



Executive Summary

1. Purpose

The purpose of this report is to present the City of Lawrence with a comprehensive master plan of its water system. The improvements recommended herein will serve the basis for the design, construction, and financing of facilities to meet the anticipated regulatory requirements, and to accommodate the City's residential and commercial growth, and system reliability needs. Implementation of the recommended improvements will provide an adequate and dependable water system for the City's existing and future customers.

2. Study Area and Scope

The Study Area is shown in Section I on Figure I-1 of this report. The various components of the Study Area have been delineated by the City of Lawrence Planning Department and are described below:

- Existing City Limits: The boundaries 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 its *2025 Transportation Plan*.

The study period for this investigation is from year 2000 through year 2025. Detailed evaluation of water demands by class and service level, and hydraulic analyses, were conducted for base year 2000 and for design years 2010 and 2025. Overall, total system demands were extrapolated to year 2050 to evaluate long-term supply requirements.

The principal elements of this study include the following:

- Evaluate historical water use trends and prepare projections of future water requirements based on population projections provided by the Lawrence-Douglas County Metropolitan Planning Office.
- Evaluate the adequacy of existing supply, treatment, and distribution system components.



- Perform a Safe Drinking Water Act (SDWA) evaluation and regulatory review of the existing treatment processes at the Kaw and Clinton Water Treatment Plants and evaluate modifications needed to meet anticipated future regulations.
- Update the existing computer model of the Lawrence water distribution system and expand the capabilities of the model to include extended-period simulations (EPS). Perform hydraulic analyses to determine the capacity of the distribution system to meet present and future water demands and deliver the updated model to the City.
- Develop a master plan of recommended water system improvements, including a phased construction program and opinions of probable cost.

3. Population and Water Demands

Actual year 2000 and projected retail water service populations used for this report are summarized in Table ES-1.

Table ES-1 Population			
Year	Population	Population Growth	
		Number of Persons	Annual Growth Rate, %
2000	79,817 ⁽¹⁾		
2010	99,600 ⁽¹⁾	19,783	2.2
2025	149,278 ⁽²⁾	49,678	2.7
2050	244,906 ⁽³⁾	95,628	2.0

⁽¹⁾ Based on spatial analysis of population by TAZ provided by Lawrence-Douglas County Metropolitan Planning Office and including all population within assumed year 2010 retail water service limits.
⁽²⁾ Projection by Lawrence-Douglas County Metropolitan Planning Office for UGA.
⁽³⁾ Projection developed for this report based on 2% per year growth rate from 2025 through 2050.



Projected total system water requirements are summarized in Table ES-2.

Table ES-2				
Projected Water Requirements (Total System)				
	Base Year ⁽¹⁾	Design Year		
		2010	2025	2050
Population	79,817	99,600	149,278	244,906
AD (mgd)	12.5	15.6	22.5	35.9
MD (mgd)	27.5	34.4	49.6	79.1
MH (mgd)	38.7	48.5	69.8	111.4
⁽¹⁾ Base year demands are calculated using design water demand projection criteria and the Year 2000 population. Base year demands are similar to recent historical demand.				

4. Findings

4.1 Water Supply

Raw water supply to the Kaw WTP consists of surface water from the Kansas River and groundwater from the Kansas River alluvium. The City recently obtained approval to develop a new water right on the Kansas River. This new right plus the existing water rights would limit the total amount of water diverted under the surface and groundwater water rights to a maximum annual volume of 8,152 million gallons (22.3 mgd), with a maximum diversion rate of 31,202 gpm (44.9 mgd).

Normal river water levels limit the supply capacity to the Kaw WTP from the Kansas River intake to approximately 16.5 mgd. The firm supply capacity to the Clinton WTP from the Clinton Reservoir intake is 20 mgd at conservation pool elevation (USGS 875.50) and 15 mgd at the projected drought water surface elevation (USGS 853.50).

The City has two contracts with the Kansas Water Office (KWO) that allow diversion of water from Clinton Reservoir. The original Contract 77-1 allowed the diversion of 3,650 million gallons per year (10 mgd) at a maximum diversion rate of 25 mgd, and the original Contract 90-5 provided for an additional annual diversion of 1,460 million gallons per year (4 mgd) while maintaining the maximum diversion rate of 25 mgd. The total annual diversion allowed under contract 77-1 has now been reduced to 3,468,957,286 gallons (9.5 mgd), and the total annual diversion allowed under contract 90-5 has been reduced to 1,287,481,489 gallons (3.52 mgd). Therefore, the total average annual yield available from the reservoir is 13.02 mgd and the maximum diversion rate is 25 mgd.



The total water rights of 35.32 mgd are sufficient to meet average day demands through year the planning year 2025 but will result in a shortfall of 0.6 mgd by year 2050.

As a result of a request by the Tri-counties water districts for a diversion of 200 million gallons per year (0.55 mgd), the KWO is considering a further reduction in the available supply to the City. Other users may also apply for water from Clinton Reservoir. The State has the right to consider the overall needs of all potential users of the reservoir and could further reduce the supply available to Lawrence. The City is discussing the KWO's plans for the Clinton Reservoir supply, as the State's decisions will have immediate impacts on the City's water system.

4.2 Water Treatment

The City of Lawrence is served by two water treatment plants (WTPs). Both use conventional lime softening treatment with flocculation, sedimentation, and filtration followed by chlorine disinfection. The Clinton WTP is located along Wakarusa Drive north of Clinton Parkway, and the Kaw WTP is at the intersection of 3rd and Indiana Streets. The Kaw WTP, originally constructed in 1917, has been expanded over the years. The treatment capacity of the Kaw WTP is currently restricted by a hydraulic bottleneck to about 16.5 mgd. Improvements are currently being implemented to remove the hydraulic bottleneck and allow the plant to produce at its rated capacity of 17.5 mgd. The Clinton WTP was recently expanded to 15 mgd.

Both plants consistently comply with all current state and federal water quality and treatment requirements. Several rules are scheduled for promulgation and implementation within the next few years. Because these rules have not yet been formally proposed or promulgated, their relative impact on current treatment operations is difficult to predict at this time. However, the information presented in this report reflects the latest thinking with regard to anticipated regulations.

It is currently anticipated that Stage 2 of the Disinfection By-products Rule will be finalized during July 2004. Stage 2A of the rule is expected to become effective by July 2007. It will add site specific maximum contaminate levels (MCLs) for disinfection by-products (TTHM and HAA5) to the existing average MCL required for the entire system. Stage 2B of the rule is expected to become effective by July 2010 and will set even lower site specific MCLs for DPBs, at revised locations based a one-year sampling program. Review of historical data indicates that both plants should be able to comply



with the requirements of the Stage 2 Disinfection By-Products Rule without significant difficulty. The only significant impact is expected to be increased analytical costs during the initial one-year period of expanded system monitoring.

The Long-Term Stage 2 Enhanced Surface Water Treatment Rule (LT2ESWTR) is expected to be promulgated during July 2004. The main focus of the LT2ESWTR is to require a two-year monitoring program to determine average *Cryptosporidium* concentrations in the source waters, and additional treatment if concentrations exceed certain levels. It is anticipated that both plants may be able to meet additional treatment requirements if the monitoring results place them in the middle “Bin 2” category. However, if future monitoring places either of the plants in the most severe “Bin 3” category, primary disinfection using ultraviolet radiation or physical removal using a membrane process could be required. It is not prudent to make any firm recommendations regarding what the City should do to prepare for compliance with this regulation because additional treatment requirements cannot be determined with any certainty until the required monitoring of the source water for *Cryptosporidium* is completed and submitted to the Kansas Department of Health and Environment (KDHE) by January 2007.

A particular emphasis with conventional treatment processes with regards to the regulations is the concept of “narrowing the margin” for error within the operations of a facility. As the regulations continue to get more restrictive the knowledge, training, supervision, and response of staff become more critical. The utility will be continually faced with the dilemmas of 1) simply meeting the regulations, which is required, versus providing enhanced treatment technologies (such as ozone disinfection, ultraviolet disinfection, and membrane filtration) to gain some of that “lost margin” back and 2) the cost to provide this enhanced level of treatment. This report is written around the concept of meeting the regulations. The governing body may elect to make a policy decision that meeting the regulations is not sufficient, and additional treatment processes may be needed to provide a higher level of treatment.

4.3 Distribution System

The existing service area of the Lawrence water system is divided into two service levels designated as Central Service and West Hills. Water to both service levels can be delivered from both treatment plants. Storage facilities in the Central Service Level consist of the Oread Reservoirs, the Kasold Reservoir, and the Harper Elevated



Tank. Storage facilities in the West Hills service level consist of the Sixth Street Elevated Tank and the Stratford Elevated Tank. Booster pumping stations located adjacent to the Oread and Kasold reservoirs can be used to pump to the West Hills service level.

Because the year 2025 service area will extend considerably beyond the current service area, new service levels will need to be added.

The Lawrence distribution system was evaluated by hydraulic analyses and various improvements were investigated to identify those most effective in meeting the projected water demands. Criteria used in developing the improvement program include increasing the system reliability, simplifying system operations, more effectively utilizing system storage to meet peak demands, and maintaining adequate pressures (at least 35 psi) under maximum hour demand conditions.

The analyses revealed localized pressure problems under maximum hour conditions in the vicinity of the Harper Elevated Tank and in the Santa Fe Industrial Park area. Ground elevations in the vicinity reach 980 feet in isolated areas. With the Harper Elevated Tank full (elevation 1015), the maximum pressure provided to this high ground elevation is only about 37 psi. These problems have been reported in previous hydraulic modeling and master planning for the Lawrence distribution system, but are not reported to be a significant concern at this time.

The existing facilities, and storage area for the distribution system crews and administrative staff are currently located at the Kaw WTP and do not meet their current needs.

5. Recommendations

Two alternatives to meet the year 2025 demand of 50 mgd were developed in detail. Both alternatives are based on expanding the existing water treatment plants since they constitute a large portion of the City's capital investment. A third water treatment plant, to be located in the vicinity of the Kansas River, northeast and west of the city, was considered, but was dropped from further consideration because of the cost to provide infrastructure to a new site and because it would involve staffing a third plant.



Table ES-3 summarizes the existing WTP capacities for the two alternatives.

Table ES-3			
WTP Capacities For Alternatives			
Facility	Existing Capacity (mgd)	Alternative 1 (mgd)	Alternative 2 (mgd)
Kaw WTP	17.5 ⁽¹⁾	25	17.5
Clinton WTP	15	25	32.5
Total	32.5	50	50

⁽¹⁾Existing capacity of 17.5 mgd is the rated treatment capacity. However, plant hydraulics currently limit the plant to 16.5 mgd.

Alternative 1 would involve the expansion of both the Kaw and Clinton WTPs to 25 mgd each to meet the future demands. Alternative 2 would involve the expansion of only the Clinton WTP to meet the projected year 2025 maximum day demand of 50 mgd. The Kaw WTP would remain at its current capacity of 17.5 mgd, whereas the Clinton WTP would be expanded from 15 mgd to 32.5 mgd.

Table ES-4 shows the comparison of the estimated capital costs of Alternative 1 and Alternative 2.

Table ES-4	
Cost Comparison of Alternatives	
Alternative	Capital Cost (\$)
Alternative 1	74,489,000
Alternative 2	73,660,000

A discussion of the relative merits and detriments of the two alternatives are summarized below:

- The cost for Alternative 1 about 1-percent higher than Alternative2, however, considering the relative accuracy of master-plan level estimating, the costs of the two alternatives are essentially the same.
- Both Alternative 1 and 2 would reliably meet the projected demands while maintaining compliance with existing drinking water regulations.



- Either alternative could be impacted by the requirement for additional source water treatment for *Cryptosporidium* removal or deactivation, but such impact cannot be determined until testing (which will start in July 2004) is completed in January 2007.
- The redundancy and security of having two plants of equal size provides an additional factor of safety in terms of meeting system demands if one of the two plants were out-of-service.

After careful consideration and review with City staff, it is recommended that the City of Lawrence proceed with implementing the water supply, treatment, and distribution system improvements identified as Alternative 1. The two plants of similar size arrangement has well served the City in recent years.

Additional information on recommended improvements under Alternative 1 is presented below.

5.1 Water Supply

The firm capacity of the existing river intake and the vertical wells at the Kaw WTP is approximately 16 mgd. Therefore, the firm capacity of the raw water supply system has to be increased to 17.5 mgd to be compatible with the plant's rated treatment capacity. The firm capacity of the intake system should be increased by installing a 30-inch parallel siphon. In addition, a program should be implemented for replacing all of the pumps at Low Service Pumping Station 2 (LSPS No. 2) with five units rated 3,050 gpm at approximately 75 feet head, to provide the required firm pumping capacity with one unit out-of-service. Other options for pump replacement capacities (such as two or three pump replacements with different rated capacities) may be considered during detailed design.

Additional surface water supply or a new groundwater supply is needed to expand the Kaw WTP raw water supply from 22.3 mgd to 25 mgd. A second intake crib should be constructed and a 24-inch raw water supply line installed to convey water to the trash well. From there, the water would be pumped through an upgraded Low Service Pumping Station 1 (LSPS No. 1) through a new 24-inch raw water transmission line to convey the water to the new treatment train. The upgrading at LSPS No. 1 would include replacement of the pumps, electrical equipment, HVAC system, and instrumentation and controls.



The Bowersock Dam has recently undergone significant maintenance and repairs. The City should plan on routinely inspecting the dam and budgeting for repairs to the more than 100 years old structure to ensure that the dam remains a viable component of the City's raw water supply system.

Improvements required to develop a firm supply capacity of 25 mgd to the Clinton WTP at the projected drought water pool elevation, include replacement of all existing pumping units with higher head units rated at approximately 180 feet. Three 10 mgd units and one 5 mgd unit should be installed.

5.2 Water Treatment

In order to expand the Kaw WTP from 17.5 mgd to 25 mgd, a new 7.5 mgd treatment train should be added and new presedimentation, primary, and secondary basins should be constructed. Circular basins are considered preferable to rectangular basins because circular softening equipment is more efficient in reducing hardness and settling out precipitate. Circular basins would provide treatment similar to that used at the Clinton WTP.

Additional filtration capacity is also needed at the Kaw WTP. It appears that the most viable option would be to construct two additional filters west of existing filters 5 through 8. For reliability, the two new filters should be of the same size as the adjacent filters, which would increase the filtration capacity by 7.8 mgd at a loading rate of 4 gpm/sf.

A new treated water reservoir with a minimum volume of 1 million gallons should be constructed to provide additional storage capacity at the site, allowing plant operation to vary from production rates. In addition to these improvements, new chemical feed facilities would need to be constructed to accommodate the increased capacity.

Expanding the Clinton WTP from 15 mgd to 25 mgd would involve the construction of a new basin train consisting of a presedimentation, a primary, and a secondary basin, and the installation of new chemical feed equipment for the new basin train; and construction of additional high service pumping facilities. Recommended high service pump station improvements are described in the following section about the distribution system. The Clinton WTP expansion project completed in 2002 already includes the filtration and transfer pump improvements necessary to process 25 mgd.



Depending upon the results of the monitoring for source water *Cryptosporidium* under LT2ESWTR, additional provisions for oocyst removal and/or inactivation may be required at the Kaw and the Clinton WTP. Depending on the severity of the *Cryptosporidium* infestation in the raw water, post-filtration UV disinfection may be required.

5.3 Distribution System

Service Levels: Much of the area west of Kansas Highway 10 (K-10) includes ground elevations that cannot be served at adequate pressures from the existing West Hills Service Level. A new Kanwaka Booster District is recommended to serve the entire area west of K-10. The Kanwaka Booster District would be supplied by booster pumping from the existing West Hills Service Level.

A South Service Level should be established for the future service area south of the Wakarusa River. The South Service level would have a maximum static hydraulic gradient of 1050, or about 30 feet higher than the existing Central Service Level.

Two areas of high ground that are expected to have a sizable future population could not be served by the future South Service Level. South 1 Booster District would be located in the southwest corner of the service area, along the south shore of Clinton Reservoir, and South 2 Booster District would be located on a ridge between Wakarusa Drive and Kasold Drive.

Storage Facilities: The City has been planning to construct additional storage in the West Hills Service Level along 6th Street, west of Wakarusa Drive. Based on the evaluations conducted for this report, this storage should have a minimum total volume of 1.0 million gallons.

No additional storage is recommended for the Central Service Level.

The additional storage volumes needed for each service level and booster district to meet projected demands through year 2025 are summarized in Table ES-5.



**Table ES-5
Recommended Additional Storage Facilities**

Service Level	Facility Designation	Volume (MGal)
West Hills Service Level	Sixth Street West Elevated Tank	1.0
Kanwaka Booster District	Kanwaka Elevated Tank	1.0
South Service Level	Central South Ground Storage	1.0
South 1 Booster District	South 1 Elevated Tank	0.25
South 2 Booster District	South 2 Elevated Tank	0.25

Pumping Facilities: Recommended pumping facilities are summarized below:

- The Kawaka Booster District should be supplied by two pumping stations for reliability and redundancy. The major pumping station should be located along Sixth Street, at the same location as the recommended 6th Street West Elevated Tank.
- The future South Service Level (including South 1 and South 2 Booster Districts) should receive the majority of its supply through a booster pumping station located in the vicinity of O’Connell Road and N 1100 Road (O’Connell Road Booster Station). Additional supplemental supply of about 2.0 mgd would be delivered directly from the Clinton WTP. A flow control valve should be installed on the existing 24-inch Central Service Level main near the intersection of 23rd Street and Wakarusa Drive to allow the Clinton WTP high service pumps to pump directly to the future South Service Level and to concurrently deliver water to the Central Service Level.
- The South 1 and South 2 Booster Districts should each be supplied by a single booster pumping station and elevated tank.
- High service pumping improvements are required for both the Kaw and the Clinton WTP as summarized below:
 - All four “old” Kaw WTP high service pumps to the Central Service Level should be replaced with 3.5 mgd units to meet year 2025 demands.



- The Kaw WTP high service pumps to the West Hills Service Level deliver only about 1.2 mgd, which is less than their reported capacity of 1.5 mgd. For reliability, the pumps should be replaced with units that would 1.5 mgd at a rated head of 350 feet.
- The Clinton WTP high service pumping capacity to the Central Service Level is not adequate to meet projected year 2025 demands. Two additional 5.0 mgd units should be installed.
- The firm rated capacity of 10 mgd from Clinton WTP high service pumping building to the West Hills Service Level is inadequate to meet the projected year 2025 demands. Two additional pumps rated at 4.5 mgd should be installed in the high service pumping building when the water treatment plant is expanded.

Distribution Mains: Significant distribution main improvements are required to deliver water from the expanded water treatment plants and to supply the expanded service area. Distribution main improvements are shown, with the locations of the other distribution system improvements discussed above, on Exhibit IV-1 in Section IV of this report.

Distribution main improvements are recommended to help sustain the water level in the Harper Elevated Tank. While a recommendation for a new “Harper Booster District” is not included in this report, additional consideration should be given to this concept if pressure concerns continue to be an issue in the area.

5.4 Operations and Maintenance Building

New operations and maintenance building space should be constructed at a location that can be separated from the water processing areas to provide a consolidated area for all Utilities Department administrative staff. An isolated site would enhance the security of the water processes as there would be no reason for the general public to require access to the plant sites. Public access is currently required at the Kaw WTP because the administrative staff is located there.



6. Capital Costs and Implementation Plan

All costs presented in this report are capital costs and have been developed from previous Black & Veatch projects of similar size and scope. All capital costs for distribution-related improvements, including pipelines, storage facilities, and pumping stations, include a 20 percent allowance for contingencies and a 20 percent allowance for engineering, legal, and administrative (ELA) costs. All capital costs for supply and treatment related improvements include a 25 percent allowance for contingencies and a 20 percent allowance for ELA. The overall water system capital costs, in 2003 dollars, for the 2025 planning period are summarized in Table ES-6.

Component	Capital Cost (\$)
Kaw Raw Water Supply Improvements	
Reliability	776,000
Growth	4,009,000
Clinton Raw Water Supply Improvement	
Reliability	--
Growth	1,151,000
Kaw WTP Improvements	
Reliability	-- ⁽¹⁾
Growth	14,561,000
Regulatory	2,476,000
Clinton WTP Improvements	
Reliability	--
Growth	7,901,000
Regulatory ⁽²⁾	2,476,000
Distribution System Improvements	36,440,000
New Operations and Maintenance Building	4,719,000
Total Improvements	74,489,000
⁽¹⁾ Reliability improvements are in the current year budget and are not included in this table for construction of a parallel header between the raw water flow splitter and presettling Basins 4 and 5, to remove a hydraulic restriction that currently limits the plant to about 16 mgd.	
⁽²⁾ UV post-filtration irradiation for Cryptosporidium inactivation may or may not be required depending upon the results of source water monitoring under the LT2ESWTR.	

An implementation plan showing 10-year capital improvements was developed and is shown Table VI-1 of the report. The phasing schedule for the Clinton WTP expansion is shown on Figure VI-1 in Section IV of this report.