LAWRENCE, KANSAS

STORMWATER MANAGEMENT MASTER PLAN

Burns & McDonnell

MAY, 1996

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Burns & McDonnell
ENGINEERS - ARCHITECTS - CONSULTANTS

May 7, 1996

Mr. George Williams, P.E.
Director of Public Works
6 East Sixth Street
Lawrence, Kansas 66044

City of Lawrence, Kansas
Stormwater Management Master Plan

Dear Mr. Williams:

Burns & McDonnell Engineers is pleased to present this final report to the City of Lawrence setting forth our analysis of the performance capability of the existing major drainage system; recommendations for improvements to the existing facilities; recommendations for policy revisions; analysis of financing options available to the City; and recommendations on establishment of a stormwater utility and rate structure as the revenue source for the stormwater management program. In addition to this report, watershed maps and a Stormwater Management Criteria manual have been prepared as separate, companion documents to this report. The criteria manual was approved by the City Commission on January 23, 1996 and formal adoption by ordinance is pending.

We wish to thank you, Mr. Mike Wildgen, Ms. Terese Gorman and other members of the City staff as well as members of the City Commission, local consultants and residents of the community for input and assistance provided throughout the process. The information made available to us and the informed review and consultation as interim reports were presented were instrumental in the successful completion of the study.

We trust that this report and the companion drainage system computer models will be of continuing value to Lawrence in your management and improvement of the City's storm drainage system.

Sincerely,

Joel A. Cerwick, P.E.
Vice President

Dena E. Mezger

Dena E. Mezger, P.E.
Project Manager

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LAWRENCE, KANSAS
STORMWATER MANAGEMENT MASTER PLAN
PROJECT NO. 94-249-4

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CERTIFICATION

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5/1/96

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STORMWATER MANAGEMENT MASTER PLAN
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PART I - EXECUTIVE SUMMARY

PART I

EXECUTIVE SUMMARY

A. PROJECT SCOPE AND BACKGROUND

This Executive Summary presents a condensed discussion of the Lawrence Stormwater Management Master Plan authorized by the City of Lawrence on May 24, 1994. The following sections of this report, together with accompanying watershed maps, computer models, and exhibits, present the detailed report and supporting information resulting from the study of the City's major drainage system which is the focus of this project.

Services performed by Burns & McDonnell Engineers of Kansas City, Missouri and Landplan, P.A., of Lawrence to complete the study included:

- Organization of a public meeting to gather information on existing drainage problems and opinions on drainage issues from citizens.
- Field investigation of the City's major drainage system.
- Preparation of a set of watershed maps covering the study area.
- Evaluation of the existing system's performance capability.
- Development of an optimized capital improvements plan for the City to correct system deficiencies.
- Preparation of capital and operating cost estimates for the system.
- Recommendation of implementation priorities for improvements.
- Development of a recommended program and annual budget for continuing maintenance of the system.

During the early phases of this project information on known drainage problems was gathered from various sources, primarily City records, the 1993 Stormwater Task Force report, and the residents of Lawrence. Information from citizens was obtained, for the most part, through a questionnaire distributed to participants in the public meeting held in October, 1994 and made available through a number of civic and neighborhood organizations. In addition to problem locations and descriptions, the surveys also asked for opinions on issues dealing with drainage policy. A total of 125 separate questionnaires were eventually returned along with copies of photos, newspaper articles, maps and even a videotape, all documenting drainage problems at various locations throughout the City. Using the information from discussions at the meeting and responses to the questionnaires, work proceeded on developing the stormwater management criteria document as well as analyzing the existing system and developing the recommended improvement projects list.

After presentation of the initial report draft to the City Commission in November, 1995 it was decided to publish the questionnaire in the Lawrence Journal World newspaper in December, 1995 to gain additional input from residents that may not have been aware of or able to attend the initial meeting. An additional 21 questionnaires along with several letters and phone calls were received after the survey appeared in the newspaper. Based on this additional information, the recommended projects list was reviewed and some revisions were made to individual project scopes and priority groups. A copy of the questionnaire and a summary of the results is included in Appendix A of this report.

B. GENERAL INFORMATION

1. DEFINITIONS

For the purposes of this study and the associated "Stormwater Management Criteria" document, the major system is considered to begin at the point where the 10-year return period peak flow to the system equals or exceeds 70 CFS. The improved drainage system comprises all components which have been constructed, installed or altered by development. This includes existing open channels which have been changed by grading or by the construction of lining materials. Unimproved drainage components, or natural channels, include all existing channels that have not been altered by grading or construction of any kind.

2. AREA INFORMATION

The 17 principal watersheds included in this study cover 26.3 square miles tributary to the Kansas and Wakarusa Rivers. Figure I-1, following this page, indicates the study area and the 17 watersheds.

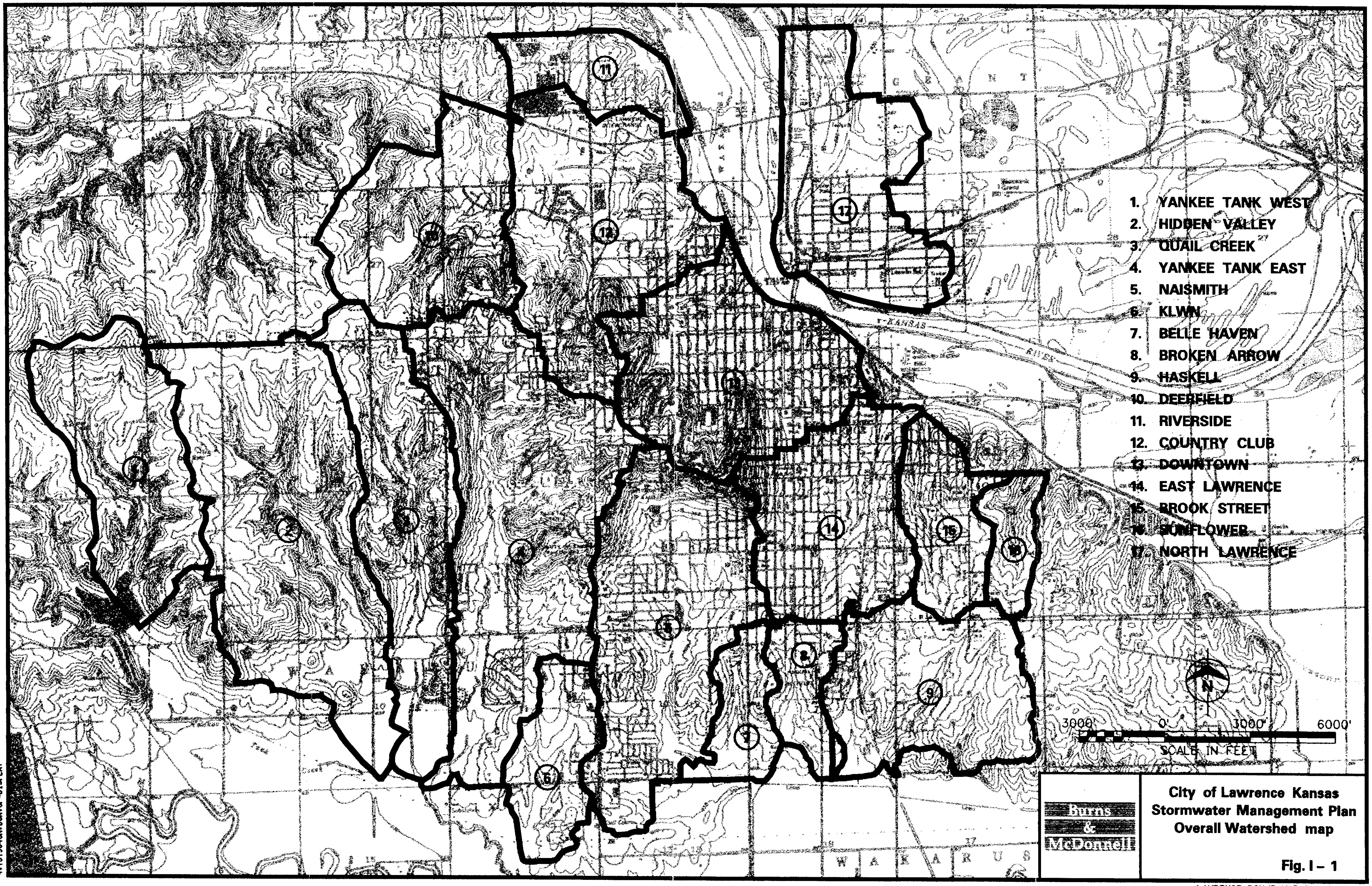
Average annual precipitation is 34.6 inches. Rainfall events that create peak demands on the system occur as convective thunderstorms an average of 50 times each year. Land slopes vary from nearly flat to approximately 20 percent in limited areas. Soils are generally silty-clay loams which are moderately pervious south of the Kansas River, and silty or sandy loams which are somewhat more permeable in North Lawrence.

Land use within the corporate limits is substantially developed with single family residential development being the largest use class. Currently developing areas are located primarily on the west and south sides of the city. A relatively large portion of the land included in the study area is occupied by the main campus of the University of Kansas and its associated facilities and property.

3. TECHNICAL INFORMATION

The project technical analysis initially was to utilize the existing 1970 and 1984 aerial mapping supplemented by information from the City's records for areas of more recent development. Shortly after this project was initiated, however, the City of Lawrence, the Douglas County Assessor's Office and several utility companies joined together to obtain new aerial mapping for a number of uses. The new photography and mapping was completed by M.J. Harden Associates of Kansas City, Missouri in mid-1995 and was used as the base mapping for the final storm drainage system analysis and mapping.

Data for modeling the existing system's performance were acquired from field investigations and a comprehensive review of City records and related studies. The Storm Water Management Model (SWMM)



City of Lawrence Kansas
Stormwater Management Plan
Overall Watershed map

Fig. I – 1

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computer program developed by the Environmental Protection Agency was the primary tool used for the analyses. In addition, two programs developed by Burns & McDonnell (SYCOST and PRIOR) were utilized for estimating costs and prioritizing recommended improvement projects.

C. EXISTING SYSTEM PERFORMANCE

1. SYSTEM COMPONENTS

The existing major drainage system within the study area consists of 193.8 miles of conveyance elements including enclosed pipe storm sewers, improved and natural open channels, and cross-road culverts in addition to several detention basins. Computer models defined the drainage system in terms of 1,395 individual sections, or reaches, for analysis. For the purposes of this study, 577 of the reaches were considered to be part of the improved drainage system. Table I-1, following, summarizes the existing system by watershed.

TABLE I-1

EXISTING SYSTEM MODEL DESCRIPTION

Watershed Name	Area (Acres)	Number Of Drainage Elements	System Hydraulic Length (Ft)
Yankee Tank West	756	46	44,010
Hidden Valley	1,788	128	109,450
Quail Creek	1,028	109	80,870
Yankee Tank East	1,747	156	120,135
Naismith	1,306	219	131,700
KLWN	486	31	32,850
Belle Haven	260	20	14,700
Broken Arrow	235	17	14,745
Haskell	824	116	72,745
Deerfield	898	89	53,785
Riverside	337	24	22,420
Country Club	1,217	117	67,580
Downtown	1,095	118	84,275
East Lawrence	830	84	63,740
Brook Street	397	41	30,630
Sunflower	189	15	10,600
North Lawrence	3,424	65	69,155
Totals	16,817	1,395	1,023,390

2. HYDRAULIC PERFORMANCE

The City's criteria applicable during the period when the majority of the existing improved drainage system was constructed required a 10-year peak design flow for all system components. (The recently approved criteria for new facilities also require that the system be designed for a 10-year return period in all areas but with additional provisions for overflow channels to handle the 100-year peak flow when combined with the conveyance element capacity.) Table I-2 summarizes the hydraulic capacity of the existing improved major drainage system in terms of its return period capacity, or level of service. Approximately one-third of this system has less than the desired 10-year design capacity based on current demands. The portions of the major system length comprised of natural, or unimproved, open channels, although not included in the summary, generally have adequate hydraulic capacity if maintained clear of major obstructions.

TABLE I-2

IMPROVED MAJOR SYSTEM LEVEL OF SERVICE

Return Period Capacity	No. of Reaches
<2 Years	115
≥2 Years <5 Years	53
≥5 Years <10 Years	33
≥10 Years <25 Years	74
≥25 Years <100 Years	67
≥100 Years	234

Although an existing system element may be identified (according to the computer model) as failing to meet either current or proposed criteria, it does not necessarily indicate deficiencies in design or construction at the time the element was originally constructed. The principal determinants of hydraulic demand on the drainage system are land use and rainfall, neither of which has remained static during the period of time over which Lawrence's system has developed. Additionally, the development of more sophisticated computer modeling techniques and other analytical methods, which permit a much more refined analysis of the systems' performance than was previously practical, has had a major impact on the results of studies and design calculations.

The mere absence of "criteria" capacity also is not necessarily indicative of a problem requiring corrective action. Corrective action is warranted only when the deficiency results in damage from flooding, an unacceptable level of nuisance or a public safety issue. Conversely, adequate hydraulic capacity does not mean that a system component is performing satisfactorily. Significant erosion, difficult maintenance, and structural deterioration are examples of problems that may warrant the replacement of a storm drainage system component having adequate total hydraulic capacity.

D. DRAINAGE POLICY

1. TECHNICAL STANDARDS

A "Stormwater Management Criteria" manual, which outlines specific technical standards and criteria for storm drainage system design, was prepared as a part of this study and submitted to the City as a separate document. After review by City staff and the public, minor revisions were made to the text and it was approved as a City standard by the City Commission on January 23, 1996. Formal adoption by ordinance is pending. Criteria contained in the manual which relate to drainage policy issues include the following.

a. All enclosed and improved open channel drainage system components shall be designed for the 10-year return period peak flow or the capacity of the existing upstream improved system, whichever is greater.

b. Surface overflow channels shall be required in all areas in addition to, and above, the 10-year conveyance element. The overflow Channel, when combined with the conveyance element, must provide sufficient capacity to convey the 100-year peak flow. Overflow channels will be covered by drainage easements with restrictions on land use within the easement required to prevent obstruction of flow.

c. Enclosed pipe-inlet systems will be required under the following conditions.

- Within the right-of-way of improved streets of new developments.
- In all areas where the bank line of an open channel, either natural or improved, would be within 30 feet of any existing habitable structure regardless of system design capacity.
- In new development areas where the permanent drainage easement of an open channel, either natural or improved, would encroach upon any existing or proposed structure.

d. Existing natural channels may be retained in the drainage system of a developed area provided flow velocities do not exceed recommended maximums based on soils present in the channel bed and bank. In addition, natural channels should remain in their original locations as much as possible.

e. Detention facilities shall be provided in connection with land development when problem areas have been identified where homes, buildings or other structures within the drainage basin and downstream from the proposed development are frequently flooded during storm events. Detention facilities shall also be required where an engineering study indicates the proposed development would cause flooding of downstream structures not previously affected; where such facilities are recommended by the City's current Stormwater Management Master Plan; or where determined by the City Engineer to be beneficial to the drainage system.

f. Dedication of easements for all improved system components to be maintained by the City shall be required as well as maintenance access connections to street right-of-way. Easements will also be required, although not for City maintenance purposes, along natural, or unimproved, channels and around private detention facilities other than parking lots, rooftop detention or similar situations. Restrictions on land use within some easements is outlined in order to insure proper function of the overflow system.

2. EXISTING SYSTEM CAPITAL IMPROVEMENTS

a. Major Drainage System Components

For the purposes of identifying and developing recommended improvement projects for this study, only those system elements where the existing deficiency has one or more of the recurring adverse effects listed below were considered.

- Building flooding at 25-year or more frequent intervals.
- Overflow of public streets by the 2-year storm for a time duration greater than 10 to 15 minutes.
- Structural failure has occurred or is impending.
- Uncontrolled discharge of water from public right-of-way onto adjacent private property results in erosion which will eventually either endanger buildings or otherwise adversely affect the use of the property, or creates a recurring nuisance and the lack of maintenance control for the property owner.

Facilities recommended for improvement were also limited to those currently maintained by the City. No improvements are recommended along natural channels located in developed areas since the City currently does not take responsibility for maintenance of those segments of the system. Improvement projects also do not include facilities over which the City has no jurisdiction. These include railroad culverts, state and county highway department culverts, and privately constructed and maintained facilities such as the University of Kansas system.

b. Minor System Components

Recent and current city policies have required developers to construct adequate storm sewers as part of the land development process. Those policies are reflected in a corresponding value and cost of the privately-owned property in those developments. Other developed areas annexed which were after development may not have a commensurate private investment in storm sewers. Because there is an inherently inequitable level of private investment, the City should limit its correction of minor system drainage problems to the following circumstances.

- When water discharged directly from a public street or other City property is causing damage in the form of structure flooding or severe erosion to the downstream property.
- When the hydraulic capacity of cross-road culverts is less than the 2-year return period demand and the deficiency causes structure flooding upstream from the culvert; or if the structural condition of the culvert is not serviceable.
- When the hydraulic capacity of the enclosed system is less than a 5-year storm demand and structure flooding has occurred, or is predicted to occur by competent professional advice, due to system inadequacies; or when structural failure has occurred, or is impending.

3. SYSTEM MAINTENANCE

The City's current policy provides for the City to maintain improved public drainage facilities within the corporate limits. Maintenance of natural or unimproved channels is currently not performed by City personnel. Upkeep of such channels is considered the responsibility of the private property owner(s) whose land abuts the channels.

In general, it is recommended that the current basic policies pertaining to drainage system maintenance by the City be continued; however, a planned regular maintenance program as outlined in Part VII of this report should be initiated. In order for this approach to be successful, however, it is essential that the City enforce its ordinance concerning the maintenance of drainage easements on private property. In addition, such enforcement should extend to private improved drainage facilities, such as drive or road culverts, on-site enclosed systems, and detention basins, which adversely impact adjoining properties when they do not function properly.

E. RECOMMENDED SYSTEM IMPROVEMENTS

1. ALTERNATIVES

System capital improvement project recommendations were developed after consideration of the benefits, performance and cost of a broad range of options including land use or zoning changes; drainage easements; removal of damageable improvements; detention; open channels; and enclosed storm drains. The resulting recommended improvement projects are essentially all structural improvements to the storm drainage infrastructure consolidated into 41 defined projects scattered throughout the City.

2. RECOMMENDED CAPITAL IMPROVEMENTS

Table I-3, following, identifies the projects by general locations along with estimated capital costs. Detailed descriptions of each one are presented in Part VI of this report. The sizes and extent of the various components included in each project were based on the best information available for a planning study of this type. Once the actual design of any particular project is undertaken, however, the specific data (such as utility locations, right-of-way restrictions, geotechnical limitations, etc.) available at that time will very likely result in revisions to the particular type or size of facility. More specific information may even require consideration of a completely different approach to the problem such as removal of existing flood-prone structures rather than improvement of the drainage system. For planning and budget purposes, however, the recommended projects components are reasonable estimates of the magnitude of the improvements required at each of the identified drainage problem locations.

TABLE I - 3

RECOMMENDED CAPITAL IMPROVEMENT PROJECTS

Project Number	Project Name	Capital Cost
1	15th St. System	$ 91,200
2	8th-9th-Crawford	130,000
3	Crestline-Westdale	139,500
4	15th St.-Iowa St.	790,400
5	Lawrence Ave.	540,000
6	29th Court	148,000
7	Ridge Court	110,000
8	23rd & Ousdahl	1,022,800
9	Carolina St. System	2,563,100
10	21st St. West System	1,256,600
11	20th St. East System	2,563,100
12	22nd-23rd St. West	297,500
13	26th-Four Wheel Dr.	544,250
14	27th St.-Saratoga	526,000
15	West Indian Ave.	325,000
16	23rd St.- Haskell Ave.	111,000
17	2nd-3rd-Michigan-Arkansas	1,140,300
18	3rd-4th-Minnesota	400,900
19	Michigan St. Culvert	102,100
20	6th St.- Arkansas	304,900
21	7th St.-Michigan St.	159,000
22	Tennessee-Kentucky	946,000
23	8th-Ohio-Tennessee	463,500
24	9th-10th-Mississippi	1,140,000
25	8th-9th-Connecticut	482,000
26	9th-Vermont-New Hampshire	137,000
27	14th St.- New Jersey	266,400
28	13th & Oregon	2,248,000
29	21st St.-Massachusetts	604,000
30	19th-Kentucky to Leanard	1,282,900
31	Haskell & Lynn	163,800
32	16th-Kentucky-N. Hampshire	2,299,700
33	13th St.-Brook St. Culvert	171,000
34	Maple Lane-19th-Brook St.	1,080,000
35	15th-Summit-Prairie	175,100
36	19th St. Culvert	35,000
37	N. 5th & Maple System	3,323,000
38	N. 8th-Maple to Levee	1,648,000
39	N. 4th-Elm to Levee	226,000
40	N. 2nd-I70 to North St.	1,494,800
41	N. 7th-Elm to Levee	285,700
	Total	$ 32,038,150

The capital cost includes construction costs, design fees, land acquisition costs (where applicable), and contingencies.

F. IMPROVEMENT PRIORITIES

1. GENERAL

Since there are many elements of the existing city-wide major drainage system that do not provide an acceptable level of service, and all cannot be corrected "first," it is necessary for the City to establish priorities on an objective basis. The end objectives in setting these priorities should be to accomplish the following overall goals.

- Provide an equal minimum level of service to all citizens as soon as possible.
- Upgrade the drainage system as a whole to meet criteria standards for a higher level of service.
- Improve the system in order to yield the best practical benefit for the earliest investment.
- Accomplish the improvement in an order such that any isolated improvement does not add to an existing problem or create a new problem elsewhere.
- Directly benefit as many individual citizens as early as practical and reasonable to maintain continuing support for an orderly prioritized program of improving drainage service.

2. PRIORITY EVALUATION

While all of the recommended improvement projects are considered necessary to provide the desired level of drainage service throughout the community, the economic realities of financing such a large capital improvements program must be recognized. To structure the financing, the program was divided into phases based on three priority groups which categorized each of the recommended improvement projects as described below.

- Group I - This highest priority group includes the critical projects defined as those where recurring residential or commercial structure flooding by surface runoff is, or appears to be, the direct result of the inadequacy of the existing storm drainage system.
- Group II - This group of projects includes those areas where the inadequacy of the existing improved drainage system

results in severe flooding of major streets which impedes pedestrian and vehicular traffic, including emergency vehicles, and creates access problems to public and/or private property for a number of people.

- Group III - This group includes the remainder of the projects which deal primarily with erosion and nuisance situations. This is considered the lowest priority group of the three categories.

The projects included in Group I are recommended as the absolute minimum for the initial phase and, because of their "critical" nature, should be completed in as short a time as possible. To plan the initial program, the projects within Group I were further prioritized using Burns & McDonnell's PRIOR computer model which calculates a point value for each project based on the nature and extent of the drainage problem and the cost of the proposed improvement. The program then essentially assigns the highest priorities to those projects that relieve deficiencies benefitting the greatest number of people at the lowest capital cost per benefitted system "user." Additional detailed information on determination of the PRIOR program points and control is presented in Part VIII of this report.

3. RECOMMENDED PLAN PRIORITIES

Table I-4 summarizes the projects included in Group I and indicates the number of points calculated for each one, the priority ranking, the estimated cost and the factor which controlled its rank among the proposed projects according to the PRIOR program.

TABLE I-4

PHASE I CAPITAL IMPROVEMENTS PROGRAM
GROUP I PROJECTS AND PRIORITY RANKINGS

Priority No.	Project No.	Description	Capital Cost ($)	PRIOR Points	Priority Control
1	17	2nd-3rd-Michigan-Arkansas	1,140,300	23	Raw Pts.
2	9	Carolina St. System	2,563,700	21	Raw Pts.
3*	28	13th & Oregon	2,248,000	15	U/S Proj.
4	29	21st St.-Massachusetts	604,000	18	Raw Pts.
5	10	21st St. West System	1,256,600	17	Raw Pts.
6	6	29th Court	148,000	16	$/Prop.
7	11	20th St. East System	2,312,650	16	Raw Pts.
8	--	Misc. Minor System Imprvmts.	112,000	14	No.Struc.
9	34	Maple Lane-19th-Brook St.	1,080,000	14	Raw Pts.
10	32	16th-Kentucky-New Hampshire	2,102,000	13	No.Struc.
11	7	Ridge Court	110,000	13	Freq.Damg.
12	26	9th-Vermont-New Hampshire	137,000	13	Raw Pts.
		Total $	13,814,250		

* - Even though fewer points were calculated for Project No. 28, it has a higher ranking because it must be completed before No. 29 to prevent increased problems in the area of No. 28 which is downstream.

Once this initial phase is complete, the second and third capital improvement programs, including the Group II and III projects, respectively, should proceed. The list of and total estimated costs for the projects included in these two phases are indicated in Tables I-5 and I-6. Prioritization of the projects in these groups will be performed by the stormwater utility staff as each phase begins.

TABLE I-5

PHASE II CAPITAL IMPROVEMENTS PROGRAM
GROUP II PROJECTS

Project No.	Description	Capital Cost ($)
4	15th-Iowa St. System	790,400
8	23rd & Ousdahl System	1,022,800
16	23rd & Haskell System	111,000
20	6th & Arkansas System	186,500
22	Tenn.-Kentucky System	946,000
23	8th-Ohio-Tenn. System	463,500
24	9th-10th-Miss. System	1,140,000
30	19th-Kentucky to Leanard	1,282,900
40	N. 2nd- I70 to North St.	1,494,800
	Total	$ 7,437,500

TABLE I-6

PHASE III CAPITAL IMPROVEMENTS PROGRAM
GROUP III PROJECTS

Project No.	Description	Capital Cost ($)
1	15th Street System	91,200
2	8th-9th-Crawford System	130,000
3	Crestline Dr.-Westdale Dr.	139,500
5	Lawrence Ave.	540,000
12	22nd-23rd St. West	297,500
13	26th St.-Four Wheel Dr.	544,250
14	27th St.-Saratoga System	526,000
15	West Indian Ave. System	325,000
18	3rd-4th-Minnesota System	400,900
19	Michigan St. Culvert	102,100
21	7th & Michigan System	159,000
25	8th-9th-Conn. System	482,000
27	14th & New Jersey	266,400
31	Haskell & Lynn	163,800
33	13th-Brook St. Culvert	171,000
35	15th-Summit-Prairie System	175,100
36	19th St. Culvert	35,000
37	N. 5th & Maple System	3,323,000
38	N. 8th- Maple to Levee	1,648,000
39	N. 4th- Elm to Levee	226,000
41	N. 7th- Elm to Levee	285,700
	Total	$10,031,450

G. FINANCIAL PLAN

The financial plan presents alternative funding mechanisms and revenue sources necessary to implement the first phase of the capital improvements program which includes the 12 Group I projects at a total estimated capital cost of $13,814,250. The plan is not an analysis of all of the possible options available to the City but a summary of basic alternatives illustrating the impact of various factors along with recommendations to aid the City in financial decisions which are in the best interest of the community.

1. FINANCING METHODS

The two alternatives for financing the recommended improvement projects are cash-basis and debt financing. Tables I-7 and I-8 present summaries of the annual and total costs for each technique based on both five-year and 10-year capital improvement program durations. All scenarios assume that the capital improvements will be constructed at a level rate over the program duration with an annual construction cost increase of 2.5 percent. Since operation and maintenance of the system is assumed to be the same under each plan, these annual costs have not been included in the figures so that only the costs of the financing methods are indicated. Additional detailed information on the assumptions and basis used in the financial analysis is presented in Part VIII of this report.

TABLE I-7

PHASE I CAPITAL IMPROVEMENTS PROGRAM
CASH FINANCING COSTS

Year	5-Year Program Annual Cost ($)	10-Year Program Annual Cost ($)
1	2,762,850	1,381,425
2	2,831,921	1,415,961
3	2,902,719	1,451,360
4	2,975,287	1,487,644
5	3,049,669	1,524,835
6	N/A	1,562,956
7	N/A	1,602,029
8	N/A	1,642,080
9	N/A	1,683,132
10	N/A	1,725,211
Totals	$ 14,522,446	$ 15,476,633

In addition to the two program durations, the annual and overall costs of the bond financing plans are also compared for the use of two types of bonds, 10-year general obligation (G.O.) bonds and 10-year revenue bonds.

TABLE I-8

PHASE I CAPITAL IMPROVEMENTS PROGRAM
BOND FINANCING COSTS

Phase I Program Duration	Bond Type	Issue Amount($)	Annual P&I($)	Total Bond Costs($)*
5 years	G.O.	12,500,000	679,340	17,046,000
5 years	Rev.	14,500,000	1,281,400	23,071,780
10 years	G.O.	9,000,000	543,470	12,273,100
10 years	Rev.	12,500,000	711,890	19,889,310

* Including bond issuance costs and reserve funds where applicable.

2. REVENUE SOURCE

It is recommended that funding for the improvement program, regardless of which financing technique is selected, be derived from revenue from a proposed stormwater utility. Such fees fairly apportion the cost of drainage service to runoff generators. An increase in the mill levy rate for funding the program entirely or in part from property taxes or the use of a special sales tax is not recommended since both methods are based only on value and have no relation to actual contributions to runoff into the drainage system for each property. The use of impact, or development, fees was also investigated as a possible additional revenue source; however, due to the extent of existing development in the watersheds included in this study, such fees were not considered applicable at this time.

The utility can act as the organizational unit for all stormwater management activities including implementation of management plan policies, oversight of the completion of the associated capital improvements program, and continuing management and maintenance of the City's drainage system. It is anticipated that the stormwater utility will fall under the jurisdiction of the Director of Public Works and will consist of a stormwater engineer, administrative clerk, and a maintenance crew. Table I-9 lists the estimated annual costs to operate the utility based on the recommended staffing levels and system maintenance program.

TABLE I-9

STORMWATER UTILITY ANNUAL COSTS

	Average Annual Salary/Cost($)
Engineer	42,170
Administrative Clerk II	20,696
Field Supervisor	29,265
Maintenance Worker I (3 @ $21,756 each)	65,268
Labor Subtotal	$ 157,399
Add labor overhead (estimated @ 35%)	55,090
Labor Total	$ 212,489
Office and Shop Area Rental, Supplies	10,000
Vehicles, Equipment, Materials	72,500
Total	$ 294,989

In addition to the annual costs indicated in the table, it is recommended that a discretionary fund of $125,000 be included in the utility budget. For the first two to three years of operation this fund can be used to acquire the necessary additional vehicles and equipment for the utility and then later be used to fund various small improvement projects not included in the major system capital improvements plan.

The proposed rate structure for the stormwater utility is presented in Table I-10. In order to determine the various property classifications and rates, the basic unit, the Equivalent Residential Unit (ERU), for the City was established. To accomplish this task, data base information for all properties within the corporate limits was obtained from the Douglas County appraiser's office and analyzed. The ERU determined for the City of Lawrence is based upon the data for single-family residential properties. Adding the land areas and total improved areas for all property identified as such, the ERU, or average parcel, was determined to be 11,320 square feet of land with 1,888 square feet of total improved area. Additional analyses of other residential classifications indicate that multi-family units average approximately two-thirds or less of a single-family unit.

TABLE I-10

PROPOSED UTILITY RATE STRUCTURE

Property Category	Total Improved Area/Parcel (SF)	No. of ERUs Billed
Single-family Residential	< 1,200	0.67
	1,200 to 3,000	1.0
	> 3,000	1.5
Multi-family Residential	N/A	0.67
Commercial	≤ 10,000	2.5
	10,001 to 25,000	8.5
	25,001 to 50,000	18.0
	50,001 to 75,000	32.0
	75,001 to 100,000	44.5
	≥ 100,000	Actual No. ERUs

3. STORMWATER UTILITY FEES

Stormwater utility charges were established at the level necessary to generate the revenue required to support the capital improvements program along with utility operation. For cash-basis financing, required annual revenues varied from approximately $2,000,000 to over $3,000,000 depending on the capital program duration. For bond financing, annual revenue requirements vary from approximately $1,900,000 to $2,375,000. Table I-11 outlines the rates required to fund the program solely from the utility's revenue based on the need for revenues of approximately $2,000,000 annually. This level would support most of the financial plan options outlined.

TABLE I-11
STORMWATER UTILITY RATES AND TOTAL REVENUES

Property Category	No. of ERUs Billed	Monthly Rate	Total No. Units	Monthly Revenue	Annual Revenue
SFR	0.67	$ 2.70	1,931	$ 5,214	$ 62,564
SFR	1.0	4.00	12,556	50,224	602,688
SFR	1.5	6.00	883	5,298	63,576
MFR	0.67	2.70	16,727	45,163	541,955
COMM1	2.5	10.00	664	$ 6,640	$ 79,680
COMM2	8.5	34.00	336	11,424	137,088
COMM3	18.0	72.00	146	10,512	126,144
COMM4	32.0	128.00	38	4,864	58,368
COMM5	44.5	178.00	23	4,094	49,128
COMM6	Actual No. ERUs	4.00/ERU	6,904[1]	27,616	331,392
			Totals	$ 171,049	$2,052,583

No reductions or waivers of monthly utility charges are recommended for any property. Although this approach has been used in some cities with development fees, it is recommended that it not be applied to the basic monthly fee. Even if developers or property owners provide on-site facilities such as detention to reduce or control runoff, ultimately some amount of stormwater will be released to the public drainage system making the property a utility "customer" along with all other users of the system. It is also often the case that regulatory detention or other techniques required by policy to reduce local runoff from a site, provide little or no benefit to the major system as a whole in reducing peak storm flows downstream. Even if some benefit initially exists, if such facilities are not properly operated or maintained it may be completely lost. Reducing fees when there may be no real long-term benefit provided to the system by certain drainage improvements does not accomplish the City's stormwater management goals or provide for fair distribution of the costs.

H. RECOMMENDATIONS

Based on the technical and financial analyses performed, it is recommended that:

1. The City proceed with establishing a stormwater utility as the organizational and financial mechanism for ongoing stormwater management in Lawrence.
2. Fees from the utility be used as the revenue source for all operating, maintenance and capital improvement costs associated with the City's storm drainage system. Development fees are not appropriate as a revenue source at this time for the watersheds studied.
3. The utility rate structure based on four residential categories and six commercial categories, as outlined previously in this section, be adopted.
4. The Phase 1 capital improvements program duration be set at five years in order to address the most serious drainage problems as quickly as possible.
5. The first phase of the program be financed using 10-year general obligation bonds.
6. The initial rate per Equivalent Residential Unit (ERU) be set at \$4.00 with rates for other tiers as indicated in Table VIII-11 in order to generate revenue of approximately \$2,000,000 annually as required by the financing option.
7. No reductions in monthly stormwater utility fees be allowed for any property.

While this plan presents options, the actual decision to proceed with any capital improvements program and choice of funding mechanisms, revenue sources and rates, is the prerogative of the City Commission. It is the City's responsibility to balance the community's needs with available resources in a manner which is acceptable to the citizens of Lawrence.

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PART II - GENERAL INFORMATION

PART II
GENERAL INFORMATION

A. AUTHORIZATION AND SCOPE

This study and report were authorized by agreement between the City of Lawrence, Kansas and Burns & McDonnell Engineers of Kansas City, Missouri on May 24, 1994. Specific services authorized were:

- Review of existing maps, records, reports, ordinances, criteria and floodplain studies to organize and collate information pertinent to the study.

- A public meeting at the beginning of the study to gather information about existing problems and public perception and opinions; public meetings at the end of the study to present findings and recommendations; and a meeting with local developers and design professionals to present recommended updated design criteria.

- A field investigation of the City's existing major drainage structures and hydrologic land use parameters to measure and record data for use in computer modeling of the system, operation and maintenance studies, and cost and priority studies.

- Preparation of system maps at a scale of 1"= 200' using recent aerial topographic mapping as a base and identification thereon of:
  - Watershed and subwatershed boundaries.
  - Existing major drainage system structures.
  - Computer model identification nomenclature.

- Evaluation of the performance capabilities and deficiencies of the existing drainage system by use of the Environmental Protection Agency's (EPA) Storm Water Management Model (SWMM) computer model for return periods ranging from two years to 100 years.

- Development of a master facility plan for the City considering the optimum combination of structural and nonstructural components capable of providing an acceptable level of drainage service under future complete development in accordance with the City's current land use plan.

- Preparation of capital and annual operation and maintenance cost estimates for the City's drainage system and for recommended improvement projects using the SYCOST computer model.

- Development of recommended priorities for implementing specific structural and nonstructural improvement projects using the PRIOR computer model.

- Preparation of a recommended plan for operating and maintaining the drainage system.

- Preparation of a financial plan with recommendations for funding improvements to and continuing management of the drainage system.

- Preparation of a storm drainage system design criteria document.

- Preparation of a written report with supplementary graphic exhibits presenting the information and recommendations developed by the study.

B. DEFINITION OF TERMS

Various technical terms are used throughout this report. They are defined as follows.

1. Detention Facility - Any structure, device or combination thereof that functions to accept inflow from surface runoff and discharge it at a controlled rate less than the peak inflow rate.

2. Developer - Any person or corporation engaged in the process of changing the use of land.

3. Development - Any activity, including construction of a subdivision, that changes, modifies or alters the land use, generally creating additional impervious surfaces on a site including, but not limited to, pavement, buildings and structures which increase stormwater runoff.

4. Enclosed Drainage System - A drainage system consisting of essentially continuous pipes and/or culverts below the ground surface.

5. Erosion - The removal of soil particles by the action of flowing water.

6. Freeboard - The vertical difference in elevation between the hydraulic gradient and a referenced point. Examples are the difference between the maximum water surface level behind a dam and the top of a dam, or the difference in elevation between the water surface at a culvert beneath the roadway and the surface of the roadway.

7. Hydraulic Gradient - The elevation of the surface of the water in the drainage system at any point.

8. Impervious Surface - Any surface that does not readily permit water to enter. Examples are roofs and concrete or asphalt-paved surfaces.

9. Improved Channel - Any channel whose characteristics are changed by either grading or construction of lining materials.

10. Level of Service - The return period for which a drainage system, or an individual element of that system has adequate hydraulic capacity.

11. Natural Channel - An existing channel that has not been appreciably altered by lining or changing its course.

12. Open System - A drainage system consisting of open channels, either natural or improved, with only comparatively short lengths enclosed by pipes or culverts.

13. Pervious Surfaces - Surfaces that readily absorb water such as yards and other unpaved areas.

14. Reach - A specific length of the storm drainage system between two points. For example, a reach may consist of a single culvert or may consist of several connected pipes or channel sections. The term "line" may also be used synonymously within the report.

15. Return Period - A statistical term for the average frequency that a given event may be expected to occur although it does not imply that the event will occur regularly at even intervals. It can also be defined as the reciprocal of the probability of an event. For example, a storm having a 10-year return period statistically can be expected to occur once in a period of 10 years, an annual probability of occurrence of 0.10, or 10%. However, the event may happen at any time and two such events may actually occur on successive days.

16. Sediment - Soil particles eroded by flowing water either in suspension in that water or as deposited.

17. Storm Drainage System - All of the natural and constructed facilities and appurtenances, such as ditches, natural channels, pipes, culverts, bridges, improved channels, street gutters, inlets and detention facilities, that serve to collect and convey surface drainage within the City.

18. Watershed - All land draining to the storm drainage system at any given point. This term is used synonymously with the terms tributary area, drainage area, drainage basin and catchment area.

C. STORM DRAINAGE SYSTEMS

There are two storm drainage systems in the City, the "major system" and the "minor system." Each must perform its function adequately to provide an acceptable level of drainage service. However, the consequences of poor performance by each system differ greatly.

The major system may be considered analogous to the City's arterial streets that serve to carry large volumes of traffic through the City. The minor system may be considered similar to the City's residential streets that serve to collect traffic from each driveway and carry it to the major streets for passage through the City.

Substandard performance by the major system is usually associated with significant consequences. When it fails to perform, comparatively large volumes of water overflow streets and property and may cause real damage by both erosion and flooding of buildings. The failure of the minor system to perform is characterized by lower volume, shorter duration overflows that may, on occasion, be a nuisance to traffic or cause objectionable quantities of water to flow across property although real damage is seldom experienced.

There is no clear line of demarcation between the major and minor systems. For the purposes of this report and in accordance with the design criteria manual developed as part of this project, the major system is considered to begin at the point at which the peak discharge for the 10-year return period storm equals or exceeds 70 CFS based upon the tributary area being fully developed in accordance with the current land use plan. This study and report are directed primarily to the major system although some minor system elements have been included for continuity of the analysis.

D. AREA INFORMATION

The City of Lawrence is located in Douglas County on the Kansas River. Major highways through the area include Interstate 70/Kansas Turnpike, U.S. Highways 24, 40 and 59, and State Highway 10. Major waterways include the Kansas River through the northeast corner and the Wakarusa River along the south edge of the city with the confluence of the two rivers east of Lawrence, near Eudora. Clinton Lake lies southwest of the city on the Wakarusa.

The University of Kansas main campus is located in approximately the center of the city and the Haskell Indian Nation University campus is located near the southeast corner. The Lawrence Municipal Airport is located northeast of the city, near the intersection of Highways 40 and 59. At this time, most new development is occuring along the south and west edges of the city.

For this study the city and adjacent areas tributary to the municipal drainage system are divided into 17 main watersheds covering a total area of 26.3 square miles. Each area is generally associated with a stream or a tributary to one of the major waterways including Deerfield, Country Club-Hope Plaza, Maple Grove, ATSF, and Brook Street Tributaries, all of which generally drain the north and east portions of Lawrence into the Kansas River. Both the east and west branches of Yankee Tank Creek, Hidden Valley Tributary, Quail Creek, KLWN Tributary, Naismith Creek, Belle Haven Tributary, Broken Arrow Tributary, and Haskell Tributary generally drain the southern and western sections of the city to the Wakarusa.

Geologically, Lawrence is located in the glaciated region of the state. Soils in the sloping uplands, which include most of the city south of the Kansas River, generally are fine-grained with moderately pervious surface soils and less pervious subsoils. They are classified according to the Unified Classification system primarily as silty-clay loams and clay loams, and as hydrologic Class C and D soils according to the Soil Conservation Service (SCS) system. Soils north of the Kansas River and along the Wakarusa are generally silty or silty-clay loams with some sandy loams in the floodplain areas which are somewhat more permeable than other soil types in the area. They typically are classified as hydrologic Class B or C soils in the SCS system.

Elevations in the area range from approximately 800 feet at the Kansas River in the northeast corner of the city, to 1070 feet in the upper reaches of the Yankee Tank West watershed. Surface slopes range from nearly level in the floodplains along the river, including North Lawrence, to almost 17 percent in several areas near the center of Lawrence (on the KU campus) and further west along the tributaries to Yankee Tank Creek.

Average annual rainfall in the area is approximately 34.6 inches. Monthly average precipitation ranges from a low of 0.88 inch in January to 5.14 inches in June. Heaviest rainfall is expected during the spring and summer months with 50 percent of the total precipitation falling in the period from May through August. The driest period is from November through February.

On the average, measurable precipitation (>0.01 inch) occurs during 419 hours spread over 97 days annually. Rainfall events that place the most frequent demands on the drainage system occur as convective thunderstorms having intense, short duration rainfall. Thunderstorms occur on about 50 days each year in Douglas County. The average annual runoff depth from precipitation is approximatley six inches. Mean annual lake evaporation in the area is approximately 44 inches.

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PART III - TECHNICAL METHODS & CRITERIA

PART III

TECHNICAL METHODS AND CRITERIA

A. SYSTEM MAPPING

Preliminary information for mapping the existing drainage system was obtained from copies of the watershed maps prepared as part of the never-completed 1980 storm drainage master plan along with the City's files and records including design drawings, subdivision plats, etc. General information concerning the existing drainage structures was obtained by reference to these records and then supplemented by information obtained during the field investigation phase of the work. Updated drainage system maps for this study were then created by transferring the major system components onto recent computerized aerial topographic maps prepared for the City by M.J. Harden Associates, Inc. of Kansas City, Missouri. During the office study phase, the system maps were expanded to include definition of major watershed boundaries and subareas tributary to each modeled reach of the drainage system based upon the new contour mapping and aerial photos.

After defining the system and individual drainage areas, the maps were keyed and coded to correspond to the computer models used for performance evaluation and confirmation of system hydraulic capacity. The completed full-size maps which indicate over 500 individual reaches of the system, have been separately furnished to City staff.

B. FIELD INVESTIGATION

A field reconnaissance survey was conducted by Landplan Engineering, P.A. in late 1994 and early 1995 to observe and confirm physical features of the existing drainage system throughout the City. Specific data such as size, materials, configuration, hydraulic condition, physical conditions, and the state of maintenance were measured, noted and recorded for approximately 600 individual reach elements throughout the 17 watersheds. Information for drainage elements not accessible for field inspection was obtained from the City's records. In addition to verifying sizes and materials of existing enclosed system and culvert elements, the following information was obtained where applicable:

- <u>Channel/culvert depth to overflow or structural damage</u>: Measurements were made of the available headwater (freeboard) at a number of principal culverts before overflow of the roadway or downstream property begins. These data were later used in office studies to evaluate allowable flow depths in the system reaches.

- <u>Open channel conveyance capacity</u>: Cross sections were measured for important open-channel reaches on the major system.

- <u>Hydraulic roughness coefficients</u>: Roughness coefficients (Manning's "n") values were estimated and recorded for system reaches in their existing condition. Table III-1 indicates the standards applied for estimating existing roughness coefficients.

TABLE III-1

FIELD EVALUATION STANDARDS FOR ROUGHNESS COEFFICIENTS

Conveyance Structure	Manning's "n"
Closed Conduits	
Reinforced Concrete Pipe	.013
Corrugated Metal Pipe	.023
Reinforced Concrete Box Culverts:	
a. Single Barrel	.013
b. Multiple Barrel, Effective	.016
Stone or Brick Masonry	.022
Improved Open Channels	
Full Concrete Lining - Good Condition	.015
Full Concrete Lining - Minor Joint Problems	.017
Full Concrete Lining - Advanced Deterioration	.020
Full Asphalt Lining - Good Condition	.017
Full Asphalt Lining - Poor Condition	.020
Grouted Masonry - Good Condition	.023
Grouted Masonry - Poor Condition	.030
Riprap	.035
Concrete Invert - Maintained Turf Sides	.020
Concrete Invert - Moderate Brush/Shrub Sides	.030
Concrete Invert - Tree and/or Improvement Obstruction	.035
Concrete Invert - Appreciable Fences	.045
Turfed - Clean, Few Obstructions	.030
Turfed - Moderate Obstructions	.035
Turfed - Severe Obstructions	.045
RR Tie - One Bank	.023
RR Tie - Both Banks	.020
Concrete Block Sides - Concrete Bottom	.019
Concrete Block Sides - Earth or Turf Bottom	.023

Natural Ditches or Channels

Straight to Moderately Sinuous

Clean Earth Banks, Earth Bottom or Smooth Rock	.030
Clean Earth Banks, Rough Rock Bottom	.035
Brushy Banks - Few Obstructions	.040
Brushy Banks - Significant Obstructions	.050
Debris and/or Weed Choked	.070

Overbank Floodways

Street R/W Perpendicular to Flow	.035
Yards - Open Grass	.030
Yards - Grass - Some Bushes and Trees	.040
Yards - Significant Trees and Bushes	.050
Unimproved - Weedy - Moderate Brush	.050
Unimproved - Heavy Brush and Trees	.060
Unimproved - Dense	.100
Unimproved - Open	.040

C. COMPUTER MODELING

1. GENERAL

Office studies were conducted to accomplish the following objectives.

- Define the performance level of the present drainage system under conditions of current land use and development.

- Define the hydraulic demand on the drainage system under conditions of future land use as defined by the City's comprehensive land use plan.

- Confirm the performance capacity of the system as improved by recommendations contained in other sections of this report.

- Evaluate alternative system improvement possibilities and evaluate the effect of various sequences and priorities of recommended improvements.

2. COMPUTER MODELS

The Environmental Protection Agency's (EPA) Storm Water Management Model (SWMM) computer program was used to model the existing storm drainage system throughout the 17 watersheds. In addition, two programs developed by Burns & McDonnell were used to estimate costs and to prioritize recommended improvements.

a. <u>SWMM</u>

The SWMM program generates runoff hydrographs at desired locations within a watershed for specific storm events and then simulates the subsequent routing through various drainage system components, including street gutters, pipes, channels and reservoirs. Although it is somewhat more complex, it was chosen over other available models because it can also simulate storm water quality. As storm water NPDES regulations are extended to cover municipalities such as Lawrence, the capability to model runoff quality will become of great importance in the City's overall management of storm water.

The model is arranged as a number of "blocks" each of which has a slightly different function or associated degree of complexity in terms of technical capabilities. The primary blocks used in analyzing a drainage system are the Runoff, Transport, and/or Extran blocks. Both the Runoff and Transport blocks can simulate storm water quality to varying degrees. For this study, the Runoff and Extran blocks were utilized.

The Runoff block is the basic hydrologic component of the model which generates the initial runoff hydrographs but can also perform relatively simple hydraulic routing through system components. It is the least complex of the program blocks and requires the least amount of specific data on the drainage system components. The runoff simulation is based on the specific input parameters for precipitation and subwatershed characteristics such as soils, slopes, and amount of impervious area. This block utilizes three preprogrammed conduit shapes: trapezoidal channels, parabolic channels, and circular pipes. Typical input for each shape includes dimensions, slope, roughness coefficient and length. For this study, the SWMM model was used to generate hydrographs to determine the peak flows at each of the drainage system components for return periods of 2, 5, 10, 25, 50 and 100 years. Routing through most of the enclosed system was also performed in the Runoff block.

The Extran block is used to route flows through the drainage system. It can also calculate water surface profiles for steady, gradually varied flow in natural or improved open channels and analyzes storage facilities within the system. It uses more complex hydraulic methods for routing than the other blocks and accounts for backwater effects. For this study the Extran block was used for routing through the large open channel portions of the drainage system where floodplain attenuation has the greatest impact and to analyze the performance of detention facilities.

b. SYCOST Program

The SYCOST program is a program primarily for estimating the budget grade costs of storm drainage systems for study and planning purposes. The program performs conceptual grade design of component system facilities then estimates their capital and annual cost using current unit prices for key items. It accommodates pipe systems with pipe sizes up to 96 inches diameter, single and multi-span box culverts, lined or natural open channels, and site specific detention facilities. Output data for each reach includes structure type and size, and cost estimates for construction, land acquisition, design fees and contingencies, total capital cost, and annual maintenance cost.

This program was used in this study to determine the value of and annual maintenance costs for the existing drainage system; to evaluate alternative facility designs; and to develop cost estimates for the most feasible proposed improvements.

c. <u>PRIOR Program</u>

The PRIOR program is a model for developing rational and logical priorities among discrete "projects" included in a large scale program or proposal for storm water system improvements. The model design is biased to assign the highest priorities to those projects that relieve deficiencies benefitting the greatest number of people at the lowest capital cost per benefitted system "user." Operation of the model sequentially determines a "score" for each project on an internally weighted scale then differentiates between equal "score" projects by secondary level comparison of component factors to establish an absolute priority ranking of all projects within the model. The evaluation scale used to determine project scores is presented in Part VI of this report.

Parameters analyzed for each project are frequency of damage from overflow of the existing system; number of damaged properties; type of damage such as structure and/or contents damage, erosion only, or nuisance only with no direct economic damage; frequency of existing system overflow; effect of inadequate system on future land development; structural condition of an existing facility, if present; magnitude of the absolute hydraulic deficiency; and capital cost of the project.

Output data from this program for each project includes priority number, priority points (or raw score), capital cost, and priority control which was the model's justification for assigning that project's priority.

For this study, the PRIOR program was utilized with the recommended improvements included in the "critical" projects list. Additional information on this list and the other improvement categories established is included in Part VI of this report.

D. RAINFALL

The design storm used in the analyses of the drainage system is defined as the pattern of rainfall over a specific period of time, or duration, for a given return period. The duration that tends to put the greatest demand on the system is termed the "critical storm duration" and is roughly equal to the time of concentration of the watershed. The time of concentration, T_c, is defined as the time at which the entire drainage area begins to contribute runoff or the time of flow from the farthest point in the watershed to the outlet. The "critical" duration then basically represents the minimum time required to insure that runoff from all parts of the drainage area is included in the peak discharge measured at the outlet.

For design of specific drainage system components such as pipes and culverts, the minimum storm duration generally will provide acceptable results. The regional conditions that are expected to produce these demands on the system are those associated with short-duration, high-intensity thunderstorms occurring as part of longer duration rainfall. However, a minimum duration will not adequately address the attenuation of flows in watersheds where there is significant detention or floodplain storage. On the other hand, too long a duration will many times overstate the peak flows that are pertinent in design of conveyance systems. Since the analysis part of this study has dual functions of evaluating the actual performance of the existing drainage system and of providing a basis for conceptual design of system improvements, a storm duration that will provide reasonable "design" values as well as evaluate the influence of storage attenuation on peak flows in the watersheds is required. A storm duration of 6 hours is used for all watersheds to insure that the modeling reflects the peak flow when all subareas of the basin are contributing runoff as well as the effects of any storage within the watershed.

Rainfall data for Douglas County were obtained from the Kansas Department of Transportation (KDOT) "Rainfall Intensity Tables for Counties in Kansas," 1991 edition. From this information, total rainfall depths for return periods of 2, 5, 10, 25, 50 and 100 years for a duration of six hours were determined as indicated in Table III-2.

TABLE III-2

DESIGN RAINFALL EVENTS

Return Period (Years)	6-hour Rainfall (Inches)
2	2.58
5	3.36
10	3.90
25	4.68
50	5.22
100	5.82

E. LAND USE

Land use parameters influencing runoff were evaluated on the basis of aerial photographs and field observation to develop existing system performance models. Considerable area is currently under development, primarily in the western sections of the city. Residential development is the largest single land use of developed area within the city. Commercial development is scattered throughout the city with concentrated areas downtown and along 6th, 23rd, and North Second Streets. Industrial uses occupy areas generally on the fringe of the city. Parks and recreation areas are scattered throughout the city. The University of Kansas and Haskell Indian Nations University campuses also represent other large single land use areas.

Runoff parameters with respect to land use are addressed for purposes of the SWMM analysis in terms of "hydraulically (directly) connected" or "effective" impervious area. Effective impervious area is defined as any impervious surface that drains directly to a defined drainage system component. An example of effective impervious area is a driveway, roof, parking area, etc., that drains directly to a street and thus to the gutter and curb inlet system. Any surface that drains onto an adjacent pervious surface, such as a roof with downspouts that drain onto a yard first, is considered ineffective and is not included in the percent impervious for the drainage area when modeling runoff with SWMM. For this study, basic land use categories and associated percentages of effective impervious area were developed for characterizing the drainage areas. These parameters are set forth in Table III-3.

TABLE III-3

LAND USE RUNOFF PARAMETERS

Land Use	Percent Total Impervious	Percent Effective Impervious
Single Family Residential	35	9
Apartment Residential	60	40
Mobile Home Parks	50	35
Industrial	70	60
Commercial	90	85
Churches and Schools	50	35
Parks, Cemeteries, Etc.	10	5
Undeveloped	0	0

F. COMPARISON TO PREVIOUS STUDIES

Previous drainage studies and reports prepared for the City include the current FEMA Flood Insurance Study (FIS), completed approximately 15 years ago; an internal drainage study covering North Lawrence prepared by Wilson & Co. in June, 1970 and updated in September, 1987; and a stormwater management plan for the Naismith Basin prepared by Burns & McDonnell in 1987. All of these reports were reviewed for applicable information during the development of this study. At the time of this report, restudies for both Lawrence and Douglas County flood insurance reports were underway and some preliminary hydrologic results were also reviewed during the course of this study.

In the period of time since those earliest studies were completed, the extent and type of development within many parts of Lawrence has obviously changed. Less obvious are the many changes or differences in the technical methods and the increased information available for analyzing the storm drainage system and simulating its performance. Therefore, it is somewhat difficult in some cases to directly compare the results of this report with those previous studies. It should not be concluded, however, that any of the reports are incorrect simply because different results have been obtained.

As an example, the FIS peak flows and those determined in this study may or may not compare favorably in several of the watersheds. The greatest differences will be noted in watersheds where considerable development has occurred since the original study. (FEMA studies do not take into consideration expected or planned future development.) Additionally, the FIS deals only with the main streams and rivers rather than the local drainage system throughout the city where many of the identified drainage problems occur and where a large part of the Stormwater

Management Plan analyses are concentrated. The specific technical methods used to determine peak flows in each case also contribute to apparent differences in the results. As discussed previously, the SWMM model using a 6-hour storm duration was used for this study while the original FIS hydrologic calculations were based on Soil Conservation Service (SCS) and Corps of Engineers (COE) models and regional equations. These models and equations are primarily based on statistical analyses of large, undeveloped drainage basins. The use of such methods can result in variations in excess of 50 percent between calculated and observed peak flows in small, urbanized basins.

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PART IV-EXISTING SYSTEM PERFORMANCE

PART IV
EXISTING SYSTEM PERFORMANCE

A. GENERAL

This section presents the results of the hydrologic and hydraulic analysis of Lawrence's major drainage system using the computer models as described in Part III of this report. The analysis was based on the storm drainage system and land use as they existed in late 1994 and early 1995. The performance of the existing system was reviewed based on both the current municipal drainage design criteria and the proposed "Stormwater Management Criteria" document which has been supplied to and accepted by City staff and the City Commission separate from this report.

The City's current design criteria require design of drainage facilities based on a ten-year return period storm. The proposed criteria also require that all enclosed pipe systems and improved open channels be capable of conveying a ten-year return period peak discharge but with the added requirement for the provisions of adequate overflow capacity to allow the combined system (conveyance element plus overflow channel) to carry the 100-year discharge without flooding adjacent structures.

However, identifying an existing system element as failing to meet either current or proposed criteria, according to the model, does not indicate deficiencies in design or construction at the time the element was originally constructed. The principal determinants of hydraulic demand on the drainage system are land use and rainfall. Neither has remained static during the period of time over which Lawrence's drainage system has developed. Major impacts on the capacity rating of the system include updated information on the predicted intensity of rainfall based on ongoing Weather Bureau statistical analysis of precipitation records; changes in land use not anticipated at the time of the original design and construction; and development of computer modeling techniques and other analytical methods that permit a more refined analysis of system performance than was previously practical.

B. EXISTING DRAINAGE PROBLEMS

During the early phases of this project information on known drainage problems was gathered from various sources, primarily City records, the 1993 Stormwater Task Force report, and the residents of Lawrence. Information from citizens was obtained, for the most part, through a questionnaire distributed to participants in a public meeting held in October, 1994 and made available through a number of civic and neighborhood organizations. In addition to problem locations and descriptions, the surveys also asked for opinions on issues dealing with drainage policy. The questionnaire was published again later in the Lawrence Journal World newspaper in December, 1995 to gain additional input from residents that may not have been aware of the initial meeting.

After the distribution in October, 1994 a total of 125 separate questionnaires were eventually returned along with copies of photos, newspaper articles, maps and even a videotape, all documenting drainage problems at various locations throughout the City. An additional 21 questionnaires along with several letters and phone calls were received after the survey appeared in the newspaper. A copy of the questionnaire and a summary of the results is included in Appendix A of this report.

The problems identified by these surveys, along with others previously identified by the City and the Stormwater Task Force records, were compared with the results of the existing system analysis to aid in the identification of those problems due to actual system deficiencies and those apparently due to other conditions. In addition, the information on the specific types of problems was used in categorizing the proposed improvements into basic priority groups discussed in Part VI of this report.

C. BASIN MODEL DEVELOPMENT

1. MODEL ARRANGEMENT

Computer models were developed for 17 principal watersheds including the City of Lawrence and immediately adjacent areas. Each of the watersheds has its own unique drainage system tributary to one of the main waterways in the area. The models for the watersheds within the study include 1,395 pipe, culvert, detention and open channel reaches totaling 1,023,390 lineal feet (193.8 miles) of drainage system components. Basin area incorporated into the models totals 16,817 acres, or 26.3 square miles.

In general, only the larger detention facilities which actually impacted the overall system performance were included in the models. A number of small ponds with small drainage areas are indicated on the aerial mapping throughout the City and numerous other detention facilities are located on individual commercial tracts as required by current City detention policy; however, these basins were not included in the modeling since their impacts tend to be very localized rather than on the system as a whole.

System maps indicating watershed limits and individual model reaches developed as part of this study have been separately furnished to City staff members. A summary description of the model content is indicated by Table IV-1.

TABLE IV-1
EXISTING SYSTEM MODEL DESCRIPTION

Watershed Name	Area (Acres)	Number Of Drainage Elements	System Hydraulic Length (Ft)
Yankee Tank West	756	46	44,010
Hidden Valley	1,788	128	109,450
Quail Creek	1,028	109	80,870
Yankee Tank East	1,747	156	120,135
Naismith	1,306	219	131,700
KLWN	486	31	32,850
Belle Haven	260	20	14,700
Broken Arrow	235	17	14,745
Haskell	824	116	72,745
Deerfield	898	89	53,785
Riverside	337	24	22,420
Country Club	1,217	117	67,580
Downtown	1,095	118	84,275
East Lawrence	830	84	63,740
Brook Street	397	41	30,630
Sunflower	189	15	10,600
North Lawrence	3,424	65	69,155
Totals	16,817	1,395	1,023,390

2. HYDRAULIC CAPACITY RATING

The SWMM model was used to determine the demand discharge, or peak flow, to each system element. The hydraulic capacity of each element was determined using Manning's equation or standard headwater nomographs as applicable. Although the model's calculations are precise with respect to the rainfall, land use, and system data, they are predicting system performance that is naturally variable. Infinitely changing rainfall rates, seasonal and other changes in day-to-day conditions of the land surface and vegetation, and the changing maintenance condition of the system itself will all influence the actual performance of the system at any given time.

Due to these natural variations, it is not realistic to conclude that a system element is not capable of supplying a given level of hydraulic service (i.e. 5-year, 10-year, etc.) simply because the model indicates a small capacity deficiency during the modeled storm. Therefore, deficiencies were not interpreted as being significant if the magnitude of the deficiency was relatively small (less than 10 percent) or if it was determined that the deficiency was of a short duration (10 to 15 minutes).

3. LEVEL OF SERVICE

The level of service was determined for the elements of the existing improved conveyance system which excludes detention basins and natural open channels. Of the 1,395 conveyance elements in the watershed models, 577 are part of the improved system which were evaluated for performance. Table IV-2 summarizes the overall hydraulic performance capability of the improved system throughout all of the watersheds.

TABLE IV-2
IMPROVED SYSTEM LEVEL OF SERVICE

Watershed	<2 Yr	≥2-<5 Yr	≥5-<10 Yr	≥10-<25 Yr	≥25-<100 Yr	≥100 Yr
	Number Of Reaches With Return Period Capacity					
Yankee Tank West	1	0	0	1	2	2
Hidden Valley	1	3	2	8	10	34
Quail Creek	5	3	3	7	2	25
Yankee Tank East	9	6	2	7	10	31
Naismith	35	8	5	6	9	28
KLWN	3	3	0	0	1	0
Belle Haven	2	0	1	4	1	1
Broken Arrow	5	0	1	1	0	1
Haskell	1	2	0	5	7	41
Deerfield	2	2	2	3	8	10
Riverside	0	0	0	5	1	4
Country Club	3	9	5	6	3	26
Downtown	12	8	5	13	5	14
East Lawrence	19	3	3	4	3	5
Brook Street	3	3	2	3	3	4
Sunflower	0	1	0	0	1	1
North Lawrence	14	3	2	1	2	7
Totals	115	53	33	74	67	234

D. EXISTING SYSTEM PERFORMANCE

The following sections of the report briefly describe the 17 watersheds analyzed for the Stormwater Management Plan and outline the results of the hydrologic and hydraulic modeling of the existing storm drainage system. A brief description of each reach within each watershed's major drainage system along with references to the system map sheet where each reach can be found are presented in Appendix B.

1. YANKEE TANK WEST WATERSHED

a. Location

The Yankee Tank West watershed covers 756 acres (1.18 square miles) at the western edge of Lawrence. Most of the watershed is outside of the current corporate limits. It headwaters just north of US 40 approximately a mile west of Wakarusa Drive. The watershed extends two miles south draining into Yankee Tank Lake, a private lake, just north of Clinton Parkway. The area is relatively steep and elevations range from 1073 in the northwest corner at the upper end to 880 at its outlet into the lake.

b. Land Use

This watershed is currently undeveloped with most of the area covered by woods or pasture grasses. However, rapid growth in and around Lawrence is pushing development in this direction. The Yankee Tank Lake Estates subdivision, a single-family residential development, has been platted along the east side of the lake. Additional planned land use in the watershed is also primarily single-family residential with a school located adjacent to the west edge of the basin. The plat and proposed land use plan indicate considerable open space along the existing channels will be left undeveloped. Because of the rapid development in the western portions of the city, the Yankee Tank West watershed drainage system was analyzed as if the proposed development already existed.

c. Existing Drainage System

The existing drainage system in the Yankee Tank West watershed is a series of earth and rock-lined natural open channel sections. Two culverts, one pipe (Line 1-3160) and one concrete box (Line 1-3200), are located across Highway 40 near the north end. Another pipe culvert (Line 1-3070) is located across an existing north-south county road near the west edge of the basin. Several small ponds are scattered throughout the basin. The entire system eventually drains to Yankee Tank Lake, a controlled small reservoir, at the lower end of the basin.

The condition of the system varies throughout the watershed. At the time of the field inventory, most reaches of the channel itself were fairly clean but had fairly dense growth along the banks. In a few areas deadfall and debris obstructed portions of the channel. The top slab of the concrete box culvert (Line 1-3200) across the highway was noted as cracked and sagging.

d. System Performance

Of the five improved reaches in this watershed, only one is indicated to have less than a 10-year capacity once the area develops as planned. The analysis, however, does not reflect the extensive improved drainage system elements that will be associated with this development and provided by the developer. Improved major system performance for the Yankee Tank West watershed is summarized in Table IV-3.

TABLE IV - 3
EXISTING IMPROVED SYSTEM PERFORMANCE - YANKEE TANK WEST WATERSHED

Line No.	Capacity (cfs)	Peak Flows (CFS) 2-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr	Level Of Service
3070	26	65	105	136	183	221	262	<2
3160	14	4	7	9	12	15	18	50
3200	150	26	44	59	79	96	114	>100
3890	230	94	124	144	172	198	222	>100
3900	115	74	94	107	126	145	161	10

2. HIDDEN VALLEY WATERSHED

a. Location

The Hidden Valley watershed includes 1,788 acres (2.79 square miles) on the west edge of Lawrence along the Hidden Valley Tributary to Yankee Tank Creek. The watershed headwaters at US 40 approximately one-half mile west of Wakarusa Drive. The basin is approximately one mile wide and two and one-half miles long. Land slopes adjacent to the tributary are relatively steep. Elevations in the basin range from 1067 at the northwest corner to 826 at the outlet.

b. Land Use

Approximately 80 percent of the land in the Hidden Valley watershed is either already developed or currently under development. Undeveloped areas remain at the south end of the watershed, south of Clinton Parkway, and along the west edge, west of Wakarusa. The area on the west edge has been platted, however, as part of the Yankee Tank Lake Estates subdivision and was considered fully developed for purposes of this analysis. Existing development is primarily single-family and multi-family residential with some commercial land uses mixed in along Wakarusa and Clinton Parkway. The Alvamar Golf Course and surrounding residential development occupies a significant portion of the southern half of the basin.

c. Existing Drainage System

The existing major drainage system in this watershed is a combination of open and enclosed components. Existing open channels have been retained as the major components with culverts and bridges at road crossings and only relatively short sections enclosed through some residential areas. Several of the bridges are located in the golf course and are used only by golfers, carts, and maintenance vehicles. The minor system generally consists of an enclosed pipe-curb inlet system along streets. Two detention basins are located on the golf course, one just west of Inverness Drive between Nicklaus and Turnberry Drives (Line 2-3105), and the other east of Inverness Drive and north of Wimbledon Drive (Line 2-3110). A third basin is located north of 15th Street and east of Wagon Wheel (Line 2-3270).

Most open channels are earth or turf-lined with a few concrete-lined reaches. Enclosed pipe components are primarily corrugated metal pipes (CMP). Most of the major cross-road culverts are also large diameter CMPs or CMP arches although a few are reinforced concrete boxes. Since development in this area is all relatively recent, most drainage system components appear to be in good condition. Erosion and sedimentation appears to be the major problem in several newly developed areas where turf or other surface treatments have not yet been established or installed.

d. System Performance

Of the 58 improved reaches in this watershed, six have less than a 10-year return period capacity with only one having less than a 2-year capacity. None of these reaches are associated with drainage problems that require system improvements.

Based on maximum water elevations in the detention basins during a storm event, the two golf course basins included in the system model have approximately 10-year return period capacities. The third basin has approximately a 2-year capacity.

Improved major system performance for the Hidden Valley watershed is summarized in Table IV-4.

TABLE IV - 4
EXISTING IMPROVED SYSTEM PERFORMANCE - HIDDEN VALLEY WATERSHED

Line No.	Capacity (cfs)	Peak Flows (CFS) 2-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr	Level Of Service
3090	45	6	8	10	13	15	17	>100
3130	370	6	7	7	8	9	17	>100
3160	18	6	7	7	8	9	17	100
3170	5000	825	1239	1536	1896	2164	2342	>100
3190	>500	3	4	6	8	10	12	>100
3200	54	13	19	24	31	35	41	>100
3220	43	17	26	33	42	50	57	25
3230	65	17	26	33	42	50	57	>100
3240	40	6	10	13	18	21	25	>100
3250	45	6	10	13	18	21	25	>100
3260	600	125	183	229	290	338	387	>100
3280	250	81	111	134	165	190	217	>100
3320	53	10	14	16	20	23	27	>100
3330	170	40	58	73	93	108	124	>100
3340	260	134	188	230	287	332	379	10
3360	1223	225	327	408	519	605	697	25
3370	517	225	327	408	519	605	697	25
3380	4000	663	928	1123	1400	1619	1843	>100
3410	720	167	248	317	411	483	560	>100
3420	130	8	11	14	18	21	24	>100
3430	55	8	11	14	18	21	24	>100
3440	90	8	11	14	18	21	24	>100
3450	680	124	188	243	318	374	436	>100
3460	430	137	207	264	340	400	469	50
3470	900	183	262	325	412	481	552	>100
3480	160	62	91	115	148	174	201	25
3490	134	62	97	125	167	202	239	10
3500	140	52	88	118	160	196	233	10
3520	48	15	24	30	39	45	52	50

TABLE IV - 4 (CONT'D)
EXISTING IMPROVED SYSTEM PERFORMANCE - HIDDEN VALLEY WATERSHED

Line No.	Capacity (cfs)	Peak Flows (CFS) 2-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr	Level Of Service
3530	105	53	76	98	126	149	173	10
3560	290	66	97	121	153	178	203	>100
3570	90	39	59	74	96	112	130	10
3580	65	19	28	35	44	51	59	100
3590	60	38	55	70	89	103	118	<10
3600	81	20	32	42	55	65	76	>100
3610	38	27	34	39	46	52	57	10
3620	263	64	94	117	148	174	200	>100
3630	320	166	212	242	287	323	358	50
3640	240	170	217	248	294	331	367	10
3660	90	90	114	131	154	172	190	2
3680	90	90	114	131	154	172	190	2
3690	43	49	62	71	84	94	103	<2
3700	90	49	62	71	84	94	103	50
3710	78	21	27	30	37	41	44	>100
3720	36	4	5	6	7	8	9	>100
3730	60	46	58	66	78	88	97	<10
3740	55	40	50	57	67	75	82	10
3750	36	5	6	7	8	9	10	>100
3760	45	5	6	7	8	9	10	>100
3770	27	5	6	7	9	10	11	>100
3780	103	13	17	20	25	28	31	>100
3790	173	27	38	47	61	71	82	>100
3800	160	36	51	63	81	95	110	>100
3810	136	27	38	47	60	71	81	>100
3820	130	77	97	111	131	147	162	25
3830	103	58	74	86	101	113	125	25
3840	190	58	74	86	101	113	125	>100
3850	1080	953	1580	2100	2400	2550	2720	2

3. QUAIL CREEK WATERSHED

a. Location

The Quail Creek watershed encompasses 1,028 acres (1.61 square miles) in the western half of the city along the Quail Creek tributary to Yankee Tank Creek. The area is roughly bounded by Kasold on the east, Monterey Way and Crossgate Drive on the west, 6th Street on the north, and 27th Street on the south. The basin headwaters approximately one-fourth mile north of 6th Street, west of Minter Way, at elevation 1024 and extends 2-1/2 miles south to its outlet at elevation 820.

b. <u>Land Use</u>

The Quail Creek watershed is nearing complete development. The primary land use in the area is single-family residential. Areas of townhomes and multi-family residential units are located north of Harvard and east of Monterey Way, and north of 6th St. There is neighborhood commercial development along 6th, 15th and Kasold. An area of commercial shopping and office properties is located around the intersection of 23rd St. and Kasold. Part of the Alvamar Golf Course and associated residential development is located in the southern half of the basin, just west of Kasold. A park is located on the east side of Monterey Way between Harvard and Tiffany Dr. Undeveloped areas are located along 15th St. between Kasold and Monterey Way, and at the south end of the basin.

c. <u>Existing Drainage System</u>

For the most part, Quail Creek has remained an open channel through this watershed. Enclosed reaches collect the drainage from the developed areas adjacent to the creek, discharging into the channel at various points along its length. Box culverts and small bridges are located at road crossings along the channel. Several detention ponds are located in the basin, primarily on the Alvamar Golf Course.

The improved system in this basin is relatively new and appears to be in good condition. Pipe materials are mostly corrugated metal. The channels have earthen bottoms with brushy or wooded banks. Overbank areas are generally maintained turf for most of the channel's length. Erosion was the major maintenance problem noted in the area.

d. <u>System Performance</u>

Of the 45 improved reaches analyzed in this watershed, only nine provide a level of service less than 10 years. Of the nine, seven provide a 2-year level or less, two of which are included in recommended improvement projects described in Part VI of this report.

Improved major system performance for the Quail Creek watershed is summarized in Table IV-5.

TABLE IV - 5
EXISTING IMPROVED SYSTEM PERFORMANCE - QUAIL CREEK WATERSHED

Line No.	Capacity (cfs)	Peak Flows (CFS) 2-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr	Level Of Service
3000	395	219	328	416	536	635	733	10
3020	95	18	26	33	42	49	56	>100
3050	220	130	196	249	324	384	446	<10
3060	45	22	32	40	51	60	69	10
3080	62	15	22	28	35	41	45	>100
3090	230	101	152	194	252	300	348	<25
3110	180	80	119	151	196	232	267	<25
3120	46	10	15	19	24	28	32	>100
3140	140	51	76	97	126	149	171	<50
3160	75	22	32	40	50	59	66	>100
3170	80	4	7	9	13	15	18	>100
3180	48	1	1	1	2	2	3	>100
3190	33	8	11	14	18	21	24	>100
3200	30	3	5	6	7	9	10	>100
3210	69	10	15	19	24	28	32	>100
3220	68	8	11	14	17	20	23	>100
3250	370	276	422	537	698	833	966	<5
3260	84	25	37	46	58	68	77	>100
3270	62	24	35	44	57	67	77	25
3280	153	32	47	60	77	91	105	>100
3320	1680	418	643	822	1071	1274	1478	>100
3330	43	45	68	86	112	132	152	2
3340	45	47	70	89	113	132	152	2
3350	39	6	9	11	14	16	18	>100
3360	50	20	32	41	54	65	76	<25
3390	218	39	65	86	117	143	169	>100
3400	235	47	74	97	132	161	192	>100
3410	2010	532	821	1050	1370	1650	1910	100
3420	154	31	41	49	59	68	75	>100
3430	1380	687	1060	1390	1810	2150	2670	10
3450	1380	718	1103	1449	1887	2223	2589	<10
3470	26	16	23	29	37	43	49	5
3480	43	12	17	21	26	30	34	>100
3500	62	13	17	21	26	29	33	>100
3510	85	15	20	24	29	34	38	>100
3520	24	13	18	21	26	30	33	<25
3530	46	9	12	15	19	22	25	>100
3540	27	2	3	4	5	6	6	>100
3550	27	4	6	6	7	8	9	>100
3560	3600	632	980	1290	1684	2003	2504	>100
3590	125	536	828	1060	1380	1660	1920	<2
3640	125	464	714	914	1190	1410	1640	<2
3650	110	446	686	876	1140	1350	1570	<2

TABLE IV - 5 (CONT'D)
EXISTING IMPROVED SYSTEM PERFORMANCE - QUAIL CREEK WATERSHED

Line No.	Capacity (cfs)	Peak Flows (CFS) 2-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr	Level Of Service
3680	115	435	668	853	1110	1320	1530	<2
3710	125	509	786	1010	1310	1570	1820	<2

4. YANKEE TANK EAST WATERSHED

a. Location

The Yankee Tank East watershed covers 1,747 acres (2.73 square miles) in the west central portion of the city bounded roughly by 6th Street on the north, Iowa on the east, Kasold on the west, and 31st Street on the south. The upper end of the basin, located northeast of the intersection of 6th and Kasold, has an elevation of 1045. The outlet into Yankee Tank Creek, south of 31st, is at elevation 824.

b. Land Use

This watershed is approximately two-thirds developed in a mix of residential, commercial and institutional land uses. Residential areas are primarily single-family with multi-family areas located north of 15th St. Commercial development is concentrated along 6th St. in the north end and along 15th St. near Kasold. An office/commercial area is also located at 23rd and Kasold. Approximately one-fourth of the area, located between 23rd, Iowa, 15th and Kasold, comprises the west campus of the University of Kansas which is nearly all undeveloped at this time. The Sunset Hill Elementary School and West Junior High School are located in the area between 9th and Harvard, west of Crestline. Open areas in the basin are concentrated along the open drainage channels.

c. Existing Drainage System

The upper end of the East Branch of the Yankee Tank, north of Harvard Road, has been enclosed in a pipe system through the residential development in that area. South of Harvard, however, the main drainage is an open channel and continues as such to the basin outlet. Minor enclosed systems collect runoff from residential areas bordering the main channel and discharge into it along its entire length.

The improved system in this watershed is relatively new and still in good condition for the most part. Pipe system materials are both concrete and corrugated metal. The natural open channels have earthen bottoms with the overbank conditions varying from maintained turf to wooded with fairly dense underbrush, depending on the specific location. A few maintenance needs were noted during the field reconnaissance phase of the project.

d. System Performance

Of the 65 improved reaches in this watershed, 17 provide less than a 10-year level of service with nine of those providing less than a 2-year level. Nine of the 17 reaches are included in recommended improvement projects described in Part VI of this report. Improved major system performance for the Yankee Tank East watershed is summarized in Table IV-6.

TABLE IV - 6
EXISTING IMPROVED SYSTEM PERFORMANCE - YANKEE TANK EAST WATERSHED

Line No.	Capacity (cfs)	Peak Flows (CFS) 2-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr	Level Of Service
3000	61	23	37	48	63	75	88	25
3010	76	40	61	78	100	119	138	10
3020	118	56	84	106	136	160	186	10
3030	53	10	15	19	24	29	33	>100
3060	5040	1400	1910	2230	2700	3090	3540	>100
3070	223	62	91	114	145	169	194	>100
3080	81	47	69	86	110	128	147	<10
3090	80	38	56	70	88	102	116	10
3100	47	14	23	29	38	46	54	50
3110	56	16	25	33	44	52	62	50
3120	413	16	25	32	42	50	58	>100
3130	168	60	78	91	110	125	140	>100
3140	480	640	943	1030	1100	1180	1170	<2
3150	240	310	458	503	631	742	846	<2
3160	2583	1350	1540	1620	1680	1750	1730	>100
3170	85	29	43	54	68	79	91	50
3180	40	22	32	40	50	58	66	10
3210	2200	1610	2360	2880	3550	4130	4790	2

TABLE IV - 6 (CONT'D)
EXISTING IMPROVED SYSTEM PERFORMANCE - YANKEE TANK EAST WATERSHED

Line No.	Capacity (cfs)	Peak Flows (CFS) 2-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr	Level Of Service
3230	110	21	30	36	45	53	60	>100
3240	70	21	29	36	46	53	61	>100
3250	80	21	30	37	46	53	60	>100
3260	22	5	7	8	9	10	12	>100
3280	70	17	24	30	37	43	50	>100
3300	1250	449	617	748	923	1060	1210	100
3303	85	610	848	1030	1280	1480	1690	<2
3306	2800	679	939	1153	1420	1632	1854	>100
3310	350	157	206	242	292	329	368	50
3320	2200	157	206	242	292	329	368	>100
3330	521	151	198	233	281	319	358	>100
3340	218	135	174	201	239	269	299	10
3350	48	133	170	197	234	263	293	<2
3360	66	137	174	200	236	265	293	<2
3370	372	27	38	47	59	69	78	>100
3371	114	35	52	66	87	103	120	50
3380	176	36	54	69	89	105	122	>100
3390	111	18	27	34	43	51	59	>100
3391	75	11	16	21	27	32	37	>100
3400	378	242	334	405	503	581	663	5
3410	115	223	302	361	442	504	568	<2
3420	257	143	189	224	272	310	348	10
3430	86	73	98	117	143	163	184	2
3440	66	12	15	18	22	24	27	>100
3450	156	56	78	94	117	134	152	100
3460	110	31	43	52	65	75	85	>100
3470	170	136	192	235	296	344	391	2
3480	280	150	213	262	329	382	435	10
3490	115	103	146	180	227	265	303	2
3500	100	47	65	78	97	112	127	25
3510	50	23	30	34	41	46	51	100
3530	175	51	71	88	110	126	147	>100
3532	125	51	71	88	110	126	147	50
3540	165	39	57	72	93	108	127	>100
3550	103	42	63	80	103	120	142	25
3560	148	22	30	35	43	49	55	>100
3570	165	20	27	32	39	44	49	>100
3580	165	224	327	405	512	598	685	<2
3590	220	246	358	444	560	632	753	<2
3600	330	258	377	467	589	664	796	2
3620	312	289	425	527	669	749	904	2
3630	280	300	438	542	686	768	925	<2
3640	190	59	89	112	142	165	184	100
3650	55	19	29	36	47	56	65	50
3660	210	59	89	112	142	165	184	>100
3730	22	3	6	8	12	14	16	>100
3740	100	23	38	49	66	78	91	>100

5. NAISMITH WATERSHED

a. Location

The Naismith watershed covers 1,306 acres (2.04 square miles) in the south central portion of Lawrence along Naismith Creek, a tributary to the Wakarusa River. It is bounded roughly by 15th Street on the north, Louisiana on the east, Iowa on the west, and the Wakarusa floodplain on the south. The basin headwaters at an elevation of 1045 approximately one-fourth mile north of 15th Street and just west of Naismith Drive on the KU campus. The outlet, defined for this study, is located near the intersection of Louisiana and 31st Street at an elevation of approximately 818. The basin is roughly 2.5 miles long and one mile wide.

b. Land Use

The Naismith watershed is over 80 percent developed. Only a relatively small area of undeveloped land remains south of 31st Street. Most of the area has been developed for residential purposes, predominantly single-family, with several areas of multi-family units south of 23rd. Neighborhood commercial land uses, such as restaurants, groceries and small specialty shops, are concentrated along 23rd Street, approximately in the center of the basin, and along Iowa south of 23rd St. The northwest corner of the basin is occupied primarily by University of Kansas residence halls, married student housing, and several fraternity houses. Lawrence High School is located in the northeast quadrant of the basin. A relatively large mobile home park, Gaslight Village, is located in the southwest corner of the watershed, just east of Iowa. Open land along Naismith Creek south of 23rd is wooded for most of the length.

c. Existing Drainage System

The main drainage way, Naismith Creek, is located approximately in the center of this watershed. The upper end of the creek, north of 19th St. on the KU campus, is an enclosed pipe system. Portions of this system will be improved and enlarged in the near future in accordance with the university's own stormwater master plan. The improved system elements were included in the existing system model to insure that the impact of these changes is reflected in the downstream analysis. A small detention area located on the campus, north of 15th and west of Naismith Drive, was not included in the model because its capacity and outlet structure provide little control and negligible impact on the downstream drainage system.

From 19th St. to 23rd St. the channel has been straightened and improved with concrete lining to a depth of three feet. Larger culverts or bridges (Lines 5-3780, 3800 and 3810) have been constructed at the road crossings in this section in the past five years as a result of recommendations from the earlier Naismith Basin study. South of 23rd St. the creek is a natural channel for the most part. A smaller branch system drains the southwest corner of the watershed, discharging to the natural drainage south of 31st St.

The enclosed system in this basin is in relatively good shape overall. The portions north of 23rd St. are mostly in the range of 25 to 40 years old while the sections of the system south of 23rd St. are relatively new. Pipe materials are primarily corrugated metal. The natural portions of the main channel have an earthen bottom. Overbank areas are densely wooded in the sections south of 23rd St. Several maintenance needs were noted during field observations.

d. System Performance

Of the 91 improved reaches analyzed in this watershed, 48 reaches provide less than a 10-year level of service. Thirty-five of those provide less than a 2-year level. Many of the 48 reaches are included in the recommended system improvement projects described in Part VI of this report. Improved major system performance for the Naismith watershed is summarized in Table IV-7.

TABLE IV - 7
EXISTING IMPROVED SYSTEM PERFORMANCE - NAISMITH WATERSHED

Line No.	Capacity (cfs)	Peak Flows (CFS) 2-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr	Level Of Service
2335	6	116	161	198	245	282	319	<2
2355	16	83	111	135	167	192	217	<2
2435	23	95	127	152	186	212	238	<2
2445	15	35	48	57	69	78	88	<2
2452	19	46	60	71	85	96	107	<2
2457	25	44	58	69	83	94	104	<2
2485	25	65	88	105	130	152	172	<2
2505	23	86	118	143	175	200	225	<2
2515	14	48	67	81	100	115	129	<2
2535	7	51	67	78	94	106	118	<2
3000	41	33	45	56	70	79	88	2
3010	21	33	45	56	70	79	88	<2
3030	47	52	69	81	98	110	123	<2
3040	36	89	116	134	161	183	204	<2
3100	32	34	49	60	75	85	100	<2
3110	62	31	44	54	69	80	91	10
3120	74	32	45	55	70	82	94	25
3135	400	155	200	232	276	310	346	>100
3150	40	30	38	43	51	57	63	5-10
3160	60	29	37	42	50	56	62	100
3170	2040	163	209	243	289	324	362	>100
3180	190	138	178	207	246	276	308	10
3190	54	101	128	146	172	191	211	<2
3200	96	59	75	87	104	116	129	10
3210	105	129	165	191	227	254	284	<2
3220	3934	144	186	217	227	254	284	>100
3230	27	24	32	38	46	52	58	2
3240	27	12	16	20	24	28	31	50
3250	9	12	17	21	25	29	32	<2
3260	38	63	80	93	111	124	138	<2
3270	40	66	84	97	115	130	144	<2
3280	40	57	73	84	100	113	126	<2
3290	224	122	160	188	226	257	288	25
3300	371	127	166	196	236	267	300	>100
3320	36	10	13	15	18	21	23	>100
3330	25	10	14	17	20	23	25	100
3340	134	119	155	183	221	251	281	2
3360	44	75	100	119	144	164	183	<2
3361	62	62	83	99	121	137	154	2
3362	66	64	84	99	119	134	149	2
3363	102	46	62	74	90	102	114	50
3370	1331	493	674	813	1020	1210	1470	50

TABLE IV - 7 (CONT'D)
EXISTING IMPROVED SYSTEM PERFORMANCE - NAISMITH WATERSHED

Line No.	Capacity (cfs)	Peak Flows (CFS) 2-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr	Level Of Service
3380	7600	543	745	901	1140	1390	1700	>100
3390	2400	661	911	1110	1390	1640	1910	>100
3420	55	7	8	10	12	13	15	>100
3430	29	10	13	15	17	19	21	>100
3440	447	211	290	348	428	497	569	25
3445	95	219	302	363	446	512	587	<2
3450	53	44	47	48	51	53	57	50
3451	53	217	300	360	443	508	581	<2
3460*	38	38	38	38	38	38	38	2
3470	35	225	311	373	458	528	605	<2
3480	62	226	314	382	465	548	626	<2
3490	53	212	293	352	432	498	570	<2
3500	63	221	307	374	459	536	611	<2
3510	276	62	84	100	123	140	157	>100
3520	260	55	74	88	109	125	142	>100
3530	546	61	83	100	122	139	157	>100
3540	331	31	41	49	59	67	74	>100
3550	100	34	46	55	67	76	85	>100
3570	241	158	214	257	316	361	408	<10
3580	130	56	78	96	119	137	156	<50
3600	368	57	79	98	122	142	162	>100
3610	109	57	79	98	122	142	162	10
3620	142	3	5	6	8	9	11	>100
3630	153	3	5	6	8	10	11	>100
3640	873	44	59	70	85	97	109	>100
3650	99	42	58	70	86	98	111	50
3680	46	47	66	79	96	110	123	2
3690	82	43	61	74	91	105	118	10
3700	49	69	98	119	148	170	193	<2
3720	222	246	329	396	488	560	633	2
3730	467	320	435	523	642	733	827	5
3740	670	391	532	640	787	897	1010	10
3750	116	87	119	145	179	204	228	5
3760	57	85	118	145	179	206	233	<2
3770	38	90	124	151	184	210	236	<2
3780	>1500	398	541	650	799	910	1030	>100
3790	615[1]	398	541	650	799	910	1030	5
	5956[2]							>100
3800	>1500	490	669	807	993	1130	1280	>100
3810	>1500	492	672	810	997	1140	1290	>100
3820	722[1]	490	669	807	993	1130	1280	5
	6984[2]							>100
3830	520[1]	492	672	810	997	1140	1290	2
	5027[2]							>100
3840	688[1]	493	674	812	1000	1140	1290	5
	6659[2]							>100
3850	53	59	79	95	117	133	152	<2

TABLE IV - 7 (CONT'D)
EXISTING IMPROVED SYSTEM PERFORMANCE - NAISMITH WATERSHED

Line No.	Capacity (cfs)	Peak Flows (CFS) 2-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr	Level Of Service
3851	53	59	79	95	117	133	152	<2
3852	76	98	134	161	197	224	252	<2
3860	11	41	59	72	90	104	118	<2
3870	29	48	69	86	109	126	143	<2
3875	158	53	76	94	119	138	156	100
3880	81	51	73	90	113	131	149	<10

* - Modeled as an overflow line for Line 3500; no direct runoff.
1 - Capacity of the lined portion of the channel only
2 - Total capacity of the channel

6. KLWN WATERSHED

a. Location

The KLWN watershed includes 486 acres (0.76 square mile) located near the southwest corner of the corporate limits along the KLWN Tributary. Although in close proximity to the confluence of Yankee Tank Creek and the Wakarusa River, this tributary actually turns to the east and eventually drains into Naismith Creek near 31st and Louisiana. The area headwaters at Iowa, just south of 23rd Street, and extends approximately 1.5 miles south. Elevations range from 917 at the upper end to approximately 826 at the outlet.

b. Land Use

Approximately half of this watershed is developed. The area north of 31st Street is a combination of residential and commercial land uses. Strip shopping centers, Walmart, and similar commercial development is located along Iowa, north of 31st St. The north third of the basin is multi-family residential with single-family residential development further south. Holcum Park, with a large baseball/softball complex, is located east of Lawrence Ave. and north of 27th St. The area south of 31st, which is almost completely in the floodplain of the Wakarusa, remains undeveloped.

c. Existing Drainage System

The existing major drainage system in this watershed consists primarily of natural open channel sections of the KLWN Tributary and one main branch. The upper ends of the system are enclosed within the developed areas but then discharge into the main channels. Three cross-road culverts (Lines 6-3020, 3120 and 3210) carry flow across 27th St. The channel sections flow through both agricultural and undeveloped areas south of 27th.

The improved system in this basin is relatively new. Most pipe materials are corrugated metal. Two of the three main culverts across 27th St. (Lines 6-3020 and 3120) are concrete boxes. The channels all have earthen bottoms. The overbank areas vary from maintained turf and agricultural fields to tall weeds, brush and dense trees depending on the specific location. No real maintenance needs were noted in this area.

d. System Performance

Of the seven improved reaches analyzed in this watershed, six provide a level of service of 5 years or less. Three of these lines are included in one of the recommended improvement projects described in Part VI of this report. Improved major system performance for the KLWN watershed is summarized in Table IV-8.

TABLE IV - 8
EXISTING IMPROVED SYSTEM PERFORMANCE - KLWN WATERSHED

Line No.	Capacity (cfs)	Peak Flows (CFS) 2-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr	Level Of Service
3035	27	22	29	33	40	45	50	5
3050	66	145	195	233	285	326	367	<2
3060	49	90	126	153	190	219	248	<2
3070	49	68	91	109	133	152	171	<2
3080	57	44	60	72	90	103	117	5
3090	68	34	47	57	70	80	90	25
3100	31	35	48	58	72	83	94	2

7. BELLE HAVEN WATERSHED

a. Location

The Belle Haven watershed includes 260 acres (0.41 square mile) at the south edge of the city. The area is roughly centered on Louisiana Street extending approximately 1.5 miles from 15th Street on the north to 31st Street on the south. The maximum width of the basin is approximately one-half mile. Elevations range from 886 at the upper end to 812 at its outlet near 31st and Iowa.

b. Land Use

The Belle Haven watershed is approximately two-thirds developed in a mix of residential and commercial-industrial land use. The commercial development is located primarily along 23rd St. and south on Louisiana. An area of multi-family residential development is adjacent to the commercial area with mostly single-family units further south. Broken Arrow Elementary and South Junior High Schools, and Broken Arrow Park are located on the east side of Louisiana and south of 27th St. near the boundary between the Belle Haven and Broken Arrow watersheds. The southeast portion of the basin between 29th Terr. and 31st St. is currently undeveloped.

c. Existing Drainage System

The existing drainage system in this watershed consists primarily of street gutters draining to curb inlets and the associated minor enclosed system. The main drainageway which runs lengthwise approximately through the center of the basin, is enclosed north of 27th Street (Lines 7-3670, 3081, 3080, 3090 and 3100). South of 27th it is an open channel with cross-road culverts at two locations. Minor enclosed system pipes which collect drainage from the cul-de-sacs on each side, outlet to the open channel at several locations.

Nearly all of the pipe reaches in the improved system in this basin are corrugated metal and appear to be in good condition. The open channels have earthen bottoms with brushy or wooded overbanks in most sections. Only one minor maintenance item was noted during field observations.

d. System Performance

Of the nine improved reaches analyzed in this watershed, three provide less than a 10-year level of service, all of which are included in one of the recommended improvement projects described in Part VI of this report. Improved major system performance for the Belle Haven watershed is summarized in Table IV-9.

TABLE IV - 9
EXISTING IMPROVED SYSTEM PERFORMANCE - BELLE HAVEN WATERSHED

Line No.	Capacity (cfs)	Peak Flows (CFS) 2-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr	Level Of Service
3010	310	183	258	316	394	455	520	10
3040	260	145	201	243	299	342	388	10
3060	3318	255	383	468	587	689	797	>100
3070	186	135	186	226	279	320	361	5
3080	61	126	174	212	263	303	343	<2
3081	77	122	168	202	248	284	318	<2
3090	157	103	138	166	202	230	258	<10
3100	135	78	103	122	148	169	189	10
3110	102	55	71	83	99	112	123	25

8. BROKEN ARROW WATERSHED

a. Location

The Broken Arrow watershed encompasses 235 acres (0.37 square mile) on the south edge of Lawrence between Louisiana Street and the Haskell Indian Nations University campus, and from 23rd Street to the flood protection levee along the north side of the Wakarusa River. The area drains to the Broken Arrow Tributary of Naismith Creek. Elevations range from 901 at the upper end, near 23rd and Leanard, to 818 at the outlet at 31st St.

b. Land Use

This watershed is primarily undeveloped land south of 25th St. A part of the Haskell campus occupies the north and east portions of the basin. Single-family residential development covers most of the remainder of the developed areas. A portion of the Broken Arrow Elementary/South Junior High campus is located in the southwest corner of the basin.

c. Existing Drainage System

In the upper one-fourth of the basin, south of 23rd St., the existing drainage system is an enclosed system composed of small diameter pipes (24" or less). Beyond this enclosed system, Broken Arrow Tributary is an open channel through the undeveloped portion of the watershed with minor system components that outlet into it at two locations. The channel crosses 31st St. through a double 9'x 5' RCB (Line 8-3000) and drains into Naismith Creek.

The enclosed system elements in this basin all appear to be corrugated metal and are in generally good condition. The main channel has an earthen bottom with grassy overbank areas. The overbank is sparsely wooded along a portion of the channel length. No maintenance needs were noted in this watershed.

d. System Performance

Of the eight improved reaches analyzed in this watershed, six provide less than a 10-year level of service with five less than a 2-year level. Five of the six reaches are included in one of the recommended improvement projects described in Part VI of this report. Improved major system performance for the Broken Arrow watershed is summarized in Table IV-10.

TABLE IV - 10
EXISTING IMPROVED SYSTEM PERFORMANCE - BROKEN ARROW WATERSHED

Line No.	Capacity (cfs)	Peak Flows (CFS) 2-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr	Level Of Service
3000	990	195	302	390	515	616	723	>100
3020	18	27	37	45	56	65	74	<2
3031	80	158	230	288	369	433	499	<2
3040	28	60	86	107	135	157	179	<2
3050	21	37	52	63	78	90	102	<2
3060	35	26	37	45	55	64	73	5
3090	66	34	51	63	80	94	107	10
3100	28	34	51	63	80	94	107	<2

9. HASKELL WATERSHED

a. Location

The Haskell watershed includes 824 acres in the southeast corner of the city. The main drainageway is the Haskell Tributary to Naismith Creek which drains the area west of Haskell Avenue. Two other branches drain the area to the east. The basin is roughly bounded by 23rd Street (K10) on the north, the city limits on the east, the Haskell Indian Nations University campus on the west, and the Wakarusa levee on the south. It headwaters just north of 23rd Street and east of Haskell Avenue at an elevation of 925. Elevations at the south edge are 818 at 31st St.

b. Land Use

Approximately half of this watershed is currently developed. Most recent development has been residential in the area east of Haskell Ave. The Haskell Indian Nations University campus and associated property occupies most of the western half of the basin. Some commercial and light industrial development is located primarily along 23rd Street.

c. Existing Drainage System

The existing drainage system in Haskell watershed, as defined for this study, is divided into three main branches, each with a separate outlet at the south end of the basin. Each branch is a combination of enclosed elements and open channel sections. Generally, the enclosed portions of the system are located in the north half of the watershed which includes most of the developed areas. In the more undeveloped south half, two of the three branches are still basically natural channels. The easternmost branch discharges into a large pond near the southeast corner of the basin.

The middle branch, which begins in the vicinity of 23rd and Harper and flows southwest, has been improved for much of its length. The upper half is an enclosed pipe system. The open channels in the lower half have been graded and straightened with concrete lining constructed where it runs through residential development.

Most pipe materials in the enclosed systems are corrugated metal. The natural channel sections have earthen bottoms and brushy or wooded banks and overbanks. The system is a mixture of new and old lines. Erosion appeared to be the major maintenance problem in the newer areas. Culverts and channels obstructed by silt and debris were the major problems in the older sections of the system.

d. System Performance

Only three of the 56 improved reaches analyzed in this watershed provide less than a 10-year level of service. One of the three (Line 9-3420) is recommended for replacement under one of the improvement projects described in Part VI of the report. Improved major system performance for the Haskell watershed is summarized in Table IV-11.

TABLE IV - 11
EXISTING IMPROVED SYSTEM PERFORMANCE - HASKELL WATERSHED

Line No.	Capacity (cfs)	Peak Flows (CFS) 2-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr	Level Of Service
3020	370	263	331	372	462	528	597	10
3050	213	76	102	122	149	170	191	>100
3080	101	16	22	26	33	39	44	>100
3090	92	16	22	26	33	39	44	>100
3110	47	42	58	70	87	100	113	2
3120	51	25	35	43	53	62	70	25
3130	40	26	36	44	55	64	73	10
3140	134	24	34	41	50	57	66	>100
3201	1704	349	463	565	700	798	892	>100
3250	432	162	230	283	356	405	471	50
3260	512	159	226	278	350	397	464	>100
3270	11694	159	226	278	350	397	464	>100
3280	670	145	207	255	323	368	430	>100
3290	527	145	207	255	323	368	430	>100
3300	354	128	182	227	285	326	382	>100
3310	292	128	182	227	285	326	382	>100
3320	300	92	132	163	206	239	274	>100
3330	176	84	121	152	193	226	261	10
3340	323	55	78	97	123	143	164	>100
3350	82	41	59	74	93	110	126	10

TABLE IV - 11 (CONT'D)
EXISTING IMPROVED SYSTEM PERFORMANCE - HASKELL WATERSHED

Line No.	Capacity (cfs)	Peak Flows (CFS) 2-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr	Level Of Service
3380	141	17	25	32	40	47	55	>100
3390	122	12	16	19	23	27	30	>100
3390	67	7	11	14	19	23	27	>100
3410	266	77	103	122	149	170	192	>100
3420	39	47	62	75	92	106	120	<2
3430	19	8	10	11	14	15	17	>100
3440	58	4	5	6	7	7	8	>100
3450	97	12	16	20	25	30	34	>100
3460	224	42	61	76	96	112	128	>100
3470	76	6	8	10	12	14	16	>100
3480	94	6	8	10	13	15	17	>100
3510	96	9	13	15	19	22	26	>100
3520	702	177	253	313	388	446	509	>100
3530	174	33	49	62	80	95	110	>100
3540	94	10	15	19	24	28	32	>100
3560	156	21	32	41	53	64	75	>100
3580	115	27	41	52	67	80	94	>100
3590	173	42	61	76	94	114	131	>100
3600	165	41	60	74	94	111	127	>100
3601	103	42	61	76	96	114	131	25
3610	70	22	34	43	55	65	75	50
3620	133	11	16	20	25	30	34	>100
3630	148	11	16	20	25	30	34	>100
3640	166	46	69	85	110	131	152	>100
3650	245	46	69	87	111	131	152	>100
3651	79	30	45	57	73	85	99	25
3660	96	30	46	58	75	89	103	50
3670	90	27	40	51	66	78	90	100
3700	62	27	40	51	67	80	93	10
3720	26	25	37	46	59	69	79	2
3730	181	37	56	70	90	106	123	>100
3740	77	27	41	53	68	80	93	25
3750	55	12	18	24	31	36	42	>100
3760	284	45	67	86	111	131	152	>100
3770	104	15	20	23	28	31	35	>100
3780	60	16	22	26	31	34	38	>100

10. DEERFIELD WATERSHED

a. Location

The Deerfield watershed covers 898 acres (1.40 square miles) in and adjacent to the northwest corner of Lawrence. It headwaters at 6th Street (US 40) approximately half way between Kasold and Monterey Way at an elevation of 1024 and extends north approximately 2 miles. The main drainageway is the Deerfield Tributary which flows north and west into Baldwin Creek which eventually drains to the Kansas River north of Lawrence. For this study, the basin outlet has been defined at the point near Kasold where the main channel crosses I-70 at an elevation of approximately 846.

b. Land Use

Approximately one-third of this watershed is developed or currently under development, primarily as single-family residential neighborhoods. Two new large-lot residential subdivisions are under development and, for the purposes of this analysis, were assumed to be complete. There is a relatively small area of industrial/warehouse development north of I-70 on the east side of the basin. Steep grades along the main channels within the watershed will somewhat limit further development.

c. Existing Drainage System

The existing major drainage system in the Deerfield watershed is composed primarily of natural open channels with culverts at road crossings. There are two extended enclosed sections in the developed areas in the southeast quadrant of the basin. One section roughly parallels Lawrence Ave. and the other runs adjacent to Rock Fence. Both systems begin approximately at Trail Rd. and discharge into an open channel on the north side of Tomahawk Dr. Several small ponds noted during the initial field inventory have been eliminated by the current development. Only one detention basin (Line 10-3280), located west of Monterey Way and north of Stetson Dr., is included in the system analysis.

The improved system appears to be in generally good condition overall. Pipe materials in the enclosed sections are a combination of concrete and corrugated metal. A number of the open channel sections through the developed areas have been riprap or concrete lined with maintained turf banks and overbanks. In the natural sections, the channels have earthen bottoms with brushy or wooded banks and overbanks. Only a few maintenance needs were noted during field observations.

d. System Performance

Of the 27 improved reaches analyzed in this watershed, six provide less than a 10-year level of service. None of these lines, however, contribute to drainage problems serious enough to be included in any of the recommended improvement projects. The detention basin included in the system model (Line 10-3280) has approximately a 10-year capacity based on the maximum water elevation in the basin during storm events. Improved major system performance for the Deerfield watershed is summarized in Table IV-12.

TABLE IV - 12
EXISTING IMPROVED SYSTEM PERFORMANCE - DEERFIELD WATERSHED

Line No.	Capacity (cfs)	Peak Flows (CFS) 2-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr	Level Of Service
3000	22	22	34	43	57	68	80	2
3010	90	32	47	60	77	91	105	50
3030	490	42	62	77	99	116	134	>100
3050	90	42	62	77	99	116	134	10
3100	125	66	99	126	164	195	227	10
3110	210	66	99	126	164	195	227	50
3111	246	65	98	125	162	193	224	>100
3120	185	71	104	132	170	200	231	25
3130	317	94	138	174	222	260	299	>100
3140	76	6	9	11	14	16	19	>100
3160	1080	389	578	734	942	1118	1274	25
3170	740	421	626	794	1020	1210	1380	<10
3190	253	63	91	114	144	168	193	>100
3200	95	40	60	75	96	113	131	25
3210	71	28	42	53	68	80	93	25
3230	536	169	250	321	420	498	567	50
3250	827	48	72	92	120	142	166	>100
3251	23	15	22	28	36	42	49	5
3255	540	421	626	794	1020	1210	1380	2
3260	330	23	32	43	57	64	80	>100
3300	30	13	21	28	38	46	55	10
3320	80	109	178	234	316	383	459	<2
3330	69	109	177	232	311	375	448	<2
3340	912	135	220	289	390	473	566	>100
3380	1200	187	306	402	545	661	790	>100
3410	2660	512	795	1060	1390	1670	2020	>100
3430	1540	512	795	1060	1390	1670	2020	25

11. RIVERSIDE WATERSHED

a. Location

The Riverside watershed covers 337 acres (0.53 square mile) on the north edge of Lawrence, north of I-70. It headwaters approximately one-fourth of a mile north of Lakeview Boulevard and one-half mile east of Kasold, outside of the corporate limits. The elevation in the upper end (the northwest corner) is 918. The basin outlets to the Kansas River through a culvert under the ATSF railroad at an approximate elevation of 828.

b. Land Use

Approximately one-half of the basin is undeveloped or used for agricultural purposes. The area west of Iowa and south of Lakeview is developed for industrial use. A small residential area lies east of Iowa and north of the turnpike.

c. Existing Drainage System

The major drainage system in the Riverside watershed is primarily natural open channels with culverts at road crossings. The culverts all appear to be corrugated metal pipes with the exception of two concrete boxes at larger crossings (Lines 11-3000 and 3040). The channel sections generally have earthen bottoms, brushy banks and wooded overbank areas. Few maintenance needs were noted during field observations.

d. System Performance

Of the ten improved reaches analyzed in this watershed, none has less than a 10-year level of service. Improved major system performance for the Riverside watershed is summarized in Table IV-13.

TABLE IV - 13
EXISTING IMPROVED SYSTEM PERFORMANCE - RIVERSIDE WATERSHED

Line No.	Capacity (cfs)	Peak Flows (CFS) 2-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr	Level Of Service
3000	550	155	207	248	306	352	401	>100
3020	35	8	12	16	21	26	31	>100
3040	280	155	207	248	306	352	401	<25
3060	50	24	36	47	61	73	86	10
3080	244	7	12	15	20	24	29	>100
3090	55	30	45	57	76	90	105	10
3091	70	37	57	73	95	113	133	10
3092	37	20	30	39	51	61	71	10
3110	26	7	11	13	17	20	23	100
3130	650	208	304	385	507	606	709	50

12. COUNTRY CLUB WATERSHED

a. Location

The Country Club watershed includes 1,217 acres (1.90 square miles) of land in the north central part of Lawrence which drains to the Kansas River. It is approximately two miles long and 1-1/2 miles wide. The basin headwaters at the south end, near 9th and Iowa, at an elevation of 1039 and outlets through a culvert under the ATSF railroad just north of 2nd St at approximately elevation 830.

b. Land Use

This watershed is a mixture of land uses. The area east of US 59 and north of 2nd St., as well as the area west of Iowa and north of 6th, are undeveloped, primarily due to steep grades. Along Iowa, generally north of 9th St., the development is primarily commercial office and light industrial space. Another small industrial area is located in the north end, north of I-70. Lawrence Memorial Hospital is near the east edge of the basin on Michigan. Residential development is a mix of single and multi-family areas. Mobile home parks are located in the vicinity of 2nd and Michigan. Buford Watson Park is located between Tennessee and Kentucky, from 6th to 8th Streets, and contains the municipal swimming pool and other recreational facilities.

c. <u>Existing Drainage System</u>

The existing system in this watershed is a combination of open and enclosed reaches draining to several branches which eventually combine into one tributary to the Kansas River at the outlet. In the developed areas, located in the south and east sections of the basin, minor enclosed systems collect runoff and route it to larger enclosed reaches which eventually discharge into open channels. The undeveloped north and west portions of the area are drained primarily by open channels with culverts located only at major road crossings. The natural channels have earthen bottoms. The density of the vegetation along the banks varies depending on the location of the specific channel section.

The improved system in this watershed is a combination of concrete and corrugated metal pipe materials. The system is beginning to show signs of age. Several maintenance needs were noted during field reconnaissance, although none were considered to be serious in terms of public safety.

d. <u>System Performance</u>

Of the 52 improved reaches analyzed in this watershed, 17 provide less than a 10-year level of service although only three provide less than a 2-year level. Of these 17 reaches, six are included in recommended improvement projects described in Part VI of this report. Improved major system performance for the Country Club watershed is summarized in Table IV-14.

TABLE IV - 14
EXISTING IMPROVED SYSTEM PERFORMANCE - COUNTRY CLUB WATERSHED

Line No.	Capacity (cfs)	Peak Flows (CFS) 2-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr	Level Of Service
3020	106	36	45	51	60	67	74	>100
3030	340	278	389	476	593	684	776	<5
3033	360	270	377	460	574	665	755	<5
3040	360	242	337	411	511	590	672	5
3050	300	171	242	295	369	416	462	10
3070	760	174	248	303	379	444	507	>100

TABLE IV - 14 (CONT'D)
EXISTING IMPROVED SYSTEM PERFORMANCE - COUNTRY CLUB WATERSHED

Line No.	Capacity (cfs)	Peak Flows (CFS) 2-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr	Level Of Service
3090	260	152	220	271	342	401	461	10
3110	526	158	225	276	343	400	459	>100
3120	1146	147	211	261	329	386	443	>100
3140	550	30	43	54	66	79	92	>100
3150	90	75	105	128	159	183	207	2
3160	70	75	104	129	162	187	213	2
3180	174	22	30	35	43	49	55	>100
3220	304	579	877	1100	1380	1830	2180	<2
3231	350*	589	903	1110	1470	1780	2110	<2
3250	230	185	280	355	457	541	627	2
3280	90	34	52	67	87	103	120	25
3300	65	12	18	23	30	35	40	>100
3320	630	131	200	255	331	394	456	>100
3330	193	81	129	167	223	269	317	10
3340	115	70	112	146	193	232	273	5
3375	140	32	53	70	95	117	139	100
3380	247	42	64	80	101	118	136	>100
3390	56	38	57	71	93	111	129	5
3410	198	18	28	36	47	56	65	>100
3420	149	17	26	34	44	52	60	>100
3430	736	171	227	271	332	381	432	>100
3440	185	171	228	272	333	382	432	2
3460	185	155	204	242	294	336	380	<5
3480	190	49	75	96	124	145	169	>100
3500	750	329	499	615	731	898	1070	25
3520	570	1450	1680	1730	1670	1710	1620	<2
3540	111	31	49	63	81	95	109	100
3550	32	29	42	51	64	74	85	2
3560	140	73	112	138	189	225	260	10
3570	230	43	68	87	118	143	171	>100
3580	2840	43	68	87	118	143	171	>100
3590	80	41	63	78	107	127	146	10
3600	111	12	18	23	31	36	42	>100
3610	100	4	6	7	9	10	11	>100
3620	58	49	75	96	124	146	169	2
3630	60	11	16	21	27	32	37	>100
3640	22	5	8	11	14	16	19	100
3650	50	38	49	57	67	76	84	5
3660	121	8	12	15	19	23	27	>100
3670	112	38	49	57	67	76	84	>100
3680	615	34	44	52	62	70	77	>100
3700	90	39	61	77	100	119	138	<25
3710	70	42	64	82	106	126	146	5
3720	625	151	217	265	329	385	444	>100
3730	45	2	3	3	4	4	5	>100
3740	365	158	225	277	346	403	460	25

* - Capacity of half of the structure. Other half is full of silt.

13. DOWNTOWN WATERSHED

a. Location

The Downtown watershed covers 1,095 acres (1.71 square miles) in the east central part of the city. The upper end is in the southwest corner of the basin on the University of Kansas campus. The basin drains to the Kansas River at several points through culverts under the ATSF railroad. Elevations range from 1045 at the upper end to 790 at the river.

b. Land Use

This watershed is essentially 100 percent developed. It includes Lawrence's central business district as well as a large part of the KU campus. The commercial business district is centered on Massachusetts, the main street, from 6th St. to approximately 15th St. Additional neighborhood commercial areas are located further south on Massachusetts to about 19th. A municipal park, Sout Park, with a community center is located along both sides of Massachusetts between 11th and S. Park Streets, and the Douglas County Courthouse is located at the corner of 11th and Mass. The remainder of the basin is made up of older residential neighborhoods.

c. Existing Drainage System

The existing drainage system in this watershed is nearly all enclosed with only a few relatively short sections of open channel. There are three main branches of the system within the basin, each of which outlets separately to the Kansas River. The enclosed system is composed of a variety of shapes and materials including natural stone, brick or concrete arches or tunnels; natural stone or concrete boxes; and concrete and corrugated metal pipes and pipe-arches. The few channel sections are primarily earthen bottoms with grassy or brushy banks.

The Downtown drainage system includes some of the oldest lines in the city but is in surprisingly good condition. It appears that a number of the older reaches have been relined and repaired. A number of maintenance needs were noted throughout the basin, however, and further investigation should be undertaken since a considerable amount of the system was not readily accessible for inspection during the field reconnaissance phase of the project.

d. System Performance

Twenty-five of the 57 improved reaches analyzed in this watershed provide less than a 10-year level of service and 12 of those provide less than a 2-year level. Twelve of the 25 reaches are included in recommended improvement projects described in Part VI of this report. Improved major system performance for the Downtown watershed is summarized in Table IV-15.

TABLE IV - 15
EXISTING IMPROVED SYSTEM PERFORMANCE - DOWNTOWN WATERSHED

Line No.	Capacity (cfs)	Peak Flows (CFS) 2-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr	Level Of Service
3000	656	363	502	607	751	863	980	10
3020	1010	352	490	590	734	845	960	>100
3030	404	206	286	349	433	496	564	10
3050	363	193	268	325	404	467	527	10
3060	212	166	233	282	350	407	462	2
3070	176	114	162	197	245	283	322	5
3080	290	95	133	162	202	233	263	>100
3100	115	95	134	164	205	238	271	2
3111	242	79	111	135	168	195	221	>100
3120	180	56	79	97	122	143	160	>100
3140	278	123	175	216	271	315	361	25
3150	315	122	172	210	263	304	347	50
3160	218	112	159	195	244	284	324	10
3180	149	81	113	138	174	203	232	10
3190	131	67	96	119	151	177	204	10
3200	22	1	1	2	2	3	3	>100
3201	323	62	90	113	144	169	195	>100
3211	106	59	86	108	138	162	187	10
3220	191	48	73	93	120	141	163	>100
3240	76	19	27	33	42	48	55	>100
3250	348	51	69	81	98	111	125	>100
3260	36	55	73	86	105	120	134	<2
3301	586	250	336	402	495	565	642	50
3310	338	247	332	397	491	561	633	5
3320	229	238	322	386	475	545	615	<2
3340	338	239	323	387	476	547	617	5

TABLE IV - 15 (CONT'D)
EXISTING IMPROVED SYSTEM PERFORMANCE - DOWNTOWN WATERSHED

Line No.	Capacity (cfs)	Peak Flows (CFS) 2-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr	Level Of Service
3350	992	242	327	392	483	554	624	>100
3360	74	104	141	169	206	235	265	<2
3370	51	78	106	128	156	178	201	<2
3380	32	47	66	81	102	118	134	<2
3399	767	223	306	369	458	527	596	>100
3400	444	236	325	392	482	553	621	10
3401	248	211	288	348	430	495	559	2
3402	256	215	294	354	437	502	567	2
3403	412	223	306	370	458	527	596	10
3404	423	216	296	358	443	511	577	10
3405	467	226	311	375	464	533	602	25
3406	341	216	296	357	441	507	573	<10
3410	231	215	298	363	451	521	590	2
3420	225	181	247	298	365	418	470	2
3421	175	197	271	327	404	464	524	<2
3430	152	113	155	186	228	260	293	5
3440	49	66	90	110	137	158	180	<2
3500	701	227	299	351	422	480	537	>100
3530	855	266	354	420	511	584	656	>100
3540	379	239	315	373	451	514	575	10
3550	466	284	381	456	558	641	723	10
3560	468	231	307	367	448	514	577	25
3570	138	205	273	326	398	455	514	<2
3580	153	113	155	188	233	268	304	5
3590	89	53	75	92	116	135	155	10
3600	11	32	44	53	66	76	85	<2
3610	16	34	46	55	69	79	90	<2
3620	209	76	96	111	131	147	163	>100
3630	39	37	47	54	64	72	80	2
3650	26	31	40	46	54	61	67	<2
3660	19	36	48	52	61	68	75	<2

14. EAST LAWRENCE WATERSHED

a. Location

The East Lawrence watershed covers 830 acres (1.30 square miles) in the area roughly bounded by 13th St. on the north, Harper on the east, 23rd St. on the south, and Louisiana on the west. It headwaters near 15th and Louisiana at an elevation of 1030. The basin slopes generally north and east to the Kansas River, draining through a culvert under the ATSF railroad at approximately elevation 814.

b. Land Use

The western half of the watershed is relatively dense, older single-family residential neighborhoods. Some of the large, older homes near the KU campus have been converted to apartments. The eastern half of the basin is less densely developed, primarily as commercial/industrial areas adjacent to the railroad. A small part of the southeast corner of the KU campus is also located in the basin.

c. Existing Drainage System

The existing drainage system in the East Lawrence watershed is primarily an enclosed system divided into two main branches which join just south of 13th St. and west of the ATSF railroad tracks. The system continues from this point as an enclosed component to Haskell Ave. where it discharges into an open channel section. This channel combines with the Brook Street Tributary approximately 400 feet north of Brook St. and 12th. The combined channel flows to the east and eventually discharges to the Kansas River.

Overall, the improved system in this watershed is in fairly good structural condition. The large concrete box segments at the lower ends of the system appear to be in very good shape. Most of the smaller pipes are corrugated metal and appear to be generally acceptable. Most channel sections have earthen bottoms with grassy banks and overbanks. Vertical stone block walls have been constructed along one section of channel through a residential area and the channel bottom appears to have been lined with stone or concrete at one time. The bottom lining is broken up and sediment has built up in several areas. Maintenance needs noted in the area are related primarily to channels and culverts obstructed by silt and debris.

d. System Performance

Of the 37 improved reaches analyzed in this watershed, 25 provide less than a 10-year level of service with 19 providing less than a 2-year level. Of the 25 reaches with less than a 10-year capacity, 21 are included in recommended improvement projects described in Part VI of this report. A small detention area in Parnell Park, south of 15th St. and east of Maryland, was evaluated and determined to have negligible impact on the system due to its very small storage capacity in relation to the tributary area. Improved major system performance for the East Lawrence watershed is summarized in Table IV-16.

TABLE IV - 16
EXISTING IMPROVED SYSTEM PERFORMANCE - EAST LAWRENCE WATERSHED

Line No.	Capacity (cfs)	Peak Flows (CFS) 2-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr	Level Of Service
3010	661	700	999	1220	1540	1810	2090	<2
3020	452	477	684	831	1050	1250	1460	<2
3021	48	15	22	26	33	39	44	100
3031	26	10	16	22	29	34	40	10
3050	296	126	188	237	307	363	421	25
3070	216	127	190	238	308	363	422	<10
3090	55	97	143	181	233	273	316	<2
3100	58	79	118	149	195	231	270	<2
3109	21	5	7	9	12	14	17	>100
3110	128	63	94	121	158	187	219	10
3120	16	36	54	69	90	107	124	<2
3130	31	74	105	127	159	189	207	<2
3140	48	71	101	123	152	179	200	<2
3150	15	66	94	114	141	174	174	<2
3160	21	59	86	103	128	147	166	<2
3170	13	45	65	80	100	115	130	<2
3190	185	71	93	109	130	148	166	>100
3210	60	14	18	21	26	29	32	>100
3220	98	57	77	93	115	132	149	10
3230	62	53	72	86	105	120	135	2
3240	29	45	59	70	85	97	108	<2
3250	258	201	285	350	440	509	580	<5
3260	116	190	267	327	410	471	537	<2
3270	258	183	259	318	398	460	524	5
3280	155	188	264	322	400	459	521	<2
3290	53	61	84	102	126	144	163	<2
3300	34	42	58	70	87	100	113	<2
3310	418	126	176	213	268	312	357	>100
3320	60	116	162	199	248	286	326	<2
3330	40	96	134	163	202	231	262	<2
3340	19	73	100	120	149	172	195	<2
3350	11	21	29	35	43	49	56	<2

TABLE IV - 16 (CONT'D)
EXISTING IMPROVED SYSTEM PERFORMANCE - EAST LAWRENCE WATERSHED

Line No.	Capacity (cfs)	Peak Flows (CFS) 2-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr	Level Of Service
3360	55	23	33	41	53	62	71	25
3370	48	24	35	43	55	65	75	10
3380	26	24	35	44	56	66	77	2
3390	32	18	31	38	49	57	66	5
3410	85	43	57	66	79	91	101	25

15. BROOK STREET WATERSHED

a. Location

The Brook Street watershed is located along the eastern edge of the city, from 23rd St. to the river, approximately between Harper and Haskell Avenues. The 397-acre (0.62 square mile) basin headwaters at 23rd St. at elevation 910 and outlets to the Kansas River near the north end at elevation 814.

b. Land Use

This watershed is composed primarily of single-family residential neighborhoods with a few small areas of multi-family units and mobile homes. A cemetery is located in the northeast section of the basin. There is also a relatively small amount of commercial development in the south end and the southeast corner is open land.

c. Existing Drainage System

The existing drainage system in this watershed consists primarily of the Brook Street Tributary. The main channel is enclosed for approximately half of its length beginning at 21st Terr. near the south end. The open channel portion crosses 15th St. through a 10'x 6' RCB (Line 15-3050) and continues as a series of open channel and road culvert sections. A small detention basin is adjacent to the cemetery.

Pipe materials throughout the watershed are primarily corrugated metal. The open channel section of the main tributary has an earthen bottom which has been lined with riprap in several locations. The overbank areas are generally maintained turf. No maintenance needs were noted in this watershed.

d. System Performance

Of the 18 improved reaches analyzed in this watershed, eight provide less than a 10-year level of service. Seven of the eight are included in recommended improvement projects described in Part VI of this report. Improved major system performance for the Brook Street watershed is summarized in Table IV-17.

TABLE IV - 17
EXISTING IMPROVED SYSTEM PERFORMANCE - BROOK STREET WATERSHED

Line No.	Capacity (cfs)	Peak Flows (CFS) 2-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr	Level Of Service
2001	30	21	30	37	47	55	64	5
2010	63	14	21	26	34	39	45	>100
3010	69	317	468	600	749	886	1020	<2
3030	498	273	400	498	641	758	880	10
3050	600	218	317	398	498	581	672	50
3070	155	162	236	293	371	433	497	2
3071	169	156	227	284	362	425	490	2
3072	108	18	26	33	41	48	54	>100
3080	113	133	194	244	312	366	424	<2
3090	120	63	90	113	144	169	195	10
3100	53	40	57	71	90	104	120	5
3110	87	31	45	55	70	82	95	50
3120	83	13	20	25	33	38	45	>100
3130	50	61	88	109	137	160	185	<2
3140	184	54	88	114	148	172	198	50
3150	71	55	89	115	149	173	198	2
3160	97	42	68	90	118	139	161	10
3170	222	47	70	89	115	135	157	>100

16. SUNFLOWER WATERSHED

a. Location

The Sunflower watershed covers 189 acres (0.30 square mile) at the very eastern edge of Lawrence. The upper end is located just north of State Highway K10 approximately one-fourth mile east of Harper Ave. The area slopes toward the north, eventually draining to the Kansas River. Elevations range from 925 at the south end to 826 in the north at 15th St.

b. Land Use

This watershed is approximately 50 percent undeveloped. A small amount of commercial development is located in the southern half of the basin. Mobile home parks are located in the southwest corner and near the center in the area between the extension of 17th St. and 19th St. A new residential subdivision, Ashbury, has been platted in the area east of Harper Ave. between approximately 16th and 17th Streets.

c. Existing Drainage System

The existing drainage system in this watershed is composed almost entirely of natural channels. The only enclosed elements on the major system are several corrugated metal pipe culverts at road crossings. What appears to be a farm pond (Line 16-3030) is located toward the lower end of the basin, just south of 15th St. The plat for the Ashbury subdivision indicates that this pond is to be removed as part of the development.

The channels have earthen bottoms and sides. The overbank areas are generally wooded with fairly dense underbrush in most areas. A few, relatively minor maintenance needs were noted during field observations.

d. System Performance

Of the three improved reaches analyzed in this watershed, one provides less than a 10-year level of service and is included in one of the recommended improvement projects described in Part VI of this report.

The removal of the existing pond along with development in the basin will increase flows to the downstream system; however, the existing cross road culvert at 15th St. has considerable excess capacity to handle the increased flows although some type of energy dissipation may be required at the outlet of the culvert due to the increased flows. The area downstream from 15th St. is undeveloped and there does not appear to be any other adverse impact in the vicinity. Improved major system performance for the Sunflower watershed is summarized in Table IV-18.

TABLE IV - 18
EXISTING IMPROVED SYSTEM PERFORMANCE - SUNFLOWER WATERSHED

Line No.	Capacity (cfs)	Peak Flows (CFS) 2-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr	Level Of Service
3000	1760	175	266	307	357	388	416	>100
3050	240	92	139	178	231	275	320	25
3070	70	66	101	130	169	202	237	2

17. NORTH LAWRENCE WATERSHED

a. Location

The North Lawrence watershed includes 934 acres (1.46 square miles) on the north side of the Kansas River and generally within the corporate limits. In addition to the area specifically mapped as part of this analysis and report, another subbasin of 1,220 acres (1.91 square miles), located west of the ATSF railroad line, and one of 1,270 acres (1.98 square miles) north of US 40 drain into the area through a railroad bridge and box culverts under US Highways 59 and 40 (Lines 17-3060, 3070 and 3080).

The watershed is extremely flat. The high point in the basin is at approximately elevation 830 in the northeast corner. The land slopes generally east and south on the north side of US 40, and south and west on the south side of the highway. Outlets from the basin are culverts through the flood protection levee on the south and west edges with outlet elevations varying from approximately 790 to 812.

b. Land Use

The basin is a mixture of commercial and residential land uses although there is still considerable open area. Much of the surrounding area is agricultural. Commercial development is concentrated along N. 2nd St. from the Kansas River to the turnpike. Other commercial and light industrial developments are scattered throughout the basin with some located north of I-70. The residential areas are primarily low-density single-family neighborhoods and several mobile home parks. The old Union Pacific train depot, currently under renovation, is located near N. 2nd. and Locust Streets.

c. Existing Drainage System

The existing major drainage system in the North Lawrence watershed is a combination of very flat open channels, cross-road culverts, and enclosed pipe segments. Most of the developed residential area is drained by roadside ditches which discharge to relatively small diameter pipe sections that eventually discharge through the levee at several locations. These pipe systems generally are gravity systems although a 2700-gpm pump station is required near 5th and Maple to discharge drainage from the area north of the railroad line into the enclosed system that continues south along 5th St. Because of the small pumping capacity, however, standing water in the vicinity appears to be a regular problem.

Standing water is also a common occurrence in much of the open channel system draining the large areas north of US 40 and west of the railroad. The culverts across US 40 and 59 are relatively small for the large upstream drainage areas causing unplanned detention in these areas.

This condition continues in the wide, flat channel that carries the drainage to the culverts and pump station adjacent to N. 2nd St, north of Lyon. Under normal conditions, flows enter the 36-inch pipe (Line 17-3100) that continues south along N. 2nd to the Kansas River as a 30-inch pipe (Line 17-3030). When this pipe's capacity is exceeded, flow is diverted through the triple 8'x 4' box culvert under N. 2nd

(Line 17-3000) and eventually drains by gravity through the levee via a 60-inch outlet pipe (Line 17-3010). The new 40,000-gpm pump station is used only when the Kansas River stage is too high to allow gravity drainage from the system or when runoff from intense localized storms exceeds the capacity of the gravity system.

d. System Performance

Nineteen of the 29 improved reaches analyzed in this watershed provide less than a 10-year level of service. Fourteen of those reaches are included in recommended improvement projects described in Part VI of this report. Improved major system performance for the North Lawrence watershed is summarized in Table IV-19.

TABLE IV - 19
EXISTING IMPROVED SYSTEM PERFORMANCE - NORTH LAWRENCE WATERSHED

Line No.	Capacity (cfs)	Peak Flows (CFS) 2-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr	Level Of Service
3000	696	207	370	567	693	792	864	25
3010*	140	207	370	567	693	792	864	<2
3020*	53	11	18	28	40	48	54	100
3030	57	68	85	96	110	124	136	<2
3050	220	36	117	208	260	270	283	>10
3060	70	6	13	23	40	51	64	>100
3070	47	6	13	24	41	53	66	25
3080	282	33	111	197	222	219	217	100
3110	>5000	204	405	752	1090	1230	1350	>100
3111	>5000	205	493	1020	1690	2000	2320	>100
3120	125	84	215	516	888	1070	1340	<5
3140	155	51	158	317	424	450	484	5
3160*	29	50	87	112	141	176	203	<2
3170	5	6	9	12	15	19	22	2
3180*	34	10	35	49	65	90	100	5
3181	3	8	14	19	25	30	35	<2
3190*	17	23	32	39	47	58	66	<2
3191	4	8	8	9	9	10	11	<2
3192**	4	6	6	6	6	6	6	100
3193	3	37	59	82	104	126	140	<2
3200*	29	24	36	48	61	71	82	2
3201	4	9	12	15	18	21	23	<2
3210	28	14	20	24	29	34	38	<2
3220	10	79	103	120	143	171	179	<2
3224	25	123	164	191	227	262	276	<2
3230	12	43	56	65	77	88	97	<2

TABLE IV - 19 (CONT'D)
EXISTING IMPROVED SYSTEM PERFORMANCE - NORTH LAWRENCE WATERSHED

Line	Capacity	Peak Flows (CFS)						Level Of
No.	(cfs)	2-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr	Service
3240	8	27	36	41	48	55	61	<2
3250	6	14	18	21	25	28	31	<2
3275	235	18	80	175	227	225	223	100

* Levee outlets.
** Pump discharge line.

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APPENDIX B - EXISTING DRAINAGE SYSTEM INVENTORY

EXISTING DRAINAGE SYSTEM INVENTORY

The following pages provide brief descriptions of the line, or reach, numbers included in the existing drainage system computer models for each watershed. Along with the description, each line is referenced to the map number or sheet where it can be located. These maps have been provided separately to the City. In addition to these descriptions, photographs and other specific information on most of the lines can be found in the field inventory books prepared for each watershed. These documents were submitted separately to both the City and Burns & McDonnell by Landplan Engineering of Lawrence as part of this overall study.

WATERSHED NO. 1 - YANKEE TANK WEST
EXISTING SYSTEM DESCRIPTION

REACH NO.	MAP NO. REFERENCE	DESCRIPTION
1-3000	13/14	Natural channel
1-3010	13	Natural channel
1-3020	13	Natural channel
1-3030	13	Natural channel
1-3040	13	Natural channel
1-3050	13	Natural channel
1-3060	13	Natural channel
1-3070	13	24-inch RCP across county road
1-3080	13	Natural channel
1-3090	13	Natural channel
1-3100	13	Natural channel
1-3110	13	Natural channel
1-3120	13	Natural channel
1-3130	20	Natural channel
1-3140	20	Natural channel
1-3150	20	Natural channel
1-3160	13	18-inch CSP across Hwy. 40
1-3170	13	Natural channel
1-3180	13	Natural channel
1-3181	13	10'x 15' pond
1-3190	13	Natural channel
1-3200	6/13	3'x 3' RCB across Hwy. 40
1-3210	13	Natural channel
1-3885	20	Natural channel
1-3890	20/21	48-inch CSP across new street in Foxfire subdivision
1-3895	21	Natural channel
1-3900	21	48-inch CSP across new street in Foxfire subdivision

WATERSHED NO. 2 - HIDDEN VALLEY
EXISTING SYSTEM DESCRIPTION

REACH NO.	MAP NO. REFERENCE	DESCRIPTION
2-3000	22	Natural channel
2-3010	22	Bridge on golf course
2-3020	21	Natural channel
2-3025	21	Natural channel
2-3030	21	Bridge on golf course
2-3040	22	Natural channel
2-3050	22	Natural channel
2-3060	22	Bridge on golf course
2-3070	22	Bridge on golf course
2-3080	22	Natural channel
2-3090	22	36-inch CSP NE of Prestwick Dr. & Cir.
2-3100	22	Natural channel
2-3105	21	400'x 300' det. pond, W. of Inverness, N. of Turnberry
2-3110	22	200'x 70' det. pond N. of Wimbledon & E. of Inverness
2-3120	22	Natural channel
2-3130	22	10'x 4' RCB across Wimbledon Dr. near Wimbledon Cir.
2-3140	22	Natural channel
2-3150	22	10-ft turf channel downstream of Line 3160
2-3160	22	24-inch CSP near downstream end of Line 3140
2-3170	22/28	Double 20'x 9.5' RCB across Waterford/23rd
2-3180	22	Natural channel
2-3190	28	6-ft conc. channel, S. side 23rd, W. of Crossgate
2-3200	22	42-inch CSP along Crossgate, N. of Waterford
2-3210	22	Natural channel
2-3220	22	36-inch CSP along Crossgate, N. of Crossgate Ct.
2-3230	22	42-inch CSP across Crossgate near Crossgate Ct.
2-3231	22	Natural channel
2-3240	22	30-inch CSP E. of Crossgate, upstream end of Line 3250
2-3250	22	36-inch CSP across Crossgate, near N. end
2-3260	15/22	108-inch CSP across 15th below det. pond (Line 3270)
2-3270	15	400'x 950' det. pond, N. of 15th & W. of Monterrey Way
2-3280	21/27	72-inch CSP across 23rd, E. of Wakarusa
2-3290	21	4-ft. conc. channel, N. side 23rd, E. of Wakarusa
2-3300	21	4-ft. conc. channel, N. side 23rd, E. of Wakarusa
2-3310	21	8-ft channel, NE of 23rd & Wakarusa
2-3320	21	36-inch CSP, E. side Wakarusa, S. of Turnberry
2-3330	21/27	60-inch CSP across 23rd, W. of Inverness
2-3340	27	72-inch CSP across Ranch St., S. of 23rd
2-3350	27	Natural channel
2-3360	27	6-ft. riprap channel W. of Inverness
2-3370	27/28	5.67'x 4.4' RCB across Inverness, S. of 23rd
2-3380	14/21	18'x 10' CSPA across 15th St., W. of Inverness
2-3390	14	Natural channel
2-3400	14	Natural channel
2-3410	14	Triple 75"x 55" CSPA across Inverness, N. of Vantuyl
2-3420	14	36-inch CSP across Inverness @ Monterrey Hill Dr.
2-3430	14	36-inch CSP @ Monterrey Hill Dr.

WATERSHED NO. 2 - HIDDEN VALLEY (CONT'D.)
EXISTING SYSTEM DESCRIPTION

REACH NO.	MAP NO. REFERENCE	DESCRIPTION
2-3440	14	Triple 42"x 28" CSPA across Anthony Michael
2-3450	14	Double 66-inch CSP across 12th, W. of Vantuyl
2-3451	14	Natural channel
2-3452	14	Natural channel
2-3460	14	Double 66-inch CSP across Vantuyl near Oak Tree Dr.
2-3461	14	Natural channel
2-3470	14	Triple 78"x 50" CSPA across Inverness, E. of Wakarusa
2-3471	14	Natural channel
2-3480	14/15	54-inch CSP across Harvard near Mulberry
2-3490	14	69"x 47" CSPA across N. end of Oak Tree Dr.
2-3500	14	60-inch rubber-lined CSP across Grove Dr.
2-3510	14	Natural channel
2-3530	15	48-inch CSP across 12th, E. of Wagon Wheel
2-3540	15	Natural channel
2-3550	15	Natural channel
2-3560	15	Double 48-inch CSP across 13th, E. of Wagon Wheel
2-3570	15	48-inch CSP along Somerset Ct.
2-3580	15	36-inch CSP along Harvard, E. of Andover
2-3590	15	36-inch CSP @ Harvard & Andover
2-3600	14	48-inch CSP along Jefferson Way & Colonial Dr.
2-3610	14	36-inch CSP along Colonial Dr.
2-3620	14	81"x 59" CSPA across Wakarusa, S. of Harvard
2-3630	14	84-inch CSP across Wakarusa, S. of Inverness
2-3640	14	72-inch CSP @ outlet end of Line 3630
2-3650	14	Natural channel
2-3660	14	48-inch CSP from commercial area west of Wakarusa
2-3670	14	Private commercial detention w/12-inch outlet
2-3680	14	66"x 51" CSPA across Wakarusa, N. of 15th
2-3690	21	30-inch CSP S. of 15th, E. of Wakarusa
2-3700	14	48-inch CSP across 15th, E. of Wakarusa
2-3710	21	42-inch CSP along 15th & Wakarusa (SE corner)
2-3720	21	43"x 27" CSPA W. of Wakarusa, S. of 15th
2-3730	21	Double 43"x 27" CSPA across Wakarusa, S. of 15th
2-3740	21	50"x 31" CSPA along W. side Wakarusa
2-3750	21	43"x 27" CSPA along W. side Wakarusa
2-3760	21	43"x 27" CSPA along W. side Wakarusa, N. of 18th
2-3770	21	35"x 24" CSPA along W. side Wakarusa, N. of 18th
2-3780	21	48-inch CSP along W. side Wakarusa, S. of 18th
2-3790	21	66"x 51" CSPA along W. side Wakarusa, S. of Turnberry
2-3800	21	73"x 55" CSPA across Wakarusa, S. of Turnberry
2-3810	21	54-inch CSP along W. side Wakarusa, S. of Turnberry
2-3820	21	48-inch CSP @ W. end Troon Lane
2-3830	21	54-inch CSP along Carmel Dr., Troon La. to Merion Cir.
2-3840	21	66-inch CSP N. of Inverness @ Merion Cir.
2-3850	28	15'x 7' RCB across 27th & Crossgate
2-3860	28	Natural channel
2-3870	28	Natural channel
2-3880	28	Natural channel

WATERSHED NO. 3 - QUAIL CREEK
EXISTING SYSTEM DESCRIPTION

REACH NO.	MAP NO. REFERENCE	DESCRIPTION
3-3000	15	4'x 6' RCB across Harvard Rd., E. of Monterrey Way
3-3010	15	Natural channel
3-3020	15	42-inch CSP across Monterrey Way, N. of Harvard
3-3030	15	Natural channel
3-3040	15	Natural channel
3-3050	15	Double 57"x 38" CSPA across Elizabeth Ct.
3-3060	15	40"x 30" CSPA across Monterrey Way @ Wilshire Dr.
3-3070	15	Natural channel
3-3080	15	36-inch CSP across Monterrey Way, S. of Wilshire Dr.
3-3090	15	Double 57"x 38" CSPA @ priv. drive, N. of Eliz. Ct.
3-3100	15	Natural channel
3-3110	15	Double 57"x 38" CSPA across Monterrey Way @ W. 8th
3-3120	15	40"x 30" CSPA @ priv. drive, E. side Monterrey Way
3-3130	15	Natural channel
3-3140	8/15	70"x 42" CSPA across 6th, W. of Monterrey Way
3-3150	8	Natural channel
3-3160	8	36-inch CSP S. of Overland Dr., W. of Monterrey Way
3-3170	8	42-inch CSP, N. side of 6th, W. of Monterrey Way
3-3180	8	36-inch CSP, N. side of 6th, W. of Monterrey Way
3-3190	8	30-inch CSP across Monterrey, N. of 6th
3-3200	8	41"x 31" CSPA, N. side of 6th, E. of Monterrey Way
3-3210	8/15	56"x 38" CSPA across 6th, E. of Monterrey Way
3-3215	15	Natural channel
3-3220	8	48"x 36" CSPA, N. side of 6th, W. of Monterrey Way
3-3230	15	Natural channel
3-3240	15	Natural channel
3-3250	15	60-inch CSP across Tiffany Dr.
3-3260	15	36-inch CSP across Randall Rd., N. of 13th
3-3270	15	42-inch CSP, W. side Randall Rd. to S. side of 13th
3-3280	15	54-inch CSP south of 13th
3-3290	15	Natural channel
3-3300	15	Natural channel
3-3310	15	Natural channel
3-3320	15/22	Double 10'x 8' RCB across 15th near Alvamar Dr.
3-3330	22	36-inch CSP along 15th, E. of Alvamar Dr.
3-3340	22	43"x 27" CSPA across Alvamar Dr. @ 15th
3-3350	22	36"x 22" CSPA along 15th, W. of Alvamar Dr.
3-3360	22	36-inch CSP across St. Andrews Dr., S. of 15th
3-3370	22	Natural channel
3-3380	22	Natural channel
3-3390	22	60-inch CSP along Cedar Creek Ct.
3-3400	22	73"x 58" CSPA @ end of Cedar Creek Ct.
3-3410	22	Triple 10'x 8' RCB Cedar Creek Dr.
3-3420	22	60-inch CSP across 22nd St.
3-3430	28	Triple 10'x 5' RCB across 24th St.
3-3450	28	Triple 10'x 5' RCB across Brush Creek Dr.
3-3460	28	Natural channel

WATERSHED NO. 3 - QUAIL CREEK (CONT'D)
EXISTING SYSTEM DESCRIPTION

REACH NO.	MAP NO. REFERENCE	DESCRIPTION
3-3470	28	37"x 24" RCPA along Brush Creek Dr.
3-3480	28	37"x 24" RCPA along Brush Creek Dr.
3-3490	28	Natural channel
3-3500	22	36-inch CSP along 22nd, W. of Kasold
3-3510	22	48-inch CSP along 22nd @ Cedar Creek Dr.
3-3520	22	30-inch CSP N. of Clinton Parkway, E. of Hartford
3-3530	22	46"x 36" CSPA N. of Clinton Parkway, E. of Hartford
3-3540	22	36-inch CSP N. of Clinton Parkway & W. of Kasold
3-3550	28	30-inch CSP along Clinton Parkway, W. of Kasold
3-3560	22/28	Double 18'x 9' RCB across Clinton Parkway
3-3570	28	Natural channel
3-3575	22	Bridge on golf course
3-3380	22	Natural channel
3-3590	22	48-inch CSP on golf course
3-3600	22	Natural channel
3-3610	22	Golf course detention pond
3-3620	22	Natural channel
3-3630	22	Natural channel
3-3640	22	48-inch CSP on golf course
3-3641	22	Golf course detention pond
3-3650	22	48-inch CSP on golf course
3-3660	22	Natural channel
3-3670	22	Natural channel
3-3680	22	48-inch CSP on golf course
3-3690	22	Natural channel
3-3700	22	Natural channel
3-3710	22	48-inch CSP on golf course
3-3720	22	Natural channel
3-3730	22	Golf course detention pond

WATERSHED NO. 4 - YANKEE TANK EAST
EXISTING SYSTEM DESCRIPTION

REACH NO.	MAP NO. REFERENCE	DESCRIPTION
4-3000	23	36-inch CSP along 22nd St., E. of Melholland
4-3010	23	58"x 36" CSPA along 22nd, Melholland to Atchison
4-3020	23	58"x 36" CSPA, W. of Atchison Ave.
4-3030	23	36-inch CSP culvert, unimproved rd. NW of Vail Way
4-3040	23	Natural channel
4-3050	23	Natural channel
4-3060	23	Quadruple 15'x 8' RCB across 23rd, E. of Kasold
4-3070	29	66"x 54" CSPA W. of Atchison @ 27th St.
4-3080	29	48-inch CSP along 27th St., E. of Atchison
4-3090	29	42-inch CSP between 26th & 27th, E. of Atchison
4-3100	23	24-inch CSP & 18-inch RCP, KU west campus, N. of 23rd
4-3110	23	36-inch RCP, KU west campus, N. of 23rd
4-3120	23	6'x 3' RCB, KU west campus, N. of 23rd
4-3130	29	42-inch RCP S. side 23rd, W. of Crestline
4-3140	23	12'x 5' RCB along 23rd, Atchison Ave. to Lawrence Ave.
4-3150	29	6'x 5' RCB along 23rd, Lawrence Ave. to W. of Atchison
4-3160	29	15'x 5.5' RCB S. of 23rd, W. of Atchison
4-3170	29	42"x 29" RCPHE W. of Atchison Ave. @ 23rd Terr.
4-3180	29	42"x 29" RCPHE along 23rd Terr., E. of Atchison Ave.
4-3190	29	Natural channel
4-3200	29	Natural channel
4-3201	29	Natural channel
4-3210	28/29	Quadruple 10'x 7' RCB across Kasold, N. of 31st
4-3220	28	Natural channel
4-3230	28	36-inch RCP culvert @ future street
4-3240	28	36-inch CSP across drive, S. of Winterbrook @ Kasold
4-3250	28	36-inch RCP across Winterbrook, W. side Kasold
4-3260	28	24-inch CSP across drive, N. of 28th St., W. of Kasold
4-3270	28	Roadside channel, W. side Kasold, S. of 28th St.
4-3280	28	30-inch RCP across 28th St., W. side Kasold
4-3290	28	Roadside channel, W. side Kasold, N. of 28th St.
4-3300	16	10'x 10' RCB across Lawrence Ave., S. of Harvard
4-3301	16	Natural channel
4-3302	16	Natural channel
4-3303	16	54"x 42" CSPA N. of 15th & E. of Lawrence Ave.
4-3306	16/23	Double 10'x 10' RCB across 15th near Lawrence Ave.
4-3310	16	84" CSP across Harvard, W. of Lawrence Ave.
4-3320	16	6-ft conc. channel, N. of Harvard & W. of Lawrence Ave
4-3330	16	60-inch RCP between Lawrence Ave. & Jana Dr. (N)
4-3340	16	48-inch RCP between Lawrence Ave. & Jana Dr. (N)
4-3350	16	42-inch CSP along 9th & across Holiday
4-3360	16	36-inch CSP across 9th, N. of Holiday
4-3370	16	48-inch RCP, N. of Jana Dr. near end of Hill Ct.
4-3371	16	58"x 44" CSPA across Jana Dr. to Line 3370
4-3380	16	48-inch CSP across Holiday & along Jana Dr.
4-3390	15/16	42-inch CSP, east end 9th, E. of Kasold
4-3391	15	36-inch CSP along 9th, E. of Kasold

WATERSHED NO. 4 - YANKEE TANK EAST (CONT'D.)
EXISTING SYSTEM DESCRIPTION

REACH NO.	MAP NO. REFERENCE	DESCRIPTION
4-3400	16	72-inch CSP across Harvard @ Lawrence Ave.
4-3410	16	48-inch CSP along Lawrence Ave., N. of Harvard
4-3420	16	48-inch RCP along Lawrence Ave., N. of 9th
4-3430	16	42-inch CSP along Lawrence Ave., N. of 8th
4-3440	16	36-inch CSP along Lawrence Ave., N. of 7th
4-3450	16	42-inch RCP E. of Lawrence Ave. between 8th & 9th
4-3460	16	36-inch RCP along Wellington Rd. & 7th St.
4-3470	16	60-inch RCP across Westdale Cir.
4-3480	16	72-inch RCP across Westdale Rd.
4-3490	16	48-inch RCP across Crestline Dr.
4-3500	16	60"x 38" RCPA across Centennial, N. of Westdale Rd.
4-3510	16	36-inch CSP S. of Harvard & E. of Centennial
4-3520	16	Natural channel
4-3521	16	Natural channel
4-3522	16	Natural channel
4-3523	16	Natural channel
4-3524	16	Natural channel
4-3525	16	Natural channel
4-3530	16	36-inch RCP across University Dr. @ Stratford Rd.
4-3531	16	Natural channel
4-3533	16	Natural channel
4-3532	16	48-inch CSP across Westbrooke, N. of 15th
4-3540	16	42-inch RCP N. of University Dr. @ Stratford Rd.
4-3550	16	36-inch RCP between University Dr. & Stratford Rd.
4-3560	23	36-inch RCP, SW of intersection of 15th & Iowa
4-3570	23	36-inch RCP along 15th, W. of Iowa
4-3580	23	60-inch CSP along 15th, W. of Iowa
4-3590	23	66-inch CSP along 15th, W. of Iowa
4-3600	23	72-inch CSP along Westbrooke, S. of 15th
4-3610	23	Natural channel
4-3620	23	6'x 6' RCB, KU west campus
4-3630	23	72-inch CSP, KU west campus
4-3640	17	5'x 4' RCB across Iowa, N. of 15th
4-3642	17	Natural channel
4-3650	17	36-inch RCP across Emery near Hillcrest
4-3660	16	58-inch CSP across 15th, W. of Iowa
4-3670	16	Natural channel
4-3680	23	Natural channel
4-3690	23	Natural channel
4-3700	23	Natural channel
4-3720	23	480'x 240' detention pond, KU west campus
4-3730	23	24-inch RCP outlet from det. pond/Line 3720
4-3735	23	Natural channel
4-3740	23	48-inch CSP, KU west campus

WATERSHED NO. 5 - NAISMITH
EXISTING SYSTEM DESCRIPTION

REACH NO.	MAP NO. REFERENCE	DESCRIPTION
5-2335	24	24-inch CSP along 21st St., E. of Carolina
5-2355	24	24-inch CSP along 21st St., Carolina to Louisiana
5-2358	25	18-inch CSP along Louisiana, S. of 21st
5-2365	25	18-inch CSP along 21st, Ohio to Louisiana
5-2380	25	18-inch CSP along Louisiana, 19th to 21st
5-2435	24	30-inch CSP along 21st, W. of Clifton Ct.
5-2445	24	24-inch CSP E. of Ousdahl, 20th St. to 21st. St.
5-2452	24	24-inch CSP along 21st, W. of Ousdahl
5-2457	24	30-inch CSP along 21st, E. of Stewart
5-2485	24	36"x 24" CSPA along Maine, N. of 20th St.
5-2505	24	30-inch CSP along Alabama, 18th to 19th
5-2515	24	21-inch CSP along Alabama, 17th to 18th
5-2535	24	29"x 18" CSPA along Missouri, N. of 19th
5-3000	30	43"x 27" CSPA @ end of 29th Ct.
5-3010	30	36"x 22" CSPA along 29th Ct, W. of Missouri
5-3020	30	Bridge over Naismith Channel @ 27th St.
5-3030	30	36-inch CSP along 27th, W. of 27th St. bridge
5-3040	30	36-inch RCP @ end of Ridge Ct., S. of 27th
5-3050	30	30"x 18" CSPA @ entrance to mobile home park
5-3060	30	Natural channel
5-3070	30	Two 36"x 22" CSPA @ entrance to mobile home park
5-3080	30	Natural channel
5-3090	30	Natural channel
5-3100	30	43"x 29" CSPA along 25th Ct.
5-3110	30	36-inch CSP across Ousdahl @ 25th Ct.
5-3120	30	30-inch CSP across Cedarwood between 25th & 26th
5-3130	30	Natural channel
5-3135	34	Double 54-inch RCP (priv. prop.),SE corner 31st & Iowa
5-3150	34	36-inch CSP (priv. prop.), SE corner 31st & Iowa
5-3160	34	42-inch CSP (priv. prop.), SE corner 31st & Iowa
5-3170	34	6-ft conc. & turf channel, S. side 31st, E. of Iowa
5-3180	34	60-inch RCP across priv. dr., S. side 31st, E. of Iowa
5-3190	34	42-inch CSP across Iowa, S. of 31st
5-3200	34	Double 42-inch CSP S. of 31st & E. of Iowa
5-3210	34	54-inch RCP across priv. dr., SE corner of 31st & Iowa
5-3220	34	6-ft conc. & turf channel, S. side 31st, E. of Iowa
5-3230	30	36-inch CSP across 31st, E. side of Iowa
5-3240	30	36-inch CSP along N. side 31st, E. of Iowa
5-3250	30	24-inch CSP along N. side 31st, W. of Ousdahl
5-3260	30	Double 36-inch CSP along Iowa, N. of 31st
5-3270	30	42-inch CSP along Iowa near 29th
5-3280	29	36-inch CSP along Iowa, 27th to 29th
5-3290	30	66-inch CSP S. of Eddingham, E. of Ousdahl
5-3300	30	72-inch CSP @ outlet of Line 3290
5-3310	30	24-inch CSP along Naismith Dr., S. of Eddingham
5-3320	30	30-inch CSP @ outlet of Line 3330
5-3330	30	24-inch CSP across Naismith Dr., N. of 25th

WATERSHED NO. 5 - NAISMITH (CONT'D.)
EXISTING SYSTEM DESCRIPTION

REACH NO.	MAP NO. REFERENCE	DESCRIPTION
5-3340	30	72"x 44" CSPA thru comm. area @ 23rd & Ousdahl
5-3360	24	58"x 36" CSPA along N. side 23rd, E. of Ousdahl
5-3361	24	58"x 36" CSPA N. of 23rd, W. of Ousdahl (comm. area)
5-3362	24	48-inch CSP N. of 23rd, W. of Ousdahl (comm. area)
5-3363	24	42-inch CSP N. of 23rd, E. of Iowa (comm. area)
5-3370	30	14'x 8' CSPA @ inlet to Line 3380 (@ 23rd & Naismith)
5-3380	30	20'x 9' RCB across 23rd St. @ Naismith Dr.
5-3390	30	10-ft riprap channel @ outlet of Line 3380
5-3400	30	Bridge across Naismith Channel @ 24th St.
5-3410	30	Natural channel
5-3420	30	36-inch CSP across Naismith Dr., S. of 24th
5-3430	30	36-inch CSP across Naismith Dr., S. of 24th
5-3440	30	7'x 5' RCB along S. side 23rd, E. of Naismith Dr.
5-3445	24	6'x 2.25' RCB across 23rd, W. of Alabama
5-3450	24	58"x 36" CSPA 22nd Terr. to 23rd, W. of Alabama
5-3451	24	58"x 36" CSPA along N. side 23rd, W. of Alabama
5-3460	24	58"x 36" CSPA along 22nd Terr., W. of Alabama
5-3470	24	58"x 36" CSPA along Alabama, 22nd to 22nd Terr.
5-3480	24	58"x 36" CSPA along 22nd Terr., E. of Alabama
5-3490	24	58"x 36" CSPA 22nd to 21st, E. of Carolina
5-3500	24	48-inch CSP along Alabama, 22nd Terr. to 23rd
5-3510	24	8'x 3' RCB E. of Naismith, N. of 18th (KU)
5-3520	24	60-inch RCP, SE of Naismith & Sunnyside Ave. (KU)
5-3530	24	60-inch RCP, S. of Sunnyside Ave. (KU)
5-3540	24	48-inch RCP, N. of Sunnyside Ave. (KU)
5-3550	24	36-inch CSP, N. of Sunnyside Ave. (KU)
5-3560	24	36-inch CSP, N. of Sunnyside Ave. (KU)
5-3570	24	48-inch RCP, N. side of baseball field (KU)
5-3575	24	66-inch RCP, S. side of tennis courts (KU)
5-3580	24	54-inch RCP, W. side of tennis courts (KU)
5-3600	24	54-inch RCP, S. of Irving Hill Rd. (KU)
5-3610	24	48-inch RCP, 15th to Irving Hill Rd. (KU)
5-3620	24	42-inch RCP, N. side Anschutz Pavilion (KU)
5-3630	24	36-inch RCP S. of Irving Hill Rd. (KU)
5-3640	24	7'x 5.5' RCB NW corner tennis courts (KU)
5-3650	24	36-inch RCP, NW of 19th & Naismith (KU)
5-3670	24	30-inch CSP, NW of 19th & Naismith (KU)
5-3680	24	36-inch CSP, NW of 19th & Naismith (KU)
5-3690	24	36-inch RCP N. of 19th (KU)
5-3700	24	48-inch RCP along 19th, W. of Naismith Dr.
5-3710	24	54-inch RCP along Naismith (KU)
5-3715	24	78-inch RCP along Naismith, N. of 18th (KU)
5-3720	24	72-inch CSP along Naismith Dr., 18th to 19th (KU)
5-3730	24	84"x 65" CSPA along Naismith, 19th to 20th
5-3740	24	89"x 72" CSPA along Naismith, S. of 20th
5-3750	24	48-inch CSP along 21st, W. of Naismith Dr.
5-3760	24	42-inch CSP along 21st @ Emerald, W. of Naismith Dr.

WATERSHED NO. 5 - NAISMITH (CONT'D.)
EXISTING SYSTEM DESCRIPTION

REACH NO.	MAP NO. REFERENCE	DESCRIPTION
5-3770	24	36-inch CSP along 21st @ Hillview, W. of Naismith Dr.
5-3780	24	Bridge across Naismith Channel @ 21st St.
5-3790	24	7-ft. conc.-lined Naismith Channel, N. of 21st
5-3800	24	Bridge across Naismith Channel @ 22nd St.
5-3810	24	Bridge across Naismith Channel @ 22nd Terr.
5-3820	24	7-ft. conc.-lined Naismith Channel, 21st to 22nd
5-3830	24	7-ft. conc.-lined Naismith Channel, 22nd to 22nd Terr.
5-3840	24	7-ft. conc.-lined Naismith Channel, 22nd Terr. to 23rd
5-3850	24	60"x 48" CSPA along 20th St., E. of Naismith Dr.
5-3851	24	65"x 40" CSPA along 20th St., Alabama to Maine
5-3852	24	58"x 36" CSPA along Alabama, 19th to 20th
5-3860	24	36"x 22" CSPA 22nd to 22nd Terr., W. of Naismith Dr.
5-3870	24	43"x 27" CSPA 22nd Terr. to 23rd, W. of Naismith Dr.
5-3875	24	4'x 4' RCB across 23rd, W. of Naismith Dr.
5-3880	30	48-inch CSP along S. side 23rd, W. of Naismith Dr.

WATERSHED NO. 6 - KLWN
EXISTING SYSTEM DESCRIPTION

REACH NO.	MAP NO. REFERENCE	DESCRIPTION
6-3000	33	Natural channel
6-3010	33	Natural channel
6-3011	33	Natural channel
6-3020	29/33	7'x 4' RCB across 31st St. @ 4-Wheel Dr.
6-3030	29	Natural channel
6-3035	29	36-inch CSP W. of 4-Wheel Dr. @ 29th Terr.
6-3040	29	Natural channel
6-3050	29	65"x 40" CSPA across 27th St., W. of Iowa
6-3060	29	58"x 36" CSPA near end of 26th, W. of Iowa
6-3070	29	58"x 36" CSPA @ end of 26th, W. of Iowa
6-3080	29	50"x 31" CSPA along Melrose, N. of 26th St.
6-3090	29	48-inch CSP W. side of comm. area, N. of 26th
6-3100	29	30-inch CSP W. side of comm. area, N. of 26th
6-3120	29/33	6'x 4' RCB across 31st near Harrison Ave.
6-3200	33	Natural channel
6-3210	29/33	18-inch CSP across 31st, E. of Lawrence Ave.

WATERSHED NO. 7 - BELLE HAVEN
EXISTING SYSTEM DESCRIPTION

REACH NO.	MAP NO. REFERENCE	DESCRIPTION
7-3000	30	Natural channel
7-3010	30	83"x 52" CSPA across 29th @ Belle Haven Dr.
7-3030	30	Natural channel
7-3040	30	83"x 52" CSPA across 27th Terr. @ Belle Haven Dr.
7-3050	30	Natural channel
7-3060	30/31	Double 14'x 7' RCB @ 31st & Louisiana
7-3070	30	63"x 42" CSPA across 27th @ Belle Haven Dr.
7-3080	30	65"x 40" CSPA along Belle Haven Dr., N. of 27th
7-3081	30	71"x 34" CSPA along Belle Haven Dr., N. of 27th
7-3090	30	48-inch RCP along Belle Haven Dr., 25th to Belle Crest
7-3100	30	42-inch RCP @ Belle Haven Dr. & 25th
7-3110	30	36-inch RCP from NE of 25th & Belle Haven to Louisiana

WATERSHED NO. 8 - BROKEN ARROW
EXISTING SYSTEM DESCRIPTION

REACH NO.	MAP NO. REFERENCE	DESCRIPTION
8-3000	31	Double 9'x 5' RCB across 31st, E. of Louisiana
8-3010	31	Natural channel
8-3020	31	24-inch RCP along Barker Ave., N. of Pawnee
8-3025	31	Natural channel
8-3030	31	Natural channel
8-3031	31	54"x 37" CSPA across channel (Haskell campus)
8-3040	31	30-inch RCP @ SW corner Mass. & West Indian
8-3050	31	24-inch RCP along Mass., S. of West Indian
8-3060	31	24-inch RCP along West Indian, W. of Barker
8-3090	31	30-inch RCP @ SE corner Vermont & Kansas
8-3100	31	24-inch RCP across Vermont, N. of Kansas

WATERSHED NO. 9 - HASKELL
EXISTING SYSTEM DESCRIPTION

REACH NO.	MAP NO. REFERENCE	DESCRIPTION
9-3000	31	Natural channel
9-3010	31	Natural channel
9-3020	31	88"x 54" RCPA (Haskell campus)
9-3040	31	Natural channel
9-3050	31	60-inch RCP (Haskell campus)
9-3060	31	Natural channel
9-3080	26/32	36-inch RCP across Haskell @ 23rd
9-3090	26	36-inch RCP along 23rd, E. of Haskell
9-3100	31	Natural channel
9-3110	31	36-inch RCP SW of Oregon & 28th St.
9-3120	31	42-inch CSP across 28th @ Oregon
9-3130	31	36-inch CSP along Oregon N. of 28th
9-3140	31	49"x 32" RCPA (Haskell campus)
9-3200	31	Natural channel
9-3201	31	Double 12'x 5' RCB across 31st St., W. of Haskell
9-3210	31	12-inch RCP across 30th St., W. of Haskell
9-3220	31	Natural channel
9-3240	31	Natural channel
9-3250	31	Natural channel
9-3260	31	6'x 6' RCB across 29th St., W. side Haskell
9-3270	31	10-ft conc & turf channel, W. side Haskell, N. of 29th
9-3280	32	8'x 6' RCB across Haskell, S. of 29th Terr.
9-3290	32	5-ft conc. channel S. of 29th Terr.
9-3300	32	6'x 6' RCB across 29th Terr., E. of Haskell
9-3310	32	5-ft conc. channel between Ponderosa & Maverick
9-3320	32	5'x 5' RCB across 27th, E. of Ponderosa
9-3330	32	54-inch RCP W. of Maverick & N. of 27th
9-3340	32	48-inch RCP W. of Maverick & S. of 25th Terr.
9-3350	32	42-inch RCP N. of 25th Terr. to N. of Willow Cove
9-3360	32	24-inch RCP across Ponderosa, S. of 27th
9-3380	26/32	6'x 3' RCB across 23rd, E. of Harper
9-3390	25	36-inch CSP across 22nd St., W. of Haskell
9-3400	32	1000'x 450' lake
9-3405	25	Natural channel
9-3410	25/31	7'x 4' RCB across 23rd, W. of Haskell
9-3420	31	42-inch CSP along S. side 23rd, W. of Haskell
9-3430	25	36"x 18" RCPA @ priv. drive, NW of 23rd & Haskell
9-3440	25	58"x 24" RCPA @ priv. drive, NW of 23rd & Haskell
9-3450	32	48"x 32" RCPA along Haskell, S. of 24th
9-3460	31	52"x 36" RCPA across Haskell @ 24th St.
9-3470	32	48-inch RCP along Haskell, S. of 25th
9-3480	32	36-inch RCP along Haskell, N. of 25th Terr.
9-3490	31	75'x 25' private detention pond
9-3500	31	2'x 2.5' RCB (Haskell campus)
9-3510	31	36-inch RCP (Haskell campus)
9-3520	31	Double 13'x 2.5' RCB across 31st, W. of Haskell
9-3530	32	60-inch CSP between Willow Cove and 24th, W. of Harper

WATERSHED NO. 9 - HASKELL (CONT'D.)
EXISTING SYSTEM DESCRIPTION

REACH NO.	MAP NO. REFERENCE	DESCRIPTION
9-3540	32	36-inch RCP S. of 24th & W. of Harper
9-3560	32	71"x 47" CSPA along 24th, W. of Harper
9-3570	32	Natural channel
9-3580	32	48-inch CSP S. of 24th, W. of Harper
9-3590	32	71"x 47" CSPA N. of Willow Cove
9-3600	32	60"x 39" RCPHE N. of Willow Cove
9-3601	32	49"x 31" RCPA N. of Willow Cove
9-3610	32	36-inch RCP across Ponderosa, N. of 27th
9-3620	32	48-inch CSP across 27th between Harper & Whitmore
9-3630	32	48-inch CSP across 27th between Harper & Whitmore
9-3640	32	72"x 52" CSPA across & N. of 27th
9-3650	32	68"x 51" CSPA N. of 27th to Hampton
9-3660	32	48-inch CSP along Hampton, Whitmore to Cranley
9-3670	32	55"x38" CSPA along Cranley,N. of Hampton to 25th Terr.
9-3700	32	36-inch CSP N. of 25th Terr. near Anderson (extended)
9-3710	32	Natural channel
9-3720	32	30-inch CSP south of Anderson & 24th Terr.
9-3730	32	54-inch CSP W. of Kensington, N. of 29th St.
9-3740	32	48-inch CSP along Kensington, S. of 28th St.
9-3750	32	36-inch CSP along Kensington, N. of 28th St.
9-3760	32	Double 48-inch CSP across 29th, W. of Kensington
9-3775	32	Natural channel

WATERSHED NO. 10 - DEERFIELD
EXISTING SYSTEM DESCRIPTION

REACH NO.	MAP NO. REFERENCE	DESCRIPTION
10-3000	8	24-inch RCP across Trail Rd.
10-3010	8	42-inch CSP across Boulder Ct.
10-3030	8	20-ft. riprap channel N. of Boulder Ct.
10-3050	8	42-inch CSP across Riverview Rd.
10-3100	8	48-inch CSP across Stetson Dr.
10-3110	8	3-ft. rock channel N. of Trail Rd.
10-3111	8	3-ft. rock channel N. & E. of Stetson Dr.
10-3120	9	42-inch RCP so. of Riverview Rd. near Rock Fence
10-3130	9	54-inch RCP between Rock Fence Rd. & Saddlehorn Dr.
10-3140	9	36-inch RCP along Lance Ct.
10-3150	9	Natural channel
10-3160	9	Double 9'x 6'RCB across Princeton
10-3170	9	12-ft. conc. chan., W. of Arrowhead, S. of Peterson
10-3180	9	Natural channel
10-3190	9	48-inch CSP, W. of Lawrence Ave - Ranger to Tomahawk
10-3200	9	42-inch CSP, W. of Lawrence Ave & S. of Ranger Rd.
10-3210	9	36-inch CSP W. of Lawrence Ave & S. of Longhorn
10-3220	9	Natural channel
10-3230	8/9	8'x 6' RCB across Kasold @ Tomahawk Dr.
10-3240	8	Natural channel
10-3250	9	5-ft. riprap channel W. of Rock Fence
10-3251	9	30-inch CSP, N. of Trail Rd., E. of Frontier
10-3255	2/3	Double 9'x 6' RCB across Peterson Rd.
10-3260	8	6'x 5' RCB across Monterrey Way, N. of Stetson
10-3265	2	Natural channel
10-3270	8	Natural channel
10-3280	8	350'x 125' detention pond, W. of Monterrey Way
10-3290	8	Natural channel
10-3300	8	30-inch CSP across Monterrey Way, S. of Peterson Rd.
10-3310	8	Natural channel
10-3320	8	60"x 42" RCPA across Peterson RD., W. of Kasold
10-3330	8	6'x 1.5' RCB along S. side of Peterson Rd.
10-3340	1/8	Double 8'x 4.5' RCB across Peterson Rd., W. of Kasold
10-3350	8	Natural channel
10-3380	1/2	Double 8'x 7' RCB across Kasold, N. of Peterson Rd.
10-3390	2	Natural channel
10-3400	1	Natural channel
10-3410	2	14'x 8' RCB across Kasold, N. of I70
10-3420	2	Natural channel
10-3430	2	14'x 8' RCB across I70
10-3440	2	Natural channel
10-3441	2	Natural channel

WATERSHED NO. 11 - RIVERSIDE
EXISTING SYSTEM DESCRIPTION

REACH NO.	MAP NO. REFERENCE	DESCRIPTION
11-3000	2	Double 5'x 5' RCB across Iowa near Timberedge Rd.
11-3010	2	Natural channel
11-3020	2/3	35"x 24" CSPA across Iowa, N. of I70
11-3030	2	Natural channel
11-3040	2	4'x 4' RCB across Iowa (extended) near Timberedge Rd.
11-3050	3	Natural channel
11-3060	3	36-inch CSP across California, S. of Riverside
11-3070	3	Natural channel
11-3080	3	5-ft. turf channel W. of California
11-3090	3	36-inch CSP across Riverside @ Colorado
11-3091	3	42-inch CSP across Riverside @ Colorado
11-3092	3	30-inch CSP across Riverside @ Colorado
11-3100	3	Natural channel
11-3110	3	24-inch CSP
11-3120	3	Natural channel
11-3130	3	76" CSP across I70, W. of RR
11-3200	3	Natural channel
11-3210	3	Natural channel
11-3220	3	Natural channel

WATERSHED NO. 12 - COUNTRY CLUB
EXISTING SYSTEM DESCRIPTION

REACH NO.	MAP NO. REFERENCE	DESCRIPTION
12-3000	10	Natural channel
12-3005	10	Natural channel
12-3010	10	52'x 7' bridge near N. end of Maine
12-3020	10	36"x 24" RCPHE W. of Maine & 2nd
12-3030	10	84" CSP along 2nd St., E. of Michigan
12-3033	10	81" CSP along Michigan between 2nd & 3rd
12-3040	10	81" CSP along 3rd between Michigan & Minnesota
12-3050	10	72" CSP along 3rd, W. of Minnesota
12-3060	10	Natural channel
12-3070	9/10	10'x 6.5' CSPA across Iowa @ 4th St.
12-3080	9	Natural channel
12-3090	9	6'x 6' RCB W. side of Iowa
12-3100	9	Natural channel
12-3110	9	5.5'x 7' RCB across McDonald Dr. near 6th
12-3120	9	6.5'x 7' RCB across 6th St. @ McDonald Dr.
12-3140	16/17	4'x 4' RCB across Iowa, S. of 6th
12-3150	10	42" RCP along Minnesota, S. of 3rd
12-3160	10	36" RCP along Minnesota, N. of 4th
12-3180	9	42-inch RCP across McDonald Dr., N. of 6th
12-3200	10	Natural channel
12-3210	3	Natural channel
12-3220	3	16'x 2' RCB across Michigan, N. of Pinewood Dr.
12-3230	3	Natural channel
12-3240	10	Natural channel
12-3231	3	Double 13'x 5' CSPA in Wood Creek townhomes
12-3250	10	60" RCP across McDonald Dr., N. of 2nd
12-3260	10	Natural channel
12-3270	10	Natural channel
12-3280	9	60"x 36" CSPA across Iowa @ McDonald Dr.
12-3290	9	Natural channel
12-3300	9	36-inch RCP along Rockledge Dr., W. of McDonald Dr.
12-3310	10	Natural channel
12-3320	9/10	7'x 5' RCB across Iowa, N. of Princeton
12-3330	9	48-inch RCP, Princeton to W. side of Iowa
12-3340	9	42-inch RCP along Providence Rd., S. of Princeton
12-3360	2	Natural channel
12-3361	2	Natural channel
12-3370	9	Natural channel
12-3375	9	48-inch RCP across Princeton, W. of Yorkshire
12-3380	9	60-inch RCP along N. side Princeton @ Crestline Dr.
12-3390	9	36-inch RCP across Princeton, W. of Crestline Dr.
12-3410	3	48-inch RCP across I70 ramp @ turnpike interchange
12-3420	3	42-inch RCP across I70
12-3430	2	6-ft. concrete channel, W. side of Iowa
12-3440	2	72"x 48" RCPA across drive, W. side of Iowa
12-3450	2	Natural channel
12-3460	2	72"x 48" RCPA across I70, W. of Iowa

WATERSHED NO. 12 - COUNTRY CLUB (CONT'D.)
EXISTING SYSTEM DESCRIPTION

REACH NO.	MAP NO. REFERENCE	DESCRIPTION
12-3470	3	Natural channel
12-3480	3	60-inch CSP across Michigan, S. of I70
12-3490	3	Natural channel
12-3500	2	10'x 6' RCB across Iowa, N. of Peterson Rd.
12-3510	3	Natural channel
12-3520	3	6'x 5' RCB across McDonald Dr., S. of interchange
12-3530	3	Natural channel
12-3540	3	48-inch RCP across I70 near turnpike interchange
12-3550	3	42-inch RCP across I70 @ turnpike interchange
12-3560	2	5'x 4' RCB across Peterson Rd., W. of Iowa
12-3570	2	Double 48-inch CSP, N. of Peterson Rd. & W. of Iowa
12-3580	2	6-ft. rock channel, N. of Peterson Rd. & W. of Iowa
12-3590	2	42-inch CSP across Peterson Rd., W. of Iowa
12-3600	2	54-inch CSP, N. of Peterson Rd. & W. of Iowa
12-3610	2	30-inch RCP across I70
12-3620	3	Double 30-inch CSP across frontage rd.
12-3630	3	36-inch CSP across I70 ramp @ turnpike interchange
12-3640	3	36"x 24" CSPA across I70 @ turnpike interchange
12-3650	3	42"x 27" CSPA across McDonald Dr.
12-3660	3	36-inch RCP across frontage rd. @ turnpike interchange
12-3670	3/10	Concrete v-ditch along W. side McDonald Dr.
12-3680	3/10	10-ft. turf channel along E. side McDonald Dr.
12-3700	10	60"x 36" CSPA, W. side of McDonald Dr., S. of 2nd
12-3710	10	54"x 40" CSPA across 2nd, W. side of McDonald Dr.
12-3720	10	96-inch CSP E. side of Iowa @ McDonald
12-3730	10	36-inch RCP across McDonald @ 6th
12-3740	9/16	4.5'x 4' RCB across ramp @ 6th & McDonald Dr.

WATERSHED NO. 13 - DOWNTOWN
EXISTING SYSTEM DESCRIPTION

REACH NO.	MAP NO. REFERENCE	DESCRIPTION
13-3000	11	Quadruple 48-inch CIP across RR
13-3010	11	Natural channel
13-3020	10	6'x 7' RCB, N. side of 5th, Mississippi to Indiana
13-3030	10	5'x 5.5' RCB, S. of 5th, Illinois to Mississippi
13-3040	10	Natural channel
13-3050	10	72-inch CSP W. of Maine between 5th & 6th
13-3060	10	66-inch rubber-lined CSP N. of 6th & Missouri
13-3070	10	54-inch CSP along E. side of Arkansas, S. of 6th
13-3080	17	4'x 4' RCB along W. side Michigan, S. of 7th
13-3100	17	48-inch CSP SW of 7th & Michigan
13-3110	17	Natural channel
13-3111	17	36-inch CSP & 3.5'x 3.5' RCB across 8th near Michigan
13-3120	17	48-inch CSP across 9th between Avalon & Emery
13-3122	17	Natural channel
13-3140	10	5'x 5' RCB E. of Mississippi from S. of 6th to 7th
13-3150	10	5'x 5' RCB from Illinois to Mississippi, S. of 6th
13-3160	10/17	60-inch CSP N. of 7th between Illinois & Alabama
13-3180	17	54-inch CSP along 8th & Alabama (S. of 7th)
13-3190	17	48-inch CSP along 9th & Missouri (S. of 8th)
13-3200	17	24-inch CSP S. of 9th between Missouri & Arkansas
13-3201	17	54-inch CSP along Arkansas, S. of 9th
13-3210	17	Natural channel
13-3211	17	62"x 45" CSPA W. of Arkansas & S. of Michigan
13-3220	17	42-inch RCP E. of Emery & S. of 10th (extended)
13-3221	17	Natural channel
13-3240	10	36-inch CSP N. of 6th & E. of Michigan
13-3250	10	5'x 4' RCB across 6th @ Arkansas
13-3260	10	30-inch CSP along S. side of 6th, Florida to Arkansas
13-3300	11	Double 78-inch CIP downstream from RR culvert
13-3301	11	78-inch CSP across RR
13-3310	11	78-inch CSP N. of 6th & Kentucky
13-3320	11	6'x 6.6' RCB, 7th to 6th in Buford Watson Park
13-3340	18	6'x 6.6' RCB E. side Tennessee, S. of 7th
13-3350	18	6'x 7.33' RCB E. side Tennessee, N. of 8th
13-3360	18	42-inch RCP along Tennessee, 10th to 8th
13-3370	18	42-inch CSP along Kentucky, 11th to 10th
13-3380	18	36-inch CSP along Kentucky, 12th to 11th
13-3399	17	6'x 6.5' RCB SW of 8th & Louisiana
13-3400	17	72-inch RCP N. of 9th & W. of Louisiana
13-3401	18	6'x 6.33' stone box, S. of 8th between Tenn. & Ohio
13-3402	18	6'x 6' stone box, NW corner Tennessee & 8th
13-3403	18	5'x 9' stone box across Louisiana, S. of 8th
13-3404	18	72-inch RCP W. of Ohio & S.of 8th
13-3405	18	6'x 6' stone box E. of Louisiana & S. of 8th
13-3406	18	6'x 5.5' RCB E. of Ohio & S. of 8th
13-3410	17	6'x 5' stone box, 10th-9th, W. of Miss.- W. of La.
13-3420	17	4.5'x 4.5' brick box, S. of 11th & W. of Miss. (KU)

EXISTING SYSTEM DESCRIPTION

REACH NO.	MAP NO. REFERENCE	DESCRIPTION
13-3421	17	3.5'x 5' brick box, 11th-10th between Miss. & Ill.
13-3430	17	42-inch RCP E. side stadium (KU)
13-3440	17	36-inch CSP S. side stadium (KU)
13-3441	17	Pond (KU)
13-3442	17	12'x 3.5' RCP pond outlet (KU)
13-3500	18	7'x 12' stone box downstream from RR culvert
13-3510	18	Natural channel
13-3530	18	10'x 9' RCB across RR
13-3540	18	84-inch CSP upstream end RR culvert
13-3550	18	6.25'x 6.25' RCB NE corner 8th & Pennsylvania
13-3560	18	6'x 6' RCB along 8th, W. of New York to Penn.
13-3570	18	5.5'x 5.33' stone box between Conn. & N.Y., 8th-9th
13-3580	18	4'x 4' RCB between Conn. & N.Y., 9th-10th
13-3590	18	48-inch brick pipe between Conn. & N.Y., 10th-11th
13-3600	18	24-inch CSP along 11th & S. on Rhode Island
13-3610	18	24-inch CSP, Mass. to R.I., S. of 11th
13-3620	18	4'x 4' RCB along 9th, W. of R.I. to E. of Conn.
13-3630	18	36-inch brick pipe along 9th, Vermont to W. of R.I.
13-3650	18	30-inch CSP along Pennsylvania, 8th to 9th
13-3660	18	24-inch CSP along 9th, Penn. to Delaware

WATERSHED NO. 14 - EAST LAWRENCE
EXISTING SYSTEM DESCRIPTION

REACH NO.	MAP NO. REFERENCE	DESCRIPTION
14-3000	19	Natural channel
14-3010	18	10'x 6' RCB, 13th to 12th, Oregon to Haskell
14-3020	18	6'x 6' RCB along W. side RR, 15th to 13th
14-3021	25	36-inch CSP along 15th, E. of Maryland
14-3030	25	Natural channel with detention @ 15th
14-3031	25	36"x 22" CSPA S. of 15th, Delaware to E. of Maryland
14-3040	25	Natural channel
14-3050	25	8'x 4' RCB across 19th, E. of Learnard
14-3060	25	8-ft. conc. block channel, SE of 19th & Learnard
14-3070	25	8'x 4' RCB across Learnard, S. of 19th
14-3080	25	Natural channel
14-3090	25	51"x 31" CSPA N. side Barker Ct.
14-3100	25	54"x 42" CSPA across Barker & along R.I., S. of 20th
14-3109	25	30-inch CSP along Massachusetts, 22nd to 21st
14-3110	25	4'x 3.5' RCB N. of 21st, Mass. to R.I.
14-3120	25	30-inch CSP along 21st, Kentucky to Mass.
14-3130	25	30-inch CSP along 19th, E. of Learnard
14-3140	25	36-inch CSP along 19th, Connecticut to Learnard
14-3150	25	30-inch CSP along 19th, N. Hampshire to Conn.
14-3160	25	27-inch CSP along 19th, Mass. to N.H.
14-3170	25	24-inch CSP along 19th, Kentucky to Mass.
14-3180	25	Channel along W. side RR, N. of 19th
14-3190	25	75"x 48" CSPA across 19th, W. side RR
14-3200	25	Channel along W. side RR, S. of 19th
14-3210	25	36-inch RCP, priv. prop. E. of Delaware, S. of 19th
14-3220	25	60"x 38" CSPA along Lynn, W. of Haskell
14-3230	26	58"x 36" CSPA across Haskell @ Lynn/18th
14-3240	26	43"x 27" CSPA along Haskell 19th to Lynn/18th
14-3250	18	5'x 5' RCB S. of 13th, New Jersey to Oregon
14-3260	18	5'x 4' RCB across New Jersey & E. to N.Y., S. of 13th
14-3270	18	5'x 4' RCB across New York @ 14th
14-3280	18	5'x 4' RCB along 14th, Connecticut to New York
14-3290	18	36-inch CSP along 14th, Rhode Island to Connecticut
14-3300	18	30-inch CSP along 14th, New Hampshire to Rhode Island
14-3310	18	6'x 4.5' RCB, 15th & R.I. to 14th & Conn.
14-3320	25	42-inch CSP along 15th, N.H. to R.I.
14-3330	25	42-inch CSP along N.H. S. of 15th & 16th to Mass.
14-3340	25	24-inch CSP along 16th, Kentucky to Mass.
14-3350	25	21-inch CSP along Kentucky, 15th to 16th
14-3360	25	50"x 36" CSPA along 19th, W. of RR
14-3370	25	50"x 33" CSPA @ 19th & Moodie
14-3380	25	Two 24-inch CSP @ 19th & Moodie
14-3390	25	40"x 30" CSPA along Moodie, S. of 19th
14-3400	25	Natural channel
14-3410	25	50"x 31" CSPA across 19th, E. side RR

WATERSHED NO. 15 - BROOK STREET
EXISTING SYSTEM DESCRIPTION

REACH NO.	MAP NO. REFERENCE	DESCRIPTION
15-2000	26	Turf channel S. of 21st Terr.
15-2001	26	30-inch CSP S. of 21st Terr.
15-2010	26	4-ft conc. channel between 18th & 18th Terr.
15-2100	19	Turf channel along S. side Oak Hill
15-3000	19	Natural channel
15-3001	19	Bridge near 12th & Brook St.
15-3010	19	48-inch CSP across 13th @ Brook St.
15-3020	19	12-ft. riprap channel, S. of 13th, E. of Brook
15-3030	19	Double 48-inch CSP across Brook St., S. of 13th
15-3040	19	Natural channel
15-3050	26	10'x 6' RCB across 15th, E. of Haskell
15-3060	26	Natural channel
15-3070	26	60-inch RCP along Maple Lane, N. of Glenn
15-3071	26	36-inch RCP W. of Maple Lane between 18th & 18th Terr.
15-3072	26	75-inch CSP, N. end of Maple Lane
15-3080	26	54-inch RCP along Maple Lane, N. of 19th
15-3090	26	65"x 40" CSPA along Maple Lane, 19th to 21st
15-3100	26	42-inch CSP along 21st St., W. of Maple Lane
15-3110	26	42-inch CSP 21st Terr. to 21st St., W. of Maple Lane
15-3111	26	36-inch CSP S. of 21st. Terr.
15-3120	26	42-inch CSP along Maple Lane, S. of 21st
15-3130	26	36-inch CSP W. side Maple Lane @ 19th
15-3140	26	48-inch RCP along 15th, W. of Prairie
15-3150	26	42-inch CSP S. of 15th @ Prairie
15-3160	26	36-inch RCP S. of 15th, W. of Cadet Ave.
15-3161	26	75'x 75' detention pond in cemetery
15-3170	19	6'x 4' RCB across 13th @ Brook St.

WATERSHED NO. 16 - SUNFLOWER
EXISTING SYSTEM DESCRIPTION

REACH NO.	MAP NO. REFERENCE	DESCRIPTION
16-2000	26	Natural channel
16-2010	26	Natural channel
16-3000	26	8'x 7.5' RCB across 15th E. of Lindenwood
16-3010	26	Natural channel
16-3030	26	180'x 550' detention pond S. of 15th
16-3040	26	Natural channel
16-3050	26	60-inch CSP culvert under mobile home park rd.
16-3060	26	Natural channel
16-3070	26	36-inch CSP culvert under 19th
16-3080	26	Natural channel
16-3090	26	Natural channel

WATERSHED NO. 17 - NORTH LAWRENCE
EXISTING SYSTEM DESCRIPTION

REACH NO.	MAP NO. REFERENCE	DESCRIPTION
17-3000	11	Triple 8'x 4' RCB across N. 2nd @ pump station
17-3002	11	Natural channel
17-3010	11	60-inch RCP through levee west of N. 2nd
17-3020	11	48-inch RCP through levee west of N. 2nd
17-3030	11	30-inch CSP along N. 2nd, pump station to river
17-3040	11	5'x 4' RCB at pump station outlet
17-3050	4	5'x 5' RCB across Hwy 59 @ Hwy 40
17-3060	4	36-inch RCP across Hwy 40 @ Hwy 59
17-3070	4	36-inch RCP across Hwy 40 @ Hwy 59
17-3080	4	6'x 4' RCB across Hwy 59 @ Hwy 40
17-3090	11	Double 30-inch CIP pump discharge lines
17-3100	11	36-inch CSP at pump station outlet
17-3110	11	8-ft. concrete channel to pump station
17-3111	11	20-ft. concrete channel to pump station
17-3120	11	60-inch CSP across N. 3rd, so. of North St.
17-3130	11	20-ft. concrete channel, North St. to N.3rd
17-3140	11	60-inch CSP across North St., between N. 3rd & N. 4th
17-3150	11	40,000 GPM pump station, N. 2nd St.
17-3160	12	30-inch RCP through levee @ so. end of N. 8th St.
17-3170	12	18-inch CSP along N. 8th, Maple to levee
17-3180	11	30-inch RCP through levee @ so. end of N. 7th St.
17-3181	11	18-inch CSP along N. 7th, Elm to levee
17-3190	11	30-inch RCP through levee @ so. end of N. 6th St.
17-3191	11	24-inch CSP along N. 5th, Locust to levee
17-3192	11	18-inch CSP discharge line from 5th & Maple pump sta.
17-3193	11	15-inch CSP along Lincoln & N. 6th (from 7th to Maple)
17-3200	11	30-inch RCP through levee @ so. end of N. 5th St.
17-3201	11	18-inch CSP along N. 5th, Elm to levee
17-3210	11	30-inch RCP along Locust, N. 3rd to N. 2nd
17-3220	4	30-inch CSP along N. 3rd
17-3224	11	30-inch CSP along N. 3rd, so. of North St.
17-3230	4	24-inch CSP along N. 2nd, so. of I70
17-3240	4	18-inch CSP along N. 2nd, so. of I70
17-3250	4	15-inch CSP along N. 2nd, so. of I70
17-3260	4	Natural channel
17-3270	4	Natural channel
17-3275	4	RCB across Hwy. 40, E. of Hwy. 59

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PART V - DRAINAGE POLICY

PART V

DRAINAGE POLICY

A. GENERAL

Because typical urban land ownerships are small, and approximately 15 percent of the land area is typically owned by the municipality itself in the form of street right-of-way, it's not practical for each landowner to individually provide and maintain a private drainage system. Therefore, municipalities have by necessity and tradition assumed responsibility for establishing specific drainage systems within their boundaries and have become the "owners" of most structural drainage systems. In so doing the municipality also accepts the corresponding duty to maintain those improved facilities. For the City to reasonably manage drainage in its boundaries it must:

- Specifically define a common level of service to be established.
- Provide for the construction of physical components of the drainage system.
- Control the use of land to avoid the obstruction of drainage.
- Provide for physical maintenance of drainage system improvements to ensure their function is not impaired.

Equitable division of responsibility for management of drainage between the City and private property owners is a fundamental consideration in establishing policies for providing drainage service. Pure equity must be tempered with practical constraints. The ultimate objective is to provide an equal and acceptable level of drainage service to all citizens and to fairly apportion the cost of that service.

This section discusses the principal public policy issues that are integral to implementing a drainage management plan. Specific policy recommendations in this section are from the "Stormwater Management Criteria" manual and were generally used to develop the capital improvement project list and maintenance program recommendations presented in other sections of this report.

B. SYSTEM DESIGN CRITERIA RECOMMENDATIONS

The Lawrence City Commission approved the "Stormwater Management Criteria" manual, prepared and submitted separately from this report, during its January 23, 1996 meeting upon recommendation of the City staff and the consultant and formal adoption by ordinance is pending. This manual defines what is generally accepted as a reasonable level of service for storm drainage systems and outlines current standards of practice and technology for design of those systems. Included in the specific policy recommendations contained within the manual which relate to policy issues are the following:

1. All enclosed and improved open channel drainage system components shall be designed for the 10-year return period peak flow or the capacity of the existing upstream improved system, whichever is greater.

2. Surface overflow channels shall be required in all areas in addition to, and above, the 10-year conveyance element. The overflow Channel, when combined with the conveyance element, must provide sufficient capacity to convey the 100-year peak flow. Overflow channels will be covered by drainage easements with restrictions on land use within the easement required to prevent obstruction of flow.

3. Enclosed pipe-inlet systems will be required under the following conditions.
   a. Within the right-of-way of improved streets of new developments.
   b. In all areas where the bank line of an open channel, either natural or improved, would be within 30 feet of any existing habitable structure regardless of system design capacity.
   c. In new development areas where the permanent drainage easement of an open channel, either natural or improved, would encroach upon any existing or proposed structure.

4. Existing natural channels may be retained in the drainage system of a developed area provided flow velocities do not exceed recommended

maximums based on soils present in the channel bed and bank. In addition, natural channels should remain in their original locations as much as possible.

5. Detention facilities shall be provided in connection with land development when problem areas have been identified where homes, buildings or other structures within the drainage basin and downstream from the proposed development are frequently flooded during storm events. Detention facilities shall also be required where an engineering study indicates the proposed development would cause flooding of downstream structures not previously affected; where such facilities are recommended by the City's current Stormwater Management Master Plan; or where determined by the City Engineer to be beneficial to the drainage system.

6. Dedication of easements for all improved system components to be maintained by the City shall be required as well as maintenance access connections to street right-of-way. Easements will also be required, although not for City maintenance purposes, along natural, or unimproved, channels and around private detention facilities other than parking lots, rooftop detention or similar situations. Restrictions on land use within some easements is outlined in order to insure proper function of the overflow system.

C. LOT GRADING AND EROSION CONTROL REQUIREMENTS

As a part of the 1993 report prepared by the City's Stormwater Task Force, a recommendation was made to amend existing City codes to require plot plans with building permit applications for all construction not requiring site plan approval. Specific information relative to lot grading, structure elevations, etc., is outlined in the recommended code. In addition to the Task Force recommendation, this management plan suggests the City adopt regulations requiring erosion control plans for all new construction projects to prevent siltation on streets and in the existing downstream drainage system. Both the plot plans and erosion control plans would most logically be submitted to and reviewed by the City's Department of Building Inspection at the time a building permit application is submitted. Review by the City's stormwater engineer would also be appropriate during the process.

In considering either of these suggestions, however, it should be noted that in both cases additional expenses will be incurred by both the City and the builders and developers. Preparation of the plot plans and erosion control plans by either the builder or a consultant, as well as the installation of erosion control measures, will add costs to the development of property. Verification of grading and elevations in conformance with the plot plan will require additional surveys and submittals to the City. Review of the plans within the Building Inspection Department will require additional labor hours and costs. If the City also takes responsibility for the verification of elevations and for enforcement of erosion control requirements, it is conceivable that an additional full-time survey crew and an inspector would be required for this purpose, at least during the construction season. Fees for building permits would need to be increased to cover these expenses. Ultimately, all of these costs will be passed along to the individual property owner when the lot is sold.

A copy of the Task Force's plot plan requirements, and a summary of erosion and sediment control principles are included in Appendix III. Also included are copies of Kansas Department of Transportation (KDOT) standard details for various erosion control methods for reference.

D. <u>EXISTING SYSTEM CAPITAL IMPROVEMENTS</u>

When an existing drainage system component is replaced, the replacement unit should be designed and constructed to meet current City criteria and standards. The mere failure of any existing element of the drainage system to meet those current standards for hydraulic capacity should, however, not be cause for automatically planning and budgeting for its replacement. Sound and maintainable facilities should only be replaced when their lack of capacity results in, or will result in, economic consequences commensurate with the cost of replacement, or when there is an overriding public safety or property damage issue involved. In any case, it should be remembered that it is still the responsibility of the property owner to direct water which naturally drains across that property around any structures, through yards, and down the continuing natural drainage course.

1. Major Drainage System Components

The following recommendations apply to the upgrading of existing major drainage system elements that have been previously provided by developers and accepted by the City; those which cross or are located in public right-of-way or other City-owned property; or those that are not subject to developer improvement in connection with the development of open land. These are the general guidelines used in determining which improvement projects, as outlined in Part VI of this report, the City should be responsible for designing and constructing. It is recommended that the City replace major system facilities where:

a. Building flooding occurs at 25-year or more frequent intervals.
b. Overflow of public streets by the 2-year storm lasts for a time duration greater than 10 to 15 minutes.
c. Structural failure has occurred or is impending.
d. Uncontrolled discharge of water from public right-of-way onto adjacent private property results in erosion which will eventually either endanger buildings or otherwise adversely affect the use of the property, or creates a recurring nuisance and the lack of maintenance control for the property owner.

2. Minor System Components

For a number of years, the City has required developers to construct curb and gutter and storm sewer systems in their developments and dedicate them to the City for operation and maintenance. The capital cost of these "minor system" improvements was, in effect, paid for by individual property owners as part of the purchase price of those lots; however, some areas within the corporate limits, such as those annexed after development, have no such improved facilities. Their "minor system" consists of small roadside ditches and driveway culverts. Property owners in these areas have not made an individual investment commensurate with that of other property owners.

Because of the different levels of individual investment, it is not equitable for the City to upgrade the unimproved minor drainage system simply to relieve the adjoining property owners of what may be perceived as a nuisance. The City as a whole, however, derives specific and general benefits from unimpeded traffic flow and free access by emergency and public service vehicles so it is necessary that the City maintain the unimproved minor system to assure its continued function. In addition, since the runoff from the street right-of-way is a part of the total system demand, and the culverts and ditches on the right-of-way act to concentrate and channelize flow at its point of release to private property, the City has the common duty to control its release to avoid damage to such property. Therefore, it is recommended that, relative to minor drainage system elements, the City:

a. Construct new or upgraded minor system drainage facilities only when water discharged directly from a public street or other City property is causing damage in the form of structure flooding or severe erosion to the downstream property.

b. Require individual property owners to install and repair driveway culverts on streets not having curb and gutter with enclosed drainage systems.

c. Replace cross-road culverts when hydraulic capacity is less than 2-year return period demand and the deficiency causes structure flooding upstream from the culvert or if their structural condition is not serviceable.

d. Replace or extend enclosed pipe-inlet systems only when the hydraulic capacity is less than a 5-year storm demand and structure flooding has occurred, or is predicted to occur by competent professional advice, due to system inadequacies; or when structural failure has occurred, or is impending.

E. SYSTEM MAINTENANCE

The City's current policy provides for the City to maintain improved drainage facilities within the corporate limits. Improved facilities include enclosed pipe-inlet systems, road culverts and roadside ditches within public street right-of-way, and improved open channels, generally those lined with concrete or riprap. Maintenance of natural or unimproved channels is currently not performed by City personnel. Upkeep of those channels is considered the responsibility of the private property owner(s) whose land abuts the channels.

In general, it is recommended that the current basic policies pertaining to drainage system maintenance by the City be continued; however, a planned regular maintenance program should be initiated. Specific recommendations concerning maintenance practices and current maintenance needs are discussed in more detail in Part VII of this report. In order for this approach to be successful, however, it is essential that the City enforce its ordinance concerning the maintenance of drainage easements on private property. In addition, such enforcement should extend to private improved drainage facilities, such as drive or road culverts, on-site enclosed systems, and detention basins, which adversely impact adjoining properties when they do not function properly.

F. IMPACT ON EXISTING CITY ORDINANCES

Several new ordinances or resolutions relating to stormwater management have been adopted recently, primarily as a result of the City's Stormwater Task Force recommendations. These revisions or additions to the municipal codes concern issues such as restrictions on drainage easements and maintenance of easements on private property; requirements for minimum structure elevations on plats; and the authority to establish a stormwater utility. In addition to those ordinances, the following revisions, amendments, or deletions are recommended in accordance with the recommendations contained in this report and the separate "Stormwater Management Criteria" document.

1. Eliminate Resolution No. 4631, "A Resolution Establishing a Storm Water Detention Policy for the City of Lawrence," dated March 15, 1983. With the adoption of the new criteria manual, this resolution is no longer applicable.

2. Revise Section IV.C, Paragraphs 1 and 2, of Resolution No. 5614, "A Resolution Establishing the Development Policy for the Financing of Public Improvements within the City of Lawrence, Kansas," dated April 19, 1994. The first paragraph references a "major drainage area map

designating drainage courses of city-wide significance" and indicates that the City will not participate in the funding of drainage improvements along any drainage course not designated on the map. The second paragraph encourages the use of open drainage but also indicates that the City will negotiate the amount of participation and financing method for each case where enclosed system improvements are deemed necessary in substantially developed areas. Both of these paragraphs appear to be somewhat in conflict with the recommendations of this study or, at least, no longer applicable.

During the course of researching existing data available for this study, no major drainage area map could be located within City records. In addition, this report outlines not only specific improvement recommendations but also guidelines for determining when the City will be responsible for system improvements which is basically different than the policy outlined in Paragraph 2. It is recommended that both of these paragraphs be eliminated or substantially reworded to agree with this report assuming the study and its recommendations are adopted by the City.

3. It is recommended that an ordinance be adopted extending the City's right to enforce maintenance of private drainage facilities through the Director of Public Works, similar to the ordinance for maintaining drainage easements. A copy of such an ordinance section, in use by the City of Columbia, Missouri is included as an example at the end of this report section.

4. Resolutions requiring plot plans and erosion control plans for approval of building permits will be required if such policies are adopted.

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EXCERPT FROM CHAPTER 12A - LAND PRESERVATION
CODE OF ORDINANCES OF THE CITY OF COLUMBIA, MISSOURI

PERTAINING TO MAINTENANCE OF STORM DRAINAGE FACILITIES

Sec. 12A-91. Maintenance of storm drainage facilities.

Storm drainage facilities which have not been dedicated to and accepted by the city shall be maintained by the owner of the land on which they are located. Storm water detention facilities which serve more than one lot or tract shall be maintained by the owners of the lots or tracts served.

Sec. 12A-92. Failure to maintain declared a nuisance: abatement procedure.

(a) Failure to adequately maintain a storm drainage facility is hereby declared a nuisance.

(b) Whenever the director determines that a storm drainage facility is inadequately maintained, he shall give notice to the property owner or owners of his determination and order the nuisance abated. The abatement order shall state the number of days within which the nuisance must be abated. The director shall also give notice of the right of the property owner or owners to appeal the abatement order.

(c) The notice required in subsection (b) shall be in writing and shall either be personally served or mailed by certified or registered mail, return receipt requested. When service cannot be had by either of the above two methods, then service may be made by publication. Notice by publication shall be made by inserting the required notice in a newspaper of general circulation published in the county for at least once each week for a period of two weeks. Notice shall be considered given when the owner is personally served, the mail is delivered, or the last required newspaper notice is published.

(d) A property owner may appeal the director's abatement order by filing a written demand for a hearing with the city manager. A demand for a hearing must be received by the city manager within ten (10) days after the notice required in subsection (b) was given.

(e) After receiving a timely written demand for a hearing, the city manager shall designate a hearing officer to conduct the hearing. The hearing shall be conducted in accordance with the provisions of Chapter 536 of the Revised Statutes of Missouri. The hearing officer may either affirm, modify or reverse the abatement order.

(f) If the owner or owners fail to comply with the order of abatement, the director may cause the nuisance to be abated and shall certify the cost of such abatement to the city council. The city council may, by ordinance, levy the cost thereof as a special tax bill against the property. The tax bill shall be collected in the same manner as other special tax bills and shall be a lien on the property until paid.

PART IV-EXISTING SYSTEM PERFORMANCE

PART IV
EXISTING SYSTEM PERFORMANCE

A. GENERAL

This section presents the results of the hydrologic and hydraulic analysis of Lawrence's major drainage system using the computer models as described in Part III of this report. The analysis was based on the storm drainage system and land use as they existed in late 1994 and early 1995. The performance of the existing system was reviewed based on both the current municipal drainage design criteria and the proposed "Stormwater Management Criteria" document which has been supplied to and accepted by City staff and the City Commission separate from this report.

The City's current design criteria require design of drainage facilities based on a ten-year return period storm. The proposed criteria also require that all enclosed pipe systems and improved open channels be capable of conveying a ten-year return period peak discharge but with the added requirement for the provisions of adequate overflow capacity to allow the combined system (conveyance element plus overflow channel) to carry the 100-year discharge without flooding adjacent structures.

However, identifying an existing system element as failing to meet either current or proposed criteria, according to the model, does not indicate deficiencies in design or construction at the time the element was originally constructed. The principal determinants of hydraulic demand on the drainage system are land use and rainfall. Neither has remained static during the period of time over which Lawrence's drainage system has developed. Major impacts on the capacity rating of the system include updated information on the predicted intensity of rainfall based on ongoing Weather Bureau statistical analysis of precipitation records; changes in land use not anticipated at the time of the original design and construction; and development of computer modeling techniques and other analytical methods that permit a more refined analysis of system performance than was previously practical.

B. EXISTING DRAINAGE PROBLEMS

During the early phases of this project information on known drainage problems was gathered from various sources, primarily City records, the 1993 Stormwater Task Force report, and the residents of Lawrence. Information from citizens was obtained, for the most part, through a questionnaire distributed to participants in a public meeting held in October, 1994 and made available through a number of civic and neighborhood organizations. In addition to problem locations and descriptions, the surveys also asked for opinions on issues dealing with drainage policy. The questionnaire was published again later in the Lawrence Journal World newspaper in December, 1995 to gain additional input from residents that may not have been aware of the initial meeting.

After the distribution in October, 1994 a total of 125 separate questionnaires were eventually returned along with copies of photos, newspaper articles, maps and even a videotape, all documenting drainage problems at various locations throughout the City. An additional 21 questionnaires along with several letters and phone calls were received after the survey appeared in the newspaper. A copy of the questionnaire and a summary of the results is included in Appendix A of this report.

The problems identified by these surveys, along with others previously identified by the City and the Stormwater Task Force records, were compared with the results of the existing system analysis to aid in the identification of those problems due to actual system deficiencies and those apparently due to other conditions. In addition, the information on the specific types of problems was used in categorizing the proposed improvements into basic priority groups discussed in Part VI of this report.

C. BASIN MODEL DEVELOPMENT

1. MODEL ARRANGEMENT

Computer models were developed for 17 principal watersheds including the City of Lawrence and immediately adjacent areas. Each of the watersheds has its own unique drainage system tributary to one of the main waterways in the area. The models for the watersheds within the study include 1,395 pipe, culvert, detention and open channel reaches totaling 1,023,390 lineal feet (193.8 miles) of drainage system components. Basin area incorporated into the models totals 16,817 acres, or 26.3 square miles.

In general, only the larger detention facilities which actually impacted the overall system performance were included in the models. A number of small ponds with small drainage areas are indicated on the aerial mapping throughout the City and numerous other detention facilities are located on individual commercial tracts as required by current City detention policy; however, these basins were not included in the modeling since their impacts tend to be very localized rather than on the system as a whole.

System maps indicating watershed limits and individual model reaches developed as part of this study have been separately furnished to City staff members. A summary description of the model content is indicated by Table IV-1.

TABLE IV-1
EXISTING SYSTEM MODEL DESCRIPTION

Watershed Name	Area (Acres)	Number Of Drainage Elements	System Hydraulic Length (Ft)
Yankee Tank West	756	46	44,010
Hidden Valley	1,788	128	109,450
Quail Creek	1,028	109	80,870
Yankee Tank East	1,747	156	120,135
Naismith	1,306	219	131,700
KLWN	486	31	32,850
Belle Haven	260	20	14,700
Broken Arrow	235	17	14,745
Haskell	824	116	72,745
Deerfield	898	89	53,785
Riverside	337	24	22,420
Country Club	1,217	117	67,580
Downtown	1,095	118	84,275
East Lawrence	830	84	63,740
Brook Street	397	41	30,630
Sunflower	189	15	10,600
North Lawrence	3,424	65	69,155
Totals	16,817	1,395	1,023,390

2. HYDRAULIC CAPACITY RATING

The SWMM model was used to determine the demand discharge, or peak flow, to each system element. The hydraulic capacity of each element was determined using Manning's equation or standard headwater nomographs as applicable. Although the model's calculations are precise with respect to the rainfall, land use, and system data, they are predicting system performance that is naturally variable. Infinitely changing rainfall rates, seasonal and other changes in day-to-day conditions of the land surface and vegetation, and the changing maintenance condition of the system itself will all influence the actual performance of the system at any given time.

Due to these natural variations, it is not realistic to conclude that a system element is not capable of supplying a given level of hydraulic service (i.e. 5-year, 10-year, etc.) simply because the model indicates a small capacity deficiency during the modeled storm. Therefore, deficiencies were not interpreted as being significant if the magnitude of the deficiency was relatively small (less than 10 percent) or if it was determined that the deficiency was of a short duration (10 to 15 minutes).

3. LEVEL OF SERVICE

The level of service was determined for the elements of the existing improved conveyance system which excludes detention basins and natural open channels. Of the 1,395 conveyance elements in the watershed models, 577 are part of the improved system which were evaluated for performance. Table IV-2 summarizes the overall hydraulic performance capability of the improved system throughout all of the watersheds.

TABLE IV-2
IMPROVED SYSTEM LEVEL OF SERVICE

	Number Of Reaches With Return Period Capacity					
Watershed	<2 Yr	≥2-<5 Yr	≥5-<10 Yr	≥10-<25 Yr	≥25-<100 Yr	≥100 Yr
Yankee Tank West	1	0	0	1	2	2
Hidden Valley	1	3	2	8	10	34
Quail Creek	5	3	3	7	2	25
Yankee Tank East	9	6	2	7	10	31
Naismith	35	8	5	6	9	28
KLWN	3	3	0	0	1	0
Belle Haven	2	0	1	4	1	1
Broken Arrow	5	0	1	1	0	1
Haskell	1	2	0	5	7	41
Deerfield	2	2	2	3	8	10
Riverside	0	0	0	5	1	4
Country Club	3	9	5	6	3	26
Downtown	12	8	5	13	5	14
East Lawrence	19	3	3	4	3	5
Brook Street	3	3	2	3	3	4
Sunflower	0	1	0	0	1	1
North Lawrence	14	3	2	1	2	7
Totals	115	53	33	74	67	234

D. EXISTING SYSTEM PERFORMANCE

The following sections of the report briefly describe the 17 watersheds analyzed for the Stormwater Management Plan and outline the results of the hydrologic and hydraulic modeling of the existing storm drainage system. A brief description of each reach within each watershed's major drainage system along with references to the system map sheet where each reach can be found are presented in Appendix B.

1. YANKEE TANK WEST WATERSHED

a. Location

The Yankee Tank West watershed covers 756 acres (1.18 square miles) at the western edge of Lawrence. Most of the watershed is outside of the current corporate limits. It headwaters just north of US 40 approximately a mile west of Wakarusa Drive. The watershed extends two miles south draining into Yankee Tank Lake, a private lake, just north of Clinton Parkway. The area is relatively steep and elevations range from 1073 in the northwest corner at the upper end to 880 at its outlet into the lake.

b. <u>Land Use</u>

This watershed is currently undeveloped with most of the area covered by woods or pasture grasses. However, rapid growth in and around Lawrence is pushing development in this direction. The Yankee Tank Lake Estates subdivision, a single-family residential development, has been platted along the east side of the lake. Additional planned land use in the watershed is also primarily single-family residential with a school located adjacent to the west edge of the basin. The plat and proposed land use plan indicate considerable open space along the existing channels will be left undeveloped. Because of the rapid development in the western portions of the city, the Yankee Tank West watershed drainage system was analyzed as if the proposed development already existed.

c. <u>Existing Drainage System</u>

The existing drainage system in the Yankee Tank West watershed is a series of earth and rock-lined natural open channel sections. Two culverts, one pipe (Line 1-3160) and one concrete box (Line 1-3200), are located across Highway 40 near the north end. Another pipe culvert (Line 1-3070) is located across an existing north-south county road near the west edge of the basin. Several small ponds are scattered throughout the basin. The entire system eventually drains to Yankee Tank Lake, a controlled small reservoir, at the lower end of the basin.

The condition of the system varies throughout the watershed. At the time of the field inventory, most reaches of the channel itself were fairly clean but had fairly dense growth along the banks. In a few areas deadfall and debris obstructed portions of the channel. The top slab of the concrete box culvert (Line 1-3200) across the highway was noted as cracked and sagging.

d. System Performance

Of the five improved reaches in this watershed, only one is indicated to have less than a 10-year capacity once the area develops as planned. The analysis, however, does not reflect the extensive improved drainage system elements that will be associated with this development and provided by the developer. Improved major system performance for the Yankee Tank West watershed is summarized in Table IV-3.

TABLE IV - 3
EXISTING IMPROVED SYSTEM PERFORMANCE - YANKEE TANK WEST WATERSHED

Line No.	Capacity (cfs)	Peak Flows (CFS) 2-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr	Level Of Service
3070	26	65	105	136	183	221	262	<2
3160	14	4	7	9	12	15	18	50
3200	150	26	44	59	79	96	114	>100
3890	230	94	124	144	172	198	222	>100
3900	115	74	94	107	126	145	161	10

2. HIDDEN VALLEY WATERSHED

a. Location

The Hidden Valley watershed includes 1,788 acres (2.79 square miles) on the west edge of Lawrence along the Hidden Valley Tributary to Yankee Tank Creek. The watershed headwaters at US 40 approximately one-half mile west of Wakarusa Drive. The basin is approximately one mile wide and two and one-half miles long. Land slopes adjacent to the tributary are relatively steep. Elevations in the basin range from 1067 at the northwest corner to 826 at the outlet.

b. Land Use

Approximately 80 percent of the land in the Hidden Valley watershed is either already developed or currently under development. Undeveloped areas remain at the south end of the watershed, south of Clinton Parkway, and along the west edge, west of Wakarusa. The area on the west edge has been platted, however, as part of the Yankee Tank Lake Estates subdivision and was considered fully developed for purposes of this analysis. Existing development is primarily single-family and multi-family residential with some commercial land uses mixed in along Wakarusa and Clinton Parkway. The Alvamar Golf Course and surrounding residential development occupies a significant portion of the southern half of the basin.

c. Existing Drainage System

The existing major drainage system in this watershed is a combination of open and enclosed components. Existing open channels have been retained as the major components with culverts and bridges at road crossings and only relatively short sections enclosed through some residential areas. Several of the bridges are located in the golf course and are used only by golfers, carts, and maintenance vehicles. The minor system generally consists of an enclosed pipe-curb inlet system along streets. Two detention basins are located on the golf course, one just west of Inverness Drive between Nicklaus and Turnberry Drives (Line 2-3105), and the other east of Inverness Drive and north of Wimbledon Drive (Line 2-3110). A third basin is located north of 15th Street and east of Wagon Wheel (Line 2-3270).

Most open channels are earth or turf-lined with a few concrete-lined reaches. Enclosed pipe components are primarily corrugated metal pipes (CMP). Most of the major cross-road culverts are also large diameter CMPs or CMP arches although a few are reinforced concrete boxes. Since development in this area is all relatively recent, most drainage system components appear to be in good condition. Erosion and sedimentation appears to be the major problem in several newly developed areas where turf or other surface treatments have not yet been established or installed.

d. System Performance

Of the 58 improved reaches in this watershed, six have less than a 10-year return period capacity with only one having less than a 2-year capacity. None of these reaches are associated with drainage problems that require system improvements.

Based on maximum water elevations in the detention basins during a storm event, the two golf course basins included in the system model have approximately 10-year return period capacities. The third basin has approximately a 2-year capacity.

Improved major system performance for the Hidden Valley watershed is summarized in Table IV-4.

TABLE IV - 4
EXISTING IMPROVED SYSTEM PERFORMANCE - HIDDEN VALLEY WATERSHED

Line No.	Capacity (cfs)	Peak Flows (CFS) 2-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr	Level Of Service
3090	45	6	8	10	13	15	17	>100
3130	370	6	7	7	8	9	17	>100
3160	18	6	7	7	8	9	17	100
3170	5000	825	1239	1536	1896	2164	2342	>100
3190	>500	3	4	6	8	10	12	>100
3200	54	13	19	24	31	35	41	>100
3220	43	17	26	33	42	50	57	25
3230	65	17	26	33	42	50	57	>100
3240	40	6	10	13	18	21	25	>100
3250	45	6	10	13	18	21	25	>100
3260	600	125	183	229	290	338	387	>100
3280	250	81	111	134	165	190	217	>100
3320	53	10	14	16	20	23	27	>100
3330	170	40	58	73	93	108	124	>100
3340	260	134	188	230	287	332	379	10
3360	1223	225	327	408	519	605	697	25
3370	517	225	327	408	519	605	697	25
3380	4000	663	928	1123	1400	1619	1843	>100
3410	720	167	248	317	411	483	560	>100
3420	130	8	11	14	18	21	24	>100
3430	55	8	11	14	18	21	24	>100
3440	90	8	11	14	18	21	24	>100
3450	680	124	188	243	318	374	436	>100
3460	430	137	207	264	340	400	469	50
3470	900	183	262	325	412	481	552	>100
3480	160	62	91	115	148	174	201	25
3490	134	62	97	125	167	202	239	10
3500	140	52	88	118	160	196	233	10
3520	48	15	24	30	39	45	52	50

TABLE IV - 4 (CONT'D)
EXISTING IMPROVED SYSTEM PERFORMANCE - HIDDEN VALLEY WATERSHED

Line No.	Capacity (cfs)	Peak Flows (CFS) 2-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr	Level Of Service
3530	105	53	76	98	126	149	173	10
3560	290	66	97	121	153	178	203	>100
3570	90	39	59	74	96	112	130	10
3580	65	19	28	35	44	51	59	100
3590	60	38	55	70	89	103	118	<10
3600	81	20	32	42	55	65	76	>100
3610	38	27	34	39	46	52	57	10
3620	263	64	94	117	148	174	200	>100
3630	320	166	212	242	287	323	358	50
3640	240	170	217	248	294	331	367	10
3660	90	90	114	131	154	172	190	2
3680	90	90	114	131	154	172	190	2
3690	43	49	62	71	84	94	103	<2
3700	90	49	62	71	84	94	103	50
3710	78	21	27	30	37	41	44	>100
3720	36	4	5	6	7	8	9	>100
3730	60	46	58	66	78	88	97	<10
3740	55	40	50	57	67	75	82	10
3750	36	5	6	7	8	9	10	>100
3760	45	5	6	7	8	9	10	>100
3770	27	5	6	7	9	10	11	>100
3780	103	13	17	20	25	28	31	>100
3790	173	27	38	47	61	71	82	>100
3800	160	36	51	63	81	95	110	>100
3810	136	27	38	47	60	71	81	>100
3820	130	77	97	111	131	147	162	25
3830	103	58	74	86	101	113	125	25
3840	190	58	74	86	101	113	125	>100
3850	1080	953	1580	2100	2400	2550	2720	2

3. QUAIL CREEK WATERSHED

a. Location

The Quail Creek watershed encompasses 1,028 acres (1.61 square miles) in the western half of the city along the Quail Creek tributary to Yankee Tank Creek. The area is roughly bounded by Kasold on the east, Monterey Way and Crossgate Drive on the west, 6th Street on the north, and 27th Street on the south. The basin headwaters approximately one-fourth mile north of 6th Street, west of Minter Way, at elevation 1024 and extends 2-1/2 miles south to its outlet at elevation 820.

b. Land Use

The Quail Creek watershed is nearing complete development. The primary land use in the area is single-family residential. Areas of townhomes and multi-family residential units are located north of Harvard and east of Monterey Way, and north of 6th St. There is neighborhood commercial development along 6th, 15th and Kasold. An area of commercial shopping and office properties is located around the intersection of 23rd St. and Kasold. Part of the Alvamar Golf Course and associated residential development is located in the southern half of the basin, just west of Kasold. A park is located on the east side of Monterey Way between Harvard and Tiffany Dr. Undeveloped areas are located along 15th St. between Kasold and Monterey Way, and at the south end of the basin.

c. Existing Drainage System

For the most part, Quail Creek has remained an open channel through this watershed. Enclosed reaches collect the drainage from the developed areas adjacent to the creek, discharging into the channel at various points along its length. Box culverts and small bridges are located at road crossings along the channel. Several detention ponds are located in the basin, primarily on the Alvamar Golf Course.

The improved system in this basin is relatively new and appears to be in good condition. Pipe materials are mostly corrugated metal. The channels have earthen bottoms with brushy or wooded banks. Overbank areas are generally maintained turf for most of the channel's length. Erosion was the major maintenance problem noted in the area.

d. System Performance

Of the 45 improved reaches analyzed in this watershed, only nine provide a level of service less than 10 years. Of the nine, seven provide a 2-year level or less, two of which are included in recommended improvement projects described in Part VI of this report.

Improved major system performance for the Quail Creek watershed is summarized in Table IV-5.

TABLE IV - 5
EXISTING IMPROVED SYSTEM PERFORMANCE - QUAIL CREEK WATERSHED

Line No.	Capacity (cfs)	Peak Flows (CFS) 2-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr	Level Of Service
3000	395	219	328	416	536	635	733	10
3020	95	18	26	33	42	49	56	>100
3050	220	130	196	249	324	384	446	<10
3060	45	22	32	40	51	60	69	10
3080	62	15	22	28	35	41	45	>100
3090	230	101	152	194	252	300	348	<25
3110	180	80	119	151	196	232	267	<25
3120	46	10	15	19	24	28	32	>100
3140	140	51	76	97	126	149	171	<50
3160	75	22	32	40	50	59	66	>100
3170	80	4	7	9	13	15	18	>100
3180	48	1	1	1	2	2	3	>100
3190	33	8	11	14	18	21	24	>100
3200	30	3	5	6	7	9	10	>100
3210	69	10	15	19	24	28	32	>100
3220	68	8	11	14	17	20	23	>100
3250	370	276	422	537	698	833	966	<5
3260	84	25	37	46	58	68	77	>100
3270	62	24	35	44	57	67	77	25
3280	153	32	47	60	77	91	105	>100
3320	1680	418	643	822	1071	1274	1478	>100
3330	43	45	68	86	112	132	152	2
3340	45	47	70	89	113	132	152	2
3350	39	6	9	11	14	16	18	>100
3360	50	20	32	41	54	65	76	<25
3390	218	39	65	86	117	143	169	>100
3400	235	47	74	97	132	161	192	>100
3410	2010	532	821	1050	1370	1650	1910	100
3420	154	31	41	49	59	68	75	>100
3430	1380	687	1060	1390	1810	2150	2670	10
3450	1380	718	1103	1449	1887	2223	2589	<10
3470	26	16	23	29	37	43	49	5
3480	43	12	17	21	26	30	34	>100
3500	62	13	17	21	26	29	33	>100
3510	85	15	20	24	29	34	38	>100
3520	24	13	18	21	26	30	33	<25
3530	46	9	12	15	19	22	25	>100
3540	27	2	3	4	5	6	6	>100
3550	27	4	6	6	7	8	9	>100
3560	3600	632	980	1290	1684	2003	2504	>100
3590	125	536	828	1060	1380	1660	1920	<2
3640	125	464	714	914	1190	1410	1640	<2
3650	110	446	686	876	1140	1350	1570	<2

TABLE IV - 5 (CONT'D)
EXISTING IMPROVED SYSTEM PERFORMANCE - QUAIL CREEK WATERSHED

Line No.	Capacity (cfs)	Peak Flows (CFS) 2-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr	Level Of Service
3680	115	435	668	853	1110	1320	1530	<2
3710	125	509	786	1010	1310	1570	1820	<2

4. YANKEE TANK EAST WATERSHED

a. Location

The Yankee Tank East watershed covers 1,747 acres (2.73 square miles) in the west central portion of the city bounded roughly by 6th Street on the north, Iowa on the east, Kasold on the west, and 31st Street on the south. The upper end of the basin, located northeast of the intersection of 6th and Kasold, has an elevation of 1045. The outlet into Yankee Tank Creek, south of 31st, is at elevation 824.

b. Land Use

This watershed is approximately two-thirds developed in a mix of residential, commercial and institutional land uses. Residential areas are primarily single-family with multi-family areas located north of 15th St. Commercial development is concentrated along 6th St. in the north end and along 15th St. near Kasold. An office/commercial area is also located at 23rd and Kasold. Approximately one-fourth of the area, located between 23rd, Iowa, 15th and Kasold, comprises the west campus of the University of Kansas which is nearly all undeveloped at this time. The Sunset Hill Elementary School and West Junior High School are located in the area between 9th and Harvard, west of Crestline. Open areas in the basin are concentrated along the open drainage channels.

c. Existing Drainage System

The upper end of the East Branch of the Yankee Tank, north of Harvard Road, has been enclosed in a pipe system through the residential development in that area. South of Harvard, however, the main drainage is an open channel and continues as such to the basin outlet. Minor enclosed systems collect runoff from residential areas bordering the main channel and discharge into it along its entire length.

The improved system in this watershed is relatively new and still in good condition for the most part. Pipe system materials are both concrete and corrugated metal. The natural open channels have earthen bottoms with the overbank conditions varying from maintained turf to wooded with fairly dense underbrush, depending on the specific location. A few maintenance needs were noted during the field reconnaissance phase of the project.

d. System Performance

Of the 65 improved reaches in this watershed, 17 provide less than a 10-year level of service with nine of those providing less than a 2-year level. Nine of the 17 reaches are included in recommended improvement projects described in Part VI of this report. Improved major system performance for the Yankee Tank East watershed is summarized in Table IV-6.

TABLE IV - 6
EXISTING IMPROVED SYSTEM PERFORMANCE - YANKEE TANK EAST WATERSHED

Line No.	Capacity (cfs)	Peak Flows (CFS) 2-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr	Level Of Service
3000	61	23	37	48	63	75	88	25
3010	76	40	61	78	100	119	138	10
3020	118	56	84	106	136	160	186	10
3030	53	10	15	19	24	29	33	>100
3060	5040	1400	1910	2230	2700	3090	3540	>100
3070	223	62	91	114	145	169	194	>100
3080	81	47	69	86	110	128	147	<10
3090	80	38	56	70	88	102	116	10
3100	47	14	23	29	38	46	54	50
3110	56	16	25	33	44	52	62	50
3120	413	16	25	32	42	50	58	>100
3130	168	60	78	91	110	125	140	>100
3140	480	640	943	1030	1100	1180	1170	<2
3150	240	310	458	503	631	742	846	<2
3160	2583	1350	1540	1620	1680	1750	1730	>100
3170	85	29	43	54	68	79	91	50
3180	40	22	32	40	50	58	66	10
3210	2200	1610	2360	2880	3550	4130	4790	2

TABLE IV - 6 (CONT'D)
EXISTING IMPROVED SYSTEM PERFORMANCE - YANKEE TANK EAST WATERSHED

Line No.	Capacity (cfs)	Peak Flows (CFS) 2-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr	Level Of Service
3230	110	21	30	36	45	53	60	>100
3240	70	21	29	36	46	53	61	>100
3250	80	21	30	37	46	53	60	>100
3260	22	5	7	8	9	10	12	>100
3280	70	17	24	30	37	43	50	>100
3300	1250	449	617	748	923	1060	1210	100
3303	85	610	848	1030	1280	1480	1690	<2
3306	2800	679	939	1153	1420	1632	1854	>100
3310	350	157	206	242	292	329	368	50
3320	2200	157	206	242	292	329	368	>100
3330	521	151	198	233	281	319	358	>100
3340	218	135	174	201	239	269	299	10
3350	48	133	170	197	234	263	293	<2
3360	66	137	174	200	236	265	293	<2
3370	372	27	38	47	59	69	78	>100
3371	114	35	52	66	87	103	120	50
3380	176	36	54	69	89	105	122	>100
3390	111	18	27	34	43	51	59	>100
3391	75	11	16	21	27	32	37	>100
3400	378	242	334	405	503	581	663	5
3410	115	223	302	361	442	504	568	<2
3420	257	143	189	224	272	310	348	10
3430	86	73	98	117	143	163	184	2
3440	66	12	15	18	22	24	27	>100
3450	156	56	78	94	117	134	152	100
3460	110	31	43	52	65	75	85	>100
3470	170	136	192	235	296	344	391	2
3480	280	150	213	262	329	382	435	10
3490	115	103	146	180	227	265	303	2
3500	100	47	65	78	97	112	127	25
3510	50	23	30	34	41	46	51	100
3530	175	51	71	88	110	126	147	>100
3532	125	51	71	88	110	126	147	50
3540	165	39	57	72	93	108	127	>100
3550	103	42	63	80	103	120	142	25
3560	148	22	30	35	43	49	55	>100
3570	165	20	27	32	39	44	49	>100
3580	165	224	327	405	512	598	685	<2
3590	220	246	358	444	560	632	753	<2
3600	330	258	377	467	589	664	796	2
3620	312	289	425	527	669	749	904	2
3630	280	300	438	542	686	768	925	<2
3640	190	59	89	112	142	165	184	100
3650	55	19	29	36	47	56	65	50
3660	210	59	89	112	142	165	184	>100
3730	22	3	6	8	12	14	16	>100
3740	100	23	38	49	66	78	91	>100

5. NAISMITH WATERSHED

a. Location

The Naismith watershed covers 1,306 acres (2.04 square miles) in the south central portion of Lawrence along Naismith Creek, a tributary to the Wakarusa River. It is bounded roughly by 15th Street on the north, Louisiana on the east, Iowa on the west, and the Wakarusa floodplain on the south. The basin headwaters at an elevation of 1045 approximately one-fourth mile north of 15th Street and just west of Naismith Drive on the KU campus. The outlet, defined for this study, is located near the intersection of Louisiana and 31st Street at an elevation of approximately 818. The basin is roughly 2.5 miles long and one mile wide.

b. Land Use

The Naismith watershed is over 80 percent developed. Only a relatively small area of undeveloped land remains south of 31st Street. Most of the area has been developed for residential purposes, predominantly single-family, with several areas of multi-family units south of 23rd. Neighborhood commercial land uses, such as restaurants, groceries and small specialty shops, are concentrated along 23rd Street, approximately in the center of the basin, and along Iowa south of 23rd St. The northwest corner of the basin is occupied primarily by University of Kansas residence halls, married student housing, and several fraternity houses. Lawrence High School is located in the northeast quadrant of the basin. A relatively large mobile home park, Gaslight Village, is located in the southwest corner of the watershed, just east of Iowa. Open land along Naismith Creek south of 23rd is wooded for most of the length.

c. Existing Drainage System

The main drainage way, Naismith Creek, is located approximately in the center of this watershed. The upper end of the creek, north of 19th St. on the KU campus, is an enclosed pipe system. Portions of this system will be improved and enlarged in the near future in accordance with the university's own stormwater master plan. The improved system elements were included in the existing system model to insure that the impact of these changes is reflected in the downstream analysis. A small detention area located on the campus, north of 15th and west of Naismith Drive, was not included in the model because its capacity and outlet structure provide little control and negligible impact on the downstream drainage system.

From 19th St. to 23rd St. the channel has been straightened and improved with concrete lining to a depth of three feet. Larger culverts or bridges (Lines 5-3780, 3800 and 3810) have been constructed at the road crossings in this section in the past five years as a result of recommendations from the earlier Naismith Basin study. South of 23rd St. the creek is a natural channel for the most part. A smaller branch system drains the southwest corner of the watershed, discharging to the natural drainage south of 31st St.

The enclosed system in this basin is in relatively good shape overall. The portions north of 23rd St. are mostly in the range of 25 to 40 years old while the sections of the system south of 23rd St. are relatively new. Pipe materials are primarily corrugated metal. The natural portions of the main channel have an earthen bottom. Overbank areas are densely wooded in the sections south of 23rd St. Several maintenance needs were noted during field observations.

d. <u>System Performance</u>

Of the 91 improved reaches analyzed in this watershed, 48 reaches provide less than a 10-year level of service. Thirty-five of those provide less than a 2-year level. Many of the 48 reaches are included in the recommended system improvement projects described in Part VI of this report. Improved major system performance for the Naismith watershed is summarized in Table IV-7.

TABLE IV - 7
EXISTING IMPROVED SYSTEM PERFORMANCE - NAISMITH WATERSHED

Line No.	Capacity (cfs)	Peak Flows (CFS) 2-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr	Level Of Service
2335	6	116	161	198	245	282	319	<2
2355	16	83	111	135	167	192	217	<2
2435	23	95	127	152	186	212	238	<2
2445	15	35	48	57	69	78	88	<2
2452	19	46	60	71	85	96	107	<2
2457	25	44	58	69	83	94	104	<2
2485	25	65	88	105	130	152	172	<2
2505	23	86	118	143	175	200	225	<2
2515	14	48	67	81	100	115	129	<2
2535	7	51	67	78	94	106	118	<2
3000	41	33	45	56	70	79	88	2
3010	21	33	45	56	70	79	88	<2
3030	47	52	69	81	98	110	123	<2
3040	36	89	116	134	161	183	204	<2
3100	32	34	49	60	75	85	100	<2
3110	62	31	44	54	69	80	91	10
3120	74	32	45	55	70	82	94	25
3135	400	155	200	232	276	310	346	>100
3150	40	30	38	43	51	57	63	5-10
3160	60	29	37	42	50	56	62	100
3170	2040	163	209	243	289	324	362	>100
3180	190	138	178	207	246	276	308	10
3190	54	101	128	146	172	191	211	<2
3200	96	59	75	87	104	116	129	10
3210	105	129	165	191	227	254	284	<2
3220	3934	144	186	217	227	254	284	>100
3230	27	24	32	38	46	52	58	2
3240	27	12	16	20	24	28	31	50
3250	9	12	17	21	25	29	32	<2
3260	38	63	80	93	111	124	138	<2
3270	40	66	84	97	115	130	144	<2
3280	40	57	73	84	100	113	126	<2
3290	224	122	160	188	226	257	288	25
3300	371	127	166	196	236	267	300	>100
3320	36	10	13	15	18	21	23	>100
3330	25	10	14	17	20	23	25	100
3340	134	119	155	183	221	251	281	2
3360	44	75	100	119	144	164	183	<2
3361	62	62	83	99	121	137	154	2
3362	66	64	84	99	119	134	149	2
3363	102	46	62	74	90	102	114	50
3370	1331	493	674	813	1020	1210	1470	50

TABLE IV - 7 (CONT'D)
EXISTING IMPROVED SYSTEM PERFORMANCE - NAISMITH WATERSHED

Line No.	Capacity (cfs)	Peak Flows (CFS) 2-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr	Level Of Service
3380	7600	543	745	901	1140	1390	1700	>100
3390	2400	661	911	1110	1390	1640	1910	>100
3420	55	7	8	10	12	13	15	>100
3430	29	10	13	15	17	19	21	>100
3440	447	211	290	348	428	497	569	25
3445	95	219	302	363	446	512	587	<2
3450	53	44	47	48	51	53	57	50
3451	53	217	300	360	443	508	581	<2
3460*	38	38	38	38	38	38	38	2
3470	35	225	311	373	458	528	605	<2
3480	62	226	314	382	465	548	626	<2
3490	53	212	293	352	432	498	570	<2
3500	63	221	307	374	459	536	611	<2
3510	276	62	84	100	123	140	157	>100
3520	260	55	74	88	109	125	142	>100
3530	546	61	83	100	122	139	157	>100
3540	331	31	41	49	59	67	74	>100
3550	100	34	46	55	67	76	85	>100
3570	241	158	214	257	316	361	408	<10
3580	130	56	78	96	119	137	156	<50
3600	368	57	79	98	122	142	162	>100
3610	109	57	79	98	122	142	162	10
3620	142	3	5	6	8	9	11	>100
3630	153	3	5	6	8	10	11	>100
3640	873	44	59	70	85	97	109	>100
3650	99	42	58	70	86	98	111	50
3680	46	47	66	79	96	110	123	2
3690	82	43	61	74	91	105	118	10
3700	49	69	98	119	148	170	193	<2
3720	222	246	329	396	488	560	633	2
3730	467	320	435	523	642	733	827	5
3740	670	391	532	640	787	897	1010	10
3750	116	87	119	145	179	204	228	5
3760	57	85	118	145	179	206	233	<2
3770	38	90	124	151	184	210	236	<2
3780	>1500	398	541	650	799	910	1030	>100
3790	615[1]	398	541	650	799	910	1030	5
	5956[2]							>100
3800	>1500	490	669	807	993	1130	1280	>100
3810	>1500	492	672	810	997	1140	1290	>100
3820	722[1]	490	669	807	993	1130	1280	5
	6984[2]							>100
3830	520[1]	492	672	810	997	1140	1290	2
	5027[2]							>100
3840	688[1]	493	674	812	1000	1140	1290	5
	6659[2]							>100
3850	53	59	79	95	117	133	152	<2

TABLE IV - 7 (CONT'D)
EXISTING IMPROVED SYSTEM PERFORMANCE - NAISMITH WATERSHED

Line No.	Capacity (cfs)	Peak Flows (CFS) 2-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr	Level Of Service
3851	53	59	79	95	117	133	152	<2
3852	76	98	134	161	197	224	252	<2
3860	11	41	59	72	90	104	118	<2
3870	29	48	69	86	109	126	143	<2
3875	158	53	76	94	119	138	156	100
3880	81	51	73	90	113	131	149	<10

* - Modeled as an overflow line for Line 3500; no direct runoff.
1 - Capacity of the lined portion of the channel only
2 - Total capacity of the channel

6. KLWN WATERSHED

a. Location

The KLWN watershed includes 486 acres (0.76 square mile) located near the southwest corner of the corporate limits along the KLWN Tributary. Although in close proximity to the confluence of Yankee Tank Creek and the Wakarusa River, this tributary actually turns to the east and eventually drains into Naismith Creek near 31st and Louisiana. The area headwaters at Iowa, just south of 23rd Street, and extends approximately 1.5 miles south. Elevations range from 917 at the upper end to approximately 826 at the outlet.

b. Land Use

Approximately half of this watershed is developed. The area north of 31st Street is a combination of residential and commercial land uses. Strip shopping centers, Walmart, and similar commercial development is located along Iowa, north of 31st St. The north third of the basin is multi-family residential with single-family residential development further south. Holcum Park, with a large baseball/softball complex, is located east of Lawrence Ave. and north of 27th St. The area south of 31st, which is almost completely in the floodplain of the Wakarusa, remains undeveloped.

c. Existing Drainage System

The existing major drainage system in this watershed consists primarily of natural open channel sections of the KLWN Tributary and one main branch. The upper ends of the system are enclosed within the developed areas but then discharge into the main channels. Three cross-road culverts (Lines 6-3020, 3120 and 3210) carry flow across 27th St. The channel sections flow through both agricultural and undeveloped areas south of 27th.

The improved system in this basin is relatively new. Most pipe materials are corrugated metal. Two of the three main culverts across 27th St. (Lines 6-3020 and 3120) are concrete boxes. The channels all have earthen bottoms. The overbank areas vary from maintained turf and agricultural fields to tall weeds, brush and dense trees depending on the specific location. No real maintenance needs were noted in this area.

d. System Performance

Of the seven improved reaches analyzed in this watershed, six provide a level of service of 5 years or less. Three of these lines are included in one of the recommended improvement projects described in Part VI of this report. Improved major system performance for the KLWN watershed is summarized in Table IV-8.

TABLE IV - 8
EXISTING IMPROVED SYSTEM PERFORMANCE - KLWN WATERSHED

Line No.	Capacity (cfs)	Peak Flows (CFS) 2-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr	Level Of Service
3035	27	22	29	33	40	45	50	5
3050	66	145	195	233	285	326	367	<2
3060	49	90	126	153	190	219	248	<2
3070	49	68	91	109	133	152	171	<2
3080	57	44	60	72	90	103	117	5
3090	68	34	47	57	70	80	90	25
3100	31	35	48	58	72	83	94	2

7. BELLE HAVEN WATERSHED

a. Location

The Belle Haven watershed includes 260 acres (0.41 square mile) at the south edge of the city. The area is roughly centered on Louisiana Street extending approximately 1.5 miles from 15th Street on the north to 31st Street on the south. The maximum width of the basin is approximately one-half mile. Elevations range from 886 at the upper end to 812 at its outlet near 31st and Iowa.

b. Land Use

The Belle Haven watershed is approximately two-thirds developed in a mix of residential and commercial-industrial land use. The commercial development is located primarily along 23rd St. and south on Louisiana. An area of multi-family residential development is adjacent to the commercial area with mostly single-family units further south. Broken Arrow Elementary and South Junior High Schools, and Broken Arrow Park are located on the east side of Louisiana and south of 27th St. near the boundary between the Belle Haven and Broken Arrow watersheds. The southeast portion of the basin between 29th Terr. and 31st St. is currently undeveloped.

c. Existing Drainage System

The existing drainage system in this watershed consists primarily of street gutters draining to curb inlets and the associated minor enclosed system. The main drainageway which runs lengthwise approximately through the center of the basin, is enclosed north of 27th Street (Lines 7-3670, 3081, 3080, 3090 and 3100). South of 27th it is an open channel with cross-road culverts at two locations. Minor enclosed system pipes which collect drainage from the cul-de-sacs on each side, outlet to the open channel at several locations.

Nearly all of the pipe reaches in the improved system in this basin are corrugated metal and appear to be in good condition. The open channels have earthen bottoms with brushy or wooded overbanks in most sections. Only one minor maintenance item was noted during field observations.

d. System Performance

Of the nine improved reaches analyzed in this watershed, three provide less than a 10-year level of service, all of which are included in one of the recommended improvement projects described in Part VI of this report. Improved major system performance for the Belle Haven watershed is summarized in Table IV-9.

TABLE IV - 9
EXISTING IMPROVED SYSTEM PERFORMANCE - BELLE HAVEN WATERSHED

Line No.	Capacity (cfs)	Peak Flows (CFS) 2-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr	Level Of Service
3010	310	183	258	316	394	455	520	10
3040	260	145	201	243	299	342	388	10
3060	3318	255	383	468	587	689	797	>100
3070	186	135	186	226	279	320	361	5
3080	61	126	174	212	263	303	343	<2
3081	77	122	168	202	248	284	318	<2
3090	157	103	138	166	202	230	258	<10
3100	135	78	103	122	148	169	189	10
3110	102	55	71	83	99	112	123	25

8. BROKEN ARROW WATERSHED

a. Location

The Broken Arrow watershed encompasses 235 acres (0.37 square mile) on the south edge of Lawrence between Louisiana Street and the Haskell Indian Nations University campus, and from 23rd Street to the flood protection levee along the north side of the Wakarusa River. The area drains to the Broken Arrow Tributary of Naismith Creek. Elevations range from 901 at the upper end, near 23rd and Leanard, to 818 at the outlet at 31st St.

b. Land Use

This watershed is primarily undeveloped land south of 25th St. A part of the Haskell campus occupies the north and east portions of the basin. Single-family residential development covers most of the remainder of the developed areas. A portion of the Broken Arrow Elementary/South Junior High campus is located in the southwest corner of the basin.

c. Existing Drainage System

In the upper one-fourth of the basin, south of 23rd St., the existing drainage system is an enclosed system composed of small diameter pipes (24" or less). Beyond this enclosed system, Broken Arrow Tributary is an open channel through the undeveloped portion of the watershed with minor system components that outlet into it at two locations. The channel crosses 31st St. through a double 9'x 5' RCB (Line 8-3000) and drains into Naismith Creek.

The enclosed system elements in this basin all appear to be corrugated metal and are in generally good condition. The main channel has an earthen bottom with grassy overbank areas. The overbank is sparsely wooded along a portion of the channel length. No maintenance needs were noted in this watershed.

d. System Performance

Of the eight improved reaches analyzed in this watershed, six provide less than a 10-year level of service with five less than a 2-year level. Five of the six reaches are included in one of the recommended improvement projects described in Part VI of this report. Improved major system performance for the Broken Arrow watershed is summarized in Table IV-10.

TABLE IV - 10
EXISTING IMPROVED SYSTEM PERFORMANCE - BROKEN ARROW WATERSHED

Line	Capacity	Peak Flows (CFS)						Level Of
No.	(cfs)	2-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr	Service
3000	990	195	302	390	515	616	723	>100
3020	18	27	37	45	56	65	74	<2
3031	80	158	230	288	369	433	499	<2
3040	28	60	86	107	135	157	179	<2
3050	21	37	52	63	78	90	102	<2
3060	35	26	37	45	55	64	73	5
3090	66	34	51	63	80	94	107	10
3100	28	34	51	63	80	94	107	<2

9. HASKELL WATERSHED

a. Location

The Haskell watershed includes 824 acres in the southeast corner of the city. The main drainageway is the Haskell Tributary to Naismith Creek which drains the area west of Haskell Avenue. Two other branches drain the area to the east. The basin is roughly bounded by 23rd Street (K10) on the north, the city limits on the east, the Haskell Indian Nations University campus on the west, and the Wakarusa levee on the south. It headwaters just north of 23rd Street and east of Haskell Avenue at an elevation of 925. Elevations at the south edge are 818 at 31st St.

b. Land Use

Approximately half of this watershed is currently developed. Most recent development has been residential in the area east of Haskell Ave. The Haskell Indian Nations University campus and associated property occupies most of the western half of the basin. Some commercial and light industrial development is located primarily along 23rd Street.

c. Existing Drainage System

The existing drainage system in Haskell watershed, as defined for this study, is divided into three main branches, each with a separate outlet at the south end of the basin. Each branch is a combination of enclosed elements and open channel sections. Generally, the enclosed portions of the system are located in the north half of the watershed which includes most of the developed areas. In the more undeveloped south half, two of the three branches are still basically natural channels. The easternmost branch discharges into a large pond near the southeast corner of the basin.

The middle branch, which begins in the vicinity of 23rd and Harper and flows southwest, has been improved for much of its length. The upper half is an enclosed pipe system. The open channels in the lower half have been graded and straightened with concrete lining constructed where it runs through residential development.

Most pipe materials in the enclosed systems are corrugated metal. The natural channel sections have earthen bottoms and brushy or wooded banks and overbanks. The system is a mixture of new and old lines. Erosion appeared to be the major maintenance problem in the newer areas. Culverts and channels obstructed by silt and debris were the major problems in the older sections of the system.

d. System Performance

Only three of the 56 improved reaches analyzed in this watershed provide less than a 10-year level of service. One of the three (Line 9-3420) is recommended for replacement under one of the improvement projects described in Part VI of the report. Improved major system performance for the Haskell watershed is summarized in Table IV-11.

TABLE IV - 11
EXISTING IMPROVED SYSTEM PERFORMANCE - HASKELL WATERSHED

Line No.	Capacity (cfs)	Peak Flows (CFS) 2-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr	Level Of Service
3020	370	263	331	372	462	528	597	10
3050	213	76	102	122	149	170	191	>100
3080	101	16	22	26	33	39	44	>100
3090	92	16	22	26	33	39	44	>100
3110	47	42	58	70	87	100	113	2
3120	51	25	35	43	53	62	70	25
3130	40	26	36	44	55	64	73	10
3140	134	24	34	41	50	57	66	>100
3201	1704	349	463	565	700	798	892	>100
3250	432	162	230	283	356	405	471	50
3260	512	159	226	278	350	397	464	>100
3270	11694	159	226	278	350	397	464	>100
3280	670	145	207	255	323	368	430	>100
3290	527	145	207	255	323	368	430	>100
3300	354	128	182	227	285	326	382	>100
3310	292	128	182	227	285	326	382	>100
3320	300	92	132	163	206	239	274	>100
3330	176	84	121	152	193	226	261	10
3340	323	55	78	97	123	143	164	>100
3350	82	41	59	74	93	110	126	10

TABLE IV - 11 (CONT'D)
EXISTING IMPROVED SYSTEM PERFORMANCE - HASKELL WATERSHED

Line No.	Capacity (cfs)	Peak Flows (CFS) 2-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr	Level Of Service
3380	141	17	25	32	40	47	55	>100
3390	122	12	16	19	23	27	30	>100
3390	67	7	11	14	19	23	27	>100
3410	266	77	103	122	149	170	192	>100
3420	39	47	62	75	92	106	120	<2
3430	19	8	10	11	14	15	17	>100
3440	58	4	5	6	7	7	8	>100
3450	97	12	16	20	25	30	34	>100
3460	224	42	61	76	96	112	128	>100
3470	76	6	8	10	12	14	16	>100
3480	94	6	8	10	13	15	17	>100
3510	96	9	13	15	19	22	26	>100
3520	702	177	253	313	388	446	509	>100
3530	174	33	49	62	80	95	110	>100
3540	94	10	15	19	24	28	32	>100
3560	156	21	32	41	53	64	75	>100
3580	115	27	41	52	67	80	94	>100
3590	173	42	61	76	94	114	131	>100
3600	165	41	60	74	94	111	127	>100
3601	103	42	61	76	96	114	131	25
3610	70	22	34	43	55	65	75	50
3620	133	11	16	20	25	30	34	>100
3630	148	11	16	20	25	30	34	>100
3640	166	46	69	85	110	131	152	>100
3650	245	46	69	87	111	131	152	>100
3651	79	30	45	57	73	85	99	25
3660	96	30	46	58	75	89	103	50
3670	90	27	40	51	66	78	90	100
3700	62	27	40	51	67	80	93	10
3720	26	25	37	46	59	69	79	2
3730	181	37	56	70	90	106	123	>100
3740	77	27	41	53	68	80	93	25
3750	55	12	18	24	31	36	42	>100
3760	284	45	67	86	111	131	152	>100
3770	104	15	20	23	28	31	35	>100
3780	60	16	22	26	31	34	38	>100

10. DEERFIELD WATERSHED

a. Location

The Deerfield watershed covers 898 acres (1.40 square miles) in and adjacent to the northwest corner of Lawrence. It headwaters at 6th Street (US 40) approximately half way between Kasold and Monterey Way at an elevation of 1024 and extends north approximately 2 miles. The main drainageway is the Deerfield Tributary which flows north and west into Baldwin Creek which eventually drains to the Kansas River north of Lawrence. For this study, the basin outlet has been defined at the point near Kasold where the main channel crosses I-70 at an elevation of approximately 846.

b. Land Use

Approximately one-third of this watershed is developed or currently under development, primarily as single-family residential neighborhoods. Two new large-lot residential subdivisions are under development and, for the purposes of this analysis, were assumed to be complete. There is a relatively small area of industrial/warehouse development north of I-70 on the east side of the basin. Steep grades along the main channels within the watershed will somewhat limit further development.

c. Existing Drainage System

The existing major drainage system in the Deerfield watershed is composed primarily of natural open channels with culverts at road crossings. There are two extended enclosed sections in the developed areas in the southeast quadrant of the basin. One section roughly parallels Lawrence Ave. and the other runs adjacent to Rock Fence. Both systems begin approximately at Trail Rd. and discharge into an open channel on the north side of Tomahawk Dr. Several small ponds noted during the initial field inventory have been eliminated by the current development. Only one detention basin (Line 10-3280), located west of Monterey Way and north of Stetson Dr., is included in the system analysis.

The improved system appears to be in generally good condition overall. Pipe materials in the enclosed sections are a combination of concrete and corrugated metal. A number of the open channel sections through the developed areas have been riprap or concrete lined with maintained turf banks and overbanks. In the natural sections, the channels have earthen bottoms with brushy or wooded banks and overbanks. Only a few maintenance needs were noted during field observations.

d. System Performance

Of the 27 improved reaches analyzed in this watershed, six provide less than a 10-year level of service. None of these lines, however, contribute to drainage problems serious enough to be included in any of the recommended improvement projects. The detention basin included in the system model (Line 10-3280) has approximately a 10-year capacity based on the maximum water elevation in the basin during storm events. Improved major system performance for the Deerfield watershed is summarized in Table IV-12.

TABLE IV - 12
EXISTING IMPROVED SYSTEM PERFORMANCE - DEERFIELD WATERSHED

Line No.	Capacity (cfs)	Peak Flows (CFS) 2-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr	Level Of Service
3000	22	22	34	43	57	68	80	2
3010	90	32	47	60	77	91	105	50
3030	490	42	62	77	99	116	134	>100
3050	90	42	62	77	99	116	134	10
3100	125	66	99	126	164	195	227	10
3110	210	66	99	126	164	195	227	50
3111	246	65	98	125	162	193	224	>100
3120	185	71	104	132	170	200	231	25
3130	317	94	138	174	222	260	299	>100
3140	76	6	9	11	14	16	19	>100
3160	1080	389	578	734	942	1118	1274	25
3170	740	421	626	794	1020	1210	1380	<10
3190	253	63	91	114	144	168	193	>100
3200	95	40	60	75	96	113	131	25
3210	71	28	42	53	68	80	93	25
3230	536	169	250	321	420	498	567	50
3250	827	48	72	92	120	142	166	>100
3251	23	15	22	28	36	42	49	5
3255	540	421	626	794	1020	1210	1380	2
3260	330	23	32	43	57	64	80	>100
3300	30	13	21	28	38	46	55	10
3320	80	109	178	234	316	383	459	<2
3330	69	109	177	232	311	375	448	<2
3340	912	135	220	289	390	473	566	>100
3380	1200	187	306	402	545	661	790	>100
3410	2660	512	795	1060	1390	1670	2020	>100
3430	1540	512	795	1060	1390	1670	2020	25

11. RIVERSIDE WATERSHED

a. Location

The Riverside watershed covers 337 acres (0.53 square mile) on the north edge of Lawrence, north of I-70. It headwaters approximately one-fourth of a mile north of Lakeview Boulevard and one-half mile east of Kasold, outside of the corporate limits. The elevation in the upper end (the northwest corner) is 918. The basin outlets to the Kansas River through a culvert under the ATSF railroad at an approximate elevation of 828.

b. Land Use

Approximately one-half of the basin is undeveloped or used for agricultural purposes. The area west of Iowa and south of Lakeview is developed for industrial use. A small residential area lies east of Iowa and north of the turnpike.

c. Existing Drainage System

The major drainage system in the Riverside watershed is primarily natural open channels with culverts at road crossings. The culverts all appear to be corrugated metal pipes with the exception of two concrete boxes at larger crossings (Lines 11-3000 and 3040). The channel sections generally have earthen bottoms, brushy banks and wooded overbank areas. Few maintenance needs were noted during field observations.

d. System Performance

Of the ten improved reaches analyzed in this watershed, none has less than a 10-year level of service. Improved major system performance for the Riverside watershed is summarized in Table IV-13.

TABLE IV - 13
EXISTING IMPROVED SYSTEM PERFORMANCE - RIVERSIDE WATERSHED

Line No.	Capacity (cfs)	Peak Flows (CFS) 2-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr	Level Of Service
3000	550	155	207	248	306	352	401	>100
3020	35	8	12	16	21	26	31	>100
3040	280	155	207	248	306	352	401	<25
3060	50	24	36	47	61	73	86	10
3080	244	7	12	15	20	24	29	>100
3090	55	30	45	57	76	90	105	10
3091	70	37	57	73	95	113	133	10
3092	37	20	30	39	51	61	71	10
3110	26	7	11	13	17	20	23	100
3130	650	208	304	385	507	606	709	50

12. COUNTRY CLUB WATERSHED

a. Location

The Country Club watershed includes 1,217 acres (1.90 square miles) of land in the north central part of Lawrence which drains to the Kansas River. It is approximately two miles long and 1-1/2 miles wide. The basin headwaters at the south end, near 9th and Iowa, at an elevation of 1039 and outlets through a culvert under the ATSF railroad just north of 2nd St at approximately elevation 830.

b. Land Use

This watershed is a mixture of land uses. The area east of US 59 and north of 2nd St., as well as the area west of Iowa and north of 6th, are undeveloped, primarily due to steep grades. Along Iowa, generally north of 9th St., the development is primarily commercial office and light industrial space. Another small industrial area is located in the north end, north of I-70. Lawrence Memorial Hospital is near the east edge of the basin on Michigan. Residential development is a mix of single and multi-family areas. Mobile home parks are located in the vicinity of 2nd and Michigan. Buford Watson Park is located between Tennessee and Kentucky, from 6th to 8th Streets, and contains the municipal swimming pool and other recreational facilities.

c. Existing Drainage System

The existing system in this watershed is a combination of open and enclosed reaches draining to several branches which eventually combine into one tributary to the Kansas River at the outlet. In the developed areas, located in the south and east sections of the basin, minor enclosed systems collect runoff and route it to larger enclosed reaches which eventually discharge into open channels. The undeveloped north and west portions of the area are drained primarily by open channels with culverts located only at major road crossings. The natural channels have earthen bottoms. The density of the vegetation along the banks varies depending on the location of the specific channel section.

The improved system in this watershed is a combination of concrete and corrugated metal pipe materials. The system is beginning to show signs of age. Several maintenance needs were noted during field reconnaissance, although none were considered to be serious in terms of public safety.

d. System Performance

Of the 52 improved reaches analyzed in this watershed, 17 provide less than a 10-year level of service although only three provide less than a 2-year level. Of these 17 reaches, six are included in recommended improvement projects described in Part VI of this report. Improved major system performance for the Country Club watershed is summarized in Table IV-14.

TABLE IV - 14
EXISTING IMPROVED SYSTEM PERFORMANCE - COUNTRY CLUB WATERSHED

Line No.	Capacity (cfs)	Peak Flows (CFS) 2-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr	Level Of Service
3020	106	36	45	51	60	67	74	>100
3030	340	278	389	476	593	684	776	<5
3033	360	270	377	460	574	665	755	<5
3040	360	242	337	411	511	590	672	5
3050	300	171	242	295	369	416	462	10
3070	760	174	248	303	379	444	507	>100

TABLE IV - 14 (CONT'D)
EXISTING IMPROVED SYSTEM PERFORMANCE - COUNTRY CLUB WATERSHED

Line No.	Capacity (cfs)	Peak Flows (CFS) 2-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr	Level Of Service
3090	260	152	220	271	342	401	461	10
3110	526	158	225	276	343	400	459	>100
3120	1146	147	211	261	329	386	443	>100
3140	550	30	43	54	66	79	92	>100
3150	90	75	105	128	159	183	207	2
3160	70	75	104	129	162	187	213	2
3180	174	22	30	35	43	49	55	>100
3220	304	579	877	1100	1380	1830	2180	<2
3231	350*	589	903	1110	1470	1780	2110	<2
3250	230	185	280	355	457	541	627	2
3280	90	34	52	67	87	103	120	25
3300	65	12	18	23	30	35	40	>100
3320	630	131	200	255	331	394	456	>100
3330	193	81	129	167	223	269	317	10
3340	115	70	112	146	193	232	273	5
3375	140	32	53	70	95	117	139	100
3380	247	42	64	80	101	118	136	>100
3390	56	38	57	71	93	111	129	5
3410	198	18	28	36	47	56	65	>100
3420	149	17	26	34	44	52	60	>100
3430	736	171	227	271	332	381	432	>100
3440	185	171	228	272	333	382	432	2
3460	185	155	204	242	294	336	380	<5
3480	190	49	75	96	124	145	169	>100
3500	750	329	499	615	731	898	1070	25
3520	570	1450	1680	1730	1670	1710	1620	<2
3540	111	31	49	63	81	95	109	100
3550	32	29	42	51	64	74	85	2
3560	140	73	112	138	189	225	260	10
3570	230	43	68	87	118	143	171	>100
3580	2840	43	68	87	118	143	171	>100
3590	80	41	63	78	107	127	146	10
3600	111	12	18	23	31	36	42	>100
3610	100	4	6	7	9	10	11	>100
3620	58	49	75	96	124	146	169	2
3630	60	11	16	21	27	32	37	>100
3640	22	5	8	11	14	16	19	100
3650	50	38	49	57	67	76	84	5
3660	121	8	12	15	19	23	27	>100
3670	112	38	49	57	67	76	84	>100
3680	615	34	44	52	62	70	77	>100
3700	90	39	61	77	100	119	138	<25
3710	70	42	64	82	106	126	146	5
3720	625	151	217	265	329	385	444	>100
3730	45	2	3	3	4	4	5	>100
3740	365	158	225	277	346	403	460	25

* - Capacity of half of the structure. Other half is full of silt.

13. DOWNTOWN WATERSHED

a. Location

The Downtown watershed covers 1,095 acres (1.71 square miles) in the east central part of the city. The upper end is in the southwest corner of the basin on the University of Kansas campus. The basin drains to the Kansas River at several points through culverts under the ATSF railroad. Elevations range from 1045 at the upper end to 790 at the river.

b. Land Use

This watershed is essentially 100 percent developed. It includes Lawrence's central business district as well as a large part of the KU campus. The commercial business district is centered on Massachusetts, the main street, from 6th St. to approximately 15th St. Additional neighborhood commercial areas are located further south on Massachusetts to about 19th. A municipal park, Sout Park, with a community center is located along both sides of Massachusetts between 11th and S. Park Streets, and the Douglas County Courthouse is located at the corner of 11th and Mass. The remainder of the basin is made up of older residential neighborhoods.

c. Existing Drainage System

The existing drainage system in this watershed is nearly all enclosed with only a few relatively short sections of open channel. There are three main branches of the system within the basin, each of which outlets separately to the Kansas River. The enclosed system is composed of a variety of shapes and materials including natural stone, brick or concrete arches or tunnels; natural stone or concrete boxes; and concrete and corrugated metal pipes and pipe-arches. The few channel sections are primarily earthen bottoms with grassy or brushy banks.

The Downtown drainage system includes some of the oldest lines in the city but is in surprisingly good condition. It appears that a number of the older reaches have been relined and repaired. A number of maintenance needs were noted throughout the basin, however, and further investigation should be undertaken since a considerable amount of the system was not readily accessible for inspection during the field reconnaissance phase of the project.

d. System Performance

Twenty-five of the 57 improved reaches analyzed in this watershed provide less than a 10-year level of service and 12 of those provide less than a 2-year level. Twelve of the 25 reaches are included in recommended improvement projects described in Part VI of this report. Improved major system performance for the Downtown watershed is summarized in Table IV-15.

TABLE IV - 15
EXISTING IMPROVED SYSTEM PERFORMANCE - DOWNTOWN WATERSHED

Line No.	Capacity (cfs)	Peak Flows (CFS) 2-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr	Level Of Service
3000	656	363	502	607	751	863	980	10
3020	1010	352	490	590	734	845	960	>100
3030	404	206	286	349	433	496	564	10
3050	363	193	268	325	404	467	527	10
3060	212	166	233	282	350	407	462	2
3070	176	114	162	197	245	283	322	5
3080	290	95	133	162	202	233	263	>100
3100	115	95	134	164	205	238	271	2
3111	242	79	111	135	168	195	221	>100
3120	180	56	79	97	122	143	160	>100
3140	278	123	175	216	271	315	361	25
3150	315	122	172	210	263	304	347	50
3160	218	112	159	195	244	284	324	10
3180	149	81	113	138	174	203	232	10
3190	131	67	96	119	151	177	204	10
3200	22	1	1	2	2	3	3	>100
3201	323	62	90	113	144	169	195	>100
3211	106	59	86	108	138	162	187	10
3220	191	48	73	93	120	141	163	>100
3240	76	19	27	33	42	48	55	>100
3250	348	51	69	81	98	111	125	>100
3260	36	55	73	86	105	120	134	<2
3301	586	250	336	402	495	565	642	50
3310	338	247	332	397	491	561	633	5
3320	229	238	322	386	475	545	615	<2
3340	338	239	323	387	476	547	617	5

TABLE IV - 15 (CONT'D)
EXISTING IMPROVED SYSTEM PERFORMANCE - DOWNTOWN WATERSHED

Line No.	Capacity (cfs)	Peak Flows (CFS) 2-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr	Level Of Service
3350	992	242	327	392	483	554	624	>100
3360	74	104	141	169	206	235	265	<2
3370	51	78	106	128	156	178	201	<2
3380	32	47	66	81	102	118	134	<2
3399	767	223	306	369	458	527	596	>100
3400	444	236	325	392	482	553	621	10
3401	248	211	288	348	430	495	559	2
3402	256	215	294	354	437	502	567	2
3403	412	223	306	370	458	527	596	10
3404	423	216	296	358	443	511	577	10
3405	467	226	311	375	464	533	602	25
3406	341	216	296	357	441	507	573	<10
3410	231	215	298	363	451	521	590	2
3420	225	181	247	298	365	418	470	2
3421	175	197	271	327	404	464	524	<2
3430	152	113	155	186	228	260	293	5
3440	49	66	90	110	137	158	180	<2
3500	701	227	299	351	422	480	537	>100
3530	855	266	354	420	511	584	656	>100
3540	379	239	315	373	451	514	575	10
3550	466	284	381	456	558	641	723	10
3560	468	231	307	367	448	514	577	25
3570	138	205	273	326	398	455	514	<2
3580	153	113	155	188	233	268	304	5
3590	89	53	75	92	116	135	155	10
3600	11	32	44	53	66	76	85	<2
3610	16	34	46	55	69	79	90	<2
3620	209	76	96	111	131	147	163	>100
3630	39	37	47	54	64	72	80	2
3650	26	31	40	46	54	61	67	<2
3660	19	36	48	52	61	68	75	<2

14. EAST LAWRENCE WATERSHED

a. Location

The East Lawrence watershed covers 830 acres (1.30 square miles) in the area roughly bounded by 13th St. on the north, Harper on the east, 23rd St. on the south, and Louisiana on the west. It headwaters near 15th and Louisiana at an elevation of 1030. The basin slopes generally north and east to the Kansas River, draining through a culvert under the ATSF railroad at approximately elevation 814.

b. <u>Land Use</u>

The western half of the watershed is relatively dense, older single-family residential neighborhoods. Some of the large, older homes near the KU campus have been converted to apartments. The eastern half of the basin is less densely developed, primarily as commercial/industrial areas adjacent to the railroad. A small part of the southeast corner of the KU campus is also located in the basin.

c. <u>Existing Drainage System</u>

The existing drainage system in the East Lawrence watershed is primarily an enclosed system divided into two main branches which join just south of 13th St. and west of the ATSF railroad tracks. The system continues from this point as an enclosed component to Haskell Ave. where it discharges into an open channel section. This channel combines with the Brook Street Tributary approximately 400 feet north of Brook St. and 12th. The combined channel flows to the east and eventually discharges to the Kansas River.

Overall, the improved system in this watershed is in fairly good structural condition. The large concrete box segments at the lower ends of the system appear to be in very good shape. Most of the smaller pipes are corrugated metal and appear to be generally acceptable. Most channel sections have earthen bottoms with grassy banks and overbanks. Vertical stone block walls have been constructed along one section of channel through a residential area and the channel bottom appears to have been lined with stone or concrete at one time. The bottom lining is broken up and sediment has built up in several areas. Maintenance needs noted in the area are related primarily to channels and culverts obstructed by silt and debris.

d. <u>System Performance</u>

Of the 37 improved reaches analyzed in this watershed, 25 provide less than a 10-year level of service with 19 providing less than a 2-year level. Of the 25 reaches with less than a 10-year capacity, 21 are included in recommended improvement projects described in Part VI of this report. A small detention area in Parnell Park, south of 15th St. and east of Maryland, was evaluated and determined to have negligible impact on the system due to its very small storage capacity in relation to the tributary area. Improved major system performance for the East Lawrence watershed is summarized in Table IV-16.

TABLE IV - 16
EXISTING IMPROVED SYSTEM PERFORMANCE - EAST LAWRENCE WATERSHED

Line No.	Capacity (cfs)	Peak Flows (CFS) 2-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr	Level Of Service
3010	661	700	999	1220	1540	1810	2090	<2
3020	452	477	684	831	1050	1250	1460	<2
3021	48	15	22	26	33	39	44	100
3031	26	10	16	22	29	34	40	10
3050	296	126	188	237	307	363	421	25
3070	216	127	190	238	308	363	422	<10
3090	55	97	143	181	233	273	316	<2
3100	58	79	118	149	195	231	270	<2
3109	21	5	7	9	12	14	17	>100
3110	128	63	94	121	158	187	219	10
3120	16	36	54	69	90	107	124	<2
3130	31	74	105	127	159	189	207	<2
3140	48	71	101	123	152	179	200	<2
3150	15	66	94	114	141	174	174	<2
3160	21	59	86	103	128	147	166	<2
3170	13	45	65	80	100	115	130	<2
3190	185	71	93	109	130	148	166	>100
3210	60	14	18	21	26	29	32	>100
3220	98	57	77	93	115	132	149	10
3230	62	53	72	86	105	120	135	2
3240	29	45	59	70	85	97	108	<2
3250	258	201	285	350	440	509	580	<5
3260	116	190	267	327	410	471	537	<2
3270	258	183	259	318	398	460	524	5
3280	155	188	264	322	400	459	521	<2
3290	53	61	84	102	126	144	163	<2
3300	34	42	58	70	87	100	113	<2
3310	418	126	176	213	268	312	357	>100
3320	60	116	162	199	248	286	326	<2
3330	40	96	134	163	202	231	262	<2
3340	19	73	100	120	149	172	195	<2
3350	11	21	29	35	43	49	56	<2

TABLE IV - 16 (CONT'D)
EXISTING IMPROVED SYSTEM PERFORMANCE - EAST LAWRENCE WATERSHED

Line No.	Capacity (cfs)	Peak Flows (CFS) 2-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr	Level Of Service
3360	55	23	33	41	53	62	71	25
3370	48	24	35	43	55	65	75	10
3380	26	24	35	44	56	66	77	2
3390	32	18	31	38	49	57	66	5
3410	85	43	57	66	79	91	101	25

15. BROOK STREET WATERSHED

a. Location

The Brook Street watershed is located along the eastern edge of the city, from 23rd St. to the river, approximately between Harper and Haskell Avenues. The 397-acre (0.62 square mile) basin headwaters at 23rd St. at elevation 910 and outlets to the Kansas River near the north end at elevation 814.

b. Land Use

This watershed is composed primarily of single-family residential neighborhoods with a few small areas of multi-family units and mobile homes. A cemetery is located in the northeast section of the basin. There is also a relatively small amount of commercial development in the south end and the southeast corner is open land.

c. Existing Drainage System

The existing drainage system in this watershed consists primarily of the Brook Street Tributary. The main channel is enclosed for approximately half of its length beginning at 21st Terr. near the south end. The open channel portion crosses 15th St. through a 10'x 6' RCB (Line 15-3050) and continues as a series of open channel and road culvert sections. A small detention basin is adjacent to the cemetery.

Pipe materials throughout the watershed are primarily corrugated metal. The open channel section of the main tributary has an earthen bottom which has been lined with riprap in several locations. The overbank areas are generally maintained turf. No maintenance needs were noted in this watershed.

d. System Performance

Of the 18 improved reaches analyzed in this watershed, eight provide less than a 10-year level of service. Seven of the eight are included in recommended improvement projects described in Part VI of this report. Improved major system performance for the Brook Street watershed is summarized in Table IV-17.

TABLE IV - 17
EXISTING IMPROVED SYSTEM PERFORMANCE - BROOK STREET WATERSHED

Line No.	Capacity (cfs)	Peak Flows (CFS) 2-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr	Level Of Service
2001	30	21	30	37	47	55	64	5
2010	63	14	21	26	34	39	45	>100
3010	69	317	468	600	749	886	1020	<2
3030	498	273	400	498	641	758	880	10
3050	600	218	317	398	498	581	672	50
3070	155	162	236	293	371	433	497	2
3071	169	156	227	284	362	425	490	2
3072	108	18	26	33	41	48	54	>100
3080	113	133	194	244	312	366	424	<2
3090	120	63	90	113	144	169	195	10
3100	53	40	57	71	90	104	120	5
3110	87	31	45	55	70	82	95	50
3120	83	13	20	25	33	38	45	>100
3130	50	61	88	109	137	160	185	<2
3140	184	54	88	114	148	172	198	50
3150	71	55	89	115	149	173	198	2
3160	97	42	68	90	118	139	161	10
3170	222	47	70	89	115	135	157	>100

16. SUNFLOWER WATERSHED

a. Location

The Sunflower watershed covers 189 acres (0.30 square mile) at the very eastern edge of Lawrence. The upper end is located just north of State Highway K10 approximately one-fourth mile east of Harper Ave. The area slopes toward the north, eventually draining to the Kansas River. Elevations range from 925 at the south end to 826 in the north at 15th St.

b. Land Use

This watershed is approximately 50 percent undeveloped. A small amount of commercial development is located in the southern half of the basin. Mobile home parks are located in the southwest corner and near the center in the area between the extension of 17th St. and 19th St. A new residential subdivision, Ashbury, has been platted in the area east of Harper Ave. between approximately 16th and 17th Streets.

c. Existing Drainage System

The existing drainage system in this watershed is composed almost entirely of natural channels. The only enclosed elements on the major system are several corrugated metal pipe culverts at road crossings. What appears to be a farm pond (Line 16-3030) is located toward the lower end of the basin, just south of 15th St. The plat for the Ashbury subdivision indicates that this pond is to be removed as part of the development.

The channels have earthen bottoms and sides. The overbank areas are generally wooded with fairly dense underbrush in most areas. A few, relatively minor maintenance needs were noted during field observations.

d. System Performance

Of the three improved reaches analyzed in this watershed, one provides less than a 10-year level of service and is included in one of the recommended improvement projects described in Part VI of this report.

The removal of the existing pond along with development in the basin will increase flows to the downstream system; however, the existing cross road culvert at 15th St. has considerable excess capacity to handle the increased flows although some type of energy dissipation may be required at the outlet of the culvert due to the increased flows. The area downstream from 15th St. is undeveloped and there does not appear to be any other adverse impact in the vicinity. Improved major system performance for the Sunflower watershed is summarized in Table IV-18.

TABLE IV - 18
EXISTING IMPROVED SYSTEM PERFORMANCE - SUNFLOWER WATERSHED

Line No.	Capacity (cfs)	Peak Flows (CFS) 2-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr	Level Of Service
3000	1760	175	266	307	357	388	416	>100
3050	240	92	139	178	231	275	320	25
3070	70	66	101	130	169	202	237	2

17. NORTH LAWRENCE WATERSHED

a. Location

The North Lawrence watershed includes 934 acres (1.46 square miles) on the north side of the Kansas River and generally within the corporate limits. In addition to the area specifically mapped as part of this analysis and report, another subbasin of 1,220 acres (1.91 square miles), located west of the ATSF railroad line, and one of 1,270 acres (1.98 square miles) north of US 40 drain into the area through a railroad bridge and box culverts under US Highways 59 and 40 (Lines 17-3060, 3070 and 3080).

The watershed is extremely flat. The high point in the basin is at approximately elevation 830 in the northeast corner. The land slopes generally east and south on the north side of US 40, and south and west on the south side of the highway. Outlets from the basin are culverts through the flood protection levee on the south and west edges with outlet elevations varying from approximately 790 to 812.

b. Land Use

The basin is a mixture of commercial and residential land uses although there is still considerable open area. Much of the surrounding area is agricultural. Commercial development is concentrated along N. 2nd St. from the Kansas River to the turnpike. Other commercial and light industrial developments are scattered throughout the basin with some located north of I-70. The residential areas are primarily low-density single-family neighborhoods and several mobile home parks. The old Union Pacific train depot, currently under renovation, is located near N. 2nd. and Locust Streets.

c. <u>Existing Drainage System</u>

The existing major drainage system in the North Lawrence watershed is a combination of very flat open channels, cross-road culverts, and enclosed pipe segments. Most of the developed residential area is drained by roadside ditches which discharge to relatively small diameter pipe sections that eventually discharge through the levee at several locations. These pipe systems generally are gravity systems although a 2700-gpm pump station is required near 5th and Maple to discharge drainage from the area north of the railroad line into the enclosed system that continues south along 5th St. Because of the small pumping capacity, however, standing water in the vicinity appears to be a regular problem.

Standing water is also a common occurrence in much of the open channel system draining the large areas north of US 40 and west of the railroad. The culverts across US 40 and 59 are relatively small for the large upstream drainage areas causing unplanned detention in these areas.

This condition continues in the wide, flat channel that carries the drainage to the culverts and pump station adjacent to N. 2nd St, north of Lyon. Under normal conditions, flows enter the 36-inch pipe (Line 17-3100) that continues south along N. 2nd to the Kansas River as a 30-inch pipe (Line 17-3030). When this pipe's capacity is exceeded, flow is diverted through the triple 8'x 4' box culvert under N. 2nd

(Line 17-3000) and eventually drains by gravity through the levee via a 60-inch outlet pipe (Line 17-3010). The new 40,000-gpm pump station is used only when the Kansas River stage is too high to allow gravity drainage from the system or when runoff from intense localized storms exceeds the capacity of the gravity system.

d. System Performance

Nineteen of the 29 improved reaches analyzed in this watershed provide less than a 10-year level of service. Fourteen of those reaches are included in recommended improvement projects described in Part VI of this report. Improved major system performance for the North Lawrence watershed is summarized in Table IV-19.

TABLE IV - 19
EXISTING IMPROVED SYSTEM PERFORMANCE - NORTH LAWRENCE WATERSHED

Line No.	Capacity (cfs)	Peak Flows (CFS) 2-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr	Level Of Service
3000	696	207	370	567	693	792	864	25
3010*	140	207	370	567	693	792	864	<2
3020*	53	11	18	28	40	48	54	100
3030	57	68	85	96	110	124	136	<2
3050	220	36	117	208	260	270	283	>10
3060	70	6	13	23	40	51	64	>100
3070	47	6	13	24	41	53	66	25
3080	282	33	111	197	222	219	217	100
3110	>5000	204	405	752	1090	1230	1350	>100
3111	>5000	205	493	1020	1690	2000	2320	>100
3120	125	84	215	516	888	1070	1340	<5
3140	155	51	158	317	424	450	484	5
3160*	29	50	87	112	141	176	203	<2
3170	5	6	9	12	15	19	22	2
3180*	34	10	35	49	65	90	100	5
3181	3	8	14	19	25	30	35	<2
3190*	17	23	32	39	47	58	66	<2
3191	4	8	8	9	9	10	11	<2
3192**	4	6	6	6	6	6	6	100
3193	3	37	59	82	104	126	140	<2
3200*	29	24	36	48	61	71	82	2
3201	4	9	12	15	18	21	23	<2
3210	28	14	20	24	29	34	38	<2
3220	10	79	103	120	143	171	179	<2
3224	25	123	164	191	227	262	276	<2
3230	12	43	56	65	77	88	97	<2

TABLE IV - 19 (CONT'D)
EXISTING IMPROVED SYSTEM PERFORMANCE - NORTH LAWRENCE WATERSHED

Line No.	Capacity (cfs)	Peak Flows (CFS) 2-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr	Level Of Service
3240	8	27	36	41	48	55	61	<2
3250	6	14	18	21	25	28	31	<2
3275	235	18	80	175	227	225	223	100

* Levee outlets.
** Pump discharge line.

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APPENDIX B - EXISTING DRAINAGE SYSTEM INVENTORY

EXISTING DRAINAGE SYSTEM INVENTORY

The following pages provide brief descriptions of the line, or reach, numbers included in the existing drainage system computer models for each watershed. Along with the description, each line is referenced to the map number or sheet where it can be located. These maps have been provided separately to the City. In addition to these descriptions, photographs and other specific information on most of the lines can be found in the field inventory books prepared for each watershed. These documents were submitted separately to both the City and Burns & McDonnell by Landplan Engineering of Lawrence as part of this overall study.

WATERSHED NO. 1 - YANKEE TANK WEST
EXISTING SYSTEM DESCRIPTION

REACH NO.	MAP NO. REFERENCE	DESCRIPTION
1-3000	13/14	Natural channel
1-3010	13	Natural channel
1-3020	13	Natural channel
1-3030	13	Natural channel
1-3040	13	Natural channel
1-3050	13	Natural channel
1-3060	13	Natural channel
1-3070	13	24-inch RCP across county road
1-3080	13	Natural channel
1-3090	13	Natural channel
1-3100	13	Natural channel
1-3110	13	Natural channel
1-3120	13	Natural channel
1-3130	20	Natural channel
1-3140	20	Natural channel
1-3150	20	Natural channel
1-3160	13	18-inch CSP across Hwy. 40
1-3170	13	Natural channel
1-3180	13	Natural channel
1-3181	13	10'x 15' pond
1-3190	13	Natural channel
1-3200	6/13	3'x 3' RCB across Hwy. 40
1-3210	13	Natural channel
1-3885	20	Natural channel
1-3890	20/21	48-inch CSP across new street in Foxfire subdivision
1-3895	21	Natural channel
1-3900	21	48-inch CSP across new street in Foxfire subdivision

WATERSHED NO. 2 - HIDDEN VALLEY
EXISTING SYSTEM DESCRIPTION

REACH NO.	MAP NO. REFERENCE	DESCRIPTION
2-3000	22	Natural channel
2-3010	22	Bridge on golf course
2-3020	21	Natural channel
2-3025	21	Natural channel
2-3030	21	Bridge on golf course
2-3040	22	Natural channel
2-3050	22	Natural channel
2-3060	22	Bridge on golf course
2-3070	22	Bridge on golf course
2-3080	22	Natural channel
2-3090	22	36-inch CSP NE of Prestwick Dr. & Cir.
2-3100	22	Natural channel
2-3105	21	400'x 300' det. pond, W. of Inverness, N. of Turnberry
2-3110	22	200'x 70' det. pond N. of Wimbledon & E. of Inverness
2-3120	22	Natural channel
2-3130	22	10'x 4' RCB across Wimbledon Dr. near Wimbledon Cir.
2-3140	22	Natural channel
2-3150	22	10-ft turf channel downstream of Line 3160
2-3160	22	24-inch CSP near downstream end of Line 3140
2-3170	22/28	Double 20'x 9.5' RCB across Waterford/23rd
2-3180	22	Natural channel
2-3190	28	6-ft conc. channel, S. side 23rd, W. of Crossgate
2-3200	22	42-inch CSP along Crossgate, N. of Waterford
2-3210	22	Natural channel
2-3220	22	36-inch CSP along Crossgate, N. of Crossgate Ct.
2-3230	22	42-inch CSP across Crossgate near Crossgate Ct.
2-3231	22	Natural channel
2-3240	22	30-inch CSP E. of Crossgate, upstream end of Line 3250
2-3250	22	36-inch CSP across Crossgate, near N. end
2-3260	15/22	108-inch CSP across 15th below det. pond (Line 3270)
2-3270	15	400'x 950' det. pond, N. of 15th & W. of Monterrey Way
2-3280	21/27	72-inch CSP across 23rd, E. of Wakarusa
2-3290	21	4-ft. conc. channel, N. side 23rd, E. of Wakarusa
2-3300	21	4-ft. conc. channel, N. side 23rd, E. of Wakarusa
2-3310	21	8-ft channel, NE of 23rd & Wakarusa
2-3320	21	36-inch CSP, E. side Wakarusa, S. of Turnberry
2-3330	21/27	60-inch CSP across 23rd, W. of Inverness
2-3340	27	72-inch CSP across Ranch St., S. of 23rd
2-3350	27	Natural channel
2-3360	27	6-ft. riprap channel W. of Inverness
2-3370	27/28	5.67'x 4.4' RCB across Inverness, S. of 23rd
2-3380	14/21	18'x 10' CSPA across 15th St., W. of Inverness
2-3390	14	Natural channel
2-3400	14	Natural channel
2-3410	14	Triple 75"x 55" CSPA across Inverness, N. of Vantuyl
2-3420	14	36-inch CSP across Inverness @ Monterrey Hill Dr.
2-3430	14	36-inch CSP @ Monterrey Hill Dr.

WATERSHED NO. 2 - HIDDEN VALLEY (CONT'D.)
EXISTING SYSTEM DESCRIPTION

REACH NO.	MAP NO. REFERENCE	DESCRIPTION
2-3440	14	Triple 42"x 28" CSPA across Anthony Michael
2-3450	14	Double 66-inch CSP across 12th, W. of Vantuyl
2-3451	14	Natural channel
2-3452	14	Natural channel
2-3460	14	Double 66-inch CSP across Vantuyl near Oak Tree Dr.
2-3461	14	Natural channel
2-3470	14	Triple 78"x 50" CSPA across Inverness, E. of Wakarusa
2-3471	14	Natural channel
2-3480	14/15	54-inch CSP across Harvard near Mulberry
2-3490	14	69"x 47" CSPA across N. end of Oak Tree Dr.
2-3500	14	60-inch rubber-lined CSP across Grove Dr.
2-3510	14	Natural channel
2-3530	15	48-inch CSP across 12th, E. of Wagon Wheel
2-3540	15	Natural channel
2-3550	15	Natural channel
2-3560	15	Double 48-inch CSP across 13th, E. of Wagon Wheel
2-3570	15	48-inch CSP along Somerset Ct.
2-3580	15	36-inch CSP along Harvard, E. of Andover
2-3590	15	36-inch CSP @ Harvard & Andover
2-3600	14	48-inch CSP along Jefferson Way & Colonial Dr.
2-3610	14	36-inch CSP along Colonial Dr.
2-3620	14	81"x 59" CSPA across Wakarusa, S. of Harvard
2-3630	14	84-inch CSP across Wakarusa, S. of Inverness
2-3640	14	72-inch CSP @ outlet end of Line 3630
2-3650	14	Natural channel
2-3660	14	48-inch CSP from commercial area west of Wakarusa
2-3670	14	Private commercial detention w/12-inch outlet
2-3680	14	66"x 51" CSPA across Wakarusa, N. of 15th
2-3690	21	30-inch CSP S. of 15th, E. of Wakarusa
2-3700	14	48-inch CSP across 15th, E. of Wakarusa
2-3710	21	42-inch CSP along 15th & Wakarusa (SE corner)
2-3720	21	43"x 27" CSPA W. of Wakarusa, S. of 15th
2-3730	21	Double 43"x 27" CSPA across Wakarusa, S. of 15th
2-3740	21	50"x 31" CSPA along W. side Wakarusa
2-3750	21	43"x 27" CSPA along W. side Wakarusa
2-3760	21	43"x 27" CSPA along W. side Wakarusa, N. of 18th
2-3770	21	35"x 24" CSPA along W. side Wakarusa, N. of 18th
2-3780	21	48-inch CSP along W. side Wakarusa, S. of 18th
2-3790	21	66"x 51" CSPA along W. side Wakarusa, S. of Turnberry
2-3800	21	73"x 55" CSPA across Wakarusa, S. of Turnberry
2-3810	21	54-inch CSP along W. side Wakarusa, S. of Turnberry
2-3820	21	48-inch CSP @ W. end Troon Lane
2-3830	21	54-inch CSP along Carmel Dr., Troon La. to Merion Cir.
2-3840	21	66-inch CSP N. of Inverness @ Merion Cir.
2-3850	28	15'x 7' RCB across 27th & Crossgate
2-3860	28	Natural channel
2-3870	28	Natural channel
2-3880	28	Natural channel

WATERSHED NO. 3 - QUAIL CREEK
EXISTING SYSTEM DESCRIPTION

REACH NO.	MAP NO. REFERENCE	DESCRIPTION
3-3000	15	4'x 6' RCB across Harvard Rd., E. of Monterrey Way
3-3010	15	Natural channel
3-3020	15	42-inch CSP across Monterrey Way, N. of Harvard
3-3030	15	Natural channel
3-3040	15	Natural channel
3-3050	15	Double 57"x 38" CSPA across Elizabeth Ct.
3-3060	15	40"x 30" CSPA across Monterrey Way @ Wilshire Dr.
3-3070	15	Natural channel
3-3080	15	36-inch CSP across Monterrey Way, S. of Wilshire Dr.
3-3090	15	Double 57"x 38" CSPA @ priv. drive, N. of Eliz. Ct.
3-3100	15	Natural channel
3-3110	15	Double 57"x 38" CSPA across Monterrey Way @ W. 8th
3-3120	15	40"x 30" CSPA @ priv. drive, E. side Monterrey Way
3-3130	15	Natural channel
3-3140	8/15	70"x 42" CSPA across 6th, W. of Monterrey Way
3-3150	8	Natural channel
3-3160	8	36-inch CSP S. of Overland Dr., W. of Monterrey Way
3-3170	8	42-inch CSP, N. side of 6th, W. of Monterrey Way
3-3180	8	36-inch CSP, N. side of 6th, W. of Monterrey Way
3-3190	8	30-inch CSP across Monterrey, N. of 6th
3-3200	8	41"x 31" CSPA, N. side of 6th, E. of Monterrey Way
3-3210	8/15	56"x 38" CSPA across 6th, E. of Monterrey Way
3-3215	15	Natural channel
3-3220	8	48"x 36" CSPA, N. side of 6th, W. of Monterrey Way
3-3230	15	Natural channel
3-3240	15	Natural channel
3-3250	15	60-inch CSP across Tiffany Dr.
3-3260	15	36-inch CSP across Randall Rd., N. of 13th
3-3270	15	42-inch CSP, W. side Randall Rd. to S. side of 13th
3-3280	15	54-inch CSP south of 13th
3-3290	15	Natural channel
3-3300	15	Natural channel
3-3310	15	Natural channel
3-3320	15/22	Double 10'x 8' RCB across 15th near Alvamar Dr.
3-3330	22	36-inch CSP along 15th, E. of Alvamar Dr.
3-3340	22	43"x 27" CSPA across Alvamar Dr. @ 15th
3-3350	22	36"x 22" CSPA along 15th, W. of Alvamar Dr.
3-3360	22	36-inch CSP across St. Andrews Dr., S. of 15th
3-3370	22	Natural channel
3-3380	22	Natural channel
3-3390	22	60-inch CSP along Cedar Creek Ct.
3-3400	22	73"x 58" CSPA @ end of Cedar Creek Ct.
3-3410	22	Triple 10'x 8' RCB Cedar Creek Dr.
3-3420	22	60-inch CSP across 22nd St.
3-3430	28	Triple 10'x 5' RCB across 24th St.
3-3450	28	Triple 10'x 5' RCB across Brush Creek Dr.
3-3460	28	Natural channel

WATERSHED NO. 3 - QUAIL CREEK (CONT'D)
EXISTING SYSTEM DESCRIPTION

REACH NO.	MAP NO. REFERENCE	DESCRIPTION
3-3470	28	37"x 24" RCPA along Brush Creek Dr.
3-3480	28	37"x 24" RCPA along Brush Creek Dr.
3-3490	28	Natural channel
3-3500	22	36-inch CSP along 22nd, W. of Kasold
3-3510	22	48-inch CSP along 22nd @ Cedar Creek Dr.
3-3520	22	30-inch CSP N. of Clinton Parkway, E. of Hartford
3-3530	22	46"x 36" CSPA N. of Clinton Parkway, E. of Hartford
3-3540	22	36-inch CSP N. of Clinton Parkway & W. of Kasold
3-3550	28	30-inch CSP along Clinton Parkway, W. of Kasold
3-3560	22/28	Double 18'x 9' RCB across Clinton Parkway
3-3570	28	Natural channel
3-3575	22	Bridge on golf course
3-3380	22	Natural channel
3-3590	22	48-inch CSP on golf course
3-3600	22	Natural channel
3-3610	22	Golf course detention pond
3-3620	22	Natural channel
3-3630	22	Natural channel
3-3640	22	48-inch CSP on golf course
3-3641	22	Golf course detention pond
3-3650	22	48-inch CSP on golf course
3-3660	22	Natural channel
3-3670	22	Natural channel
3-3680	22	48-inch CSP on golf course
3-3690	22	Natural channel
3-3700	22	Natural channel
3-3710	22	48-inch CSP on golf course
3-3720	22	Natural channel
3-3730	22	Golf course detention pond

WATERSHED NO. 4 - YANKEE TANK EAST
EXISTING SYSTEM DESCRIPTION

REACH NO.	MAP NO. REFERENCE	DESCRIPTION
4-3000	23	36-inch CSP along 22nd St., E. of Melholland
4-3010	23	58"x 36" CSPA along 22nd, Melholland to Atchison
4-3020	23	58"x 36" CSPA, W. of Atchison Ave.
4-3030	23	36-inch CSP culvert, unimproved rd. NW of Vail Way
4-3040	23	Natural channel
4-3050	23	Natural channel
4-3060	23	Quadruple 15'x 8' RCB across 23rd, E. of Kasold
4-3070	29	66"x 54" CSPA W. of Atchison @ 27th St.
4-3080	29	48-inch CSP along 27th St., E. of Atchison
4-3090	29	42-inch CSP between 26th & 27th, E. of Atchison
4-3100	23	24-inch CSP & 18-inch RCP, KU west campus, N. of 23rd
4-3110	23	36-inch RCP, KU west campus, N. of 23rd
4-3120	23	6'x 3' RCB, KU west campus, N. of 23rd
4-3130	29	42-inch RCP S. side 23rd, W. of Crestline
4-3140	23	12'x 5' RCB along 23rd, Atchison Ave. to Lawrence Ave.
4-3150	29	6'x 5' RCB along 23rd, Lawrence Ave. to W. of Atchison
4-3160	29	15'x 5.5' RCB S. of 23rd, W. of Atchison
4-3170	29	42"x 29" RCPHE W. of Atchison Ave. @ 23rd Terr.
4-3180	29	42"x 29" RCPHE along 23rd Terr., E. of Atchison Ave.
4-3190	29	Natural channel
4-3200	29	Natural channel
4-3201	29	Natural channel
4-3210	28/29	Quadruple 10'x 7' RCB across Kasold, N. of 31st
4-3220	28	Natural channel
4-3230	28	36-inch RCP culvert @ future street
4-3240	28	36-inch CSP across drive, S. of Winterbrook @ Kasold
4-3250	28	36-inch RCP across Winterbrook, W. side Kasold
4-3260	28	24-inch CSP across drive, N. of 28th St., W. of Kasold
4-3270	28	Roadside channel, W. side Kasold, S. of 28th St.
4-3280	28	30-inch RCP across 28th St., W. side Kasold
4-3290	28	Roadside channel, W. side Kasold, N. of 28th St.
4-3300	16	10'x 10' RCB across Lawrence Ave., S. of Harvard
4-3301	16	Natural channel
4-3302	16	Natural channel
4-3303	16	54"x 42" CSPA N. of 15th & E. of Lawrence Ave.
4-3306	16/23	Double 10'x 10' RCB across 15th near Lawrence Ave.
4-3310	16	84" CSP across Harvard, W. of Lawrence Ave.
4-3320	16	6-ft conc. channel, N. of Harvard & W. of Lawrence Ave
4-3330	16	60-inch RCP between Lawrence Ave. & Jana Dr. (N)
4-3340	16	48-inch RCP between Lawrence Ave. & Jana Dr. (N)
4-3350	16	42-inch CSP along 9th & across Holiday
4-3360	16	36-inch CSP across 9th, N. of Holiday
4-3370	16	48-inch RCP, N. of Jana Dr. near end of Hill Ct.
4-3371	16	58"x 44" CSPA across Jana Dr. to Line 3370
4-3380	16	48-inch CSP across Holiday & along Jana Dr.
4-3390	15/16	42-inch CSP, east end 9th, E. of Kasold
4-3391	15	36-inch CSP along 9th, E. of Kasold

WATERSHED NO. 4 - YANKEE TANK EAST (CONT'D.)
EXISTING SYSTEM DESCRIPTION

REACH NO.	MAP NO. REFERENCE	DESCRIPTION
4-3400	16	72-inch CSP across Harvard @ Lawrence Ave.
4-3410	16	48-inch CSP along Lawrence Ave., N. of Harvard
4-3420	16	48-inch RCP along Lawrence Ave., N. of 9th
4-3430	16	42-inch CSP along Lawrence Ave., N. of 8th
4-3440	16	36-inch CSP along Lawrence Ave., N. of 7th
4-3450	16	42-inch RCP E. of Lawrence Ave. between 8th & 9th
4-3460	16	36-inch RCP along Wellington Rd. & 7th St.
4-3470	16	60-inch RCP across Westdale Cir.
4-3480	16	72-inch RCP across Westdale Rd.
4-3490	16	48-inch RCP across Crestline Dr.
4-3500	16	60"x 38" RCPA across Centennial, N. of Westdale Rd.
4-3510	16	36-inch CSP S. of Harvard & E. of Centennial
4-3520	16	Natural channel
4-3521	16	Natural channel
4-3522	16	Natural channel
4-3523	16	Natural channel
4-3524	16	Natural channel
4-3525	16	Natural channel
4-3530	16	36-inch RCP across University Dr. @ Stratford Rd.
4-3531	16	Natural channel
4-3533	16	Natural channel
4-3532	16	48-inch CSP across Westbrooke, N. of 15th
4-3540	16	42-inch RCP N. of University Dr. @ Stratford Rd.
4-3550	16	36-inch RCP between University Dr. & Stratford Rd.
4-3560	23	36-inch RCP, SW of intersection of 15th & Iowa
4-3570	23	36-inch RCP along 15th, W. of Iowa
4-3580	23	60-inch CSP along 15th, W. of Iowa
4-3590	23	66-inch CSP along 15th, W. of Iowa
4-3600	23	72-inch CSP along Westbrooke, S. of 15th
4-3610	23	Natural channel
4-3620	23	6'x 6' RCB, KU west campus
4-3630	23	72-inch CSP, KU west campus
4-3640	17	5'x 4' RCB across Iowa, N. of 15th
4-3642	17	Natural channel
4-3650	17	36-inch RCP across Emery near Hillcrest
4-3660	16	58-inch CSP across 15th, W. of Iowa
4-3670	16	Natural channel
4-3680	23	Natural channel
4-3690	23	Natural channel
4-3700	23	Natural channel
4-3720	23	480'x 240' detention pond, KU west campus
4-3730	23	24-inch RCP outlet from det. pond/Line 3720
4-3735	23	Natural channel
4-3740	23	48-inch CSP, KU west campus

WATERSHED NO. 5 - NAISMITH
EXISTING SYSTEM DESCRIPTION

REACH NO.	MAP NO. REFERENCE	DESCRIPTION
5-2335	24	24-inch CSP along 21st St., E. of Carolina
5-2355	24	24-inch CSP along 21st St., Carolina to Louisiana
5-2358	25	18-inch CSP along Louisiana, S. of 21st
5-2365	25	18-inch CSP along 21st, Ohio to Louisiana
5-2380	25	18-inch CSP along Louisiana, 19th to 21st
5-2435	24	30-inch CSP along 21st, W. of Clifton Ct.
5-2445	24	24-inch CSP E. of Ousdahl, 20th St. to 21st. St.
5-2452	24	24-inch CSP along 21st, W. of Ousdahl
5-2457	24	30-inch CSP along 21st, E. of Stewart
5-2485	24	36"x 24" CSPA along Maine, N. of 20th St.
5-2505	24	30-inch CSP along Alabama, 18th to 19th
5-2515	24	21-inch CSP along Alabama, 17th to 18th
5-2535	24	29"x 18" CSPA along Missouri, N. of 19th
5-3000	30	43"x 27" CSPA @ end of 29th Ct.
5-3010	30	36"x 22" CSPA along 29th Ct, W. of Missouri
5-3020	30	Bridge over Naismith Channel @ 27th St.
5-3030	30	36-inch CSP along 27th, W. of 27th St. bridge
5-3040	30	36-inch RCP @ end of Ridge Ct., S. of 27th
5-3050	30	30"x 18" CSPA @ entrance to mobile home park
5-3060	30	Natural channel
5-3070	30	Two 36"x 22" CSPA @ entrance to mobile home park
5-3080	30	Natural channel
5-3090	30	Natural channel
5-3100	30	43"x 29" CSPA along 25th Ct.
5-3110	30	36-inch CSP across Ousdahl @ 25th Ct.
5-3120	30	30-inch CSP across Cedarwood between 25th & 26th
5-3130	30	Natural channel
5-3135	34	Double 54-inch RCP (priv. prop.),SE corner 31st & Iowa
5-3150	34	36-inch CSP (priv. prop.), SE corner 31st & Iowa
5-3160	34	42-inch CSP (priv. prop.), SE corner 31st & Iowa
5-3170	34	6-ft conc. & turf channel, S. side 31st, E. of Iowa
5-3180	34	60-inch RCP across priv. dr., S. side 31st, E. of Iowa
5-3190	34	42-inch CSP across Iowa, S. of 31st
5-3200	34	Double 42-inch CSP S. of 31st & E. of Iowa
5-3210	34	54-inch RCP across priv. dr., SE corner of 31st & Iowa
5-3220	34	6-ft conc. & turf channel, S. side 31st, E. of Iowa
5-3230	30	36-inch CSP across 31st, E. side of Iowa
5-3240	30	36-inch CSP along N. side 31st, E. of Iowa
5-3250	30	24-inch CSP along N. side 31st, W. of Ousdahl
5-3260	30	Double 36-inch CSP along Iowa, N. of 31st
5-3270	30	42-inch CSP along Iowa near 29th
5-3280	29	36-inch CSP along Iowa, 27th to 29th
5-3290	30	66-inch CSP S. of Eddingham, E. of Ousdahl
5-3300	30	72-inch CSP @ outlet of Line 3290
5-3310	30	24-inch CSP along Naismith Dr., S. of Eddingham
5-3320	30	30-inch CSP @ outlet of Line 3330
5-3330	30	24-inch CSP across Naismith Dr., N. of 25th

REACH NO.	MAP NO. REFERENCE	DESCRIPTION
5-3340	30	72"x 44" CSPA thru comm. area @ 23rd & Ousdahl
5-3360	24	58"x 36" CSPA along N. side 23rd, E. of Ousdahl
5-3361	24	58"x 36" CSPA N. of 23rd, W. of Ousdahl (comm. area)
5-3362	24	48-inch CSP N. of 23rd, W. of Ousdahl (comm. area)
5-3363	24	42-inch CSP N. of 23rd, E. of Iowa (comm. area)
5-3370	30	14'x 8' CSPA @ inlet to Line 3380 (@ 23rd & Naismith)
5-3380	30	20'x 9' RCB across 23rd St. @ Naismith Dr.
5-3390	30	10-ft riprap channel @ outlet of Line 3380
5-3400	30	Bridge across Naismith Channel @ 24th St.
5-3410	30	Natural channel
5-3420	30	36-inch CSP across Naismith Dr., S. of 24th
5-3430	30	36-inch CSP across Naismith Dr., S. of 24th
5-3440	30	7'x 5' RCB along S. side 23rd, E. of Naismith Dr.
5-3445	24	6'x 2.25' RCB across 23rd, W. of Alabama
5-3450	24	58"x 36" CSPA 22nd Terr. to 23rd, W. of Alabama
5-3451	24	58"x 36" CSPA along N. side 23rd, W. of Alabama
5-3460	24	58"x 36" CSPA along 22nd Terr., W. of Alabama
5-3470	24	58"x 36" CSPA along Alabama, 22nd to 22nd Terr.
5-3480	24	58"x 36" CSPA along 22nd Terr., E. of Alabama
5-3490	24	58"x 36" CSPA 22nd to 21st, E. of Carolina
5-3500	24	48-inch CSP along Alabama, 22nd Terr. to 23rd
5-3510	24	8'x 3' RCB E. of Naismith, N. of 18th (KU)
5-3520	24	60-inch RCP, SE of Naismith & Sunnyside Ave. (KU)
5-3530	24	60-inch RCP, S. of Sunnyside Ave. (KU)
5-3540	24	48-inch RCP, N. of Sunnyside Ave. (KU)
5-3550	24	36-inch CSP, N. of Sunnyside Ave. (KU)
5-3560	24	36-inch CSP, N. of Sunnyside Ave. (KU)
5-3570	24	48-inch RCP, N. side of baseball field (KU)
5-3575	24	66-inch RCP, S. side of tennis courts (KU)
5-3580	24	54-inch RCP, W. side of tennis courts (KU)
5-3600	24	54-inch RCP, S. of Irving Hill Rd. (KU)
5-3610	24	48-inch RCP, 15th to Irving Hill Rd. (KU)
5-3620	24	42-inch RCP, N. side Anschutz Pavilion (KU)
5-3630	24	36-inch RCP S. of Irving Hill Rd. (KU)
5-3640	24	7'x 5.5' RCB NW corner tennis courts (KU)
5-3650	24	36-inch RCP, NW of 19th & Naismith (KU)
5-3670	24	30-inch CSP, NW of 19th & Naismith (KU)
5-3680	24	36-inch CSP, NW of 19th & Naismith (KU)
5-3690	24	36-inch RCP N. of 19th (KU)
5-3700	24	48-inch RCP along 19th, W. of Naismith Dr.
5-3710	24	54-inch RCP along Naismith (KU)
5-3715	24	78-inch RCP along Naismith, N. of 18th (KU)
5-3720	24	72-inch CSP along Naismith Dr., 18th to 19th (KU)
5-3730	24	84"x 65" CSPA along Naismith, 19th to 20th
5-3740	24	89"x 72" CSPA along Naismith, S. of 20th
5-3750	24	48-inch CSP along 21st, W. of Naismith Dr.
5-3760	24	42-inch CSP along 21st @ Emerald, W. of Naismith Dr.

WATERSHED NO. 5 - NAISMITH (CONT'D.)
EXISTING SYSTEM DESCRIPTION

REACH NO.	MAP NO. REFERENCE	DESCRIPTION
5-3770	24	36-inch CSP along 21st @ Hillview, W. of Naismith Dr.
5-3780	24	Bridge across Naismith Channel @ 21st St.
5-3790	24	7-ft. conc.-lined Naismith Channel, N. of 21st
5-3800	24	Bridge across Naismith Channel @ 22nd St.
5-3810	24	Bridge across Naismith Channel @ 22nd Terr.
5-3820	24	7-ft. conc.-lined Naismith Channel, 21st to 22nd
5-3830	24	7-ft. conc.-lined Naismith Channel, 22nd to 22nd Terr.
5-3840	24	7-ft. conc.-lined Naismith Channel, 22nd Terr. to 23rd
5-3850	24	60"x 48" CSPA along 20th St., E. of Naismith Dr.
5-3851	24	65"x 40" CSPA along 20th St., Alabama to Maine
5-3852	24	58"x 36" CSPA along Alabama, 19th to 20th
5-3860	24	36"x 22" CSPA 22nd to 22nd Terr., W. of Naismith Dr.
5-3870	24	43"x 27" CSPA 22nd Terr. to 23rd, W. of Naismith Dr.
5-3875	24	4'x 4' RCB across 23rd, W. of Naismith Dr.
5-3880	30	48-inch CSP along S. side 23rd, W. of Naismith Dr.

WATERSHED NO. 6 - KLWN
EXISTING SYSTEM DESCRIPTION

REACH NO.	MAP NO. REFERENCE	DESCRIPTION
6-3000	33	Natural channel
6-3010	33	Natural channel
6-3011	33	Natural channel
6-3020	29/33	7'x 4' RCB across 31st St. @ 4-Wheel Dr.
6-3030	29	Natural channel
6-3035	29	36-inch CSP W. of 4-Wheel Dr. @ 29th Terr.
6-3040	29	Natural channel
6-3050	29	65"x 40" CSPA across 27th St., W. of Iowa
6-3060	29	58"x 36" CSPA near end of 26th, W. of Iowa
6-3070	29	58"x 36" CSPA @ end of 26th, W. of Iowa
6-3080	29	50"x 31" CSPA along Melrose, N. of 26th St.
6-3090	29	48-inch CSP W. side of comm. area, N. of 26th
6-3100	29	30-inch CSP W. side of comm. area, N. of 26th
6-3120	29/33	6'x 4' RCB across 31st near Harrison Ave.
6-3200	33	Natural channel
6-3210	29/33	18-inch CSP across 31st, E. of Lawrence Ave.

WATERSHED NO. 7 - BELLE HAVEN
EXISTING SYSTEM DESCRIPTION

REACH NO.	MAP NO. REFERENCE	DESCRIPTION
7-3000	30	Natural channel
7-3010	30	83"x 52" CSPA across 29th @ Belle Haven Dr.
7-3030	30	Natural channel
7-3040	30	83"x 52" CSPA across 27th Terr. @ Belle Haven Dr.
7-3050	30	Natural channel
7-3060	30/31	Double 14'x 7' RCB @ 31st & Louisiana
7-3070	30	63"x 42" CSPA across 27th @ Belle Haven Dr.
7-3080	30	65"x 40" CSPA along Belle Haven Dr., N. of 27th
7-3081	30	71"x 34" CSPA along Belle Haven Dr., N. of 27th
7-3090	30	48-inch RCP along Belle Haven Dr., 25th to Belle Crest
7-3100	30	42-inch RCP @ Belle Haven Dr. & 25th
7-3110	30	36-inch RCP from NE of 25th & Belle Haven to Louisiana

WATERSHED NO. 8 - BROKEN ARROW
EXISTING SYSTEM DESCRIPTION

REACH NO.	MAP NO. REFERENCE	DESCRIPTION
8-3000	31	Double 9'x 5' RCB across 31st, E. of Louisiana
8-3010	31	Natural channel
8-3020	31	24-inch RCP along Barker Ave., N. of Pawnee
8-3025	31	Natural channel
8-3030	31	Natural channel
8-3031	31	54"x 37" CSPA across channel (Haskell campus)
8-3040	31	30-inch RCP @ SW corner Mass. & West Indian
8-3050	31	24-inch RCP along Mass., S. of West Indian
8-3060	31	24-inch RCP along West Indian, W. of Barker
8-3090	31	30-inch RCP @ SE corner Vermont & Kansas
8-3100	31	24-inch RCP across Vermont, N. of Kansas

WATERSHED NO. 9 - HASKELL
EXISTING SYSTEM DESCRIPTION

REACH NO.	MAP NO. REFERENCE	DESCRIPTION
9-3000	31	Natural channel
9-3010	31	Natural channel
9-3020	31	88"x 54" RCPA (Haskell campus)
9-3040	31	Natural channel
9-3050	31	60-inch RCP (Haskell campus)
9-3060	31	Natural channel
9-3080	26/32	36-inch RCP across Haskell @ 23rd
9-3090	26	36-inch RCP along 23rd, E. of Haskell
9-3100	31	Natural channel
9-3110	31	36-inch RCP SW of Oregon & 28th St.
9-3120	31	42-inch CSP across 28th @ Oregon
9-3130	31	36-inch CSP along Oregon N. of 28th
9-3140	31	49"x 32" RCPA (Haskell campus)
9-3200	31	Natural channel
9-3201	31	Double 12'x 5' RCB across 31st St., W. of Haskell
9-3210	31	12-inch RCP across 30th St., W. of Haskell
9-3220	31	Natural channel
9-3240	31	Natural channel
9-3250	31	Natural channel
9-3260	31	6'x 6' RCB across 29th St., W. side Haskell
9-3270	31	10-ft conc & turf channel, W. side Haskell, N. of 29th
9-3280	32	8'x 6' RCB across Haskell, S. of 29th Terr.
9-3290	32	5-ft conc. channel S. of 29th Terr.
9-3300	32	6'x 6' RCB across 29th Terr., E. of Haskell
9-3310	32	5-ft conc. channel between Ponderosa & Maverick
9-3320	32	5'x 5' RCB across 27th, E. of Ponderosa
9-3330	32	54-inch RCP W. of Maverick & N. of 27th
9-3340	32	48-inch RCP W. of Maverick & S. of 25th Terr.
9-3350	32	42-inch RCP N. of 25th Terr. to N. of Willow Cove
9-3360	32	24-inch RCP across Ponderosa, S. of 27th
9-3380	26/32	6'x 3' RCB across 23rd, E. of Harper
9-3390	25	36-inch CSP across 22nd St., W. of Haskell
9-3400	32	1000'x 450' lake
9-3405	25	Natural channel
9-3410	25/31	7'x 4' RCB across 23rd, W. of Haskell
9-3420	31	42-inch CSP along S. side 23rd, W. of Haskell
9-3430	25	36"x 18" RCPA @ priv. drive, NW of 23rd & Haskell
9-3440	25	58"x 24" RCPA @ priv. drive, NW of 23rd & Haskell
9-3450	32	48"x 32" RCPA along Haskell, S. of 24th
9-3460	31	52"x 36" RCPA across Haskell @ 24th St.
9-3470	32	48-inch RCP along Haskell, S. of 25th
9-3480	32	36-inch RCP along Haskell, N. of 25th Terr.
9-3490	31	75'x 25' private detention pond
9-3500	31	2'x 2.5' RCB (Haskell campus)
9-3510	31	36-inch RCP (Haskell campus)
9-3520	31	Double 13'x 2.5' RCB across 31st, W. of Haskell
9-3530	32	60-inch CSP between Willow Cove and 24th, W. of Harper

WATERSHED NO. 9 - HASKELL (CONT'D.)
EXISTING SYSTEM DESCRIPTION

REACH NO.	MAP NO. REFERENCE	DESCRIPTION
9-3540	32	36-inch RCP S. of 24th & W. of Harper
9-3560	32	71"x 47" CSPA along 24th, W. of Harper
9-3570	32	Natural channel
9-3580	32	48-inch CSP S. of 24th, W. of Harper
9-3590	32	71"x 47" CSPA N. of Willow Cove
9-3600	32	60"x 39" RCPHE N. of Willow Cove
9-3601	32	49"x 31" RCPA N. of Willow Cove
9-3610	32	36-inch RCP across Ponderosa, N. of 27th
9-3620	32	48-inch CSP across 27th between Harper & Whitmore
9-3630	32	48-inch CSP across 27th between Harper & Whitmore
9-3640	32	72"x 52" CSPA across & N. of 27th
9-3650	32	68"x 51" CSPA N. of 27th to Hampton
9-3660	32	48-inch CSP along Hampton, Whitmore to Cranley
9-3670	32	55"x38" CSPA along Cranley,N. of Hampton to 25th Terr.
9-3700	32	36-inch CSP N. of 25th Terr. near Anderson (extended)
9-3710	32	Natural channel
9-3720	32	30-inch CSP south of Anderson & 24th Terr.
9-3730	32	54-inch CSP W. of Kensington, N. of 29th St.
9-3740	32	48-inch CSP along Kensington, S. of 28th St.
9-3750	32	36-inch CSP along Kensington, N. of 28th St.
9-3760	32	Double 48-inch CSP across 29th, W. of Kensington
9-3775	32	Natural channel

WATERSHED NO. 10 - DEERFIELD
EXISTING SYSTEM DESCRIPTION

REACH NO.	MAP NO. REFERENCE	DESCRIPTION
10-3000	8	24-inch RCP across Trail Rd.
10-3010	8	42-inch CSP across Boulder Ct.
10-3030	8	20-ft. riprap channel N. of Boulder Ct.
10-3050	8	42-inch CSP across Riverview Rd.
10-3100	8	48-inch CSP across Stetson Dr.
10-3110	8	3-ft. rock channel N. of Trail Rd.
10-3111	8	3-ft. rock channel N. & E. of Stetson Dr.
10-3120	9	42-inch RCP so. of Riverview Rd. near Rock Fence
10-3130	9	54-inch RCP between Rock Fence Rd. & Saddlehorn Dr.
10-3140	9	36-inch RCP along Lance Ct.
10-3150	9	Natural channel
10-3160	9	Double 9'x 6'RCB across Princeton
10-3170	9	12-ft. conc. chan., W. of Arrowhead, S. of Peterson
10-3180	9	Natural channel
10-3190	9	48-inch CSP, W. of Lawrence Ave - Ranger to Tomahawk
10-3200	9	42-inch CSP, W. of Lawrence Ave & S. of Ranger Rd.
10-3210	9	36-inch CSP W. of Lawrence Ave & S. of Longhorn
10-3220	9	Natural channel
10-3230	8/9	8'x 6' RCB across Kasold @ Tomahawk Dr.
10-3240	8	Natural channel
10-3250	9	5-ft. riprap channel W. of Rock Fence
10-3251	9	30-inch CSP, N. of Trail Rd., E. of Frontier
10-3255	2/3	Double 9'x 6' RCB across Peterson Rd.
10-3260	8	6'x 5' RCB across Monterrey Way, N. of Stetson
10-3265	2	Natural channel
10-3270	8	Natural channel
10-3280	8	350'x 125' detention pond, W. of Monterrey Way
10-3290	8	Natural channel
10-3300	8	30-inch CSP across Monterrey Way, S. of Peterson Rd.
10-3310	8	Natural channel
10-3320	8	60"x 42" RCPA across Peterson RD., W. of Kasold
10-3330	8	6'x 1.5' RCB along S. side of Peterson Rd.
10-3340	1/8	Double 8'x 4.5' RCB across Peterson Rd., W. of Kasold
10-3350	8	Natural channel
10-3380	1/2	Double 8'x 7' RCB across Kasold, N. of Peterson Rd.
10-3390	2	Natural channel
10-3400	1	Natural channel
10-3410	2	14'x 8' RCB across Kasold, N. of I70
10-3420	2	Natural channel
10-3430	2	14'x 8' RCB across I70
10-3440	2	Natural channel
10-3441	2	Natural channel

WATERSHED NO. 11 - RIVERSIDE
EXISTING SYSTEM DESCRIPTION

REACH NO.	MAP NO. REFERENCE	DESCRIPTION
11-3000	2	Double 5'x 5' RCB across Iowa near Timberedge Rd.
11-3010	2	Natural channel
11-3020	2/3	35"x 24" CSPA across Iowa, N. of I70
11-3030	2	Natural channel
11-3040	2	4'x 4' RCB across Iowa (extended) near Timberedge Rd.
11-3050	3	Natural channel
11-3060	3	36-inch CSP across California, S. of Riverside
11-3070	3	Natural channel
11-3080	3	5-ft. turf channel W. of California
11-3090	3	36-inch CSP across Riverside @ Colorado
11-3091	3	42-inch CSP across Riverside @ Colorado
11-3092	3	30-inch CSP across Riverside @ Colorado
11-3100	3	Natural channel
11-3110	3	24-inch CSP
11-3120	3	Natural channel
11-3130	3	76" CSP across I70, W. of RR
11-3200	3	Natural channel
11-3210	3	Natural channel
11-3220	3	Natural channel

WATERSHED NO. 12 - COUNTRY CLUB
EXISTING SYSTEM DESCRIPTION

REACH NO.	MAP NO. REFERENCE	DESCRIPTION
12-3000	10	Natural channel
12-3005	10	Natural channel
12-3010	10	52'x 7' bridge near N. end of Maine
12-3020	10	36"x 24" RCPHE W. of Maine & 2nd
12-3030	10	84" CSP along 2nd St., E. of Michigan
12-3033	10	81" CSP along Michigan between 2nd & 3rd
12-3040	10	81" CSP along 3rd between Michigan & Minnesota
12-3050	10	72" CSP along 3rd, W. of Minnesota
12-3060	10	Natural channel
12-3070	9/10	10'x 6.5' CSPA across Iowa @ 4th St.
12-3080	9	Natural channel
12-3090	9	6'x 6' RCB W. side of Iowa
12-3100	9	Natural channel
12-3110	9	5.5'x 7' RCB across McDonald Dr. near 6th
12-3120	9	6.5'x 7' RCB across 6th St. @ McDonald Dr.
12-3140	16/17	4'x 4' RCB across Iowa, S. of 6th
12-3150	10	42" RCP along Minnesota, S. of 3rd
12-3160	10	36" RCP along Minnesota, N. of 4th
12-3180	9	42-inch RCP across McDonald Dr., N. of 6th
12-3200	10	Natural channel
12-3210	3	Natural channel
12-3220	3	16'x 2' RCB across Michigan, N. of Pinewood Dr.
12-3230	3	Natural channel
12-3240	10	Natural channel
12-3231	3	Double 13'x 5' CSPA in Wood Creek townhomes
12-3250	10	60" RCP across McDonald Dr., N. of 2nd
12-3260	10	Natural channel
12-3270	10	Natural channel
12-3280	9	60"x 36" CSPA across Iowa @ McDonald Dr.
12-3290	9	Natural channel
12-3300	9	36-inch RCP along Rockledge Dr., W. of McDonald Dr.
12-3310	10	Natural channel
12-3320	9/10	7'x 5' RCB across Iowa, N. of Princeton
12-3330	9	48-inch RCP, Princeton to W. side of Iowa
12-3340	9	42-inch RCP along Providence Rd., S. of Princeton
12-3360	2	Natural channel
12-3361	2	Natural channel
12-3370	9	Natural channel
12-3375	9	48-inch RCP across Princeton, W. of Yorkshire
12-3380	9	60-inch RCP along N. side Princeton @ Crestline Dr.
12-3390	9	36-inch RCP across Princeton, W. of Crestline Dr.
12-3410	3	48-inch RCP across I70 ramp @ turnpike interchange
12-3420	3	42-inch RCP across I70
12-3430	2	6-ft. concrete channel, W. side of Iowa
12-3440	2	72"x 48" RCPA across drive, W. side of Iowa
12-3450	2	Natural channel
12-3460	2	72"x 48" RCPA across I70, W. of Iowa

WATERSHED NO. 12 - COUNTRY CLUB (CONT'D.)
EXISTING SYSTEM DESCRIPTION

REACH NO.	MAP NO. REFERENCE	DESCRIPTION
12-3470	3	Natural channel
12-3480	3	60-inch CSP across Michigan, S. of I70
12-3490	3	Natural channel
12-3500	2	10'x 6' RCB across Iowa, N. of Peterson Rd.
12-3510	3	Natural channel
12-3520	3	6'x 5' RCB across McDonald Dr., S. of interchange
12-3530	3	Natural channel
12-3540	3	48-inch RCP across I70 near turnpike interchange
12-3550	3	42-inch RCP across I70 @ turnpike interchange
12-3560	2	5'x 4' RCB across Peterson Rd., W. of Iowa
12-3570	2	Double 48-inch CSP, N. of Peterson Rd. & W. of Iowa
12-3580	2	6-ft. rock channel, N. of Peterson Rd. & W. of Iowa
12-3590	2	42-inch CSP across Peterson Rd., W. of Iowa
12-3600	2	54-inch CSP, N. of Peterson Rd. & W. of Iowa
12-3610	2	30-inch RCP across I70
12-3620	3	Double 30-inch CSP across frontage rd.
12-3630	3	36-inch CSP across I70 ramp @ turnpike interchange
12-3640	3	36"x 24" CSPA across I70 @ turnpike interchange
12-3650	3	42"x 27" CSPA across McDonald Dr.
12-3660	3	36-inch RCP across frontage rd. @ turnpike interchange
12-3670	3/10	Concrete v-ditch along W. side McDonald Dr.
12-3680	3/10	10-ft. turf channel along E. side McDonald Dr.
12-3700	10	60"x 36" CSPA, W. side of McDonald Dr., S. of 2nd
12-3710	10	54"x 40" CSPA across 2nd, W. side of McDonald Dr.
12-3720	10	96-inch CSP E. side of Iowa @ McDonald
12-3730	10	36-inch RCP across McDonald @ 6th
12-3740	9/16	4.5'x 4' RCB across ramp @ 6th & McDonald Dr.

WATERSHED NO. 13 - DOWNTOWN
EXISTING SYSTEM DESCRIPTION

REACH NO.	MAP NO. REFERENCE	DESCRIPTION
13-3000	11	Quadruple 48-inch CIP across RR
13-3010	11	Natural channel
13-3020	10	6'x 7' RCB, N. side of 5th, Mississippi to Indiana
13-3030	10	5'x 5.5' RCB, S. of 5th, Illinois to Mississippi
13-3040	10	Natural channel
13-3050	10	72-inch CSP W. of Maine between 5th & 6th
13-3060	10	66-inch rubber-lined CSP N. of 6th & Missouri
13-3070	10	54-inch CSP along E. side of Arkansas, S. of 6th
13-3080	17	4'x 4' RCB along W. side Michigan, S. of 7th
13-3100	17	48-inch CSP SW of 7th & Michigan
13-3110	17	Natural channel
13-3111	17	36-inch CSP & 3.5'x 3.5' RCB across 8th near Michigan
13-3120	17	48-inch CSP across 9th between Avalon & Emery
13-3122	17	Natural channel
13-3140	10	5'x 5' RCB E. of Mississippi from S. of 6th to 7th
13-3150	10	5'x 5' RCB from Illinois to Mississippi, S. of 6th
13-3160	10/17	60-inch CSP N. of 7th between Illinois & Alabama
13-3180	17	54-inch CSP along 8th & Alabama (S. of 7th)
13-3190	17	48-inch CSP along 9th & Missouri (S. of 8th)
13-3200	17	24-inch CSP S. of 9th between Missouri & Arkansas
13-3201	17	54-inch CSP along Arkansas, S. of 9th
13-3210	17	Natural channel
13-3211	17	62"x 45" CSPA W. of Arkansas & S. of Michigan
13-3220	17	42-inch RCP E. of Emery & S. of 10th (extended)
13-3221	17	Natural channel
13-3240	10	36-inch CSP N. of 6th & E. of Michigan
13-3250	10	5'x 4' RCB across 6th @ Arkansas
13-3260	10	30-inch CSP along S. side of 6th, Florida to Arkansas
13-3300	11	Double 78-inch CIP downstream from RR culvert
13-3301	11	78-inch CSP across RR
13-3310	11	78-inch CSP N. of 6th & Kentucky
13-3320	11	6'x 6.6' RCB, 7th to 6th in Buford Watson Park
13-3340	18	6'x 6.6' RCB E. side Tennessee, S. of 7th
13-3350	18	6'x 7.33' RCB E. side Tennessee, N. of 8th
13-3360	18	42-inch RCP along Tennessee, 10th to 8th
13-3370	18	42-inch CSP along Kentucky, 11th to 10th
13-3380	18	36-inch CSP along Kentucky, 12th to 11th
13-3399	17	6'x 6.5' RCB SW of 8th & Louisiana
13-3400	17	72-inch RCP N. of 9th & W. of Louisiana
13-3401	18	6'x 6.33' stone box, S. of 8th between Tenn. & Ohio
13-3402	18	6'x 6' stone box, NW corner Tennessee & 8th
13-3403	18	5'x 9' stone box across Louisiana, S. of 8th
13-3404	18	72-inch RCP W. of Ohio & S.of 8th
13-3405	18	6'x 6' stone box E. of Louisiana & S. of 8th
13-3406	18	6'x 5.5' RCB E. of Ohio & S. of 8th
13-3410	17	6'x 5' stone box, 10th-9th, W. of Miss.- W. of La.
13-3420	17	4.5'x 4.5' brick box, S. of 11th & W. of Miss. (KU)

WATERSHED NO. 13 - DOWNTOWN (CONT'D.)
EXISTING SYSTEM DESCRIPTION

REACH NO.	MAP NO. REFERENCE	DESCRIPTION
13-3421	17	3.5'x 5' brick box, 11th-10th between Miss. & Ill.
13-3430	17	42-inch RCP E. side stadium (KU)
13-3440	17	36-inch CSP S. side stadium (KU)
13-3441	17	Pond (KU)
13-3442	17	12'x 3.5' RCP pond outlet (KU)
13-3500	18	7'x 12' stone box downstream from RR culvert
13-3510	18	Natural channel
13-3530	18	10'x 9' RCB across RR
13-3540	18	84-inch CSP upstream end RR culvert
13-3550	18	6.25'x 6.25' RCB NE corner 8th & Pennsylvania
13-3560	18	6'x 6' RCB along 8th, W. of New York to Penn.
13-3570	18	5.5'x 5.33' stone box between Conn. & N.Y., 8th-9th
13-3580	18	4'x 4' RCB between Conn. & N.Y., 9th-10th
13-3590	18	48-inch brick pipe between Conn. & N.Y., 10th-11th
13-3600	18	24-inch CSP along 11th & S. on Rhode Island
13-3610	18	24-inch CSP, Mass. to R.I., S. of 11th
13-3620	18	4'x 4' RCB along 9th, W. of R.I. to E. of Conn.
13-3630	18	36-inch brick pipe along 9th, Vermont to W. of R.I.
13-3650	18	30-inch CSP along Pennsylvania, 8th to 9th
13-3660	18	24-inch CSP along 9th, Penn. to Delaware

WATERSHED NO. 14 - EAST LAWRENCE
EXISTING SYSTEM DESCRIPTION

REACH NO.	MAP NO. REFERENCE	DESCRIPTION
14-3000	19	Natural channel
14-3010	18	10'x 6' RCB, 13th to 12th, Oregon to Haskell
14-3020	18	6'x 6' RCB along W. side RR, 15th to 13th
14-3021	25	36-inch CSP along 15th, E. of Maryland
14-3030	25	Natural channel with detention @ 15th
14-3031	25	36"x 22" CSPA S. of 15th, Delaware to E. of Maryland
14-3040	25	Natural channel
14-3050	25	8'x 4' RCB across 19th, E. of Learnard
14-3060	25	8-ft. conc. block channel, SE of 19th & Learnard
14-3070	25	8'x 4' RCB across Learnard, S. of 19th
14-3080	25	Natural channel
14-3090	25	51"x 31" CSPA N. side Barker Ct.
14-3100	25	54"x 42" CSPA across Barker & along R.I., S. of 20th
14-3109	25	30-inch CSP along Massachusetts, 22nd to 21st
14-3110	25	4'x 3.5' RCB N. of 21st, Mass. to R.I.
14-3120	25	30-inch CSP along 21st, Kentucky to Mass.
14-3130	25	30-inch CSP along 19th, E. of Learnard
14-3140	25	36-inch CSP along 19th, Connecticut to Learnard
14-3150	25	30-inch CSP along 19th, N. Hampshire to Conn.
14-3160	25	27-inch CSP along 19th, Mass. to N.H.
14-3170	25	24-inch CSP along 19th, Kentucky to Mass.
14-3180	25	Channel along W. side RR, N. of 19th
14-3190	25	75"x 48" CSPA across 19th, W. side RR
14-3200	25	Channel along W. side RR, S. of 19th
14-3210	25	36-inch RCP, priv. prop. E. of Delaware, S. of 19th
14-3220	25	60"x 38" CSPA along Lynn, W. of Haskell
14-3230	26	58"x 36" CSPA across Haskell @ Lynn/18th
14-3240	26	43"x 27" CSPA along Haskell 19th to Lynn/18th
14-3250	18	5'x 5' RCB S. of 13th, New Jersey to Oregon
14-3260	18	5'x 4' RCB across New Jersey & E. to N.Y., S. of 13th
14-3270	18	5'x 4' RCB across New York @ 14th
14-3280	18	5'x 4' RCB along 14th, Connecticut to New York
14-3290	18	36-inch CSP along 14th, Rhode Island to Connecticut
14-3300	18	30-inch CSP along 14th, New Hampshire to Rhode Island
14-3310	18	6'x 4.5' RCB, 15th & R.I. to 14th & Conn.
14-3320	25	42-inch CSP along 15th, N.H. to R.I.
14-3330	25	42-inch CSP along N.H. S. of 15th & 16th to Mass.
14-3340	25	24-inch CSP along 16th, Kentucky to Mass.
14-3350	25	21-inch CSP along Kentucky, 15th to 16th
14-3360	25	50"x 36" CSPA along 19th, W. of RR
14-3370	25	50"x 33" CSPA @ 19th & Moodie
14-3380	25	Two 24-inch CSP @ 19th & Moodie
14-3390	25	40"x 30" CSPA along Moodie, S. of 19th
14-3400	25	Natural channel
14-3410	25	50"x 31" CSPA across 19th, E. side RR

WATERSHED NO. 15 - BROOK STREET
EXISTING SYSTEM DESCRIPTION

REACH NO.	MAP NO. REFERENCE	DESCRIPTION
15-2000	26	Turf channel S. of 21st Terr.
15-2001	26	30-inch CSP S. of 21st Terr.
15-2010	26	4-ft conc. channel between 18th & 18th Terr.
15-2100	19	Turf channel along S. side Oak Hill
15-3000	19	Natural channel
15-3001	19	Bridge near 12th & Brook St.
15-3010	19	48-inch CSP across 13th @ Brook St.
15-3020	19	12-ft. riprap channel, S. of 13th, E. of Brook
15-3030	19	Double 48-inch CSP across Brook St., S. of 13th
15-3040	19	Natural channel
15-3050	26	10'x 6' RCB across 15th, E. of Haskell
15-3060	26	Natural channel
15-3070	26	60-inch RCP along Maple Lane, N. of Glenn
15-3071	26	36-inch RCP W. of Maple Lane between 18th & 18th Terr.
15-3072	26	75-inch CSP, N. end of Maple Lane
15-3080	26	54-inch RCP along Maple Lane, N. of 19th
15-3090	26	65"x 40" CSPA along Maple Lane, 19th to 21st
15-3100	26	42-inch CSP along 21st St., W. of Maple Lane
15-3110	26	42-inch CSP 21st Terr. to 21st St., W. of Maple Lane
15-3111	26	36-inch CSP S. of 21st. Terr.
15-3120	26	42-inch CSP along Maple Lane, S. of 21st
15-3130	26	36-inch CSP W. side Maple Lane @ 19th
15-3140	26	48-inch RCP along 15th, W. of Prairie
15-3150	26	42-inch CSP S. of 15th @ Prairie
15-3160	26	36-inch RCP S. of 15th, W. of Cadet Ave.
15-3161	26	75'x 75' detention pond in cemetery
15-3170	19	6'x 4' RCB across 13th @ Brook St.

WATERSHED NO. 16 - SUNFLOWER
EXISTING SYSTEM DESCRIPTION

REACH NO.	MAP NO. REFERENCE	DESCRIPTION
16-2000	26	Natural channel
16-2010	26	Natural channel
16-3000	26	8'x 7.5' RCB across 15th E. of Lindenwood
16-3010	26	Natural channel
16-3030	26	180'x 550' detention pond S. of 15th
16-3040	26	Natural channel
16-3050	26	60-inch CSP culvert under mobile home park rd.
16-3060	26	Natural channel
16-3070	26	36-inch CSP culvert under 19th
16-3080	26	Natural channel
16-3090	26	Natural channel

WATERSHED NO. 17 - NORTH LAWRENCE
EXISTING SYSTEM DESCRIPTION

REACH NO.	MAP NO. REFERENCE	DESCRIPTION
17-3000	11	Triple 8'x 4' RCB across N. 2nd @ pump station
17-3002	11	Natural channel
17-3010	11	60-inch RCP through levee west of N. 2nd
17-3020	11	48-inch RCP through levee west of N. 2nd
17-3030	11	30-inch CSP along N. 2nd, pump station to river
17-3040	11	5'x 4' RCB at pump station outlet
17-3050	4	5'x 5' RCB across Hwy 59 @ Hwy 40
17-3060	4	36-inch RCP across Hwy 40 @ Hwy 59
17-3070	4	36-inch RCP across Hwy 40 @ Hwy 59
17-3080	4	6'x 4' RCB across Hwy 59 @ Hwy 40
17-3090	11	Double 30-inch CIP pump discharge lines
17-3100	11	36-inch CSP at pump station outlet
17-3110	11	8-ft. concrete channel to pump station
17-3111	11	20-ft. concrete channel to pump station
17-3120	11	60-inch CSP across N. 3rd, so. of North St.
17-3130	11	20-ft. concrete channel, North St. to N.3rd
17-3140	11	60-inch CSP across North St., between N. 3rd & N. 4th
17-3150	11	40,000 GPM pump station, N. 2nd St.
17-3160	12	30-inch RCP through levee @ so. end of N. 8th St.
17-3170	12	18-inch CSP along N. 8th, Maple to levee
17-3180	11	30-inch RCP through levee @ so. end of N. 7th St.
17-3181	11	18-inch CSP along N. 7th, Elm to levee
17-3190	11	30-inch RCP through levee @ so. end of N. 6th St.
17-3191	11	24-inch CSP along N. 5th, Locust to levee
17-3192	11	18-inch CSP discharge line from 5th & Maple pump sta.
17-3193	11	15-inch CSP along Lincoln & N. 6th (from 7th to Maple)
17-3200	11	30-inch RCP through levee @ so. end of N. 5th St.
17-3201	11	18-inch CSP along N. 5th, Elm to levee
17-3210	11	30-inch RCP along Locust, N. 3rd to N. 2nd
17-3220	4	30-inch CSP along N. 3rd
17-3224	11	30-inch CSP along N. 3rd, so. of North St.
17-3230	4	24-inch CSP along N. 2nd, so. of I70
17-3240	4	18-inch CSP along N. 2nd, so. of I70
17-3250	4	15-inch CSP along N. 2nd, so. of I70
17-3260	4	Natural channel
17-3270	4	Natural channel
17-3275	4	RCB across Hwy. 40, E. of Hwy. 59

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PART VI - RECOMMENDED SYSTEM IMPROVEMENTS

PART VI

RECOMMENDED SYSTEM IMPROVEMENTS

A. ALTERNATIVE SYSTEM COMPONENTS

1. GENERAL

There are two basic types of drainage system components, "structural" and "nonstructural." Both types must be operated in a complementary way to avoid drainage "problems." Each element of the system has a cost associated with providing it. The goal of this plan is to recommend the best balanced combination of all system elements that will provide an acceptable level of service at the greatest economic benefit to the City as a whole.

2. NONSTRUCTURAL ELEMENTS

Nonstructural elements of a drainage system are generally those elements that don't involve significant capital construction but function as a part of the system of limiting runoff. Their "cost" is primarily measured by generally lowered tax revenue and economic activity, although some direct maintenance cost often applies to their continued performance. Once they become part of the "system" they can't readily be modified because such modifications will increase runoff to the entire downstream system reducing its level of service. Nonstructural elements include the following.

a. Zoning and Land Use

Zoning ordinances prescribe types of land use and density of development which determines, in part, relative runoff rates. Dense land use, such as commercial or industrial development, generates high runoff rates compared to residential or agricultural land use; areas of small lots will generate more runoff than areas developed in large lots. In real estate vernacular, the "highest and best use" of land produces the greatest tax revenue which corresponds with the densest types of development. Down-zoning to reduce runoff, and the associated cost of the downstream drainage system, reduces the potential revenue from properties. This loss of revenues, then, can be viewed as the "cost" of zoning with respect to drainage.

b. Drainage Easements

Drainage easements involve the acquisition of the right to construct and maintain improved drainage facilities and to periodically use a natural channel and its overbank floodway or the overflow channel above an improved conveyance element to convey drainage. In some sense, these easements represent a form of limited conservation zoning in that they can be written so as to preclude any improvement of the land occupied by the easement. Drainage easements follow the natural or improved channel or pipe alignment and vary in width to include all land below the elevation of the design hydraulic gradient or water surface elevation. In some instances it may also be desirable to extend the easement to allow for some amount of freeboard above that level also. Representative easement widths are in the range of 50 to 100 feet for natural channels and 15 to 40 feet for improved system facilities.

Because these easements are typically located on private property, maintenance responsibility generally falls to the individual property owners. Natural channels and their overbank areas require little initial construction but must be maintained on a regular basis to remove obstructing debris and snags. Overflow channels above enclosed pipes or along improved channels must also be maintained to prevent obstructions to flow.

c. Regulatory Detention

Regulatory detention is the adoption of appropriate ordinances and implementation of regulations that, while permitting intense land uses, require the provision, operation, and maintenance of on-site detention facilities to limit the peak rate of discharge from the owner's, or developer's, site to the downstream system. These regulations require no direct capital investment by the City but have the effect of either diminishing the net developable land by the area required for detention or requiring more costly structures as part of the development. They are most effective when physically located at the upper end of watersheds.

d. Removal of Improvements

The purchase, demolition, and removal of structures subject to damage from drainage is a viable method of providing drainage service to the City as a whole. Drainage "problems" are the damage and/or extreme nuisance resulting from the flow of storm water on private and public property. Removal of the affected improvements is a viable choice in cases where the cost of managing the water is disproportionately large compared with the value of the improvement.

3. STRUCTURAL ELEMENTS

Structural elements of a drainage system are those designed to collect and convey runoff. They include structures that require a significant capital investment to build, and will depreciate over a long period of time. Structural components of the system include conveyance facilities and public detention facilities.

a. Conveyance Facilities

Conveyance facilities are the conventional drainage structures such as pipes, curb and area inlets, culverts, bridges, and lined open channels.

b. Public Detention Facilities

Public detention facilities are ponds, dry ponds, and functionally similar structures constructed with controlled service and emergency spillways that are operated by the City to reduce the peak rate of flow in the drainage system. Land enclosed by some may be capable of other beneficial uses such as open parks and buffer zones between different land use areas. The construction cost of the facility is often moderate when compared with alternative structural conveyance facilities. Because they are functionally most effective when located near the upper reaches of watersheds, the land occupied is valuable, and its acquisition forms a large part of the cost of their development. They require regular maintenance in the form of mowing and periodic removal of the sediment trapped by the facility.

4. COMPARISON OF ALTERNATIVES

Table VI-1 presents a qualitative comparison of the performance and cost impact typical of the alternative system components.

TABLE VI-1

COMPARISON OF ALTERNATIVES

System Component	Land Area Required	Land Value	Tax Base Effect	Regular Maint. Required	Capital Cost	Depr.
Nonstructural						
Downzoning	None	High	Negative	None	None	None
Drainage Easements	High	Low	None	High	None	None
Regulatory Detention	Moderate	High	Slight	None	None	None
Removal of Improvements	Moderate	High	Negative	None	None	None
Structural						
Enclosed Pipe/Culvert	Low	None	None	Moderate	High	High
Lined Open Channels	Moderate	None	None	Moderate	Moderate	High
Municipal Detention Basins	High	High	Slight	High	Moderate	Low

5. EVALUATION OF ALTERNATIVES

a. Zoning and Land Use

The majority of open land available for development within the drainage basins included in this study is located along the west edge of Lawrence. Other areas, although more limited in extent, are in the south and southeast sections of the City. Zoning in these areas is primarily residential with some neighborhood commercial. Several parcels are platted or currently under development in the vicinity.

No areas where zoning has been defined, either in currently developed or undeveloped sections of the City, were identified where zoning changes would eliminate existing problems. In addition, because of the lack of an improved drainage system in much of the undeveloped area, no areas were identified where downzoning would prevent future problems of such magnitude to preclude development.

b. Drainage Easements

It is recommended that the City require dedication of drainage easements for all new or reconstructed major system conveyance elements, including natural channels retained in the system in developing areas. The major system is defined as those sections of the drainage system where the 10-year peak discharge equals or exceeds 70 CFS. These easements should cover the overflow area for the element, whether open channel or enclosed system, determined as the 100-year flood elevation plus one foot for freeboard. Limitations on permanent obstructions within the easement should be included in the dedication. Specific requirements for drainage easements are included in the proposed "Stormwater Management Criteria" document which has been included as an appendix to this report.

c. Regulatory Detention

The City's current drainage policies include the use of regulatory detention in connection with commercial development; however, continuation of this policy as currently applied is not recommended. In general, detention requirements should be based on actual need rather than an arbitrary rule. In most areas where existing problems have been identified, physical space for adequate detention facilities is not available and small, localized basins will not eliminate major problems. It is recommended, therefore, that the detention policy be revised as outlined in the "Stormwater Management Criteria" manual prepared as a separate document from this report.

d. Removal of Improvements

The removal of improvements was not identified as a recommended alternative in any of the watersheds as a solution to existing drainage problems; however, at the time detailed design for any recommended project is undertaken, this option should be investigated in more detail. Based upon current appraised values of the specific properties impacted by flooding, removal of those existing improvements may be a more cost effective solution than infrastructure improvements to the storm drainage system.

e. Conveyance Facilities

The recommended system improvements primarily involve enlarged or modified conveyance facilities, typically through replacement of existing facilities with larger pipes or box culverts. Open channels currently included in the system were retained. Specific information and policies dealing with selection and design of conveyance elements is presented in the "Stormwater Management Design Criteria" document.

f. Public Detention Facilities

A public detention facility was investigated in the Country Club watershed between Iowa and Michigan, south of I-70, as a possible means of eliminating the need for improvements to the existing culvert on Michigan (Line 12-3220 shown on Fig. VI-12). However, the capital cost of the detention basin and its annual maintenance cost were determined to be greater than the improvements required for the culvert and road.

The possibility for other public detention facilities is limited by the extent of existing development in most of the watersheds evaluated. In the Yankee Tank West watershed much of the area already drains to Clinton Lake, a private detention/recreational facility, and substantial green spaces are indicated along the major open channels in planned developments which can function as temporary detention areas. Public detention possibilities are more likely to be feasible in currently undeveloped watersheds, such as Baldwin Creek, and should be thoroughly investigated as those areas develop.

B. CAPITAL IMPROVEMENT PROJECTS

1. SCOPE

The general locations of capital improvement projects recommended by the study to correct deficiencies in the existing drainage system are indicated on Figure VI-1a and b. Projects include one or more deficient modeled reaches of the drainage system that have been grouped to define a project that is logically constructable as an entity and, when complete, will eliminate an existing deficiency within the drainage system.

Although essentially all existing major drainage system components were included in the analysis and problem identification process, not all elements that fail to meet the proposed recommended hydraulic criteria for new construction are included in the project recommendations. Locations where deficiencies are indicated by the analysis but where there are no apparent or reported adverse effects are not recommended for improvement. In addition, facilities such as state highway culverts, railroad culverts and privately-owned drainage facilities have not been recommended for improvement since the City does not have jurisdiction over those system elements.

Generally, the recommended projects include only those major drainage system elements which are currently public facilities where the existing deficiency has one or more of the following recurring adverse effects.

- Building flooding at 25 year or more frequent intervals due to inadequacy of the existing public drainage system.
- Overflow of public streets by the 2-year storm for a time duration greater than 15 minutes.
- Erosion on private property due to the direct discharge from public drainage facilities that, if permitted to continue, will eventually either endanger buildings or adversely affect the use of the property.
- Recurring nuisance and the lack of maintenance control created by the uncontrolled discharge of water collected in public right-of-way onto adjacent private property.

Improvements along natural channels that are located in developed areas, and which by definition are part of the major drainage system, are not included in the recommended projects list. While it is noted that problems related to open channels have been reported at a number of locations, the City's policy to date has been not to perform maintenance or make repairs on existing, unimproved channels retained in the drainage system of developed areas. Many of these locations, however, have been included in a list of "discretionary" projects which is presented and discussed later in this section.

2. RECOMMENDED PLAN SUMMARY

Table VI-2 summarizes the projects and the costs included in the recommended improvements program. The following pages present the detailed information and sketches indicating the location and extent for each one. Information on cost estimating and priority ranking is discussed in more detail later in this section. In addition to the projects listed, improvements are planned along N. 2nd Street, just north of the river, as part of a street improvement project which includes some of the reaches identified as deficient in the North Lawrence system.

It should be noted that the recommended projects are essentially all composed of improvements to the storm drainage infrastructure. The sizes and extent of various components are based on the best preliminary information and assumptions available for a planning study of this type. Once the actual design of any improvement project is undertaken, the specific data available for the site at that time (such as underground utility locations, easement or right-of-way restrictions, geotechnical limitations, etc.) will very likely result in revisions to the particular type or size of facility. As noted previously, more specific information may even require consideration of a completely different approach to the problem such as removal of existing flood-prone structures rather than improvement of the drainage system. For planning and budget purposes, however, the system components included in the recommended project descriptions are reasonable estimates of the magnitude of the improvements required at each of the identified drainage problem locations.

TABLE VI - 2
RECOMMENDED CAPITAL IMPROVEMENT PROJECTS

Project Number	Project Name	Capital Cost	Annual Maint. Cost
1	15th St. System	$ 91,200	$ 120
2	8th-9th-Crawford	130,000	160
3	Crestline-Westdale	139,500	150
4	15th St.-Iowa St.	790,400	890
5	Lawrence Ave.	540,000	650
6	29th Court	148,000	220
7	Ridge Court	110,000	165
8	23rd & Ousdahl	1,022,800	1,235
9	Carolina St. System	2,563,100	2,620
10	21st St. West System	1,256,600	1,535
11	20th St. East System	2,563,100	2,735
12	22nd-23rd St. West	297,500	575
13	26th-Four Wheel Dr.	544,250	560
14	27th St.-Saratoga	526,000	510
15	West Indian Ave.	325,000	500
16	23rd St.- Haskell Ave.	111,000	155
17	2nd-3rd-Michigan-Arkansas	1,140,300	1,310
18	3rd-4th-Minnesota	400,900	570
19	Michigan St. Culvert	102,100	60
20	6th St.- Arkansas	304,900	430
21	7th St.-Michigan St.	159,000	170
22	Tennessee-Kentucky	946,000	1,235
23	8th-Ohio-Tennessee	463,500	435
24	9th-10th-Mississippi	1,140,000	1,140
25	8th-9th-Connecticut	482,000	480
26	9th-Vermont-New Hampshire	137,000	220
27	14th St.- New Jersey	266,400	530
28	13th & Oregon	2,248,000	2,150
29	21st St.-Massachusetts	604,000	700
30	19th-Kentucky to Leanard	1,282,900	1,420
31	Haskell & Lynn	163,800	245
32	16th-Kentucky-New Hampshire	2,299,700	1,460
33	13th St.-Brook St. Culvert	171,000	155
34	Maple Lane-19th-Brook St.	1,080,000	1,160
35	15th-Summit-Prairie	175,100	225
36	19th St. Culvert	35,000	45
37	N. 5th & Maple System	3,323,000	5,000
38	N. 8th-Maple to Levee	1,648,000	2,000
39	N. 4th-Elm to Levee	226,000	350
40	N. 2nd-I70 to North St.	1,494,800	1,630
41	N. 7th-Elm to Levee	285,700	465
	Totals	$ 32,038,150	$ 36,365

LAWRENCE, KANSAS
STORMWATER MANAGEMENT MASTER PLAN
CAPITAL IMPROVEMENT PROJECT RECOMMENDATION

PROJECT NAME: 15th St. System

PROJECT IDENTIFICATION NUMBER: 1

PERTINENT DATA SUMMARY:

Watershed: Quail Creek
Priority Group: III Priority No.: N/A
Design Capacity: 86 - 89 cfs
Cost Estimates: Capital $ 91,200 Annual $ 120
Model Reach Number(s): 3 - 3330, 3340
Map Reference Sheets: 22
Return Period: 10 years

EXISTING PROBLEM DESCRIPTION:

The existing system of pipes located along 15th St. beginning approximately 1300 feet west of Kasold Dr. and continuing to the west for 300 feet, currently provides a 2-year level of service. The system overflows will be conveyed along 15th St. to the west creating traffic problems for this heavily traveled street.

RECOMMENDED IMPROVEMENTS:

Replace the existing system with 1) 31" X 51" RCPA for the upstream section of the system along 15th St. (Line 3340) and 2) 42-inch RCP for the downstream section of the system (Line 3330). All replacements will be completed within the existing street right-of-way. The downstream system is adequate to handle flows after the improvements are made.

LAWRENCE, KANSAS
STORMWATER MANAGEMENT MASTER PLAN
CAPITAL IMPROVEMENT PROJECT RECOMMENDATION

PROJECT NAME: 8th St. - 9th St. - Crawford System

PROJECT IDENTIFICATION NUMBER: 2

PERTINENT DATA SUMMARY:

Watershed: Yankee Tank East
Priority Group: III Priority No.: N/A
Design Capacity: 197 - 200 CFS
Cost Estimates: Capital $ 130,000 Annual $ 160
Model Reach Number(s): 4 - 3350, 3360
Map Reference Sheets: 16
Return Period: 10 years

EXISTING PROBLEM DESCRIPTION:

The existing system of pipes along Crawford between Chalk Hill Ct. and Holiday Dr. and then approximately 250 feet to the northwest to an open channel, has less than a 2-year capacity. As a result of the undersized system, the water will back up in the upstream channel and could flood the areas adjacent to the channel. Reportedly, flooding problems have occurred near 8th St. and Arizona along an upstream channel.

RECOMMENDED IMPROVEMENTS:

Replace the existing system with 1) 65" X 40" RCPA along Crawford between Holiday Dr. and the open channel to the northwest (Line 3360) and 2) 73" X 45" RCPA along Crawford between Holiday Dr. and Chalk Hill Ct. (Line 3350). The replacements will be completed within the current street right-of-way. The downstream system is adequate to handle increased flows after improvements are made.

LAWRENCE, KANSAS
STORMWATER MANAGEMENT MASTER PLAN
CAPITAL IMPROVEMENT PROJECT RECOMMENDATION

PROJECT NAME: Crestline Dr. - Westdale Dr. System

PROJECT IDENTIFICATION NUMBER: 3

PERTINENT DATA SUMMARY:
Watershed: Yankee Tank East
Priority Group: III Priority No.: N/A
Design Capacity: 180 - 235 CFS
Cost Estimates: Capital $ 139,500 Annual $ 150
Model Reach Number(s): 4 - 3470, 3480, 3490
Map Reference Sheet(s): 16
Return Period: 10 years

EXISTING PROBLEM DESCRIPTION:

The existing culvert (Line 3470) located across Westdale Circle approximately 150 feet northwest of Westdale Rd., and the culvert (Line 3490) located beneath Crestline Dr. approximately 150 feet north of Westdale Rd., both provide a 2-year level of service. In both cases, water has the potential to back up in the upstream channel, flood several residences, and overtop the road creating access problems to the homes in the area. A third culvert (line 3480), which is located further downstream beneath Westdale Rd., currently has a 10-year capacity provided water is allowed to build up at the upstream end level with the top of the road. This depth of headwater causes the ponding to extend close to the house near the upstream end of the culvert.

RECOMMENDED IMPROVEMENTS:

Replace the culverts with the following: 1) 84" X 61" RCPA for the culvert at Westdale Circle (Line 3470) and 2) 60-inch RCP for the culvert across Crestline Dr. (Line 3490). Due to the increased capacity in these two culverts, the downstream culvert at Westdale (Line 3480) will also need to be enlarged. To provide the required capacity, add a 72-inch RCP parallel to the existing culvert. All replacements can be accomplished within existing drainage easements or street right-of-way.

LAWRENCE, KANSAS
STORMWATER MANAGEMENT MASTER PLAN
CAPITAL IMPROVEMENT PROJECT RECOMMENDATION

PROJECT NAME: 15th St. - Iowa St. System

PROJECT IDENTIFICATION NUMBER: 4

PERTINENT DATA SUMMARY:

Watershed: Yankee Tank East
Priority Group: II Priority No.: N/A
Design Capacity: 405 - 467 CFS
Cost Estimates: Capital $ 790,400 Annual $ 890
Model Reach Number(s): 4 - 3580, 3590, 3600
Map Reference Sheets: 23
Return Period: 10 years

EXISTING PROBLEM DESCRIPTION:

The existing system of pipes which is located along 15th St. beginning approximately 700 feet west of Iowa St. and heading west to Westbrooke St. and then continuing south along Westbrooke St. approximately 350 feet to an open channel (Line 3610), is inadequate. Lines 3580 and 3590 provide less than a 2-year level of service, and line 3600 has a 2-year capacity. The system overflows will impact 15th St. as the water will collect in the depression area at the intersection of 15th St., Crestline Dr., and Westbrooke St. creating traffic problems along this heavily traveled thoroughfare.

RECOMMENDED IMPROVEMENTS:

Replace the existing system with 1) 60-inch RCP along 15th St. beginning approximately 700 feet west of Iowa St. and heading west to Crestline Dr. (Line 3580); 2) 66-inch RCP along 15th St. between Crestline Dr. and Westbrooke St. (Line 3590); and 3) 72-inch RCP along Westbrooke St. between 15th St. and the open channel (Line 3600). All replacements will be completed within the existing street right-of-ways or drainage easements. The downstream channel appears to be adequate for the increased flows due to the improvements.

If the existing system (lines 3580, 3590, and 3600) is determined to be in good condition, the existing pipe could be improved to carry the 10-year discharge by lining the invert of the pipe with concrete instead of replacing it.

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STORMWATER MANAGEMENT MASTER PLAN
CAPITAL IMPROVEMENT PROJECT RECOMMENDATION

PROJECT NAME: Lawrence Ave.

PROJECT IDENTIFICATION NUMBER: 5

PERTINENT DATA SUMMARY:
Watershed: Yankee Tank East
Priority Group: III Priority No.: N/A
Design Capacity: 117 - 361 CFS
Cost Estimates: Capital $ 540,000 Annual $ 650
Model Reach Number(s): 4- 3400, 3410, 3430
Map Reference Sheets: 16
Return Period: 10 years

EXISTING PROBLEM DESCRIPTION:

The existing system of pipes along Lawrence Ave. between 7th St. and 8th St. and between 9th St. and Steven Dr. provides a level of service of 2 years for Line 3430 and less than 2 years for Line 3410. The system overflows will be conveyed along Lawrence Ave. to the south potentially flooding the street.

RECOMMENDED IMPROVEMENTS:

Replace the existing system along Lawrence Ave. with a 42-inch RCP for the section between 7th and 8th St. (Line 3430) and a 60-inch RCP from 9th St. to Steven Dr. (Line 3410). With these improvements in place, the capacity of downstream Line 3400 will be less than a 10-year level. Replace this line with a 72-inch RCP. The replacements will be completed within the existing street right-of-way.

If the existing pipes in all three reaches are determined to be in good condition, the existing pipe could be improved to carry the 10-year discharge by lining the invert of the pipe with concrete or completely lining the interior of existing corrugated metal pipes instead of replacing them completely.

PROJECT NAME: 29th Court

PROJECT IDENTIFICATION NUMBER: 6

PERTINENT DATA SUMMARY:

Watershed: Naismith
Priority Group: I   Priority No.: 6
Design Capacity: 56 CFS
Cost Estimates: Capital $ 148,000   Annual $ 220
Model Reach Number(s): 5-3000, 3010
Map Reference Sheets: 30
Return Period: 10 years

EXISTING PROBLEM DESCRIPTION:

The existing system along 29th Court west of Missouri St. consists of a 43"x 27" CMPA (Line 3000) at the lower end and a 36"x 24" CMPA (Line 3010) at the upper end. Line 3000 provides a 2-year level of service and Line 3010 provides less than a 2-year level. This lack of capacity results in overflows into the street which drain onto and across the lots at the west end of the cul-de-sac. Flooding of at least one house in this location has been reported.

RECOMMENDED IMPROVEMENTS:

Replace both lines with a 51"x 31" RCPA for the entire length within the existing street right-of-way and drainage easement. The downstream system is adequate for any increased flows although the impact of these improvements will be negligible.

LAWRENCE, KANSAS
STORMWATER MANAGEMENT MASTER PLAN
CAPITAL IMPROVEMENT PROJECT RECOMMENDATION

PROJECT NAME: Ridge Court

PROJECT IDENTIFICATION NUMBER: 7

PERTINENT DATA SUMMARY:

Watershed: Naismith
Priority Group: I Priority No.: 11
Design Capacity: 134 CFS
Cost Estimates: Capital $ 110,000 Annual $ 165
Model Reach Number(s): 5-3040
Map Reference Sheets:
Return Period: 10 years

EXISTING PROBLEM DESCRIPTION:

The existing system in this area is a 36" CMP (Line 3040) that runs along Ridge Court south of 27th Terr. and makes a 90-degree bend to the east south of 28th Terr. The line discharges into an open channel near the south end of Ousdahl. The existing reach provides less than a 2-year level of service resulting in frequent overflows into the street. Flooding of at least one house at the end of the street has been reported.

RECOMMENDED IMPROVEMENTS:

Replace the existing pipe with a 58"x 36" RCPA along the current alignment.

LAWRENCE, KANSAS
STORMWATER MANAGEMENT MASTER PLAN
CAPITAL IMPROVEMENT PROJECT RECOMMENDATION

PROJECT NAME: 23rd and Ousdahl System

PROJECT IDENTIFICATION NUMBER: 8

PERTINENT DATA SUMMARY:

Watershed: Naismith
Priority Group: II Priority No.: N/A
Design Capacity: 99-183 CFS
Cost Estimates: Capital $ 1,022,800 Annual $ 1,235
Model Reach Number(s): 5-3340, 3360, 3361, 3362
Map Reference Sheets: 24, 30
Return Period: 10 years

EXISTING PROBLEM DESCRIPTION:

The existing drainage system consists of Line 3340, a 72"x 44" CMPA running across the shopping center parking lot on the southeast corner of the 23rd & Ousdahl intersection; Line 3360, a 58"x 36" CMPA along the north side of 23rd ST. just east of Ousdahl; Line 3361, a 58"x 36" CMPA running north on Ousdahl and then west behind the commercial properties fronting 23rd St.; and Line 3362, a 48" CMP also located behind the commercial buildings on 23rd. All of these provide a 2-year or less level of service which results in flooding of the streets. The intersection of 23rd and Ousdahl is a low point in the area and is frequently inundated and impassable.

RECOMMENDED IMPROVEMENTS:

Leave Line 3340 through the shopping center in service but divert part of the flow to a new parallel line. Add a 48" RCP beginning at the intersection and running south along Ousdahl then east on 24th St., tying into the existing system on the south end of Line 3340. As part of this bypass system, replace the existing 18" CMP along the south side of 23rd St., from Ousdahl to Ridge Court, with a 4.5'x 2' RCB. The small portion of Line 3340 along 24th St. will also need to be replaced with a 4'x 4' RCB. Replace Line 3360 with a 5'x 3' RCB and Lines 3361 and 3362 with a 48" RCP (or equivalent 58"x 36" RCPA). All of the improvements will be made within the existing street right-of-way or drainage easements.

As an option for Lines 3361 and 3362, the corrugated metal lines hydraulic characteristics could be improved enough to provide the required capacity by installing a smooth lining. The decision on lining vs. replacement will depend primarily on the structural condition of the pipes at the time the improvements are to be made.

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STORMWATER MANAGEMENT MASTER PLAN
CAPITAL IMPROVEMENT PROJECT RECOMMENDATION

PROJECT NAME: Carolina Street System

PROJECT IDENTIFICATION NUMBER: 9

PERTINENT DATA SUMMARY:
Watershed: Naismith
Priority Group: I Priority No.: 2
Design Capacity: 35-375 CFS
Cost Estimates: Capital $ 2,563,700 Annual $ 2,620
Model Reach Number(s): 5-2335, 2355, 3445, 3450, 3451, 3460, 3470, 3480, 3490, 3500
Map Reference Sheets: 24
Return Period: 10 years

EXISTING PROBLEM DESCRIPTION:

The existing system in this area begins with Line 2355 (24" CMP) along 21st ST. from Louisiana west to Carolina, and Line 2335 (18" CMP) along 21st from Alabama east to Carolina. Just east of the Carolina-21st St. intersection, these two reaches discharge into Line 3490 (58"x 36" CMPA) which runs south, parallel to and approximately 200 ft. east of Carolina, to 22nd St. At 22nd, Line 3480 (58"x 36" CMPA) turns to the west, continuing to the 22nd ST.-Alabama intersection where Line 3470 turns south along Alabama. At 22nd Terr., the system splits into two branches. Line 3500 (48" CMP) continues south along Alabama while Line 3460 (58"x 36" CMPA) runs west along 22nd Terr. for approximately 400 ft. At this point, the flow turns south through Line 3450 (58"x 36" CMPA) and joins Line 3451 (58"x 36" CMPA) carrying flows from Line 3500 at the north side of 23rd St. The system crosses 23rd St. in Line 3445 (6'x 2.25' RCB).

This system is severely undersized with all lines providing much less than a 2-year level of service. The area is subject to frequent flooding of streets and yards and, on several occasions, houses or other structures. The problem is exacerbated by overflows from the system at 20th and Alabama which run down Alabama to 21st St. Flooding was severe enough at one location on 22nd Terr. that the City purchased and removed a house that had been subject to repeated problems.

RECOMMENDED IMPROVEMENTS:

Replace Lines 2335 and 2355 with a 30" RCP and a 6'x 2.5' RCB, respectively. Leave Line 3490 in service and add a parallel 6'x 3' RCB along Carolina to 20th St. Replace the small section of Line 3480 along 20th from Carolina to Alabama with a 8'x 3' RCB. Replace Lines 3470, 3500 and 3451 with a double 8'x 3.5' RCB along Alabama to 23rd and west along 23rd to Line 3445. Leave Lines 3450 and 3460 in service as overflow lines. Replace Line 3445 across 23rd St. with a triple 5.5'x 3' RCB.

All improvements will be made within the existing street right-of-way.

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STORMWATER MANAGEMENT MASTER PLAN
CAPITAL IMPROVEMENT PROJECT RECOMMENDATION

PROJECT NAME: 21st Street West System

PROJECT IDENTIFICATION NUMBER: 10

PERTINENT DATA SUMMARY:
Watershed: Naismith
Priority Group: I Priority No.: 5
Design Capacity: 57-152 CFS
Cost Estimates: Capital $ 1,256,600 Annual $ 1,535
Model Reach Number(s): 5-2435, 2445, 2452, 2457, 3750, 3760, 3770
Map Reference Sheets:
Return Period: 10 years

EXISTING PROBLEM DESCRIPTION:

The existing system along 21st St. west of Naismith Dr. begins north of 21st between Stewart and the cul-de-sac at the west end of 20th Terr. Line 2457 (30" CMP)runs south to 21st and then east. Line 2452 (24" CMP) begins approximately 300 ft. east of the bend and continues along 21st to a point about halfway between Ousdahl and Clifton Ct. At this point Line 2445 (24" CMP), which runs from 20th St. to 21st, joins Line 2452. The combined flows continue to the east along 21st in Line 2435 (30" CMP). At Clifton Ct., this line discharges into Line 3770 (36" CMP). The system continues along 21st St. in Lines 3760 (42" CMP) and 3750 (48" CMP) discharging into Naismith Creek at the 21st St. bridge, Line 3780.

All of the lines in this system, except Line 3750, provide less than a 2-year level of service. Line 3750 provides a 5-year level of service. The inadequacy of this system results in frequent flooding of streets and yards and has caused flooding of houses near both the upper and lower ends.

RECOMMENDED IMPROVEMENTS:

Replace Lines 2445, 2452 and 2457 with 36" RCPs (or equivalent 43"x 27" RCPAs). Replace Lines 2435, 3750, 3760 and 3770 with a 5.5'x 3' RCB. All of the improvements will be constructed within existing street right-of-way or drainage easements. The downstream channel and bridges are adequate for the increased flows.

LAWRENCE, KANSAS
STORMWATER MANAGEMENT MASTER PLAN
CAPITAL IMPROVEMENT PROJECT RECOMMENDATION

PROJECT NAME: 20th Street East System

PROJECT IDENTIFICATION NUMBER: 11

PERTINENT DATA SUMMARY:

Watershed: Naismith
Priority Group: I Priority No.: 7
Design Capacity: 78-261 CFS
Cost Estimates: Capital $ 2,563,100 Annual $ 2,735
Model Reach Number(s): 5-2485, 2505, 2515, 2535, 3740, 3850, 3851, 3852
Map Reference Sheets: 24
Return Period: 10 years

EXISTING PROBLEM DESCRIPTION:

The existing system in this area begins at 17th and Alabama with Line 2515 (21" CMP) and runs south along Alabama through Line 2505 (30" CMP) between 18th and 19th, and Line 3852 (58"x 36" CMPA) between 19th and 20th. At 20th St., Line 3851 (65"x 40" CMPA) turns to the west. Lines 2485 (36"x 24" CMPA) and 2535 (29"x 18" CMPA), which run along Missouri north of 20th, combine with Line 3851 at the intersection of 20th and Missouri. Line 3850 (60"x 48" CMPA) continues west along 20th, discharging into the enclosed portion of Naismith Creek, Line 3740, which also collects flows from KU's system.

All of the reaches in this system provide considerably less than a 2-year level of service except for Line 3740 which currently provides approximately a 10-year level; however, Line 3740 also will need to be replaced due to planned improvements to KU's system. The undersized system to the east of Naismith results in frequent street flooding. The major impact of the inadequate system, however, occurs in the Carolina Street system where overflows from Line 3852 drain south along Alabama, inundating the already undersized system at 21st St.

RECOMMENDED IMPROVEMENTS:

Replace Lines 2485 and 2535 along Missouri with a 4.5'x 2.5' RCB and a 5'x 2' RCB, respectively. Replace Lines 2505 and 2515 along Alabama with a 4.5'x 3' Rcb and a 43"x 27" RCPA, respectively. Replace Line 3740 with a 11'x 6' RCB, Line 3852 with a 5'x 3' RCB, and Lines 3850 and 3851 with a 7'x 5' RCB. Along with the larger system reaches, additional curb inlets will be required to allow the drainage into the system. All improvements will be constructed within existing street right-of-way.

Note: Although there are currently no reports of actual structure flooding in this area, this project has been included in the critical projects list (discussed later in this section) due to its impact on the downstream Carolina Street system where flooding does occur.

LAWRENCE, KANSAS
STORMWATER MANAGEMENT MASTER PLAN
CAPITAL IMPROVEMENT PROJECT RECOMMENDATION

PROJECT NAME: 22nd St.-23rd St. West

PROJECT IDENTIFICATION NUMBER: 12

PERTINENT DATA SUMMARY:
Watershed: Naismith
Priority Group: III   Priority No.: N/A
Design Capacity: 72-86 CFS
Cost Estimates: Capital $ 297,500   Annual $ 575
Model Reach Number(s): 5-3860, 3870
Map Reference Sheets: 24
Return Period: 10 years

EXISTING PROBLEM DESCRIPTION:

The existing system consists of Lines 3860 (36"x 22" CMPA) and 3870 (43"x 27" CMPA) running south between 22nd St and 23rd St. approximately 400 ft. west of Naismith Dr. The pipes run along the side lot lines of houses facing 22nd and 22nd Terr., and commercial buildings along 23rd St. Both of these reaches provide less than a 2-year level of service resulting in overflows from the system running through yards.

RECOMMENDED IMPROVEMENTS:

Replace both Lines 3860 and 3870 with 58"x 36" RCPAs within the existing drainage easements. (It is assumed that easements already exist for this portion of the system.)

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STORMWATER MANAGEMENT MASTER PLAN
CAPITAL IMPROVEMENT PROJECT RECOMMENDATION

PROJECT NAME: 26th St. - Four Wheel Drive

PROJECT IDENTIFICATION NUMBER: 13

PERTINENT DATA SUMMARY:
Watershed: KLWN
Priority Group: III Priority No.: N/A
Design Capacity: 109-233 CFS
Cost Estimates: Capital $ 544,250 Annual $ 560
Model Reach Number(s): 6-3050, 3060, 3070
Map Reference Sheets: 29
Return Period: 10 years

EXISTING PROBLEM DESCRIPTION:

The existing system in this area includes Line 3050 (65"x 40" CMPA), Line 3060 (58"x 36" CMPA), and Line 3070 (58"x 36" CMPA) running from 26th St. to 27th St. just east of Four Wheel Dr. All three of these lines provide less than a 2-year level of service resulting in street flooding.

RECOMMENDED IMPROVEMENTS:

Replace Lines 3050, 3060 and 3070 with a 8'x 3.5' RCB, a 7'x 3' RCB, and a 5'x 3' RCB, respectively, within the existing street right-of-way and drainage easement.

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STORMWATER MANAGEMENT MASTER PLAN
CAPITAL IMPROVEMENT PROJECT RECOMMENDATION

PROJECT NAME: 27th St. - Saratoga System

PROJECT IDENTIFICATION NUMBER: 14

PERTINENT DATA SUMMARY:
Watershed: Belle Haven
Priority Group: III Priority No.: N/A
Design Capacity: 202- 226 CFS
Cost Estimates: Capital $ 526,000 Annual $ 510
Model Reach Number(s): 7 - 3070, 3080, 3081
Map Reference Sheets: 30
Return Period: 10 years

EXISTING PROBLEM DESCRIPTION:

The existing system beginning at 27th St. between Haven Dr. and Louisiana St. and to the north to Saratoga is currently undersized. The lines 3080 and 3081 provide a level of service less than 2 years, and line 3070 has a 5-year level of service. The system overflow travels through the backyards of the homes fronting on Haven Dr. and by the homes around both Saratoga and Seabrook cul-de-sacs. Reportedly, water flows towards the cul-de-sac on Saratoga and drains into some of the homes. Downstream from this area at 28th Pl. and 29th Pl., the cul-de-sacs experience a similar problem as the one in Saratoga cul-de-sac.

RECOMMENDED IMPROVEMENTS:

Replace the existing system with a single 7.5' X 3' RCB (Lines 3070, 3080, 3081). In Saratoga and Seabrook cul-de-sacs, the current drainage from the street could be collected and conveyed to the improved system by placing curb inlets in the cul-de-sac and extending a pipe from the cul-de-sac to the RCB. Similarly at 28th Pl and 29th Pl, curb inlets should be placed in the cul-de-sac with a pipe extending into the natural channel to the west. All major system improvements will be constructed within current drainage easements or street right-of-ways. The extension of an enclosed system from the cul-de-sacs would require additional easements.

Note: Although this project as a whole has been included in Priority Group III, the minor system improvements required to eliminate structure flooding are included in a Group I project, separate from the other improvements described here.

PROJECT NAME: West Indian Ave. System

PROJECT IDENTIFICATION NUMBER: 15

PERTINENT DATA SUMMARY:

Watershed: Broken Arrow
Priority Group: III Priority No.: N/A
Design Capacity: 45 - 107 CFS
Cost Estimates: Capital $ 325,000 Annual $ 500
Model Reach Number(s): 8 - 3020, 3040, 3050, 3060, 3100
Map Reference Sheets: 31
Return Period: 10 years

EXISTING PROBLEM DESCRIPTION:

The existing system of pipes begins at Pawnee Ave. approximately 600 feet east of Massachusetts St. and heads south to West Indian Ave., then west along West Indian Ave. to West Perimeter Rd., south along West Perimeter Rd., and finally southwest into a natural channel. The system components of 3020, 3040, and 3050 provide less than a 2-year level of service, and pipe number 3060 has a 5-year level of service. Also, the existing culvert across Vermont St. at West Indian Ave (Line 3100) provides a level of service less than 2 years. The overflow from the system runs through a residential area and along the street causing traffic and access problems in the area.

RECOMMENDED IMPROVEMENTS:

Replace the entire system with 1) 36-inch RCP starting at Pawnee Ave. approximately 600 feet east of Massachusetts then south to West Indian Ave. (Line 3020); 2) 36-inch RCP along West Indian Ave. (Line 3060); 3) 36-inch RCP continuing along West Indian Ave to West Perimeter Rd. and south along West Perimeter Rd. (Line 3050); 4) 48-inch RCP from West Perimeter Rd. to the southeast into the natural channel (Line 3040); and 5)a single 4.5' X 2' RCB across Vermont St. at West Indian Ave (Line 3100). All of these improvements will be constructed within the existing street right-of-ways or drainage easements. The modifications to line 3100 could also be considered as a separate project.

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CAPITAL IMPROVEMENT PROJECT RECOMMENDATION

PROJECT NAME: 23rd St. - Haskell Ave. System

PROJECT IDENTIFICATION NUMBER: 16

PERTINENT DATA SUMMARY:
Watershed: Haskell
Priority Group: II Priority No.: N/A
Design Capacity: 75 CFS
Cost Estimates: Capital $ 111,000 Annual $ 155
Model Reach Number(s): 9 - 3420
Map Reference Sheets: 31
Return Period: 10 years

EXISTING PROBLEM DESCRIPTION:

The existing system is located along 23rd St beginning at Haskell Ave. and heads west for approximately 425 feet, and it has a level of service of less than 2 years. The system overflows will flood the intersection of 23rd St. and Haskell Ave. causing traffic problems through this major intersection.

RECOMMENDED IMPROVEMENTS:

Replace the existing pipe with a 42-inch RCP for its entire length along 23rd St. (Line 3420). The replacement will be completed within the existing street right-of-way. If line 3420 is determined to be in good condition and has adequate slope, the existing pipe could be improved to carry the 10-year discharge by lining the invert of the pipe with concrete instead of replacing it.

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CAPITAL IMPROVEMENT PROJECT RECOMMENDATION

PROJECT NAME: 2nd St. - 3rd St. - Michigan St. - Arkansas St. System

PROJECT IDENTIFICATION NUMBER: 17

PERTINENT DATA SUMMARY:
Watershed: Country Club
Priority Group: I   Priority No.: 1
Design Capacity: 411 - 476 CFS
Cost Estimates: Capital $ 1,140,300   Annual $ 1,310
Model Reach Number(s): 12 - 3030, 3033, 3040 (exist.); 3031 and 3032 (new).
Map Reference Sheets: 10
Return Period: 10 years

EXISTING PROBLEM DESCRIPTION:

The existing system of pipes begins at the intersection of Minnesota St. and 3rd St. and continues to the east along 3rd St. to Michigan St. At Michigan St., the system turns to the north and follows Michigan St. to 2nd St., and finally, it travels along 2nd St. to the east to Arkansas St. Lines 3030 and 3033 provide less than a 5-year level of service, and line 3040 has a capacity of 5 years. The system overflows will impact the surrounding residential developments, particularly, the homes on the east side of Michigan St. between 2nd and 3rd St. The lack of an improved minor system in the area also contributes to yard and structure flooding. Several homes have reportedly been flooded in this area more than once.

RECOMMENDED IMPROVEMENTS:

Replace the existing system as follows: 1) 84-inch RCP along 3rd St. between Minnesota and Michigan St. (Line 3040); 2) 84-inch RCP along Michigan between 2nd and 3rd St. (Line 3033); and 3) 84-inch RCP along 2nd St. between Michigan and Arkansas St. (Line 3030). In addition, extend a 15-inch RCP (Line 3031) north along Michigan from 2nd St., and a 24-inch RCP (Line 3032) west along 2nd St. from Michigan. The replacements and additional will be completed within the existing street right-of-way.

Provided that the pipes are found to be in good condition and the pipe slopes are adequate, the inverts of the existing system could be lined with concrete instead of being replaced in order to convey the 10-year flows.

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STORMWATER MANAGEMENT MASTER PLAN
CAPITAL IMPROVEMENT PROJECT RECOMMENDATION

PROJECT NAME: 3rd St. - 4th St. - Minnesota St. System

PROJECT IDENTIFICATION NUMBER: 18

PERTINENT DATA SUMMARY:

Watershed: Country Club
Priority Group: III Priority No.: N/A
Design Capacity: 128 - 129 CFS
Cost Estimates: Capital $ 400,900 Annual $ 570
Model Reach Number(s): 12 - 3150, 3160 (exist.); 3161 and 3162 (new).
Map Reference Sheets: 10
Return Period: 10 years

EXISTING PROBLEM DESCRIPTION:

The existing system of pipes located along Minnesota St. between 4th St. and 3rd St. provides a 2-year level of service. The system overflows will be carried along Minnesota St. to the north and along 3rd St. to the east. The residents on the southeastern corner of the intersection of Minnesota St. and 3rd St. may experience some flooding in their yards.

RECOMMENDED IMPROVEMENTS:

Replace the downstream section of the existing system from 4th St. with a 58" X 36" RCPA (Line 3160) and replace the upstream section of the system along Minnesota to 3rd St. with a 48-inch RCP (Line 3150). In addition, extend a 36-inch RCP (Line 3161) west along 4th St. between Minnesota and Wyoming, and a 24-inch RCP (Line 3162) from Wyoming to California. The improvements will be constructed within existing street right-of-ways.

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STORMWATER MANAGEMENT MASTER PLAN
CAPITAL IMPROVEMENT PROJECT RECOMMENDATION

PROJECT NAME: Michigan St. Culvert

PROJECT IDENTIFICATION NUMBER: 19

PERTINENT DATA SUMMARY:
Watershed: Country Club
Priority Group: III Priority No.: N/A
Design Capacity: 1100 CFS
Cost Estimates: Capital $ 102,100 Annual $ 60
Model Reach Number(s): 12 - 3220
Map Reference Sheets: 3
Return Period: 10 years

EXISTING PROBLEM DESCRIPTION:

The existing box culvert across Michigan St. approximately 1300 feet south of the Kansas Turnpike (I70) has a level of service of less than 2 years. The open channel upstream from the structure will store the excess water and has the potential to flood portions of the surrounding townhome development. The water may also overtop Michigan St. causing access problem along the street. The downstream channel is very flat and reportedly poorly maintained, contributing to the problems at the culvert; however, that channel is located in Douglas Co. and outside the jurisdiction of the City.

RECOMMENDED IMPROVEMENTS:

Replace the existing box culvert with a triple cell 8' X 5.5' RCB. In order to obtain the required depth, road reconstruction along Michigan St. is necessary. Michigan St. will have to be raised approximately 2 feet in the vicinity of the box culvert and will require a total length of road reconstruction of approximately 525 feet. Also, minor grading operations may be needed upstream of the RCB in order to widen the existing channel to correspond to the wider box culvert. The replacement of the culvert will be completed within existing street right-of-way. Additional construction and drainage easements, however, may have to be secured for the road reconstruction and regrading upstream of the culvert.

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STORMWATER MANAGEMENT MASTER PLAN
CAPITAL IMPROVEMENT PROJECT RECOMMENDATION

PROJECT NAME: 6th St. - Arkansas St. System

PROJECT IDENTIFICATION NUMBER: 20

PERTINENT DATA SUMMARY:
Watershed: Downtown
Priority Group: II Priority No.: N/A
Design Capacity: 86 - 282 CFS
Cost Estimates: Capital $ 186,500 Annual $ 280
Model Reach Number(s): 13 - 3070, 3250, 3260 (exist.); 3061 (new).
Map Reference Sheets: 10
Return Period: 10 years

EXISTING PROBLEM DESCRIPTION:

The existing system is located along 6th St. between Florida St. and Arkansas St. and then turns north across 6th St at Arkansas St. The crossing at 6th St. and Arkansas is a parallel system consisting of a 5' X 4' RCB (Line 3250) and a 54-inch CSP (Line 3070). Lines 3060 and 3070 have approximately a 5-year level of service while Line 3250 provides a level of service greater than 100 years. The RCB conveys the portion of the flow from Line 3260 and flow collected in curb inlets along 6th St. Overflow from the system would travel along 6th St. to the east causing flooding on one of the city's major thoroughfares.

RECOMMENDED IMPROVEMENTS:

Line 3260, along 6th St. between Florida and Arkansas, should be replaced by a 36-inch RCP. The parallel system at 6th and Arkansas should be eliminated to improve system continuity and facilitate system maintenance. The modifications include reconstructing the system on the south side of 6th St. by connecting Line 3070 into the existing 5' X 4' RCB (Line 3250) and abandoning the remaining portion of 3070 to the north. A new 48-inch RCP (Line 3061) will be added parallel to Line 3060 to provide adequate capacity. After completing these improvements, the RCB (Line 3250) will provide a level of service of 25 years. The reconstruction and replacement will be completed within the existing street right-of-way.

LAWRENCE, KANSAS
STORMWATER MANAGEMENT MASTER PLAN
CAPITAL IMPROVEMENT PROJECT RECOMMENDATION

PROJECT NAME: 7th St. - Michigan St. System

PROJECT IDENTIFICATION NUMBER: 21

PERTINENT DATA SUMMARY:

Watershed: Downtown
Priority Group: III Priority No.: N/A
Design Capacity: 164 CFS
Cost Estimates: Capital $ 159,000 Annual $ 170
Model Reach Number(s): 13 - 3100
Map Reference Sheets: 17
Return Period: 10 years

EXISTING PROBLEM DESCRIPTION:

The existing 48-inch CSP culvert (Line 3100) located across Michigan, just south of the intersection of 7th St. and Michigan St., provides a 2-year level of service. The channel directly upstream from this pipe has the potential to back-up and flood the residential areas along the west side of Michigan St. and the commercial area to the west of the existing channel due to the lack of capacity.

RECOMMENDED IMPROVEMENTS:

The existing pipe should be replaced by a 65" X 40" RCPA between the intersection of 7th St. and Michigan St. and the drainage channel to the southwest. The replacement will be completed within existing drainage easements.

LAWRENCE, KANSAS
STORMWATER MANAGEMENT MASTER PLAN
CAPITAL IMPROVEMENT PROJECT RECOMMENDATION

PROJECT NAME: Tennessee St. - Kentucky St. System

PROJECT IDENTIFICATION NUMBER: 22

PERTINENT DATA SUMMARY:

Watershed: Downtown
Priority Group: II   Priority No.: N/A
Design Capacity: 81 - 169 CFS
Cost Estimates: Capital $ 946,000   Annual $ 1,235
Model Reach Number(s): 13 - 3360, 3370, 3380
Map Reference Sheets: 18
Return Period: 10 years

EXISTING PROBLEM DESCRIPTION:

The existing system of pipes along Tennessee St. from 8th St. to 10th St. then west along 10th St. to Kentucky St. and along Kentucky St. south to 12th St. has a capacity of less than 2 years. The system overflows will travel to the north along Kentucky St. causing traffic problems on a heavily traveled thoroughfare and may flood some residential and commercial properties on the east side of Kentucky St. at the upstream end of the system. The overflows along 10th St. will flow generally to the east through a residential area and then continue to the north also along Kentucky. Similarly, the surcharged stormwater on Tennessee St. will flow to the north primarily in the street causing traffic problems along the major street.

RECOMMENDED IMPROVEMENTS:

Replace the entire system with 1) 48-inch RCP along Tennessee between 8th St. and 10th St. (Line 3360); 2) 48-inch RCP along 10th from Tennessee St. to Kentucky St. and south along Kentucky to 11th St. (Line 3370); and 3)42-inch RCP along Kentucky St. from 11th St. to 12th St. (Line 3380). The replacements of these pipes will be completed within the existing street right-of-ways.

After these improvements are made, the downstream system (Lines 3310, 3320 and 3340) will all provide slightly less than a 10-year level of service; however, because these reaches are in Buford Watson Park, no real damage will occur from overflows.

LAWRENCE, KANSAS
STORMWATER MANAGEMENT MASTER PLAN
CAPITAL IMPROVEMENT PROJECT RECOMMENDATION

PROJECT NAME: 8th St. - Ohio St. - Tennessee St. System

PROJECT IDENTIFICATION NUMBER: 23

PERTINENT DATA SUMMARY:
Watershed: Downtown
Priority Group: II Priority No.: N/A
Design Capacity: 348 - 354 CFS
Cost Estimates: Capital $ 463,500 Annual $ 435
Model Reach Number(s): 13 - 3401, 3402
Map Reference Sheets: 18
Return Period: 10 years

EXISTING PROBLEM DESCRIPTION:

The existing system of stone boxes structures beginning in the rear yards of the homes fronting on Ohio St. and Tennessee St. to the south of 8th St., running north to 8th St. and then east along 8th St. to Tennessee St. only has a 2-year level of service. The system overflows have the potential to flood the residential properties in the southwest corner of the intersection of 8th St. and Tennessee St. Some of the excess water will travel to the north along Tennessee St. and collect in Buford Watson Park located at the southeast corner of the intersection of 7th and Tennessee St.

RECOMMENDED IMPROVEMENTS:

Replace the existing stone boxes with RCB as follows: 1) 6' X 6' RCB behind the homes on both Ohio St. and Tennessee St. from 8th St. and approximately 250 feet to the south (Line 3401); 2) 6' X 6' RCB along 8th St. beginning approximately 150 feet east of Ohio St. and continuing to the east to Tennessee St (Line 3402). The replacements of these stone boxes will be completed within the existing street right-of-ways or drainage easements.

LAWRENCE, KANSAS
STORMWATER MANAGEMENT MASTER PLAN
CAPITAL IMPROVEMENT PROJECT RECOMMENDATION

PROJECT NAME: 9th St. - 10th St. - Mississippi St. System

PROJECT IDENTIFICATION NUMBER: 24

PERTINENT DATA SUMMARY:
Watershed: Downtown
Priority Group: II   Priority No.: N/A
Design Capacity: 327 - 363 CFS
Cost Estimates: Capital $ 1,140,000   Annual $ 1,140
Model Reach Number(s): 13 - 3410, 3421
Map Reference Sheets: 17
Return Period: 10 years

EXISTING PROBLEM DESCRIPTION:

The existing system of RCBs (Lines 3410 and 3421) begins at 11th St. and heads to the north to 10th St. approximately 150 feet west of Mississippi St., continues to the northeast to Mississippi St. approximately 300 feet south of 9th St., turns to the east for approximately 150 feet, then north to 9th St. behind the homes on both Mississippi St. and Indiana St., and finally east along 9th St. to approximately 150 feet east of Indiana St. Line 3410 has a 2-year capacity, and line 3421 provides less than a 2-year level of service. The system overflows could flood several residential and commercial areas around 9th and Mississippi, and water could travel along 9th St. creating traffic problems along the major street.

RECOMMENDED IMPROVEMENTS:

The existing system should be replaced with 1) 5' X 4' RCB for the section of the system 150 feet west of Mississippi St. between 11th and 10th St. (Line 3421); and 2) 5' X 5' RCB for the remaining portion of the system from 10th St. to 9th St. and east past Indiana St. (Line 3410). The improvements will be made within the existing street right-of-ways and drainage easements.

After the improvements are made, Lines 3399 through 3406 will have adequate capacity as long as improvements to Lines 3401 and 3402, as described under Project 23, are completed first.

LAWRENCE, KANSAS
STORMWATER MANAGEMENT MASTER PLAN
CAPITAL IMPROVEMENT PROJECT RECOMMENDATION

PROJECT NAME: 8th St. - 9th St. - Connecticut St. System

PROJECT IDENTIFICATION NUMBER: 25

PERTINENT DATA SUMMARY:
Watershed: Downtown
Priority Group: III Priority No.: N/A
Design Capacity: 326 CFS
Cost Estimates: Capital $ 482,000 Annual $ 480
Model Reach Number(s): 13 - 3570
Map Reference Sheets: 18
Return Period: 10 years

EXISTING PROBLEM DESCRIPTION:

The existing stone box starts at 9th St. and runs north to 8th St. and is located approximately 150 feet east of Connecticut St. The current structure provides less than a 2-year level of service. The system overflows could impact the residential areas bounded by 9th St., New York St., 8th St., and Connecticut St. Also, water will flow to the east along 8th St. towards the industrial region at the RR tracks.

RECOMMENDED IMPROVEMENTS:

Replace the entire length of the existing stone box with a 5' X 5.5' RCB. The replacement will be made within existing drainage easements or street right-of-ways.

LAWRENCE, KANSAS
STORMWATER MANAGEMENT MASTER PLAN
CAPITAL IMPROVEMENT PROJECT RECOMMENDATION

PROJECT NAME: 9th St. - Vermont St. - New Hampshire St. System

PROJECT IDENTIFICATION NUMBER: 26

PERTINENT DATA SUMMARY:
Watershed: Downtown
Priority Group: I Priority No.: 12
Design Capacity: 54 CFS
Cost Estimates: Capital $ 137,000 Annual $ 220
Model Reach Number(s): 13 - 3630
Map Reference Sheets: 18
Return Period: 10 years

EXISTING PROBLEM DESCRIPTION:

The existing brick pipe, located along 9th St. between Vermont St. and New Hampshire St., currently has a capacity of 2-years. The system will surcharge into 9th St., potentially flooding the street and creating traffic problems along this heavily traveled street. Flooding of commercial buildings in the area has been reported in the past.

RECOMMENDED IMPROVEMENTS:

The current pipe should be replaced by a 36-inch RCP for its entire length along 9th St. The pipe replacement will be completed within the street right-of-way.

LAWRENCE, KANSAS
STORMWATER MANAGEMENT MASTER PLAN
CAPITAL IMPROVEMENT PROJECT RECOMMENDATION

PROJECT NAME: 14th and New Jersey

PROJECT IDENTIFICATION NUMBER: 27

PERTINENT DATA SUMMARY:
Watershed: East Lawrence
Priority Group: III Priority No.: N/A
Design Capacity: 70-327 CFS
Cost Estimates: Capital $ 266,400 Annual $ 530
Model Reach Number(s): 14-3280, 3290, 3300
Map Reference Sheets: 18
Return Period: 10 years

EXISTING PROBLEM DESCRIPTION:

The existing system in this area runs along 14th St. from Massachusetts to New York and then northeasterly to New Jersey, between 13th and 14th, and consists of reaches 3260, 3270, 3280, 3290 and 3300. All of the lines except 3270 provide less than a 2-year level of service resulting in street flooding and access problems in the area.

RECOMMENDED IMPROVEMENTS:

To increase the system capacity 1) add one 4'x 4' cell to Line 3280, an existing 5'x 4' RCB along 14th St. between Connecticut and New York; 2) replace Line 3290, a 36" CMP, with a 42" RCP; and 3) replace Line 3300, a 30" CMP, with a 36" RCP. All improvements will be constructed in existing street right-of-way.

LAWRENCE, KANSAS
STORMWATER MANAGEMENT MASTER PLAN
CAPITAL IMPROVEMENT PROJECT RECOMMENDATION

PROJECT NAME: 13th and Oregon Streets

PROJECT IDENTIFICATION NUMBER: 28

PERTINENT DATA SUMMARY:

Watershed: East Lawrence
Priority Group: I Priority No.: 3
Design Capacity: 90-560 CFS
Cost Estimates: Capital $ 2,248,000 Annual $ 2,150
Model Reach Number(s): 14 - 3010, 3020, 3250, 3260
Map Reference Sheets: 18
Return Period: 10 years

EXISTING PROBLEM DESCRIPTION:

The existing system consists of a 5'x 4' RCB (Line 3260) located along New Jersey for part of the distance between 13th and 14th Streets; a 5'x 5' RCB (Line 3250) approximately 200 ft. south of and parallel to 13th St.; a 6'x 6' RCB (Line 3020) beginning at the south side of 15th St. near Maryland and continuing north parallel to the railroad to its intersection with Line 3250 near 13th and Oregon; and a 10'x 6' RCB (Line 3010) from this intersection northeast to the east side of Haskell, just north of 12th St. Currently, Lines 3010, 3020 and 3260 provide less than a 2-year level of service while Line 3250 provides between a 2 and 5-year level resulting in flooding of streets and private property in the area. Flooding of a commercial structure just north of 15th St., adjacent to the railroad, has been reported several times. A small detention area south of 15th St., in Parnell Park, has inadequate storage capacity and little room for expansion to alleviate this problem.

RECOMMENDED IMPROVEMENTS:

Add a second 10'x 6' barrel to Line 3010; a 4'x 6' barrel to Line 3020; a 3'x 5' barrel to Line 3250; and a 13'x 5' barrel to Line 3260.

LAWRENCE, KANSAS
STORMWATER MANAGEMENT MASTER PLAN
CAPITAL IMPROVEMENT PROJECT RECOMMENDATION

PROJECT NAME: 21st and Massachusetts

PROJECT IDENTIFICATION NUMBER: 29

PERTINENT DATA SUMMARY:
Watershed: East Lawrence
Priority Group: I Priority No.: 4
Design Capacity: 69-181 CFS
Cost Estimates: Capital $ 604,000 Annual $ 700
Model Reach Number(s): 14-3090, 3100, 3120
Map Reference Sheets: 25
Return Period: 10 years

EXISTING PROBLEM DESCRIPTION:

The existing system in this area begins at 21st and Kentucky with Line 3120, a 30" CMP, running east along 21st to Mass. Line 3110, a 4'x 3.5' RCB, then angles northeast to New Hampshire approximately one-half block north of 21st and continues east to Rhode Island. Line 3100, a 54"x 42" CMPA, turns north and runs along Rhode Island for approximately 300 ft. before turning east again to Barker Ave. The system ends with Line 3090, a 51"x 30" CMPA angling across Barker Ct. and discharging into an open channel north of the cul-de-sac. All of the reaches except Line 3110 provide less than a 2-year level of service which results in street and yard flooding in the area. Because of the very flat grades in the area, the water is also slow to recede once the enclosed system can accept more inflow. Flooding of several structures has been reported in the vicinity.

RECOMMENDED IMPROVEMENTS:

Replace Lines 3090 and 3100 with a 5.5'x 3' RCB and Line 3120 with a 52"x 32" RCPA. Line 3110 should be left as-is in the system. Line 3120 and approximately half of Line 3100 will be constructed in the existing street right-of way. The remainder of Line 3100 and Line 3090 will be constructed along their existing alignments. It is assumed that drainage easements for both lines already exist.

LAWRENCE, KANSAS
STORMWATER MANAGEMENT MASTER PLAN
CAPITAL IMPROVEMENT PROJECT RECOMMENDATION

PROJECT NAME: 19th - Kentucky to Leanard

PROJECT IDENTIFICATION NUMBER: 30

PERTINENT DATA SUMMARY:

Watershed: East Lawrence
Priority Group: II Priority No.: N/A
Design Capacity: 80-127 CFS
Cost Estimates: Capital $ 1,282,900 Annual $ 1,420
Model Reach Number(s): 14-3130, 3140, 3150, 3160, 3170
Map Reference Sheets: 25
Return Period: 10 years

EXISTING PROBLEM DESCRIPTION:

The existing system runs along 19th St. from Kentucky to just east of Leanard and consists of Lines 3130 (30" CMP), 3140 (36" CMP), 3150 (30" CMP), 3160 (27" CMP), and 3170 (24" CMP). All of these reaches provide less than a 2-year level of service resulting in street flooding along a heavily-traveled route. Flat slopes along part of the length and relatively few curb inlets also cause the water to recede slowly once the pipe system empties and is able to accept additional inflow.

RECOMMENDED IMPROVEMENTS:

Replace Lines 3130, 3140, 3150 and 3160 with a 5'x 2.5' RCB and Line 3170 with a 4'x 2.5' RCB. Additional curb inlets along the entire system will also be required to correct the problem. All of these improvements will be constructed in the existing street right-of-way.

LAWRENCE, KANSAS
STORMWATER MANAGEMENT MASTER PLAN
CAPITAL IMPROVEMENT PROJECT RECOMMENDATION

PROJECT NAME: Haskell and Lynn

PROJECT IDENTIFICATION NUMBER: 31

PERTINENT DATA SUMMARY:
Watershed: East Lawrence
Priority Group: III   Priority No.: N/A
Design Capacity: 70-86 CFS
Cost Estimates: Capital $ 163,800   Annual $ 245
Model Reach Number(s): 14-3230, 3240
Map Reference Sheets: 26
Return Period: 10 years

EXISTING PROBLEM DESCRIPTION:

The existing system in this area includes Line 3230, a 58"x 36" CMPA across Haskell Ave. at its intersection with Lynn, and Line 3240, a 43"x 27" CMPA along Haskell from 19th to Lynn. Both of these lines provide less than a 2-year level of service which results in overflows into the street and intersection.

RECOMMENDED IMPROVEMENTS:

Replace both lines with 51"x 31" RCPA and add curb inlets on the south side of the intersection at Lynn. All improvements will be constructed in the existing street right-of-way.

LAWRENCE, KANSAS
STORMWATER MANAGEMENT MASTER PLAN
CAPITAL IMPROVEMENT PROJECT RECOMMENDATION

PROJECT NAME: 16th - Kentucky to New Hampshire

PROJECT IDENTIFICATION NUMBER: 32

PERTINENT DATA SUMMARY:

Watershed: East Lawrence
Priority Group: I Priority No.: 10
Design Capacity: 35-199 CFS
Cost Estimates: Capital $ 2,299,700 Annual $ 1,460
Model Reach Number(s): 14-3320, 3330, 3340, 3350
Map Reference Sheets: 25
Return Period: 10 years

EXISTING PROBLEM DESCRIPTION:

Line 3350, a 21" CMP, begins the existing system at the corner of 15th and Kentucky running south along Kentucky then east on 16th to Vermont. At Vermont, Line 3340, a 24" CMP, runs along 16th to Massachusetts. Line 3330, a 42" CMP, begins at Massachusetts, angles slightly northeast and then runs north along New Hampshire to 15th St. Line 3320, also a 42" CMP, runs east along 15th from New Hampshire to Barker. All of these existing lines provide less than a 2-year level of service resulting in street flooding in the area. Flooding of residential structures has been reported in the area.

RECOMMENDED IMPROVEMENTS:

Replace Lines 3320, 3340 and 3350 with a 5'x 4' RCB, a 42" RCP, and a 36"x 22" RCPA, respectively. For additional capacity in Line 3330 without disturbing the residential property where the line is located, extend a 48" RCP from the existing system alignment east along 15th to New Hampshire and then north along New Hampshire, tying back into line 3330 where it enters the street right-of-way. From that point, replace the remainder of Line 3330 to 15th St. with a 5'x 4' RCB. All improvements will be constructed in existing street right-of-way.

LAWRENCE, KANSAS
STORMWATER MANAGEMENT MASTER PLAN
CAPITAL IMPROVEMENT PROJECT RECOMMENDATION

PROJECT NAME: 13th St. - Brook St. Culvert

PROJECT IDENTIFICATION NUMBER: 33

PERTINENT DATA SUMMARY:

Watershed: Brook Street
Priority Group: III Priority No.: N/A
Design Capacity: 600 CFS
Cost Estimates: Capital $ 171,000 Annual $ 155
Model Reach Number(s): 15 - 3010
Map Reference Sheets: 19
Return Period: 10 years

EXISTING PROBLEM DESCRIPTION:

The existing 48" culvert is located across 13th St. approximately 30 feet east of Brook St., and it provides a level of service less than 2 years. Line 3170 which has a capacity of 50 years is located in a separate channel only about 25 feet to the east of line 3010. The current system will create a back up in the channel on the east side of Brook St. and may overflow into the residential area and overtop the street.

RECOMMENDED IMPROVEMENTS:

Replace the existing 48-inch culvert (Line 3010) and create a single culvert structure which crosses 13th St. Two additional 6' X 4' RCB cells should be added next to the existing 6' X 4' RCB (Line 3170) in order to provide a 10-year level of service for the combined flows through the improved structure. Additionally, regrading and minor earthwork will be required upstream of the new structure to create a single point of convergence for the flows from both tributaries into the new culvert. The replacement will be completed within the existing street right-of-way. However, additional drainage easements may have to be secured in the area upstream of the new structure.

LAWRENCE, KANSAS
STORMWATER MANAGEMENT MASTER PLAN
CAPITAL IMPROVEMENT PROJECT RECOMMENDATION

PROJECT NAME: Maple Lane - 19th St. - Brook St. System

PROJECT IDENTIFICATION NUMBER: 34

PERTINENT DATA SUMMARY:
Watershed: Brook Street
Priority Group: I Priority No.: 9
Design Capacity: 71 - 284 CFS
Cost Estimates: Capital $ 1,080,000 Annual $ 1,160
Model Reach Number(s): 15 - 3070, 3071, 3080, 3100, 3130
Map Reference Sheets: 26
Return Period: 10 years

EXISTING PROBLEM DESCRIPTION:

One section of the existing system begins at the intersection of 21st St. and Maple Lane and continues to the southwest along 21st St. for approximately 250 feet. This portion of the system, line 3100, has a level of service of less than 5 years. Next, line 3130, which crosses Maple Lane on the south side of 19th St., has a capacity of less than 2 years. The existing system then follows Maple Lane from 19th St. north to Brook St. and then continues to the northwest where it discharges into an open channel. The downstream end of the system, line 3071, has a capacity of 2 years, and lines 3070 and 3080 provide a level of service of less than 2 years. The majority of the system overflows will be conveyed along Maple Lane to the north creating traffic and access problems in the area. Flooding of residential structures has been reported in the area.

RECOMMENDED IMPROVEMENTS:

The existing system should be replaced with 1) 42-inch RCP for line 3100 along Maple Lane from 21st St. and to the southwest; 2) 58" X 36" RCPA across Maple Lane at 19th St. (Line 3130); 3) 88" X 54" RCPA along Maple Lane between 19th St. and 18th St. (Line 3080); 4) 88" X 54" RCPA along Maple Lane from 18th St. north to Brook St. (Line 3070); and 5) 78-inch RCP between Brook St. and the open channel to the northwest (Line 3071). All the replacements will be completed within existing street right-of-ways.

If line 3100 is determined to be in good condition, the existing pipe could be improved to carry the 10-year discharge by lining the invert of the pipe with concrete. Also, this section of the system could be considered as a separate project which would have a capital cost of $67,500 and an annual cost of $91.

LAWRENCE, KANSAS
STORMWATER MANAGEMENT MASTER PLAN
CAPITAL IMPROVEMENT PROJECT RECOMMENDATION

PROJECT NAME: 15th St. - Summit St. - Prairie Ave. System

PROJECT IDENTIFICATION NUMBER: 35

PERTINENT DATA SUMMARY:

Watershed: Brook Street
Priority Group: III Priority No.: N/A
Design Capacity: 115 CFS
Cost Estimates: Capital $ 175,100 Annual $ 225
Model Reach Number(s): 15-3150
Map Reference Sheets: 26
Return Period: 10 years

EXISTING PROBLEM DESCRIPTION:

The existing 42-inch CSP pipe along 15th St. beginning 100 feet west of Summit St. and continuing to Prairie Ave. has a 2-year level of service. The system overflows will flood the residential areas to the north of 15th St. Overflows will also be conveyed along 15th St., Prairie Ave. and Prospect Ave. creating problems for traffic in this area.

RECOMMENDED IMPROVEMENTS:

Replace the existing pipe with a 48-inch RCP for its entire length along 15th St. The replacement will occur within the existing street right-of-way.

LAWRENCE, KANSAS
STORMWATER MANAGEMENT MASTER PLAN
CAPITAL IMPROVEMENT PROJECT RECOMMENDATION

PROJECT NAME: 19th Street Culvert

PROJECT IDENTIFICATION NUMBER: 36

PERTINENT DATA SUMMARY:
Watershed: Sunflower
Priority Group: III   Priority No.: N/A
Design Capacity: 130 CFS
Cost Estimates: Capital $ 35,000   Annual $ 45
Model Reach Number(s): 16-3070
Map Reference Sheets: 26
Return Period: 10 years

EXISTING PROBLEM DESCRIPTION:

The existing 36-inch culvert across 19th St. provides a 2-year level of service. At return periods greater than 2 years, flows overtop the street at this location creating traffic and access problems. Since this street is the primary access to the mobile home park and industrial area on the east side of the channel, this could also result in a safety issue if emergency vehicles are unable to traverse the street because of high water.

RECOMMENDED IMPROVEMENTS:

Replace the existing pipe with a 48-inch RCP culvert in the existing street right-of-way.

LAWRENCE, KANSAS
STORMWATER MANAGEMENT MASTER PLAN
CAPITAL IMPROVEMENT PROJECT RECOMMENDATION

PROJECT NAME: N. 5th St. and Maple System

PROJECT IDENTIFICATION NUMBER: 37

PERTINENT DATA SUMMARY:
Watershed: North Lawrence
Priority Group: III Priority No.: N/A
Design Capacity: 10-95 CFS; 75 CFS Pump Station
Cost Estimates: Capital $ 3,323,000 Annual $ 5,000
Model Reach Number(s): 17-2001, 2002, 2003, 2004, 2005, 2006 (new); 17-3190, 3191, 3193 (existing)
Map Reference Sheet: 11
Return Period: 10 years

EXISTING PROBLEM DESCRIPTION:

The existing improved drainage facilities serving the area east of N. 3rd St. and north of the Union Pacific railroad is limited to a 15-inch diameter corrugated steel pipe (Line 3193) which drains to a 2700-gpm pump station near 6th and Maple. The pump station is required to convey all drainage from north of the railroad to the gravity drains that flow south along 6th St. to the levee. Most of the remainder of the drainage system consists of very flat roadside ditches, drive culverts and low areas which trap runoff preventing it from reaching the enclosed system or pump station.

The improved system currently provides approximately a 2-year level of service with fairly limited ponding in the vicinity of the pump station. At higher return periods, water ponds over a much larger area surrounding and possibly flooding several homes and other structures in the area.

RECOMMENDED IMPROVEMENTS:

Add enclosed drainage system components to collect and convey water from throughout the area to the pump station, and enlarge the existing improved reaches and pumping capacity. New lines include:

- 2001 - 36"x22" RCPA along Maple from 4th St. to the pump station.
- 2002 - 43"x27" RCPA along Perry from 4th St. to 6th St.
- 2003 - 21" RCP along Lincoln from 4th St. to 5th St.
- 2004 - 43"x27" RCPA along 5th St. from Lyon to Lincoln.
- 2005 - 6'x 2' RCB along Lincoln from 5th St. to 6th St.
- 2006 - 4'x 2' RCB along 6th St. from Lyon to Lincoln.

In addition, replace the portion of Line 3193 along Lincoln, east of 6th St., with a 5.5'x 2' RCB and the rest of it, along 6th to the pump station, with a double 5'x 2' RCB.

To provide a 10-year level of service in the system, replace the existing pump station, increasing the capacity to 33,000 gpm. In addition, a 10 ac-ft storage pond adjacent to the pump station will be required which will necessitate the purchase of approximately three acres in the vicinity of 6th and Maple, presumably on the northwest corner of the intersection immediately adjacent to the pump station. Approximately 1,800 lineal feet of discharge piping to the river will also be required. It is recommended that the pump discharge line be separate from the gravity system south of the railroad.

To increase the level of service south of the railroad, the connection between Line 3192, across the railroad, and Line 3191 should be severed. Replace Line 3191 with a 43"x27" RCPA for its entire length along 6th St. from Locust to the levee. Add a second 30" RCP through the levee to increase outlet capacity.

LAWRENCE, KANSAS
STORMWATER MANAGEMENT MASTER PLAN
CAPITAL IMPROVEMENT PROJECT RECOMMENDATION

PROJECT NAME: N. 8th Street - Maple to Levee

PROJECT IDENTIFICATION NUMBER: 38

PERTINENT DATA SUMMARY:

Watershed: North Lawrence
Priority Group: III Priority No.: N/A
Design Capacity: 10-120 CFS
Cost Estimates: Capital $ 1,648,000 Annual $ 2,000
Model Reach Number(s): 17-2231, 2232, 2233, 2234, 2235, 2236 (new); 17-3160, 3170 (existing)
Map Reference Sheet: 12
Return Period: 10 years

EXISTING PROBLEM DESCRIPTION:

The improved drainage system in this area consists of a single 18-inch corrugated steel pipe along 8th St. from Maple to the levee (Line 3170), and a 30-inch concrete pipe outlet through the levee (Line 3160). The rest of the drainage system consists of roadside ditches, drive culverts, and low areas that trap runoff, preventing it from reaching the improved system. The existing system provides less than a 2-year level of service to this area.

RECOMMENDED IMPROVEMENTS:

Add new enclosed drainage system components to collect and convey water from throughout the area and enlarge existing improved reaches. New lines include:

- 2231 - 29"x18" RCPA along Locust and between Locust and Elm.
- 2232 - 6'x 2' RCB along Elm, east of 8th St.
- 2233 - 24" RCP along Elm west of 8th St.
- 2234 - 43"x27" RCPA south of Elm and east of 8th to drain low areas.
- 2235 - 18" RCP east of 8th and along Ash (extended) to drain low area.
- 2236 - 18" RCP north of Elm and east of 8th to drain low area.

In addition, replace the portion of Line 3170 along 8th from Maple to Elm with a 24" RCP; the section from Elm to Ash with a 5'x 2.5' RCB; and the rest of it, from Ash to the levee, with a 5.5'x 2.5' RCB. Replace Line 3160 with a 3.5'x 2.5' RCB to increase the outlet capacity. If the existing 30" pipe through the levee is in good condition, it could remain in place and a second 36" RCP could be installed to provide the additional capacity.

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STORMWATER MANAGEMENT MASTER PLAN
CAPITAL IMPROVEMENT PROJECT RECOMMENDATION

PROJECT NAME: N. 4th Street - Elm to Levee

PROJECT IDENTIFICATION NUMBER: 39

PERTINENT DATA SUMMARY:

Watershed: North Lawrence
Priority Group: III   Priority No.: N/A
Design Capacity: 15-50 CFS
Cost Estimates: Capital $ 226,000   Annual $ 350
Model Reach Number(s): 17-3200, 3201
Map Reference Sheets: 11
Return Period: 10 years

EXISTING PROBLEM DESCRIPTION:

The existing improved drainage system consists of a 18" CSP along 4th from Elm to the levee (Line 3201) and a 30" RCP outlet through the levee (Line 3200). This system provides approximately a 2-year level of service.

RECOMMENDED IMPROVEMENTS:

Replace Line 3201 with a 36"x 22" RCPA for its entire length and replace Line 3200 through the levee with a 51"x 31" RCPA for increased outlet capacity. If the existing 30" pipe through the levee is in good condition, it could remain in place and a second 30" RCP could be installed to provide the additional capacity.

LAWRENCE, KANSAS
STORMWATER MANAGEMENT MASTER PLAN
CAPITAL IMPROVEMENT PROJECT RECOMMENDATION

PROJECT NAME: N. 2nd Street - I70 to North St.

PROJECT IDENTIFICATION NUMBER: 40

PERTINENT DATA SUMMARY:
Watershed: North Lawrence
Priority Group: II Priority No.: N/A
Design Capacity: 20-120 CFS
Cost Estimates: Capital $ 1,494,800 Annual $ 1,630
Model Reach Number(s): 17-3220, 3224, 3230, 3240, 3250
Map Reference Sheet: 4
Return Period: 10 years

EXISTING PROBLEM DESCRIPTION:

The system analysis indicates that the existing enclosed system along N. 2nd St., south of I70, provides less than a 2-year level of service. The system of pipes, ranging in size from 15 to 30-inch in diameter, drains the area along this heavily-traveled road through the retail areas along N. 2nd and further north to the turnpike interchange and Highways 40 and 59. The lack of capacity can result in flooded streets and impaired access in the area.

RECOMMENDED IMPROVEMENTS:

To provide a 10-year level of service, replace Lines 3220 and 3224 with 6'x 3' RCB; Line 3230 with a 5'x 3' RCB; Line 3240 with a 4'x 2' RCB; and Line 3250 with a 2'x 2' RCB.

LAWRENCE, KANSAS
STORMWATER MANAGEMENT MASTER PLAN
CAPITAL IMPROVEMENT PROJECT RECOMMENDATION

PROJECT NAME: N. 7th Street - Elm to the Levee

PROJECT IDENTIFICATION NUMBER: 41

PERTINENT DATA SUMMARY:
Watershed: North Lawrence
Priority Group: III Priority No.: N/A
Design Capacity: 20-50 CFS
Cost Estimates: Capital $ 285,700 Annual $ 465
Model Reach Number(s): 17-3182, 3183 (new); 17-3180, 3181 (existing)
Map Reference Sheet: 11, 12
Return Period: 10 years

EXISTING PROBLEM DESCRIPTION:

The existing improved system consists of a 18" CSP (Line 3181) along 7th between Elm and the levee, and a 30" RCP outlet through the levee. The rest of the system is composed of roadside ditches and a low area east of 7th and south of Elm that traps runoff. The existing system provides approximately a 2-year level of service.

RECOMMENDED IMPROVEMENTS:

To provide a 10-year level of service, replace Line 3181 with a 36"x22" RCPA for its entire length and add new Line 3182, a 24" RCP east of 7th along Elm for 600 ft., and new Line 3183, a 18" RCP extending 400 ft. south of Elm from the end of 3182 to drain the low area. Also, replace Line 3180 with a 51"x31" RCPA through the levee or, if the existing 30" pipe is in good condition, add a second 30" pipe to increase capacity of the outlet.

3. DISCRETIONARY PROJECTS

In addition to the recommended improvement projects, a separate list of 20 potential improvement projects was compiled which have been identified as discretionary projects. Many of these projects cover those problems which appear to be due to the inadequacy of or total lack of an existing minor improved drainage system. The projects include drainage reaches which 1) have been reported by citizens as causing problems on their properties; 2) have been identified by the analysis as being deficient in capacity; or 3) involve existing natural channels that are not currently the responsibility the City to maintain or improve. Because most of the reaches are part of the minor drainage system, the lack of capacity does not currently result in serious recurring or frequent adverse effects, or pose problems for more than a few property owners due to remote locations or a relatively small magnitude of deficiency.

The discretionary projects list is recommended as a beginning point for the proposed stormwater utility staff to investigate, evaluate and prioritize the minor system drainage problems to a degree of detail which is beyond the scope of this study and report. Basic problem identification and suggestions for possible corrections are provided as a starting point only. After each problem is thoroughly investigated, the decision can be made whether 1) the City will be responsible for fixing it (through the utility); 2) the project should proceed but be funded by special benefit district financing; or, 3) it is a private issue and not due to existing system inadequacies, so that the responsibility for correction should be left to the property owner. The list is intended to be ongoing and constantly changing as projects are completed or eliminated and new ones are identified and added to the list. In order to fund those projects determined to be the City's responsibility, it is recommended that an additional $125,000 be budgeted each year by the stormwater utility once it is well established and funded to be used at the discretion of the staff. Brief descriptions of the existing problems and possible solutions for each are presented on the following pages.

PROJECT NAME: Sherwood Drive

Watershed: Deerfield
Map Reference Sheet: 2

PROJECT DESCRIPTION: The existing natural channel behind the homes on the north side of Sherwood Dr., just east of Kasold, is eroding and threatening the yards along this reach. To control this problem, it will be necessary to stabilize the toe of the channel bank and possibly part of the bank slope. Gabion or concrete walls and channel lining, gabion mats, reinforced vegetative cover, or a combination of these materials are possible methods for the repair.

PROJECT NAME: Trail Rd. - Cattleman Trail System

Watershed: Deerfield
Map Reference Sheets: 8

PROJECT DESCRIPTION: The existing cross-road culvert is located across Trail Rd. approximately 200 feet east of Cattleman Trail. Water will collect in the depression area on the upstream side of the culvert and could flood several residences in the area. Also, the water could overtop Trail Rd. and continue to the north in the improved open channel (Line 3110). To eliminate this problem, replace the existing culvert (Line 3000) across Trail Rd. with a 44" X 27" RCPA within existing street right-of-way or drainage easements.

PROJECT NAME: Tomahawk Drive

Watershed: Deerfield
Map Reference Sheet: 9

PROJECT DESCRIPTION: The existing natural channel behind the homes on the north side of Tomahawk Dr., east of Kasold, is eroding. The channel depth and bank slope has reportedly increased considerably in the past few years presenting a possible safety hazard and potentially threatening developed property along the channel. To control the erosion, the channel bottom and banks should be stabilized with materials such as gabion walls and mats, concrete, reinforced vegetation, or a combination of methods.

PROJECT NAME: 2nd St. - Iowa St. System

Watershed: Country Club
Map Reference Sheets: 9

PROJECT DESCRIPTION: The existing 36-inch CSP beginning at the intersection of Iowa St. and 2nd St. and running north for approximately 450 feet has level of service of 2 years. The system overflows will collect in the low point of Iowa St. immediately to the north of pipe 3550 creating traffic problems along this major city thoroughfare. Replace the existing pipe with a 36-inch RCP along Iowa St. for its entire length within the existing street right-of-way. If line 3550 is determined to be in good condition, the existing pipe could be improved to carry the 10-year discharge by lining the invert of the pipe with concrete instead of replacing it.

PROJECT NAME: Peterson Road & Yorkshire Drive

Watershed: Country Club
Map Reference Sheets: 9

PROJECT DESCRIPTION: The existing open channel along the back lot line between Yorkshire and Crestline Dr., just south of Peterson Rd., is fairly flat and does not drain readily resulting in standing water. To eliminate this problem, one possible option is to regrade and line the low-flow channel with concrete to insure complete drainage.

PROJECT NAME: 4th Street - Maine to Indiana

Watershed: Downtown
Map Reference Sheets: 10

PROJECT DESCRIPTION: Several yards on Illinois along the south side of 4th St. are flooded by uncontrolled runoff from the street due to the lack of enclosed pipe-curb and gutter system. To eliminate this problem, consider enlarging the existing 12-inch pipe along Indiana between 4th and 5th, and extending the enclosed system west along 4th St. to approximately Maine.

<u>PROJECT NAME:</u> Harvard & Crestline

Watershed: Yankee Tank East
Map Reference Sheet: 16

PROJECT DESCRIPTION: The open channel along the back lot lines on the south side of Harvard, between Centennial and Crestline, is eroding. The depth of water in the channel occasionally is enough to almost reach some of the houses. To control the erosion, it is recommended that the low flow channel be stabilized with a relatively smooth lining such as gabion mats or concrete. This improvement, along with enlarging downstream culverts, will allow the water to pass more quickly and minimize the depth of flow.

<u>PROJECT NAME:</u> 15th Street & Lawrence Ave.

Watershed: Yankee Tank East
Map Reference Sheet: 16

PROJECT DESCRIPTION: The natural channel behind the homes on the east side of Lawrence Ave., just north of 15th St., is eroding to the extent that utilities and private property are threatened. To control the erosion, the toe of the channel bank and at least part of the bank slope itself should be stabilized with gabion or concrete walls and/or lining.

<u>PROJECT NAME:</u> Avalon & Cambridge

Watershed: Downtown
Map Reference Sheet: 17

PROJECT DESCRIPTION: The natural drainage channel behind the houses on the east side of Avalon is eroding. The tributary area and the channel itself are extremely steep resulting in very high flow velocities and thus the erosion. Much of the immediate area does not have an improved local drainage system. Lining at least the low-flow portion of the channel with either grouted riprap or concrete will probably be required to control the erosion. In addition, construction of a local enclosed system along Cambridge and Oxford and the extension of the system along High Dr. to the east will help in directing and diverting runoff so discharge points into the channel can be better controlled.

PROJECT NAME: Park St. - Rhode Island St. - 11th St. System

Watershed: Downtown
Map Reference Sheets: 18

PROJECT DESCRIPTION: The existing system of pipes begins at the intersection of Massachusetts St. and Park St., continues to the east along Park St. to Rhode Island St., follows Rhode Island to the north to 11th St., and turns east along 11th St. to Connecticut St. The current system, both line 3600 and 3610, has less than a 2-year capacity. The overflows from the inadequate system will flow to the east along Park St. and could continue to the northeast through a residential area. The overflows along Rhode Island St. and 11th St. will travel to the north and east, respectively and will impact the traffic on these major thoroughfares. The existing pipe system should be replaced with 1) 43" X 27" RCPA along Park St. between Massachusetts St. and Rhode Island St.(Line 3610); and 2) 43" X 27" RCPA along Rhode Island St. and along 11th St. (Line 3600). These improvements will be completed within the street right-of-ways or existing drainage easements.

PROJECT NAME: 9th St. - Pennsylvania St. System

Watershed: Downtown
Map Reference Sheets: 18

PROJECT DESCRIPTION: The existing system of pipes begins at the intersection of 9th St. and Delaware St. and continues to the west along 9th St. to Pennsylvania St. and then turns to the north along Pennsylvania St. to 8th St. The current level of service of lines 3650 and 3660 is less than 2-years. The overflows from the undersized system could impact the industrial regions to the north and east of the system. The existing system should be modified as follows: 1) 36-inch RCP from Delaware St. to Pennsylvania St. along 9th St. (Line 3660) and 2) 42-inch RCP between 9th St. and 8th St. along Pennsylvania St. (Line 3650). All replacements will be completed within the current street right-of-ways.

PROJECT NAME: 11th Street & Ohio

Watershed: Downtown
Map Reference Sheet: 18

PROJECT DESCRIPTION: The existing enclosed system in this vicinity is limited to relatively small diameter lines along 11th between Louisiana and Ohio, and between Tennessee and Kentucky. These lines are in very poor structural condition. The system along 11th St. should be replaced and enlarged, including adding curb inlet capacity, and tied into the major system running along Kentucky. In addition, the minor system should be extended along Ohio and Tennessee both north and south of 11th to collect runoff before it all reaches 11th St.

PROJECT NAME: 15th Street & Medinah

Watershed: Quail Creek
Map Reference Sheet: 22

PROJECT DESCRIPTION: The existing natural channel is eroding the backyards along the west side of Medinah, south of 15th St., and water backs up close to some of the houses near the south end of the block where it ponds at the inlet to an existing culvert under the Alvamar Golf Course cart path. To control the erosion, stabilization of the channel bank with gabion or concrete walls and/or lining will be required. To eliminate the ponding at the culvert, which is severely undersized, will require replacement with a larger culvert or a parallel line for additional capacity. Since the culvert is privately owner, the cooperation of and coordination with the golf course owners will be essential.

PROJECT NAME: Barker Ave. to Leanard Ave. - 17th to 19th

Watershed: East Lawrence
Map Reference Sheet: 25

PROJECT DESCRIPTION: The existing enclosed drainage system in this area is limited to a 15-inch pipe along Barker between Johnson and 19th. The remainder of the area is drained by roadside ditches or the streets themselves providing little control of runoff, especially when ditches are not properly maintained. A number of the property owners in this area have indicated problems with drainage from public streets inundating their properties. Erosion in one of the larger ditches is also causing problems. To eliminate these problems, an enclosed system should be extended north along Barker from 19th to 17th St. and then west along 17th to New Hampshire. A second system should be added along Leanard from approximately Forrest to just north of Johnson where it turns to the east and is extended to discharge directly into the existing channel.

PROJECT NAME: 21st Ter. System

Watershed: Brook Street
Map Reference Sheets: 26

PROJECT DESCRIPTION: The existing pipe, located across 21st Ter. approximately 650 feet west of Maple Lane, provides a 2-year level of service. As a result of the undersized pipe, the water will back up in the upstream channel and could flood the residential homes located adjacent to the channel. Replace the entire length of the existing pipe with a 44" X 27" RCPA within existing street right-of-way or drainage easements.

PROJECT NAME: Crestline Court

Watershed: KLWN
Map Reference Sheet: 29

PROJECT DESCRIPTION: Drainage from the street flows through the yards at the end of the cul-de-sac. The inlet capacity of the system along Crestline Ct. and the location of outlet piping should be checked to be sure it is adequate. If the system is properly designed and constructed, paved swales or flumes could be considered to control and direct the runoff to the back of the lots.

PROJECT NAME: Meadow Place Addition - Atchison Circle

Watershed: Yankee Tank East
Map Reference Sheet: 29

PROJECT DESCRIPTION: Several homeowners have complained about the erosion and lack of maintenance on the large open channel that runs through this area. The erosion appears to be worst near the south end (near Atchison Cir.) where the channel bends almost 90° to the west to flow through the culvert under Kasold. To control the erosion, the channel will need to be stabilized with gabion or concrete walls and/or lining.

PROJECT NAME: Dakota - Nebraska System

Watershed: Broken Arrow
Map Reference Sheet: 31

PROJECT DESCRIPTION: The area south of 23rd St. from Ohio to Vermont drains to a pair of curb inlets on Dakota and a pair on Nebraska connected by an 18-inch pipe which discharges into an open channel just south of Nebraska. The system is undersized and results in street and yard flooding for several homes around the low point. To eliminate this problem, additional inlet capacity should be provided on both streets and the pipe enlarged. The outlet pipe should also be extended to discharge farther away from the street and houses.

PROJECT NAME: Ponderosa-Trail Dust Court

Watershed: Haskell
Map Reference Sheet: 32

PROJECT DESCRIPTION: Drainage from Trail Dust Ct. runs off onto lower properties along the west side of Ponderosa. This may be due simply to the homes on Ponderosa being situated directly in the natural drainage path of runoff from the hillside. The inlet capacity of the enclosed system on Trail Dust Ct. should be checked, however, to be sure it is adequate. If the existing system is properly sized, another possible approach is to provide some type of letdown ditch or flume to control the location and direction of runoff from the hillside.

PROJECT NAME: North Lawrence Diversion

Watershed: North Lawrence
Map Reference Sheet:

PROJECT DESCRIPTION: One possible method to improve the level of drainage service at Line 3000 (triple 8'x 4' RCB beneath N. 2nd St.) during interior rainfall events and low to moderate Kansas River stages, is to divert the area now tributary to Line 3080 (6'x 4' RCB beneath US 59) directly to the river. Construction of the diversion would reduce the area tributary to the existing basin outlet by 1,270 acres and would increase the level of service afforded by existing drainage facilities at the outlet from approximately a 2-year return period to a 5 to 10-year return period.

Such a diversion would require the construction of a structure through the foundation of the existing main stem flood protection levee, and an outlet channel to the left bank of the Kansas River. The diversion structure would be sized to convey a peak rate of 197 CFS with a headwater elevation of 820.7. This design would roughly parallel the operation of the existing 6'x 4' RCB beneath the highway during a 10-year rainfall event.

The outlet would require construction of a 5.5'x 5.5' RCB and approximately 1,000 lineal feet of channel. It would also be necessary to construct a sluice gate on the upstream end of the 6'x 4' RCB beneath US 59, which would normally be closed. The gate would be opened only during high Kansas River stages when it is desired to evacuate upstream ponding to the existing pump station at the basin outlet (adjacent to N. 2nd St.).

Given typical requirements for such a crossing of the main stem flood protection levee, this diversion would be relatively expensive. Construction issues include the need for a temporary levee built to not less than the 100-year flood stage on the river-side of the existing levee, the permitting process required for construction in a waterway, and potential environmental permit problems related to the probable presence of wetland areas along the river.

C. PROGRAM COST ESTIMATES

1. BASIS

Cost estimates for the recommended conveyance element improvements were prepared by the SYCOST computer model that generates planning grade estimates for both the capital and annual operating and maintenance cost of storm drainage system components. Although the program is capable of estimating land costs, the cost estimates for the recommended projects assume that all easements necessary for the construction and maintenance of improvements, including drainage easements, will be dedicated by property owners without charge to the City.

The time basis of cost estimates is October, 1995 with a corresponding Engineering News Record Construction Cost Index for the Kansas City Metropolitan Area of 5511. Recent price trends indicate that an annual cost escalation factor of 3 to 4 percent compounded annually is appropriate for escalating base year estimates to future year implementation schedules.

2. PRICING

The cost items and their corresponding unit prices incorporated in the SYCOST model, as applied to prepare program estimates, are listed in the SYCOST User's Manual provided separately to the City staff. Planning grade quantities of the applicable key items are calculated internally by the model to generate summary cost estimates.

3. ESTIMATES

Estimated costs for each of the recommended improvement projects, as calculated by the program, are included with the individual project descriptions. Costs include the following items.

- Const. - The direct construction cost
- Land - The cost of purchased easements, if required.
- F&C - Fees and contingencies as an allowance to include engineering and inspection.
- Capital - The "first cost" is the sum of Const. + Land + F&C.

- Annual - The average annual cost to maintain, repair, and manage the system over its useful life.

Annual costs are not expended at a uniform rate. They are paid intermittently as repair, cleaning, or other maintenance of the facility as needed.

D. IMPROVEMENT PRIORITIES

1. GENERAL

Since there are many elements of the existing city-wide drainage system that do not provide an acceptable level of service, and all cannot be corrected "first," it is necessary for the City to establish priorities on an objective basis. The end objectives in setting these priorities should be to accomplish the following overall goals.

- Provide an equal minimum level of service to all citizens as soon as possible.
- Upgrade the drainage system as a whole to meet criteria standards for a higher level of service.
- Improve the system in order to yield the best practical benefit for the earliest investment.
- Accomplish the improvement in an order such that any isolated improvement does not add to an existing problem or create a new problem elsewhere.
- Directly benefit as many individual citizens as early as practical and reasonable to maintain continuing support for an orderly prioritized program of improving drainage service.

2. PRIORITY EVALUATION

Priority recommendations for capital improvement projects were formulated on two levels. The initial evaluation involved categorizing each of the recommended improvement projects according to one of three groups described below. The priority group for each recommended improvement project is indicated on the project descriptions presented previously. The list of discretionary projects was not prioritized on this or any other basis.

- Group I - This highest priority group includes the critical projects defined as those where recurring residential or commercial structure flooding by surface runoff is, or appears to be, the direct result of the inadequacy of the existing storm drainage system. These problems generally result in the greatest property damage as well as pose health and safety concerns. Information on the type of flooding occurring at various locations was obtained from the storm drainage questionnaires, City complaint records and the City staff's knowledge of the problem areas. This category does not include those situations where water enters structures due to groundwater seepage through cracks in a foundation, sanitary sewer backups, or where a structure has been located directly in an existing drainage path with no provisions for handling or redirecting the normal runoff. While still problems, these instances are not a direct result of an inadequate storm drainage system unable to handle surface runoff. Of the 41 projects described in the recommended improvements, eleven fit into this category. In addition, one project is included which involves several minor system improvements required to correct structure flooding problems in several areas including the minor system components of Project No. 14.
- Group II - This group of projects includes those areas where the inadequacy of the existing improved drainage system results in severe flooding of major streets which impedes pedestrian and vehicular traffic, including emergency vehicles, and creates access problems to public and/or private property for a number of people. Of the 41 recommended improvement projects, nine are included in this category.
- Group III - This group includes the remainder of the projects which deal primarily with erosion and nuisance situations. This is considered the lowest priority group of the three categories.

The second step in the prioritization process involves ranking individual projects within the larger groups. To accomplish this task, Burns & McDonnell's PRIOR computer model was utilized. This program essentially assigns the highest priorities to those projects that relieve deficiencies benefitting the greatest number of people at the lowest capital cost per benefitted system "user." It determines a "score" for each project based upon an internally weighted scale and then differentiates between equal score projects by comparison of secondary level factors. The following paragraphs describe in general the parameters used by the program to evaluate and compare projects. Specific information on each category and the points assigned to each factor are outlined in the PRIOR Program User's Manual provided separately to City staff.

a. First Order Calculations

PRIOR uses the following factors and a calibrated scale of "priority points" to calculate a raw score for each project in the model.

(1) Frequency of Structure and Contents Damage.

(2) Relative Magnitude of Damage

(a) Structural and contents

(b) Erosion

(c) Nuisance

(3) Frequency of Hydraulic Inadequacy

(4) Effect on City Development

(5) Structural Condition of Existing Facility

(6) Magnitude of 10-year Hydraulic Deficiency

(7) Capital Cost per Benefitted Property

b. Second Order

After calculating the raw score, the model differentiates between projects having the same number of total points in the following order.

(1) Frequency of damaged is compared. Projects having the most frequent incidence of damage are assigned the highest priority. If there is no difference in this category then;

(2) Point scores in the structural and contents damage category are compared. Those projects having the higher score in this area are assigned the higher priorities. If there is no difference in this category then;

(3) Point scores in the category of capital cost per benefitted property are compared. Those projects having the lower cost per benefitted property are assigned the higher priority. If there is no difference in this category then;

(4) Point scores in the erosion damage category are compared. Those projects having the higher score in this area are assigned the higher priorities. If there is no difference in this category then;

(5) Point scores in the nuisance category are compared. Those projects having the higher score in this area are assigned the higher priority then;

(6) Point scores in the category of absolute project cost are compared. Those projects having the lower cost are assigned the higher priority.

c. <u>System Adjustments</u>

After second order differentiation of priority without regard to the physical hydraulic relationship between projects, priorities are reevaluated on a "system" basis to insure that implementation of a high priority upstream project will not unreasonably worsen downstream conditions. Worsened conditions are defined as:

- Increasing discharge to an area already experiencing structure and contents damage at 10-year or more frequent return periods; or
- Increasing discharge to downstream areas having 2-year or less return period capacity, regardless of any associated damage; or
- Increasing discharge to a downstream area experiencing erosion damage at return periods more frequent than 5 years.

3. RECOMMENDED PLAN PRIORITIES

While all of the recommended improvement projects identified in this part of the report are considered necessary to provide the desired level of drainage service throughout the community, the economic realities of financing such a large capital improvements program must be recognized. To structure the financing, the program was divided into phases based on the priority groups. The projects included in Group I are recommended as the absolute minimum for the initial phase and, because of their "critical" nature, should be completed in as short a time as possible. To plan this initial program, the projects within Group I were further prioritized using the PRIOR computer program described previously. Priority numbers for the Group I projects are also indicated in the detailed project descriptions. Table VI-3 summarizes the projects included in Group I and the priority ranking of each one within that category.

TABLE VI - 3
PHASE I CAPITAL IMPROVEMENTS PROGRAM
GROUP I PROJECTS AND PRIORITY RANKINGS

Priority No.	Project No.	Description	Capital Cost ($)	PRIOR Points	Priority Control
1	17	2nd-3rd-Michigan-Arkansas	1,140,300	23	Raw Pts.
2	9	Carolina St. System	2,563,700	21	Raw Pts.
3*	27	13th & Oregon	2,248,000	15	U/S Proj.
4	29	21st St.-Massachusetts	604,000	18	Raw Pts.
5	10	21st St. West System	1,256,600	17	Raw Pts.
6	6	29th Court	148,000	16	$/Prop.
7	11	20th St. East System	2,312,650	16	Raw Pts.
8	--	Misc. Minor System Imprvmts.	112,000	14	No.Struc.
9	34	Maple Lane-19th-Brook St.	1,080,000	14	Raw Pts.
10	32	16th-Kentucky-New Hampshire	2,102,000	13	No.Struc.
11	7	Ridge Court	110,000	13	Freq.Damg.
12	26	9th-Vermont-New Hampshire	137,000	13	Raw Pts.
		Total $	13,814,250		

* - Project No. 28 must be completed before No. 29 which is upstream. Constructing No. 29 first could increase problems downstream in the area of No. 28.

Once this initial phase is complete, the second capital improvement program, including the Group II projects, should proceed followed by the Group III projects in a third phase. The list of projects and total estimated costs for the projects included in the second and third phase are listed in Tables VI-4 and VI-5. Prioritization of the projects in each of these groups will be performed by the stormwater utility staff as each phase begins.

TABLE VI - 4
PHASE II CAPITAL IMPROVEMENTS PROGRAM
GROUP II PROJECTS

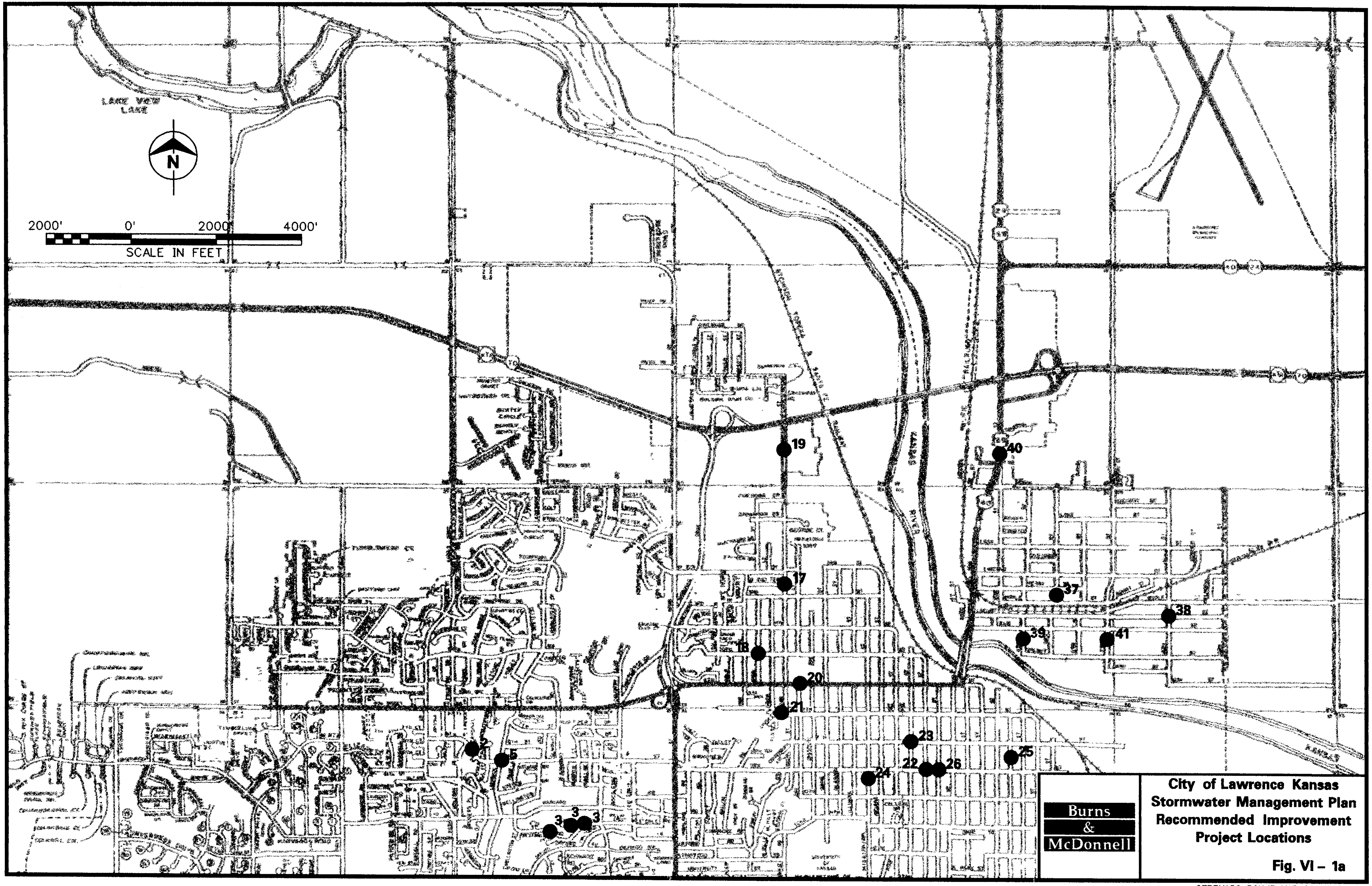
Project No.	Description	Capital Cost ($)
4	15th-Iowa St. System	790,400
8	23rd & Ousdahl System	1,022,800
16	23rd & Haskell System	111,000
20	6th & Arkansas System	186,500
22	Tenn.-Kentucky System	946,000
23	8th-Ohio-Tenn. System	463,500
24	9th-10th-Miss. System	1,140,000
30	19th-Kentucky to Leanard	1,282,900
40	N. 2nd- I70 to North St.	1,494,800
	Total	$ 7,437,500

TABLE VI - 5
PHASE III CAPITAL IMPROVEMENTS PROGRAM
GROUP III PROJECTS

Project No.	Description	Capital Cost ($)
1	15th Street System	91,200
2	8th-9th-Crawford System	130,000
3	Crestline Dr.-Westdale Dr.	139,500
5	Lawrence Ave.	540,000
12	22nd-23rd St. West	297,500
13	26th St.-Four Wheel Dr.	544,250
14	27th St.-Saratoga System	526,000
15	West Indian Ave. System	325,000
18	3rd-4th-Minnesota System	400,900
19	Michigan St. Culvert	102,100
21	7th & Michigan System	159,000
25	8th-9th-Conn. System	482,000
27	14th & New Jersey	266,400
31	Haskell & Lynn	163,800
33	13th-Brook St. Culvert	171,000
35	15th-Summit-Prairie System	175,100
36	19th St. Culvert	35,000
37	N. 5th & Maple System	3,323,000
38	N. 8th- Maple to Levee	1,648,000
39	N. 4th- Elm to Levee	226,000
41	N. 7th- Elm to Levee	285,700
	Total	$10,031,450

The list of recommended improvement projects still does not include all of the drainage concerns reported by residents of Lawrence. In a number of cases the reported problem was determined to be a result of structures located directly in the natural drainage path for the surrounding area or poor grading around the structure. While these situations are certainly problems for the property owners, the questions becomes whether or not the city should be responsible for correcting them. Generally, unless there is clear evidence that the failure of the City's drainage system to perform is the cause of the problem, it is not recommended that the City pay to fix the problem. In such cases, developers, builders, and home owners should be expected to accept the responsibility for directing runoff which naturally drains onto a property, directing it around the structure, through the yard and continuing down the natural drainage course. Planning, quality control, adequate research and good judgement are still necessary on the part of these individuals when property is developed or purchased. Repairs in these cases would be more appropriately funded by special benefit districts or by the private property owners.

* * * * *



City of Lawrence Kansas
Stormwater Management Plan
Recommended Improvement
Project Locations

Fig. VI – 1a

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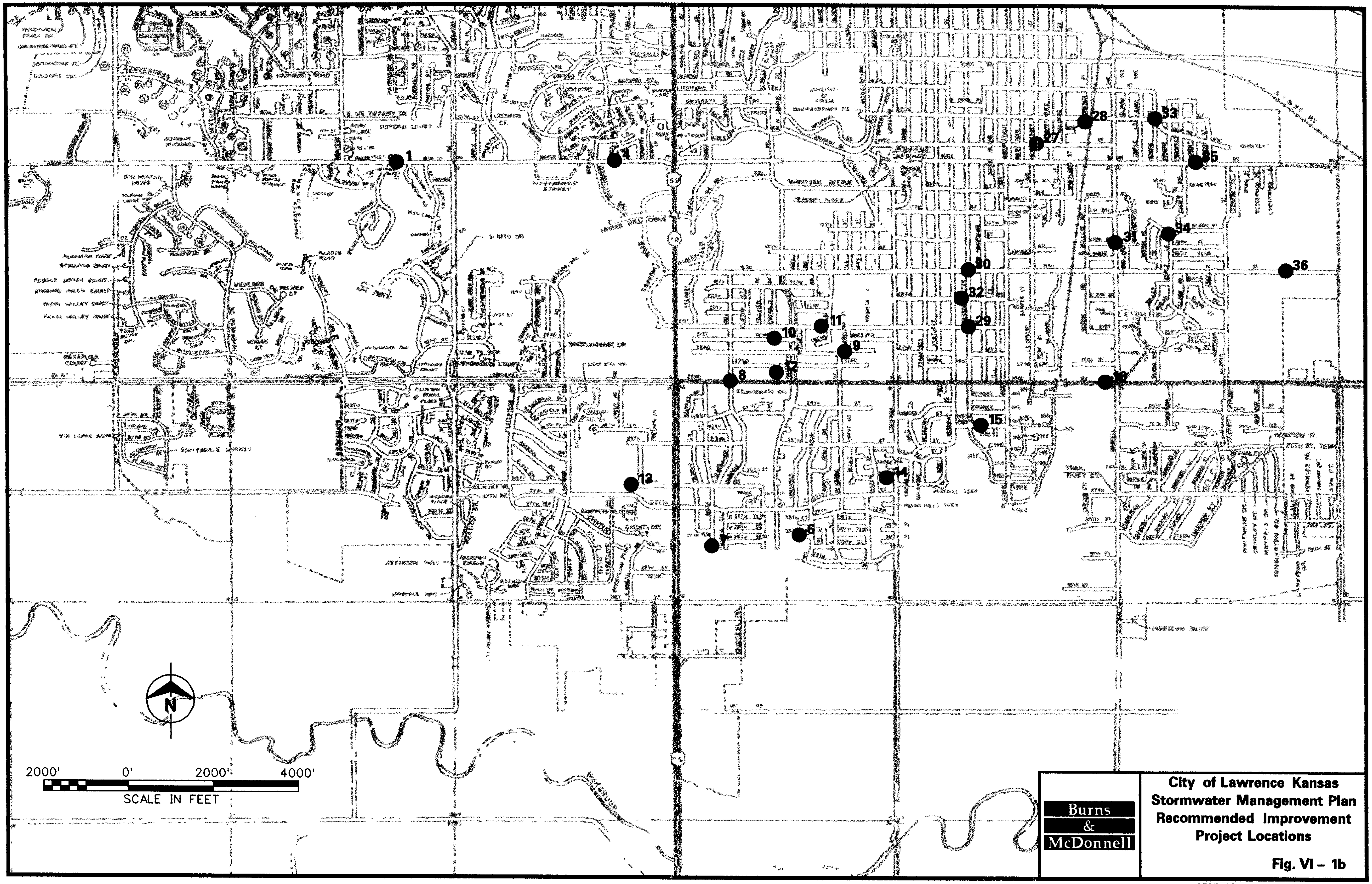

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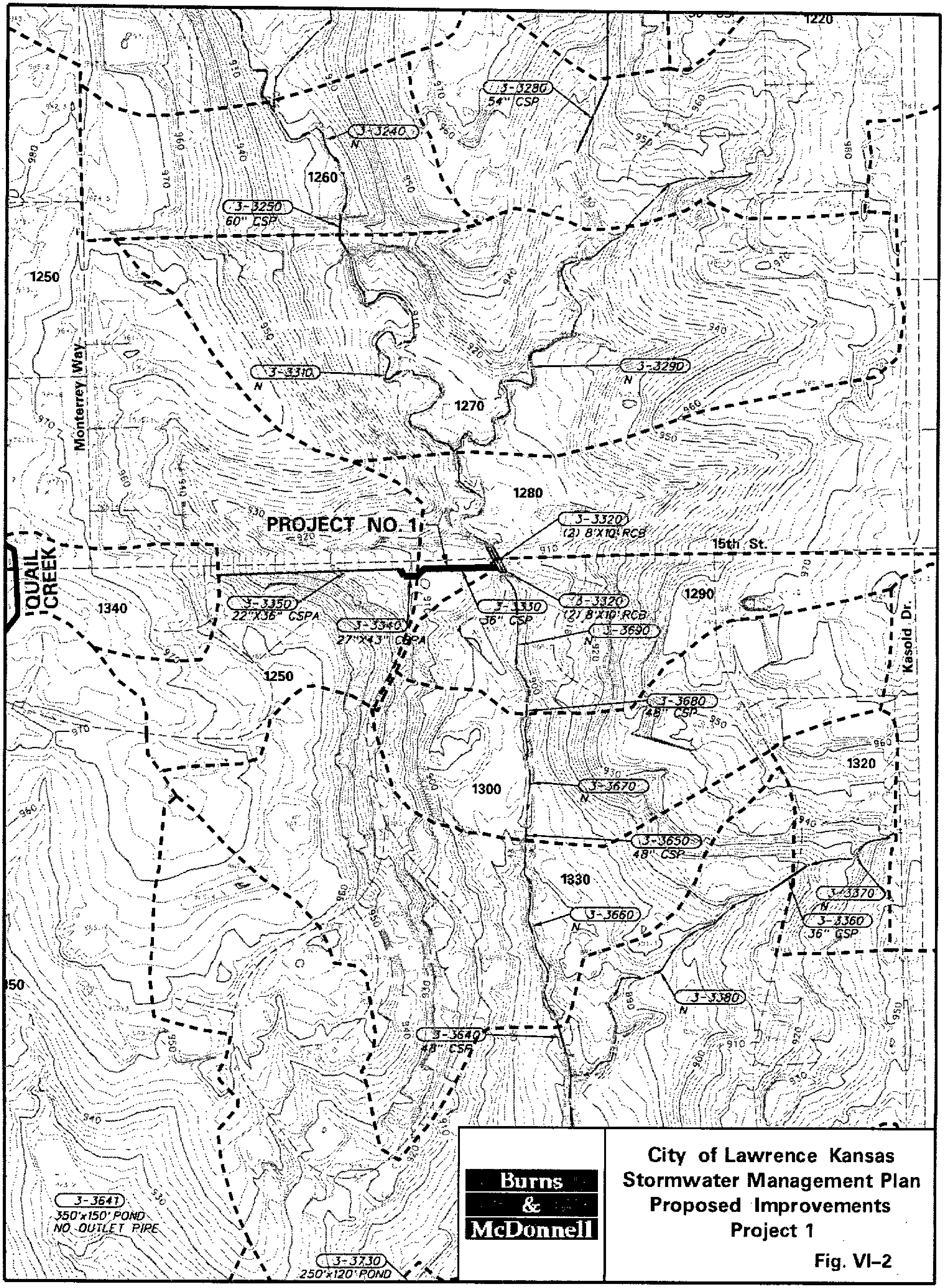

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City of Lawrence Kansas
Stormwater Management Plan
Proposed Improvements
Project 1

Fig. VI–2

PRPIMP10.DGN/8-APR-96 14:33/JDR
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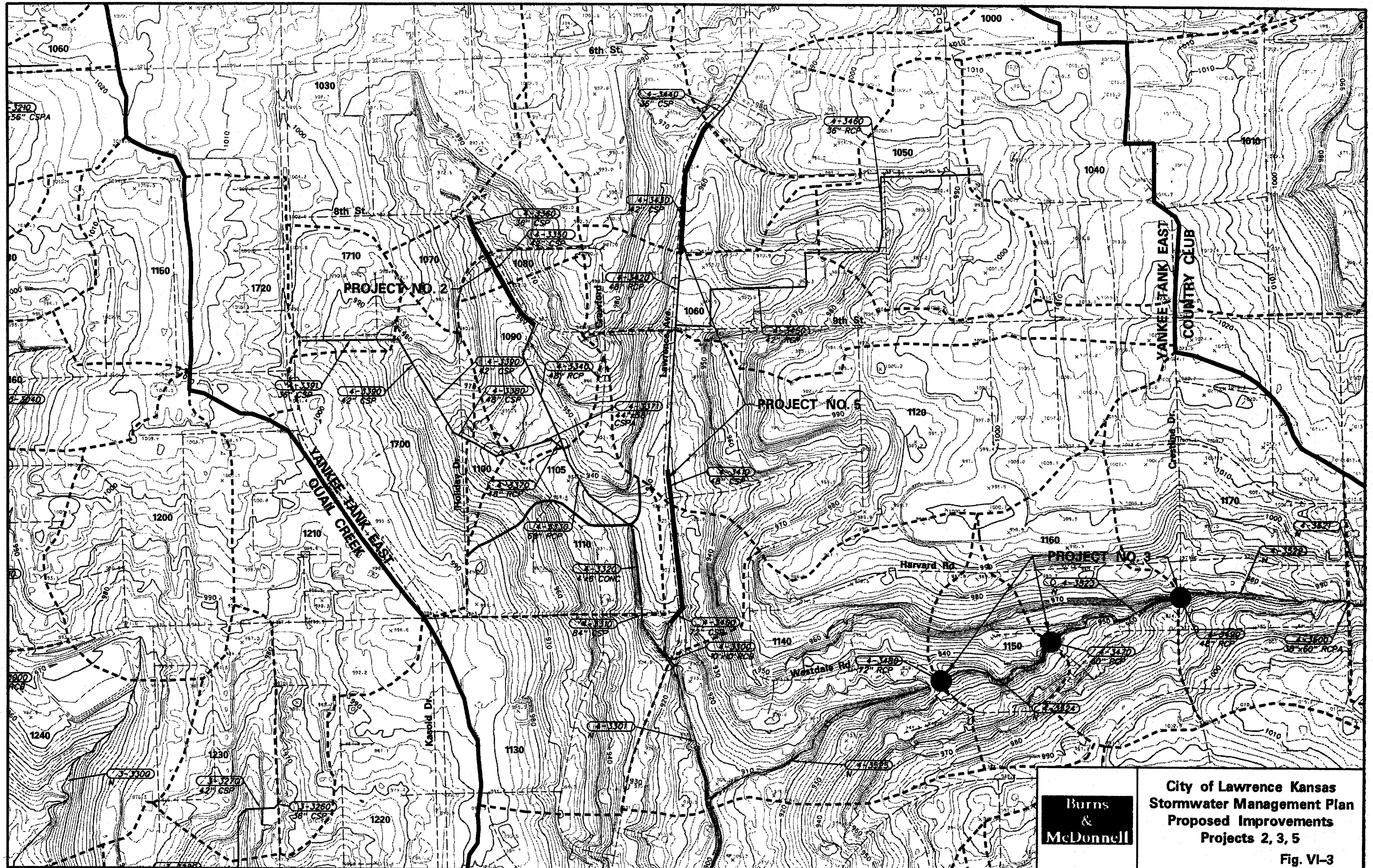

City of Lawrence Kansas
Stormwater Management Plan
Proposed Improvements
Projects 2, 3, 5

Fig. VI-3

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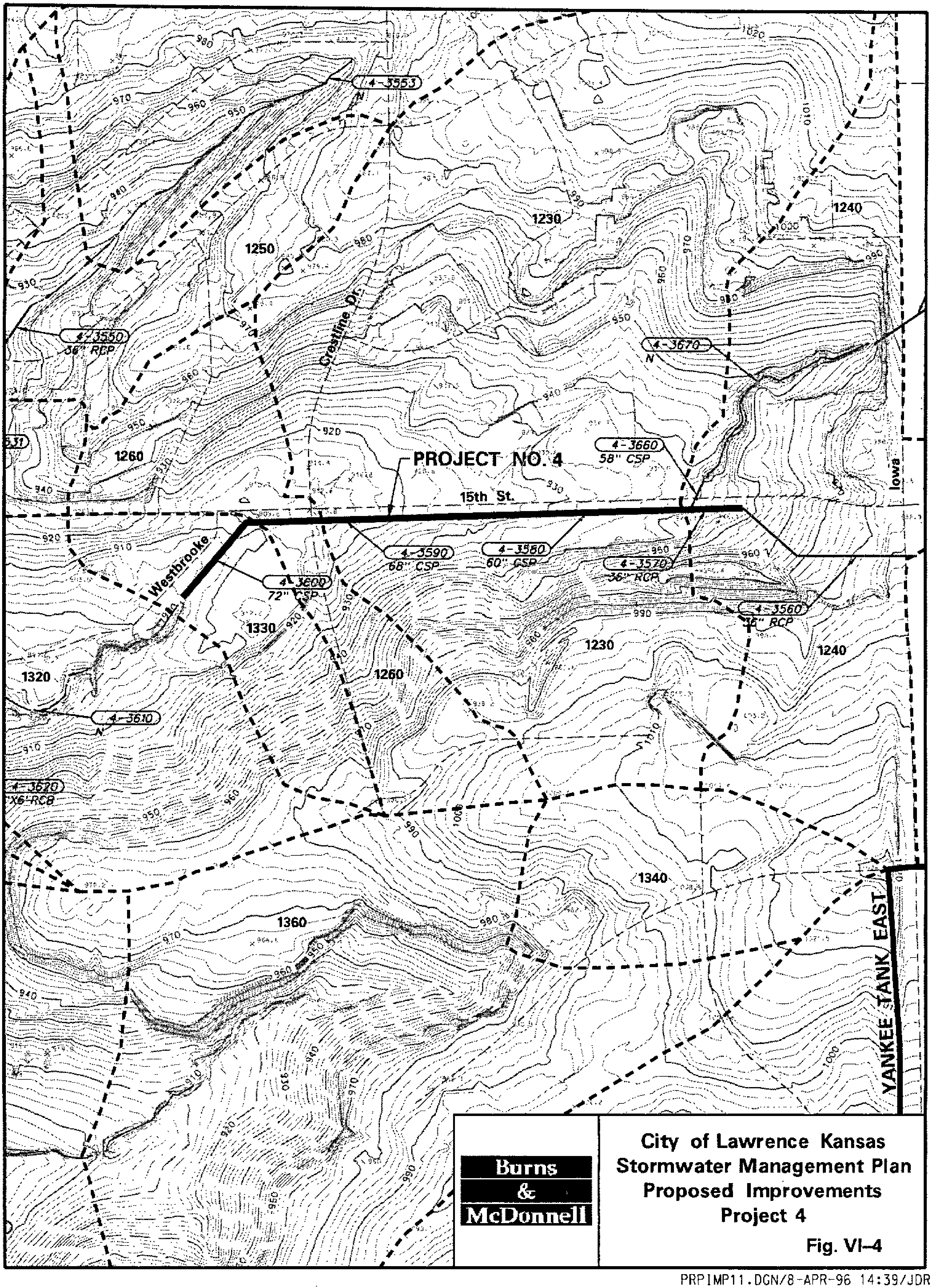

Burns & McDonnell	City of Lawrence Kansas Stormwater Management Plan Proposed Improvements Project 4 Fig. VI-4

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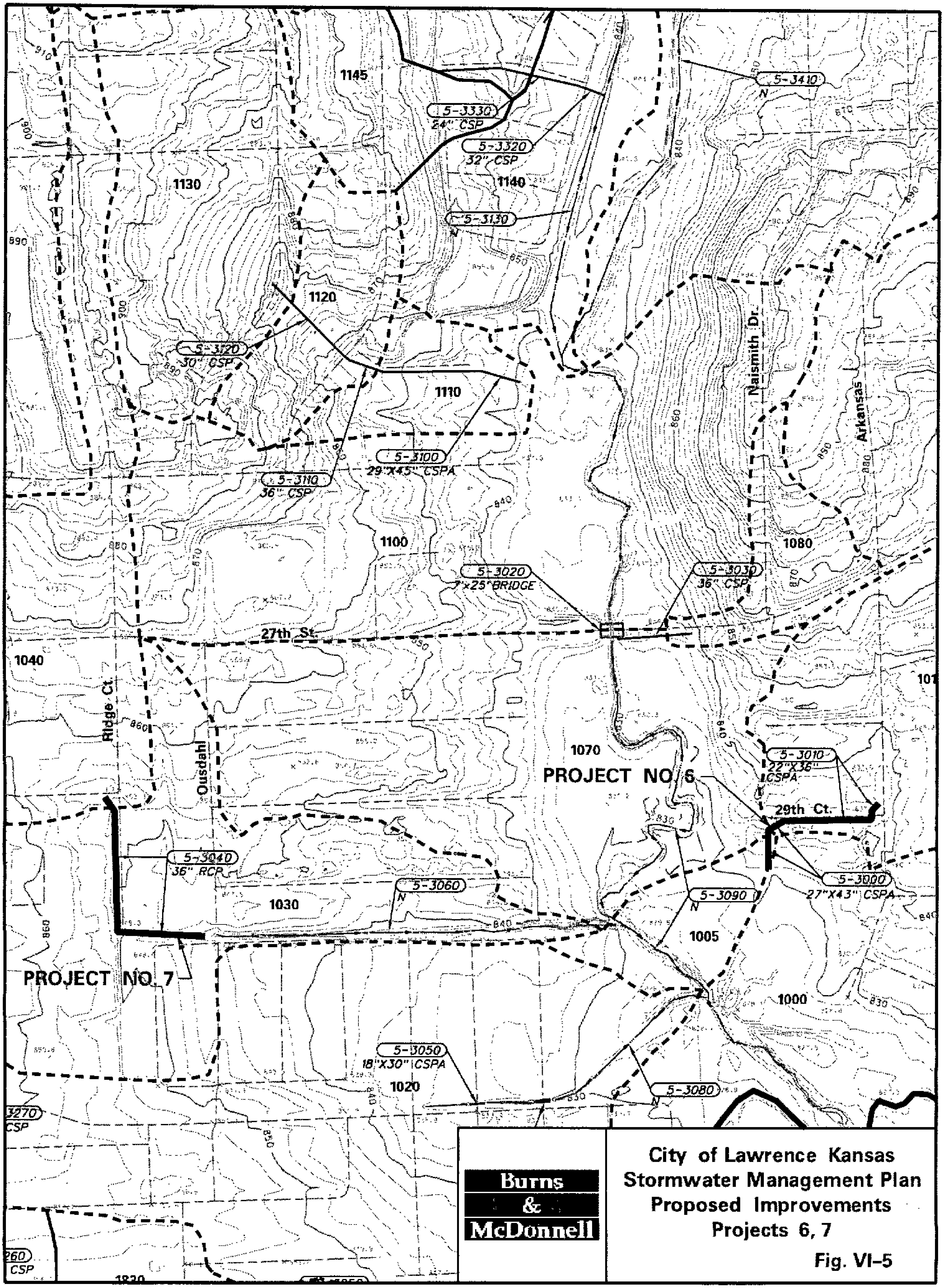

City of Lawrence Kansas
Stormwater Management Plan
Proposed Improvements
Projects 6, 7

Fig. VI-5

PRPIMP19.DGN/8-APR-96 14:41/JDR
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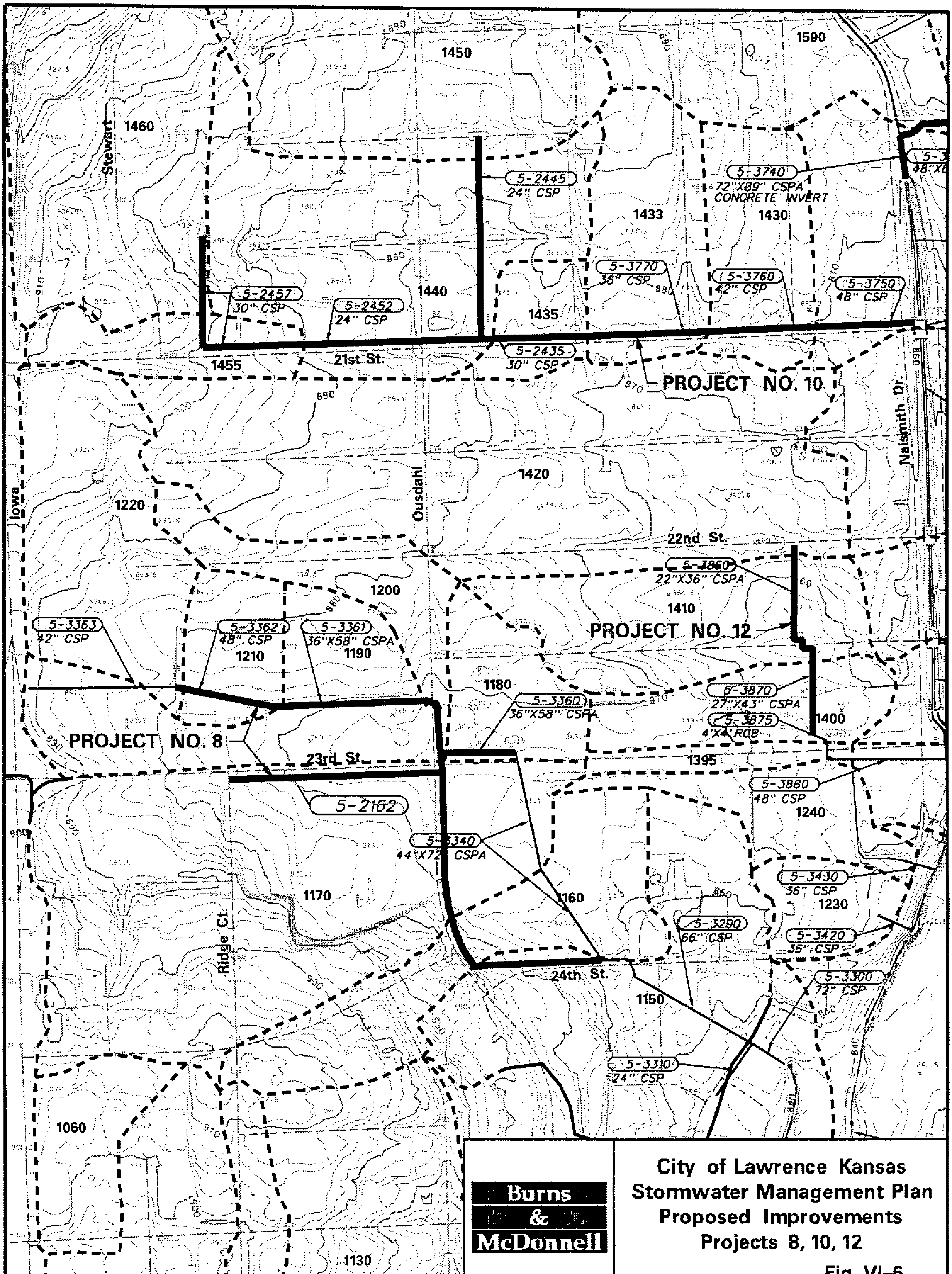

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City of Lawrence Kansas
Stormwater Management Plan
Proposed Improvements
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Fig. VI–6

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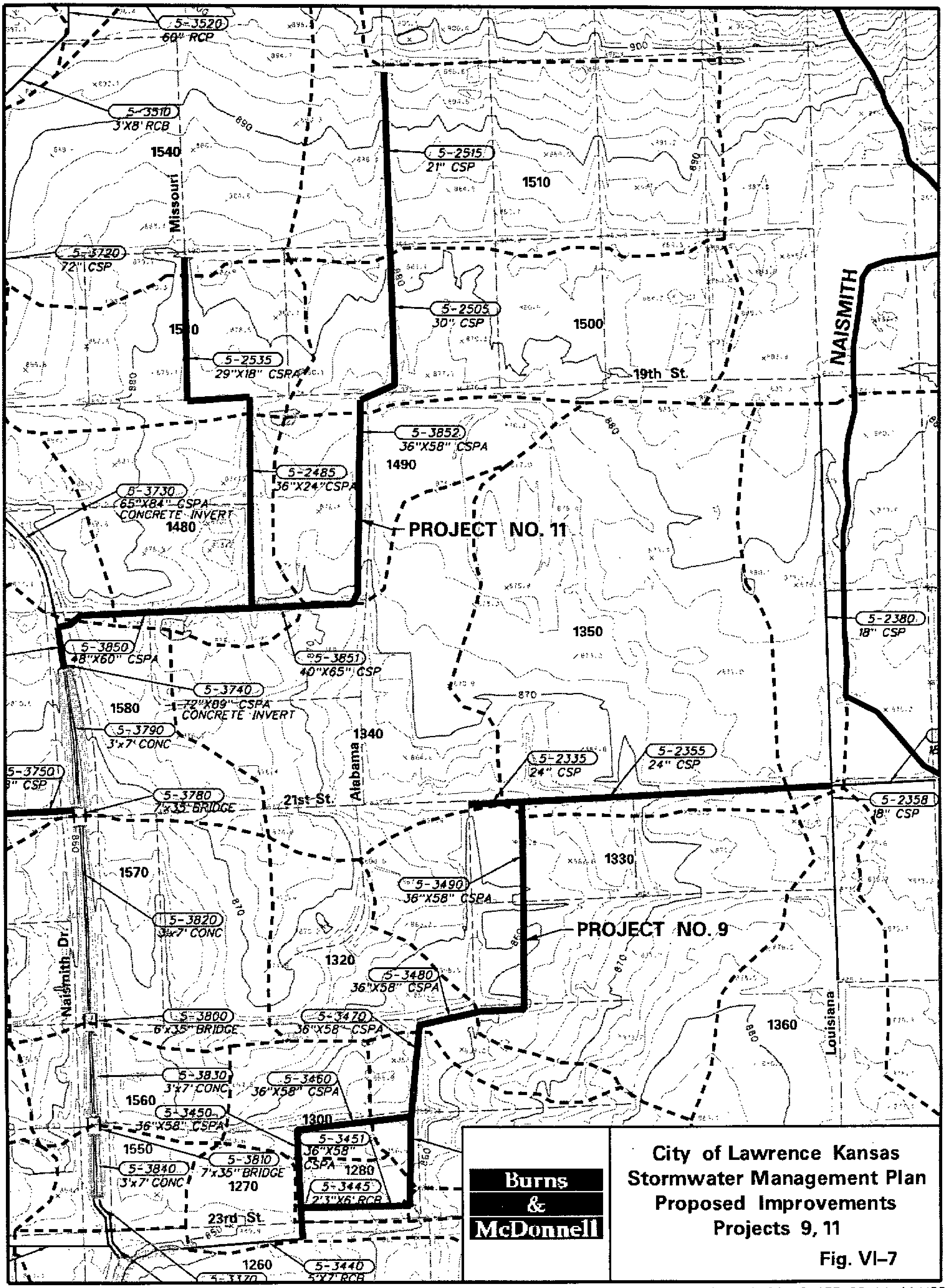

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City of Lawrence Kansas
Stormwater Management Plan
Proposed Improvements
Projects 9, 11

Fig. VI-7

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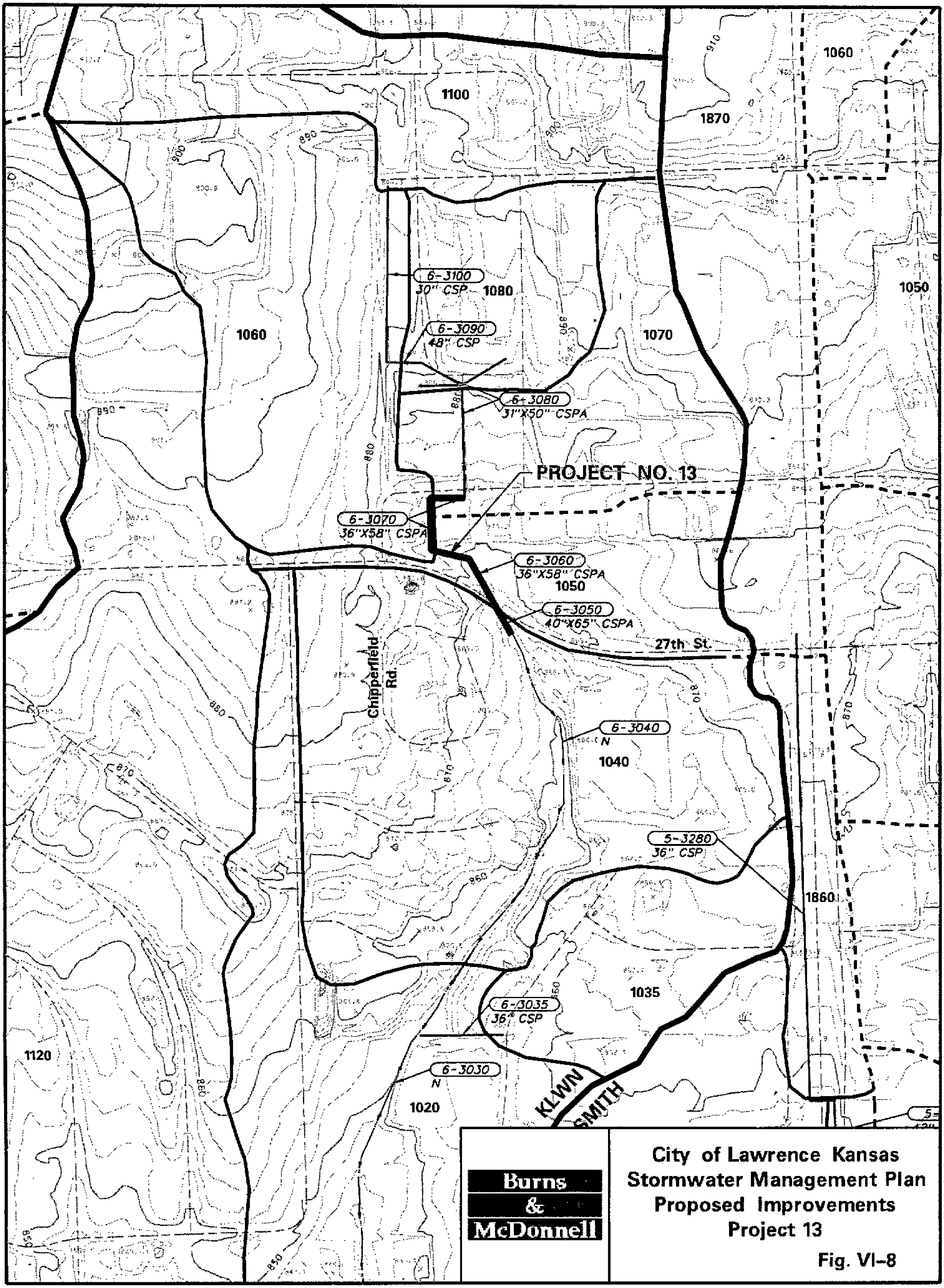

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City of Lawrence Kansas
Stormwater Management Plan
Proposed Improvements
Project 13

Fig. VI-8

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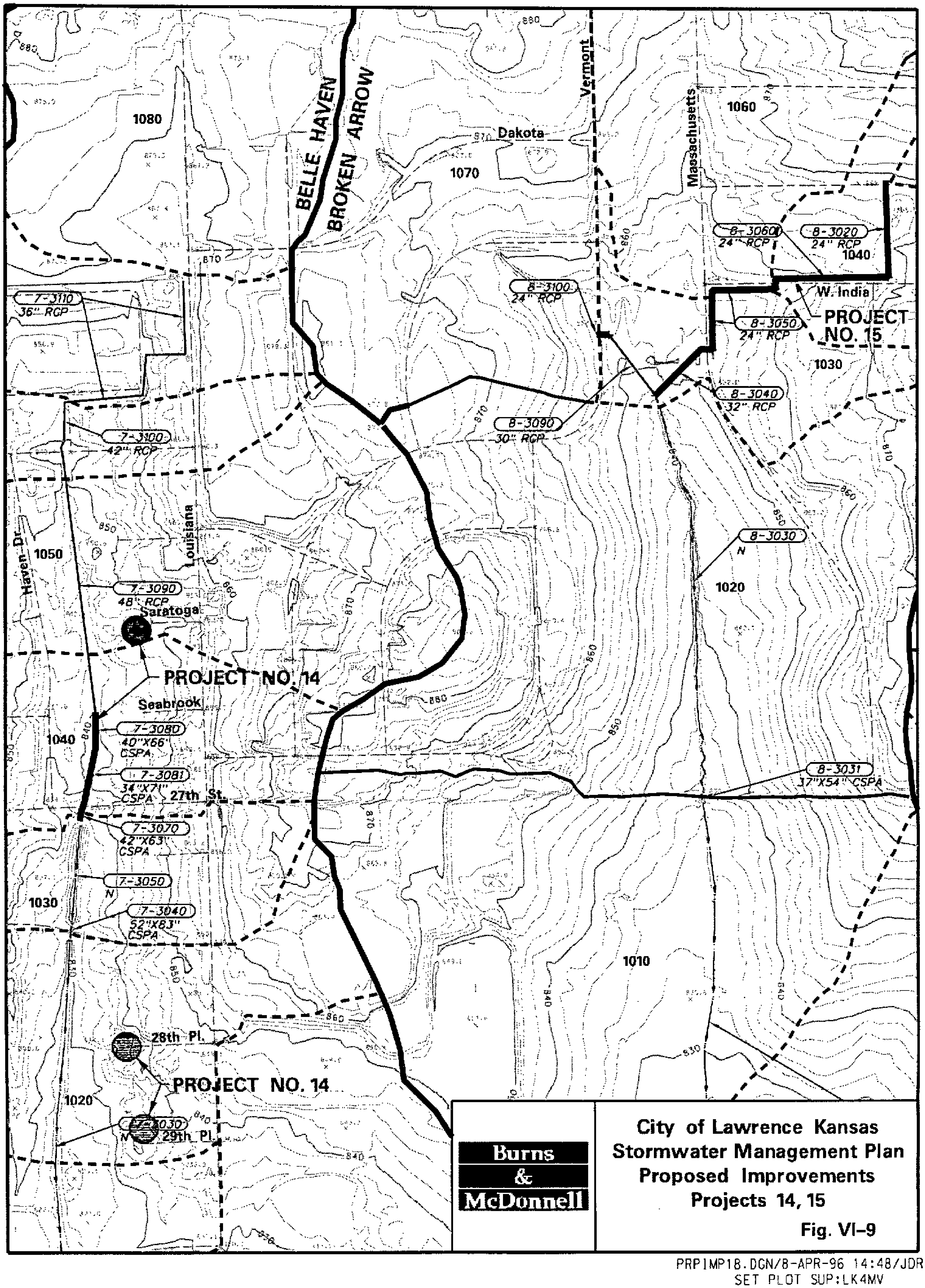

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City of Lawrence Kansas
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Proposed Improvements
Projects 14, 15

Fig. VI–9

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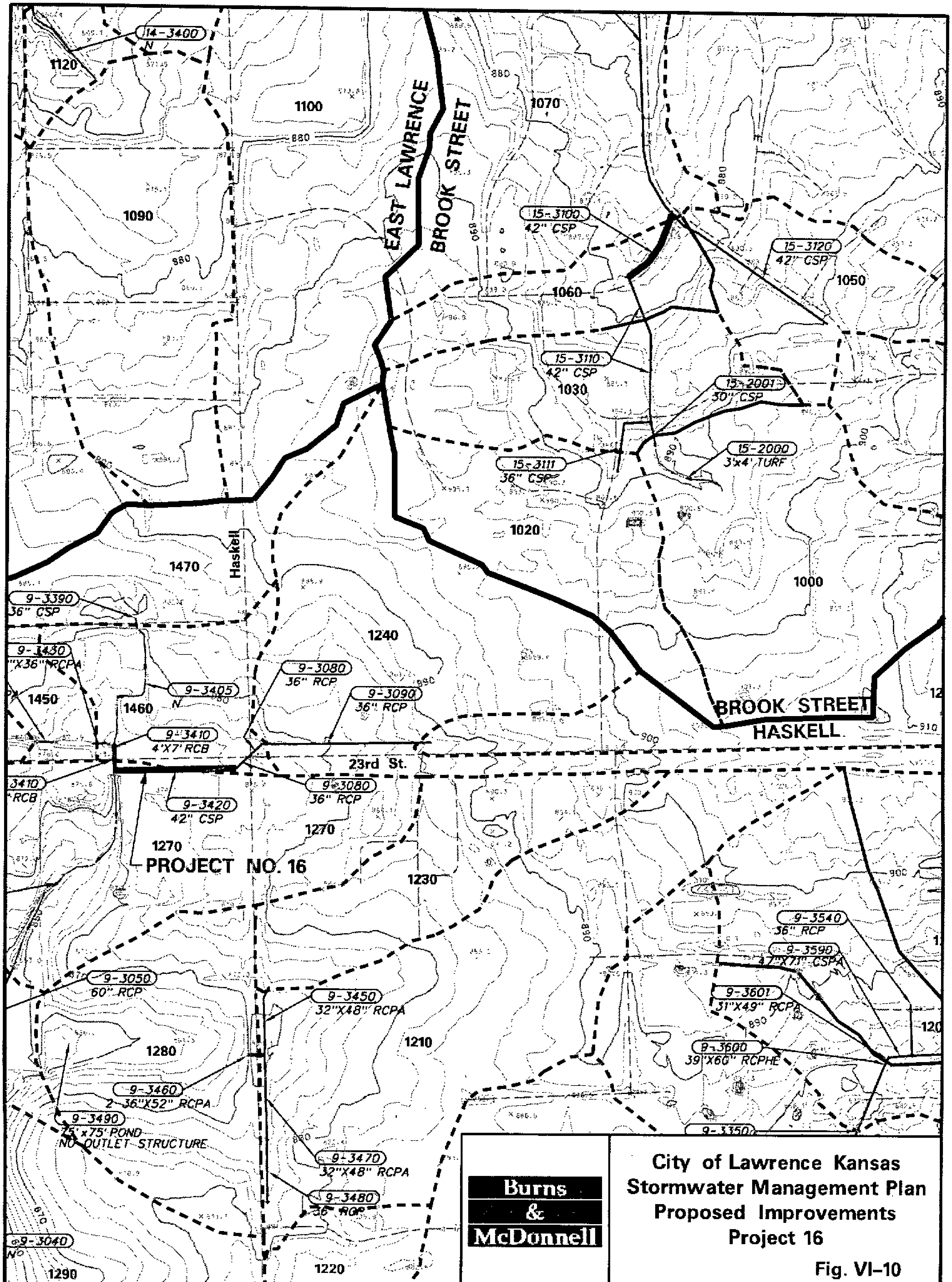

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City of Lawrence Kansas
Stormwater Management Plan
Proposed Improvements
Project 16

Fig. VI-10

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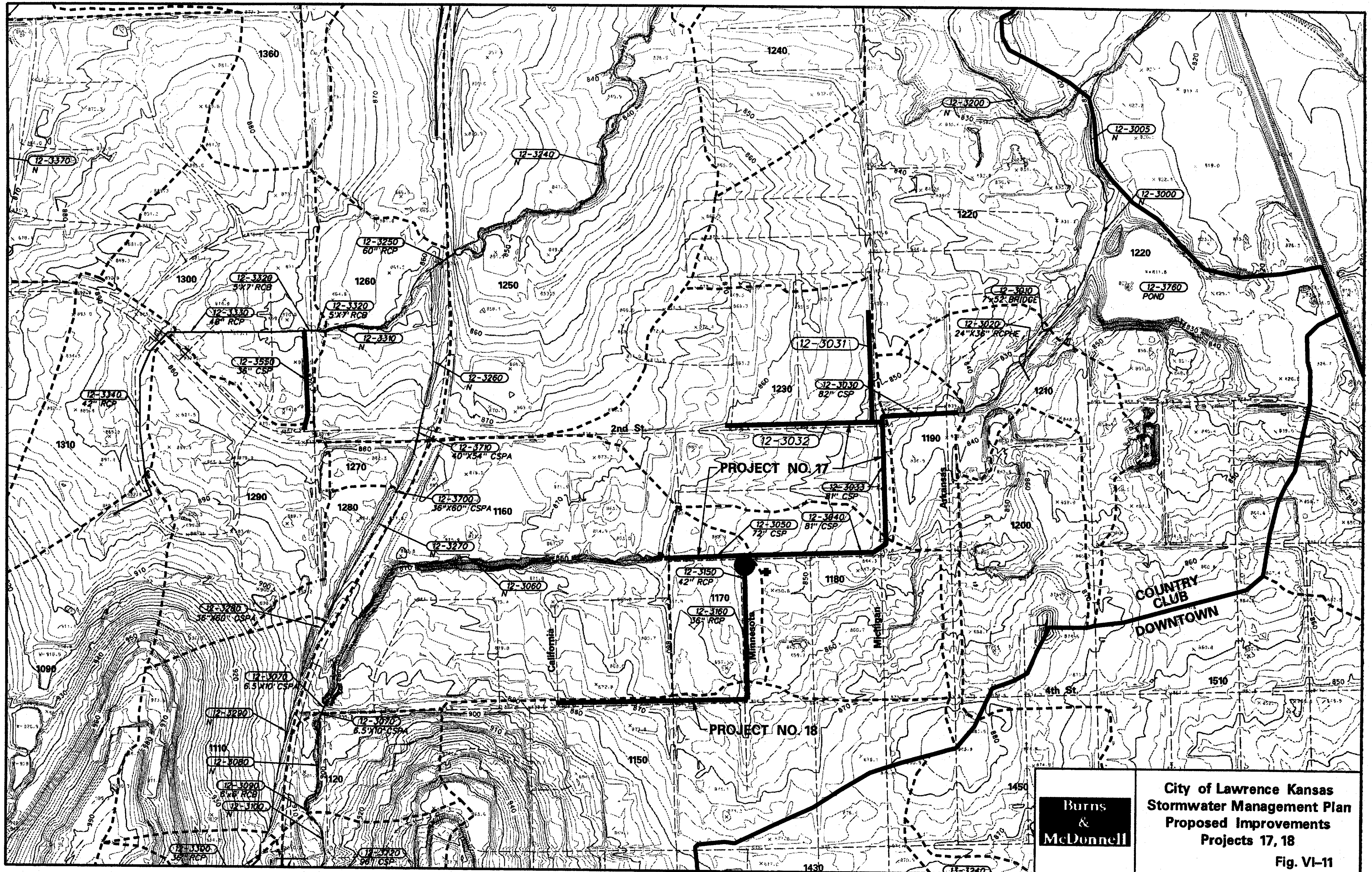

City of Lawrence Kansas
Stormwater Management Plan
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Projects 17, 18

Fig. VI–11

PRPIMP04.DGN/8-APR-96 14:52/JDR
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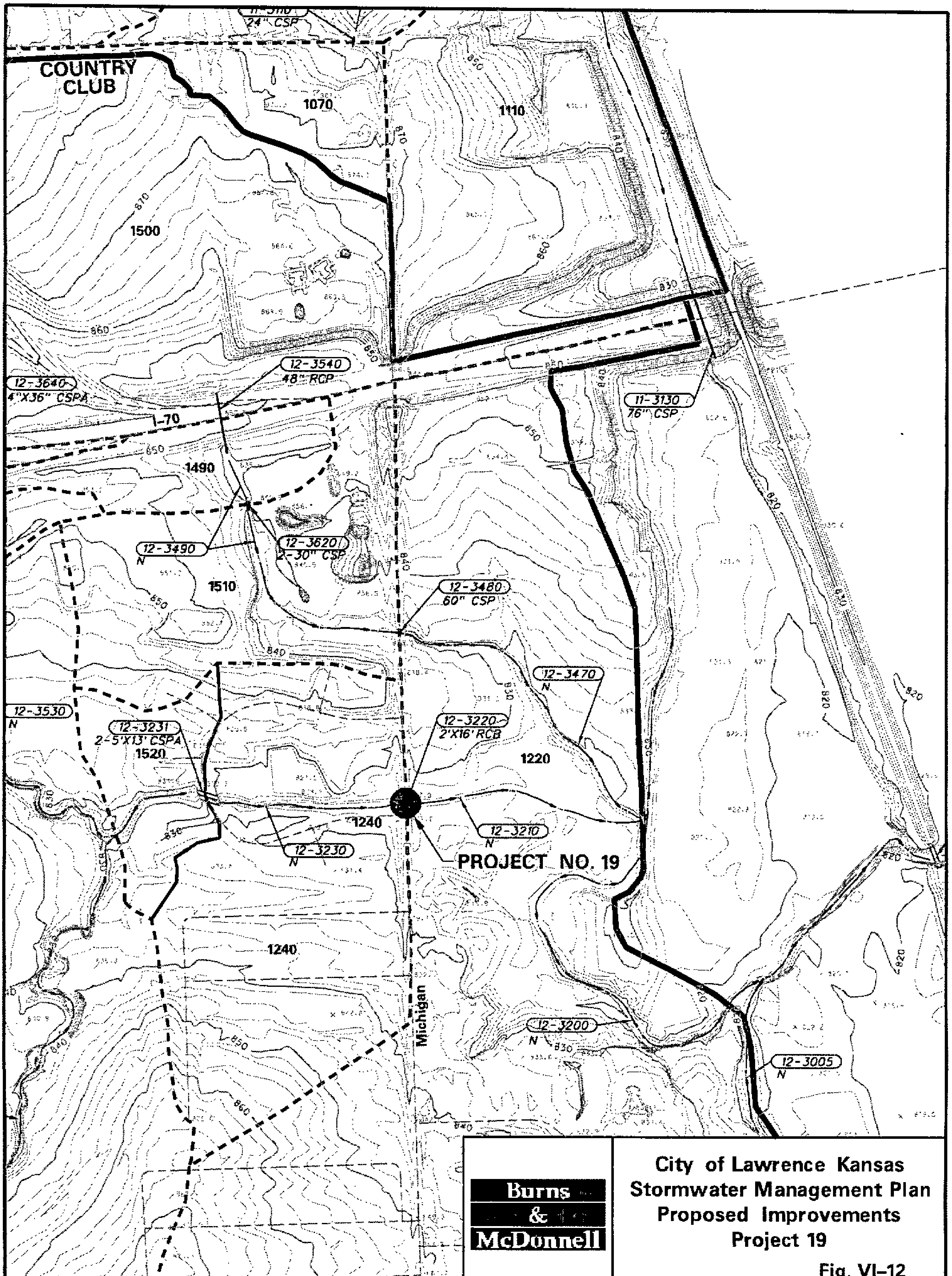

City of Lawrence Kansas
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Project 19

Fig. VI-12

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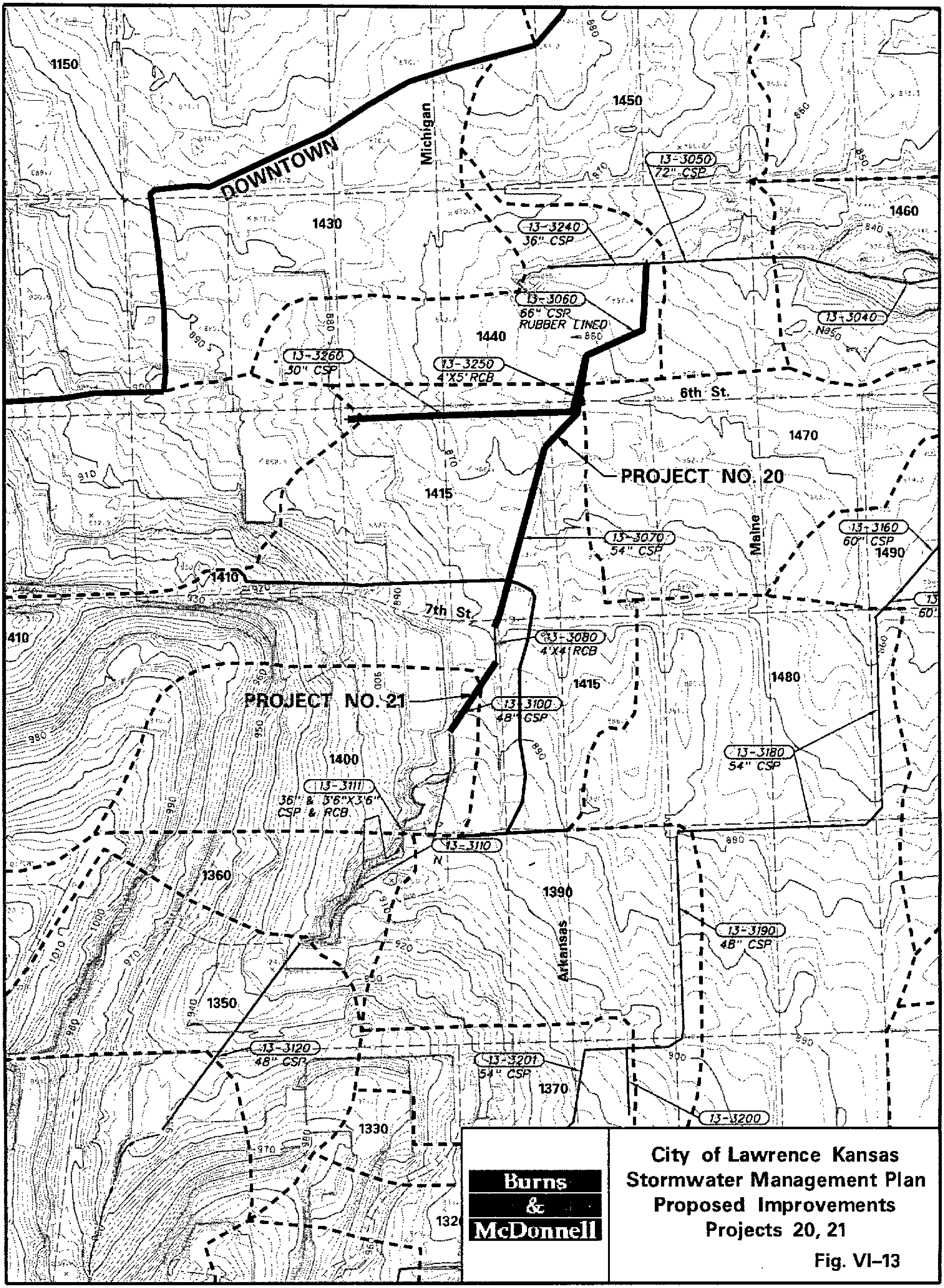

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City of Lawrence Kansas
Stormwater Management Plan
Proposed Improvements
Projects 20, 21

Fig. VI-13

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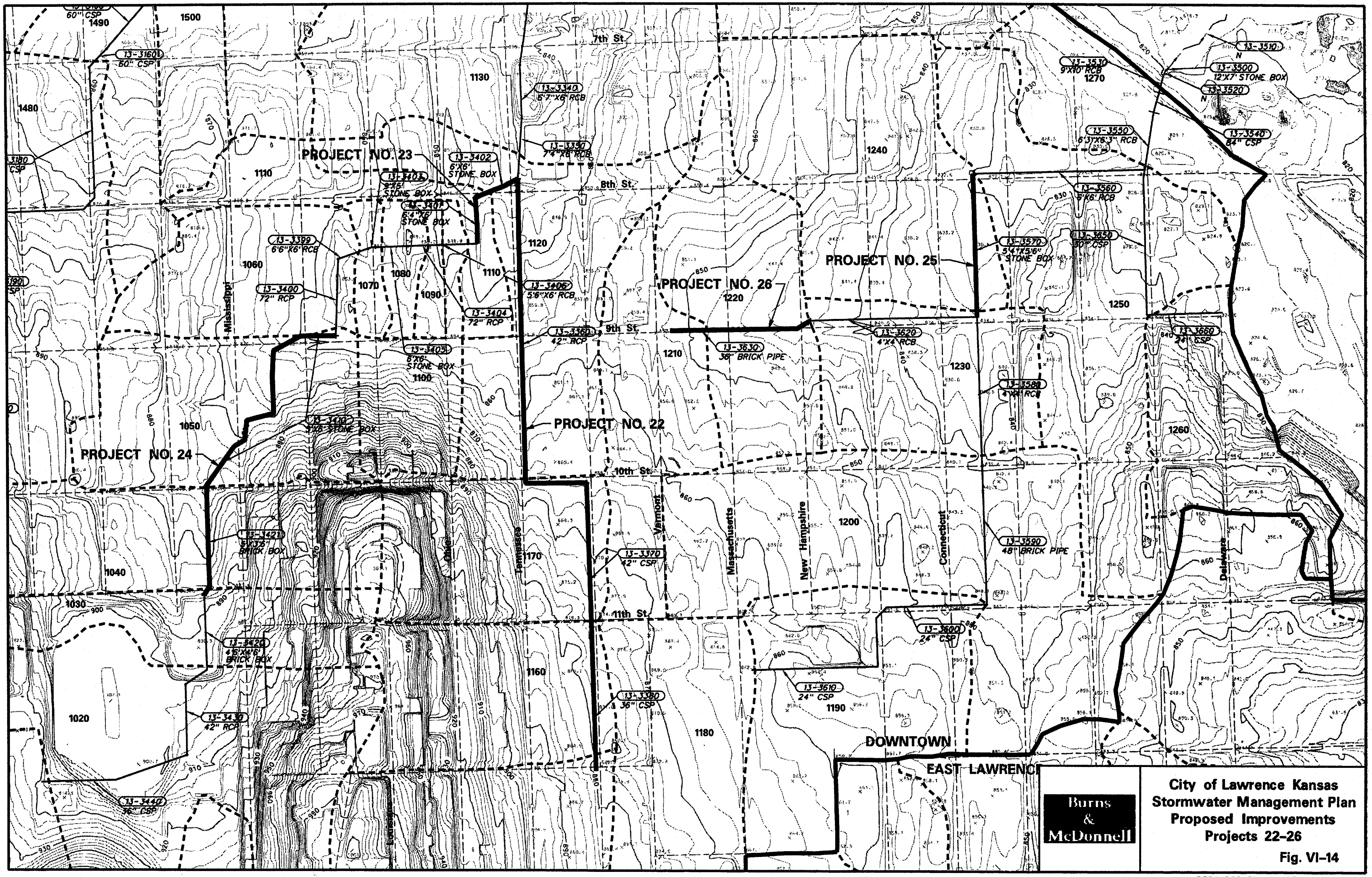

City of Lawrence Kansas
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Projects 22-26

Fig. VI-14

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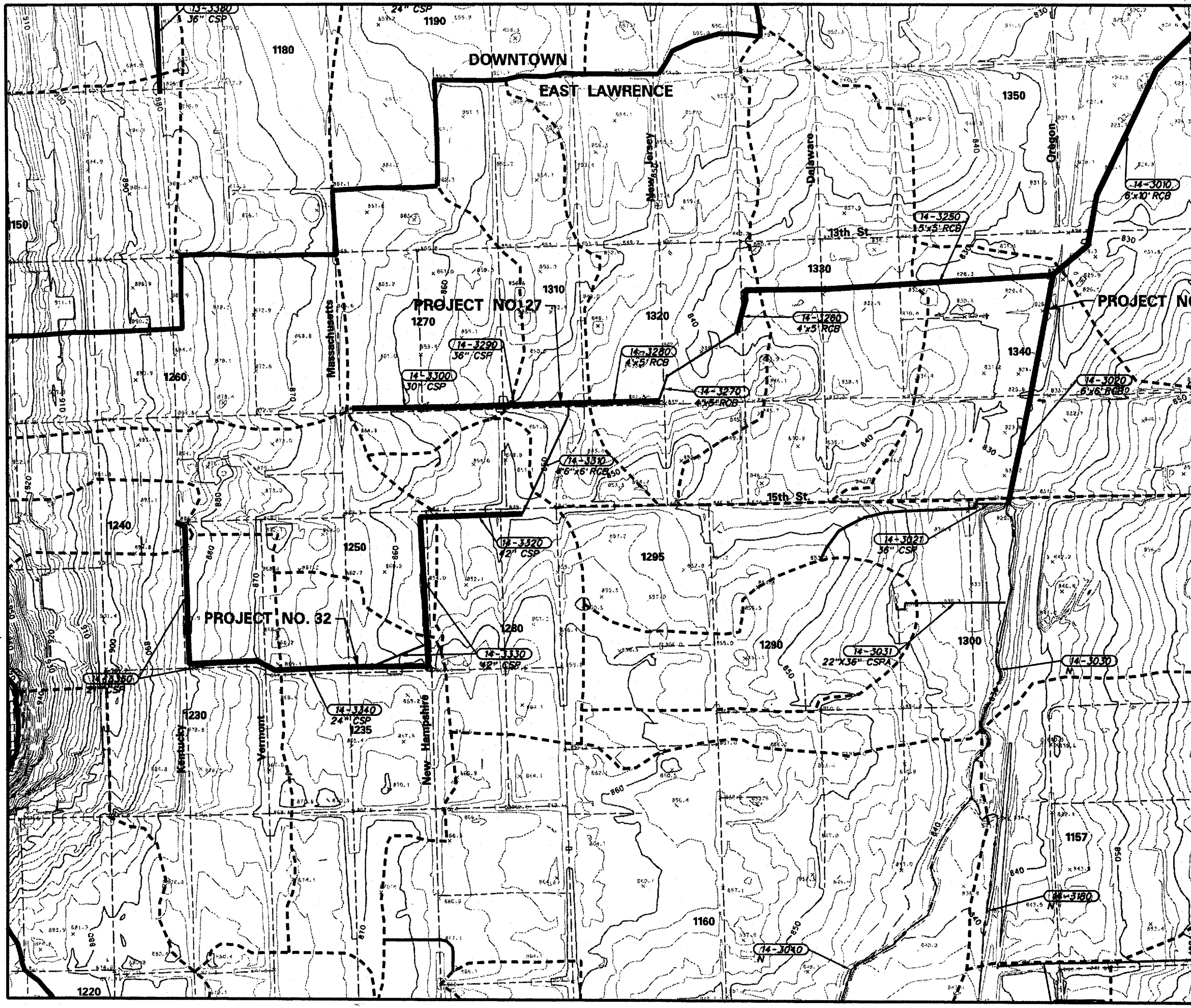

City of Lawrence Kansas
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Projects 27, 28, 32, 33
Fig. VI-15

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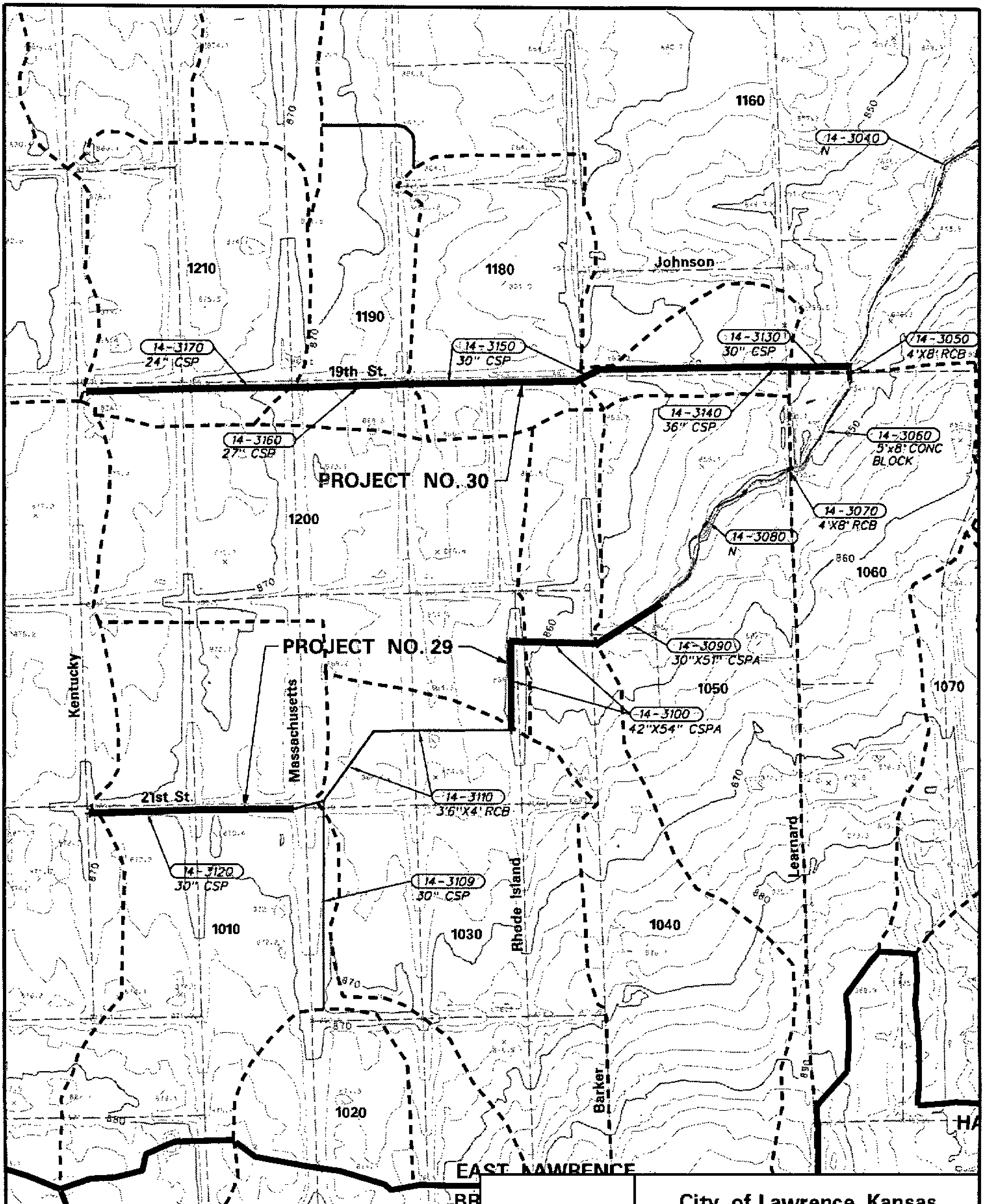

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Projects 29, 30

Fig. VI-16

PRPIMP20.DGN/8-APR-96 15:02/JDR
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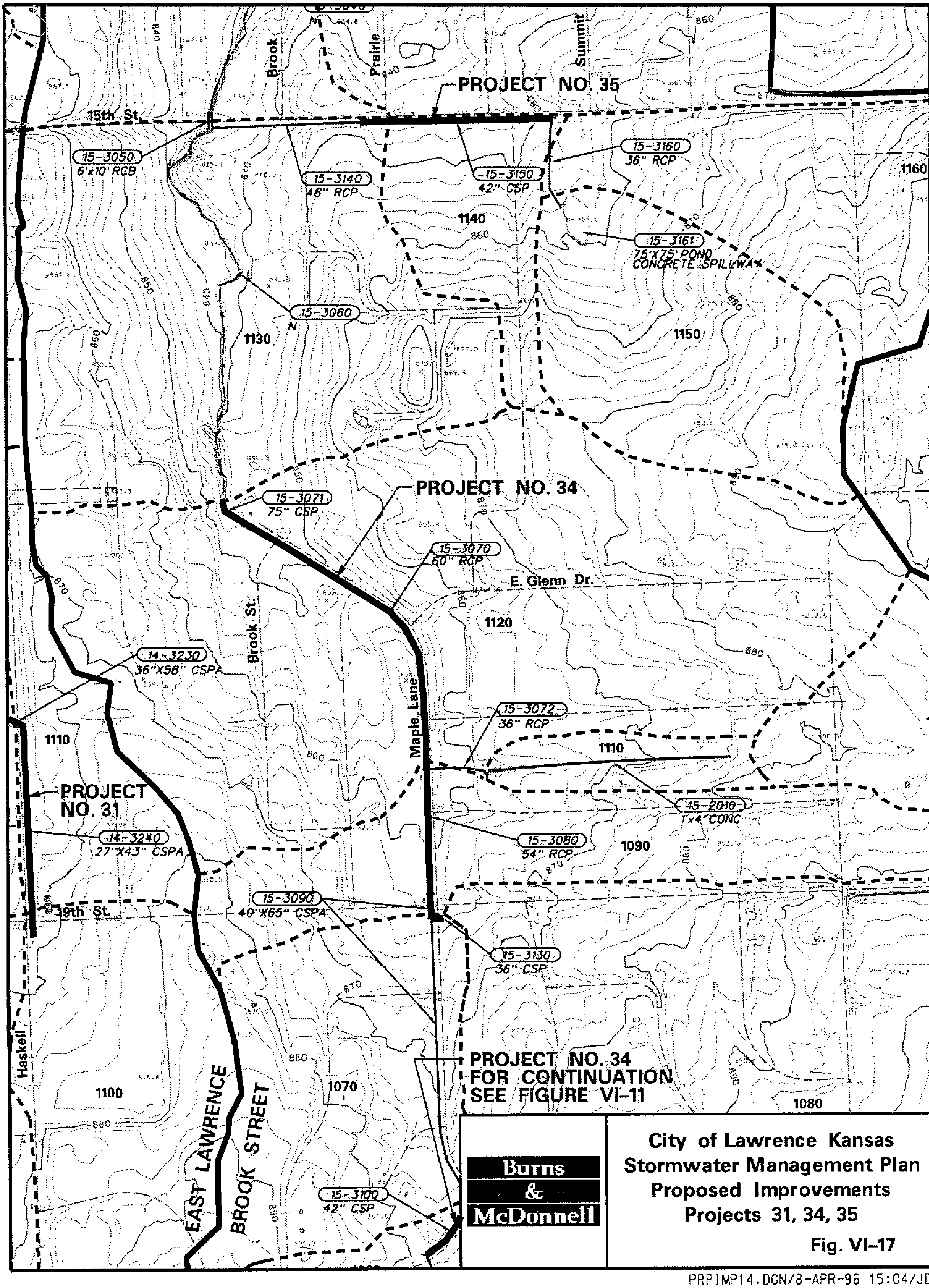

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Fig. VI-17

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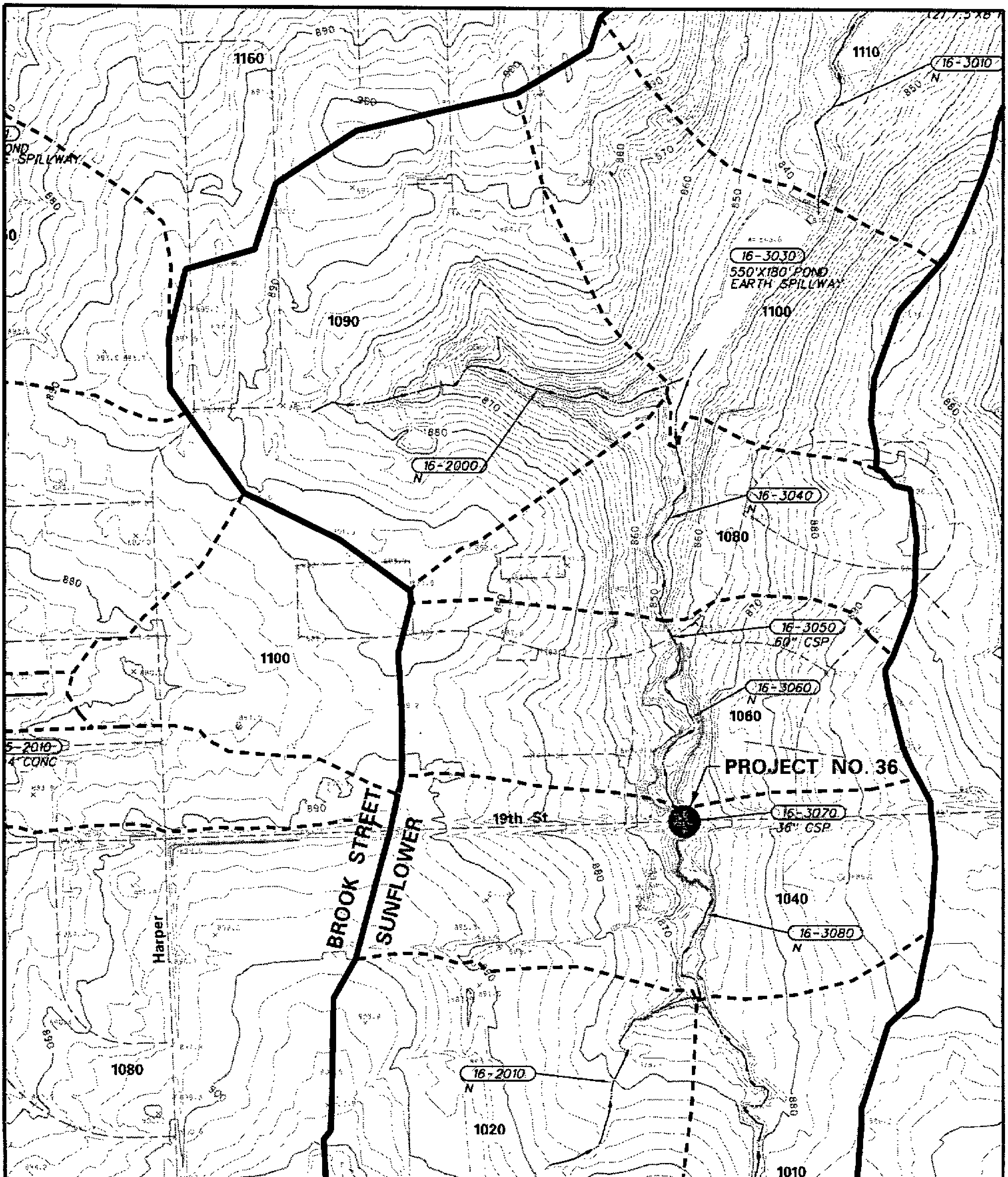

City of Lawrence Kansas
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Project 36

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Fig. VI-18

PRPIMP16.DGN/8-APR-96 15:06/JDR
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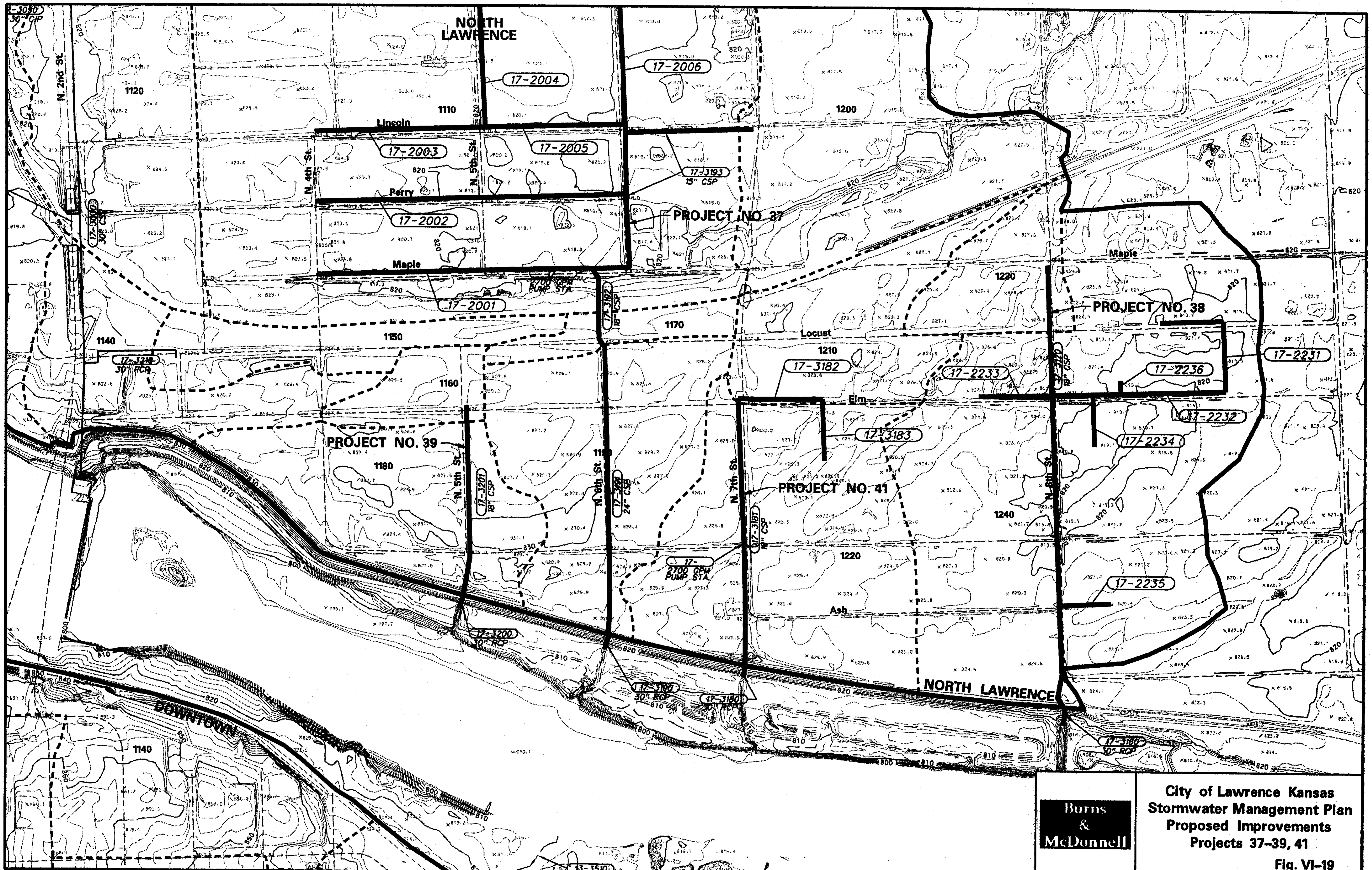

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City of Lawrence Kansas
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Proposed Improvements
Projects 37-39, 41

Fig. VI-19

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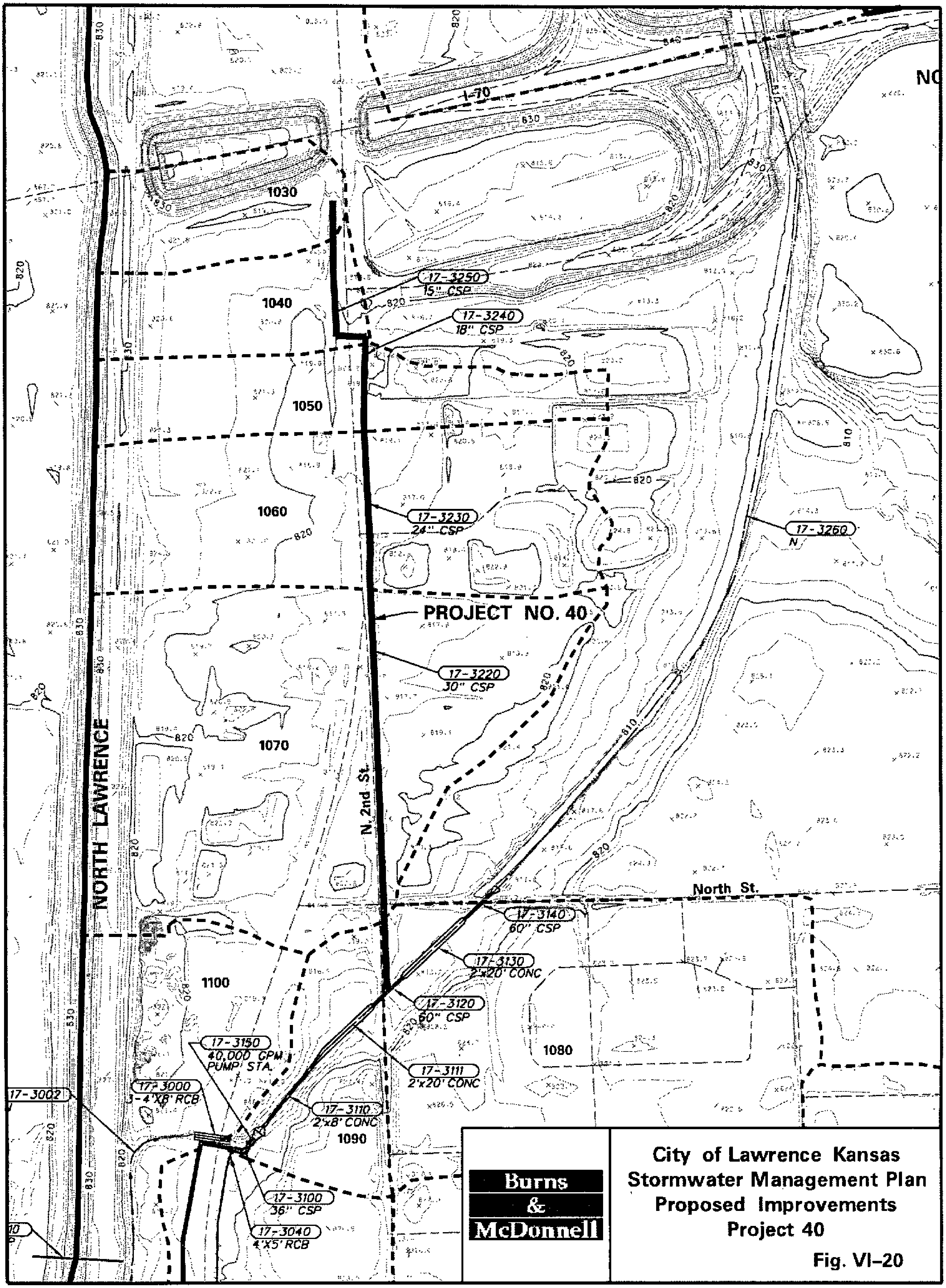

City of Lawrence Kansas
Stormwater Management Plan
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Project 40

Fig. VI-20

PRPIMP02.DGN/8-APR-96 15:08/JDR
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PART VII - OPERATION AND MAINTENANCE

PART VII

OPERATION AND MAINTENANCE

A. GENERAL

Continuing regular maintenance of the storm drainage system is essential to assure that the system hydraulic capacity is available when storm runoff occurs. It is equally essential to preserve the considerable capital value of the system.

Generally, there is not a clear and accepted line of demarcation between street and drainage maintenance activities and budgets. Maintenance of the storm drainage system shares a need for many of the same types of equipment and labor as is common to sanitary sewer and street maintenance. Because of these common factors, it is logical to assign responsibility for storm drainage system maintenance to the Public Works Department.

B. MAINTENANCE RESPONSIBILITY

The City currently assumes maintenance responsibility for improved drainage system facilities within the corporate limits and will continue to do so in the future. These facilities include enclosed pipe-inlet systems, road culverts, roadside ditches within city street right-of-way, and improved open channels, generally those which are concrete or riprap-lined. Maintenance of public detention facilities, if constructed in the future, will become the responsibility of the City.

Maintenance of natural or unimproved channels is currently not performed by City personnel which will continue to be policy in the future. Upkeep of these facilities is the responsibility of the private property owner(s) whose land abuts the channels.

C. ORGANIZATION AND EQUIPMENT

The following labor and equipment availability is recommended for performing normal maintenance of the storm drainage system. These recommendations assume that the City will continue its policy of not performing regular maintenance along unimproved channels which is particularly labor intensive. In the event that position is reversed, additional labor and equipment will be required.

TABLE VII -1

ORGANIZATION AND EQUIPMENT FOR STORM DRAINAGE SYSTEM MAINTENANCE

ITEM	DESCRIPTION	NO.
1.0	LABOR	
1.1	Field Supervisor	1
1.2	Maintenance Worker I	3-4
2.0	EQUIPMENT	
2.1	Jet Rodder	1
2.2	Industrial Tractor/Loader Backhoe	1
2.3	Tractor/Mower	1
2.4	Concrete Mixer - 3-1/2 cu ft	1
2.5	Portable Generator	1
2.6	Air Compressor	1
2.7	Truck, Dump Body	1
2.8	Truck, Flat Bed Utility or Pickup	1
2.10	Hand Tools	-

The average hourly cost for a maintenance crew and equipment as described above is estimated to be $105 to $110 (without overhead and administrative costs) depending on the specific crew size and equipment required for a given task. The cost will generally be lower for strictly system inspection work than for actual construction or repair projects.

D. MAINTENANCE TASKS

There is not a clear line of demarcation between work classified as maintenance and that more properly classified as construction. City maintenance in the context of this study is defined as work necessary to preserve the capacity and function of an existing facility which can be performed by reasonably available conventional city equipment and labor forces. The following types of maintenance tasks are those necessary to effectively maintain the storm drainage system.

1. INSPECTION

System facilities should be routinely inspected and maintenance scheduled to correct deficiencies noted during the inspection. A systematic method of record keeping should be initiated to record the inspection and track the maintenance history of individual system components. Routine inspection can be performed by public works maintenance staff personnel with special follow-up inspections by staff professional engineers or consultants in those infrequent instances that the routine inspection identifies any unusual structural or operational defect in the facility. The following is the recommended inspection schedule for the various drainage facilities.

FACILITY TYPE	INSPECTION FREQUENCY
Inlet/Catch Basins	Annual
Open Channels	Annual
Culverts on Open Channels	Annual
Roadside Ditches	Annual
Detention Basins	Annual

Interior inspection of pipe storm sewers is not routinely necessary; however, those sections of pipe having a known history of becoming obstructed due to the entry of debris and sediment from upstream open ditches should be inspected annually. Television inspection is recommended for old existing pipe and box structures not accessible for visual inspection.

2. ROADSIDE DITCHES

Normal recurring maintenance needs are removal of sediment and debris from the ditch and driveway culverts. Although located in street right-of-way, regular mowing in season should be considered the responsibility of the abutting property owner. It is also recommended that replacement of private driveway culverts be the responsibility of the property owner.

The rate of ditch sedimentation will vary across the City. Where grades are steep, the rate will be relatively slow while flatter ditch slopes will result in a higher sedimentation rate. A maintenance interval of two years is suggested for initial programming until experience in specific areas indicates the need to shorten or lengthen the time period.

3. <u>CULVERTS ON OPEN CHANNELS</u>

Normal recurring maintenance needs are the removal of debris and sediment. Multi-barrel culverts are most prone to the accumulation of obstructing sediment. In areas where maintenance of natural open channels is adequate, the maintenance requirements for culverts will decrease.

Structural repairs such as minor patching of surface spalls, joint sealing, etc., will be necessary during the service life of the structures at irregular intervals. Sediment removal should be expected on an annual basis.

4. <u>LINED OPEN CHANNELS</u>

Annual maintenance requirements are usually limited to the removal of debris. Periodic surface patching and repair of joints in concrete-lined sections should be performed on an as-needed basis. Expansion joints and cracks that permit vegetation to lodge and produce root damage should be treated with an appropriate herbicide to control vegetation. Replacement or repair of lining material in riprap or gabion-lined channels should also be performed on an as-needed basis. Brush or other vegetation which obstructs the channel or causes deformation or displacement of the lining should be cut periodically.

Scheduled storm drainage system inspection and routine maintenance activities should be planned for the months of October or November through April to assure maximum system capacity during the late spring and summer, typically the season of heaviest normal rain. This time period also allows the crews to take advantage of the most favorable conditions for accessibility of the work when weeds and brush in many areas are minimal. Such seasonal scheduling of maintenance is also most conducive to efficient overall utilization of staff and equipment by keeping them available for repair and construction projects during the spring and summer months.

E. ANNUAL MAINTENANCE

The City's existing major drainage system, as evaluated for this study, includes 193.8 miles of pipe, culverts, and open channels. Average annual maintenance costs over the useful life of the improved major system components, as estimated by the SYCOST model, is $ 97,000 per year. Maintenance costs associated with the minor system are expected to be at least as much as for the major system which results in an annual expense for the entire system of $ 175,000 to $ 200,000. This annual budget will suffice to address the apparent maintenance needs of the existing system but will not provide for a prudent reserve fund for increasing maintenance as the system ages and expands. It also does not include costs for maintaining the natural channel components of the system which would add approximately $ 100,000 annually.

F. MAINTENANCE OF PRIVATE SYSTEM FACILITIES

Regular maintenance of all storm drainage facilities is necessary to insure the system's continuing function at an acceptable level of service. However, maintenance of components which are the responsibility of private property owners is often neglected, especially along natural channels, creating potential drainage problems. Depending on the size and location of the element, its failure to function properly can affect the system as a whole and impact a much larger group than just the residents in the immediate area. Maintenance of private components can be difficult to regulate or enforce. To insure that adequate private storm drainage maintenance is performed, the City has already enacted an ordinance allowing the Director of Public Works to direct property owners to maintain the drainage easements on their tracts. In the event the required maintenance is not performed, City crews can complete the work and bill the property owner for the actual labor, equipment and administrative costs. As discussed in the policy section of this report, it is recommended that this ordinance be expanded to specifically include private enclosed system components, improved channels, etc., in addition to easements. It is also important that the ordinance be consistently enforced to insure proper function of the overall drainage system.

In addition to the requirements for maintaining the actual drainage system, it is suggested the City adopt a policy and appropriate regulations requiring erosion control plans for all new construction projects as outlined previously in the policy section of this report. These plans can be as simple as requiring a line of hay bales along the edges of a residential building lot, to a more complex system of silt fencing, filters and siltation ponds on larger projects. Such requirements are intended to prevent siltation on public streets and in the existing downstream drainage system which increases the City's maintenance program and costs. As discussed previously, these requirements appear to be most appropriately incorporated in the building permit process.

G. <u>SPECIFIC MAINTENANCE NEEDS</u>

Overall, the City's storm drainage system appears to be in generally good shape. During the course of the system inventory, conducted primarily in February and March of 1995, however, a number of maintenance needs were noted in the field reports. The majority of the problem areas involve sedimentation in and around pipe, box culvert, and bridges entrances which restricts flow and decreases the system capacity.

It is also suggested that additional inspection of many of the older enclosed sections of the system, such as those in the Downtown and East Lawrence watersheds, be performed as soon as feasible since these reaches were not always safely accessible to the technician performing the inventory. Some of these areas will probably require the use of television inspection methods due to safety issues.

The following is a brief summary of the maintenance required. Some of the problems have probably already been resolved since the time of the field survey. The list is intended as a starting point for the stormwater utility or street maintenance crew(s) to begin a system maintenance program. It does not include any system reaches recommended for replacement or improvement as part of the critical projects list of the capital improvement plan.

<u>Hidden Valley Watershed:</u>

1. Line 2-3090: Remove sediment and debris obstructing approximately half of entrance of 36-inch pipe at Prestwick Dr.

2. Line 2-3190: Repair/replace deteriorated bottom of 6-ft. wide concrete channel along south side of 23rd St., west of Crossgate.

3. Line 2-3340: Remove sediment at entrance of 72-inch pipe across Ranch St., south of 23rd.

4. Line 2-3410: Remove sediment at entrance of triple 75x55 CMPA culvert across Inverness, near the intersection with Vantuyl.

5. Line 2-3440: Remove sediment and debris at entrance to triple 42x28 CMPA culvert across Anthony Michael.

6. Line 2-3560: Remove sediment, debris and rock obstructing approximately half of entrance of double 48-inch culvert across 13th St., near Lawrence Ct.

7. Line 2-3610: Remove sediment and debris at entrance of 36-inch pipe across Jefferson Way and Colonial Way.

8. Line 2-3620: Remove sediment/mud obstructing approximately half of 81x59 CMPA across Wakarusa, just south of Harvard.

9. Line 2-3720/3730: Remove sediment and debris obstructing double 49x33 CMPA across Wakarusa.

10. Line 2-3800: Remove sediment filling approximately one-third of 73x55 CMPA across Wakarusa.

11. Line 2-3820: Remove sediment, rocks and debris obstructing entrance of 48-inch pipe across Troon Lane near Balmoral.

<u>Quail Creek Watershed:</u>

12. Line 3-3080: Remove sediment/mud partially obstructing 36-inch pipe across Monterrey Way, south of Elizabeth Ct., and drain standing water.

13. Line 3-3140: Remove sediment/mud obstructing approximately half of 70x48 CMPA across 6th St., west of Monterrey Way.

14. Line 3-3160: Remove sediment/mud obstructing 36-inch pipe across Overland Dr., west of Monterrey Way.

15. Line 3-3280: Fill scour hole at downstream end of 54-inch pipe at end of Randall Rd. system and provide energy dissipator to prevent reoccurrence.

16. Line 3-3480: Reinstall end section at upper end of 37x24 RCPA along Brush Creek Dr. Repair undercut area at pipe inlet and provide riprap or other erosion protection to prevent reoccurrence.

Yankee Tank East Watershed:

17. Line 4-3160: Remove sediment and weeds from 15-ft. concrete channel along south side of 23rd St., west of Lawrence Ave.

18. Line 4-3210: Remove 1-2 ft of sediment at entrance and inside quadruple 10'x7' RCB across Kasold, north of 31st St.

19. Line 4-3320: Remove accumulated silt and debris and repair deteriorated concrete in bottom of 6-ft. lined channel between Lawrence Ave. and Jana Dr., north of Harvard.

20. Line 4-3660: Remove sediment, rocks and debris at entrance of 54-inch pipe across 15th St., west of Iowa.

Naismith Watershed:

21. Line 5-3170: Repair/replace concrete lining in 6-ft. channel along south side of 31st St., east of Iowa. (This may be a private facility in which case the property owner should be responsible for maintenance.)

22. Line 5-3230: Remove sediment/mud obstructing downstream end of 36-inch pipe across 31st St., east of Iowa.

23. Line 5-3440: Remove rocks and debris from 7'x5' RCB along south side of 23rd St., just east of Naismith Dr.

Belle Haven Watershed:

24. Line 7-3040: Remove sediment obstructing 83x52 CMPA across 27th Terr., west of Louisiana.

Broken Arrow Watershed:

25. Line 8-3000: Remove approximately 1-2 ft. of sediment from double 9'x 5' RCB across 31st St., east of Louisiana.

Haskell Watershed:

26. Line 9-3110: Remove trash, rocks, debris, and accumulated sediment blocking the downstream end of 36-inch pipe across 28th St. near Oregon.

27. Line 9-3201: Check for sediment buildup or other obstructions at double 12'x 5' RCB across 31st St., west of Haskell, and remove as necessary. (At time of inventory, box was almost completely full of water and appeared to be backing up.)

28. Line 9-3310: Remove sediment, weeds and brush from 5-ft. concrete channel located between Ponderosa and Maverick, south of 27th St.

29. Line 9-3380: Repair/replace wingwall of 6'x 3' RCB across 23rd St., near Harper.

30. Line 9-3520: Check for sediment buildup or other obstructions at double 13'x 2.5' RCB across 31st St., just west of Haskell, and remove as necessary. (At time of inventory, box was approximately half full of water and appeared to be partially full of silt.)
31. Line 9-3700: Remove sediment, rocks, and weeds at entrance to 36-inch pipe across 25th Terr., near Hampton. (Pipe should be carefully inspected for structural integrity since a metal shed/outbuilding is sitting directly on top of it with very little cover. This is also an example of an obstructed overflow channel which should be corrected.)
32. Line 9-3730: Remove sediment/mud obstructing outlet of 54-inch pipe at end of Kensington Dr.

<u>Deerfield Watershed:</u>

33. Line 10-3050: Remove sediment and debris obstructing entrance of 42-inch pipe across Riverview Rd., west of Kasold.

<u>Riverside Watershed:</u>

34. Line 11-3000: Remove approximately 1 foot of sediment accumulation in double 5'x 5' RCB across Iowa, near Timberedge Rd.
35. Line 11-3020: Regrade outlet channel for pipe across Iowa, south of Riverside Dr. Channel invert is higher than pipe preventing drainage and causing standing water around pipe outlet.
36. Line 11-3090: Remove sediment and weeds obstructing entrance of 36-inch pipe across Riverside Dr. at Colorado.
37. Line 11-3110: Remove sediment obstructing 24-inch pipe across road near north end of Michigan.

    (Both lines 3090 and 3110 may be part of Douglas County's system in which case the county should be responsible for maintenance.)

<u>Country Club Watershed:</u>

38. Line 12-3020: Reinstall end section on outlet of 36x24 RCPA discharging into a natural channel between Arkansas and Maine Streets, north of 2nd St. (This may be a private reach in which case the property owner should be responsible for maintenance.)
39. Line 12-3140: Regrade or provide energy dissipator at outlet of 4'x 4' RCB across Iowa, south of 6th St. Approximate 2-ft. drop at end of pipe to channel creating scour hole.

40. Line 12-3231: Remove sediment completely blocking one barrel and partially blocking the other barrel of double 13'x 5' CSPA culvert across Northwood Dr.
41. Line 12-3320: Remove sediment and debris obstructing 7'x 5' RCB across Iowa, north of 2nd St.
42. Line 12-3430: Repair/replace concrete lining in 4-ft. channel due to undercut/heave, and regrade to match inverts with tributary channel, Line 3361. At the time of inventory, the invert of Line 3430 was higher than that of 3361.
43. Line 12-3480: Replace rusted 60-inch CMP across Michigan, south of I70.

Downtown Watershed:

44. Line 13-3030: Remove accumulated sediment and debris from entrance of concrete arch near the end of Illinois, south of 5th St.
45. Line 13-3111: Remove leaves, trash, other debris from entrance to 36-inch pipe and 3.5'x 3.5' RCB across 8th St., west of Michigan.
46. Line 13-3350: Thoroughly inspect 6'x 7'4" concrete arch along the west side of Tennessee, north of 8th St., for structural integrity. Large longitudinal crack noted in top, especially near end where Line 3340 connects. Joints in walls seeping.
47. Line 13-3402: Thoroughly inspect 6'x 6' stone arch across 8th St. near Tennessee for structural integrity. Loose rocks, apparently from walls and roof, noted on floor of structure.
48. Line 13-3403: Thoroughly inspect 5'x 9' stone arch across Louisiana, south of 8th St., for structural integrity. Loose rocks, apparently from walls and roof, noted on floor of structure.
49. Line 13-3410: Thoroughly inspect 6'x 5' stone box between 9th and 10th Streets, and from west of Mississippi to east side of Indiana, for structural integrity. Loose rocks, apparently from walls and roof, noted on floor of structure and top appears to be sagging.

East Lawrence Watershed:

50. Line 14-3060: Remove sediment, weeds and loose stone and blocks from concrete/stone vertical wall channel southeast of the intersection of Learnard and 10th St. Inspect walls for structural integrity since they appear to be leaning in several locations.
51. Line 14-3210: Remove sediment and weeds at entrance to 36-inch pipe between Delaware and the railroad, south of 19th St.

52. Line 14-3370: Remove sediment obstructing approximately half of 51x31 CMPA across 19th St.

53. Line 14-3410: Remove sediment obstructing approximately half of 51x31 CMPA across 19th St., east of the railroad.

Brook Street Watershed:

54. Line 15-3010: Remove sediment and trash accumulated at outlet of 48-inch pipe across 13th St., east of Brook St.

Sunflower Watershed:

55. Line 16-3050: Remove trash and other debris in and around inlet of 60-inch pipe across road through mobile home park. (This may be a private road and culvert in which case the property owner is responsible for maintenance.)

56. Line 16-3070: Remove sediment and debris at entrance to 36-inch pipe across 19th St., east of Harper.

North Lawrence Watershed:

57. Line 17-3000: Remove accumulated sediment and debris around triple 8'x 4' RCB across N. 2nd St. adjacent to pump station.

The above list of maintenance needs excludes any private components; county road, state highway or railroad culverts; or other system element for which the City does not take maintenance responsibility. It is recommended, however, that any information concerning maintenance needs on such facilities be forwarded to the appropriate agency as soon as the City becomes aware of such conditions.

* * * * *

PART VIII - FINANCIAL PLAN

PART VIII
FINANCIAL PLAN

A. SCHEDULE OF IMPROVEMENT PROGRAM

The time span over which the capital improvement program is accomplished affects both the cost of the program and the choice of method, or combination of methods, for developing revenue to support the program. Even though it would be desirable to correct all present drainage problems immediately, it is not a practical concept. Besides the financing issues, the City staff available to administer the capital improvement program is a constraint on the speed at which improvements can be made. For purposes of this analysis, the capital improvements program has been divided into three phases corresponding to the priority groups outlined in Part VI of this report. This financial plan focuses on the initial phase which includes those recommended projects categorized as critical. Program durations of five and ten years have been evaluated as a basis for determining revenue needs and options. Because of the "critical" nature and the long history of the problems involved in the first group of projects, it is recommended that this initial program be completed in the shortest time possible

B. FINANCING ALTERNATIVES

There are essentially only two financing alternatives available for funding the recommended improvement projects: cash-basis and debt financing. The cash-basis method assumes that improvements will be constructed only as adequate funds become available from the identified revenue sources. Debt financing would be accomplished through the issuance of municipal bonds of one of the following types: general obligation bonds, revenue bonds and special assessment bonds. Possible financing plans utilizing G.O. and revenue bonds are illustrated later in this report section. Of course, assuming the City does opt to finance the improvement program through bonds, it is recommended that a qualified financial advisor be consulted to develop and assess specific proposals and schedules.

In the case of general obligation bonds, Kansas statutes allow the City to issue such City-at-large bonds for construction of or improvements to main storm sewers with the municipal governing body determining what constitutes a main storm sewer system element. The improvements funded by these bonds may be constructed either by City employees or by a contractor obtained through a competitive bid process. These improvements may be authorized by ordinance and the general obligation bonds issued without a public vote. In addition, these bonds are not subject to legal limitations on the City's bond indebtedness.

The second alternative, revenue bonds, is applicable assuming a stormwater utility is created by the City. These bonds may be issued to finance improvements to any City utility and are payable solely from the fees collected for the use of that utility. They may be issued by adoption of a resolution declaring the intent of the City to make improvements and finance them through revenue bonds; however, this method is subject to a 20% protest filed within 15 days of the publication of the City's notice of intent to issue such bonds. Disadvantages of this method, compared to general obligation bonds, also include greater issuance costs, higher interest rates, and the requirement to fund a debt-service reserve account when the bonds are issued.

The third alternative, special assessment bonds, allows the City governing body to authorize the construction and financing of storm drainage projects by resolution, not subject to petition or protest, where the City-at-large pays for a portion of the project costs (up to 95 percent) and special assessments on benefitted properties pay a portion. Costs for the improvements not covered by either of these two sources may be financed by the issuance of general obligation bonds.

C. GENERAL REVENUE SOURCES

The challenge before the City of Lawrence is to both develop and implement an equitable, comprehensive funding strategy that places the cost of the stormwater management program on those who truly generate the need for the additional expenditures. A number of traditional and innovative financing techniques are available to the City to fund its proposed program, each with its own legal restraints. Explicit statutory authority exists to utilize traditional funding sources such as ad valorem property taxes, special assessments, sales taxes, occupational taxes and fees and excise taxes. In addition, authority to utilize innovative funding techniques exists pursuant to the City's home rule power or pursuant to authority implied from specific statutory grants of power including creation of a stormwater utility and imposition of impact fees on new development to recoup the cost of public facilities necessary to support new development. At this time there are no known grants or subsidies available from either state or federal sources specifically for funding storm drainage system improvements. Community Block Development Grants can include storm drainage improvements which are incidental to grant projects but are not intended to fund drainage projects as such.

D. ESTABLISHMENT OF A STORMWATER UTILITY

In late 1993, while examining the many stormwater and drainage issues facing Lawrence, the City's Stormwater Task Force recognized the possible options for financing drainage improvements and recommended creation of a stormwater utility. The City Commission, following this recommendation, approved Charter Ordinance No. 28 in September, 1993 providing comprehensive powers for the improvement, operation and maintenance of the municipal storm drainage system and the ability to establish a stormwater utility. Although utilized in other parts of the country, the utility concept relative to storm drainage has not been extensively used in the Midwest thus far. In recent years, however, the cities of Olathe, Wichita, Topeka, and Manhattan, Kansas, and Columbia and Kansas City, Missouri, have implemented the stormwater utility concept. The City of Kansas City, Kansas, in the first year of its municipal NPDES permit, will undertake a feasibility study to investigate the advantages and disadvantages of a stormwater utility, and to develop an implementation plan and a probable user fee/rate for such utility. Brief summaries of some of these existing utilities, including basic identification of the rate base and annual income, are included in Appendix D for reference.

1. <u>Utility Structure and Function</u>

The stormwater utility can act as the organizational unit for all stormwater management activities including implementation of the stormwater management plan policies, oversight of the completion of the associated capital improvement projects, and continuing management and maintenance of the City's drainage system. The authority to charge user fees through a stormwater utility for the use of stormwater services or facilities is derived from the City's authority to tax. Therefore, utility rates need not be restricted to use on facilities which are needed due to new development. Revenue from rates generally can be used for any service or facility directly related to stormwater management including planning, consultant services, educational programs, administrative costs, water quality monitoring, Best Management Practices (such as street sweeping) and capital facility costs. Utility revenues must be deposited in a dedicated fund, earmarked solely for stormwater management activities, which can be restricted from use for other governmental purposes. A dedicated revenue source also enables the City to issue revenue bonds to pay for the cost of major capital projects if that is determined to be a financing method.

It is anticipated that the stormwater utility will fall under the jurisdiction of the Director of Public Works. Initially, personnel requirements will consist of a stormwater engineer and an administrative clerk. Work tasks will include coordination with the City's finance department to set up utility accounts, acquiring necessary vehicles and equipment, planning the maintenance program, finalizing an erosion control policy, and review of plats and drainage plans for compliance with the City's adopted stormwater criteria. Assuming the utility is actually established during the summer of 1996, it will probably be possible to start billing at the beginning of 1997.

Once the utility is functional and revenues are available, a stormwater maintenance crew comprised of a field supervisor and three maintenance workers will be added to begin inspection and maintenance tasks. Until that time, necessary maintenance will be performed by City street crews as is currently the practice. It is anticipated that even after the utility is established, various pieces of equipment, such as the City's vacuum truck, will continue to be shared by the stormwater and street crews and that there will be seasonal "crossover" of personnel when work loads require it. A suggested organizational chart for the utility is indicated in Figure VIII-1.

Table VIII-1 lists the annual basic costs to operate the stormwater utility based on the recommended staffing levels. The current year's budget includes $50,000 for staff salaries. Annual capital costs for equipment and materials will vary depending on how much equipment is shared with the Street Maintenance Department and what specific maintenance projects are undertaken. Initially, expenditures are anticipated for two vehicles (a pickup truck and either a car or truck for staff), office furniture and supplies, and miscellaneous small tools and equipment which can be purchased with the $50,000 budgeted for this purpose for the current year.

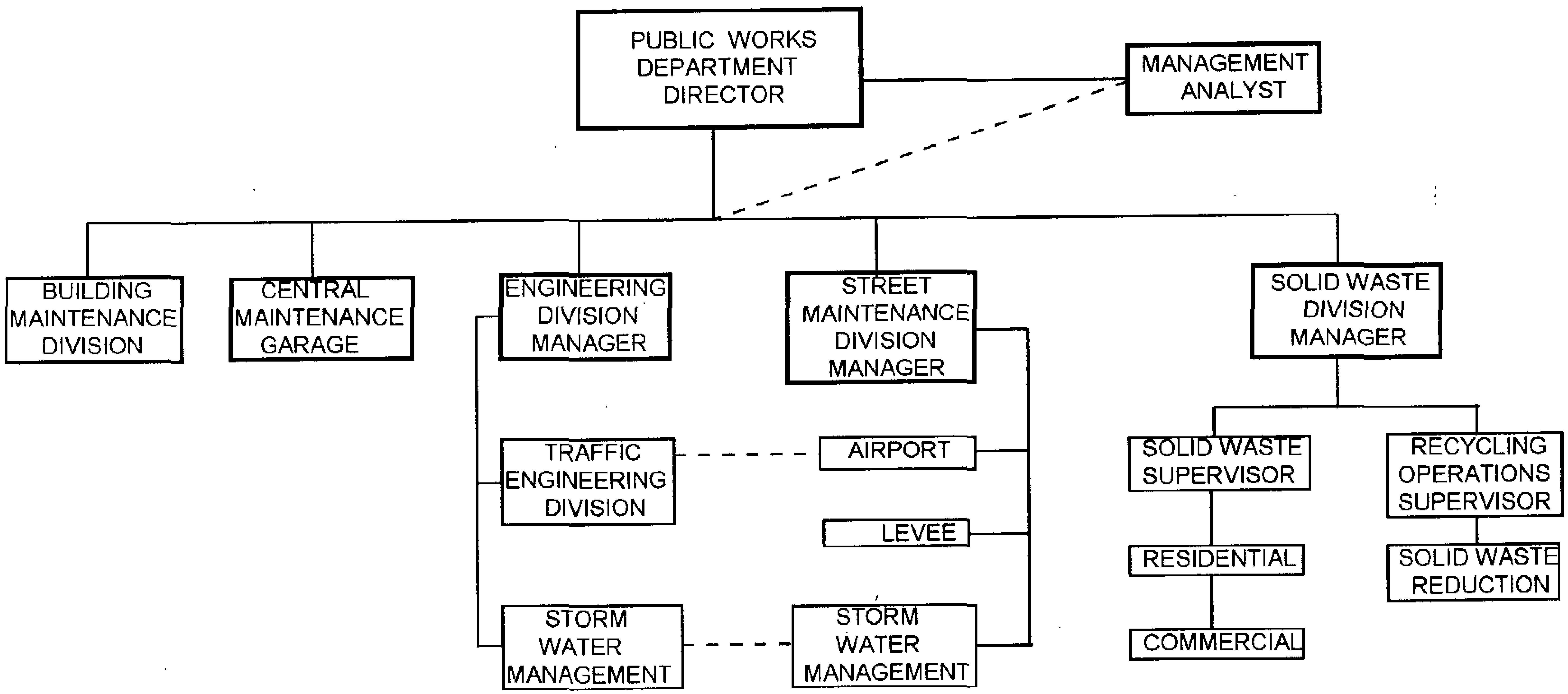
TABLE VIII-1

STORMWATER UTILITY ANNUAL COSTS

	Average Annual Salary/Cost ($)
Office Personnel	
Engineer	42,170
Administrative Clerk II	20,696
Maintenance Personnel	
Field Supervisor	29,265
Maintenance Worker I (3 @ $21,756 each)	65,268
Subtotal	$ 157,399
Add labor overhead (estimated @ 35%)	55,090
Labor Total	$ 212,489
Office and Shop Area Rental, Supplies	10,000
Vehicles, Equipment, Materials	72,500
Total	$ 294,989

FIGURE VIII-1

LAWRENCE, KANSAS STORMWATER MANAGEMENT MASTER PLAN
PUBLIC WORKS DEPARTMENT ORGANIZATION WITH STORMWATER UTILITY



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2. <u>Utility Rates</u>

Rates charged by utilities must be reasonable, just, nondiscriminatory, and uniform within a defined class of users. The utility service charge or rate will be based on the relative contribution of runoff to the storm sewer system for general categories of or individual properties determined by the amount of impervious, or improved, area on each parcel.

In order to determine the various property classifications and rates, the basic unit, the Equivalent Residential Unit (ERU), for the City must first be established. To accomplish this task data base information for all properties within the corporate limits was obtained from the Douglas County appraiser's office. These files include eight basic property classifications: residential, non-profit, agricultural, commercial (includes industrial facilities), utilities, exempt (government, churches, schools,etc.), vacant lot, and other. Within each classification are additional breakdowns with each parcel assigned a land use code indicating the specific use of the property. Residential property is identified as single-family, duplex, high-rise apartment, mobile home, etc. Commercial properties are identified by very specific land uses for industry, manufacturing, retail, offices, and exempt properties such as schools and government offices. Specific information available for each parcel includes the following.

CAMA Number (the individual parcel identifier)
Land Use (by land use code number)
Land Size (in square feet or acres)
Class (residential urban, exempt municipal, etc.)
Main Building Size (square feet)
Out Buildings Size (square feet)
Total Size (total improved area in square feet)

The "out buildings" item includes items such as garages, decks, and drives and parking. In the commercial classification it also includes such improvements as truck scales, storage bins, tanks, etc. The data base does not account for the impervious surfaces included within street and highway rights-of-way.

The ERU is based upon the data for single-family residential properties. Adding the land areas and total improved areas for all property identified as such, the ERU, or average parcel, was determined to be 11,320 square feet of land with 1,888 square feet of total improved area. Additional analyses of other residential classifications indicate that multi-family units average approximately two-thirds or less of a single-family unit. Table VIII - 2 summarizes the average unit size for each of the various classifications.

TABLE VIII - 2

AVERAGE UNITS FOR RESIDENTIAL PROPERTY

Type of Dwelling	Total No. of Units	Average Land Area/Unit(S.F.)	Average Improved Area/Unit (S.F.)
Single-family	15,370	11,320	1,888
Duplex	2,036	4,952	1,111
Triplex	276	3,250	914
Fourplex	904	2,497	621
Condo	599	N/A	1,100
Mobile Home[1]	1,290	5,535	77[2]
Garden Apts.	5,522	2,166	766
Walkup Apts.	1,800	2,127	851
Mid-Rise Apts.	60	525	314
High-Rise Apts.	120	547	236
Group Quarters[3]	2,865	883	360
Residences Converted to Apts.	1,255	2,552	577

1 In mobile home parks.
2 Does not include area of mobile home since units are taxed as personal property instead of real property.
3 Includes rooming houses, etc.

A total of 1,260 parcels with improved area were identified in the commercial data base, not including any residential units that are taxed at a commercial rate. This commercial property was not broken down further by land use codes since there is a much larger number of specific classifications covering those tracts than for residential property. Total improved area on these parcels is 30,895,042 square feet.

From this basic information a rate structure and billing system must be developed that is both equitable to the "customers" and manageable for the

City staff faced with administration of the stormwater utility. The simplest system would, of course, be to charge all properties the same uniform fee; however, this system does not address the "fairness" issue of fees based on actual use of the drainage system.

Examining the structure of the operating stormwater utilities in this region and the issues involved, it is recommended that Lawrence's rate structure be a combination of the systems used by other cities. It is proposed that residential properties be divided into three categories, or tiers, based on total improved area for the parcel. The basic ERU and associated billing rate will apply to the middle tier which includes all single-family parcels with total improved area of 1,200 to 3,000 square feet. A lower tier will apply to single-family parcels with improved area less than 1,200 square feet and to all multi-family units. This tier will be billed at 0.67 ERUs. The upper tier will include single-family parcels with improved area greater than 3,000 square feet, billed at 1.5 ERUs.

Commercial property is divided into six basic categories, or tiers, based on total improved area per parcel. The first five tiers cover parcels with improved area up to 100,000 square feet which includes all but 53 parcels within the commercial data base. Each property within these categories is billed a set rate based on the number of ERUs for an average parcel in that size classification. In the sixth tier, each parcel is billed based on the actual number of ERUs represented by its improved area. General categories were not assigned to parcels with over 100,000 square feet of improved area because the of the very broad size range covered by relatively few tracts making classification by "average" size more difficult.

Table VIII-3 summarizes the proposed stormwater utility rate classifications. Based on this structure and the actual number of units or properties of each type within Lawrence, utility revenue will be derived from a total of 42,669 ERUs.

TABLE VIII - 3

PROPOSED UTILITY RATE STRUCTURE

Property Category	Total Improved Area/Parcel (SF)	No. of ERUs Billed
Single-family Residential	< 1,200	0.67
	1,200 to 3,000	1.0
	> 3,000	1.5
Multi-family Residential	N/A	0.67
Commercial	≤ 10,000	2.5
	10,001 to 25,000	8.5
	25,001 to 50,000	18.0
	50,001 to 75,000	32.0
	75,001 to 100,000	44.5
	≥ 100,000	Actual No. ERUs

E. OTHER REVENUE SOURCES

As part of this study, impact or development fees were also investigated as a possible source of revenue for the stormwater program. While such a regulatory measure may have merit, it can be somewhat difficult to develop a program that accurately assesses the impact of new development, can be equitably and fairly applied, and is legally defensible. The program must be carefully tailored to ensure that a relationship exists between the required fee and the burden imposed on the community by the new development. These financing techniques can be used only to address demands for new or expanded public facilities created by new growth in a developing area, not to correct existing drainage problems.

To determine actual impacts on the public storm drainage system and the associated costs requires evaluation of the entire watershed as well as site-specific evaluations. Impacts and costs will naturally vary from basin to basin. A standard rate structure is not really applicable to impact fees. Each developer would be required to pay a different amount depending on the type and extent of new construction, and the extent and condition of the existing storm drainage system in the area. Because of the extent of current or imminent development in the watersheds included in this study, imposing impact fees at this point in time would be difficult. New construction in a partially developed basin would, in essence, be penalized by being required to pay impact fees not required of previous development in the same basin although all areas impact the drainage system. Therefore, it is not recommended that the use of impact fees as a revenue source be pursued for any of the watersheds included in this study; however, as development proceeds in other currently undeveloped basins, such as Baldwin Creek, development fees may be appropriate and should be considered by the City. Additional watershed studies will be required for those areas to establish actual impacts and costs.

F. PROGRAM COSTS

The estimated construction cost of the first phase of the recommended capital improvement program is $ 13,814,250. Annual and total costs for five and ten year capital improvement program durations have been determined. In addition to construction costs, the analyses have included the estimated annual costs of operating the utility and maintaining the existing drainage system. Currently these costs are included in the Public Works Department budget but not separately identified so that the actual level of expenditure is not known.

Annual administrative cost for the stormwater utility used in the financial analysis is $95,000 which includes the salaries for the stormwater engineer and clerical worker along with office and shop area rental, office supplies, etc., as referenced previously in Table VIII-1. A total annual maintenance budget of $200,000 has been included in the financial analysis, which includes the salaries for the stormwater maintenance crew as well as construction materials and supplies, and vehicle and equipment capital and operating costs as discussed previously in this section, based on the recommended maintenance program outlined in Part VII of this report. This figure includes the estimated annual maintenance cost for the major system of $97,000 with the remainder of the amount for maintenance of the minor system.

During the first few years of utility operation additional funds will be required for capital expenditures for vehicles and equipment. Therefore, in addition to the administrative and maintenance costs, the utility's budget includes an annual discretionary fund of $125,000. For the first two to three years of utility operation, it is anticipated that this additional amount will be required to obtain the necessary maintenance vehicles and equipment. (Until the utility has acquired these items, it will continue to be necessary to coordinate most equipment usage with the Street Maintenance Department.) Once the equipment has been acquired, the discretionary fund should be used for funding 1) relatively small system improvements such as the discretionary projects described in Part VI of this report; 2) minor drainage system improvements; 3) as the City's part of special assessment funding; or 4) to cover emergencies due to system failures, flooding, etc.

1. Cash-Basis Financing

Table VIII-4 indicates the assumed annual costs for construction of capital improvement projects and stormwater utility operation and maintenance tasks for five and ten year program durations. The construction costs include a 2.5 percent annual inflation rate and the O&M costs reflect an annual increase of two percent.

TABLE VIII - 4

CASH FINANCING COSTS

	5-Yr. Program Annual Cost		10-Yr. Program Annual Cost	
Year	Construction	O&M	Construction	O&M
1	$ 2,762,850	$ 420,000	$ 1,381,425	$ 420,000
2	2,831,921	428,400	1,415,961	428,400
3	2,902,719	437,000	1,451,360	437,000
4	2,975,287	445,800	1,487,644	445,800
5	3,049,669	454,700	1,524,835	454,700
6	N/A	N/A	1,562,956	463,800
7	N/A	N/A	1,602,029	473,100
8	N/A	N/A	1,642,080	482,500
9	N/A	N/A	1,683,132	492,200
10	N/A	N/A	1,725,211	502,000
Totals	$ 14,522,446	$2,185,900	$ 15,476,633	$4,599,500

Using cash-basis funding for the program, with the stormwater utility fees as the only source of revenue, the average annual revenue required for the five-year program is $3,341,670 and $2,007,613 for the ten-year program.

2. <u>Bond Financing</u>

All financial analyses of the capital improvement program costs utilizing bond financing were based on the following assumptions and conditions.

- Phase I capital improvements program will be accomplished at a level rate over its duration.
- A construction cost inflation rate of 2.5 percent per year.
- Increases in stormwater utility revenue and system operating costs of 2 percent per year, not including any utility rate changes.
- Ten-year general obligation and revenue bonds, at rates of six and seven percent respectively.
- Interest rate of 4 percent earned on invested capital funds from bonds.

Tables VIII-5 and 6 illustrate some possible financing scenarios using general obligation bonds to finance the first phase of the capital improvements program with five and ten year program durations although there are any number of variations. Tables VIII-7 and 8 present the scenarios based on financing with revenue bonds. All of these plans are based on using funds from the stormwater utility fees as the sole revenue source for operation and maintenance costs and debt service on the bonds. The total annual revenue was adjusted as required to cover annual costs. Interest earned on the bond proceeds is added to the capital improvements account to make up part of the funding for subsequent years. Annual bond costs are indicated for in the tables as "Total Proposed Debt Service." The total cost of the bond issues, which includes the total interest paid over the term of the bonds and repayment of the principal, and the required annual revenue for each plan are summarized in Table VIII-9.

TABLE VIII-5

LAWRENCE, KANSAS STORMWATER MANAGEMENT PLAN FINANCIAL WORKSHEET
5-YEAR PHASE 1 CAPITAL IMPROVEMENTS PROGRAM FINANCED BY 10-YEAR GENERAL OBLIGATION BONDS

CASHFLOW

Cashflow Table

Line No.	System Operations	Year	Month	Amount	Type	Interest	Term	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Increase
1	Revenues - Existing Stormwater Utility Fees							2,000,000	2,040,000	2,080,800	2,122,400	2,164,800	2,208,100	2,252,300	2,297,300	2,343,200	2,390,100	2.00%
2	Operating Fund Interest Earnings							26,410	81,100	126,000	160,750	191,790	218,980	249,010	282,030	318,190	357,650	
3	Stormwater Utility Expenses																	
	a Administrative incl. engr & clerk salaries, rent, etc.							95,000	96,900	98,800	100,800	102,800	104,900	107,000	109,100	111,300	113,500	2.00%
	b Maintenance incl. maint crew salaries,equip., etc.							200,000	204,000	208,100	212,300	216,500	220,800	225,200	229,700	234,300	239,000	2.00%
	c Discretionary Fund							125,000	127,500	130,100	132,700	135,400	138,100	140,900	143,700	146,800	149,500	2.00%
	Total							420,000	428,400	437,000	445,800	454,700	463,800	473,100	482,500	492,200	502,000	
4	Outstanding Debt Service							0	0	0	0	0	0	0	0	0	0	
	Proposed Debt Service:																	
5		1996	1	5,000,000	G.O	6.00%	10	679,340	679,340	679,340	679,340	679,340	679,340	679,340	679,340	679,340	679,340	
6		1997	1	0	G.O	6.00%	10		0	0	0	0	0	0	0	0	0	
7		1998	1	5,000,000	G.O	6.00%	10			679,340	679,340	679,340	679,340	679,340	679,340	679,340	679,340	
8		1999	1	0	G.O	6.00%	10				0	0	0	0	0	0	0	
9		2000	1	2,500,000	G.O	6.00%	10					339,670	339,670	339,670	339,670	339,670	339,670	
10		2001	1	0	G.O	6.00%	10						0	0	0	0	0	
11		2002	1	0	G.O	6.00%	10							0	0	0	0	
12		2003	1	0	G.O	6.00%	10								0	0	0	
13		2004	1	0	G.O	6.00%	10									0	0	
14		2005	1	0	G.O	6.00%	10										0	
15	Total Proposed Debt Service							679,340	679,340	1,358,680	1,358,680	1,698,350	1,698,350	1,698,350	1,698,350	1,698,350	1,698,350	
16	Total Operating Expenses							1,099,340	1,107,740	1,795,680	1,804,480	2,153,050	2,162,150	2,171,450	2,180,850	2,190,550	2,200,350	
17	Annual Balance							927,070	1,013,360	411,120	478,670	203,540	264,930	329,860	398,480	470,840	547,400	
18	Increase in Revenues Required							-46.4%	-49.7%	-19.8%	-22.6%	-9.4%	-12.0%	-14.6%	-17.3%	-20.1%	-22.9%	
	Major Capital Improvement Financing																	
19	Beginning Balance - Capital Funds							0	2,256,390	376,759	3,456,459	850,752	635,653	673,063	746,853	859,193	1,012,343	
20	Bond or Note Issue							5,000,000	0	5,000,000	0	2,500,000	0	0	0	0	0	
21	Issuance Costs							(25,000)	0	(25,000)	0	(12,500)	0	0	0	0	0	
22	Reserve Fund							0	0	0	0	0	0	0	0	0	0	
	Revenue Available for Capital Funds							0	900,660	932,260	285,120	317,920	11,750	45,950	80,850	116,450	152,650	
23	Interest Earnings - Capital Funds							44,240	51,630	75,160	84,460	29,150	25,660	27,840	31,490	36,700	43,550	
24	Total Available Capital Funds							5,019,240	3,208,680	6,359,179	3,826,039	3,685,322	673,063	746,853	859,193	1,012,343	1,208,543	
25	Major Capital Improvements							2,762,850	2,831,921	2,902,719	2,975,287	3,049,669	0	0	0	0	0	
26	Ending Balance - Capital Funds							2,256,390	376,759	3,456,459	850,752	635,653	673,063	746,853	859,193	1,012,343	1,208,543	
	Debt Service Coverage																	
27	Revenues Available for Debt Service							1,580,000	1,611,600	1,643,800	1,676,600	1,710,100	1,744,300	1,779,200	1,814,800	1,851,000	1,888,100	
28	Annual Debt Service							679,340	679,340	1,358,680	1,358,680	1,698,350	1,698,350	1,698,350	1,698,350	1,698,350	1,698,350	
29	Debt Service Coverage							2.33	2.37	1.21	1.23	1.01	1.03	1.05	1.07	1.09	1.11	

TABLE VIII-6

LAWRENCE, KANSAS STORMWATER MANAGEMENT PLAN FINANCIAL WORSHEET
10 -YEAR PHASE 1 CAPITAL IMPROVEMENTS PROGRAM FINANCED BY 10-YEAR GENERAL OBLIGATION BONDS

CASHFLOW

Cashflow Table

Line No.	System Operations	Year	Month	Amount	Type	Interest	Term	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Increase
1	Revenues - Existing Stormwater Utility Fees							1,900,000	1,938,000	1,976,800	2,016,300	2,056,600	2,097,700	2,139,700	2,182,500	2,226,200	2,270,700	2.00%
2	Operating Fund Interest Earnings							27,130	83,240	136,330	186,320	233,110	276,610	323,510	373,980	426,200	486,360	
3	Stormwater Utility Expenses																	
	a Administrative incl. engr & clerk salaries, rent, etc.							95,000	96,900	98,800	100,800	102,800	104,900	107,000	109,100	111,300	113,500	2.00%
	b Maintenance incl. maint crew salaries,equip.,etc.							200,000	204,000	208,100	212,300	216,500	220,800	225,200	229,700	234,300	239,000	2.00%
	c Discretionary Fund							125,000	127,500	130,100	132,700	135,400	138,100	140,900	143,700	146,600	149,500	2.00%
	Total							420,000	428,400	437,000	445,800	454,700	463,800	473,100	482,500	492,200	502,000	
4	Outstanding Debt Service							0	0	0	0	0	0	0	0	0	0	
	Proposed Debt Service:																	
5		1996	1	4,000,000	G.O	6.00%	10	543,470	543,470	543,470	543,470	543,470	543,470	543,470	543,470	543,470	543,470	
6		1997	1	0	G.O	6.00%	10		0	0	0	0	0	0	0	0	0	
7		1998	1	2,500,000	G.O	6.00%	10			339,670	339,670	339,670	339,670	339,670	338,670	339,670	339,670	
8		1999	1	0	G.O	6.00%	10				0	0	0	0	0	0	0	
9		2000	1	2,500,000	G.O	6.00%	10					339,670	339,670	339,670	339,670	339,670	339,670	
10		2001	1	0	G.O	6.00%	10						0	0	0	0	0	
11		2002	1	0	G.O	6.00%	10							0	0	0	0	
12		2003	1	0	G.O	6.00%	10								0	0	0	
13		2004	1	0	G.O	6.00%	10									0	0	
14		2005	1	0	G.O	6.00%	10										0	
15	Total Proposed Debt Service							543,470	543,470	883,140	883,140	1,222,810	1,222,810	1,222,810	1,222,810	1,222,810	1,222,810	
16	Total Operating Expenses							963,470	971,870	1,320,140	1,328,940	1,677,510	1,686,610	1,695,910	1,705,310	1,715,010	1,724,810	
17	Annual Balance							963,660	1,049,370	792,990	873,680	612,200	687,700	767,300	851,170	939,390	1,032,250	
18	Increase in Revenues Required							-50.7%	-54.1%	-40.1%	-43.3%	-29.8%	-32.8%	-35.9%	-39.0%	-42.2%	-45.5%	
	Major Capital Improvement Financing																	
19	Beginning Balance - Capital Funds							0	2,650,545	2,267,544	4,400,565	3,728,981	5,561,166	4,576,071	3,544,351	2,463,871	1,332,369	
20	Bond or Note Issue							4,000,000	0	2,500,000	0	2,500,000	0	0	0	0	0	
21	Issuance Costs							(20,000)	0	(12,500)	0	(12,500)	0	0	0	0	0	
22	Reserve Fund							0	0	0	0	0	0	0	0	0	0	
	Revenue Available for Capital Funds							0	938,530	968,130	656,660	687,360	379,090	411,090	443,790	477,190	511,190	
23	Interest Earnings - Capital Funds							51,970	96,430	130,750	159,400	182,160	198,770	159,220	117,810	74,440	29,010	
24	Total Available Capital Funds							4,031,970	3,683,505	5,851,924	5,216,625	7,086,001	6,139,026	5,146,381	4,105,951	3,015,501	1,872,569	
25	Major Capital Improvements							1,381,425	1,415,961	1,451,360	1,487,644	1,524,835	1,562,956	1,602,029	1,642,080	1,683,132	1,725,211	
26	Ending Balance - Capital Funds							2,650,545	2,267,544	4,400,565	3,728,981	5,561,166	4,576,071	3,544,351	2,463,871	1,332,369	147,358	
	Debt Service Coverage																	
27	Revenues Available for Debt Service							1,480,000	1,509,600	1,539,800	1,570,500	1,601,900	1,633,900	1,666,600	1,700,000	1,734,000	1,768,700	
28	Annual Debt Service							543,470	543,470	883,140	883,140	1,222,810	1,222,810	1,222,810	1,222,810	1,222,810	1,222,810	
29	Debt Service Coverage							2.72	2.78	1.74	1.78	1.31	1.34	1.36	1.39	1.42	1.45	

TABLE VIII-7

LAWRENCE, KANSAS STORMWATER MANAGEMENT PLAN FINANCIAL WORKSHEET
5 -YEAR PHASE 1 CAPITAL IMPROVEMENTS PROGRAM FINANCED BY 10-YEAR REVENUE BONDS

CASHFLOW

Cashflow Table

Line No.	System Operations	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Increase
1	Revenues - Existing Stormwater Utility Fees	2,375,000	2,422,500	2,471,000	2,520,400	2,570,800	2,622,200	2,674,600	2,728,100	2,782,700	2,838,400	2.00%
2	Operating Fund Interest Earnings	21,870	67,440	116,750	154,330	179,750	208,220	239,910	274,980	313,610	356,000	
3	Stormwater Utility Expenses											
	a Administrative incl. engr & clerk salaries, rent, etc.	95,000	96,900	98,800	100,800	102,800	104,900	107,000	109,100	111,300	113,500	2.00%
	b Maintenance incl. maint crew salaries,equip.,etc.	200,000	204,000	208,100	212,300	216,500	220,800	225,200	229,700	234,300	239,000	2.00%
	c Discretionary Fund	125,000	127,500	130,100	132,700	135,400	138,100	140,900	143,700	146,600	149,500	2.00%
	Total	420,000	428,400	437,000	445,800	454,700	463,800	473,100	482,500	492,200	502,000	
4	Outstanding Debt Service	0	0	0	0	0	0	0	0	0	0	
	Proposed Debt Service: Year / Month / Amount / Type / Interest / Term											
5	1996 / 1 / 9,000,000 / Revenue / 7.00% / 10	1,281,400	1,281,400	1,281,400	1,281,400	1,281,400	1,281,400	1,281,400	1,281,400	1,281,400	1,281,400	
6	1997 / 1 / 0 / Revenue / 7.00% / 10		0	0	0	0	0	0	0	0	0	
7	1998 / 1 / 0 / Revenue / 7.00% / 10			0	0	0	0	0	0	0	0	
8	1999 / 1 / 5,500,000 / Revenue / 7.00% / 10				783,080	783,080	783,080	783,080	783,080	783,080	783,080	
9	2000 / 1 / 0 / Revenue / 7.00% / 10					0	0	0	0	0	0	
10	2001 / 1 / 0 / Revenue / 7.00% / 10						0	0	0	0	0	
11	2002 / 1 / 0 / Revenue / 7.00% / 10							0	0	0	0	
12	2003 / 1 / 0 / Revenue / 7.00% / 10								0	0	0	
13	2004 / 1 / 0 / Revenue / 7.00% / 10									0	0	
14	2005 / 1 / 0 / Revenue / 7.00% / 10										0	
15	Total Proposed Debt Service	1,281,400	1,281,400	1,281,400	2,064,480	2,064,480	2,064,480	2,064,480	2,064,480	2,064,480	2,064,480	
16	Total Operating Expenses	1,701,400	1,709,800	1,718,400	2,510,280	2,519,180	2,528,280	2,537,580	2,546,980	2,556,680	2,566,480	
17	Annual Balance	695,470	780,140	869,350	164,450	231;370	302,140	376,930	456,100	539,830	627,920	
18	Increase in Revenues Required	-29.3%	-32.2%	-35.2%	-6.5%	-9.0%	-11.5%	-14.1%	-16.7%	-19.4%	-22.1%	
	Major Capital Improvement Financing											
19	Beginning Balance - Capital Funds	0	4,825,370	2,816,899	695,759	3,127,462	152,223	210,963	315,203	467,573	671,023	
20	Bond or Note Issue	9,000,000	0	0	5,500,000	0	0	0	0	0	0	
21	Issuance Costs	(225,000)	0	0	(137,500)	0	0	0	0	0	0	
22	Reserve Fund	(1,281,400)	0	0	(783,080)	0	0	0	0	0	0	
	Revenue Available for Capital Funds	0	673,600	712,700	752,600	10,120	51,620	93,920	137,020	181,120	226,020	
23	Interest Earnings - Capital Funds	94,620	149,850	68,880	74,970	64,310	7,120	10,320	15,350	22,330	31,360	
24	Total Available Capital Funds	7,588,220	5,648,820	3,598,479	6,102,749	3,201,892	210,963	315,203	467,573	671,023	928,403	
25	Major Capital Improvements	2,762,850	2,831,921	2,902,719	2,975,287	3,049,669	0	0	0	0	0	
26	Ending Balance - Capital Funds	4,825,370	2,816,899	695,759	3,127,462	152,223	210,963	315,203	467,573	671,023	928,403	
	Debt Service Coverage											
27	Revenues Available for Debt Service	1,955,000	1,994,100	2,034,000	2,074,600	2,116,100	2,158,400	2,201,500	2,245,600	2,290,500	2,336,400	
28	Annual Debt Service	1,281,400	1,281,400	1,281,400	2,064,480	2,064,480	2,064,480	2,064,480	2,064,480	2,064,480	2,064,480	
29	Debt Service Coverage	1.53	1.56	1.59	1.00	1.03	1.05	1.07	1.09	1.11	1.13	

TABLE VIII-8

LAWRENCE, KANSAS STORMWATER MANAGEMENT PLAN FINANCIAL WORKSHEET
10 -YEAR PHASE 1 CAPITAL IMPROVEMENTS PROGRAM FINANCED BY 10-YEAR REVENUE BONDS

CASHFLOW

Cashflow Table

Line No.	System Operations	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Increase
1	Revenues - Existing Stormwater Utility Fees	2,025,000	2,065,500	2,106,800	2,148,900	2,191,900	2,235,700	2,280,400	2,326,000	2,372,500	2,420,000	2.00%
2	Operating Fund Interest Earnings	26,260	80,650	131,720	179,390	223,550	264,100	300,910	333,890	370,030	409,490	
3	Stormwater Utility Expenses											
	a Administrative incl. engr & clerk salaries, rent, etc.	95,000	96,900	98,800	100,800	102,800	104,900	107,000	109,100	111,300	113,500	2.00%
	b Maintenance incl. maint crew salaries,equip.,etc.	200,000	204,000	208,100	212,300	216,500	220,800	225,200	229,700	234,300	239,000	2.00%
	c Discretionary Fund	125,000	127,500	130,100	132,700	135,400	138,100	140,900	143,700	146,600	149,500	2.00%
	Total	420,000	428,400	437,000	445,800	454,700	463,800	473,100	482,500	492,200	502,000	
4	Outstanding Debt Service	0	0	0	0	0	0	0	0	0	0	
	Proposed Debt Service: Year / Month / Amount / Type / Interest / Term											
5	1996 / 1 / 5,000,000 / Revenue / 7.00% / 10	711,890	711,890	711,890	711,890	711,890	711,890	711,890	711,890	711,890	711,890	
6	1997 / 1 / 0 / Revenue / 7.00% / 10		0	0	0	0	0	0	0	0	0	
7	1998 / 1 / 2,500,000 / Revenue / 7.00% / 10			355,940	355,940	355,940	355,940	355,940	355,940	355,940	355,940	
8	1999 / 1 / 0 / Revenue / 7.00% / 10				0	0	0	0	0	0	0	
9	2000 / 1 / 2,500,000 / Revenue / 7.00% / 10					355,940	355,940	355,940	355,940	355,940	355,940	
10	2001 / 1 / 0 / Revenue / 7.00% / 10						0	0	0	0	0	
11	2002 / 1 / 2,500,000 / Revenue / 7.00% / 10							355,940	355,940	355,940	355,940	
12	2003 / 1 / 0 / Revenue / 7.00% / 10								0	0	0	
13	2004 / 1 / 0 / Revenue / 7.00% / 10									0	0	
14	2005 / 1 / 0 / Revenue / 7.00% / 10										0	
15	Total Proposed Debt Service	711,890	711,890	1,067,830	1,067,830	1,423,770	1,423,770	1,779,710	1,779,710	1,779,710	1,779,710	
16	Total Operating Expenses	1,131,890	1,140,290	1,504,830	1,513,630	1,878,470	1,887,570	2,252,810	2,262,210	2,271,910	2,281,710	
17	Annual Balance	919,370	1,005,860	733,690	814,660	536,980	612,230	328,500	397,680	470,620	547,780	
18	Increase in Revenues Required	-45.4%	-48.7%	-34.8%	-37.9%	-24.5%	-27.4%	-14.4%	-17.1%	-19.8%	-22.6%	
	Major Capital Improvement Financing											
19	Beginning Balance - Capital Funds	0	2,837,315	2,417,504	4,100,725	3,361,371	4,711,656	3,625,611	4,614,851	3,152,661	1,627,039	
20	Bond or Note Issue	5,000,000	0	2,500,000	0	2,500,000	0	2,500,000	0	0	0	
21	Issuance Costs	(125,000)	0	(62,500)	0	(62,500)	0	(62,500)	0	0	0	
22	Reserve Fund	(711,890)	0	(355,940)	0	(355,940)	0	(355,940)	0	0	0	
	Revenue Available for Capital Funds	0	893,110	925,210	601,970	635,270	313,430	348,130	27,590	63,790	100,590	
23	Interest Earnings - Capital Funds	55,630	103,040	127,810	146,320	158,290	163,480	161,580	152,300	93,720	32,590	
24	Total Available Capital Funds	4,218,740	3,833,465	5,552,084	4,849,015	6,236,491	5,188,566	6,216,881	4,794,741	3,310,171	1,760,219	
25	Major Capital Improvements	1,381,425	1,415,961	1,451,360	1,487,644	1,524,835	1,562,956	1,602,029	1,642,080	1,683,132	1,725,211	
26	Ending Balance - Capital Funds	2,837,315	2,417,504	4,100,725	3,361,371	4,711,656	3,625,611	4,614,851	3,152,661	1,627,039	35,008	
	Debt Service Coverage											
27	Revenues Available for Debt Service	1,605,000	1,637,100	1,669,800	1,703,100	1,737,200	1,771,900	1,807,300	1,843,500	1,880,300	1,918,000	
28	Annual Debt Service	711,890	711,890	1,067,830	1,067,830	1,423,770	1,423,770	1,779,710	1,779,710	1,779,710	1,779,710	
29	Debt Service Coverage	2.25	2.30	1.56	1.59	1.22	1.24	1.02	1.04	1.06	1.08	

TABLE VIII-9

LAWRENCE, KANSAS STORMWATER MANAGEMENT PLAN
COMPARISON OF BOND FINANCING COSTS

SUMMARY

Bond Type	Bond Term (Years)	Phase 1 Program Duration(yrs)	Total Bond P & I ($)	Bond Issuance Costs ($)	Reserve Funds Required ($)	Total Bond Costs ($)	Cash Used for Capital Improvements($	Total Program Cost ($)	Annual Revenue Required ($)
G.O.	10	5	16,983,500	62,500	None	17,046,000	2,438,960	19,484,960	2,000,000
G.O.	10	10	12,228,100	45,000	None	12,273,100	5,469,030	17,742,130	1,900,000
REVENUE	10	5	20,644,800	362,500	2,064,480	23,071,780	2,149,020	25,220,800	2,375,000
REVENUE	10	10	17,797,100	312,500	1,779,710	19,889,310	3,909,090	23,798,400	2,025,000

Total Bond Issue Amounts

G.O. , 5-yr program - $ 12,500,000

G.O., 10-yr program - $ 9,000,000

Rev., 5-yr program - $ 14,500,000

Rev., 10-yr program - $ 12,500,000

G. REVENUE REQUIREMENTS

No matter which method of financing for the recommended capital improvements is selected, substantial revenue is required to fund the program. Assuming that all funding for stormwater improvements will come from the utility fees and that all recommended improvements will be made, total revenues must be approximately $ 2,000,000 annually for the ten-year cash funding plan and three of the four bond plans.

To generate this amount of revenue using the proposed utility rate structure outlined previously, the basic monthly rate for one ERU should be set at $4.00. Table VIII-10 summarizes the rates for each land use category.

TABLE VIII - 10

PROPOSED UTILITY RATES

Property Category	Total Improved Area/Parcel (SF)	No. of ERUs Billed	Monthly Rate
Single-family Residential	< 1,200	0.67	$ 2.70
	1,200 to 3,000	1.0	4.00
	> 3,000	1.5	6.00
Multi-family Residential	N/A	0.67	2.70
Commercial	≤ 10,000	2.5	10.00
	10,001 to 25,000	8.5	34.00
	25,001 to 50,000	18.0	72.00
	50,001 to 75,000	32.0	128.00
	75,001 to 100,000	44.5	178.00
	≥ 100,000	Actual No. ERUs	4.00/ERU

It is recommended that no reductions or waivers of monthly utility charges be allowed for any property. Although this approach has been used in some cities where impact or development fees are imposed on new development, it is recommended that it not be applied to the basic monthly fee. Even if developers or property owners provide on-site facilities such as detention to reduce or control runoff, ultimately some amount of stormwater will be released to the public drainage system making the property a utility "customer" along with all other users of the system. It is also often the case that regulatory detention or other techniques required by policy to reduce local runoff from a site, provide little or no benefit to the major system as a whole in reducing peak storm flows downstream. Even if there is some benefit provided by such private facilities, if they are not properly maintained the impact may be completely negated. To reduce fees when there may not be real long-term benefit provided to the system by certain drainage improvements does not really accomplish the City's stormwater management goals or provide for fair distribution of the costs.

Table VIII-11 indicates the monthly and annual revenue from the recommended rates. The total annual revenue is slightly more than actually required to meet debt service and operating expenses which allows for establishing a reserve account to be used for future replacement and expansion projects.

TABLE VIII - 11

TOTAL UTILITY REVENUES

Property Category	No. of ERUs Billed	Monthly Rate	Total No. Units	Monthly Revenue	Annual Revenue
SFR	0.67	$ 2.70	1,931	$ 5,214	$ 62,564
SFR	1.0	4.00	12,556	50,224	602,688
SFR	1.5	6.00	883	5,298	63,576
MFR	0.67	2.70	16,727	45,163	541,955
COMM1	2.5	10.00	664	6,640	79,680
COMM2	8.5	34.00	336	11,424	137,088
COMM3	18.0	72.00	146	10,512	126,144
COMM4	32.0	128.00	38	4,864	58,368
COMM5	44.5	178.00	23	4,094	49,128
COMM6	Actual No. ERUs	4.00/ERU	6,904	27,616	331,392
			Totals	$ 171,049	$2,052,583

H. RECOMMENDATIONS

Based on the analyses performed, it is recommended that:

1. The City proceed with establishing a stormwater utility as the organizational and financial mechanism for ongoing stormwater management in Lawrence.
2. Fees from the utility be used as the revenue source for all operating, maintenance and capital improvement costs associated with the City's storm drainage system. Development fees are not appropriate as a revenue source at this time for the watersheds studied.

3. The utility rate structure based on four residential categories and six commercial categories, as outlined previously in this report section, be adopted.
4. The Phase 1 capital improvements program duration be set at five years in order to address the most serious drainage problems as quickly as possible.
5. The first phase of the program be financed using 10-year general obligation bonds.
6. The initial rate per Equivalent Residential Unit (ERU) be set at $4.00 with rates for other tiers as indicated in Table VIII-11 in order to generate revenue of approximately $2,000,000 annually as required by the financing option.
7. No reductions in monthly stormwater utility fees be allowed for any property.

* * * * *

APPENDIX A - STORM DRAINAGE QUESTIONNAIRE

Burns & McDonnell

Memorandum

Date: October 24, 1994

To: Mike Wildgen
City Manager
Lawrence, Kansas

From: Dena Mezger
Project Manager
Stormwater Management Plan

RE: Public Meeting/ Open House
October 12, 1994 @ City Hall

Approximately 75 people attended the public meeting/open house concerning the Stormwater Management Master Plan over the three-hour period on October 12. The following is a summary of the discussions/events.

1. Fifteen drainage surveys were completed and turned in at the session. Several individuals indicated that they would be mailing the survey and several took extra copies to distribute to neighbors, members of homeowners' associations, etc. As of October 21, 25 surveys have been received.

2. Several residents from particular neighborhoods or areas attended the meeting as a group including members of the Centennial Neighborhood Association, south of the high school, and a group of neighbors from the vicinity of 15th and Lawrence. In addition, several residents from particular areas attended individually including several from areas adjacent to the Centennial neighborhood, and from the vicinity of Michigan and 2nd Street.

3. Reported drainage problems did not appear to be concentrated in any one particular area but were generally scattered throughout the city, even in some newer developments. Many have existed for a number of years and several were very localized, private property issues. City staff and/or Burns & McDonnell were already familiar with, or at least aware of, most of the areas. Two of those reported, which had not been previously identified, were referred to City staff to review in more detail to determine if immediate action was necessary.

4. Common themes from discussions with residents were:

   a. Frustration with the City for not fixing problems that have existed for years.
   b. Concern that new developments are being built without being required to provide sufficient new drainage facilities to prevent problems for

Burns & McDonnell

existing downstream development.

c. Concern about developers and builders that have constructed homes in areas prone to drainage problems. A number of individuals cited examples of houses built on top of filled-in drainage channels which were later flooded by drainage that had no other place to go.

d. Support for establishing specific policies that future development be required to provide adequate drainage facilities and be prevented from building in drainageways so that new problems are not created.

e. Support for the use of open channel drainage systems although prevention of erosion was an important factor. Several residents expressed support for establishing policies requiring undeveloped green space to be left along channels to prevent construction of homes or other buildings too close to the channel where the system capacity could be affected and the buildings could be subject to flooding.

5. In general, discussions were fairly positive in nature and most people attending the meeting seemed encouraged that the City is taking the first steps toward solving existing drainage problems and preventing new ones by having a master plan prepared.

* * * * *

LAWRENCE, KANSAS STORM DRAINAGE MASTER PLAN

STORMWATER DRAINAGE SURVEY

The City of Lawrence is beginning to prepare a new comprehensive Master Plan to improve storm drainage service in the City. This survey outlines topics and issues on which individuals opinions are important for the Master Plan to best meet the needs of the residents of Lawrence.

SUMMARY OF RESPONSES

A total of 125 separate questionnaires were returned. The numbers of responses to various questions do not add up to these total, however, since not all respondents answered all questions and some had multiple answers to one question.

INFORMATION ABOUT YOUR DRAINAGE PROBLEM

Please check the information that best describes your property

Open Ditch Eroding	4	Yard Doesn't Drain	40	Haven't Noticed Any Problems	16
In Back Yard	34	Street Ditch Overflows	28	Neighbors Downspouts/Yard	13
In Side Yard	21	Street Curb Overflows	69	Water Floods Structure	31
In Front Yard	10	Other Problems ?	24*		

How Often Do You Have A Problem With Drainage? (Please Check)

Every Hard Rain 77 Once A Year Or Less 19 Several Times A Year 22 Other Less Often 10

Other comments about your drainage problems.

Of the 24 "other" problems, seven specifically mentioned lack of system maintenance and 10 mentioned problems apparently related to sanitary sewer backups rather than storm drainage.

YOUR OPINIONS ON CRITERIA AND POLICY CONSIDERATIONS

Important goals of the Master Plan are 1) to develop procedures and criteria that will provide the same degree of freedom from drainage problems for everyone and 2) raise money that's neededto provide and maintain that service in a fair way. Please indicate your opinion with the statements below by marking the appropriate response.

	YES	NO
Street curbs and pipe storm sewers increase property value?	98	10
Developments that cause increased runoff should pay for necessary drainage improvements?	112	6
Its fair that people who benefit more from drainage improvements should pay more?	44	58
Its reasonable to expect property along drainage channels to be required to leave space for drainage that's always been there?	111	4
Its reasonable to expect property along drainage channels to leave space for drainage expected from reasonable upstream future development	90	18
Minor drainage nuisances, like neighbor's gutters, should be privately resolved	105	8
Open channels, if of adequate size, are an acceptable way to carry drainage	YES	NO
a) through back yards	53	46
b) along roadsides	85	17
c) through commercial and industrial developments	75	22

YOUR OPINIONS ABOUT SETTING PRIORITIES FOR IMPROVEMENTS:

Drainage improvements to address every problem in Lawrence can't be made immediately. Please indicate your opinion about which City projects should be ranked with the highest priority for completion, with 1 being most important to you and 4 being least important to you.

	1ST	2ND	3RD	4TH
Water Entering Structures	65	21	11	7
Erosion Along Channels In Yards	5	10	35	46
Overflow & Flooding In Streets & Yards	45	59	21	3
The Most People Helped Per $ Spent	10	25	23	37

LAWRENCE, KANSAS STORM DRAINAGE MASTER PLAN

STORMWATER DRAINAGE SURVEY

The City of Lawrence is beginning to prepare a new comprehensive Master Plan to improve storm drainage service in the City. This survey outlines topics and issues on which individuals opinions are important for the Master Plan to best meet the needs of the residents of Lawrence.

SUMMARY OF RESPONSES

A total of 21 additional questionnaires were returned after the survey was publicized the second time. The number of responses to various questions do not add up to this total, however since not all respondents answered all questions and some had multiple answers to 1 question.

INFORMATION ABOUT YOUR DRAINAGE PROBLEM

Please check the information that best describes your property

Open Ditch Eroding	3	Yard Doesn't Drain	1	Haven't Noticed Any Problems	0
In Back Yard	10	Street Ditch Overflows	2	Neighbors Downspouts/Yard	1
In Side Yard	0	Street Curb Overflows	9	Water Floods Structure	3
In Front Yard	1	Other Problems ?	3		

How Often Do You Have A Problem With Drainage? (Please Check)

Every Hard Rain 14 Once A Year Or Less 1 Several Times A Year 1 Other Less Often 2

Other comments about your drainage problems.

Of the "other" problems, one mentioned sanitary sewer backups.

YOUR OPINIONS ON CRITERIA AND POLICY CONSIDERATIONS

Important goals of the Master Plan are 1) to develop procedures and criteria that will provide the same degree of freedom from drainage problems for everyone and 2) raise money that's neededto provide and maintain that service in a fair way. Please indicate your opinion with the statements below by marking the appropriate response.

	YES	NO
Street curbs and pipe storm sewers increase property value?	12	3
Developments that cause increased runoff should pay for necessary drainage improvements?	14	2
Its fair that people who benefit more from drainage improvements should pay more?	5	11
Its reasonable to expect property along drainage channels to be required to leave space for drainage that's always been there?	14	0
Its reasonable to expect property along drainage channels to leave space for drainage expected from reasonable upstream future development	13	0
Minor drainage nuisances, like neighbor's gutters, should be privately resolved	13	2
Open channels, if of adequate size, are an acceptable way to carry drainage	YES	NO
a) through back yards	5	11
b) along roadsides	12	3
c) through commercial and industrial developments	9	6

YOUR OPINIONS ABOUT SETTING PRIORITIES FOR IMPROVEMENTS:

Drainage improvements to address every problem in Lawrence can't be made immediately. Please indicate your opinion about which City projects should be ranked with the highest priority for completion, with 1 being most important to you and 4 being least important to you.

	1ST	2ND	3RD	4TH
Water Entering Structures	13	2	1	1
Erosion Along Channels In Yards	2	4	6	5
Overflow & Flooding In Streets & Yards	3	9	3	2
The Most People Helped Per $ Spent	0	2	6	8

APPENDIX C - EROSION CONTROL PRINCIPLES & PLOT PLAN REQUIREMENTS

EROSION AND SEDIMENTATION CONTROL PLAN PRINCIPLES

Effective erosion and sedimentation control requires that soil surfaces be protected from the erosive forces of water and wind, both temporarily and permanently, and that the eroded soil be retained on the site and used or disposed of appropriately. These controls are necessary to prevent decreased capacity and function of existing drainage systems, degradation of stream and lake ecology, reduction in reservoir storage volume, and damage to adjacent property due to siltation.

The Kansas Department of Transportation (KDOT) currently has standard plans and details for erosion control techniques applicable to highway construction projects and the Kansas Department of Health and Environment (KDHE) is completing the final draft of an erosion and sedimentation control plan for construction activity. This plan should be available in late April or early May, 1996. Copies of the KDOT standard plans are attached as examples. It is suggested that the City coordinate its erosion control plan with the state's or use the KDHE and/or KDOT plan(s) directly. In the meantime, the following are general erosion and sedimentation control principles for reference and use in evaluating a plan for the City.

Principles

1. Developers, builders and designers should carefully review the existing conditions of the construction site selected. When possible, a site should be selected that is more suitable to the project rather than forcing the terrain to conform to the new development as any modification of a site's drainage features or topography requires protection from erosion and sedimentation.

2. When possible, construction activities should be scheduled so as to minimize the exposed area of bare soil and the duration of exposure, taking into account the season and the weather forecast. Disturbed areas should be stabilized as quickly as possible with temporary and/or permanent seeding, other vegetation, or pavement where applicable. The removal of vegetative cover and altering the soil structure by clearing,

grading and compacting the surface increases runoff velocities and volumes thereby increasing an area's susceptibility to erosion . The contractor should be required to apply stabilizing measures as soon as possible after the land has been disturbed but no longer than 14 calendar days.

3. Due to the inability of any practice to completely eliminate all erosion, it may become necessary to trap sediment on site either permanently or temporarily. A sediment trap or basin should be located where deposition will occur and where access is easily obtainable for maintenance and cleanout. Whenever possible, sediment traps and basins should be planned and constructed before other land-disturbing activities begin. Locations should be selected during site evaluation.

   In general, temporary sediment traps are used for drainage areas of five acres or less. These traps are formed by constructing an embankment of earth or granular material, or an excavation below existing grade, in the runoff path with the "dam" acting as an outlet weir. Larger sediment basins for drainage areas up to 100 acres generally involve construction of an earthen dike with a pipe or other improved outlet structure.

4. Diversion dikes and/or waterways are used to intercept runoff and divert it away from cut-and-fill slopes or other disturbed areas. These measures should be installed before clearing and grading. Utilize straw or hay bales and silt fences for temporary erosion control. Generally, straw bales are applicable only to drainage areas less than 1/2 acre such as typical residential building lots. Silt fence can be used in areas where it is possible to install 100 L.F. of fence for each 1/4 acre of drainage area.

5. Channels should be protected from erosion by using protective linings such as riprap, where applicable, and appropriate channel design, taking into consideration maintenance of the channel in the design. Practical methods of reducing velocities or controlling drainage paths should be implemented. Such methods include conveying stormwater runoff away from steep slopes to stabilized outlets; diverting runoff to temporary slope

drains or paved chutes or flumes; preserving natural vegetation when and where possible; and mulching and vegetating exposed areas immediately after construction.

6. Inspection and maintenance is necessary to maintain the effectiveness of erosion and sedimentation control measures. All erosion and sedimentation control facilities and practices should be regularly inspected to determine if they are working properly, and corrective measures should be taken immediately when deemed necessary. Inspections should occur at no less than 14 day intervals, as well as immediately following any storm event.

7. Developers and/or contractors should submit an erosion control plan, conforming to the City's adopted plan, for review and approval prior to beginning any construction activity. For construction sites greater than 5 acres in area, comply with NPDES Permit requirements as incorporated in the KDHE plan.

* * * * *

Plot Plan Requirements

All applicants for building permits not requiring site plan approval as per Chapter 20-1428 of the Code of the City of Lawrence shall submit a plot plan, in duplicate, detailing the following information at the time of application.

The Plot Plan:

1. Shall be drawn accurately and to a scale of not less than 1"=30' (one inch equals thirty feet).

2. Shall be arranged so that the top of the plan represents North or if otherwise oriented is clearly and distinctly marked.

3. Show boundaries and dimensions graphically, contain the written legal description of the property and its street address, show a written and graphic scale, and show a written description of its zoning district according to the final plat of record.

4. Show the location of all existing recorded easements (including drainage easements) according to the final plat of record.

5. Show the location of all building setback lines according to Table I, Chapter 20-608 of the Code of the City of Lawrence.

6. Show by written dimensions the relationship of the lot to any streets and rights of way which abut the boundaries of the lot.

7. Show the perimeter of the proposed construction with all cantilevers, patios, covered porches, decks, and overhangs and its relationship by dimensions to the lot boundary lines.

8. Show any suggested floor elevations, if any, according to the preliminary plat of the subdivision if the subject property has a drainage easement.

9. Show the flow line of street drainage.

Upon approval by the Department of Building Inspection one copy of the plot plan shall be stamped "Approved" and returned to the applicant at the time the permit is issued.

Elevations of the following points should be marked on the plot plan for all structures not requiring site plan approval as per Chapter 20-1428 of the Code of the City of Lawrence at the time of application for a building permit.

1. Lowest point where exterior framing contacts a concrete floor or foundation wall on

the street side of the building.

2. Lowest point where exterior framing contacts a concrete floor or foundation wall on rear or sides of the building.

3. Highest point of curb at curb cut for drive.

4. Points where drainage exits lot at lot line (There may be one or more of these exits. In the case of more than one drainage exit from the lot, all exits will be marked).

5. Points where lot lines, if extended, would intersect curb (Irregular or corner lots may have more than two such points, in which case all points will be marked).

6. Points where rear lot line intersects with side lot and adjacent or adjoining lot lines (In the event there are more than two such points of intersection, all points will be marked).

7. Highest points of drainage flow lines (If more than two such flow lines exist, the highest point of all flow lines will be marked).

8. Floor or foundation elevations of adjacent or adjoining structures,if any, at the nearest point to the subject structure.

General Standards

1. Backfill surrounding the foundation will be a minimum of 6" below the lowest exterior framing contacting a concrete floor or foundation wall.

2. All drainage swales will descend at a minimum negative grade of 2% from the foundation until reaching the point of drainage exit from the lot.

3. Perimeter backfill and yard grading will at all times slope away from the foundation a minimum of 6 inches or 2% grade (whichever is greater) to the point of drainage exit from the lot, or to a drainage swale in which the highest point is a minimum of 12 inches below the nearest point where exterior framing contacts a concrete floor or foundation wall of the structure and will maintain a slope with a minimum negative grade of 2% until it reaches the point of drainage exit from the lot. At no time will the grade of fill slopes be steeper than two horizontal to one vertical.

4. Front yards will drain to the street whenever possible. Front yards not draining to the street will drain to a swale located on a line parallel to the building foundation not less than 12 feet from the building foundation.

5. Side yard drainage swales will be located on the side yard lot lines with the highest point of the swale a minimum of 12 inches or 2% grade (whichever is greater) below the nearest point where exterior framing contacts a concrete floor or foundation wall of the structure or any adjacent or adjoining structure and shall continue to slope at a minimum grade of 2% until reaching the point of drainage exit from the lot.

6. Rear yard drainage swales will be located on a line parallel to the building foundation not less than 12 feet from the foundation.

7. Berms constructed to prevent drainage from adjacent or adjoining yards must be constructed entirely on the subject property. At no time shall such berms be constructed which would cause water to be retained by the adjacent or adjoining yards. Outlet swales will be located on the downhill side yard property lines.

8. Driveways will slope a minimum of 18 inches or 2% grade (whichever is greater) from the garage floor to the highest point of the curb at the driveway curb cut unless written approval is obtained from the building inspection department.

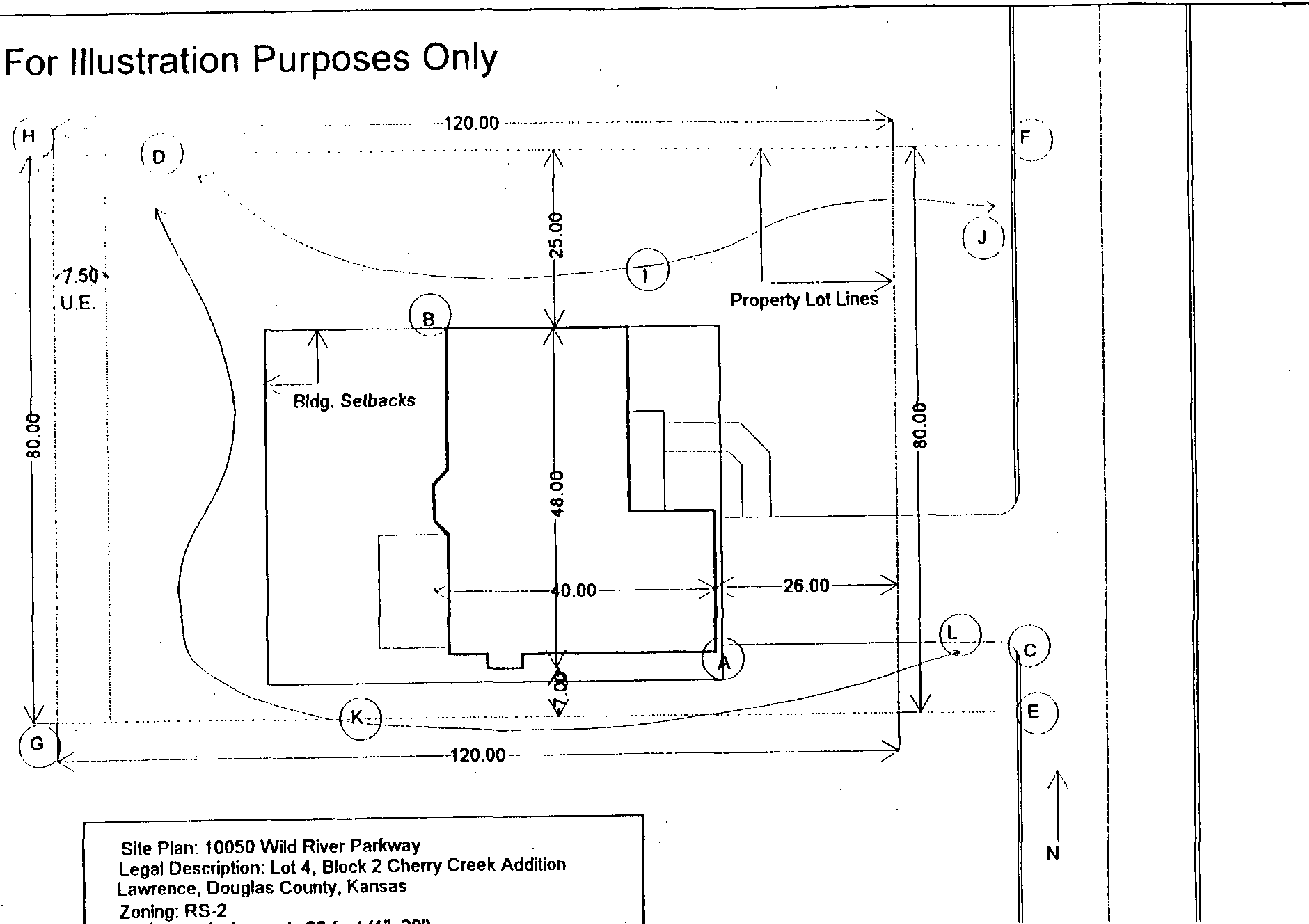
9. The elevation of the throat of all driveways will equal or exceed the highest point of the street curb at the driveway curb cut for a minimum of 5 feet from the rear of the curb before descending. Any driveway will ascend a minimum of 6" from its lowest point to the garage floor.

10. Applications for permits for properties possessing drainage easements must present required floor elevations from a licensed engineer indicating anticipated flow levels of storm water drainage based on computations of a 25 year storm.

11. All structures with exterior frame walls or openings located entirely or partially below exterior yard grade must have a protective curb or wall around the frame wall or opening equal to or higher than 3 inches above the highest point at which yard grade contacts the foundation wall at the nearest point to the opening.

12. The bottom of all outlets for storm water drainage from a structure must be located a minimum of 6 inches below the nearest point where exterior framing contacts a concrete floor or foundation wall. Such outlets will empty onto an impervious surface unless the outlet is a minimum of 3 feet from the foundation.

For Illustration Purposes Only



Site Plan: 10050 Wild River Parkway
Legal Description: Lot 4, Block 2 Cherry Creek Addition
Lawrence, Douglas County, Kansas
Zoning: RS-2
Scale: one inch equals 20 feet (1"=20')
Contractor: Ebb Tide Construction

Legend for Plot Plan Illustration

A= Lowest point where exterior framing contacts a concrete floor or foundation wall on the street side of the building.

B= Lowest point where exterior framing contacts a concrete floor or foundation wall on rear or sides of the building.

C= Highest point of curb at curb cut for drive.

D,J,L= Points where drainage exits lot at lot line (There may be one or more of these exits. In the case of more than one drainage exit from the lot, all exits will be marked).

E, F= Points where lot lines, if extended, would intersect curb (Irregular or corner lots may have more than two such points, in which case all points will be marked).

G,H= Points where rear lot line intersects with side lot and adjacent or adjoining lot lines (In the event there are more than two such points of intersection, all points will be marked).

I,K= Highest points of drainage flow lines (If more than two such flow lines exist, the highest point of all flow lines will be marked).

APPENDIX D - SUMMARY OF EXISTING STORMWATER UTILITIES

SUMMARY OF EXISTING STORMWATER UTILITIES

One of the many ways to administer and fund storm drainage system operation, maintenance, expansion and improvements is through the formation of a stormwater utility. Although utilized in other parts of the country rather extensively, this approach is relatively new to the Midwest. The basic concept is the same as for municipal water, wastewater or other utility organizations and is gaining acceptance in this area as public awareness of storm drainage issues increases.

Within this region several cities have established stormwater utilities. These include Olathe, Manhattan, Topeka and Wichita, Kansas, and Columbia and Kansas City, Missouri. Kansas City, Kansas is also investigating and evaluating implementation of a stormwater utility. The following are summaries of some of these utilities for reference and comparison.

CITY OF OLATHE, KANSAS

Olathe's utility has been in operation for approximately five years. It was enacted by an ordinance which must be renewed annually in conjunction with the city's budget. Originally, the utility was implemented for and authorized to fund only storm drainage capital improvements. It's purpose has recently been expanded to include funding of utility staff positions and system maintenance. Currently the utility generates approximately $750,000 annually.

The rate structure is divided into two main categories, residential and non-residential, with the equivalent residential unit (ERU) based on 10,000 square feet of land area. All residential customers pay the same fee of $2.00 per month. Non-residential customers are further divided into classes based on increments of 20,000 square feet of land area. The fees range from $2.00 per month for 20,000 square feet or less, up to $100.00 per month (the maximum fee for any class) for over 500,000 square feet. Fees are billed through the City's water utility.

CITY OF TOPEKA, KANSAS

Topeka's stormwater utility began operation in 1993, and is under the jurisdiction of the Department of Public Works. Property is divided into two basic classifications, residential and nonresidential. Charges are based on Equivalent Residential Units which is defined as 2,018 square feet of impervious area. This impervious area includes all buildings, driveways, parking areas, etc. The basic rate for one ERU is $2.85 per month although all residential customers do not pay the same fee. The residential classification is further divided into three rate groups as follows.

Total Impervious Area	No. of ERU's	Monthly Billing
<1,500	0.65	$1.85
>1,500, <3,500	1.00	$2.85
>3,500	1.56	$4.45

All nonresidential properties are billed on the basis of the number of ERU's for the specific parcel calculated as the total impervious area (determined from aerial photo analysis) divided by 2,018. The total charge for a parcel is then determined by multiplying the number of ERU's by $2.85. Governmental entities, including the State of Kansas, pay stormwater utility fees. The only areas excepted are impervious surfaces in public rights-of-way (streets, highways, etc.) and impervious areas at the airfield.

Billings are included with the City's water billing. Actual charges are computed daily, with the result that payments vary slightly by month. Topeka's stormwater utility generates approximately $3.66 million per year.

CITY OF WICHITA, KANSAS

Wichita's stormwater utility operates similarly to Topeka's. It is also under the jurisdiction of the Department of Public Works with two basic classifications, residential and nonresidential, although the residential classification is not further broken down as in Topeka. An ERU in Wichita is defined as 2,139 square feet with the monthly charge set at $1.66/month/ERU.

Residential customers are charged for one ERU, irrespective of lot or house size. Multi-family units also are charged one ERU per unit. Nonresidential properties are billed on the basis of the number of ERU's for the parcel times the basic ERU rate. Billings are handled as a separate line item on the City's water and sewer billing system. Governmental and tax-exempt properties are included in the rate base. Streets and highways are excluded. The airport, including the runway, is included in the rate base. Wichita's stormwater utility generates approximately $5.0 million per year.

CITY OF MANHATTAN, KANSAS

Manhattan's stormwater utility is presently funded through the imposition of a fee billed with the water and sewer billing. Residential properties, including multi-family units, are assessed at a monthly rate of $0.25 per living unit irrespective of lot or building size. Properties devoted to any use other than residential are assessed on the basis of total developed area (e.g., tract size), not impervious area. A total of six rate groups are defined with monthly fees varying from $1.30 for tracts less than or equal to 20,000 square feet, to $150.00 for tracts greater than 1,000,000 square feet. The campus of Kansas State University is specifically included in the rate base by direct reference in the ordinance.

Manhattan's stormwater utility presently generates approximately $112,000 per year. This amount, and the associated billing rates, was established as a start-up, or phase in, measure. The City's recently completed storm drainage master plan reviews the City's rates and rate base, and recommends adjustments or modifications necessary or desirable to properly fund the stormwater utility and recommended capital improvements.

CITY OF COLUMBIA, MISSOURI

Establishment of Columbia's stormwater utility, initial fee structure, and stormwater development charge on new construction were authorized by a special election in 1993. The initial proposal was based on the need to fund a $5,000,000 storm drainage capital improvements program outlined in an earlier master plan.

The rate structure is based on four residential tiers with commercial property rates based on actual impervious area. The University of Missouri's properties are included in the utility customer base although they are billed a negotiated fee rather than charges based on actual impervious area.

Initially, the residential fee was $0.65 per month for all units and $4.00 per month for all nonresidential properties. The utility fees were revised in 1994 as indicated in the following table while development charges remained as originally approved. Annual revenues from the combination of utility fees and development charges are approximately $830,000.

COLUMBIA, MISSOURI STORMWATER CHARGES

<u>Utility Charges</u>	
Multifamily dwellings with more than 4 units	$0.65/month
Single-family homes less than 750 sq. ft.	$0.65/month
Multifamily dwellings with 4 or fewer units	$0.85/month
Single-family homes 750 to 1,250 sq.ft.	$0.85/month
Single-family homes 1,250 to 2,000 sq.ft.	$1.15/month
Single-family homes more than 2,000 sq. ft.	$1.35/month
Non-residential uses of developed land	$4.00 or $0.04/100 SF imperv. area per mo., whichever is greater
<u>Development Charges on New Building Permits</u>	
Single-family homes and duplexes	$0.09/SF
Multifamily buildings, offices, schools, churches	$0.16/SF
Commercial and industrial	$0.195/SF
Use categories not listed above	$0.195/SF

The utility charges are based on "main floor area" as opposed to total impervious area per property and development charges on "total floor area." Total floor area is defined as the area within the perimeter of the outside walls of a building including basement area, main and upper floor areas, carports, garages, decks and porches. This development charge is similar in concept to an impact fee although the rates are somewhat arbitrary and not based on the actual impact of increased impervious area on the existing drainage system. The charge is waived, however, for any property served by a private detention facility constructed in accordance with City criteria and privately maintained.

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