STORMWATER MANAGEMENT
CRITERIA

FEBRUARY 2025

CITY OF LAWRENCE, KANSAS
STORMWATER MANAGEMENT CRITERIA

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Adopting Ordinance No. 6778
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CITY OF LAWRENCE, KANSAS
STORMWATER MANAGEMENT CRITERIA

1.0 GENERAL

1.1 Introduction: This document replaces in full the 1996 City of Lawrence Stormwater Management Criteria to provide uniform procedures for the design of storm drainage systems in Lawrence, Kansas. This edition of the Stormwater Management Criteria reflects the latest updates for stormwater management criteria, Lawrence Development Code, and organizes the content from multiple addendums of the 1996 criteria into the main body of the document. A chapter for post-construction Best Management Practices has been added to meet the State and City water quality requirements as a Municipal Separate Storm Sewer (MS4) permittee. The 2025 Development Code addresses stormwater management in Article 13. Article 16 describes the land disturbance permit application process. The 2025 development code is scheduled for adoption in 2025 upon acceptance by the city commission.

Specific criteria apply to the types of drainage systems and facilities ordinarily encountered in local urban and suburban areas. Other special situations may require added criteria or more complex technical analysis than included herein.

1.2 Applicability: These criteria apply to all new storm drainage systems and facilities and to the rehabilitation of existing drainage system facilities.

1.3 General Requirements: The design shall be accomplished under the direction of a Registered Professional Engineer. The design shall be based on land use in the tributary area as zoned, actually developed, or indicated by the City's current comprehensive land use plan, whichever basis produces the greatest runoff.

1.4 Definitions:

Bank Line: The line of intersection of the side slope of an open channel, whether natural or improved, and the adjacent ground.

City: The municipality or body having jurisdiction and authority to govern.

City Engineer: The municipal engineer having jurisdiction and authority to review and approve plans and designs for storm drainage systems.

Developer: Any person, partnership, association, corporation, public agency, or governmental unit proposing to engage or currently engaged in "development" as defined below excluding the widening, resurfacing, or other improvement to existing streets, alleys, and sidewalks.

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.

Drainage Easement: Easement acquired for the right to periodically use an open channel and its immediately adjacent overflow area, or the overflow channel above an enclosed system element, to convey drainage. Drainage easements preclude certain improvements to the land occupied by the easement.

Easement: Authorization by a property owner for the use by another of any designated part of the property for a specified purpose.

Enclosed Drainage: The portion of the improved drainage system consisting of underground pipes, culverts, curb inlets, area inlets and similar structures.

Floodplain: The normally dry land adjoining rivers, streams, lakes or other bodies of water that is inundated during flood events. In order to provide a standard national procedure for floodplain management, the U.S. Federal Emergency Management Agency (FEMA) has adopted the 100-year flood as the base flood.

Floodway: The channel of a stream plus any adjacent floodplain areas that must be kept free of encroachment in order for the 100-year flood to be carried without substantial increase in flood heights. FEMA's minimum standards allow an increase in flood height of 1.0 foot.

Freeboard: The difference in elevation between a reference water surface such as the base flood elevation or maximum design water surface elevation and another point of reference, such as a dam top, open channel top of bank, or finish floor elevation of a building. It is an allowance against overtopping as a safety factor for possible flooding, wave action, or other transient disturbances.

Improved Drainage: All components of the storm drainage system which have been constructed, installed or altered by development including any existing channels which have been changed by grading or by the construction of lining materials.

Major Drainage System: Natural or improved drainage ways having a peak discharge equal to or greater than 70 C.F.S. during a 10-year return period storm based upon the tributary area being fully developed in accordance with the current land use plan.

Minor Drainage System: Natural or improved drainage ways having a peak discharge less than 70 C.F.S. during a 10-year return period storm based upon the tributary area being fully developed in accordance with the current land use plan.

Natural Channel: Also referred to as unimproved drainage. All existing channels that have not been altered by previous grading or construction of any kind.

Owner: The owner of record of real property with improvements that produce runoff from rain.

Registered Professional Engineer: A licensed engineer who is registered with and authorized by the "State Board" to practice within the state of registration.

Return Period: Also referred to as return frequency or recurrence interval. 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, i.e. A 50-year storm has a probability of 0.02 (2%) of occurring in any given year.

Site: A tract, or contiguous tracts, of land owned and/or controlled by a developer or owner. Platted subdivisions, industrial and/or office-commercial parks, and other planned unit developments shall be considered a single site for purposes of applying detention facility and drainage study criteria to new development.

Storm Drainage System: All of the natural and man-made facilities and appurtenances such as ditches, natural channels, pipes, culverts, bridges, open improved channels, street gutters, inlets, and detention facilities which serve to convey surface drainage.

Storm Water Detention Facility: Any structure, device, or combination thereof with a controlled discharge rate less than its inflow rate.

1. Controlled Area: That part of the tributary area for which a detention facility is designed to control peak discharge rates.
2. Detention Storage: The volume occupied by water between the levels of the principal and emergency spillway crests during operation of the facility.
3. Dry Detention Facility: Any detention facility designed to permit no permanent impoundment of water.
4. Emergency Spillway: A device or devices used to discharge water under conditions of inflow that exceed the design inflow. The emergency spillway functions primarily to prevent damage to the detention facility that would permit the sudden release of impounded water.
5. Principal Spillway: A device such as an inlet, pipe, weir, etc., used to discharge water during operation of the facility under the conditions of the 100-year or less return frequency.
6. Private Detention Facility: Any detention facility located on a site wholly owned and controlled by one owner or entity and not platted for future subdivision of ownership. Also, all facilities incorporating detention storage of storm water in or on any of the following:

    a. Roofs of buildings or structures also used for other purposes.
    b. Paved or surfaced areas also used for other purposes such as vehicle parking.
    c. Enclosed underground pipes or structures on private property when the surface is used for other purposes.

7. Public Detention Facility: Any detention facility controlling discharge from a tributary area owned by more than one owner and/or platted for future subdivision of ownership, except as defined as a private detention facility herein.
8. Sediment Storage: The volume allocated to contain accumulated sediments within the detention facility.
9. Wet Detention Facility: A detention facility that is designed to include permanent storage of water in addition to the temporary storage used to control discharge rates from the facility.

Tributary Area: All land draining to the point of consideration, regardless of ownership. Also referred to as drainage area, basin or watershed within the context of this document.

1.5 Return Frequencies: All enclosed and improved open channel conveyance 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 with the following exceptions:

1. Facilities located within the floodway of the 100-year flood, as defined by the current Federal Emergency Management Administration (FEMA) flood insurance study, shall be designed for the 100-year peak flow.
2. Bridges, pipes and culverts crossing arterial streets shall be designed for the 50-year peak flow, unless subject to the requirements of No. 1, above.

Design discharge shall be based on fully developed land use in the tributary area as defined in the latest comprehensive land use plan.

1.6 System Types and Applications:

A. Enclosed Pipe-Inlet Systems: Enclosed systems consisting of underground pipes, culverts, curb inlets and similar functional underground structures shall be used to convey stormwater under the following conditions:

1. Within the right-of-way of improved streets, regardless of system design capacity.
2. 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.
3. 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. Requirements for drainage easements are outlined in Section 3.0 of this manual.

Enclosed systems may also be used to convey stormwater at all locations where open systems are permitted.

B. Improved Channels: Open systems consisting of improved open channels with intermittent culverts or bridges crossing streets and other surfaced areas may be used to convey stormwater in all areas of new development provided that overflow channels are included in accordance with Paragraph 1.6.D. of these criteria. In areas of existing development where channels are proposed as additions or improvements, the bank line shall not be closer than 30 feet to any habitable structure or an enclosed system will be required. Lining of improved channels will be required in accordance with the provisions of Section 8.0 of this manual.

C. Natural Channels: Existing natural channels may be retained in the drainage system of a developed area where the limits of the required drainage easements do not encroach upon any existing or proposed structure and the flow velocity of the 2-year peak discharge does not exceed the following based on soils present in the channel bed and bank.

Soil Type	Max. Velocity of 2-yr. Peak Flow (FPS)
Fine sand, sandy loam	2
Silt loam, noncolloidal silts	3
Colloidal clays & silts, fine gravel	4
Coarse gravel, cobbles	5
Shale	6
Limestone bedrock	15

Natural channels and drainage paths should be maintained in their original locations to the greatest extent possible. An existing channel and its associated 100-year overflow channel, which are part of the major drainage system as defined in this document, shall not be filled in to any extent unless an enclosed system or improved channel of equal or greater capacity than the natural channel is constructed in accordance with all other criteria for new facilities including the provisions for overflow channels.

D. Overflow Systems: As an integral part of the stormwater drainage system, whether enclosed or open, the design of overflow channels shall be required in <u>all</u> areas in addition to, and above, the 10-year conveyance elements. The overflow channel shall have sufficient hydraulic capacity to convey, when combined with the 10-year conveyance system, the 100-year peak discharge such that the water surface elevation plus one foot is at an elevation equal to or below the lowest elevation at which water may enter any proposed or existing building or structure. Overflow channels shall be included within the limits of the required drainage easements for major drainage system components and shall be subject to restrictions on allowable improvements as outlined in Section 3.0.

E. Stormwater Detention Facilities: Detention facilities shall be provided in connection with the development of land where problem areas have been identified where homes, buildings or other structures within the drainage basin and downstream from the proposed development are currently flooded in a 100-year, or more frequent, storm event. Detention facilities shall be required where 1) an engineering study indicates the proposed development would cause flooding of downstream structures; 2) such facilities are recommended by the City's current Stormwater Management Master Plan; or 3) where determined by the City Engineer to be beneficial to the system.

1. Determining Need for Detention

    a. An engineering drainage study as outlined in Section 10.0 of this manual will be required for all locations to determine the impact of the proposed development on the existing drainage system and the need for detention. The study shall include the entire drainage area tributary to the system being impacted by the proposed development. The report shall be submitted to the City with the preliminary plat or prior to any development in previously platted but yet undeveloped areas.

    b. Detention will not be required where the engineering study indicates that construction of a detention facility will increase the downstream system's peak discharge by delaying the peak from the proposed development so that it coincides with the peak discharge from the upstream area.

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

    d. When required, detention facilities shall be designed in accordance with Section 9.0.

2. These requirements apply to all development except the following:

    a. Where downstream flooding is entirely confined within the limits of the 100-year floodplain as defined by the Federal Flood Insurance Study (FIS) current at the time the development is proposed.
    b. Additions to, improvement and repair of existing single-family and duplex dwellings.
    c. Remodeling, repair, replacement, and improvement to any existing structure or facility and appurtenances that does not cause an increased area of impervious surface on the site in excess of 10% of that which existed previously.
    d. Improvements on any site having a gross land area of one-half acre or less, regardless of land use.
    e. Construction of any one new single-family or duplex dwelling unit, irrespective of the total area of the site on which the structure is situated.

f. In the Lake Alvamar Watershed 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 with 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 below will not be required to provide detention.
    a. Peak discharges from the property shall not exceed the following release rates:

2 yr storm	2.4 cfs/acre
10 yr storm	3.2 cfs/acre
100 yr storm	4.5 cfs/acre

    b. All conveyance elements and drainage easements shall be sized for the release rates above

1.7 Waivers: The City Engineer may waive specific criteria or requirements to provide specific types of stormwater facilities under the following conditions.

A. Detention Facilities: Provision to provide detention in accordance with the requirements of Section 1.6.E may be waived and/or design criteria other than those required by Section 9.0 may be approved when the developer makes satisfactory arrangements to improve or provide a downstream conveyance system of hydraulic capacity meeting these criteria for peak rates of discharge to the system, including discharge from the developer's site. The City Engineer may also permit combined downstream conveyance system improvements and other detention combinations that provide an equal or better level of control.

B. Study: The required drainage study provided by the Developer and prepared by a registered professional engineer quantifies the problems and adequately demonstrates that a waiver of a specific requirement is appropriate.

C. Overflow Channels: In previously developed areas, requirements to provide for 100-year storm conveyance by means of overflow channels may be reduced in circumstances where 100-year protection is not reasonably attainable due to the location of damageable improvements with respect to the drainage system.

1.8 Existing Drainage System: Existing drainage system component pipes, structures, and appurtenances within the project limits may be retained as elements of an improved system providing:

- They are in sound structural condition.
- Their hydraulic capacity, including surcharge, is equal to or greater than the capacity required by these criteria.
- Easements, in accordance with Section 3.0, exist or are dedicated to allow operation and maintenance.

1.9 Other References: Other agencies have technical and administrative criteria and regulations pertaining to the design, permitting and operation of drainage systems which are in addition to and which may complement these criteria. When conflicts are encountered, the most rigorous criteria shall govern.

A. Federal Insurance Agency – Floodplain Regulations and Implementing Ordinances Adopted By Municipalities: Drainage systems designed within the limits of the designated 100-year floodplain on the principal stream shall be designed to convey the flood as defined by applicable published floodplain information studies. For special flood hazard areas located in approximate Zone A zones, the developer shall prepare studies and calculations establishing the floodplain, elevation and width. These calculations shall be submitted to the reviewing agency for approval.

B. Kansas Department of Agriculture: Rules and regulations of the Division of Water Resources dealing with such issues as stream obstructions, channel changes, dams, and permits shall apply.

2.0 HYDROLOGIC CRITERIA AND METHODS

2.1 Scope: This section sets forth the hydrologic methods and parameters to be used for computations of runoff and peak rates to be accommodated by the storm drainage system.

2.2 Computation Methods for Runoff: Runoff rates to be accommodated by each element of the proposed storm drainage system shall be calculated using the criteria for land use runoff factors, rainfall, and system time outlined in the following sections. The following alternative computation methods are acceptable. Other methods, including computer models, may be utilized so long as they produce calculated runoff to the system that is substantially the same as that calculated by the following criteria.

A. Rational Method: The Rational Method may be used to calculate peak rates of runoff to elements of enclosed and open channel systems, including inlets, when the total upstream area tributary to the point of consideration is less than 300 acres or to detention facilities with tributary areas of less than 10 acres. The Rational Method is defined as follows:

$Q = C\,i\,A$, where

Q = Peak rate of runoff to system in C.F.S.

C = Runoff coefficient

i = Rainfall intensity in inches per hour

A = Tributary drainage area in acres

Rainfall intensity, used only for the Rational Method, shall be as indicated in Table A corresponding to the calculated time of concentration.

B. Hydrograph Methods: The application of hydrograph methods is required for all conveyance systems having greater than 300 tributary acres and for all detention facilities having greater than 10 tributary acres. Computer models or manual methods are permissible.

1. Acceptable computer models include the following or others as approved by the City Engineer:

a. SCS Technical Release No. 55 (TR-55) - "Urban Hydrology for Small Watersheds"

b. SCS Technical Release No. 20 - "Project Formulation - Hydrology"

c. U.S. Army Corps of Engineers, Hydrologic Engineering Center-"HEC-HMS Hydrologic Modeling System"

d. U.S. Environmental Protection Agency "Storm Water Management Model" (SWMM) or PCSWMMM with approved conditions

Copies of the above are available for purchase through National Technical Information Service (NTIS), U.S. Department of Commerce, Springfield, VA., 22161. The SWMM program is also available from the U.S. EPA Water Research website. The HEC-HMS and TR-55 packages are also available through the US Army Corps of Engineers Hydrologic Engineering Center Software website.

2. Acceptable manual methods shall include sequential calculation of the mass (in cubic or acre-feet) and the peak rate (in CFS) of runoff at 5-minute increments for:

a. Direct surface runoff.

b. Routed hydrographs at each point of interest on both enclosed and open channel systems using the "storage indication" method.
c. Inflow hydrographs to each detention facility.
d. Storage volume and elevation in each detention facility.
e. Discharge hydrographs from each detention facility.

3. For drainage system design, rainfall hyetographs for use with hydrograph methods shall be developed for a storm duration not less than the time of concentration of the drainage area or one hour, whichever is greater. The distribution of precipitation shall be by a generally-accepted method to be determined by the design engineer. For the design of detention facilities, the storm duration and distribution shall be as outlined in Section 9.0 and Addendum 1.

2.3 Runoff Coefficients: Runoff coefficients relative to development and land use shall be as indicated in Table B. The indicated "C" values are applicable to the Rational Method and the "CN" values applicable to the SCS method. The Green-Ampt and Horton infiltration equations are also both acceptable options for use in the HEC-1 or SWMM programs.

Coefficients shall be based on the more runoff-intensive surface condition of either planned future land use or existing developed land use. Future land use shall be defined by the City's adopted comprehensive land use plan. Undeveloped areas not zoned, but for which future land use is defined by the City's land use plan, shall be assigned runoff coefficients for the land use indicated by such plan. Undeveloped areas designated as agricultural or those for which no specific future land use is indicated shall be assigned a minimum of 35 percent impervious surface for purposes of the design of storm drainage systems.

As an alternative to the coefficients and for areas not listed in Table B, a composite runoff coefficient based on the actual percentages of pervious and impervious surfaces shall be used.

2.4 Time of Concentration (Tc) : The time of concentration, T_c, shall be calculated as the sum of the overland flow time, the shallow concentrated flow time and the system flow (travel) time.

A. Overland Flow Time: Determined from Figure 1. The maximum sheet flow distance for calculations shall not be greater than 300 feet for developed areas and 500 feet for undeveloped areas.

B. Shallow Concentrated Flow Time: Determined from Table C or D. The maximum shallow concentrated flow distance for calculations shall not be greater than 400 feet. Shallow concentrated flow includes flow along side and rear lot swales and overland surfaces with no defined channel beginning at the point that the flow length exceeds the applicable maximum overland flow length.

C. System Flow (Travel) Time: Determined from Figure 2. The "system" includes flow in street gutters; street ditches; enclosed pipe or box storm sewers; and improved or natural open channels. System flow time shall not be less than 5.0 minutes regardless of the calculated time.

To provide for future development when the upstream channel is unimproved, the following table shall be used for calculating system flow time. The time shall be calculated as the length of travel in the system divided by the velocity of flow.

AVERAGE CHANNEL SLOPE %	VELOCITY (FT/SEC)
<2	7
2 TO 5	10
>5	15

3.0 EASEMENTS

3.1 General Requirements: In all new development areas, developers shall be required to dedicate (plat) easements for all major drainage system components including enclosed pipe systems, improved or natural channels, and detention facilities, and for all enclosed minor system components. In previously developed areas, easements shall be acquired from the property owners at no cost to the City before any drainage system improvements are made.

3.2 Maintenance Responsibility: The City shall be responsible for maintenance of the enclosed drainage system components located in dedicated easements only. Maintenance of all improved or natural channels all overflow channels, private detention facilities, and all easements associated with these drainage system components shall be the responsibility of the individual property owners.

3.3 Permanent Drainage Easement Requirements:

A. Improved Systems: The following requirements apply to the improved drainage system. Major system easement requirements are illustrated in Figure 3.

1. Drainage easements shall be required in addition to and overlaying other permanent public or private easements, as applicable. Drainage easements for the major system shall cover the overflow area for the conveyance element, whether open channel or enclosed system, determined as the water elevation resulting from the 100-year storm peak discharge plus one foot. Water surface elevations and easement lines shall be indicated on the drainage plan as outlined in Section 10.0.
2. These easements shall be dedicated to the City and limitations on permanent obstructions shall be included in the dedication with all other concurrent uses reserved to the property owner.

a. Permissible concurrent surface uses of overflow areas include lawns, gardens, or other open uses; vehicular parking; or any other use not permanently obstructing the overflow channel.
b. Prohibited concurrent surface uses include fencing; structures such as sheds, garages or outbuildings; materials storage; or any other use obstructing the overflow channel.

3. The following are minimum widths required for drainage easements:

a. For minor system enclosed components, the pipe diameter plus six feet each side or 15 feet, whichever is greater.
b. For major system enclosed components, the width of the 100-year overflow channel, as defined in Paragraph 3.3.A.1., or 15 feet, whichever is greater.
c. For improved channels, the width of the 100-year overflow channel, as defined in Paragraph 3.3.A.1., or 30 feet, whichever is greater.
d. For detention facilities, 15 feet clear of any structure and 10 feet clear around the perimeter of the greatest of 1) the top of bank lines, 2) the 100-year water-surface contour, or 3) 1 foot outside of security fences.

4. Drainage easements shall be connected to public street right-of-ways at locations not greater than 800 feet apart, measured along the permanent easement. Such access easements shall be a minimum width of 10 feet.

B. Natural Channels: For natural channels retained in the storm drainage system, permanent easements for undeveloped green space including the channel itself, shall be platted at a width of 60 feet approximately centered on the channel, or the width of the 100-year overflow channel as defined in Paragraph 3.3.A.1., whichever is greater.

1. Minor clearing and grading within the easement is allowable but complete clearing, regrading or construction of any buildings or other improvements is prohibited.
2. These easements will be dedicated to the City but maintenance of the easement and the channel will be the responsibility of the individual property owner(s).

4.0 HYDRAULIC CALCULATION METHODS

4.1 Pipes and Open Channels: Flow shall be calculated by Manning's equation.

$$Q = \frac{A(1.486)\left(R^{2/3}\right)\left(S^{1/2}\right)}{n}$$ where:

Q = Discharge in cubic feet per second.

A = Cross sectional area of flow in square feet.

n = Roughness Coefficient (see Table E).

R = Hydraulic radius (R = A/P) in feet.

S = Slope in feet per foot.

P = Wetted perimeter in feet.

Head losses, except friction losses, shall be calculated by

$$h = k\left({V^2}/{2g}\right)^{1/2}$$ where:

h = Head loss in feet.

V = Velocity of flow in feet per second at point of interest.

2g = 64.4 feet per second per second.

k = Coefficient as shown in Table F.

4.2 Street Gutters: Flow shall be determined by Izzard's formula, below. (See Figure 4 for graphical solution.)

$$Q = \frac{0.56(z)(S^{1/2})(D^{8/3})}{n}$$

Q = The gutter flow in cubic feet per second.

Z = The reciprocal of the average cross-slope, including gutter section in feet per foot.

S = The longitudinal street grade in feet per foot.

D = The depth of flow at curb face in feet.

n = Manning's "n" as shown in Table E.

The following formula shall be used to determine the street grade (Sx) at any point on a vertical curve for use in calculating gutter flow. Grades shall be "plus" when ascending forward and "minus" when descending forward with all grades in feet per foot.

$Sx = S1 + \frac{X}{L}(S2 - S1)$ where:

S_x = The street grade on a vertical curve at point x.

S_1 = The street grade at the PC of a vertical curve.

S_2 = The street grade at the PT of a vertical curve.

X = The distance, in feet, from the PC of the curve to point x.

L = The total length of a vertical curve, in feet.

4.3 Head Losses: The following values for head losses in inlets, manholes and junction boxes may be used for design:

Structure	Head Loss (Ft.)
Inlet - One exit pipe only	0.5
Inlet - Thru flow @ less than 45° angle (one entry & one exit line)	0.1
Inlet - Thru flow @ greater than 45° angle (one entry & one exit line)	0.2
Inlet - Two or more entering lines	0.3

4.4 Culverts: Culvert flow capacity shall be calculated using Figures 5.1 through 6.6 as applicable to particular installation conditions.

4.5 Computer Methods: Computer models may be used for hydraulic calculations. For open channels the following models are permissible. Other models may be used as approved by the City Engineer.

1. U.S. Army Corps of Engineers, Hydrologic Engineering Center-"HEC-2 Water Surface Profiles"
2. Federal Highway Administration - "HY-7 WSPRO - A Computer Model for Water Surface Profile Computations"
3. U.S. EPA "Storm Water Management Model (SWMM)"

5.0 ENCLOSED SYSTEM DESIGN

5.1 General Requirements: All enclosed drainage system components (pipes, culverts and structures except bridges) shall be structurally designed for an H-20 live load, a unit weight of 120 pcf for soil cover, and minimum lateral earth pressure of 40 pcf equivalent fluid pressure. The lateral earth pressure shall be increased as necessary for special conditions when present on a project.

5.2 Pipes and Culverts:

A. Minimum Cover: Minimum cover over all pipes and culverts shall be equal to 1.5 feet.

B. Minimum Size: Minimum pipe diameter shall be 15 inches within public street right-of-ways and 12 inches in other locations.

C. Downstream Conduit Size: Conduit sizes, based on square feet of end area shall not decrease from upstream to downstream regardless of the calculated capacity of each conduit.

D. Surcharge: Surcharging of pipes under entrance control is permitted in structures subject to freeboard criteria for the structure and provision for pressure joints throughout the surcharged lengths.

E. Street Crossings: Culverts and/or bridges on open channels and conduits which cross streets shall be sized to provide a minimum freeboard at the design discharge of 0.5 feet to the lowest point in the street gutter grade. The design of these components shall also provide for a minimum freeboard of 0.5 feet to the lowest point of entry to any existing or proposed upstream habitable structure with the culvert size increased as necessary to obtain the required minimum freeboard.

F. Pipe Slopes: Minimum invert slopes shall conform to the following:

Pipe Dia. (in.)	Min. Invert Slope (%) for Round or Arch Pipe	
	RCP	CSP
12	1.9	3.5
15	1.4	2.6
18	1.1	2.0
21	0.9	1.6
24	0.8	1.4
30	0.6	1.0
36	0.4	0.8
42	0.4	0.7
48	0.3	0.5
54	0.3	0.5
60	0.2	0.4
66	0.2	0.4
72	0.2	0.3

5.3 Inlets:

A. Inlet Type and Configuration: Curb inlets shall conform to the City's standard plan indicated on the standard "Storm Sewer Details" drawing. Minimum clear opening length shall be 5.0 feet.

B. Capacity: Inlet hydraulic capacity shall be determined from Table G for curb-opening inlets on slopes and from Figure 9 for curb-opening inlets in sumps.

C. Location Requirements: Inlets shall be located along streets as required to limit the width of flow in the gutters at the 10-year peak discharge to the following limits:

Street Width, Ft. (Back to Back of Curb)	Max. Allowable Spread in Each Outside Lane, Ft. (From Face of Curb)
28 or less	10.5
>28 to 36	11.5
>36	12.0
Divided Roadways	As above for each direction

Arterial and Collector Street Intersections and at Pedestrian Crosswalks	6.0

D. Freeboard Requirements: At inlets and other points of surface water entry into the enclosed drainage system, a minimum of 0.5-ft. shall be required between the peak design water surface elevation in the structure and the lowest elevation of the inlet opening. (Figure 10 illustrates the freeboard requirement.) The water surface elevation in the structure shall be calculated as follows:

1. Invert elevation of the exit/outlet line (pipe), plus;
2. Depth (diameter) of the exit/outlet line (pipe), plus;
3. Minor losses, "h".

Minor losses shall be calculated by the equation: $h = k * (V^2/2g)$ where the coefficient "k" is determined from Table F and "V" is the velocity of the exiting line determined by dividing the flow, Q, by the area, A, of the exiting line.

E. Other Requirements:

1. A minimum drop across the invert of inlets, manholes and junction boxes shall be required as follows:

- For flow angle change equal to or less than 30° 0.1 ft.
- For flow angle change greater than 30° 0.2 ft.
- For three or more lines, all flow angles, 0.3 ft.

2. The crown elevation(s) of pipe(s) entering a structure shall be at or above the crown of the pipe exiting the structure.

6.0 ENERGY DISSIPATION

6.1 General Requirements: Energy dissipation shall be required where enclosed systems or detention basin spillways discharge to defined open channels with outlet velocities greater than the following:

System Discharge Velocity (fps)	Receiving Channel Lining Type
4.0	Natural, unlined or grass-lined
5.0	Constructed, turf-lined
7.0	Reinforced vegetation

12.0	Riprap or gabions
15.0	Concrete, grouted riprap, or natural limestone

6.2 Structure Types: Energy dissipation structures shall be required at pipe outlets with discharge velocities greater than those stated in Section 6.1. The type of structure shall be based on pipe diameter and design discharge as specified below.

A. Pipes and Pipe-Arches (d ≤ 24"): For pipes and pipe-arches less than 24-inches in diameter, either:

1. Prefabricated end sections with cast-in-place toe walls, or
2. Enclosed vertical drop structures in accordance with Figure 11.

B. Enclosed System (Q < 100 CFS): For enclosed system structures having a design discharge capacity less than 100 CFS, one of the following:

1. Enclosed vertical drop structures in accordance with Figure 11.
2. Impact basin (Bureau of Reclamation Basin VI - Figure 12).
3. KDOT Standard 521

C. Enclosed System (100 CFS ≤ Q ≤ 400 CFS): For enclosed system structures having a design discharge greater than or equal to 100 CFS but less than 400 CFS, one of the following:

1. Impact basin (Bureau of Reclamation Basin VI - Figure 12).
2. Baffled chute (Bureau of Reclamation Basin IX - Figure 13).
3. KDOT Standard 521.

D. Enclosed System (Q ≥ 400 CFS): For enclosed system structures having a design discharge greater than or equal to 400 CFS:

1. Baffled chute (Bureau of Reclamation Basin IX - Figure 13).
2. SAF Basin (Bureau of Reclamation Basin III - Figure 14).

6.3 Channel Lining: Channel lining shall be required to complete a smooth transition in flow between the energy dissipation structure and the open channel.

A. Dimensions: Channel lining shall be required downstream from all energy dissipating structures with the dimensions as specified in the table below. Where enclosed system pipes or structures discharge into a channel, either improved or natural, at an angle greater than 15 degrees from the axis of the channel, the lining shall extend both upstream and downstream from the outlet with the length in each direction as noted below. Final design details and channel lining for structures greater than 108 inches in diameter shall be subject to approval by the City Engineer.

Channel Lining at System Outlets		
Pipe Diameter (Inches)	Minimum Width (Feet)	Minimum Length (Feet)
18	4	12
24	6	14
30	7	16
36	9	18
42	10	20
48	12	20
54	13.5	22
60	15	26
66	19	26
72	20	30
84	25	36
96	30	40
108	32	40

Note: The dimensions shown in the table can be applied to box or arch culverts of equivalent waterway area.

B. Materials: Acceptable lining materials are outlined in Section 8.3.

7.0 PIPE OUTLET PROTECTION

7.1 General Requirements: Pipe outlet protection shall be required where enclosed systems or detention basin spillways discharge directly to the existing ground where no defined channel is present to reduce the depth, velocity, and energy of water, such that the flow will not significantly erode the receiving area. Protective measures are required where outlet velocities are greater than the following:

Ground Slope	System Discharge Velocity (FPS)	Receiving Area Surface
0-5%	5.0	Lawn grasses such as Fescue, Kentucky Bluegrass or Bermuda
	4.0	Grass Mixtures
	2.5	Annual grasses or Small Grains
5-10%	4.0	Lawn grasses such as Fescue, Kentucky Bluegrass or Bermuda
	3.0	Grass Mixtures

Note: The permissible velocities of flow noted above are for erosion resistant soils. For highly erodible soils, indicated by an erodibility factor (K) greater than 0.35 from the NRCS Soil Survey, the permissible velocities should be decreased by 25%. Also refer to Erosion and Sediment Control specifications section 6100.

7.2 Dimensions and Materials: For pipes with a diameter equal to or less than 36 inches, outlet protection shall extend beyond the end of the outlet pipe or end section for the minimum length and width indicated in Section 6.3 for the specific pipe size. The length and width shown for an 18-inch diameter pipe shall apply to smaller diameter pipes also. Pipes larger than 36" in diameter may not discharge directly onto the ground surface. Acceptable materials for outlet protection are riprap, grouted riprap, gabions, or concrete.

8.0 IMPROVED CHANNELS

8.1 Geometric Criteria:

A. Bottom Width: The minimum bottom width for improved channels shall be 4.0 feet.

B. Side Slopes: The maximum side slopes for trapezoidal channels shall be as follows:

1. 4 horizontal to 1 vertical for turf or reinforced vegetative lining and the overflow channel area above the lining materials.
2. 2 horizontal to 1 vertical for all other lining materials except vertical concrete or gabion walls.
3. Flatter if necessary for stability of slopes.

C. Invert Lining: The invert of all constructed channels shall be lined with concrete, riprap or gabions to a minimum height of 6 inches above the invert.

D. Alignment Changes: Alignment changes shall be achieved by circular curves only having a minimum radius of:

$R = \frac{V^2 W}{8D}$ where:

R = Radius on channel centerline, in ft.

V = Velocity of 10-year design flow, in feet per second

W = Channel width at 10-year water surface elevation, in ft.

D = Depth of 10-year design flow, in ft.

8.2 Lining Height:

A. Minimum Height: Channel lining material shall extend above the channel invert to the depth of the 10-year design discharge plus 6 inches of freeboard.

B. Increase on Curves: Along the outer side of horizontal curves, the lining height shall be increased as follows:

$y = \frac{D}{4}$ where:

y = Increased vertical height of lining, in feet.

D = Depth of 10-year design flow, in feet.

Increased lining height shall be transitioned from "y" feet to zero feet over a minimum of:

1. 30(y) feet downstream from the point of tangency (P.T.) of the channel curve.
2. 10(y) feet upstream from the point of curvature (P.C.) of the channel curve.

8.3 Lining Material Requirements: The following types of lining materials are acceptable alternates based on the peak flow velocity in the channel. Other types of lining materials not specifically listed above may be used when approved by the City Engineer.

10-Year Peak Velocity (FPS)	Permitted Lining Material
> 12.0	Sound in-situ limestone Concrete Grouted riprap
>7.0 to 12.0	Sound in-situ limestone Concrete Grouted riprap Gabions Riprap
5.1 to 6.9	In-situ limestone Concrete Grouted riprap Gabions Riprap Reinforced Turf above invert lining
5.0 and less	In-situ limestone Concrete Grouted riprap Gabions Riprap Reinforced Turf above invert lining Turf above invert lining

8.4 Optional Design for Improved Channels: In lieu of sloping banks and linings as specified above, vertical walls may be constructed for improved channels conveying greater than 400 CFS with the following requirements.

A. Vertical Walls: Shall be designed and constructed as retaining wall structures.

B. Materials: Acceptable materials for vertical walls are reinforced concrete or gabions.

C. Wall Height: The minimum wall height shall be the greater of 1.5 feet or the depth of the 1-year peak water surface plus 0.5 ft. The height shall be increased at transitions and bends.

D. Access: Adequate provisions shall be made for pedestrian entry/exit from the channel.

8.5 Subdrainage for Linings: All channel linings, except turf, shall provide for relieving back pressures and water entrapment beneath and/or behind the lining material.

A. Materials: The following are acceptable alternate methods for providing subdrainage:

1. Non-woven geotextile filter fabrics.
2. Graded aggregate filter material with a minimum thickness of 4 inches and gradation based on filter design criteria.

B. Weep Holes: For concrete or gabion-lined channels, screened 4-inch diameter "weep holes" shall be required located at the base of the sloped sides, at a maximum spacing of 15 feet on-center.

9.0 STORMWATER DETENTION

9.1 General: Public and private detention facilities may be either wet or dry. Joint uses, such as parking and recreation, not interfering with detention functions are permitted for dry facilities.

9.2 Other Regulatory Requirements: In addition to these criteria, the requirements of the Kansas State Board of Agriculture, Division of Water Resources shall apply to all detention dams meeting current regulatory size or function categories.

9.3 Allowable Release Rates: The allowable maximum release rate from any detention facility for the 100-year or more frequent storms shall not exceed 1.8 CFS per tributary acre of the developed site. When off-site areas are also tributary to the detention facility, their inflow hydrographs may be added to the above maximum release rate for the development to determine the total maximum release rate from the detention facility.

9.4 Storage Volume Requirements:

A. General: Detention storage for all facilities shall be established by hydrograph routing methods. The volume shall be as required to limit the release rate to the maximum indicated.

B. Additional Requirements: All wet detention facilities shall provide additional storage volume, in addition to the required flood storage, below the elevation of the principal spillway for five years of sediment accumulation in accordance with Figure 15. All facilities designed as wet basins shall also provide permanent storage volume as necessary to maintain a minimum water depth of 3.0 feet.

9.5 Hydrograph Routing Methods:

A. General: Hydrograph routing is required for each return period to determine maximum inflow, detention volume and release rates.

B. Rainfall Distribution: To compute the design inflow hydrograph, a Soil Conservation Service (SCS) Type-2 rainfall distribution with a 24-hour duration shall be used for developing the hydrographs. For small watersheds with very short concentration times, a shorter duration storm must be used. The following may be used as a guide:

Tc (min)	Time Step	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

C. Runoff Computation: Runoff shall be computed by the SCS curve number method. Applicable curve numbers shall be obtained from Table B. The curve number shall be weighted by proportional land use in the tributary area.

D. Routing Interval: The routing time (hydrograph ordinate) interval shall be 5 minutes.

E. Routing Method: Detention routing shall be by the storage-indication, or Modified Puls, method unless otherwise approved by the City Engineer.

F. Simplified Design: A simplified design method is acceptable only for detention facilities having 10.0 acres or less of tributary area.

1. The SCS TR-55 computer model may be utilized for computer methods.
2. By manual methods, use Figure 16 to determine required storage volume.

9.6 Principal Spillways (Outlets):

A. General: The principal spillway shall be designed to convey all discharge from the detention facility from the 100-year and more frequent (inflow and discharge equal to or less than the 100-year) storms and shall function without mechanical or electrical components.

B. Hydraulic Characteristics: The principal spillway shall have the hydraulic characteristics of a weir, pipe or orifice, or a combination of these.

C. Capacity: The spillway shall have sufficient capacity to discharge 80 percent of the detention storage volume within 24 hours after the peak inflow has entered the basin.

D. Trash Racks: Trash racks, screens, etc., shall be provided at the principal spillway as necessary to keep the facility fully operational.

9.7 Emergency Spillways:

A. Required Installations: Emergency spillways shall be required only for detention facilities formed by earth embankments or dams greater than 10.0 feet in height. Basins constructed entirely by excavation below existing grade do not require emergency spillways.

B. Return Period for Operation: Emergency spillways shall operate only for storms less frequent (higher inflow and discharge) than the 100-year storm.

C. Regulatory Criteria: The Division of Water Resources criteria shall apply to the design of emergency spillways with sufficient capacity to discharge the 6-hour PMP hydrograph without overtopping the dam.

9.8 Other Requirements:

A. Wet Basins: The design of wet detention facilities shall include provisions for complete drainage to permit sediment removal and other periodic maintenance activities.

B. Dry Basins: Dry detention facilities with storage on other than paved surfaces shall have the bottom graded at a minimum of 0.5 percent to drain to an interior concrete-paved gutter. The drainage gutter shall be 4.0 feet or greater in width.

C. Side Slopes: Slopes on the banks, dams, dikes or berms around and forming the basin shall not be steeper than:

1. 2:1 below the elevation of the principal spillway for excavated bank slopes.
2. 3:1 for all other excavation and embankment slopes.

Flatter slopes shall be required if necessary for stability with a safety factor of 2.0 for dams greater than 10 feet in height, and 1.5 for all other slopes.

D. Erosion Control: Principal spillways and outlet works, as well as conveyance system entrances to detention basins, shall be equipped with energy dissipating devices as necessary to limit the peak discharge velocity in conformance with Section 6.0.

E. Rooftop Detention: Detention storage may be met in total or in part by detention on roofs. Details of such designs shall include the depth and volume of storage, details of outlet devices and down drains, and elevations and details of overflow scuppers. Connections of roof drains to sanitary sewers are prohibited. Design loadings and special building and structural details shall be subject to approval by the City Engineer. Rooftop detention areas are exempt from sediment storage requirements.

F. Parking Lot Detention: Paved parking lots may be designed to provide temporary detention storage of stormwater on a portion of their surfaces. Generally, such detention areas shall be in the more remote portions of such parking lots. Depths of storage shall be limited to a maximum of seven inches with such areas located so that access to and from parking areas is not impaired. Parking lot detention areas are exempt from sediment storage requirements.

G. Other Detention: All or a portion of the detention storage may also be provided in underground or surface detention areas, including, but not limited to, oversized storm sewers, vaults, tanks, swales, etc.

9.9 Construction, Operation and Maintenance:

A. Public Facilities: Public detention facilities, if recommended by the Stormwater Management Master Plan or otherwise agreed upon by the City as the result of an engineering drainage study, shall be designed, constructed, operated and maintained by the City.

B. Private Facilities:

1. Private detention facilities shall be constructed by the property owner after plan approval and issuance of a permit by the City. Dedication of drainage easements to the City will be required.
2. Operation and maintenance of private detention facilities shall be the responsibility of the property owner and successors.

C. Maintenance Activities: For both public and private facilities, required maintenance activities include the following:

1. Debris removal and cleaning.
2. Cutting of vegetation.
3. Repair of erosion.
4. Removal of silt.
5. Maintenance of structural facilities, including outlet works.

10.0 DRAINAGE STUDY REQUIREMENTS

10.1 General: The study shall be prepared by a registered professional engineer in the State of Kansas in accordance with the requirements contained herein, and shall be submitted to the City Engineer for review and approval with the preliminary plat for the proposed development. The report shall include all information, including drawings and calculations, concerning the proposed development's peak rates of runoff; its internal stormwater systems; the method(s) of handling off-site drainage; and the impact on downstream drainage system facilities and development. It shall also include names of the landowner, developer and engineer; the date of submittal; a list of all permits required by local, state and federal agencies and the status of said permits; all supportive drainage calculations; and a "Drainage Plan" drawing prepared at 1"= 100" or larger unless otherwise approved by the City Engineer.

10.2 Required Information: The following information shall be shown on the "Drainage Plan" submitted as part of the preliminary plat.

A. Contours: A contour interval of 1 or 2 feet is acceptable. All existing topography and the date of the topo survey shall be indicated. Use of the City's current aerial topo maps is acceptable.

B. Bench Marks: At least one (1) bench mark adjacent to or within the proposed development shall be shown with the Mean Sea Level (MSL) Datum/National Geodetic Vertical Datum (NGVD).

C. Plat Layout: The outline of all lots and blocks plus all permanent drainage easements shall be shown. The elevation of the 100-year water surface shall be indicated for all major system drainage easements as required by Section 3.0. Lot dimensions, setback lines and utility easements are not required.

D. Storm Sewers: All storm sewers shall be shown in their approximate locations with the following data:

1. Estimated pipe size (inches).
2. Inlet locations.
3. Basin and sub-basin boundaries.
4. Q_{10} (CFS) for each sub-basin at its inlet to the system.

E. Channels: Improved channels shall be indicated on the plan with the following data:

1. Approximate channel slope (percent).
2. Estimated bottom width (feet).
3. Proposed side slopes.
4. Design discharge, Q (CFS).

F. Detention Areas: All detention facilities as required by these regulations shall be shown on the plan with the following data:

1. Static pool elevation, where applicable.
2. Maximum water surface elevations for the 2, 10 and 100-year storms.
3. Discharge rates for the 2, 10 and 100-year storms.
4. Proposed size and type of control structure.

G. FEMA Data: The limits of the FEMA floodplain and floodway along with the Base Flood Elevations (BFE) shall be shown where appropriate. Where new development is proposed adjacent to unstudied or non-detailed studied streams, the developer shall submit the appropriate backwater calculations (based on HEC-2), encroachment analysis, and floodway data to be submitted to FEMA for review and approval.

H. Minimum Elevations: Minimum structure elevations shall be indicated for each lot adjacent to a dedicated drainage easement on the major drainage system. The minimum elevation shall be the elevation of the lowest point of entry or opening into any habitable structure on that lot in accordance with current subdivision ordinances.

I. Off-Site Drainage: All off-site drainage areas which discharge into the proposed development shall be labeled with the basin size (acres) and the 10 and 100-year peak discharges (CFS). Discharge from an existing upstream storm drainage system shall be computed in accordance with the requirements of these criteria. The computed discharge shall be used to design the new downstream system even though the actual capacity of the existing upstream system may be less.

J. Street Grades: Preliminary street grades and elevations at sumps and crests shall be shown on the plan with arrows to indicate direction of drainage flows.

10.3 Document Format: The drainage report shall be a bound document containing all calculations and drawings with pockets provided for drawings to allow easy removal. All data shall be organized in such a manner as to allow timely and systematic review. A minimum of two (2) copies of the drainage report document shall be submitted to the City at the time of preliminary plat application.

11.0 CONSTRUCTION PLAN REQUIREMENTS

11.1 Scope: This section governs the preparation of plans for stormwater system construction projects.

11.2 General: The plans shall include all information necessary to build and check the design of storm drainage systems. The plans shall be arranged as required by the City Engineer. Standard details of the City may be included by reference. Plans shall be sealed by a Registered Professional Engineer and shall be submitted to the City Engineer for review and approval.

11.3 Scale: Plans shall be drawn at the following minimum scales. Larger scales may be needed to clearly present the design. Bar scales shall be shown on each sheet for each scale.

Plan:	1-inch = 50 feet
Profile:	
Vertical:	1-inch = 5 feet
Horizontal:	1-inch = 50 feet
Drainage Area Map:	
On-site:	1-inch = 200 feet
Off-site:	1-inch = 1,000 feet
Structural Plans:	1/4-inch = 1 foot
Graphic Drawings:	Varies

11.4 Required Information:

All construction plans shall show storm system plan and provile on the same sheet. The profile limits must match the plan limits on each sheet. All construction notes referencing the drainage system must be provided on the storm system plan and profile sheets.

A. Drainage Area Map: A drainage area map shall be included and shall indicate the following:

1. Ridge line of the area tributary to each principal element of the system.
2. The area in acres.
3. The runoff coefficient "C" or curve number "CN" for each area, as applicable.
4. Existing contours, proposed contours, proposed streets, property lines, and easements.
5. Drainage areas must be identified for each point of discharge to the drainage system.
6. Drainage areas must be labeled with the receiving structure number.
7. Calculations are not necessary on the drainage area map.

B. Plan View: All designed storm drainage systems shall be drawn in plan view and shall contain the following:

1. North arrow and bar scale.
2. Ties to permanent reference points for each system located outside of the street right-of-way.
3. Identification and location of each pipe, culvert, inlet, structure, and existing utility affecting construction.
4. Right-of-way, property, and drainage easement lines.
5. Existing man-made and natural topographic features, such as buildings, fences, trees, channels, ponds, streams, etc., and all existing and proposed utilities.
6. Location of test borings.
7. Existing and finish grade contours at intervals of 2.0 feet or less in elevation or equivalent detail indicating existing and finish grades and slopes.
8. A uniform set of symbols subject to approval by the City Engineer.
9. The centerline of open channels within 50 feet of an enclosed drainage system and showing the direction of flow.

C. Profile View: All designed storm drainage systems shall be drawn in profile view and shall contain the following:

1. Existing and finish surface grade along the centerline of pipe except street centerline may be used when construction includes street construction.
2. Length, size and slope of each line or channel segment. Slope shall be expressed in percent.
3. Headwater elevation at the inlet end of each culvert.
4. Flow line (invert elevation in and out) at each structure.
5. Each existing utility line crossing the alignment shall be properly located and identified as to type, size and material.
6. Test borings.
7. All station and invert elevations of manholes, junction boxes, inlets or other structures.
8. The profile shall show existing grade above the centerline as a dashed line and proposed finish grades or established street grades by solid lines. It shall also show the flow line of any drainage channel, either improved or unimproved, within 50 feet on either side of the centerline. Each line shall be properly identified. The proposed storm sewer shall be shown as double solid lines properly showing the top of the pipe.
9. All manholes, inlets or other structures shall be shown and labeled with appropriate "Standard Drawing" designation.
10. Hydraulic Grade Lines for the design storm

D. Design Information: The plans shall present design information for each culvert, structure, facility, pipe and channel segment and shall contain the following:

1. Tributary area in acres.
2. Design discharge and capacity in cubic feet per second, Q10 and Q100 peak.
3. Runoff coefficient "C" or curve number "CN", design storm return frequency, rainfall intensity (when Rational method is used for design) and Manning's "n" value.
4. Discharge velocity at design flows
5. Hydraulic grade line.
6. Type and grade of material (gage, class, etc.)
7. Assumed Tailwater Elevation
8. Assumed entrance loss coefficient Ke
9. Pipe roughness n
10. Headwater elevations for Q10 and Q100
11. Lowest elevation for roadway overtopping h road

Size, slope, and material of pipes must be listed in construction notes
Substitute Q50 for Q10 where 50-year minimum design is required.

Insert the following tables near each pipe, channel, conduit, or inlet:

Pipes/Conduits

Pipes	PIPE data		Unit
pipe name	ID	P1	
drainage area	DA	0.00	ac
Composite C	C	0.0	
Time of Concentration for DA	Tc	0.0	m
10 yr peak flow (minimum design)	Q10	0.0	cfs
100-yr peak flow (must be within R/W or D/E)	Q10	0.0	cfs
pipe roughness	n	0.00	
pipe full capacity	Qfull	0.0	cfs
actual velocity for Q10	V10	0.0	fps
actual velocity for Q1 (3 fps mini or pipe slope	V1	0.0	fps

size, slope, and material optional

Overflow Channel

	OVERFLOW CHANNEL		Units
channel name	CH	CO1	
total 100 yr bypass	Q100	0.0	cfs
depth for Q100 (verify D/E width)	n	0.000	
	d100	0.0	ft

cross section slope, and lining material must be listed in construction notes

Curb Inlet

Inlet Name	name	I1	
Total Drainage Area to inlet	DA	0.0	ac
Composite C for total DA	C	0.00	
Ti for total DA to inlet	Ti	0.0	m
10-year peak to inlet (add bypass from	Q10	0.0	cfs
100-year peak to inlet (add bypass from	Q100	0.0	cfs
allowable 10-year street flow for road	R10	0.0	cfs
allowable 100-year street flow for road	R100	0.0	cfs
road slope or zero for sump	s road	0.00	ft/
inlet length	L	0.0	ft
inlet capacity with 10-year gutter spread	Qi10	0.0	cfs
inlet capacity with 100-year gutter spread	Qi100	0.0	cfs
bypass flow from Q10	B10	0.0	cfs
bypass flow from Q100	B100	0.0	cfs

Field Inlet

Inlet Name		I1	
Total Drainage Area to inlet	DA	0.0	ac
Composite C for total DA	C	0.000	
Ti for total DA to inlet	Ti	0.0	m
10-year peak to inlet (add bypass from	Q10	0.0	cfs
100-year peak to inlet (add bypass from	Q100	0.0	cfs
inlet length	L	0.0	ft
inlet capacity	Qi10	0.0	cfs
bypass flow from Q100	B100	0.0	cfs

Open Channel

		name	
Total Drainage Area to Channel	DA	0.00	ac
Composite C for tota DA	C	0.0	
Tc for total DA to channel	Tc	0.0	m
10 year peak flow	Q10	0.0	cfs
100 year peak	Q100	0.0	cfs
channel roughness	n	0.000	
velocity for Q10 (use for lining design)	V10	0.0	fps
depth for Q10	d10	0.0	ft
depth for Q100	d100	0.0	ft

Open Channel Cross sections, slopes, and lining materials must be listed in the construction plans.

Schedules which indicate all variable dimensions and elevations covered by standards or "typical" drawings shall be shown on the plans. All design details for nonstandard structures shall be indicated on the plans. A minimum of one plan view and one sectional view shall be shown on the plans for each structure. Additional views may be required if necessary to clearly define the design. A reinforcing bar list is not required. However, the grade, type, size and location of the bars shall be clearly indicated on the plans.

12.0 POST CONSTRUCTION BEST MANAGEMENT PRACTICES

The City of Lawrence MS4 permit requires the implementation of minimum control measures that include post-construction stormwater management in new development and redevelopment projects that disturb greater than or equal to one acre, including projects less than one acre that are part of a larger common plan of development or sale, that discharge into the MS4. Beginning with the 2025 Stormwater Management Criteria development for public and private projects within the MS4 shall include Best Management Practices (BMPs) to prevent or minimize adverse water quality impacts using strategies which include a combination of structural and/or non-structural BMPs. Post construction BMPs will be inspected by the city by Municipal Services & Operations department to ensure adequate long-term operation and maintenance of BMP's by the BMP owners.

The City of Lawrence has adopted the latest version of the Mid-America Regional Council BMP manual for developments with parking in excess of required standard under city code chapter 20 Article 9 section 20-901(c):

(i) Developments that provide parking in excess of the required standards must mitigate the impacts of the increased Impervious Surface through use of storm drainage Best Management Practices (BMPs) as provided in the City's adopted BMP manual. [Mid-America Regional Council and American Public Works Association Manual for Best Management Practices for Stormwater Quality – Sept. 2003 and subsequent updates].

(ii) Beginning with this iteration of the Stormwater Management Criteria the application of BMPs using the Mid-America Regional Council and American Public Works Association Manual for Best Management Practices for Stormwater Quality – Sept. 2003 and subsequent updates shall be required for all sites requiring detention, or all sites that meet the MS4 requirement for disturbing greater than or equal to one acre, including projects that are less than one acre that are part of a larger common plan of development or sale, that discharge into the MS4.

DURATION HR:MIN	1 YR	2 YR	5 YR	10 YR	25 YR	50 YR	100 YR	200 YR	500 YR
0:05	4.71	5.60	7.06	8.26	9.91	11.18	12.45	13.74	15.43
0:06	4.36	5.18	6.52	7.63	9.16	10.33	11.51	12.69	14.26
0:07	4.07	4.84	6.09	7.13	8.56	9.66	10.75	11.86	13.33
0:08	3.83	4.56	5.74	6.72	8.06	9.09	10.13	11.17	12.55
0:09	3.63	4.32	5.43	6.36	7.63	8.61	9.59	10.58	11.88
0:10	3.45	4.10	5.17	6.05	7.26	8.19	9.12	10.06	11.30
0:11	3.29	3.91	4.92	5.76	6.91	7.80	8.69	9.58	10.77
0:12	3.15	3.74	4.71	5.51	6.61	7.46	8.31	9.16	10.30
0:13	3.02	3.59	4.52	5.29	6.34	7.16	7.97	8.79	9.88
0:14	2.91	3.45	4.35	5.09	6.11	6.89	7.67	8.47	9.51
0:15	2.81	3.34	4.20	4.92	5.90	6.66	7.41	8.18	9.18
0:16	2.73	3.24	4.08	4.78	5.74	6.47	7.20	7.94	8.92
0:17	2.66	3.16	3.98	4.66	5.59	6.30	7.01	7.73	8.68
0:18	2.59	3.08	3.88	4.55	5.45	6.15	6.84	7.54	8.46
0:19	2.53	3.01	3.80	4.44	5.33	6.01	6.68	7.37	8.26
0:20	2.47	2.95	3.72	4.35	5.22	5.88	6.54	7.20	8.08
0:21	2.42	2.88	3.64	4.26	5.11	5.76	6.40	7.05	7.90
0:22	2.37	2.83	3.57	4.18	5.01	5.64	6.27	6.91	7.74
0:23	2.32	2.77	3.50	4.10	4.91	5.53	6.15	6.77	7.59
0:24	2.28	2.72	3.43	4.02	4.82	5.43	6.04	6.65	7.44
0:25	2.24	2.67	3.37	3.95	4.73	5.33	5.93	6.52	7.30
0:26	2.19	2.62	3.31	3.87	4.65	5.24	5.82	6.41	7.17
0:27	2.15	2.57	3.25	3.81	4.56	5.14	5.72	6.29	7.05
0:28	2.11	2.53	3.19	3.74	4.49	5.05	5.62	6.19	6.93
0:29	2.08	2.48	3.14	3.67	4.41	4.97	5.52	6.08	6.81
0:30	2.04	2.44	3.08	3.61	4.33	4.88	5.43	5.98	6.70
0:31	2.01	2.40	3.03	3.55	4.27	4.81	5.35	5.89	6.59
0:32	1.98	2.36	2.99	3.50	4.20	4.73	5.27	5.80	6.50
0:33	1.94	2.32	2.94	3.44	4.14	4.66	5.19	5.71	6.40
0:34	1.91	2.29	2.89	3.39	4.07	4.59	5.11	5.63	6.31
0:35	1.88	2.25	2.85	3.34	4.01	4.52	5.03	5.55	6.22
0:36	1.85	2.22	2.80	3.29	3.95	4.46	4.96	5.47	6.13
0:37	1.83	2.18	2.76	3.24	3.89	4.39	4.89	5.39	6.05
0:38	1.80	2.15	2.72	3.19	3.84	4.33	4.82	5.31	5.96
0:39	1.77	2.12	2.68	3.15	3.78	4.27	4.75	5.24	5.88
0:40	1.75	2.09	2.64	3.10	3.73	4.21	4.69	5.17	5.80
0:41	1.72	2.06	2.60	3.06	3.67	4.15	4.62	5.10	5.73
0:42	1.70	2.03	2.57	3.01	3.62	4.09	4.56	5.03	5.65
0:43	1.67	2.00	2.53	2.97	3.57	4.04	4.50	4.97	5.58

City of Lawrence

STORMWATER MANAGEMENT DESIGN CRITERIA
RAINFALL INTENSITY (inches/hour)
TABLE A-1

CITY OF LAWRENCE, DOUGLAS COUNTY, KANSAS

DURATION HR:MIN	1 YR	2 YR	5 YR	10 YR	25 YR	50 YR	100 YR	200 YR	500 YR
0:44	1.65	1.97	2.49	2.93	3.52	3.98	4.44	4.90	5.51
0:45	1.63	1.94	2.46	2.89	3.48	3.93	4.38	4.84	5.44
0:46	1.60	1.92	2.43	2.85	3.43	3.88	4.32	4.78	5.37
0:47	1.58	1.89	2.39	2.81	3.39	3.83	4.27	4.72	5.31
0:48	1.56	1.86	2.36	2.77	3.34	3.78	4.21	4.66	5.24
0:49	1.54	1.84	2.33	2.74	3.30	3.73	4.16	4.60	5.18
0:50	1.52	1.82	2.30	2.70	3.26	3.68	4.11	4.54	5.12
0:51	1.50	1.79	2.27	2.67	3.22	3.64	4.06	4.49	5.06
0:52	1.48	1.77	2.24	2.63	3.18	3.59	4.01	4.44	5.00
0:53	1.46	1.75	2.21	2.60	3.14	3.55	3.96	4.38	4.94
0:54	1.44	1.73	2.19	2.57	3.10	3.51	3.92	4.33	4.88
0:55	1.43	1.70	2.16	2.54	3.06	3.46	3.87	4.28	4.83
0:56	1.41	1.68	2.13	2.51	3.02	3.42	3.83	4.23	4.78
0:57	1.39	1.66	2.11	2.48	2.99	3.38	3.78	4.19	4.72
0:58	1.38	1.64	2.08	2.45	2.95	3.35	3.74	4.14	4.67
0:59	1.36	1.62	2.06	2.42	2.92	3.31	3.70	4.09	4.62
1:00	1.34	1.61	2.03	2.39	2.89	3.27	3.66	4.05	4.57
1:05	1.28	1.53	1.93	2.27	2.75	3.11	3.48	3.86	4.36
1:10	1.22	1.45	1.84	2.17	2.62	2.97	3.32	3.68	4.16
1:15	1.16	1.39	1.76	2.07	2.50	2.84	3.18	3.52	3.98
1:20	1.11	1.33	1.69	1.98	2.40	2.72	3.04	3.38	3.82
1:25	1.07	1.28	1.62	1.90	2.30	2.61	2.92	3.24	3.67
1:30	1.03	1.23	1.55	1.83	2.21	2.51	2.81	3.12	3.53
1:35	0.99	1.18	1.50	1.76	2.13	2.42	2.71	3.01	3.40
1:40	0.95	1.14	1.44	1.70	2.05	2.33	2.61	2.90	3.29
1:45	0.92	1.10	1.39	1.64	1.98	2.25	2.53	2.80	3.18
1:50	0.89	1.06	1.35	1.59	1.92	2.18	2.44	2.71	3.08
1:55	0.86	1.03	1.30	1.54	1.86	2.11	2.37	2.63	2.98
2:00	0.83	1.00	1.26	1.49	1.80	2.05	2.30	2.55	2.90
2:05	0.81	0.97	1.23	1.45	1.75	1.99	2.24	2.49	2.82
2:10	0.79	0.94	1.19	1.41	1.70	1.94	2.18	2.42	2.75
2:15	0.77	0.92	1.16	1.37	1.66	1.89	2.12	2.36	2.68
2:20	0.75	0.89	1.13	1.33	1.62	1.84	2.07	2.30	2.62
2:25	0.73	0.87	1.10	1.30	1.58	1.80	2.02	2.25	2.56
2:30	0.71	0.85	1.08	1.27	1.54	1.75	1.97	2.20	2.50
2:35	0.69	0.83	1.05	1.24	1.50	1.71	1.93	2.15	2.45
2:40	0.68	0.81	1.03	1.21	1.47	1.68	1.89	2.10	2.40
2:45	0.66	0.79	1.00	1.18	1.44	1.64	1.85	2.06	2.35
2:50	0.65	0.77	0.98	1.16	1.41	1.61	1.81	2.02	2.30
2:55	0.64	0.76	0.96	1.13	1.38	1.57	1.77	1.98	2.26

City of Lawrence

STORMWATER MANAGEMENT DESIGN CRITERIA
RAINFALL INTENSITY (inches/hour)
TABLE A-2

CITY OF LAWRENCE, DOUGLAS COUNTY, KANSAS

DURATION HR:MIN	1 YR	2 YR	5 YR	10 YR	25 YR	50 YR	100 YR	200 YR	500 YR
3:00	0.62	0.74	0.94	1.11	1.35	1.54	1.74	1.94	2.21
3:15	0.59	0.70	0.89	1.05	1.28	1.46	1.64	1.83	2.10
3:30	0.56	0.66	0.84	0.99	1.21	1.38	1.56	1.74	1.99
3:45	0.53	0.63	0.80	0.94	1.15	1.31	1.48	1.66	1.90
4:00	0.50	0.60	0.76	0.90	1.10	1.25	1.41	1.58	1.82
4:15	0.48	0.57	0.73	0.86	1.05	1.20	1.35	1.52	1.74
4:30	0.46	0.55	0.70	0.82	1.00	1.15	1.30	1.45	1.67
4:45	0.44	0.53	0.67	0.79	0.96	1.10	1.25	1.40	1.60
5:00	0.43	0.51	0.64	0.76	0.93	1.06	1.20	1.34	1.54
5:15	0.41	0.49	0.62	0.73	0.89	1.02	1.15	1.29	1.49
5:30	0.40	0.47	0.60	0.70	0.86	0.98	1.11	1.25	1.43
5:45	0.38	0.45	0.58	0.68	0.83	0.95	1.08	1.21	1.39
6:00	0.37	0.44	0.56	0.66	0.80	0.92	1.04	1.17	1.34
6:30	0.35	0.41	0.52	0.62	0.76	0.87	0.98	1.10	1.26
7:00	0.33	0.39	0.49	0.59	0.71	0.82	0.93	1.04	1.20
7:30	0.31	0.37	0.47	0.55	0.68	0.78	0.88	0.99	1.13
8:00	0.30	0.35	0.45	0.53	0.64	0.74	0.84	0.94	1.08
8:30	0.28	0.34	0.43	0.50	0.61	0.70	0.80	0.89	1.03
9:00	0.27	0.32	0.41	0.48	0.59	0.67	0.76	0.85	0.98
9:30	0.26	0.31	0.39	0.46	0.56	0.64	0.73	0.82	0.94
10:00	0.25	0.30	0.37	0.44	0.54	0.62	0.70	0.78	0.90
10:30	0.24	0.28	0.36	0.43	0.52	0.59	0.67	0.75	0.87
11:00	0.23	0.27	0.35	0.41	0.50	0.57	0.65	0.73	0.83
11:30	0.22	0.26	0.33	0.39	0.48	0.55	0.62	0.70	0.80
12:00	0.22	0.26	0.32	0.38	0.47	0.53	0.60	0.67	0.77
13:00	0.20	0.24	0.30	0.36	0.44	0.50	0.56	0.63	0.73
14:00	0.19	0.23	0.29	0.34	0.41	0.47	0.53	0.59	0.68
15:00	0.18	0.21	0.27	0.32	0.39	0.44	0.50	0.56	0.64
16:00	0.17	0.20	0.26	0.30	0.37	0.42	0.47	0.53	0.61
17:00	0.16	0.19	0.24	0.29	0.35	0.40	0.45	0.50	0.58
18:00	0.16	0.19	0.23	0.27	0.33	0.38	0.43	0.48	0.55
19:00	0.15	0.18	0.22	0.26	0.32	0.36	0.41	0.46	0.53
20:00	0.14	0.17	0.21	0.25	0.30	0.35	0.39	0.44	0.50
21:00	0.14	0.16	0.21	0.24	0.29	0.33	0.38	0.42	0.48
22:00	0.13	0.16	0.20	0.23	0.28	0.32	0.36	0.40	0.46
23:00	0.13	0.15	0.19	0.22	0.27	0.31	0.35	0.39	0.45
24:00	0.13	0.15	0.18	0.22	0.26	0.30	0.34	0.38	0.43

City of Lawrence

STORMWATER MANAGEMENT DESIGN CRITERIA
RAINFALL INTENSITY (inches/hour)
TABLE A-3

CITY OF LAWRENCE, DOUGLAS COUNTY, KANSAS

LAND USE	PROPORTIONAL SURFACE CONDITION IMPERV.	TURF OR =	SCS CURVE NUMBER	RATIONAL METHOD "C"
Residential Low-Medium Density (Single Family & Duplex)	0.35	0.65	82	0.51
Residential Medium-High Density (6 or fewer D.U. per bldg. and mobile home parks)	0.50	0.50	86	0.60
Residential High Density (Over 6 D.U. per bldg.)	0.60	0.40	88	0.66
Commercial/Business	0.90	0.10	96	0.84
Industrial	0.70	0.30	91	0.72
Public/Semi-Public (Schools, Gov't., Churches, Institutional)	0.50	0.50	86	0.60
Open Space including parks, cemeteries, etc.	0.10	0.90	75	0.36
Agricultural				
Existing Use	0.05	0.95	75	0.36
Future Use	0.40	0.60	83	0.54
All Land Uses:				
100% Impervious Surfaces			98	0.90
100% Pervious Surfaces (With maintained turf cover or =)			73	0.30

Note: Coefficients developed for SCS Hydrologic Class B-C, soils typical of predominant Lawrence surficial soils.

FLOW LENGTH (FEET)	SHALLOW CONCENTRATED FLOW TIME IN MINUTES										
	PAVED SURFACE SLOPE IN PERCENT										
	0.5	**1.0**	**2.0**	**3.0**	**4.0**	**5.0**	**6.0**	**7.0**	**8.0**	**9.0**	**10.0**
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.23	0.16	0.12	0.09	0.08	0.07	0.07	0.06	0.06	0.05	0.05
40	0.46	0.33	0.23	0.19	0.16	0.15	0.13	0.12	0.12	0.11	0.10
60	0.70	0.49	0.35	0.28	0.25	0.22	0.20	0.19	0.17	0.16	0.16
80	0.93	0.66	0.46	0.38	0.33	0.29	0.27	0.25	0.23	0.22	0.21
100	1.16	0.82	0.58	0.47	0.41	0.37	0.33	0.31	0.29	0.27	0.26
120	1.39	0.98	0.70	0.57	0.49	0.44	0.40	0.37	0.35	0.33	0.31
140	1.62	1.15	0.81	0.66	0.57	0.51	0.47	0.43	0.41	0.38	0.36
160	1.86	1.31	0.93	0.76	0.66	0.59	0.54	0.50	0.46	0.44	0.41
180	2.09	1.48	1.04	0.85	0.74	0.66	0.60	0.56	0.52	0.49	0.47
200	2.32	1.64	1.16	0.95	0.82	0.73	0.67	0.62	0.58	0.55	0.52
220	2.55	1.80	1.28	1.04	0.90	0.81	0.74	0.68	0.64	0.60	0.57
240	2.78	1.97	1.39	1.14	0.98	0.88	0.80	0.74	0.70	0.66	0.62
260	3.01	2.13	1.51	1.23	1.07	0.95	0.87	0.81	0.75	0.71	0.67
280	3.25	2.30	1.62	1.33	1.15	1.03	0.94	0.87	0.81	0.77	0.73
300	3.48	2.46	1.74	1.42	1.23	1.10	1.00	0.93	0.87	0.82	0.78
320	3.71	2.62	1.86	1.51	1.31	1.17	1.07	0.99	0.93	0.87	0.83
340	3.94	2.79	1.97	1.61	1.39	1.25	1.14	1.05	0.99	0.93	0.88
360	4.17	2.95	2.09	1.70	1.48	1.32	1.20	1.12	1.04	0.98	0.93
380	4.41	3.12	2.20	1.80	1.56	1.39	1.27	1.18	1.10	1.04	0.99
400	4.64	3.28	2.32	1.89	1.64	1.47	1.34	1.24	1.16	1.09	1.04

Flow is channelized after un-concentrated length exceeds 400 ft.

FLOW LENGTH (FEET)	SHALLOW CONCENTRATED FLOW TIME IN MINUTES										
	UNPAVED SURFACE SLOPE IN PERCENT										
	0.5	**1.0**	**2.0**	**3.0**	**4.0**	**5.0**	**6.0**	**7.0**	**8.0**	**9.0**	**10.0**
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.29	0.21	0.15	0.12	0.10	0.09	0.08	0.08	0.07	0.07	0.07
40	0.58	0.41	0.29	0.24	0.21	0.18	0.17	0.16	0.15	0.14	0.13
60	0.88	0.62	0.44	0.36	0.31	0.28	0.25	0.23	0.22	0.21	0.20
80	1.17	0.83	0.58	0.48	0.41	0.37	0.34	0.31	0.29	0.28	0.26
100	1.46	1.03	0.73	0.60	0.52	0.46	0.42	0.39	0.37	0.34	0.33
120	1.75	1.24	0.88	0.72	0.62	0.55	0.51	0.47	0.44	0.41	0.39
140	2.05	1.45	1.02	0.83	0.72	0.65	0.59	0.55	0.51	0.48	0.46
160	2.34	1.65	1.17	0.95	0.83	0.74	0.67	0.62	0.58	0.55	0.52
180	2.63	1.86	1.31	1.07	0.93	0.83	0.76	0.70	0.66	0.62	0.59
200	2.92	2.07	1.46	1.19	1.03	0.92	0.84	0.78	0.73	0.69	0.65
220	3.21	2.27	1.61	1.31	1.14	1.02	0.93	0.86	0.80	0.76	0.72
240	3.51	2.48	1.75	1.43	1.24	1.11	1.01	0.94	0.88	0.83	0.78
260	3.80	2.69	1.90	1.55	1.34	1.20	1.10	1.02	0.95	0.90	0.85
280	4.09	2.89	2.05	1.67	1.45	1.29	1.18	1.09	1.02	0.96	0.91
300	4.38	3.10	2.19	1.79	1.55	1.39	1.27	1.17	1.10	1.03	0.98
320	4.67	3.31	2.34	1.91	1.65	1.48	1.35	1.25	1.17	1.10	1.05
340	4.97	3.51	2.48	2.03	1.76	1.57	1.43	1.33	1.24	1.17	1.11
360	5.26	3.72	2.63	2.15	1.86	1.66	1.52	1.41	1.31	1.24	1.18
380	5.55	3.93	2.78	2.27	1.96	1.76	1.60	1.48	1.39	1.31	1.24
400	5.84	4.13	2.92	2.39	2.07	1.85	1.69	1.56	1.46	1.38	1.31

Flow is channelized after un-concentrated length exceeds 400 ft.

TYPE OF CHANNEL	n
Closed Conduits	
Reinforced Concrete Pipe	0.013
Reinforced Concrete Elliptical Pipe	0.013
Corrugated Metal Pipe:	
2-2/3 x 1/2 in Annular Corrugations unpaved – plain	0.024
2-2/3 x 1/2 in Annular Corrugations paved invert	0.021
3 x 1 in Annular Corrugations unpaved – plain	0.027
3 x 1 in Annular Corrugations paved invert	0.023
6 x 2 in Corrugations unpaved – plain	0.033
6 x 2 Corrugations paved invert	0.028
Vitrified Clay Pipe	0.013
Asbestos Cement Pipe	0.012
Open channels (Lined)	
Gabions	0.025
Concrete	
Trowel Finish	0.013
Float Finish	0.015
Unfinished	0.017
Concrete, bottom float finished, with sides of	
Dressed Stone	0.017
Random Stone	0.020
Cement Rubble Masonry	0.025
Dry Rubble or Riprap	0.030
Gravel bottom, side of	
Random Stone	0.023
Riprap	0.030
Grass (Sod)	0.035
Open Channels (Unlimited) Excavated or Dredged	
Earth, straight and uniform	0.027
Earth, winding and sluggish	0.035
Natural stream	
Clean stream, straight	0.030
Stream with pools, sluggish reaches, heavy underbrush	0.100
Flood Plains	
Grass, no brush	0.030
With some brush	0.090
Street Curbing	0.014

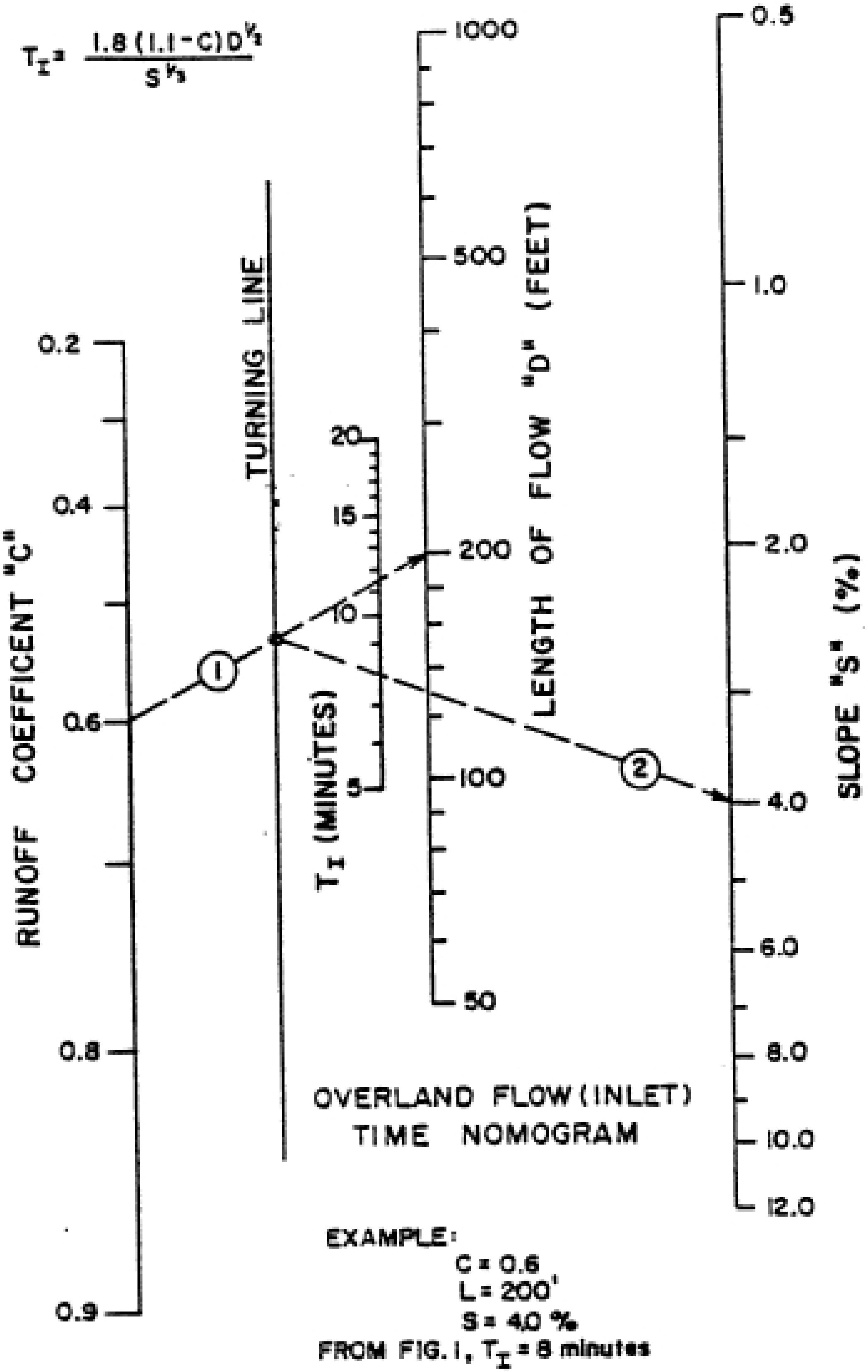
Conditions	k
Manhole, junction boxes and inlets with shaped inverts	
Thru Flow	0.15
Junction	0.40
Contraction Transition	0.10
Expansion Transition	0.20
90 degree bend	0.40
45 degree and less bends	0.30
Culvert outlet	1.00
Culvert inlets:	
Pipe, Concrete	
Projecting from fill, socket end (grooved end)	0.20
Projecting from fill, square cut end	0.50
Headwall or headwall and wingwalls	
Socket end of pipe (grooved end)	0.20
Square edge	0.50
Round (radius = 1/12 D)	0.20
Mitered to conform to fill slope	0.70
Standard end section	0.50
Beveled edges, 33.7° or 45° bevels	0.20
Side-or-slope-tapered inlet	0.20
Pipe, or Pipe-Arch, corrugated Metal	
Projecting from till (not headwall)	0.90
Headwall or headwall and wingwalls square edge	0.50
Mitered to conform to till slope, paved or unpaved slope	0.70
Standard end section	0.50
Beveled edges, 33.7° or 45° bevels	0.20
Side-or-slope-tapered inlet	0.20
Box Reinforced Concrete	
Headwall parallel to embankment (no wingwalls)	
Square edge on 3 edges	0.50
Rounded on 3 edges to radius of 1/12 barrel dimension, or beveled edges on 3 sides	0.20
Wingwalls at 30° to 75° to barrel	
Square edged at crown	0.40
Crown edge rounded to radius of 1/12 barrel dimension, or beveled top edge	0.20
Wingwall at 10° to 25° to barrel	
Square edged at crown	0.50
Wingwalls parallel (extension of sides)	
Square edged at crown	0.70
Side-or-slope-tapered inlet	0.20

GUTTER SLOPE (%)	GUTTER CAPACITY (CFS)	CURB INLET DESIGN CAPACITY (CFS) INLET LENGTH					
		5 FT	6 FT	7 FT	8 FT	10 FT	12 FT
FOR 10.5 FT. GUTTER SPREAD							
0.5	2.1	G	G	G	G	G	G
1	2.9	G	G	G	G	G	G
2	4.2	G	G	G	G	G	G
3	5.2	G	G	G	G	G	G
4	5.9	G	G	G	G	G	G
6	7.3	6.8	G	G	G	G	G
8	8.3	6.8	7.6	G	G	G	G
10	9.3	6.5	7.3	8.0	8.6	G	G
12	11.0	6.2	7.1	7.8	8.4	9.5	10.2
FOR 11.5 FT. GUTTER SPREAD							
0.5	2.7	G	G	G	G	G	G
1	3.7	G	G	G	G	G	G
2	5.2	G	G	G	G	G	G
3	6.5	G	G	G	G	G	G
4	7.5	G	G	G	G	G	G
6	9.2	8.1	8.7	9.0	9.1	G	G
8	10.6	8.1	9.0	10.2	10.6	G	G
10	11.8	7.7	8.7	9.5	10.3	11.6	G
12	13	7.5	8.4	9.2	9.9	11.2	12.3
FOR 12 FT. GUTTER SPREAD							
0.5	3	G	G	G	G	G	G
1	4.2	G	G	G	G	G	G
2	5.9	G	G	G	G	G	G
3	7.3	G	G	G	G	G	G
4	8.4	G	G	G	G	G	G
6	10.3	8.8	9.4	9.8	10.2	G	G
8	11.9	8.8	9.8	10.9	11.5	11.7	11.8
10	13.3	8.1	9.1	10.0	10.8	12.2	13.1
12	14.4	7.9	8.9	9.7	10.5	11.9	13.1

1. Capacities based on City's standard curb inlet configuration; 2% street crown, 80% inlet efficiency, and no deflectors.

2. "G" indicates inlet capacity is 100% of gutter capacity.

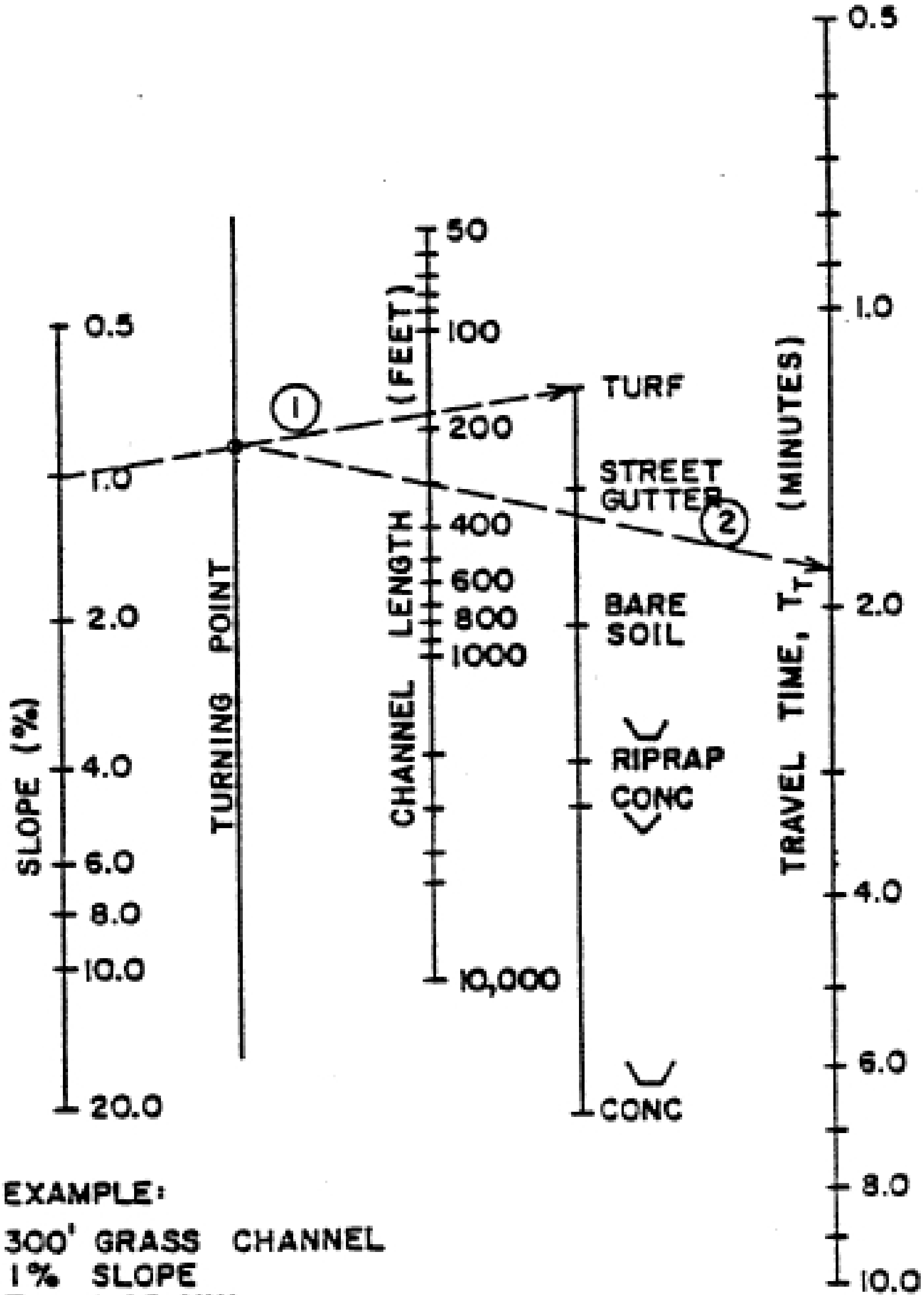
3. Interpolate linearly for slopes and capacities not shown within range of table(s).



CITY OF LAWRENCE, KANSAS
STORMWATER MANAGEMENT
DESIGN CRITERIA

OVERLAND FLOW TIME OF CONCENTRATION

FIGURE 1

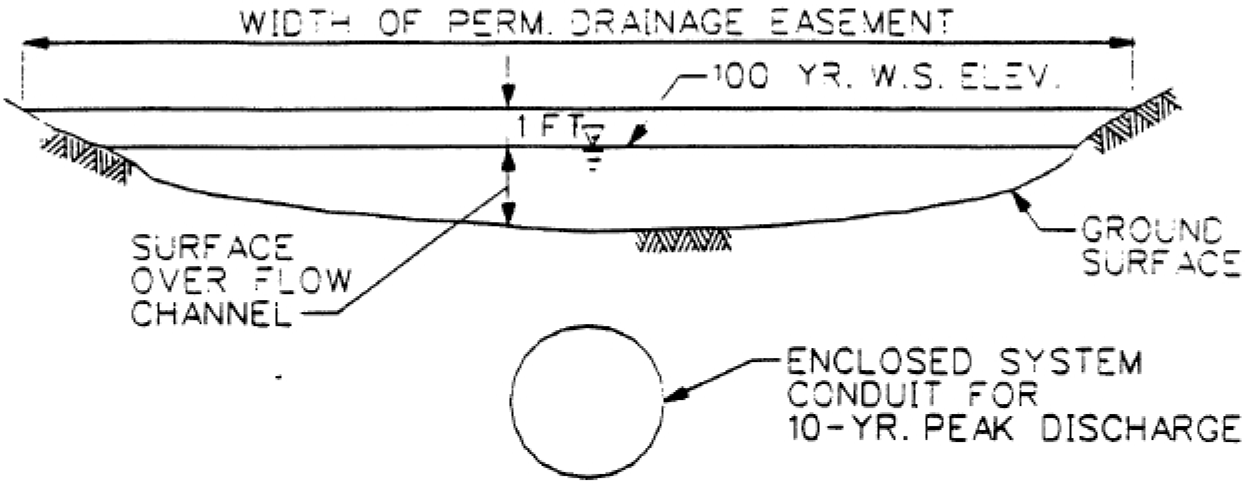


EXAMPLE:

300' GRASS CHANNEL
1% SLOPE
T_T = 1.85 MIN.

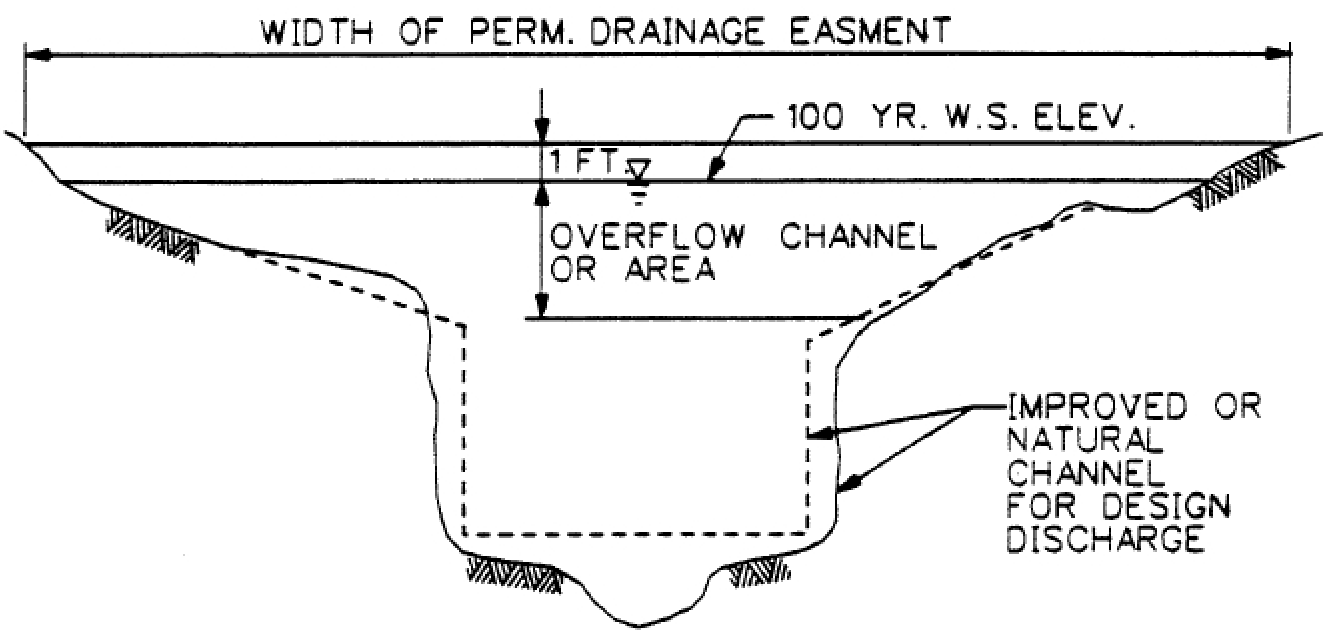
(1) Connect Slope & Channel Condition to locate point on Turning Line

(2) Extend line from Turning Line through Channel Length, Read T_T



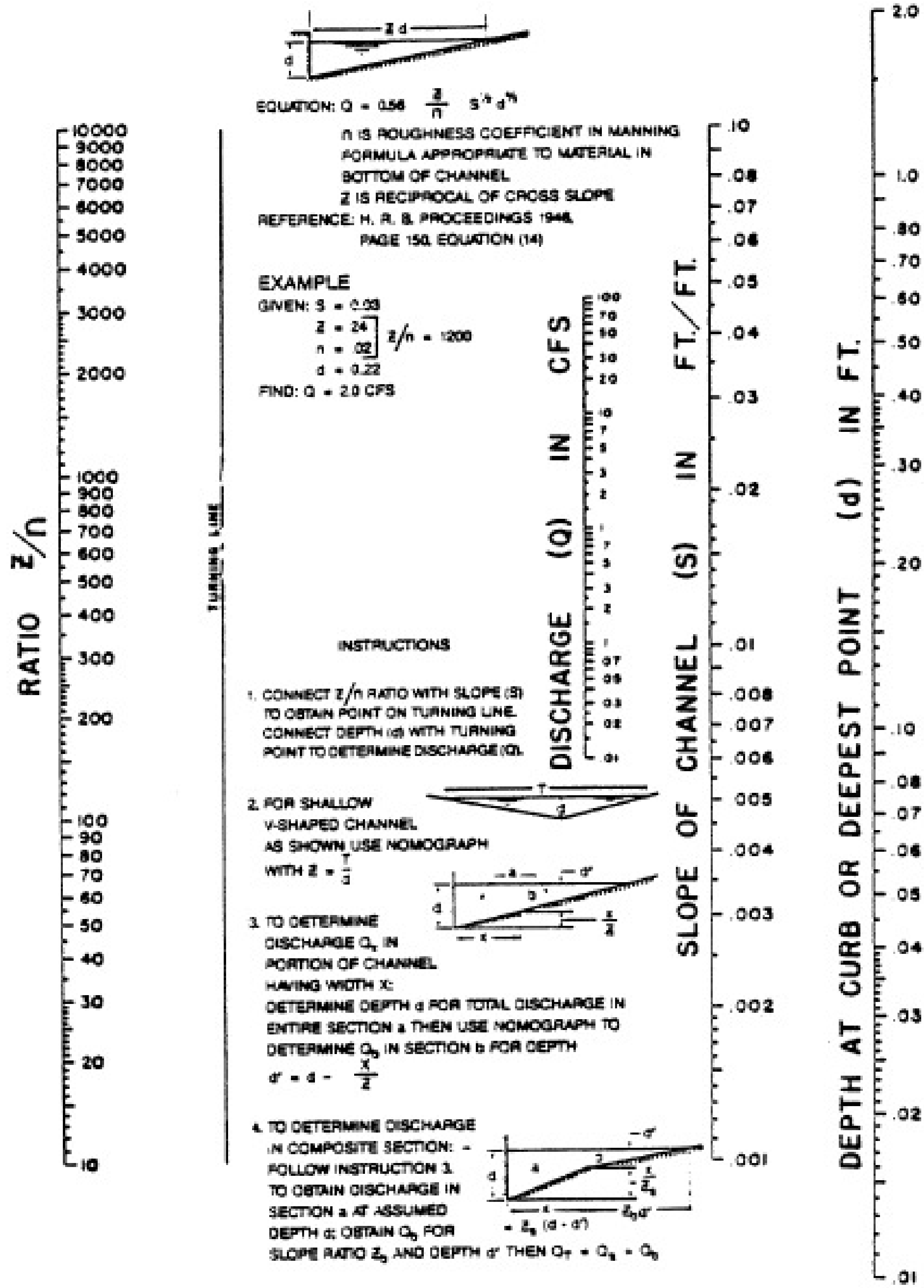
ENCLOSED SYSTEM

Not to Scale



OPEN CHANNEL

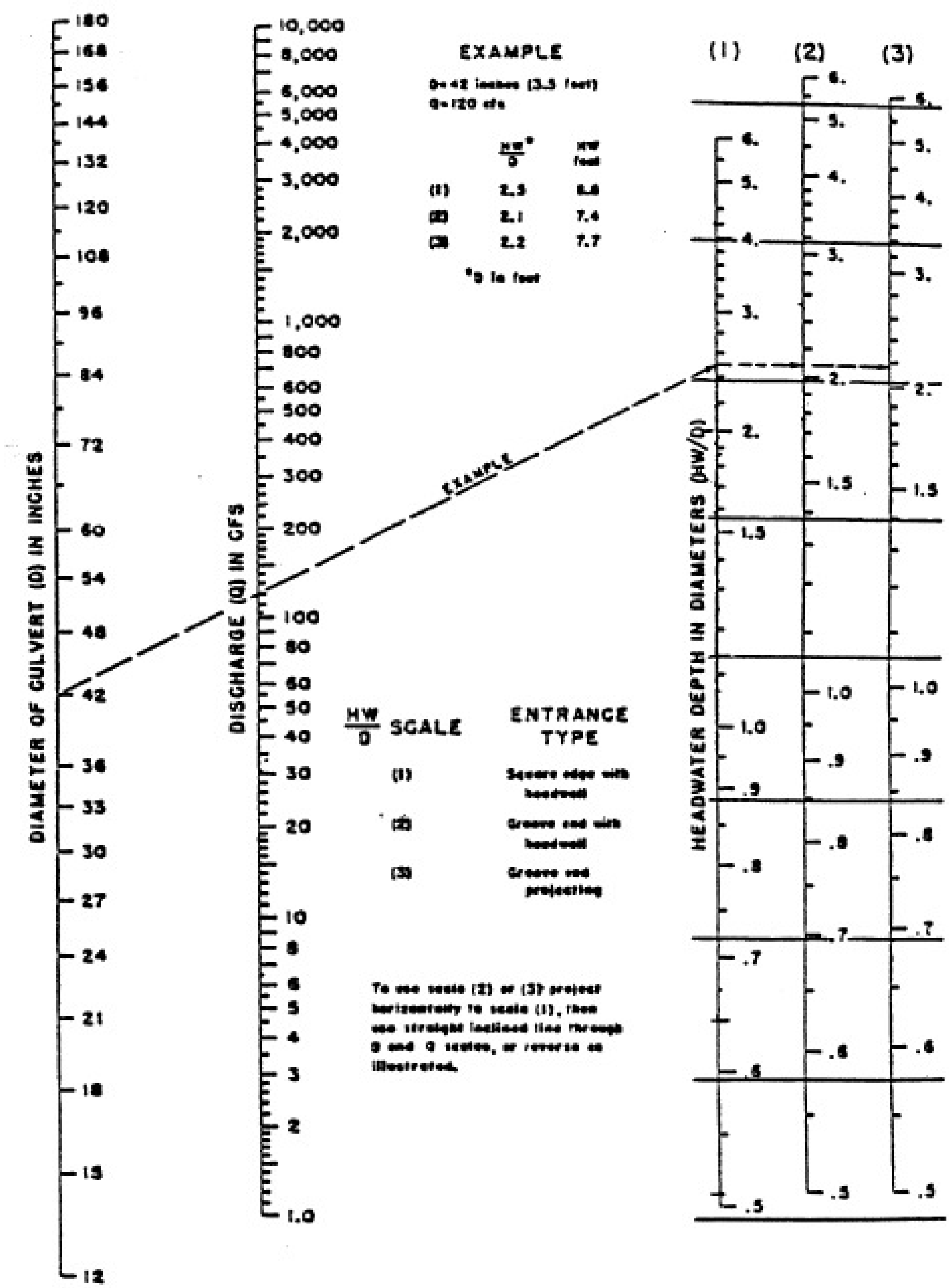
Not to Scale



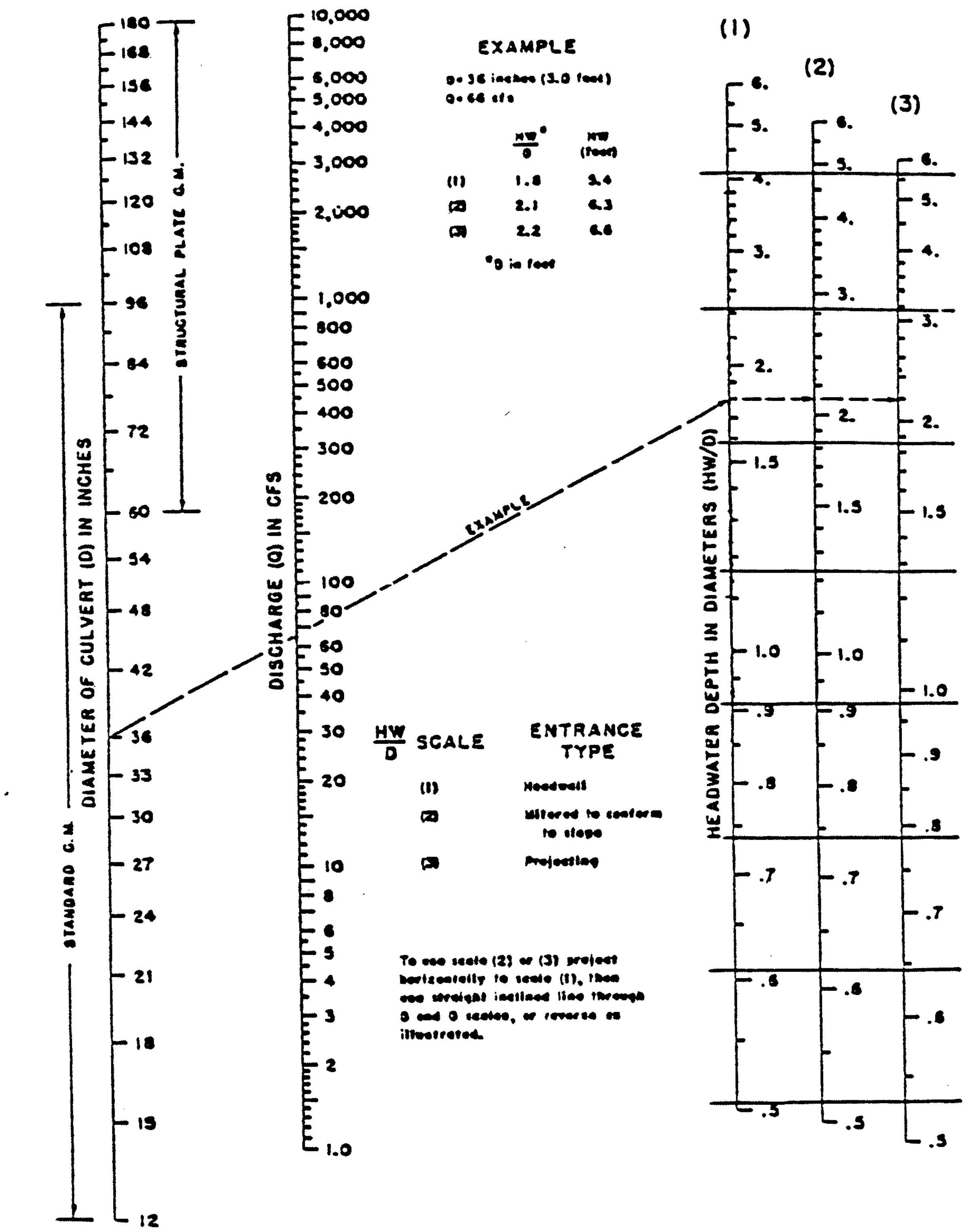
CITY OF LAWRENCE, KANSAS
STORMWATER MANAGEMENT
DESIGN CRITERIA

STREET GUTTER HYDRAULICS
(BY IZZARD'S FORMULA)

FIGURE 4



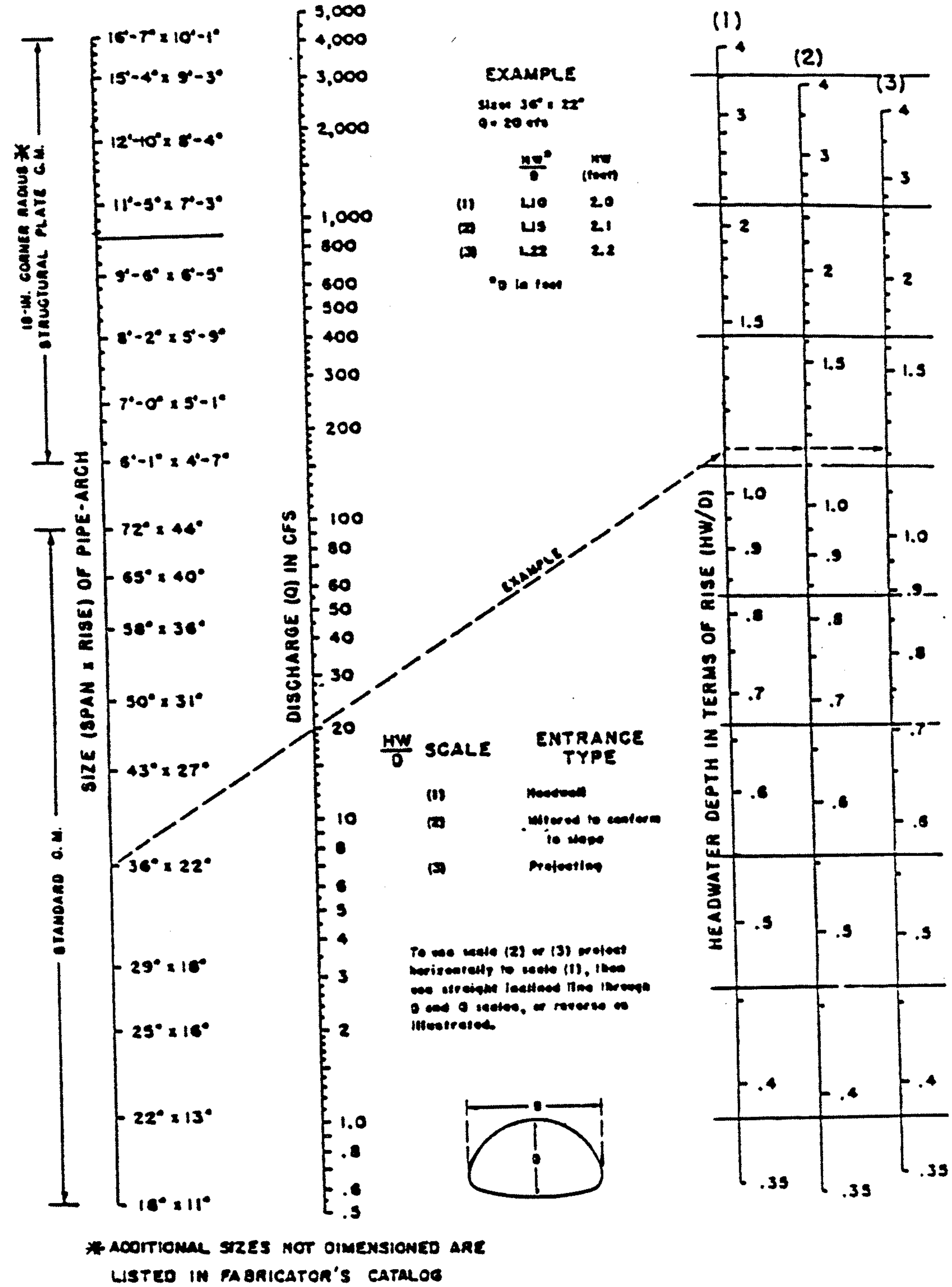
CITY OF LAWRENCE, KANSAS STORMWATER MANAGEMENT DESIGN CRITERIA	HEADWATER DEPTH FOR CONCRETE PIPE CULVERTS WITH INLET CONTROL FIGURE 5.1



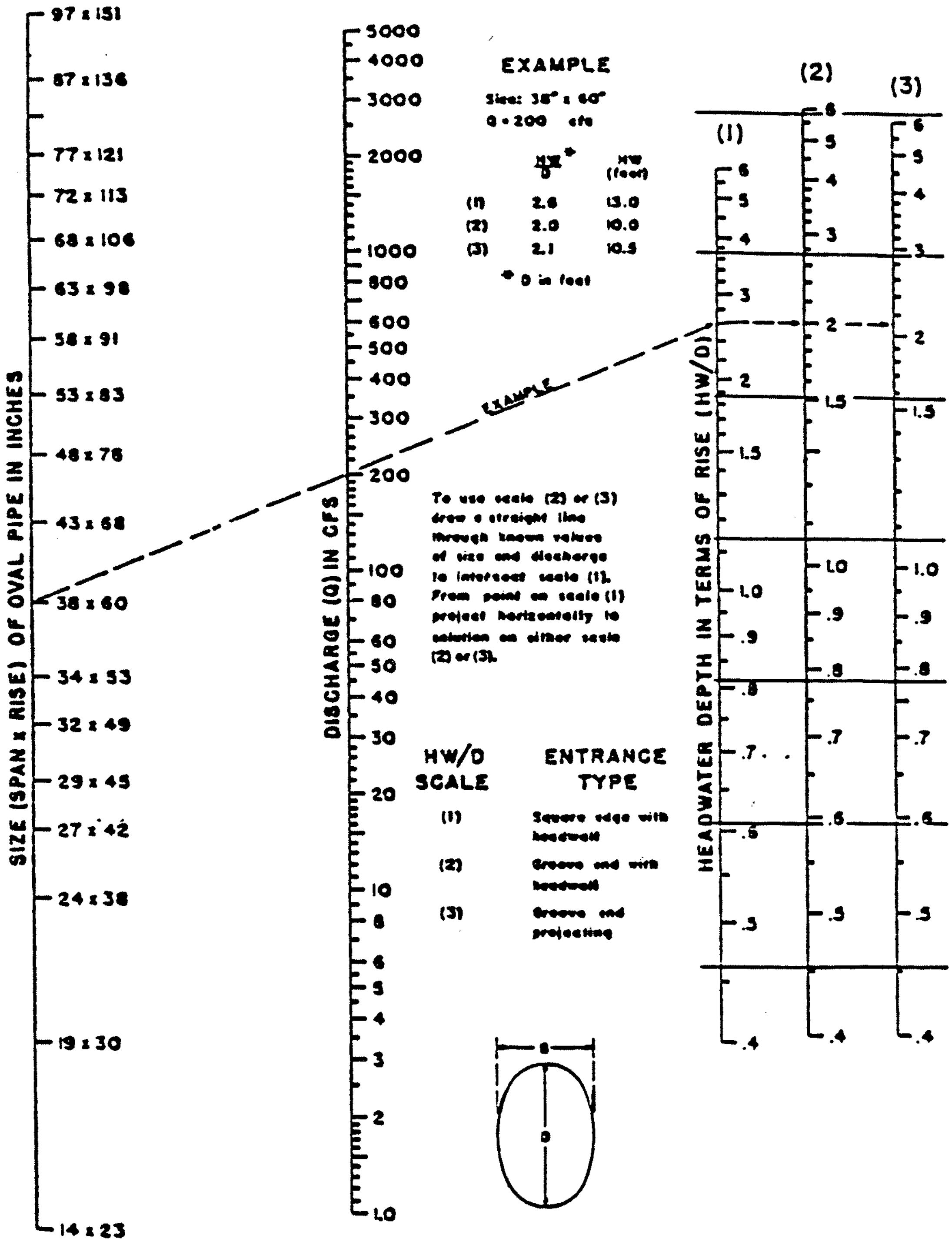
CITY OF LAWRENCE, KANSAS
STORMWATER MANAGEMENT
DESIGN CRITERIA

HEADWATER DEPTH FOR C.M. CULVERTS WITH INLET CONTROL

FIGURE 5.2



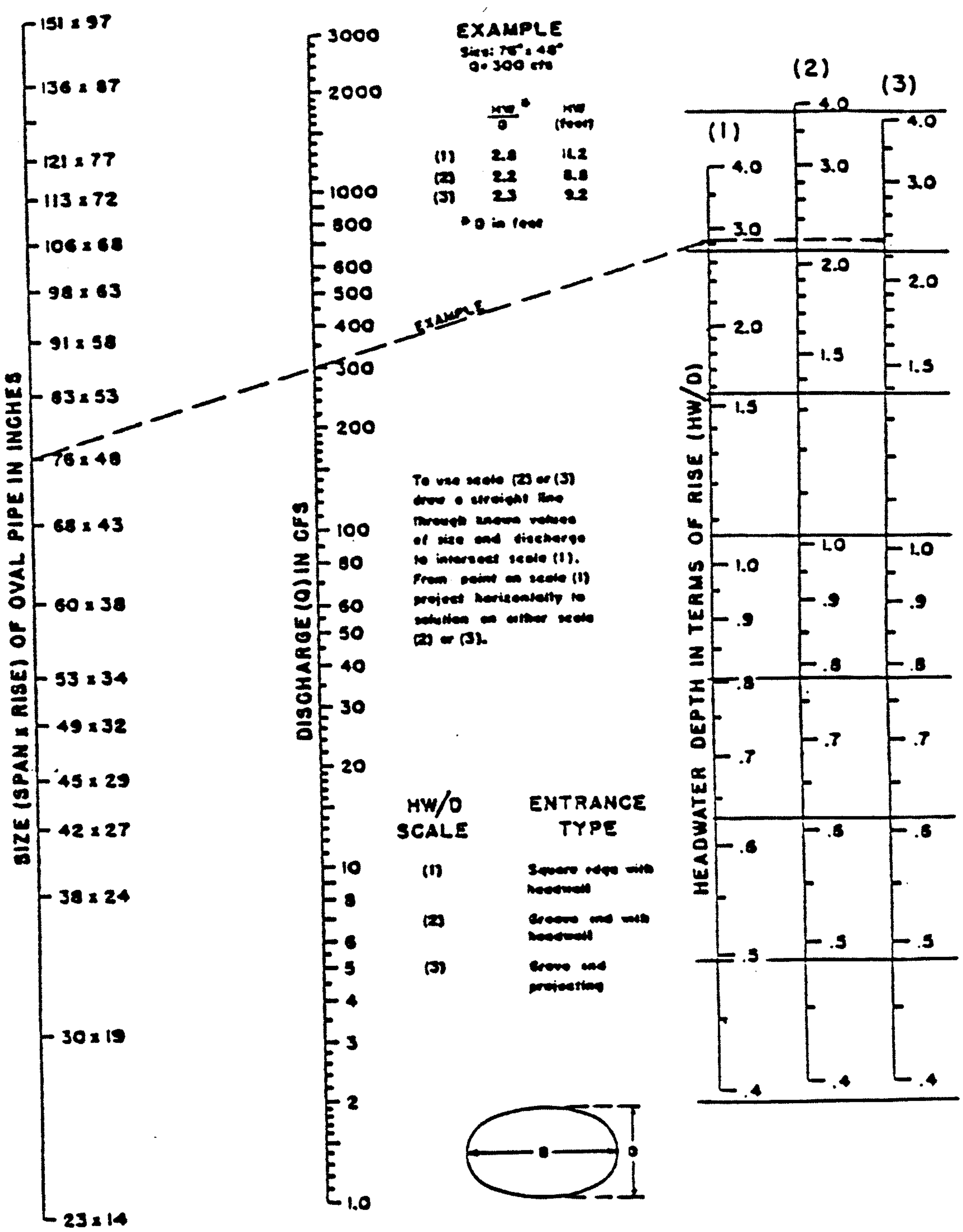
EXAMPLE
(1)
(2)
(3)
16'-7" x 10'-1"
15'-4" x 9'-3"
12'-10" x 8'-4"
11'-5" x 7'-3"
9'-6" x 6'-5"
8'-2" x 5'-9"
7'-0" x 5'-1"
6'-1" x 4'-7"
72" x 44"
65" x 40"
58" x 36"
50" x 31"
43" x 27"
36" x 22"
29" x 18"
25" x 16"
22" x 13"
18" x 11"
18-IN. CORNER RADIUS * STRUCTURAL PLATE C.M.
STANDARD C.M.
SIZE (SPAN x RISE) OF PIPE-ARCH
DISCHARGE (Q) IN CFS
HEADWATER DEPTH IN TERMS OF RISE (HW/D)
HW/D SCALE
ENTRANCE TYPE
Projecting
* ADDITIONAL SIZES NOT DIMENSIONED ARE LISTED IN FABRICATOR'S CATALOG



CITY OF LAWRENCE, KANSAS
STORMWATER MANAGEMENT
DESIGN CRITERIA

HEADWATER DEPTH FOR OVAL CONCRETE PIPE (VE) INLET CONTROL

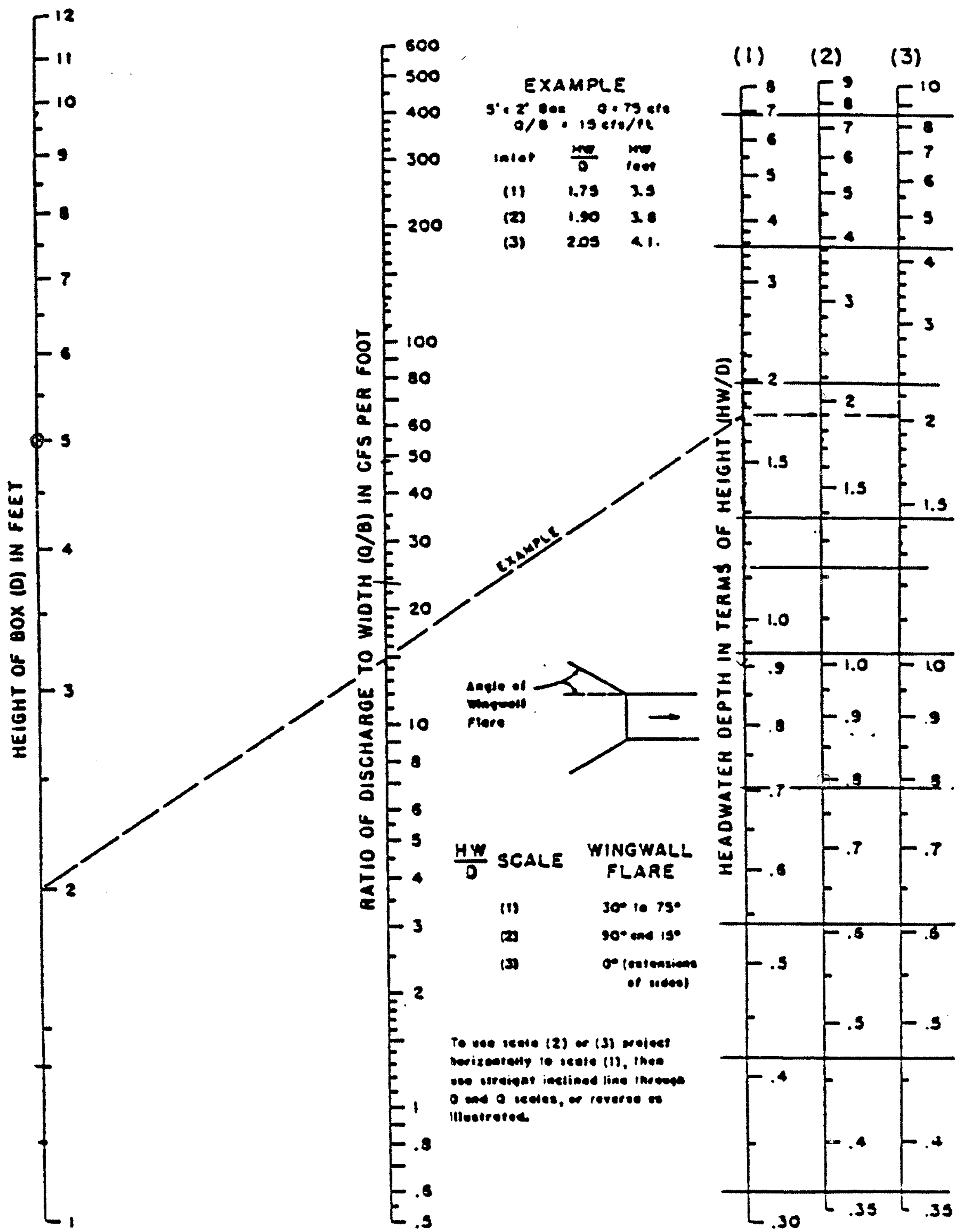
FIGURE 5.4



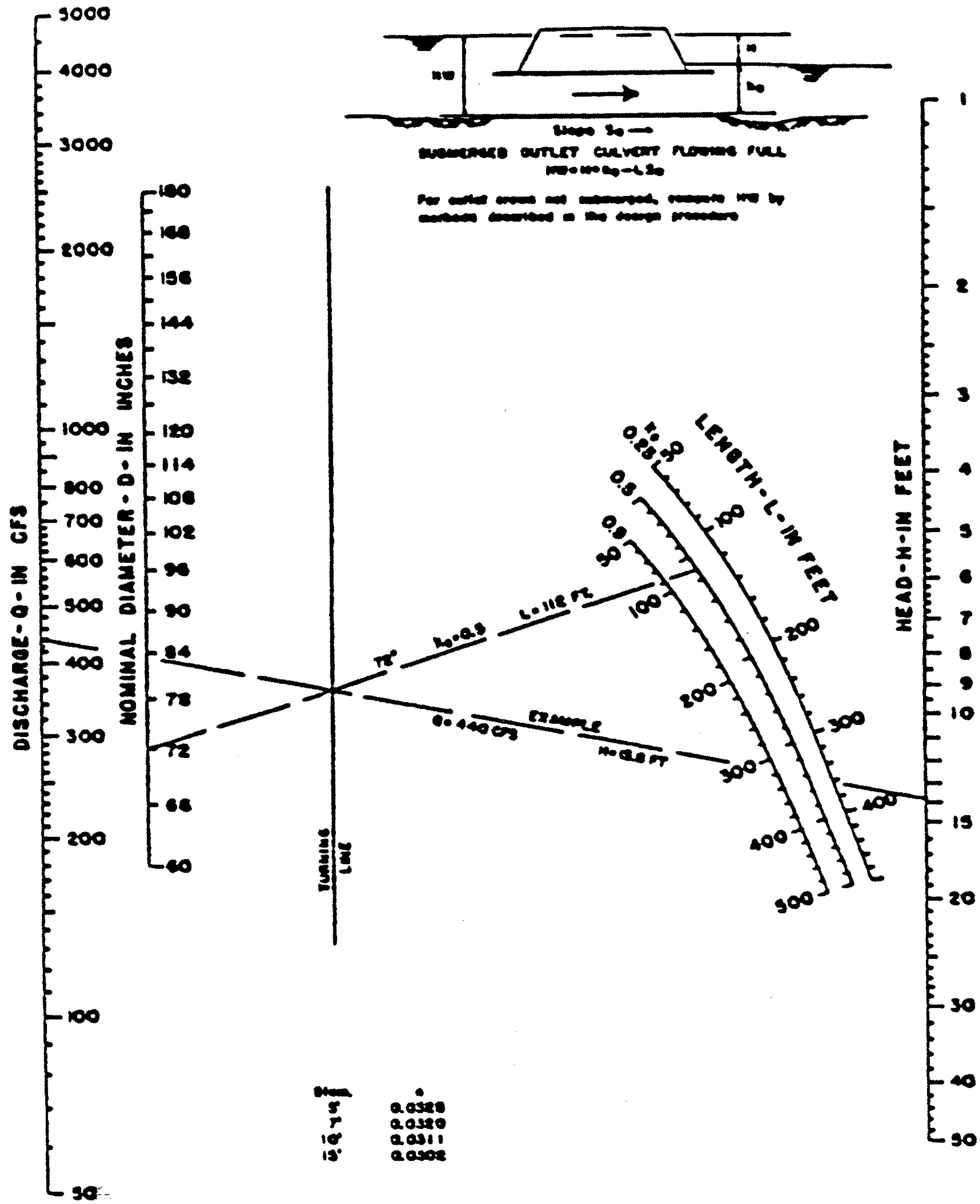
CITY OF LAWRENCE, KANSAS
STORMWATER MANAGEMENT
DESIGN CRITERIA

HEADWATER DEPTH FOR OVAL CONCRETE PIPE (HE) INLET CONTROL

FIGURE 5.5



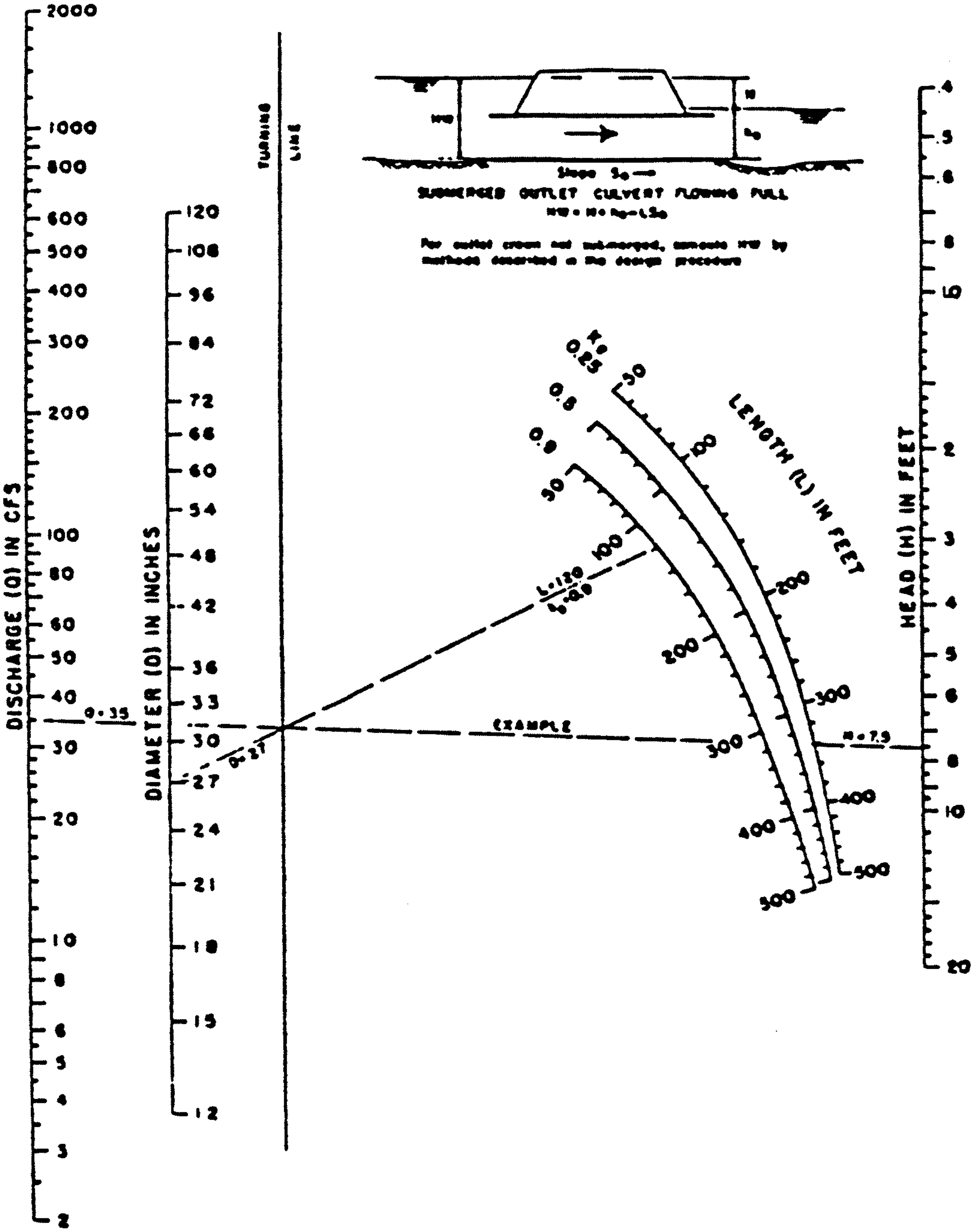
CITY OF LAWRENCE, KANSAS STORMWATER MANAGEMENT DESIGN CRITERIA	HEADWATER DEPTH FOR BOX CULVERTS WITH INLET CONTROL FIGURE 5.6

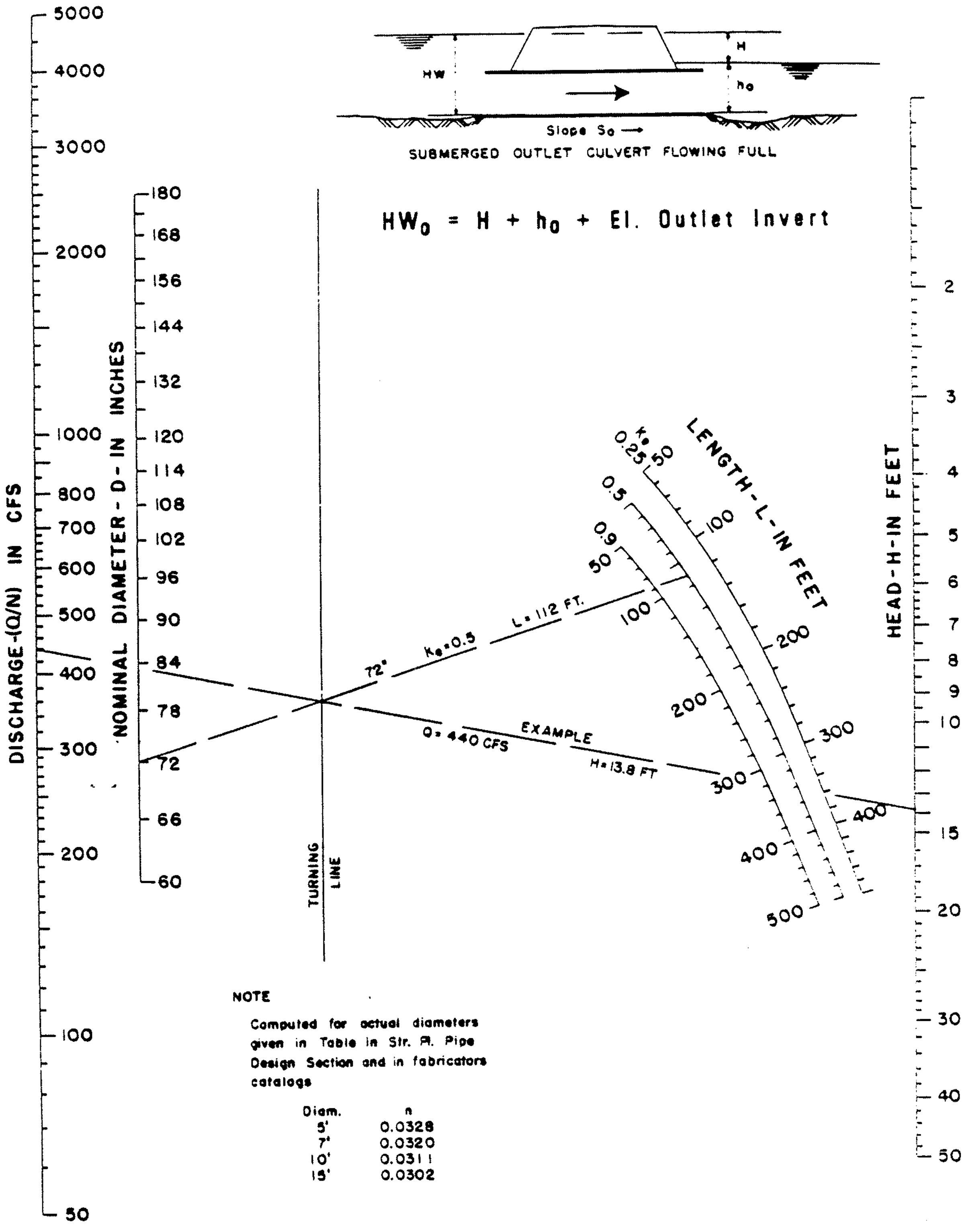


CITY OF LAWRENCE, KANSAS
STORMWATER MANAGEMENT
DESIGN CRITERIA

HEAD FOR CONCRETE PIPE
CULVERTS FLOWING FULL

FIGURE 6.1

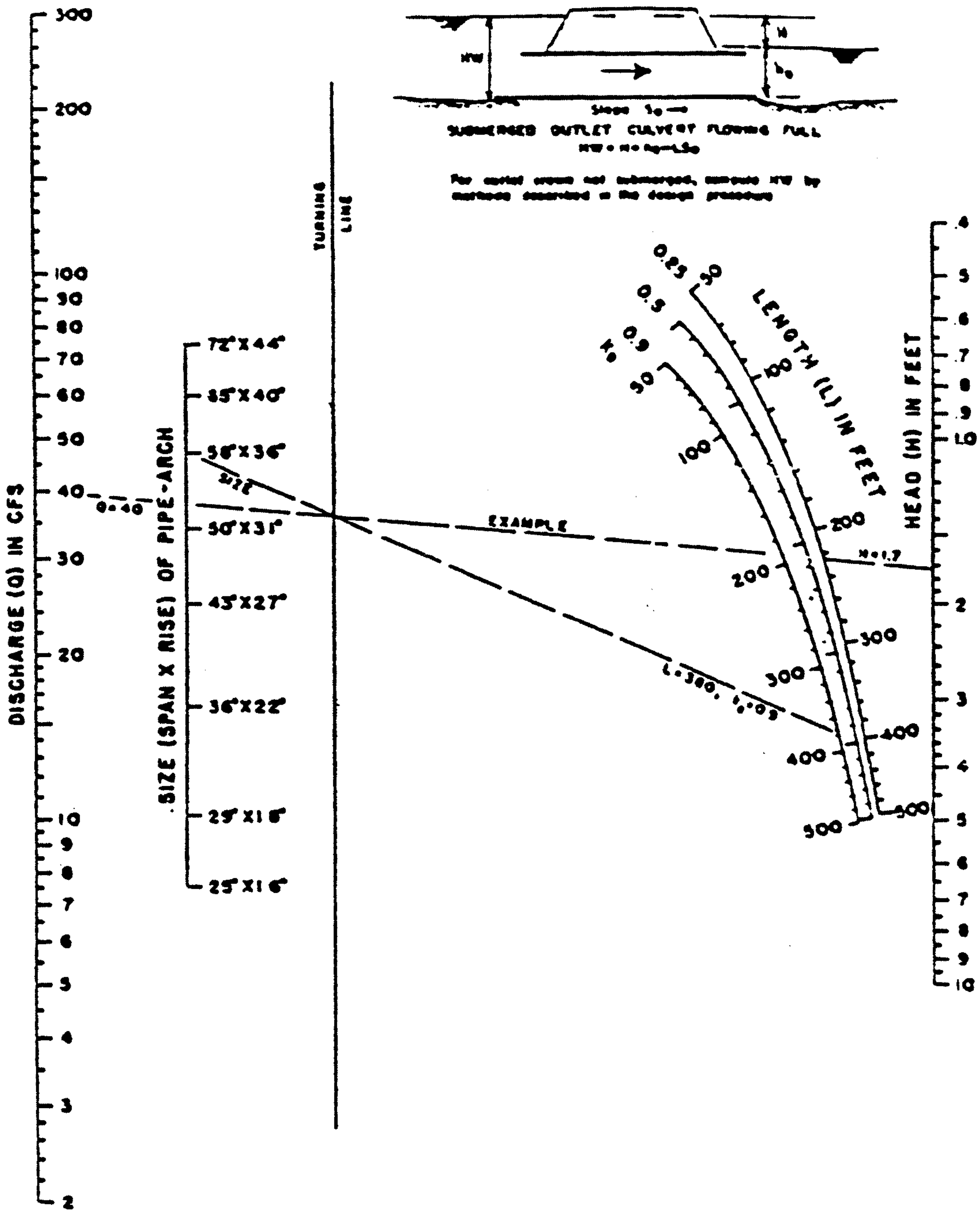

DISCHARGE (Q) IN CFS
2000
1000
800
600
500
400
300
200
100
80
60
50
40
30
20
10
8
6
5
4
3
2
Q = 35
DIAMETER (D) IN INCHES
120
108
96
84
72
66
60
54
48
42
36
33
30
27
24
21
18
15
12
D = 27
TURNING LINE
SUBMERGED OUTLET CULVERT FLOWING FULL
EXAMPLE
LENGTH (L) IN FEET
HEAD (H) IN FEET
H = 7.5



CITY OF LAWRENCE, KANSAS
STORMWATER MANAGEMENT
DESIGN CRITERIA

HEAD FOR STRUCTURAL PLATE CORRUGATED METAL PIPE CULVERTS FLOWING FULL

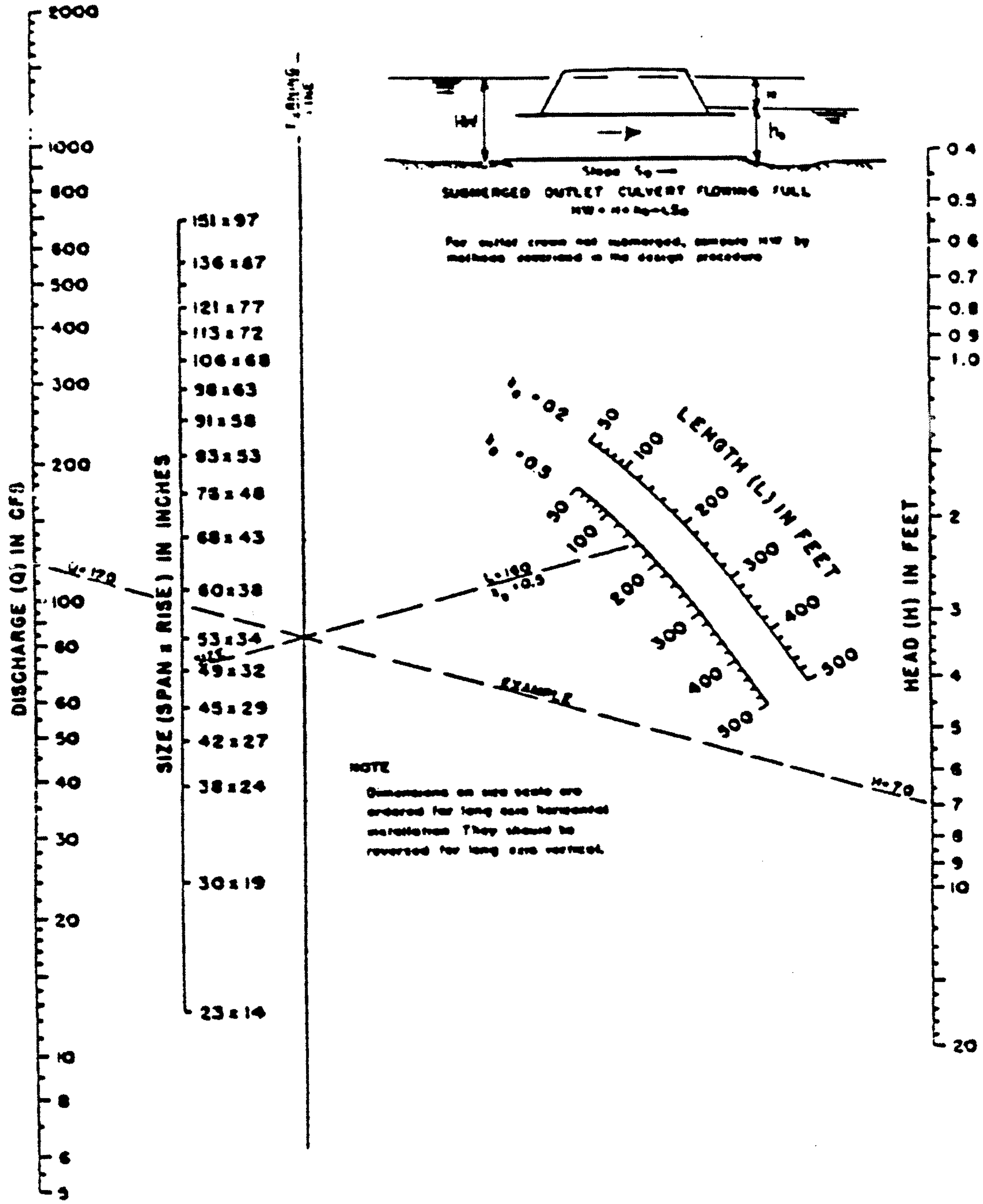
FIGURE 6.3



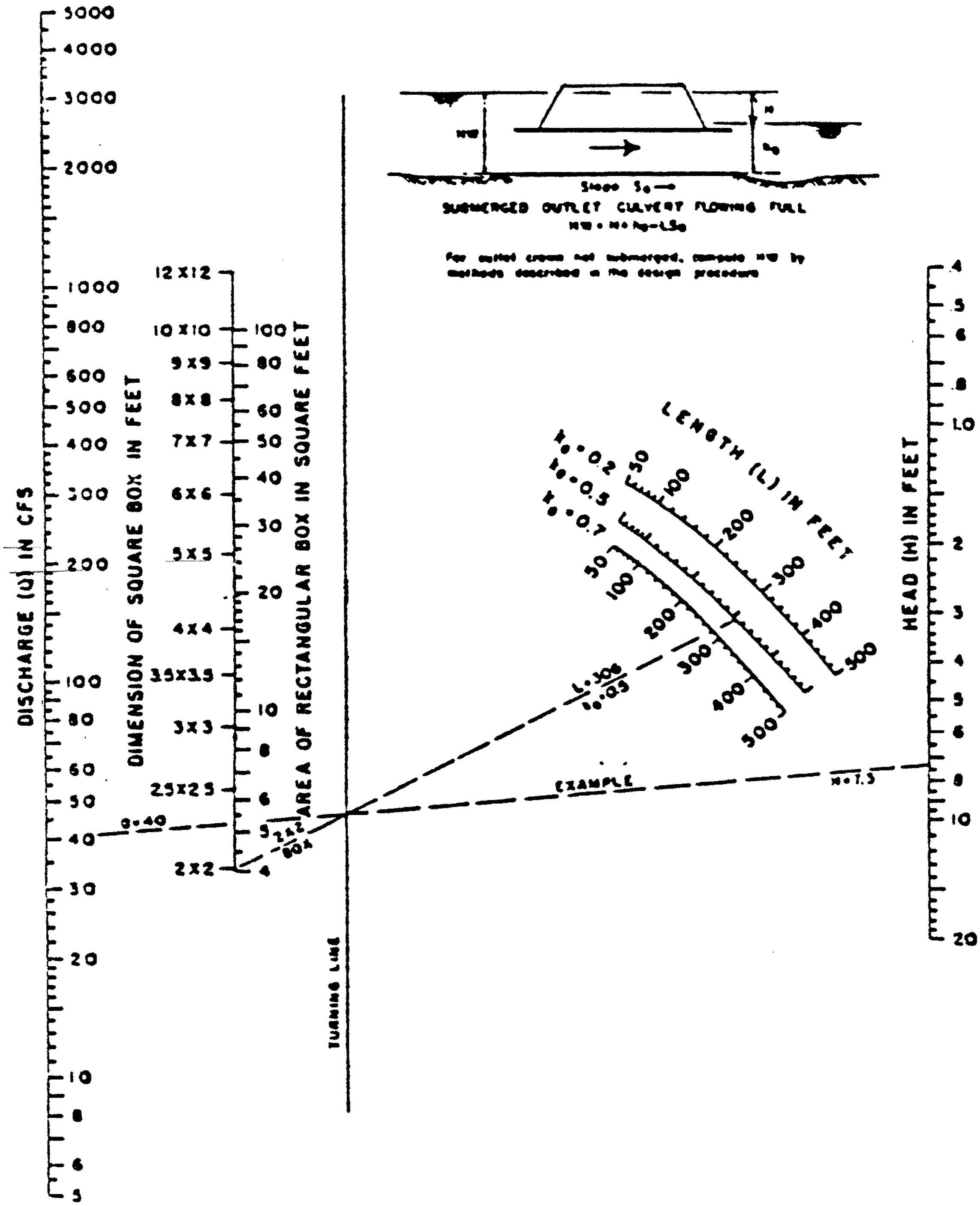
CITY OF LAWRENCE, KANSAS
STORMWATER MANAGEMENT
DESIGN CRITERIA

HEAD FOR STANDARD C.M. PIPE-ARCH
CULVERTS FLOWING FULL

FIGURE 6.4



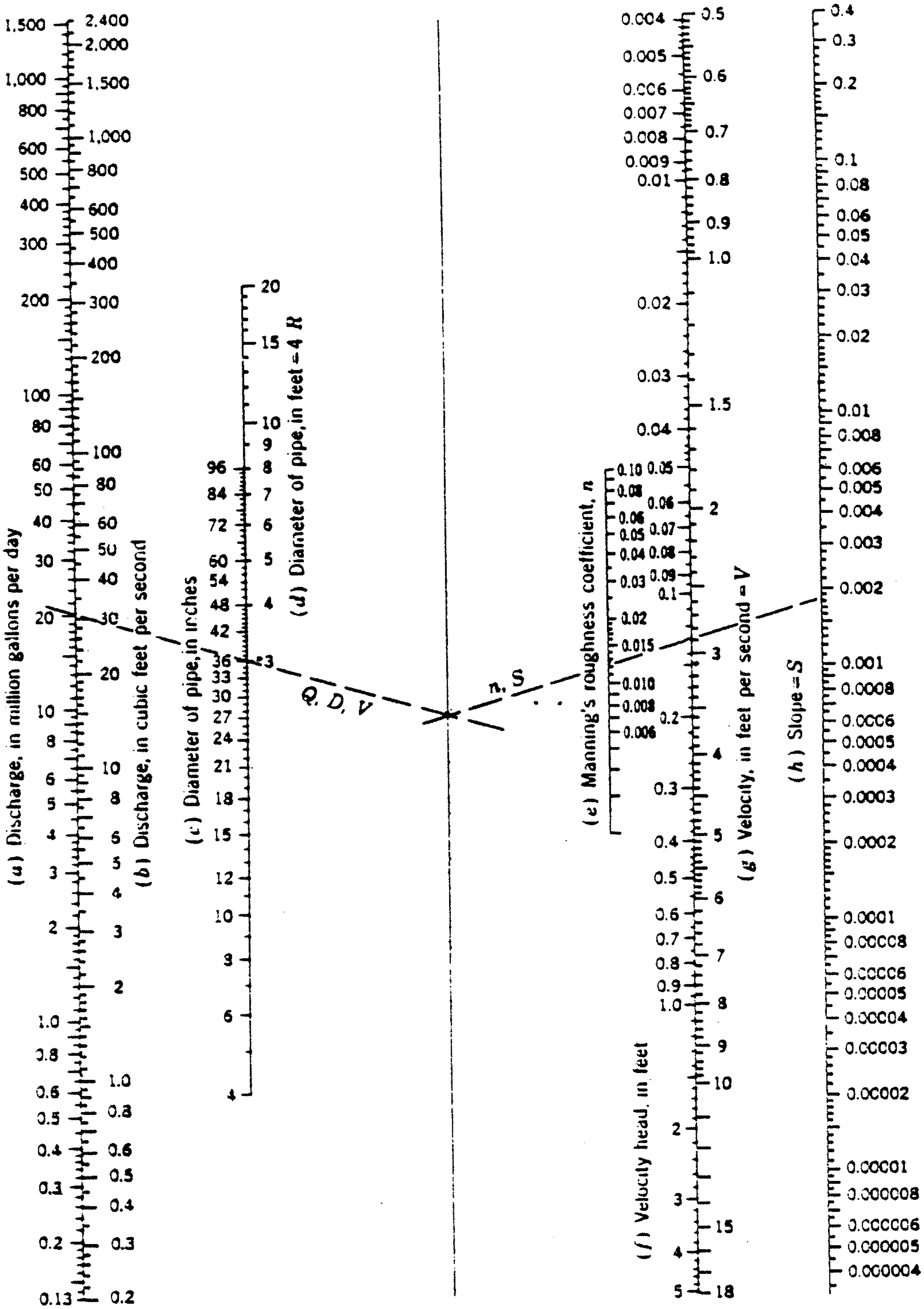
CITY OF LAWRENCE, KANSAS STORMWATER MANAGEMENT DESIGN CRITERIA	HEAD FOR OVAL CONCRETE PIPE CULVERTS FLOWING FULL (LONG AXIS HORIZONTAL FOR VERTICAL)
	FIGURE 6.5



CITY OF LAWRENCE, KANSAS
STORMWATER MANAGEMENT
DESIGN CRITERIA

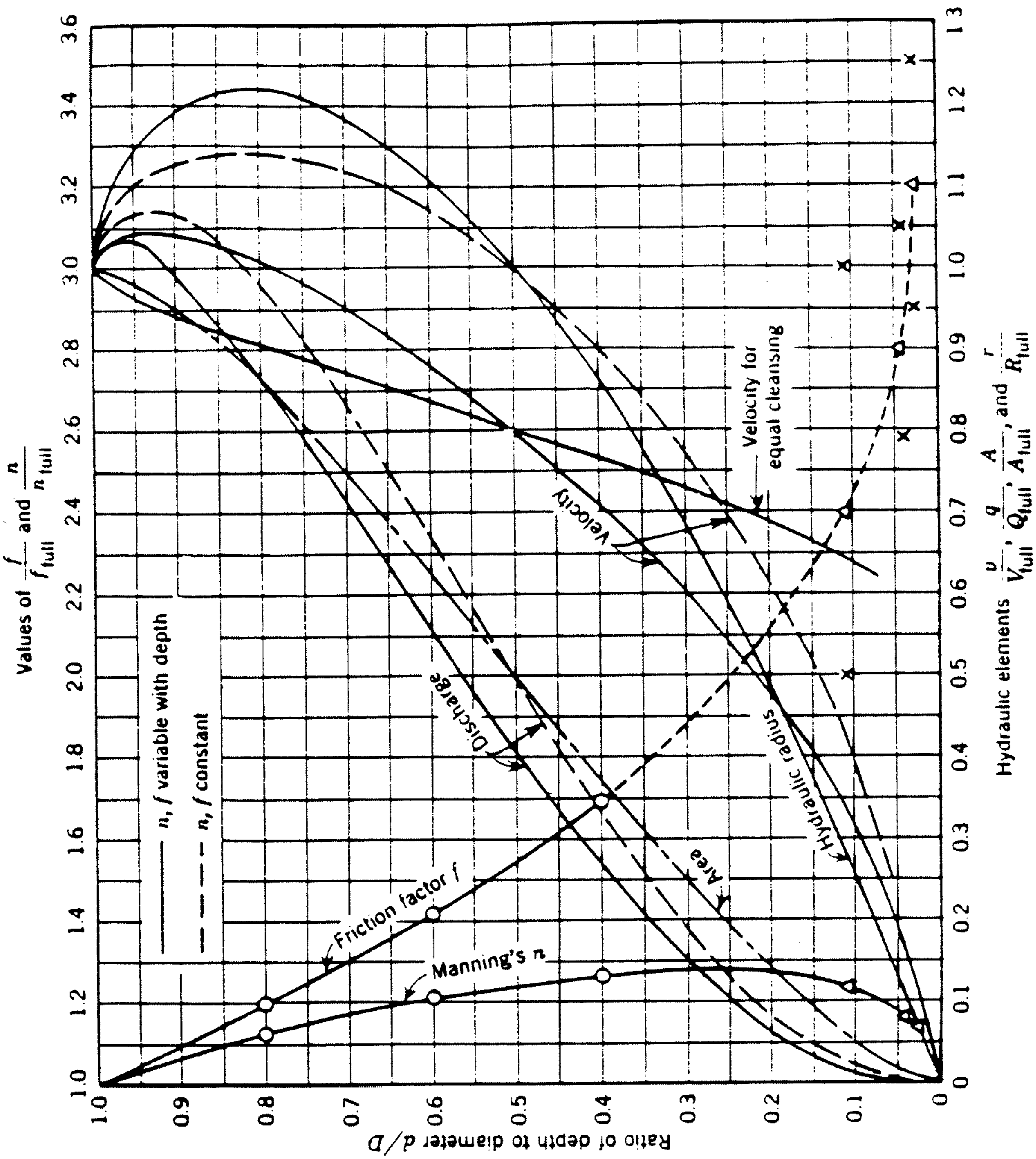
HEAD FOR CONCRETE BOX
CULVERTS FLOWING FULL

FIGURE 6.6



ALIGNMENT CHART FOR FLOW IN PIPES
(MANNING'S FORMULA)

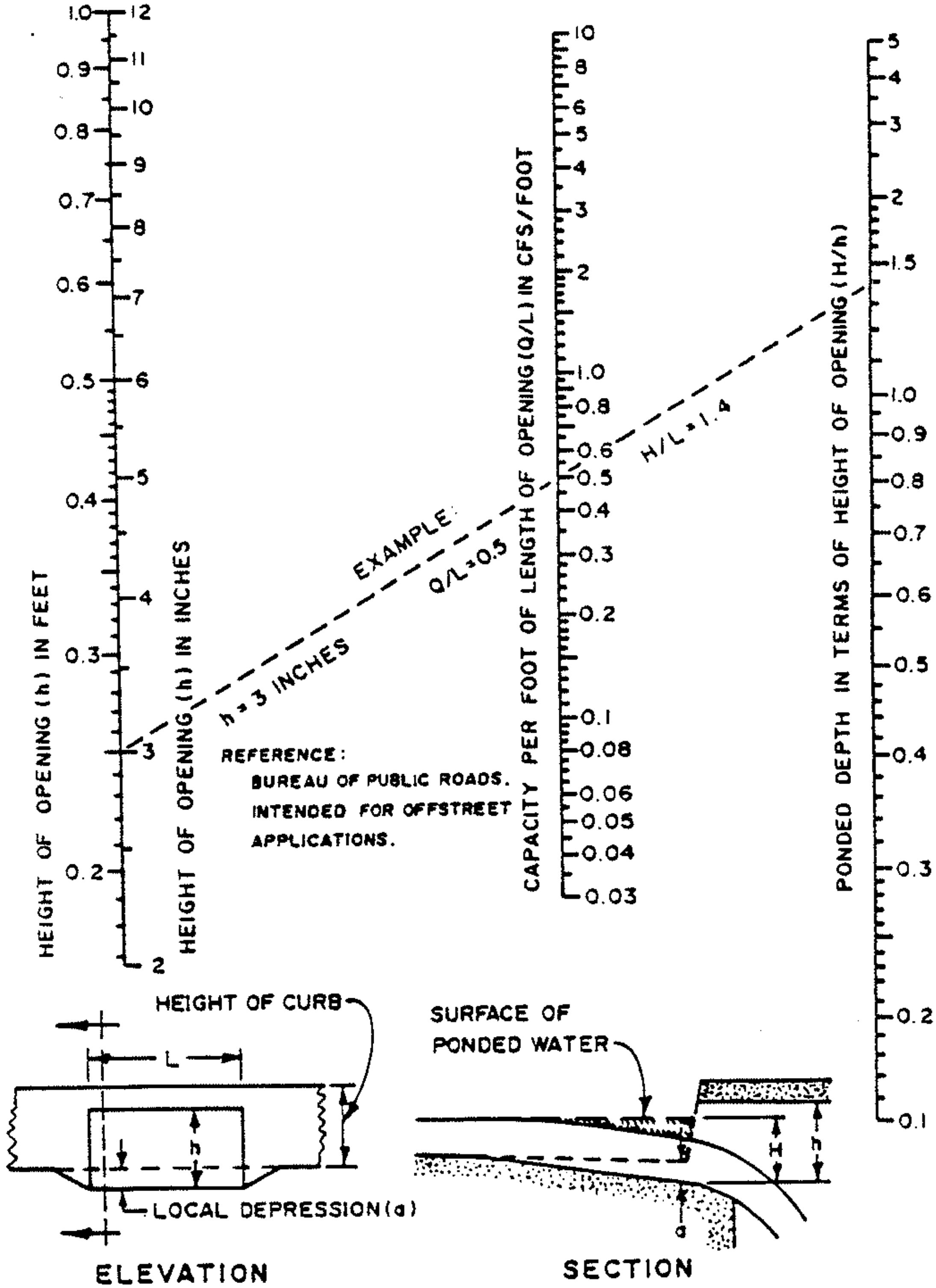
FIGURE 7



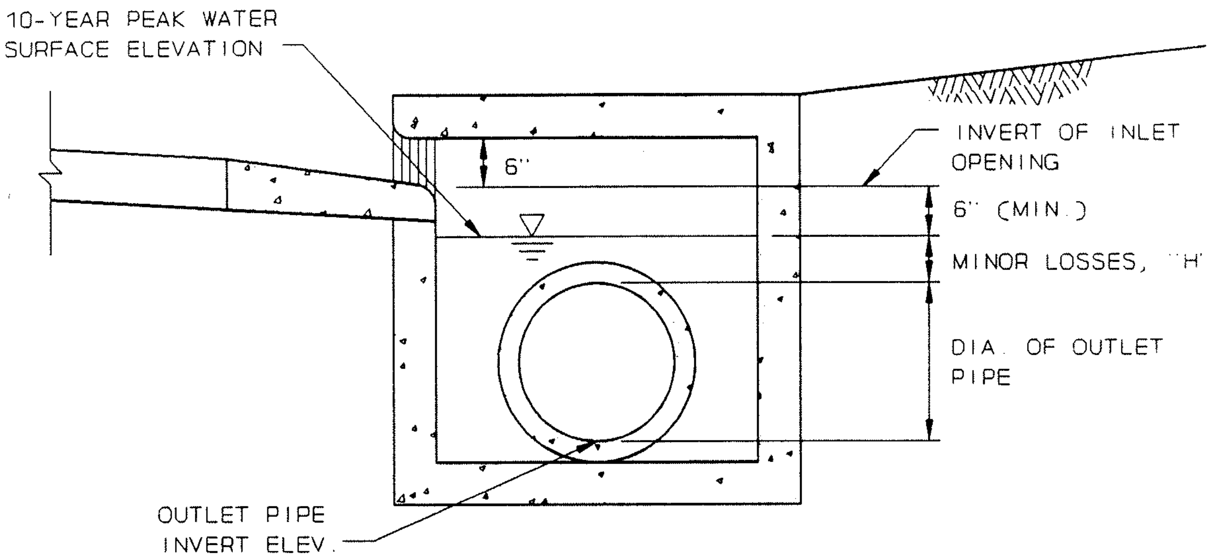
CITY OF LAWRENCE, KANSAS
STORMWATER MANAGEMENT
DESIGN CRITERIA

HYDRAULIC ELEMENTS OF
CIRCULAR CONDUITS

FIGURE 8



HEIGHT OF OPENING (h) IN FEET
HEIGHT OF OPENING (h) IN INCHES
CAPACITY PER FOOT OF LENGTH OF OPENING (Q/L) IN CFS/FOOT
PONDED DEPTH IN TERMS OF HEIGHT OF OPENING (H/h)
EXAMPLE:
h = 3 INCHES
Q/L = 0.5
H/L = 1.4
REFERENCE:
BUREAU OF PUBLIC ROADS.
INTENDED FOR OFFSTREET
APPLICATIONS.
HEIGHT OF CURB
L
h
LOCAL DEPRESSION (a)
ELEVATION
SURFACE OF
PONDED WATER
H
h
a
SECTION



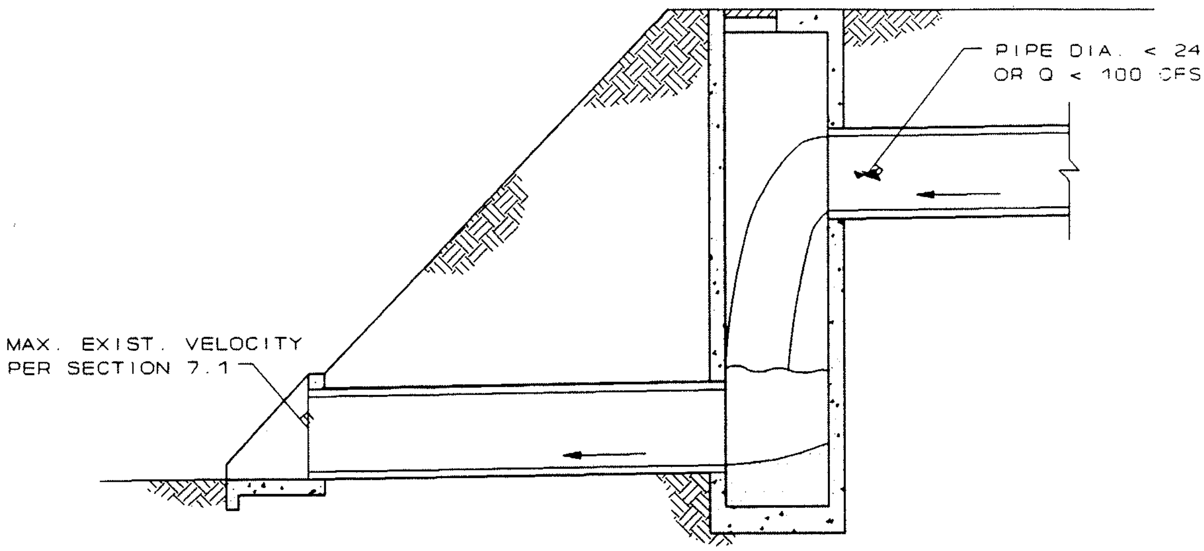
$$"H" = K(V^2/2G)$$

NOTES:

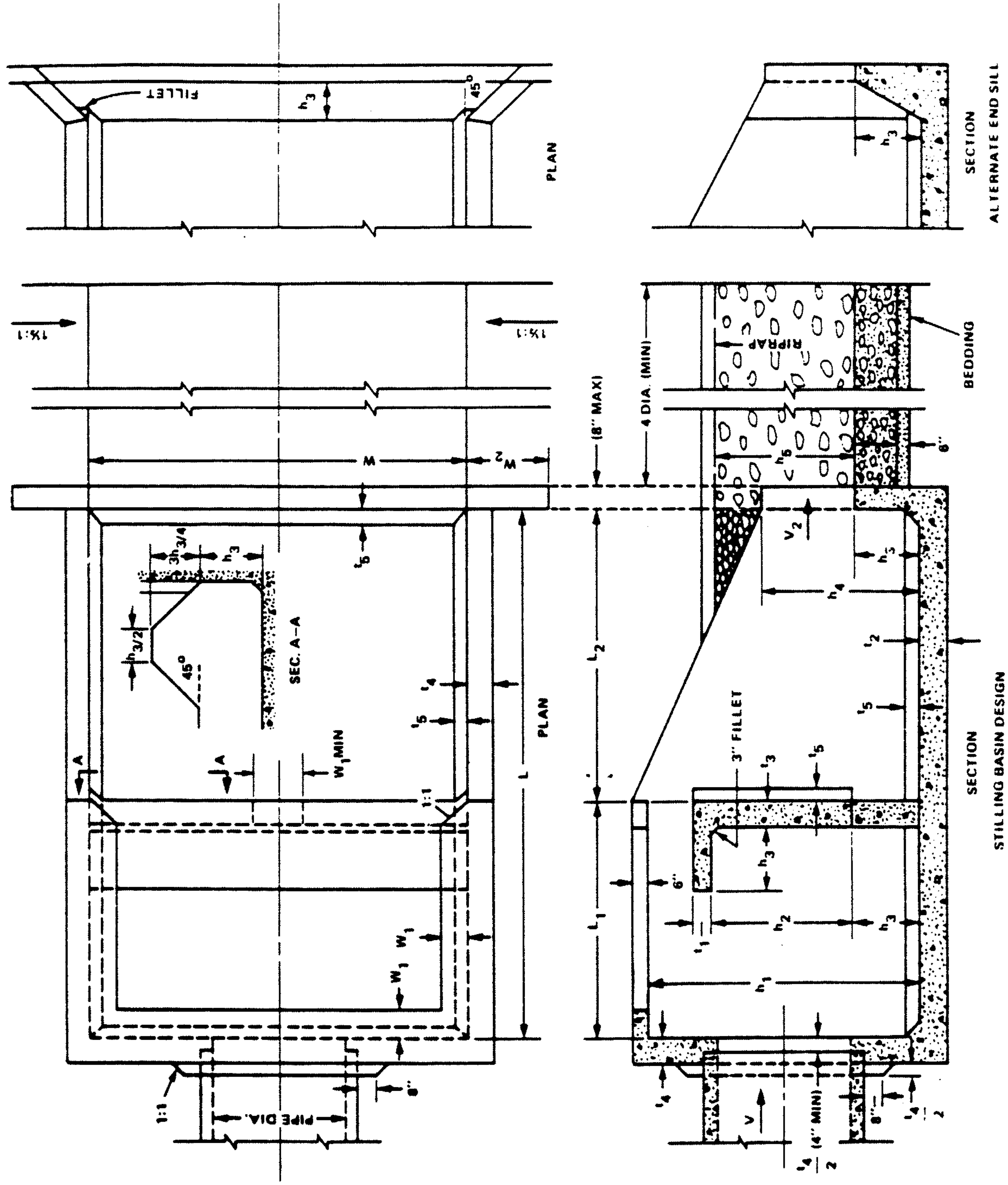
1. SEE TABLE F FOR VALUES OF "K".

2. V = Q/A WHERE
   Q = FLOW, IN CFS
   A = CROSS-SECTIONAL AREA OF OUTLET PIPE, IN SQ. FT.

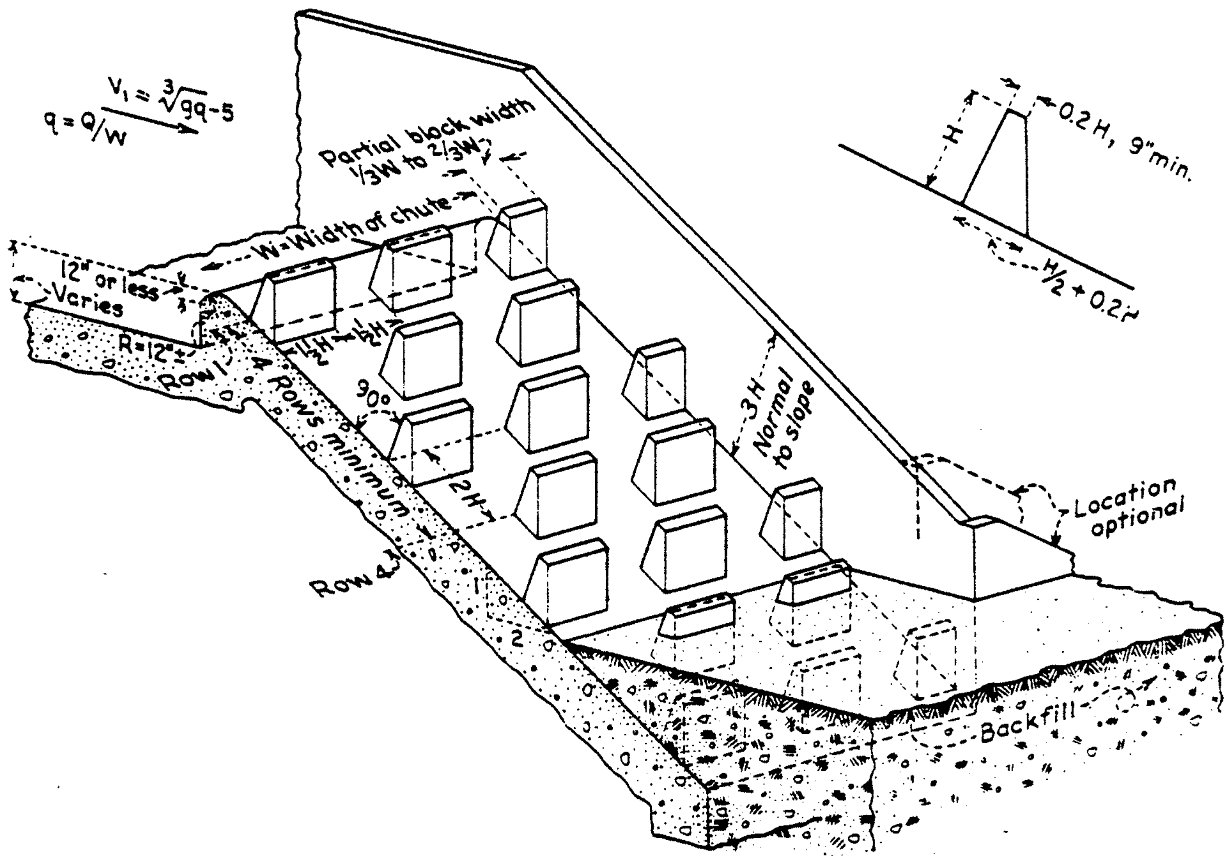
3. 2G = 64.4 FT. PER SEC. PER SEC



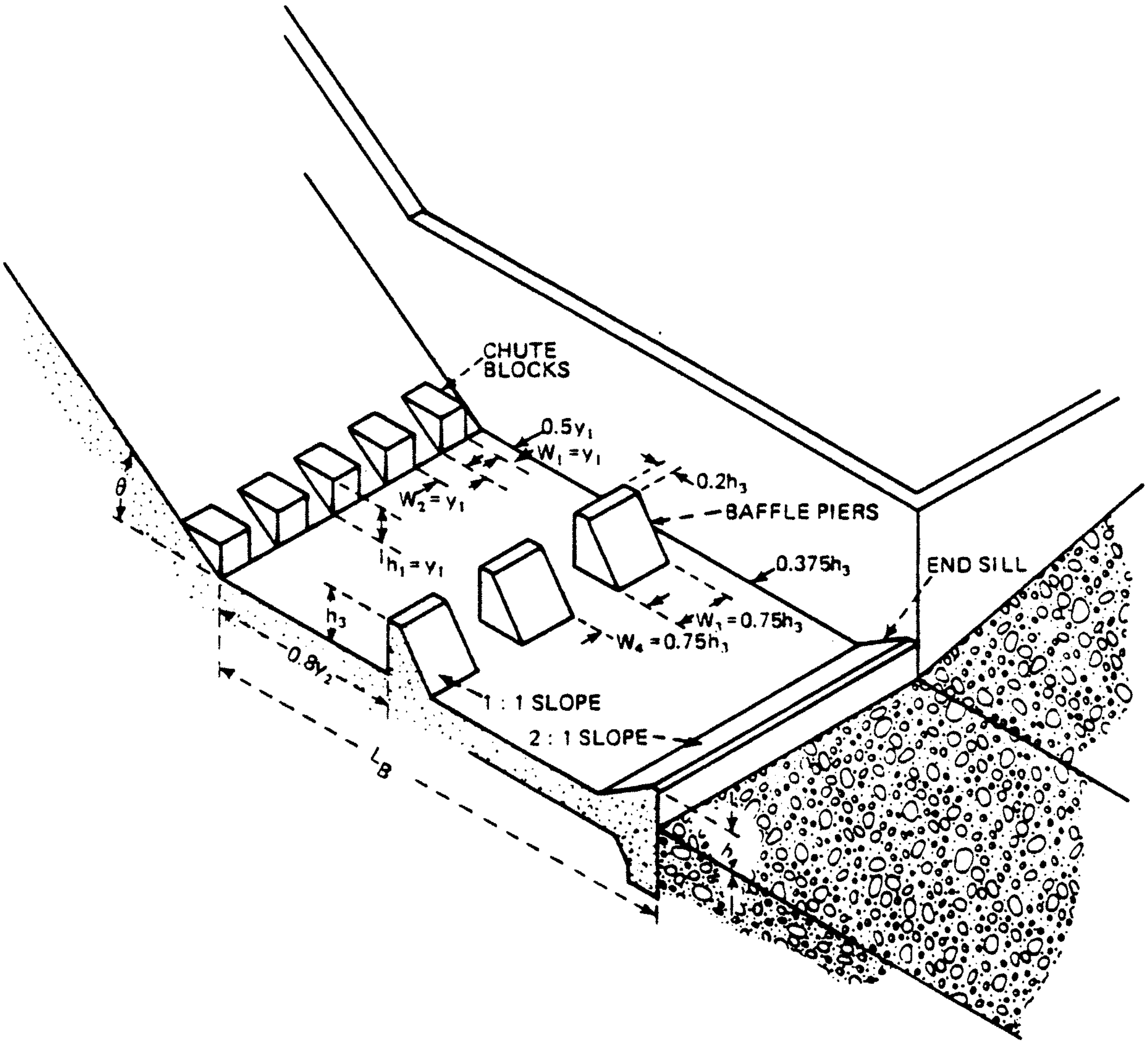
SECTION



CITY OF LAWRENCE, KANSAS STORMWATER MANAGEMENT DESIGN CRITERIA	BUREAU OF RECLAMATION TYPE VI BASIN
	FIGURE 12



$V_1 = \sqrt[3]{gq} - 5$
$q = Q/W$
Partial block width
1/3W to 2/3W
W=Width of chute
12" or less
Varies
R=12"±
Row 1
4 Rows minimum
90°
2H
Row 4
3H
Normal to slope
Location optional
Backfill
H
0.2 H, 9" min.
H/2 + 0.2H



CITY OF LAWRENCE, KANSAS STORMWATER MANAGEMENT DESIGN CRITERIA	BUREAU OF RECLAMATION TYPE III BASIN
	FIGURE 14

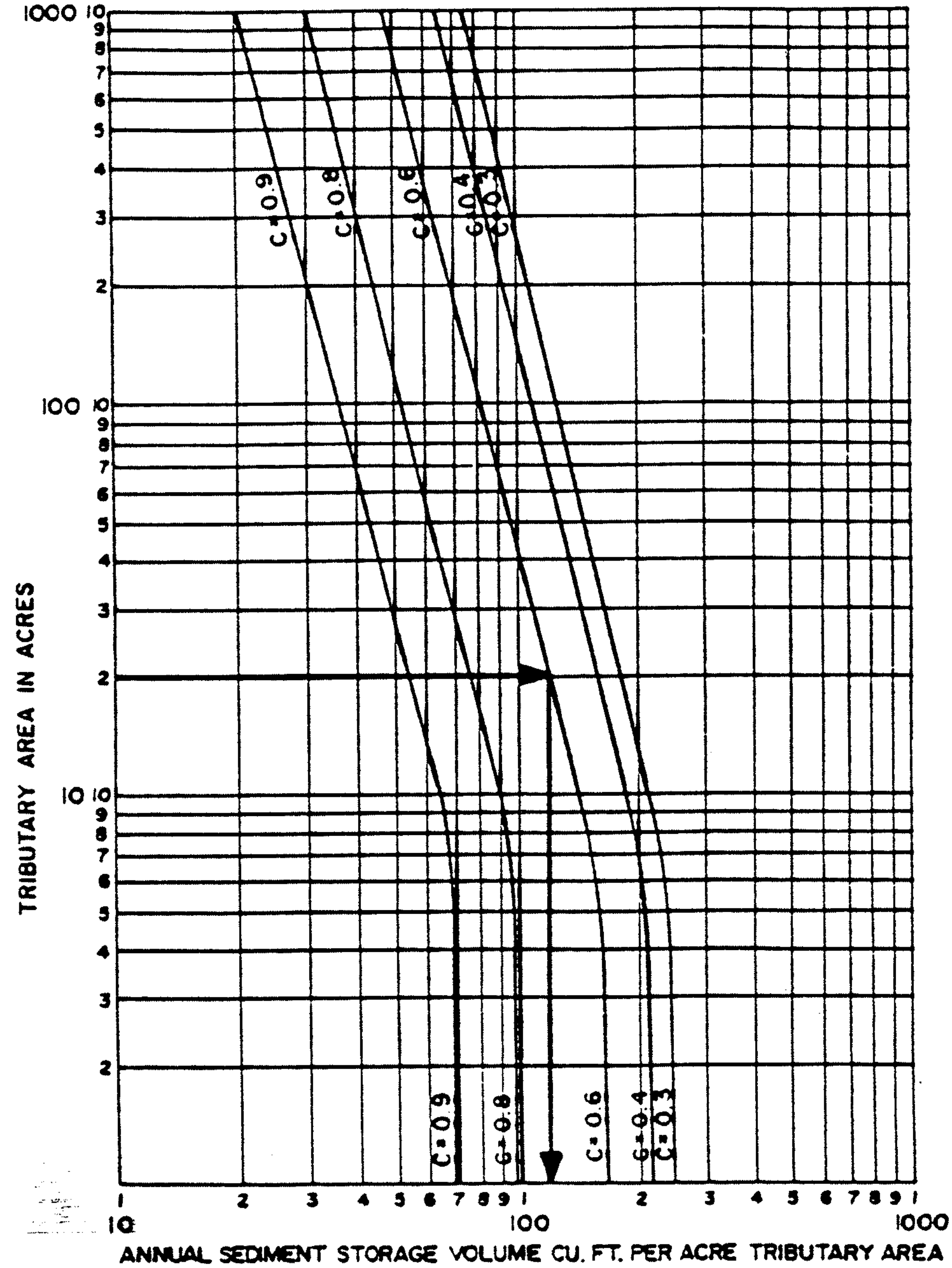
EXAMPLE:

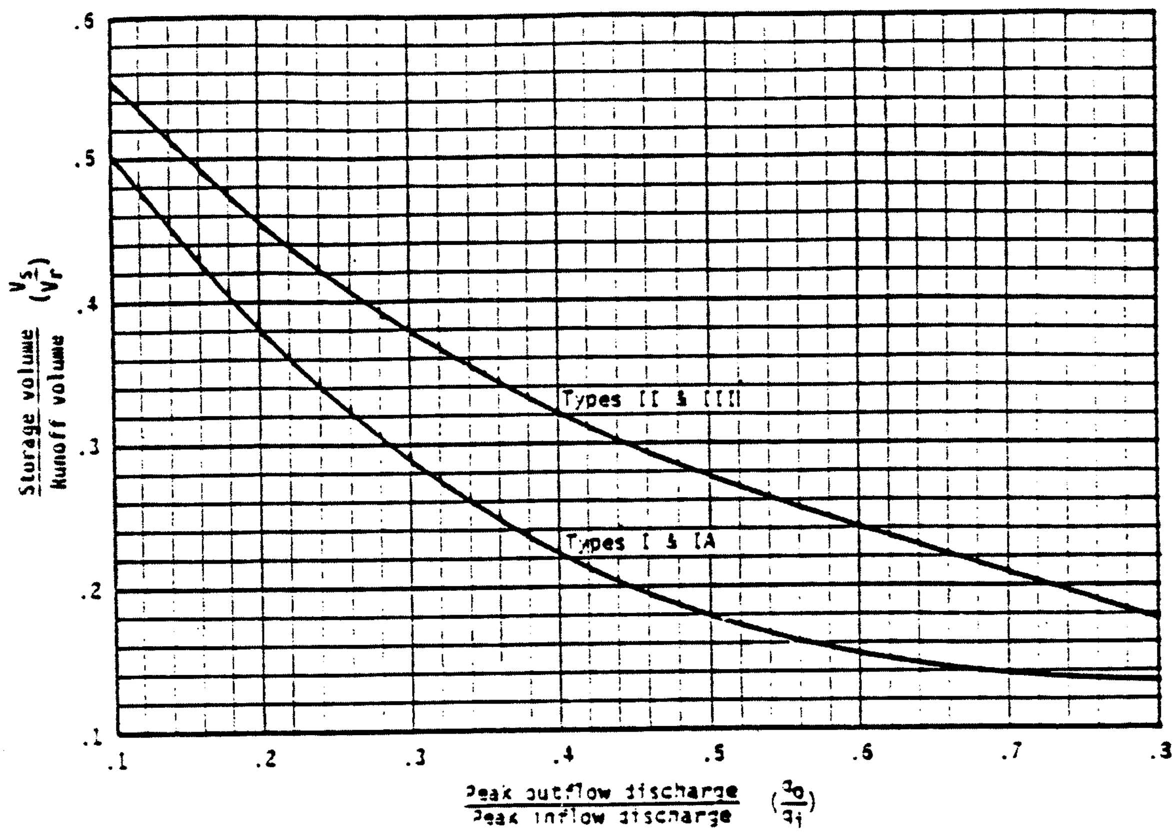
TRIBUTARY AREA = 20 ACRES

RATIONAL METHOD RUNOFF COEFFICIENT "C" = 0.6

SEDIMENT STORAGE = 120 CU. FT. PER ACRE PER YEAR

TOTAL SEDIMENT STORAGE = 120 X 20 = 2400 CU. FT. PER YEAR.





EQUATIONS

S = (1000/CN)-10.0 where:
CN = SCS Curve Number from . .
Table B
Q = (P-0.2S)^2/(P+.8S) where:
Q = Runoff in inches
P = 24 hr. rainfall in inches
Table B
VR = (Q/12)*A*43,560 where:
VR = Cu. Ft. Inflow to detention
A = Acres tributary to detention

Qi = Peak CFS inflow to detention
Calculated by either:
* Rational Method
* Hydrograph routing

Qr = Peak CFS disch. from detention
Criteria Max. (CFS/Trib. Acre)
* 1.2 CFS - 2 year
* 1.5 CFS - 10 year
* 2.0 CFS - 100 year

EXAMPLE FOR 10 YEAR STORAGE

A = 8.0 Acres
CN = 90 (C=.65)
Qr = 8*1.5 = 12 CFS
Tc = 15.0 min. (i = 5.21)
P = 5.04"

Qi = (.65*8.0*5.21) = 27 CFS
S = (1000/90)-10 = 1.11
Q = 3.92" (24 hour runoff)
VR = (3.92/12)*8*43560 =
= 113,716 Cu.Ft.

Qr/Qi = (12/27) = 0.44
FROM GRAPH, TYPE II STORM: Vs/Vr = 0.3
Vs Required = 0.3*113,716 = 34,114 cu. ft. = 0.78 acre ft.

ADOPTING ORDINANCE
NO. 67778

ORDINANCE NO. 6778

AN ORDINANCE OF THE CITY OF LAWRENCE, KANSAS ADOPTING BY REFERENCE THE "STORMWATER MANAGEMENT CRITERIA" PREPARED BY BURNS AND MCDONNELL CONSULTING ENGINEERS; ESTABLISHING REQUIREMENTS FOR CERTAIN DESIGN, CONSTRUCTION AND MAINTENANCE; ESTABLISHING APPEAL PROCEDURES AND PENALTIES.

BE IT ORDAINED BY THE GOVERNING BODY OF THE CITY OF LAWRENCE, KANSAS:

Section 1. Adoption of Stormwater Management Criteria.

There is hereby incorporated by reference, and adopted by the City of Lawrence, Kansas, that certain document entitled "Lawrence, Kansas Stormwater Management Criteria, February, 1996" prepared and published by Burns & McDonnell consulting engineers, Kansas City, Missouri, save and except such provisions as are hereafter omitted, deleted, modified or changed. Pursuant to K.S.A. 12-3010, no less than three (3) copies of the "Lawrence, Kansas Stormwater Management Criteria, February, 1996" shall be marked or stamped "Official Copy as Adopted by Ordinance No. 6778", with all sections or portions thereof intended to be omitted clearly marked to show any such omission or showing the sections, articles, chapters, parts or portions that are incorporated, and to which shall be attached a copy of Ordinance No. 6778, and filed with the City Clerk to be open to inspection and available to the public at all reasonable business hours.

Section 2. Stormwater Management Criteria; Design, Construction and Maintenance Requirements.

The Stormwater Management Criteria, adopted pursuant to Section 1, shall be used as criteria and guidelines in the design, construction, use, and maintenance of all new storm drainage systems and facilities and for the rehabilitation of existing drainage system facilities, as such terms are defined in the Stormwater Management Criteria.

Section 3. Appeals from Stormwater Management Criteria Requirements.

Any person aggrieved by any requirement established in the Stormwater Management Criteria may appeal the requirement pursuant to this Section. The appellant shall provide a written appeal request to the Director of Public Works within ten (10) days of the action or application of the Stormwater Management Criteria requirement to a particular property or activity. The Director of Public

Works, or his or her designee, shall schedule a hearing within ten (10) days of receipt of the appeal request, at which time the appellant may present relevant evidence concerning the appeal. The hearing may be waived by the appellant, and the hearing may be continued by the Director as may be necessary. The Director, or the Director's designee, shall make appropriate findings concerning the appeal, and may, after consideration of all relevant evidence: 1) Sustain the appeal, 2) Deny the appeal, or 3) Sustain the appeal with appropriate conditions and requirements. The decision of the Director of Public Works concerning the appeal shall be final.

Section 3. Penalty. The construction or use, or both, of a stormwater drainage system, in violation of the Stormwater Management Criteria, adopted in Section 1, shall be deemed a municipal offense pursuant to the general penalty provisions of the Code of the City of Lawrence, Kansas.

Section 4. Effectiveness. This ordinance shall be effective on and after August 1, 1996.

Section 5. Repeal of Resolution No. 4631. Resolution No. 4631 is repealed on the effective date of this ordinance.

Adopted this 4th day of June, 1996.

John Nalbandian, Mayor

ATTEST:

Raymond J. Hummert, City Clerk

Approved as to form and legality:

David L. Corliss, Director of Legal Services

I hereby certify that the foregoing is a true and correct copy of the original ordinance: that said ordinance was passed on the 4 day of June 1996; that the record of the final vote on its passage is found on page ___ of Journal ✓; that it was published in the Lawrence Daily Journal-World on the 11 Day of June; 1996

City Clerk

ADDENDUMS

ADDENDUM 1:
Hydrograph Methods

City of Lawrence
KANSAS

MIKE WILDGEN, CITY MANAGER

CITY OFFICES
BOX 708 66044-0708
6 EAST 6th
913-832-3000
TDD 913-832-3205
FAX 913-832-3405

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 $0.74 \times 9.82 \times 1.619 = 11.8$ 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

Chad Voigt

c: Terese Gorman

ADDENDUM 2:

Lake Alvamar Drainage Study

City of Lawrence
KANSAS

MIKE WILDGEN, CITY MANAGER

CITY OFFICES 6 EAST 6th
BOX 708 66044-0708 913-832-3000
TDD 913-832-3205
FAX 913-832-3405

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

MIKE WILDGEN, CITY MANAGER

CITY OFFICES
BOX 708 66044-0708
6 EAST 6th
785-832-3000
TDD 785-832-3205
FAX 785-832-3405

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

MIKE WILDGEN, CITY MANAGER

CITY OFFICES
BOX 708 66044-0708
6 EAST 6th
785-832-3000
TDD 785-832-3205
FAX 785-832-3405

June 16, 1999

To: Engineers and designers

From: Chad Voigt, Public Works

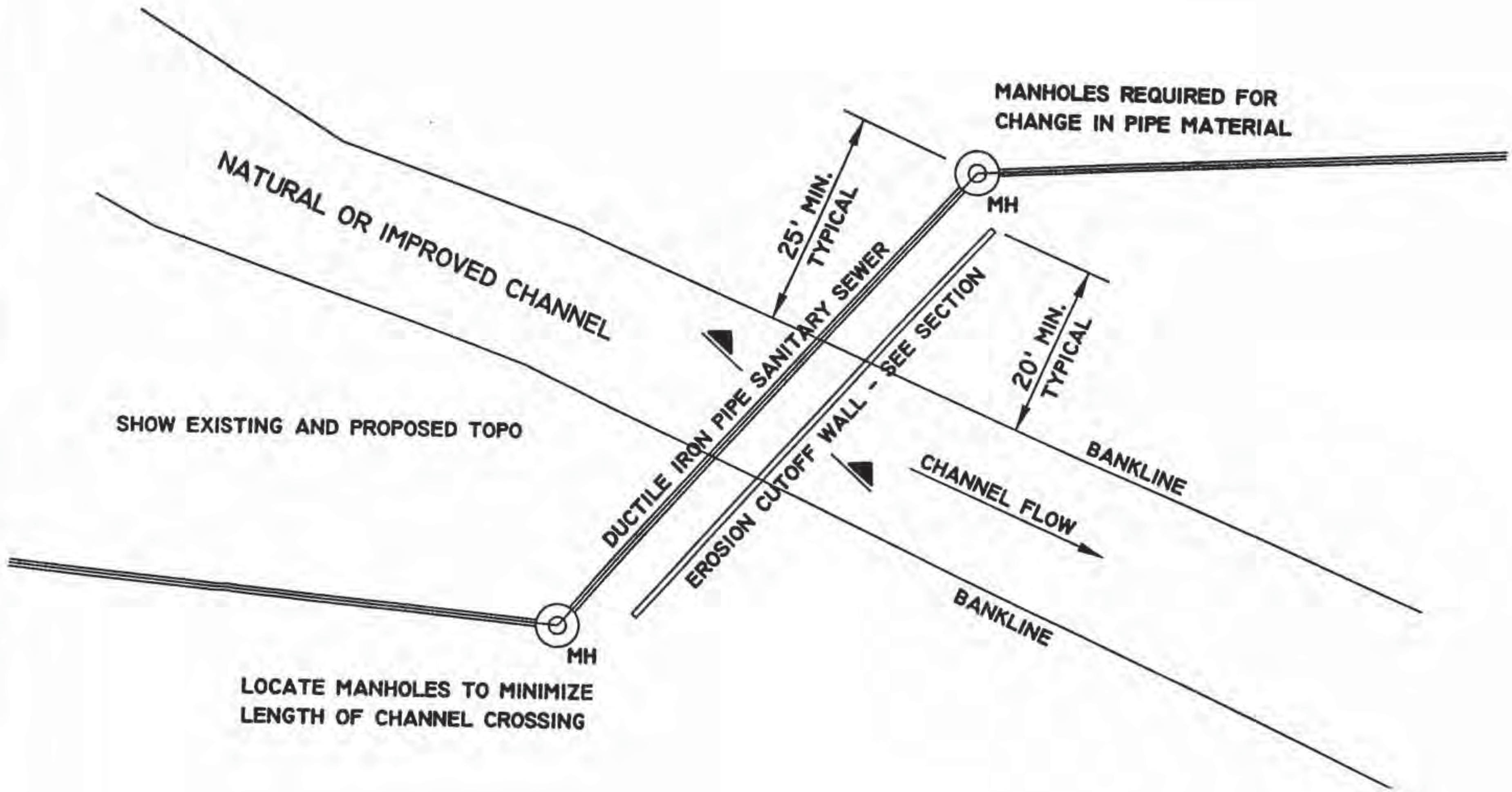
Re: Sanitary Sewer Channel Crossing Requirements

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:

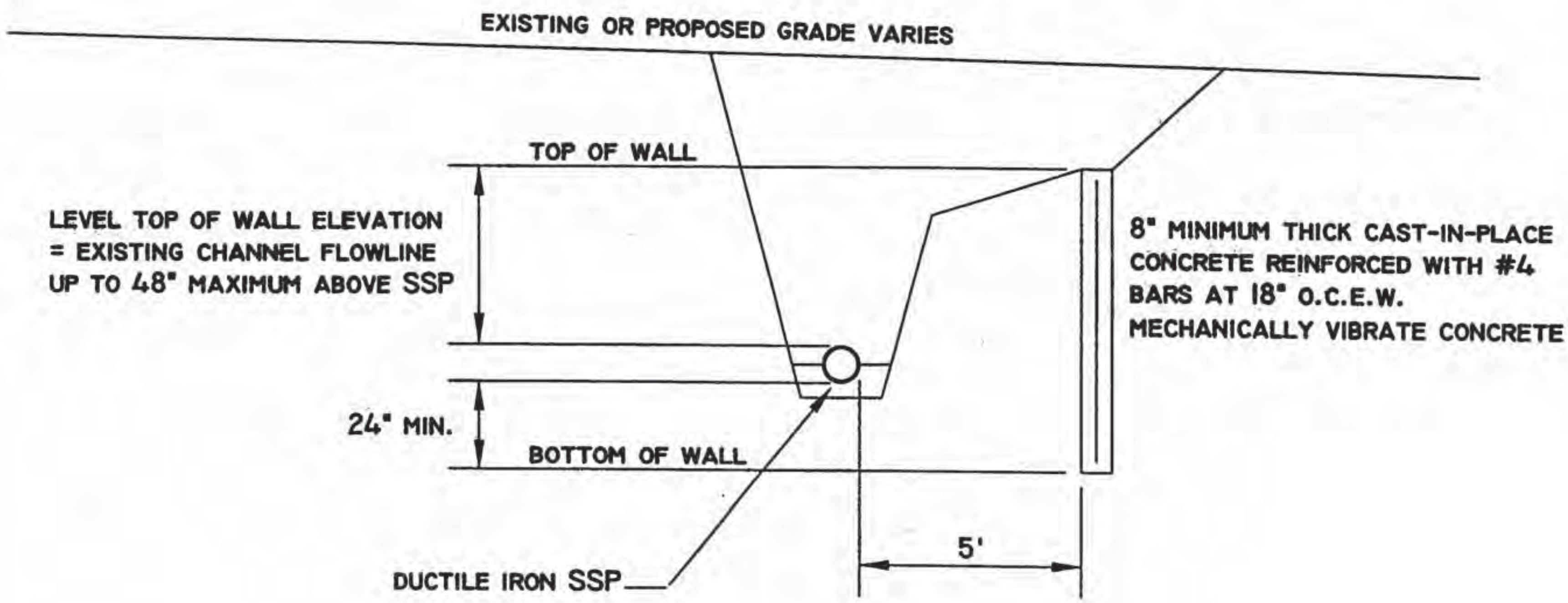
Sheets 1 through 3 attached provide design requirements for channel crossings. The drawing "Erosion Cutoff Wall Typical Section" is included on the enclosed disk.



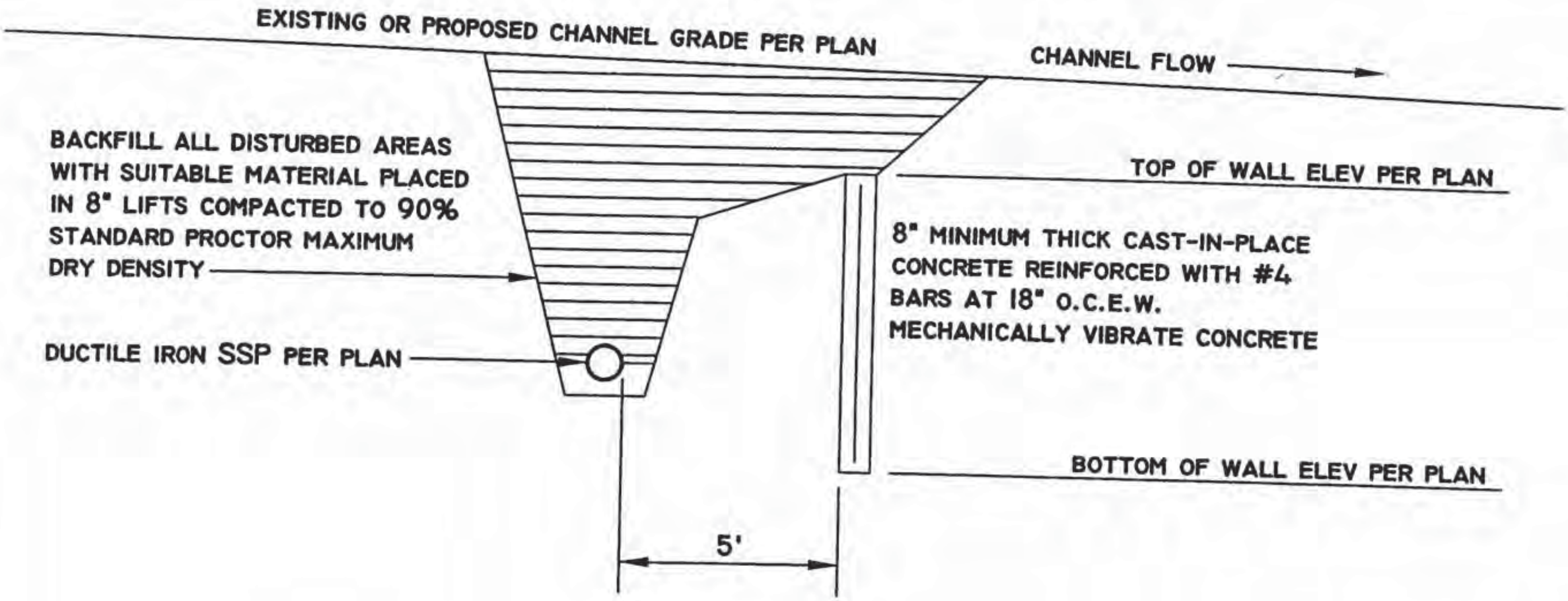
SANITARY SEWER CHANNEL CROSSING DESIGN REFERENCE

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
KANSAS

MIKE WILDGEN, CITY MANAGER

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BOX 708 66044-0708 785-832-3000
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FAX 785-832-3405

March 23, 2000

To: Stormwater System Designers

From: Chad Voigt, Public Works

Re: Update to Stormwater Management Criteria
Chapter 11 Construction Plan Requirements

This update will standardize and simplify the construction plan process. Please make the changes to all projects beyond those that are already underway.

All construction plans must be prepared as follows:

1. Storm system plan and profile views must be shown on the same sheet. The profile limits must match the plan limits on each sheet. All construction notes referencing the drainage system must be provided on the storm system plan and profile sheets only.

2. Design information must be provided per the attached format. One table per element shall be provided on the profile view. Additional design information is not required unless specifically requested.

3. The drainage area map must show existing contours, proposed contours, proposed streets, property lines and easements. Drainage areas must be identified for each point of discharge to the drainage system. Drainage areas must be labeled with the receiving structure number. Calculations are not necessary on the drainage area map.

Insert this table on the profile near each pipe

PIPE name

DA	0.00	ac	n	0.000	
C	0.0		Qfull	0.0	cfs
Tc	0.0	m			
Q10	0.0	cfs	V10	0.0	fps
Q100	0.0	cfs	V1	0.0	fps

NOTES:

DA	total drainage area to pipe
C	composite C for total DA
Tc	Tc for total DA to pipe
Q10	10-year peak (minimum design)
Q100	100-year peak (must be within R/W or D/E)
n	pipe roughness
Qfull	pipe full capacity
V10	actual velocity for Q10 (used for outlet structure requirements)
V1	actual velocity for Q1 (3 fps min or pipe slope min per table)

Size, slope and material must be listed in construction notes
HGL lines must be plotted on profile for *design* storm
Substitute Q50 for Q10 where 50-year minimum design required

Insert this table on the profile near each overflow channel

OVERFLOW CHANNEL name

Q100	0.0	cfs
n	0.000	
d100	0.0	ft

NOTES:

Q100	total 100-year bypass to overflow channel
n	roughness for uniform channel reach
d100	depth for Q100 (verify D/E width)

Cross-section, slope and lining material must be listed in construction notes

Insert this table on the profile near each curb inlet

CURB INLET name

DA	0.00	ac	s road	0.0000	ft/ft
C	0.0		L	0	ft
Ti	0.0	m			
Q10	0.0	cfs	Qi10	0.0	cfs
Q100	0.0	cfs	Qi100	0.0	cfs
R10	0.0	cfs	B10	0.0	cfs
R100	0.0	cfs	B100	0.0	cfs

NOTES:

DA	total drainage area to inlet
C	composite C for total DA
Ti	Ti for total DA to inlet
Q10	10-year peak to inlet (add bypass from other inlets)
Q100	100-year peak to inlet (add bypass from other inlets)
R10	allowable 10-year street flow for road slope
R100	allowable 100-year street flow for road slope
s road	road slope or zero for sump
L	inlet length (5' minimum)
Qi10	inlet capacity with 10-year gutter spread
Qi100	inlet capacity with 100-year gutter spread
B10	bypass flow from Q10
B100	bypass flow from Q100

Insert this table on the profile near each field inlet

FIELD INLET name

DA	0.00	ac	L	0	ft
C	0.0		Qi	0.0	cfs
Ti	0.0	m			
Q10	0.0	cfs			
Q100	0.0	cfs	B100	0.0	cfs

NOTES:

DA	total drainage area to inlet
C	composite C for total DA
Ti	Ti for total DA to inlet
Q10	10-year peak to inlet (add bypass from other inlets)
Q100	100-year peak to inlet (add bypass from other inlets)
L	inlet length
Qi	inlet capacity
B100	bypass flow from Q100

d

Insert this table on the profile near each open channel reach

OPEN CHANNEL name

DA	0.00	ac	n	0.000	
C	0.0		V10	0.0	fps
Tc	0.0	m	d10	0.0	ft
Q10	0.0	cfs	d100	0.0	ft
Q100	0.0	cfs			

NOTES:

DA	total drainage area to channel
C	composite C for total DA
Tc	Tc for total DA to channel
Q10	10-year peak
Q100	100-year peak
n	channel roughness
V10	velocity for Q10 (use for lining design)
d10	depth for Q10 (use for lining design)
d100	depth for Q100 (verify D/E width)

Cross-section, slope and lining material must be listed in construction notes

Insert this table on the profile near each culvert

CULVERT name

DA	0.00	ac	Ke	0.0	elev
C	0.0		n	0.000	
Tc	0.0	m			
Q10	0.0	cfs	h 10	0000.00	elev
Q100	0.0	cfs	h 100	0000.00	elev
TW	0000.00	elev	h road	0000.00	elev

NOTES:

DA	total drainage area to culvert
C	composite C for total DA
Tc	Tc for total DA to culvert
Q10	10-year peak
Q100	100-year peak
TW	assumed tailwater elev

Ke	assumed entrance loss coefficient
n	pipe roughness
h 10	headwater elevation for Q10
h 100	headwater elevation for Q100
h road	lowest elevation for overtopping

Size, slope and material must be listed in construction notes
Substitute Q50 for Q10 where 50-year minimum design required