ADDENDUM 1:
Hydrograph Methods

City of Lawrence
KANSAS

MIKE WILDGEN, CITY MANAGER

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COMMISSIONERS
MARTY KENNEDY
ERVIN E. HODGES
BOB MOODY
JOHN NALBANDIAN

November 25, 1997

To: Engineering consultants

Re: Hydrograph methods

The use of SCS methods for *very* small watersheds may be problematic. Recent submittals have reported results that appeared to be incorrect, so I have investigated this issue. The Stormwater Management Criteria *require* detention inflow hydrographs to be computed using the SCS 24-hour, Type II storm (9.5-B). Section 2.2-B states that hydrograph methods are required for tributary areas greater than 10 acres. The Criteria do not address appropriate methods for tributary areas smaller than this.

The SCS methods are only valid if the time step for calculation is less than 0.174 times the time of concentration. Computer methods are limited in the number of calculation points available, and an error message will typically appear if this time requirement is not satisfied. This will be the case in very small watersheds with short Tc. If an error message appears, the model is not valid.

One solution to this problem is to shorten the storm duration, allowing smaller time steps. I have run several versions of the same drainage area, using alternate storms:

A = 1.619 ac CN = 91.5 Tc = 6 minutes Tlag = 3.6 minutes

Storm	Time Step, minutes	Q100 Peak Flow, cfs	error
24-hr Type II	5	5	yes
3 peak hours of 24-hr Type II	1	10	no
Balanced 24-hr	5	13	yes
Balanced 6-hr	2	13	yes
Balanced 3-hr	1	14	no

A check using the rational formula shows that 0.74 x 9.82 x 1.619 = 11.8 cfs

The 3-hour storms are both reasonable estimates. The time step constraint of the SCS method should not be violated, or the model is not accurate.

As a result, for watersheds with short concentration times, a shorter storm duration must be used. The following may be used as a rough guide:

Tc, minutes	Time step, minutes	Storm duration, hrs
1 to 12	1	3
12 to 18	2	6
18 to 24	3	12
24 to 30	4	12
> 30	5	24 Type II

Rainfall distributions for these durations should follow the balanced approach, to be consistent with both the SCS method and the Master Plan model. Rainfall distributions must be identified and provided with the drainage study.

Hydrographs for conveyance element design are subject to the same modeling constraints, however the rational formula is a simple alternate in small watersheds.

This discussion is provided for your use. A formal revision to the criteria has not occurred; however, inaccurate modeling is not acceptable. Please address this concern in your studies.

Please call if you have any questions.

Sincerely,

Chad Voigt

c: Terese Gorman

ADDENDUM 2:

Lake Alvamar Drainage Study

City of Lawrence
KANSAS

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January 28, 1998

Matt Taylor
Landplan Engineering
1310 Wakarusa Drive
Lawrence, KS 66049

Re: Lake Alvamar Drainage Study

Dear Matt:

I have reviewed the 1-19-98 issue of the referenced study. This study is approved, and I concur with your proposed recommendations numbered 1 thru 5 on page four. All developing properties in the 2,152 acre watershed must meet these requirements for storm drainage management:

1. A developed curve number shall be established for the property using CN = 74 for pervious surface and CN = 98 for impervious surface. Detention shall be provided when the developed curve number exceeds CN = 84. Properties with a developed curve number equal to or less than CN = 84, for which the downstream system meets the requirements of #3 below, will not be required to provide detention.

2. When required, detention shall be designed using the appropriate storm duration and hydrologic method. Peak discharges from the property shall not exceed the following release rates:

2-year storm	2.4 cfs/acre
10-year storm	3.2 cfs/acre
100-year storm	4.5 cfs/acre

3. Throughout the watershed, all conveyance elements and drainage easements shall be sized for the release rates listed above applied to the entire tributary area.

4. When a ridge line divides a property into two or more drainage areas, these requirements shall be met independently for each area.

This information will be provided upon request to owners, developers and consultants. These requirements should be considered supplemental to the *1996 Stormwater Management Criteria.*

Thank you for your assistance.

Sincerely,

Chad Voigt

cc: Terese Gorman, Linda Finger

ADDENDUM 3:

Updated Curb Inlet Design Requirements

City of Lawrence
KANSAS

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MARTIN A. KENNEDY
MIKE RUNDLE
DAVID M. DUNFIELD

June 16, 1999

To: Stormwater System Designers

From: Chad Voigt, Public Works

Re: Updated Curb Inlet Design Requirements

Applicability:

This update applies to all systems that are required to comply with the City of Lawrence, Kansas *Stormwater Management Criteria*. These specifications replace Section 5.3.B, Section 5.3.C, Table G and Figure 9 of the February, 1996 *Criteria*.

Basis:

The November, 1998 revision to the Storm Sewer Standard Details sheet specifies 10" steel frame curb inlets similar to those used in several other communities. The University of Kansas, Civil Engineering Department performed a study for KDOT, which collected capacity data for these inlets. The attached specifications have been derived from that study.

Gutter capacity requirements and sump inlet capacities have been simplified based on typical Lawrence street sections.

Update:

The information below applies to ½" per foot street cross slopes, for systems designed in english units. Additional information will be provided at a later date for ¼" per foot cross slopes and for metric design units.

Curb Inlet Design Equations: ½" per foot street cross slope

1. Criteria for Allowable Street Flow (all street widths)

   During a 10-yr storm $Q_{cap} = 70\ (s)^{1/2}$ cfs

   During a 100-yr storm $Q_{cap} = 472\ (s)^{1/2}$ cfs

   s = street slope in ft/ft

2. Criteria for Sump Inlet Capacities

   During a 10-yr storm $Q_{cap} = 1.5\ L$ cfs

   During a 100-yr storm $Q_{cap} = 2.4\ L$ cfs

   L = inlet length in ft

3. Criteria for Sloped Inlet Capacities

   $$Q_{cap} = (915\ L + 1782) / (10{,}000\ (s)^{1/2})\ \text{cfs}$$

Table:

The attached table summarizes the results of these equations. These values may be read manually, or the equations may be entered into design spreadsheets.

Use:

Storm drainage systems must be designed to provide capacity for the 100-year peak flow within platted drainage easements or public right-of-way. Enclosed systems must be designed to provide capacity for a minimum of the 10-year peak flow. Where overflow restrictions exist, enclosed systems must be designed for greater capacity as required.

Allowable street flows and allowable sump inlet flows are limited by spread. Actual flows must not exceed the capacity determined by the above equations. Both the 10-year and 100-year peak flows must be checked.

On-grade inlets must be used to control street flows and sump inlet flows. Sloped inlet capacities are not related to storm frequency. Bypass flows must be accounted for in system designs.

City of Lawrence Curb Inlet Design Values: 1/2" per foot street cross slope

Inlet Length (ft)	5	6	7	8	10	12
Sump Inlet Q10 (cfs)	7.5	9.0	10.5	12.0	15.0	18.0
Sump Inlet Q100 (cfs)	12.0	14.4	16.8	19.2	24.0	28.8

Street Q10 (cfs)	Street Q100 (cfs)	Street Slope (ft/ft)	5	6	7	8	10	12
			Sloped Inlet Capacity (cfs)					
7	47	0.010	6.4	7.3	8.2	9.1	10.9	12.8
9	58	0.015	5.2	5.9	6.7	7.4	8.9	10.4
10	67	0.020	4.5	5.1	5.8	6.4	7.7	9.0
11	75	0.025	4.0	4.6	5.2	5.8	6.9	8.1
12	82	0.030	3.7	4.2	4.7	5.3	6.3	7.4
13	88	0.035	3.4	3.9	4.4	4.9	5.8	6.8
14	94	0.040	3.2	3.6	4.1	4.6	5.5	6.4
15	100	0.045	3.0	3.4	3.9	4.3	5.2	6.0
16	106	0.050	2.8	3.3	3.7	4.1	4.9	5.7
16	111	0.055	2.7	3.1	3.5	3.9	4.7	5.4
17	116	0.060	2.6	3.0	3.3	3.7	4.5	5.2
18	120	0.065	2.5	2.9	3.2	3.6	4.3	5.0
19	125	0.070	2.4	2.7	3.1	3.4	4.1	4.8
19	129	0.075	2.3	2.7	3.0	3.3	4.0	4.7
20	134	0.080	2.2	2.6	2.9	3.2	3.9	4.5
20	138	0.085	2.2	2.5	2.8	3.1	3.7	4.4
21	142	0.090	2.1	2.4	2.7	3.0	3.6	4.3
22	145	0.095	2.1	2.4	2.7	3.0	3.5	4.1
22	149	0.100	2.0	2.3	2.6	2.9	3.5	4.0

ADDENDUM 4:

Sanitary Sewer Channel Crossing Requirements

City of Lawrence
KANSAS

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MIKE RUNDLE
DAVID M. DUNFIELD

June 16, 1999

To: Engineers and designers

From: Chad Voigt, Public Works

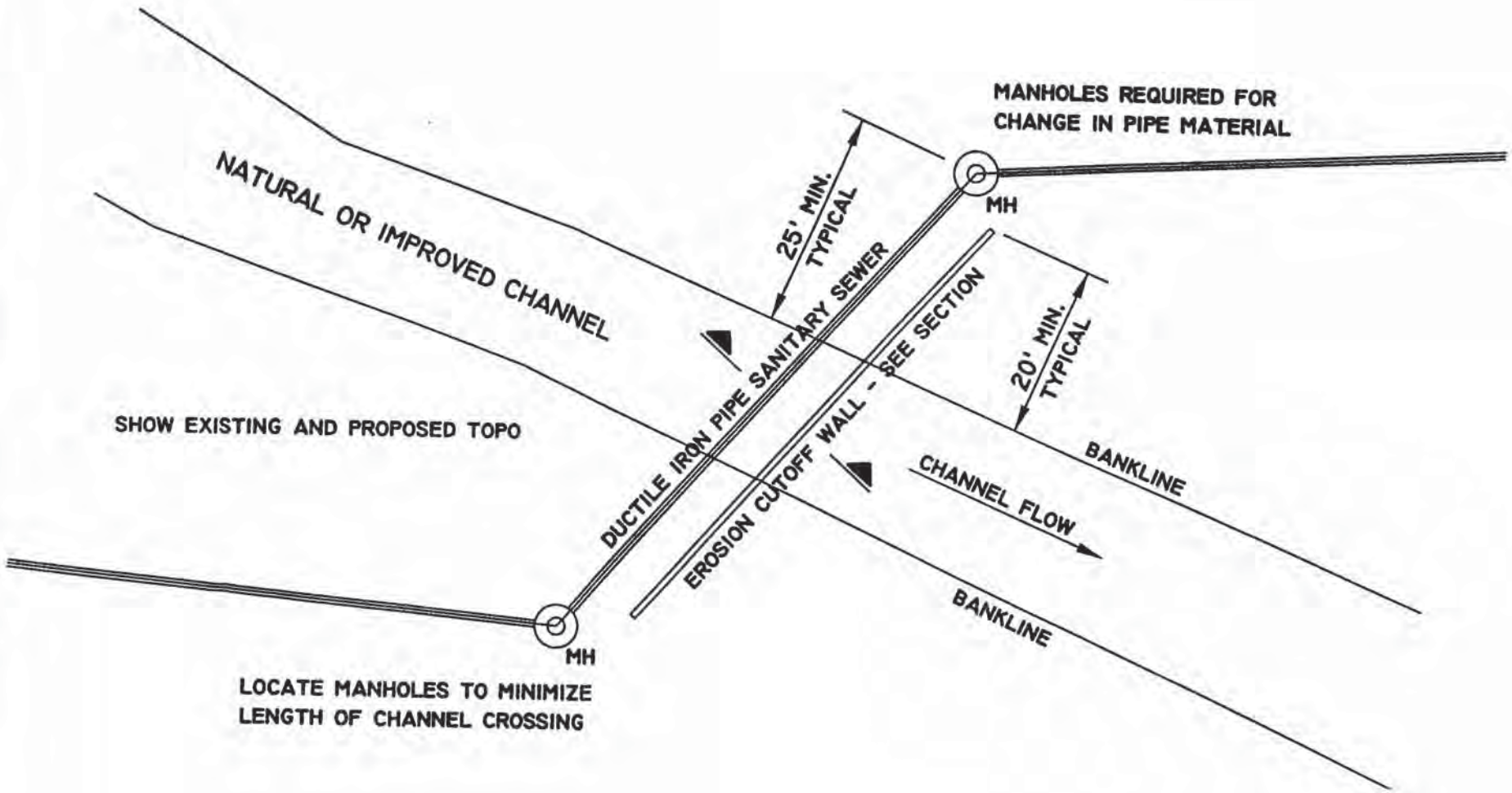
Re: Sanitary Sewer Channel Crossing Requirements

Applicability:

This update applies to all systems that are required to comply with the City of Lawrence, Kansas *Design Guidelines and Standard Specifications*. The attached drawings shall replace the previous design guideline for stream crossings. Effective immediately, all sanitary sewer projects shall comply with these requirements.

Update:

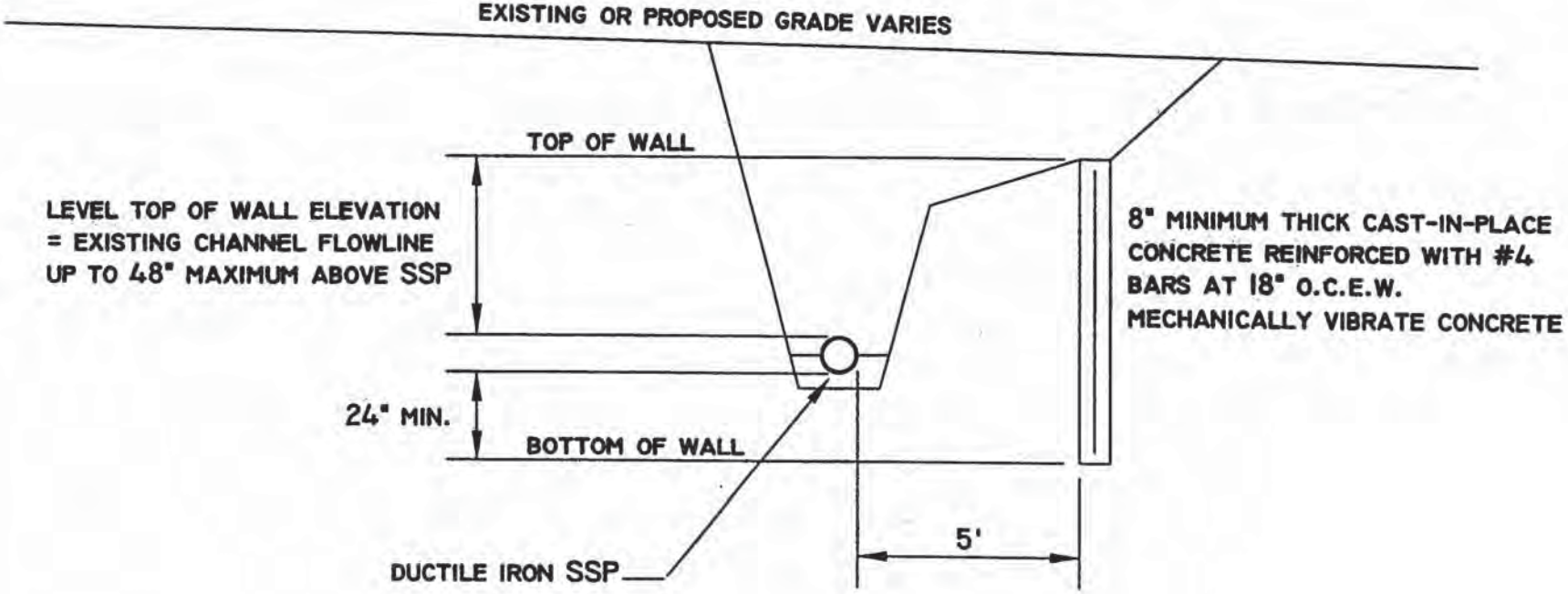
Sheets 1 through 3 attached provide design requirements for channel crossings. The drawing "Erosion Cutoff Wall Typical Section" is included on the enclosed disk.



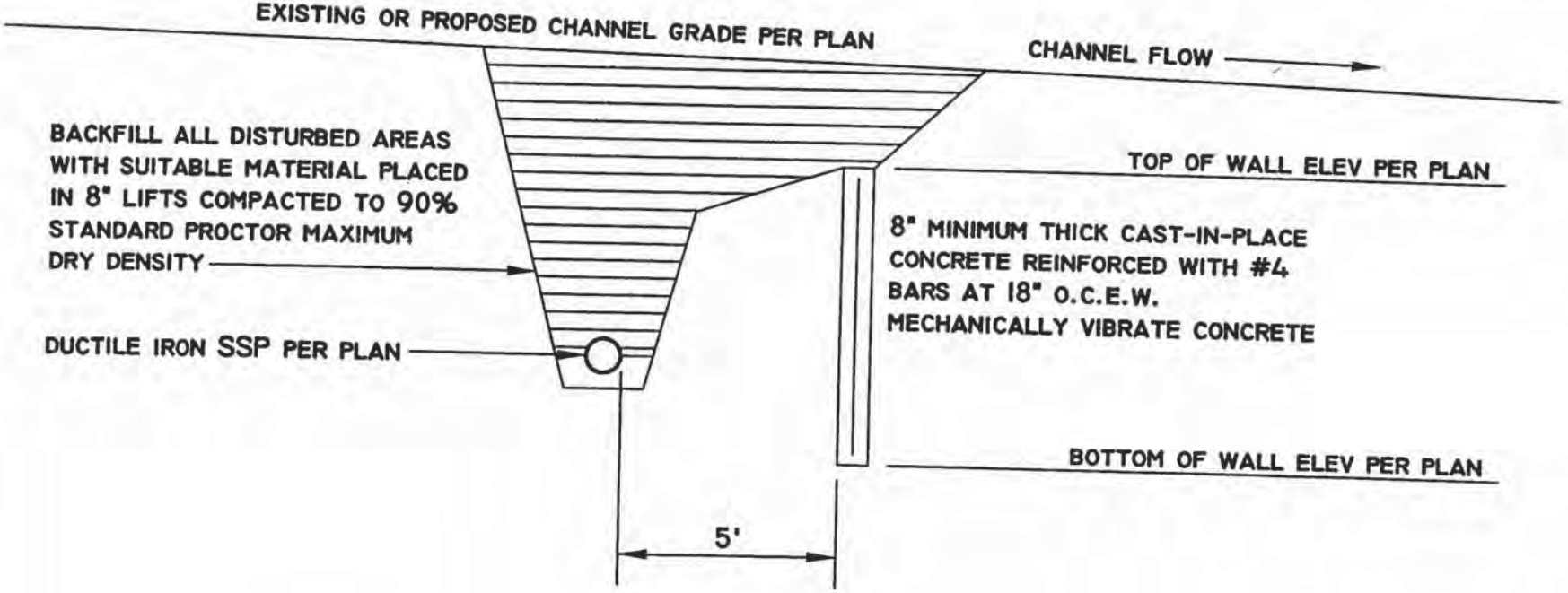
SANITARY SEWER CHANNEL CROSSING
DESIGN REFERENCE

DESIGN NOTES:

1. SANITARY SEWER MUST HAVE 30" MINIMUM COVER AT CHANNEL FLOWLINE.
2. SPECIFY EROSION CUTOFF WALL LENGTH, TOP ELEVATION AND BOTTOM ELEVATION ON PLAN VIEW AT ALL CHANNEL CROSSINGS.
3. INCLUDE EROSION CUTOFF WALL TYPICAL SECTION ON PLANS.



SANITARY SEWER CHANNEL CROSSING DESIGN REFERENCE



EROSION CUTOFF WALL TYPICAL SECTION

ADDENDUM 5:

Allowable Pipe Material within City

Right of way

City of Lawrence

CITY COMMISSION

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MIKE AMYX

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CITY MANAGER

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February 23, 2015

To: Engineers, Contractors & Developers
RE: Allowable Pipe Materials within City Right of Way

The City of Lawrence, Kansas, Design Guideline and Standard Specifications have been revised to provide guidance on what pipe material types are acceptable within City right of way. The attached Addendum supersedes the previous Addendum dated September 23, 1999.

Please note that the use of plastic pipe requires additional backfill and testing by the contractor, and that a City Inspector must be present at all times.

Please call if you have any questions.

Sincerely,

Matt Bond

Matt Bond, P.E.
Stormwater Engineer

cc: David Cronin, P.E., City Engineer

February 23, 2015
Addendum to the City of Lawrence, Kansas
Design Guidelines and Standard Specifications

Regarding the use of Polyethylene Pipe for Storm Sewers, the City of Lawrence herby adopts KDOT's Specifications with the following clarifications:

1. Polyethylene (PE) pipe is acceptable for use in public right-of way of residential streets and in drainage easements outside the public right-of-way. PE pipe is not acceptable for use in the public right-of way of collector and larger streets.

2. Changes in pipe material shall occur only at manhole structures.

3. Trench and backfill specification for PE pipe shall be as follows:

    a) No PE pipe shall be installed or backfilled without a City Engineering Inspector present. The inspector shall be notified of the installation schedule at least 48 hours prior to installation.

    b) The minimum trench width = (1½ times the pipe diameter) + 12 inches.

    c) The space between the pipe and the trench wall shall be wider that the compaction equipment used in the pipe zone.

    d) The trench width in unsupported, unstable soils will depend on the size of the pipe, the stiffness of the backfill and in-situ soil, and the depth of cover.

    e) Granular embedment shall be placed 6 inches minimum below the pipe and shall be shaped to fit the pipe to a depth of 0.25 time the pipe diameter. Where rock exist, the embedment shall be increased to 12 inches minimum below the pipe.

    f) Where flowable mortar is required, granular backfill shall be placed to the spring line of the pipe. Where flowable mortar is not required, granular backfill shall be placed to a depth of 12" above the top of the pipe.

    g) If the fill to the top of the subgrade is 3 feet or less, backfill with granular material to the top of the subgrade.

    h) If the fill to the top of the subgrade is greater than 3 feet, backfill with granular material to a point 12 inches above the top of the pipe.

    i) Granular embedment and backfill material shall comply with current City specifications.

    j) The contractor shall not deform or damage the pipe during the placement of backfill.

k) The contractor shall be responsible to prevent floating the pipe during the backfilling operations. Do not deform or damage the pipe while compacting the granular backfill. Hand tamping may be necessary adjacent to the pipe to prevent distortion.

4. The maximum barrel deflection of all PE pipe (reduction of the barrel nominal base inside diameter) shall not exceed 5%. The contractor shall use a mandrel to measure the barrel deflection of the pipe. Take the measurement at least 30 days after the installation and backfilling. If oversized diameter pipes are installed, actual inside pipe diameters may need to be considered. The contractor shall remove, reinstall or replace any pipes deformed more than 5%.

PE and PVC end section shall not be used. Where end sections are required, bolted CSP end sections shall be installed per the City Standard Detail.

February 23, 2015
Addendum to the City of Lawrence, Kansas
Design Guidelines and Standard Specifications

The City of Lawrence hereby adopts the following allowable uses of pipe materials for public storm drainage systems with the following caveat, **ALL cross road pipe SHALL** be reinforced concrete pipe (RCP):

Pipe Type	LOCATION						
	Cross‡ Road	Principal Arterial Street (ROW)	Minor Arterial Street (ROW)	Central Business District	Collector Street (ROW)	Residential Street (ROW)	Drainage Easements Outside (ROW)
Reinforced Concrete (Arch) (RCPA)	X	X	X	X	X	X	X
Reinforced Concrete (Round) (RCP)	X	X	X	X	X	X	X
Reinforced Concrete (Horizontal Elliptical) (RCHE)	X	X	X	X	X	X	X
Corrugated Steel (Circular or Arch) (CSP)						X	X
Polyethylene Pipe (PE)						X	X

‡ALL Crossroad shall be Reinforced Concrete Pipe
RCP - Reinforced Concrete Pipe, also applies to elliptical sections
CSP - Corrugated Steel Pipe
PE - Polyethylene Pipe
ROW- Right of Way

Each of the allowable pipe materials shall comply with current City specifications.

City of Lawrence
KANSAS

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DAVID M. DUNFIELD

September 23, 1999

VOID

To: Engineers, Contractors, Developers

Re: Plastic Pipe for Storm Sewers

The *City of Lawrence, Kansas, Design Guidelines and Standard Specifications* have been revised to allow the use of Polyethylene pipe and Polyvinyl Chloride pipe for storm sewers. These materials shall be designed and installed per the attached *Addendum*.

Please note that the use of plastic pipe requires additional backfill and testing by the contractor, and that a City Inspector must be present at all times.

Please call if you have any questions.

Sincerely,

Chad Voigt
Department of Public Works

c: Terese Gorman, City Engineer

VOID

September 9, 1999
An Addendum to the City of Lawrence, Kansas
Design Guidelines and Standard Specifications

The City of Lawrence hereby adopts the following allowable uses of pipe materials for public storm drainage systems:

Location	RCP	CSP	PE	PVC
Principal Arterial street right-of-way	x			
Minor Arterial street right-of-way	x			
Central Business District	x			
Collector street right-of-way	x	x		
Residential street right-of-way	x	x	x	x
Drainage Easements outside ROW	x	x	x	x

RCP Reinforced Concrete Pipe or RCEP
CSP Corrugated Steel Pipe or CSAP
PE Polyethylene (pipe)
PVC Polyvinyl Chloride (pipe)

Each of the allowable pipe materials shall comply with current City specifications.

VOID

September 9, 1999
An Addendum to the City of Lawrence, Kansas
Design Guidelines and Standard Specifications

Regarding the use of Polyethylene Pipe and Polyvinyl Chloride Pipe for Storm Sewers, the City of Lawrence hereby adopts KDOT Special Provisions 90M-0241, 90M-0242 and 90M-0210 with the following clarifications:

1. Polyethylene (PE) Pipe and Polyvinyl Chloride (PVC) Pipe are acceptable for use in the public right-of-way of residential streets and in drainage easements outside the public right-of-way. PE and PVC pipe are *not* acceptable for use in the public right-of-way of collector and larger streets.

2. Changes in pipe material shall occur only at manhole structures.

3. Trench and backfill specifications for PE and PVC pipe shall be as follows:

   a) No PE or PVC pipe shall be installed or backfilled without a City Engineering Inspector present. The inspector shall be notified of the installation schedule at least 48 hours prior to the installation.

   b) Trench width shall be 1.5 times the pipe diameter plus 12 inches.

   c) The space between the pipe and the trench wall shall be wider than the compaction equipment used in the pipe zone.

   d) Granular embedment shall be placed 6 inches minimum below the pipe and shall be shaped to fit the pipe to a depth of 0.25 times the pipe diameter. Where rock exists, the embedment shall be increased to 12 inches minimum below the pipe.

   e) Where flowable mortar is required, granular backfill shall be placed to the spring line of the pipe. Where flowable mortar is not required, granular backfill shall be placed to a depth of 12" above the top of pipe.

   f) Granular embedment and backfill material shall comply with current City specifications.

   g) The contractor shall not deform or damage the pipe during placement or backfill.

   h) The contractor shall be responsible to prevent floating of the pipe during backfill operations.

4. The maximum barrel deflection of all PE and PVC pipe shall not exceed 5 percent. The contractor shall measure barrel deflection using a mandrel. The

contractor shall mandrel all PE and PVC pipes in the presence of a City Inspector not sooner than 30 days and not later than 45 days after completion of backfill. The contractor shall remove and replace any pipes deformed more than 5 percent.

5. PE and PVC end sections shall not be used. Where end sections are required, bolted CSP end sections shall be installed per the City Standard Detail.

VOID