CITY OF LAVON, TEXAS

ORDINANCE NO. 2021-06-02

Drainage Design Manual

AN ORDINANCE OF THE CITY COUNCIL OF THE CITY OF LAVON, TEXAS AMENDING SECTION 9.01.001 PUBLIC WORKS CONSTRUCTION, SECTION (A) ADOPTION OF STANDARDS OF THE CITY OF LAVON CODE OF ORDINANCES TO ADD SECTION (A)(3) TO ADOPT A DRAINAGE DESIGN MANUAL; PROVIDING A REPEALER CLAUSE; PROVIDING A SAVINGS CLAUSE; PROVIDING A SEVERABILITY CLAUSE; PROVIDING FOR A PENALTY OF FINE NOT TO EXCEED THE SUM OF TWO THOUSAND DOLLARS ($2,000.00); AND PROVIDING FOR AN EFFECTIVE DATE, PROVIDING A REPEALER CLAUSE; PROVIDING A SAVINGS CLAUSE; PROVIDING A SEVERABILITY CLAUSE; PROVIDING FOR A PENALTY OF FINE NOT TO EXCEED THE SUM OF TWO THOUSAND DOLLARS ($2,000.00); AND PROVIDING FOR AN EFFECTIVE DATE.

Whereas, the City Council of the City of Lavon, Texas, recognizes the important relationship between stormwater quantity, stormwater quality; and adequate public facilities; and

Whereas, pursuant to Texas Pollutant Discharge Elimination System (TPDES) as regulated by the Texas Commission on Environmental Quality, the City of Lavon is required to adhere to the Municipal Separate Storm Sewer System (MS4) permit regulating municipal stormwater system; and

WHEREAS, the standards are adopted to facilitate proper construction and design activities relating to stormwater drainage facilities within the City of Lavon, Texas advancing the public safety, health and general welfare; and

WHEREAS, the City Council conducted a public hearing on June 1, 2021 to receive input regarding the proposed regulations;

WHEREAS, the City Council finds it is in the best interested of the residents of the City of Lavon to adopt drainage design regulations.

NOW THEREFORE, BE IT ORDAINED BY THE CITY COUNCIL OF THE CITY OF LAVON, TEXAS, THAT:

SECTION 1. ADOPTION OF STANDARDS

The City Council of the City of Lavon hereby adopts the Drainage Design Manual dated May 28, 2021 Exhibit "A" (hereinafter referred to as "Standards").

SECTION 2. PENALTIES

That any person or corporation violating any of the provisions of the Standards adopted by this ordinance shall upon conviction be fined a sum not to exceed two thousand dollars ($2,000.00) per day and each and every day that the provisions of the Standards are violated shall be constituted a separate and distinct offense.

SECTION 3. REPEAL OF CONFLICTING ORDINANCES

All ordinances or parts of an ordinance inconsistent or in conflict herewith are, to the extent of such inconsistency or conflict, hereby repealed.

SECTION 4. SEVERABILITY

In the event any clause, phrase, provision, sentence, or any part of this Ordinance or the application of the same to any person or circumstances shall for any reason be adjudged invalid or held unconstitutional by a court of competent jurisdiction, it shall not affect, impair, or invalidate this Ordinance as a whole or any part or provisions hereof other than the part declared to be invalid or unconstitutional; and the City Council of the City of Lavon, declares that it would have passed each and every part of the same notwithstanding the omission of any such part thus declared to be invalid or unconstitutional, whether there be one or more parts.

SECTION 5. OPEN MEETING.

It is hereby officially found and determined that all notice required by law has been given and notice of this Ordinance was posted and the Ordinance passed in accordance with the Open Meeting Act.

SECTION 6. EFFECTIVE DATE.

This Ordinance shall take effect immediately from and after its passage and the publication of the caption, as the law in such cases provides.

DULY PASSED and APPROVED by the City Council of the City of Lavon, Texas, on the 1st day of June 2021.

Vicki Sanson
Mayor

CITY OF LAVON, TEXAS

ATTEST:

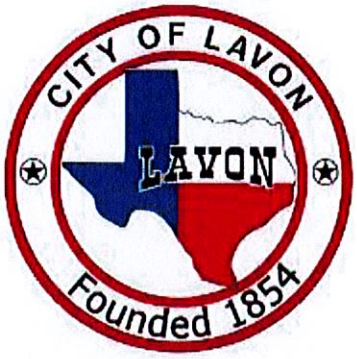
Rae Norton
City Secretary

CITY OF LAVON, TEXAS

ORDINANCE NO. 2021-06-02

EXHIBIT A

DRAINAGE DESIGN MANUAL



CITY OF LAVON
DRAINAGE DESIGN MANUAL

MAY 28, 2021

PART 1:GENERAL

1.01 PURPOSE

A. The purpose of the Drainage Design Manual is to provide a set of minimum standards for designing drainage facilities and preparing construction plans for such facilities that are to be owned, operated and/ or maintained by the City of Lavon, Texas. These standards will be used by the City Staff and consulting engineers employed by the City for the above described improvement projects, and engineers for private developments in the City of Lavon. Unusual circumstances or special designs requiring a variance from the standards in this manual may be approved by the City Administrator or designated authority.

1.02 STANDARDS OF DESIGN

A. The Standards of Design, as adopted by the City of Lavon, are set forth herein. These standards shall be considered as the minimum requirements, and it shall be the responsibility of the developer to determine if more stringent requirements are necessary for a particular development. It is not intended that the Standards of Design cover all aspects of a development. For those elements omitted, the developer will be expected to provide designs and facilities in accordance with good engineering practice and to cause to be constructed facilities utilizing first class workmanship and materials.

PART 2:DRAINAGE DESIGN

2.01 STORM DRAINAGE SYSTEM

A. The City of Lavon has adopted the North Central Texas Council of Governments iSWM Technical Manual, latest edition, to be used for design and construction of drainage facilities. Manuals adopted include: Planning, Water Quality, Hydrology, Hydraulics, Site Development Controls, Construction Controls, Construction Control Standard Details, Landscape, and Revisions to Manuals. Questions related to the use of the design methods to be used shall be determined by the City Engineer. These manuals are available from NCTOG at http://iswm.nctcog.org/.

B. Drainage facilities shall be designed and constructed at such locations and of such size and dimensions to adequately serve the development and the contributing drainage area above the development. The developer shall provide all the necessary easements and right-of-ways required for drainage structures including detention ponds, storm drains and open channels, lined or unlined. Easement widths for storm drain pipelines shall not be less than fifteen (15') feet, and easement widths for open channels shall be at least twenty-five (25') feet wider than the top width of the channel. In all cases, easements shall be of an adequate size to allow proper maintenance, including unobstructed access to the easements.

C. The design flows for the drainage system shall be calculated in accordance with the referenced iSWM methods referenced in this document. Curbs, inlets,

manholes, etc., shall be designed and constructed in accordance with the Standard Details. Materials and construction procedures shall conform to the requirements of the Standard Specifications for Construction.

D. **The developer shall comply with all requirements of the Environmental Protection Agency, the U.S. Army Corps of Engineers, State and Local Agencies and shall obtain all permits required by these agencies.**

E. The developer shall provide plans and specifications and design calculations for all drainage structures. The drainage facility requirements will depend on the type of street used within the subdivision as follows:

1. All storm water shall be carried within the paved street surface or in an enclosed pipe system or both.

2. Where an enclosed pipe system is required, a rock gabion lined open channel may be substituted for the pipe system when the equivalent pipe size exceeds 66-inches. For flows that exceed the capacity of an equivalent 84-inch pipe, an unlined open channel with a concrete pilot channel constructed in accordance with City Design Standards may be used. All open channels that are not rock gabion lined shall be designed to prevent erosion. The methods used to prevent erosion specifically shall be approved by the City Engineer.

3. The design, size, type and location of all storm drainage facilities shall be subject to the approval of the City Engineer. The requirements set forth herein are considered minimum requirements. The developer and his engineer shall bear the total responsibility for the adequacy of design. The approval of the facilities by the City Engineer in no way relieves the developer of this responsibility.

4. The developer shall be responsible for the necessary facilities to provide drainage patterns and drainage controls such that properties within the drainage area, whether upstream or downstream of the development, are not adversely affected by storm drainage from facilities on the development.

5. Storm drainage released from the site will be discharged to a natural water course of an adequate size to control the peak runoff expected after development.

2.02 HYDROLOGY

A. Design Criteria

1. In the iSWM Hydrology Manual, Table 1.1 Applications of the Recommended Hydrologic Methods, outlines the applicability of the various methods available to calculate rainfall runoff. The specific site characteristics shall be utilized to select the proper method of analysis.

B. Rainfall Intensities

1. In the iSWM Hydrology Manual, Section 5.0 Rainfall Tables provides rainfall intensities to be used for applicable hydrology methods.

2. The minimum storm frequency used will be according to the facility to be designed as listed in Table 3-1. Emergency overflows where used are to be located at sags and T-intersections of streets and designed to prevent erosion and surface water damage.

TABLE 1
DESIGN STORM FREQUENCY

Drainage Facility	Storm Frequency
Pipe storm sewers with emergency overflow to give a combined capacity of 100-year frequency	10 years
Pipe storm sewer with no emergency overflow	100 years
All open channels with a minimum of 2 feet freeboard above to the top of the bank	100 years
Culverts (pipe or concrete box)	100 years
Bridges, low point of bridge beams or similar bridge deck supporting structure to be 2 feet above 100-year storm or highest flood recorded, whichever is greater	100 years

C. Rational Method

1. Refer to the iSWM Hydrology Manual, Table 1.1 Applications of the Recommended Hydrologic Methods, for details of the use of the Rational and Modified Rational Methods.

D. Unit Hydrograph Method

1. Refer to the iSWM Hydrology Manual, Table 1.1 Applications of the Recommended Hydrologic Methods, for details on the unit hydrograph method.

E. Design According to FEMA-FIA Requirements

1. All streams that have floodway or flood plains designation by FEMA-FIA must be designated to meet the requirements of these agencies.

2.03 RUNOFF COEFFICIENTS AND TIME OF CONCENTRATION

A. Runoff coefficients and time of concentration calculations to be per the appropriate iSWM methodology.

2.04 DESIGN OF DRAINAGE FACILITIES

A. In the iSWM Hydraulics Manual, the following information can be found related to design of street drainage, closed conduit drainage, storage/detention design, open channels, culverts, bridges, and energy dissipation.

1. Flow in Gutters and Inlet Locations

a. Storm drain conduits shall begin at the point where the depth of flow based on the 100-year storm frequency reaches a point not greater than the top of curb elevation. For pavement sections that do not have curbs, including alleys, the 100-year storm shall be contained within the right-of-way. Inlets are then located as necessary to remove the flow based on a 10-year storm frequency. If, in the judgment of the Engineer, the flow in the gutter would be excessive under either of these conditions, then consideration should be given to extending the storm sewer to a point where the gutter flow can be intercepted by more reasonable inlet locations. Multiple inlets at a single location are permitted in extenuating circumstances. Where possible, inlets should be placed upstream from an intersection to prevent large amounts of water from running through intersections. Inlets should also be located on the approach street to an intersection and in alleys where necessary to prevent water from entering these intersections in amounts that would cause the allowed street capacity to be exceeded.

B. The use of the street for carrying storm water shall be limited to the following:

1. SPREAD OF WATER – 10-YEAR STORM FREQUENCY
   a. Class 1 Streets with curbs and gutters – One traffic lane on each side to remain clear.
   b. Class 2 Street – One traffic lane to remain clear.

2. SPREAD OF WATER – 100-YEAR STORM FREQUENCY
   a. Notwithstanding the requirements above, all storm water in the 100-year storm frequency shall be contained within the street or alley right-of-way or within the drainage easement. The water depth shall not be greater than any top of curb elevation

2.05 CAPACITY OF STREETS AND ALLEYS

A. Figure 1.2 in the iSWM Hydraulics Manual provides flow in triangular channels that may be used for computing the capacity of streets and alleys having a straight cross slope. The capacity of streets with parabolic crowns may be calculated from this nomograph using the composite section that most closely approximates the parabolic section. All street and alley capacities shall be calculated using a roughness coefficient of n = 0.0175

2.06 CAPACITY OF SWALES

A. The capacity of swales shall be calculated according to the Manning Equation. All calculations shall be made using a roughness coefficient from Table 3.5 of the iSWM Hydraulic Manual.

2.07 VALLEY GUTTERS

A. The use of valley gutters to convey storm water across a street intersection is subject to the following criteria:

1. A Class 1 street shall not be crossed with a valley gutter.
2. Wherever feasible, a Class 2 street shall not be crossed with a valley gutter.
3. At any intersection, perpendicular valley gutters will not be permitted and parallel valley gutters should cross only the lower classified street.

2.08 ALLEY CAPACITIES

A. In residential areas where the standard alley section capacity is exceeded, curbs may be used to provide needed capacity. However, all storm drainage shall be contained in the alley right-of-way and may not encroach onto private property especially at connecting driveways.

2.09 SIZING AND LOCATION OF INLETS

A. For determining the size and locations of inlets, the following shall be used as a minimum:

TABLE 2
INLET OPENING
REQUIREMENTS

Street Grade	Length of Inlet Opening for Each C.F.S. of Gutter Flow
Sags	0.6 Feet
Less than 2%	1.0 Feet
Greater than 3.5%	2.0 Feet

B. Inlets shall be spaced no closer than 300 feet apart without special permission from the City. The maximum length of an inlet at one location shall be 20 feet on each side of the street.

C. No more than 5 cfs can cross intersections in residential areas and no bypass of storm water across major intersections shall be allowed.

2.10 HYDRAULIC GRADIENT OF CONDUITS

A. After the computation of the quantity of storm runoff entering each inlet, the size and gradient of pipe required to carry off the design storm are to be determined.

All hydraulic gradient calculations shall begin at the outfall of the system. The following are the criteria for the starting elevation of the hydraulic gradient:

1. The 100-year water surface elevation in a creek, stream or other open channel is to be calculated for the time of peak pipe discharge in the same storm and that elevation used for beginning the hydraulic gradient.

2. When a proposed storm sewer is to be connected to an existing storm sewer system that has a design flow less than the proposed, the hydraulic gradient for the proposed storm sewer should start at the elevation of the existing storm sewers hydraulics gradient based on the proposed design year of the upstream system.

2.11 HYDRAULIC DESIGN OF CLOSED CONDUITS

A. All closed conduits shall be hydraulically designed for full flow as shown in Section 1 of the iSWM Hydraulics Manual.

B. The crown of the pipe should be near the elevation of the hydraulic gradient, in most cases to eliminate excessive excavation. The hydraulic gradient shall not be designed above the top of any inlet. The permissible difference between the hydraulic gradient and top of curb is normally 2 feet or $1.5\ V^2/2g$ where V is the velocity in feet per second and g is 32.2 feet per second. The hydraulic gradient in the inlet shall not be higher than 1 foot below the top of the inlet.

C. Velocity in Closed Conduits

1. Pipe grade shall be set to produce a velocity of not less than 3 feet per second (fps) when flowing full. Grades producing velocities of less than 3 fps will not be allowed. All storm sewer pipe and driveway culverts shall be a minimum of 18 inches in diameter. Discharge velocity shall be calculated with a tailwater depth not greater than the lesser of the top of the pipe at the pipe outlet or the actual 100-year water surface elevation in the channel.

2. Table 3 shows the maximum allowable velocities in closed conduits:

TABLE 3
RECOMMENDED MAXIMUM VELOCITY

Type of Conduit	Maximum Velocity
Culverts	15.0 fps
Inlet Laterals	15.0 fps
Storm Sewers	12.5 fps

3. Discharge velocities cannot exceed the permitted velocity of the channel or conduit at the outfall.

D. Roughness Coefficients for Conduits

1. The recommended value for the roughness coefficient "n" for concrete conduits with smooth joints and good alignment is 0.013. Where engineering judgment indicates a value other than 0.013 be used, the appropriate adjustments should be made in the calculations and the variance noted.

E. Head Losses

1. The use of pipe bends is discouraged and will be allowed only in special situations with the permission of the City Engineer.

2. Head losses and gains for wyes and pipe size changes will be calculated by the formulas:

Where $V_1 < V_2$ $\quad H_1=V_2^2/2g - V_1^2/2g$

Where $V_1 > V_2$ $\quad H_1=V_1^2/4g - V_2^2/4g$

Where:

H_1 = the head loss in feet measured at the point of wye or pipe size change

V_1 = upstream velocity

V_2 = downstream velocity

3. Head losses and gains for inlets, manholes and junction boxes will be calculated by the formula:

$$H_1=V_2^2/2g - K(V_1^2/2g)$$

Where:

H_1 = the head loss in feet measured from the downstream water surface elevation

V_1 = upstream velocity or velocity in the lateral

V_2 = downstream velocity

K = 0.50 for Inlet or junction box on main line

K = 1.25 for Manhole or inlet at beginning of line

K = 0.60 for 60° Wye Connection

K = 0.75 for 45° Wye Connection

K = 0.95 for 22.5° Wye Connection

4. Head losses for pipe bends will be calculated by the formula:

$$H_l = V^2/2g$$

Where:

H_l = the head loss in feet measured at the upstream end of the bend
V = the pipe velocity
$K = 0.50$ for 90° Bend
$K = 0.43$ for 60° Bend
$K = 0.35$ for 45° Bend
$K = 0.20$ for 22.5° Bend

5. In the case where the inlet is at the very beginning of a line, the equation becomes the following without any velocity of approach:

Where: $K_1 = 1.25$

$$H_l = V^2/2g$$

6. The minimum head loss to be used at wyes, junctions, manholes, and pipe size changes for design of storm drainage system is 0.10 foot.

2.12 OPEN CHANNELS

A. Open channels may be used to convey storm waters where closed conduits are not justified economically. A wide variety of lined, partially lined or unlined channels are permitted except that lined channels may not be constructed in single family, multi- family or City housing residential developments. All lined channels must be screened by continuous adjacent landscaping of at least 4 feet in height. In general, the use of existing channels in their natural condition is encouraged. Low flow pilot channel lining of earthen channels will be required for any earthen channel carrying more than the capacity of an equivalent 84" diameter pipe. The design of the low flow pilot channel shall conform to City Design Standards.

B. For residential developments, no more than two barrel box culverts will be permitted for stream crossings, except in unusual conditions. For unlined channel sections, the maximum side slopes are 4:1 and the maximum permitted mean velocity in the channel is 6 feet per second. Channel side slopes that are steeper than 5:1 shall be hydromulched in accordance with sections 202.6 of the NCTCOG Specifications. Temporary erosion control per Section 201 of the NCTCOG specifications is required for all channels.

C. For lined portions of channel sections, the sides may be vertical if the height of vertical wall does not exceed 3 feet. Paved and rip-rapped slopes are to have a side slope of 2:1 maximum. Permitted velocities in totally lined channels are 15 feet per second for finished concrete and 10 feet per second for rock rip-rap. Discharge velocities from lined channels may not exceed 6 feet per second. The

minimum velocity in any channel shall be greater than 2 fps, including roadway ditches.

2.13 HYDRAULIC DESIGN OF OPEN CHANNELS

A. The water surface as designed in an open channel is to be a minimum of 1 foot below the top of the channel section for concrete lined channels and 2 feet below the top of the channel section for rock rip-rap and earthen channels to provide a margin of safety for channel obstructions and for flows that exceed the design storm frequency.
B. Special care must be taken at entrances to closed conduits and culverts to provide the headwater requirements.

C. On all channels the water surface elevation, which is coincident with the hydraulic gradient, shall be calculated and shown on the construction plans.

D. Maximum allowable velocities and roughness coefficients for open channels are shown in Section 3.2.3 of the iSWM Hydraulics Manual. When the normal available grade would cause velocities in excess of the maximums, it may be necessary to design special drops or channel retards.

2.14 HYDRAULIC DESIGN OF CULVERTS

A. In the design of culverts, the Engineer shall keep head losses and velocities within reasonable limits while selecting the most economical structure. This normally requires selecting a structure that creates a head water condition and has a velocity of flow safely below the allowed maximum.

B. The vertical distance between the upstream design water surface and the roadway or bridge elevation is termed "freeboard". The dimension is included as a safety factor to protect against unusual clogging of the culvert and to provide a margin for future modifications in surrounding physical conditions. Normally, a minimum of 2 feet shall be considered a reasonable freeboard when the structure is designed to pass a design storm frequency of 100-years. Unusual surrounding physical conditions may be cause for a change in this requirement. Hydraulic design of culverts shall be in accordance with Chapter 3, iSWM Hydraulics Manual.

C. Headwalls and Entrance Conditions

1. Headwalls are to be used to protect the embankment from erosion and the culvert from displacement. Sloped headwalls conforming to the minimum slope specified in this Design Manual shall be constructed at the end of all pipe drainage facilities and vertical headwalls with wingwalls and aprons shall be constructed for all rectangular shaped hydraulic structures.

2. Special headwalls and wingwalls may be required at the entrance of all hydraulic structures where approach velocities are in excess of 8 feet per second. Culvert exit and headwall shall be designed such as the flow line of

the culvert is coincident with the flow line of the stream or channel into which the culvert discharges.

3. The maximum exit velocity from the culvert is limited to the maximum velocity allowed in the stream or channel. Concrete rip-rap is to be sued to protect the stream bed from scour and erosion. The rip-rap shall be reinforced and have toe walls to prevent undermining.

D. Headwalls and Exit Conditions

1. Headwalls are used to protect the embankment from erosion and the culvert from displacement. The headwalls, with or without wingwalls and aprons, shall be constructed in accordance with the standard drawings as required by the physical conditions of the particular installation.

2. Culvert exits and headwalls shall be designed such that the flow line of the culvert is coincident with the flow line of the stream or channel into which the culvert discharges. The maximum exit velocity from the culvert is limited to the maximum velocity allowed in the stream or channel.

3. Due to the geometry of the culvert-stream intersection, turbulence or other conditions may tend to produce erosion. Concrete rip-rap will be used to protect the stream bed from scour and erosion. The rip-rap shall be reinforced and have toe walls to prevent undermining.

E. Bridge Design Hydraulics

1. Once a design discharge and a downstream depth of flow have been determined, the size of the bridge opening can be determined. Determination of head losses through bridge structures shall be calculated.
2. The City of Lavon has the following policy with regard to the hydraulic design of bridge structures:
   a. Minor head loss due to the structure is allowed. Normal losses due to channel cross sections are allowable.
   b. Excavation of the natural channel is not normally allowed as compensation for loss of cross sectional area.
   c. Channelization upstream or downstream of the proposed bridge will normally not be permitted.
   d. Hydraulic design for bridges shall conform to the requirements of Chapter 3, iSWM Hydraulics Manual
   e. Two feet of freeboard is required between the 100-Year water surface and the bottom of the lowest beam.
   f. Bridge design shall meet all FEMA requirements when a designated floodway is crossed.

F. Detention

1. Detention will be required to prevent adverse impact up and downstream of new projects. The methods outlined in iSWM will be used to evaluate the

impact and necessary detention. In addition, to demonstrate no adverse impact, iSWM methods will be followed for those determinations.

2.15 CONSTRUCTION PLANS PREPARATION

A. Drainage Area Map

1. The drainage area map shall have a minimum scale of 1" = 200', and show the street right-of-way. For large drainage areas, a map having a minimum scale of 1" = 2000' is usually sufficient.

2. The following items/information shall be included:
   a. Acres, coefficient, and intensity for each drainage sub-area;
   b. Inlets, their size and location, the flow bypass for each, the direction of flow as indicated by flow arrows, the station for the centerline of the line;

3. Existing and proposed storm sewers;

4. Sub-areas for alleys, streets, and off-site areas;

5. Points of concentration;

6. Runoff to all inlets, dead-end streets, and alleys or to adjacent additions and/or lots;

7. A table for runoff computations;

8. Flow arrows to indicate all crests, sags and street and alley intersections;

9. North arrow;

10. Any off-site drainage shall be included;

11. Street names shall be included;

12. 100-year floodplain shall be indicated on the drainage area map.

13. When calculating runoff, the drainage area map shall show the boundary of the drainage area contributing runoff into the proposed system. This boundary should be determined from a map having a maximum contour interval of two (2) feet. The area shall be further divided into sub-areas to determine flow concentration points or inlet locations. The centerline of all streets (except Residential of Local Streets) will normally be a boundary of a drainage area, to insure that inlets are sized and positioned to fill the need without depending on storm water crossing over the street crown for proper drainage.

14. In residential areas, the centerline of the street will only be used as a drainage area boundary if the flow in either gutter has not exceeded the street crown elevation.

15. Direction of flow within streets, alleys, natural and man-made drainage ways, and at all system intersections, shall be clearly shown on the drainage area map and/or paving plans. Existing and proposed drainage inlets, storm sewer pipe systems and drainage channels shall also be clearly shown and identified on the drainage area map. Storm sewers shall show and mark station ticmarks at 100-foot intervals. Plan-profile storm sewer or drainage improvement sheet limits and match lines shall be shown with pipes and channels identified.

16. The drainage area map should show enough topography to easily determine its location within the City.

B. Plan-profile Sheets

1. Inlets

   a. Inlets shall be given the same number designation as the area or sub-area contributing runoff to the inlet. The inlet number designation shall be shown opposite the inlet. Inlets shall be located at or immediately downstream of drainage concentration points. At intersections, where possible, the end of the inlet shall be ten feet from the curb return P.T., and the inlet location shall also provide minimum interference with the use of adjacent property. Inlets in residential areas should be located in streets and alleys so the driveway access is not prohibited to the lots. Inlets located directly above storm sewer lines, as well as lateral passing through an inlet, shall be avoided. Drainage from abutting properties shall not be impaired, and shall be designed into the storm drainage system.

   b. Data opposite each inlet shall include paving or storm sewer stationing at centerline of inlet, size and type of inlet number or designation, top of curb elevation and flow line of inlet as shown on construction plans.

2. Laterals

   a. Inlet laterals leading to storm sewers, where possible, shall enter the inlet and the storm drain main at a 60-degree angle from the street side. Laterals shall be four (4) feet from top of curb to flow line of inlet, unless utilities or storm sewer depth requires otherwise. Laterals shall not enter the corners or bottoms of inlets. Lateral profiles shall be drawn showing appropriate information including the hydraulic gradient and utility crossings. Short lateral (30 feet or less) crossings utility lines will be profiled.

3. Storm Sewer

   a. In the plan view, the storm sewer designations, size of pipe, and length of each size pipe shall be shown adjacent to the storm sewer. The sewer plan shall be stationed at one hundred (100) foot intervals, and each sheet shall begin and end with even or fifty (50) foot stationing. All storm sewer components shall be stationed.

b. The profile portion of the storm sewer plan-profile sheet shall show the existing and proposed ground profile along the centerline of the proposed sewer, the hydraulic gradient of the sewer, the proposed storm sewer, and utilities that intersect the alignment of the proposed storm sewer. Also, shown shall be the diameter of the proposed pipe in inches, and the physical grade in percent. Hydraulic data for each length of storm sewer between interception points shall be shown on the profile. This data shall consist of pipe diameter in inches, the 100-year design storm discharge in cubic feet per second, slope of hydraulic gradient in percent, Manning capacity of the pipe flowing full in cubic feet per second, velocity in feet per second, and $V^2/2g$. Also, the head loss at each interception point shall be shown.

c. Elevations of the flow line of the proposed storm sewer shall be shown at one hundred (100) foot intervals on the profile. Stationing and flow line elevations shall also be shown at all pipe grade changes, pipe size changes, lateral connections, manholes and wye connections. All soffits shall be connected.

4. Plan Profile and Details Sheets

a. All plan sheets shall be drawn on 24"x36" or 22"x34" sheets, to a standard engineering scale, and shall be clearly legible when sheets are reduced to half scale. After each review, all review comments shall be addressed, additional data incorporated, and drafting of plans completed. Each plan-profile sheet shall have a benchmark shown.

2.16 CHECK LIST FOR STORM DRAINAGE PLANS

A. Drainage Area Map

1. Normally, use 1" = 200' scale for on-site, and 1" = 400' for off-site. Show match lines between any two (2) or more maps.

2. Show existing and proposed storm drains and inlets with designations.

3. Indicate sub-areas for alley, street, and off-site areas.

4. Indicate contours on map for on and off-site.

5. Use design criteria as shown in design manual.

6. Indicate zoning on drainage area map.

7. Show points of concentration and their designations.

8. Indicate runoff at all inlets, dead-end streets and alleys, or to and from adjacent additions or acreage.

9. Provide runoff calculations for all areas showing acreage, runoff coefficient, and inlet time. (Q = CIA table)

10. For cumulative runoff, show calculations.

11. Indicate all crests, sags, and street and alley intersections with flow arrows.

12. Identify direction of north to top page or the left.

13. Show limits of 100-year fully developed flood plain on drainage area map.

B. Storm Sewers

1. Diversion of flow from one natural drainage area to another will not be allowed.

2. Show plan and profile of all storm sewers.

3. Specify Class III Reinforced Concrete Pipe (RCP) or High-Density Polyethylene Pipe (HDPE) unless otherwise approved by the City Engineer in private drainage easements maintained by other than the City of Lavon.

4. Use heavier than Class III pipes where crossing streets, railroads, areas of deep fill and areas subjected to heavy loads.

5. Specify concrete strength for all structures. The minimum allowable is 4000 psi.

6. Provide inlets where street capacity is exceeded. Provide inlets where alley or driveway runoff exceeds intersecting street capacity.

7. Do not allow storm water flow from streets into alleys.

8. Do not use high velocities in storm sewer design. A maximum discharge velocity of six (6) fps at the outfall is required. Velocity dissipation may be necessary to reduce erosion.

9. Flumes may not be allowed unless specifically designated, and will not be allowed on Class 1 & 2 thoroughfares.

10. Provide headwalls and aprons for all storm sewer outfalls. Provide rip-rap around headwalls where slopes exceed 4:1.

11. Discharge flow lines of storm sewers to be two (2) feet above the flow line or creeks and channels, unless channel lining is present. Energy dissipation shall be provided when specified by the City Engineer.

12. Where fill is proposed for trench cut in creeks or outfall ditches, compaction shall be 95% of the maximum density as determined by ASTM D 698.

13. Investigations shall be made by the engineer to validate the adequacy of the storm sewer outfall to a major stream.

14. Outfall area must have adequate capacity to carry the discharge. Provide erosion control facilities with hydraulic data.

15. Any off-site drainage work or discharge to downstream property will require an easement. Easements shall be sized such that the developed flows can be conveyed within the easement. Submit field notes for off-site easement that may be required (Private development only).

C. Plan and Profile

1. Indicate property lines and lot lines along storm sewers, and show easements with dimensions.

2. If necessary, provide separate plan and profile of storm sewers, the storm drain pipes should also be shown on paving plans with a dashed line, and on sanitary sewer profiles showing the full pipe section

3. Tie storm sewer system stationing with paving stations.

4. Show pipe sizes in plan and profile.

5. Show hydraulics on each segment of pipe profile to include: Q_{10}, Q_{100}, C = Manning full flow capacity, S, V, $V^2/2g$.

6. Show curve data for all storm sewer system.

7. Show all existing utilities in plan and profile. On storm sewer profiles, as a minimum, the sanitary sewer profile will be shown.

8. Indicate existing and proposed ground line and improvements on all street, alley, and storm sewer profiles.

9. Show future streets and grades where applicable.

10. Where connections are made to existing storm sewer show computations on existing system when available. HGL will be calculated from the outfall to the connections point including the designed flows of the added on systems.

11. Indicate flow line elevations of storm sewers on profile, show pipe slope (percent grade). Match top inside of pipe where adjacent to other size pipe.

12. Intersect laterals at sixty (60) degrees with trunk line.

13. Show details of all junction boxes, headwalls, storm sewers, flumes, and manholes, when more than one pipe intersects the drainage facility or any other item that is not a standard detail.

14. Pipe direction changes will be curves using radius pipe unless approved by the City Engineer.

15. Bends in pipe may be used in unusual circumstances with approval of the City Engineer. No bend at one location may exceed thirty (30) degrees.

16. Do not use 90-degree turns on storm sewers or outfalls. Provide good alignment with junction structures or manholes (for small systems).

17. Profile outfall with typical flat bottom section.

18. Show all hydraulics, velocity head changes, gradients, and computations.

19. Show water surface at outfall or storm drain.

20. On all dead-end streets and alleys and storm sewer outfalls, show grade out to "daylight" for drainage on the profiles and provide erosion control. Show typical section and slope of "daylight" drainage. Side slopes shall not exceed 4H:1V.

21. At sags in pavement, provide a positive overflow (paved sidewalk in a swale) to act as a safety path for failure of the storm drain system. Minimum finished floor elevations will be shown on the plat to protect building against flooding should the positive overflow be used.

22. Where quantities of runoff are shown on plans or profiles, indicate storm frequency design.

23. Provide sections for road, railroad and other ditches with profiles and hydraulic computations. Show design water surface on profile.

24. For drainage ditches located in street right-of-way running parallel to street paving, show the size of each driveway culvert on the ditch profile. Assume the maximum number and width of driveways allowed for each lot. Show the hydraulic grade lines as required herein.

D. Laterals

1. Show laterals on trunk profile with stations.

2. Provide lateral profiles for laterals exceeding thirty (30) feet in length.

3. Where laterals tie into trunk lines, place at sixty (60) degree angles with centerlines. Connect them so that the longitudinal centers intersect.

4. Calculate hydraulic grade line for laterals and inlets to insure collection of storm water. Check $1.5V^2/2g$, using trunk line velocity on laterals less than 80-feet long. The H.G. at the gutter or inlet lip by adding the $1.5\ V^2/\ 2g$ to the

hydraulic gradient of the trunk line at the lateral connection. For all inlets, provide HGL and hydraulic data on profile for all profiled laterals. Lateral longer than eight (80) feet require special analysis.

5. All inlets shall have a minimum eighteen (18) inch laterals.

E. Inlets and Intakes

1. Provide inlets where street capacity is exceeded. Provide inlets where runoff from alley causes the capacity of the intersecting street to be exceeded.

2. Indicate runoff concentrating at all inlets and direction of flow. Show runoff for all stub outs, pipes and intakes.

3. On plan view, indicate size of inlet, lateral size, flow line, top-of-curb elevations, paving station, and inlet designation number.

4. Use standard curb inlets in streets. Use recessed inlets in divided streets. Use combination inlets in alleys when on a straight run. Do not use grate or combination inlet unless other solution is not available (special situation).

5. Use type "Y" or special "Y" inlets in ditches or swales. No "Glory Holes" allowed as intake for a storm sewer or at a culvert. A three (3) foot concrete apron shall be constructed around "Y" inlets.

F. Paving

1. Provide six (6) inch curb on alleys parallel to creek or channel on creek side of alley.

2. For a proposed driveway turnout, curb return P.T. must be 10 feet upstream from any existing or proposed inlet, or 5 feet downstream of a standard inlet.

3. Check the need for curbing at all alley turns and "T" intersections. Flatten grades ahead of turns and intersections.

4. Where inlets are placed in an alley, provide curbing for 10 feet on each side of combination inlets.

G. Detention Basins

1. Provide drainage area map and show all computations for runoff affecting the detention basin.

2. Provide a plot plan with existing and proposed contours for the detention basin and plan for structural measures.

3. Where earth embankment is proposed for impoundment, furnish a typical embankment section and specifications for fill include profile for the structural outflow structure and geotechnical report.

4. Provide structural details and calculations for any item not a standard detail.

5. Provide detention basin volume calculations and elevation versus storage curve.

6. Provide hydraulic calculations for outflow structure and elevation versus discharge curve.

7. Provide routings or modified rational determination of storage requirements demonstrating that critical duration is used as allowed by iSWM.

8. Fencing may be required around detention area.

H. Bridges

1. Clear the lowest member of the bridge by 2 feet above the design water surface, unless otherwise directed by the City Engineer.

2. Show geotechnical soil boring information on plan.

3. Show bridge sections upstream and downstream.

4. Provide structural details and calculations with dead load deflection diagram.

5. Provide vertical and horizontal alignment.

6. Show soil erosion protection measures and concrete rip-rap.