WWTP (Site A). The plant capacities for the Kansas River and Wakarusa River WWTP's would be 11.9 mgd and 6.9 mgd, respectively. Alternative 3, shown in Figure II-3, is similar to Alternative 2, however, a different site (Site B) was used for the proposed Wakarusa River WWTP. The selection of two Wakarusa WWTP sites was made to allow consideration of differing project costs due to site location, however, a Wakarusa WWTP could be located in many different locations along the Wakarusa River.

Anticipated future regulatory requirements for the Kansas River and the Wakarusa River were received from KDHE. The requirements were based on the National Nutrient Strategy developed by the Environmental Protection Agency (EPA). The strategy presents recommended water quality on an Ecoregion basis, which for Region IX, includes the Kansas and Wakarusa Rivers. In order to meet the new EPA nutrient strategy, biological nutrient removal facilities will be required for wastewater treatment at both the Kansas and Wakarusa Rivers. In addition, the wastewater treatment requirements will be the same for discharges to either the Kansas River or the Wakarusa River. KDHE has indicated facilities for both the Kansas and Wakarusa Rivers must meet the following biological nutrient removal requirements:

Biological Nutrient Removal Requirements
Total Phosphorous < 1.5 mg/L
Total Nitrogen < 10.0 mg/L
Ammonia Nitrogen < 1.0 mg/L

An additional requirement for a Wakarusa River discharge is that an anti-degradation review process must be completed before a National Effluent Discharge Elimination (NPDES) permit is issued for the Wakarusa River. KDHE has indicated that this review process will most likely not prevent an NPDES permit from being issued to the City of Lawrence for the Wakarusa River. Therefore, it appears that wastewater treatment plant discharges to the Wakarusa River are viable from a regulatory standpoint.

Alternative 3 has the lowest capital cost and the lowest present worth as shown in the cost-effectiveness analysis, Appendix E. A distinct difference is shown for the present worth of the capital costs. The ranking of alternatives by present worth of capital costs is shown below.

Ranking by Present Worth of Capital Costs

| Ranking | Alternative Description | Present Worth | Difference from Alt. 3 |
|---|---|---|---|
| 1 | Alt. 3 – Wakarusa WWTP (Site B) | $48,400,000 | |
| 2 | Alt. 2 – Wakarusa WWTP (Site A) | $52,000,000 | 7.4% |
| 3 | Alt. 1 – Kansas River WWTP | $56,600,000 | 16.9% |

From a cost standpoint, master planning alternatives may be considered similar if the difference in present worth is less than 10 percent. Based on capital costs only, Alternative 1 is not equivalent to the Wakarusa Alternatives 2 and 3. Alternative 3 has the lowest capital cost, however, Alternative 2 should be given consideration since the capital cost difference is less than 10 percent.

Alternative 3 has the lowest total present worth considering both project and operation and maintenance costs. The ranking of alternatives by present worth cost of both capital and operation and maintenance costs is shown below:

Ranking by Present Worth of Capital and O&M Costs

| Ranking | Alternative Description | Present Worth | Difference from Alt. 3 |
|---|---|---|---|
| 1 | Alt. 3 – Wakarusa WWTP (Site B) | $74,300,000 | |
| 2 | Alt. 2 – Wakarusa WWTP (Site A) | $78,200,000 | 5.3% |
| 3 | Alt. 1 – Kansas River WWTP | $82,000,000 | 10.4% |

The difference in total present worth cost between Alternatives 1 and 3 is larger than 10 percent, so Alternative 1 would still not be considered similar to Alternative 3. The difference in present worth between Alternatives 2 and 3, at 5.3 percent, is close enough that both plant

locations should be given consideration, however, Alternative 3 is the best option from a cost standpoint.

Alternative 3 – Wakarusa WWTP (Site B) is the most cost-effective option for the City of Lawrence and, at present, does not appear to have any fatal flaws with respect to additional issues presented in Table II-5.

Consideration should also be given to the long-term expansion of the City wastewater system. After the year 2025, further expansion of the Kansas River WWTP beyond that shown for Alternative 1 would be extremely difficult. Additional space for expansion within the existing plant layout would not be available, therefore, any future expansion after 2025 would likely require a separate treatment plant located adjacent to the existing plant. The collection system would also need to be expanded with parallel pipelines in congested areas to route flow from west and south Lawrence to the existing plant.

In a similar fashion, consideration should also be given to the impact of implementing a Wakarusa River WWTP after 2025 if Alternative 1 – Kansas River WWTP is selected now. If a Wakarusa River WWTP is implemented after 2025, a significant amount of collection system infrastructure would be constructed for Alternative 1 that would not be needed after the year 2025. Alternative 1 collection system improvements that would be unused after 2025 include the 31st Street Relief Sewer, Wakarusa Pumping Station 5C and Force Main 5C, and most of the force main for Wakarusa South Pumping Station WRS-1. The capital cost for these collection system facilities which would not be used after 2025 is $19,200,000.

Based on capital and present worth costs, review of additional issues, and long-term wastewater expansion issues beyond 2025, the recommended plan is Alternative 3 – Wakarusa River WWTP (Site B). It is recommended that collection system improvements proceed on the basis of routing flow for part of the collection system to a future Wakarusa River WWTP. The Four Seasons Holding Basins should be used as a wet-weather handling facility for all Wakarusa River WWTP service area flow originating north of the Wakarusa River. It is also recommended that studies be conducted of the additional issues including environmental, cultural resource, and flood plain impact assessments to determine the best and most favorable location for a Wakarusa River WWTP site.

# 5. Collection System Findings and Recommendations

This section summarizes collection system findings and recommendations for the Wastewater Master Plan.

## 5.1 Summary

A sanitary sewer flow and rainfall monitoring program was conducted by the Lawrence Utility Department for portions of the existing Lawrence wastewater collection system. The flow and rainfall data provided by the City was used in this master planning effort to determine system flow rates, to evaluate the rates of infiltration and inflow (I/I), and to calibrate a computer model of the Lawrence wastewater system. Six open channel flow meters and four rain gauges were installed in the study area and monitored during April and May 2000.

The City provided Black & Veatch with GIS databases that contained information on trunk sewer lines and manholes within the City limits. The trunk sanitary sewer computer model consists of approximately 87.9 miles (464,000 feet) of sewer pipe ranging in size from 8 inches to 48 inches in diameter. The trunk sewer inventory data was imported into Black & Veatch's Sanitary Sewer Management System (SSMS) to create a computerized hydraulic model.

The existing model inventory and planned collection system and wastewater treatment improvements comprise the future model inventory. Hydraulic capacity analyses were performed to identify sewers, pump stations, and force mains with insufficient capacity for future growth peak flows. Projected future growth peak flows assume the successful completion of a 20 percent I/I removal program. The analyses were then used to develop an Implementation Plan to address improvements and the phasing of the improvements.

## 5.2 Findings

Flow and rainfall monitoring showed that the levels of I/I in the collection system during storms had decreased since the 1995 Wastewater Master Plan flow and rainfall monitoring program. Sewer rehabilitation efforts by the City have reduced the number of defects through the rehabilitation program. The 1995 Wastewater Master Plan called for 30 percent removal. After review and evaluation of the successful decrease in I/I, it was estimated that the goal should be revised to 20 percent I/I removal to reflect the improvements made with I/I removal.

The results of the hydraulic modeling indicate that the Alabama pump station (PS-8) is currently overloaded. This was confirmed in conversations with City Staff. Since space to expand this pump station is limited, the preferred alternative is to redirect flow from the pump station to another subbasin by a gravity sewer line.

Based on future growth patterns, the existing treatment plant capacity, and the hydraulic modeling undertaken for current and future planning years, three alternatives were evaluated for

future collection system configurations. In one alternative, all wastewater is conveyed to the existing treatment plant. In the other two alternatives, most additional future flow is to be conveyed to the proposed Wakarusa River WWTP.

### 5.3 Recommendations

It is recommended that the Alabama Pump Station be abandoned and a gravity sewer line be installed to redirect this flow to another subbasin.

The City's current Infiltration and Inflow (I/I) removal program should be continued. Future improvements and alternatives assume that 20% of the I/I will be removed from the existing system.

It is recommend that most additional future flow be conveyed for treatment at a new Wakarusa River WWTP located south of the Wakarusa River. Flow from the Yankee Tank Creek Basin will be conveyed from the Four Seasons Pumping Station to the new WWTP via a new force main.

Recommended collection system improvement projects are shown in Table IV-4 and on Figure IV-1.

## 6. Wastewater Treatment Plant Findings and Recommendations

This section summarizes wastewater treatment plant findings and recommendations for the Wastewater Master Plan.

### 6.1 Kansas River WWTP Improvements

Several improvements will be required for the Kansas River WWTP to meet regulatory requirements and maintain system reliability. Capacity expansion is not required for liquid treatment because City growth requirements will be accommodated with the implementation of a new Wakarusa River WWTP in the year 2011. Capacity expansion is required for solids treatment because the existing anaerobic digester capacity will be exceeded. Anaerobic digester improvements will consist of converting the existing anaerobic digester storage tank to a secondary digester with gas mixers and a floating cover, expanding the gas control building, and upgrading the digester SCADA system to current City standards.

The existing dissolved air flotation (DAF) thickener is designed to normally operate on a continuous 24-hour basis without polymer addition to thicken waste activated sludge (WAS). The DAF was sized for an annual average flow capacity of 12.5 mgd to the treatment plant. With polymer addition, the DAF is sized to process maximum month WAS quantities at 12.5 mgd design within an 8 hour period per day. Without polymer addition, it is anticipated that the DAF thickener will reach its design capacity by the year 2009. However, with polymer addition, the

DAF should be capable of thickening WAS during the interim period of 2009 to 2011, prior to start-up of the new Wakarusa River WWTP in 2011. Once the Wakarusa River WWTP starts operation, the existing DAF will have capacity to thicken WAS on a 24-hour basis, without polymer addition, during the design period of 2012 to 2025.

It is anticipated that future regulations will require the addition of biological nutrient removal (BNR) facilities for total nitrogen removal and phosphorous removal. KDHE indicated the liquid treatment facilities will need to be upgraded to meet a total nitrogen limit of 10 mg/L, an ammonia limit of 1 mg/L, and a phosphorous limit of 1.5 mg/L. The timetable for these regulatory improvements has not been dictated by KDHE at this time; therefore, a speculative timeframe for BNR improvements at the Kansas River WWTP is approximately the year 2015. BNR improvements would consist of external BNR basins for Aeration Basin No.s 1 and 2, BNR modifications internal to Aeration Basin No.s 3 and 4, and a fermentor/gravity thickener for primary sludge to produce volatile fatty acids for the BNR process.

New facility improvements required for the Kansas River WWTP are as follows:

- Anaerobic Digester Improvements
- Roof for Dewatered Biosolids Storage Basin
- Vehicle and Equipment Storage Building
- Biological Nutrient Removal Facilities

## 6.2 Wakarusa River WWTP Improvements

It is recommended to implement a new Wakarusa River WWTP to meet the growth requirements for the City of Lawrence and effectively comply with future regulatory requirements. As described in the WWTP evaluation section of this Master Plan, it is the best and most cost-effective solution to implement a Wakarusa River WWTP rather than conveying and treating all wastewater flow at the Kansas River WWTP. The Wakarusa River WWTP would be designed to accommodate all flow from west Lawrence that is pumped from the Four Seasons Pumping Station and all flow conveyed from south of the Wakarusa River.

Based on population projections, it is projected that a 6.9 mgd (annual average) WWTP will be required to meet 2025 growth projections for the service area. The WWTP should be designed with BNR facilities and contain space in the hydraulic profile for filtration facilities, if required in the future. The Four Seasons Pumping Station will pump flow directly to the WWTP for the west Lawrence service area. It is anticipated the design capacity of the existing Kansas River WWTP will be reached in the year 2011, therefore, the new Wakarusa River WWTP should be constructed and in service by the year 2011. A septage receiving facility should be provided at the WWTP to serve residential and commercial customers located south of the Wakarusa River.

It is recommended that studies be conducted of plant site issues including environmental, cultural resource, and flood impact assessments to determine the best and most favorable location for a Wakarusa River WWTP site. These studies should commence immediately so that adequate time is allowed to study, identify, and purchase the land for the Wakarusa River WWTP site. Sufficient land should be procured to allow for future WWTP expansions and provide an adequate buffer zone to residential and commercial development.

## 6.3 Project Costs and Implementation Plan

All costs presented within this report are Opinions of Probable Project Cost and have been developed from previous Black & Veatch projects of similar size and scope. All collection system related improvements including pipelines, storage facilities and pumping stations include a 20 percent allowance for contingencies and 20 percent allowance for engineering, legal and administrative (ELA) costs. All wastewater treatment plant related improvements include a 25 percent allowance for contingencies and 20 percent allowance for engineering, legal and administrative costs.

The overall wastewater system capital costs, in 2003 dollars, for the 2025 planning period are summarized in Table ES-2. Wastewater treatment plant improvements indicated below include a new 6.9 mgd Wakarusa River WWTP, with biological nutrient removal and biological nutrient removal improvements for the existing 12.5 mgd Kansas River WWTP.

**Capital Cost Summary of Implementation Plan**
**Table ES-2**

| | Capital Cost ($) |
|---|---|
| Gravity Sewers | $18,059,000 |
| Pump Stations and Force Mains | $11,607,000 |
| Sewer Extensions (City Developed) [(1)] | $7,079,000 |
| I/I Reduction Program | $650,000 |
| Wastewater Treatment Plant Improvements | $70,570,000 |
| CMOM | $200,000 |
| General Improvements | $1,500,000 |
| **Total** | $109,665,000 |

[(1)]City developed sewer extensions only include extension projects E-WRS-3-01, E-WRS-4-01, E-WRS-5-01, E-WRS-5-05, E-WRS-6-01, E-NL3PS1, and E-FM-NL3.

A detailed wastewater system implementation plan containing capital costs by planning year is shown in Table IV-4.