HUNT COUNTY

ENGINEERING STANDARDS MANUAL

APPROVED BY COMMISSIONERS COURT ON DECEMBER 22, 2020

by

Order #16548

Table of Contents

[This Page Intentionally Left Blank for Double-Sided Printing]

CHAPTER 1. DRAINAGE GENERAL PROVISIONS

1.1 Authority

These regulations are adopted by the Commissioners' Court of Hunt County, Texas, acting in its capacity as the governing body of Hunt County. The authority of Hunt County to adopt these regulations and for the contents hereof is derived from the following statutes: Section 232.003 of the Texas Local Government Code (LGC), Texas Transportation Code Section 251.001 – 251.019 and Section 254.001 – 254.019, as amended; the State of Texas Flood Control Insurance Act (Texas Water Code Section 16.315); and the National Flood Insurance Act, as amended. These regulations may be amended at any time by a majority of Commissioners' Court.

1.2 Drainage Goals and Objectives

The purpose of the policies and design standards set forth herein is to ensure a consistent and adequate approach to stormwater management within Hunt County, Texas. This authority is explicitly granted to the County through State and National legal statutes listed in **Section 1.1**. The County's regulations were developed in adherence with this general authority. Applicable provisions are summarized below and are hereby adopted as governing stormwater management goals and objectives:

1. Adopt reasonable specifications to provide adequate drainage for each street or road in a subdivision in accordance with standard engineering practices
2. Adopt reasonable specifications that provide for drainage in a subdivision to:
    a. Efficiently manage the flow of stormwater runoff in the subdivision; and
    b. Coordinate subdivision drainage with the general storm drainage pattern for the area
3. Require plats to provide for drainage in a subdivision to:
    a. Provide positive drainage away from all buildings
    b. Coordinate individual lot drainage with the general storm drainage pattern for the area
4. Guide the development of proposed future construction, where practicable, away from locations which are threatened by flood hazards
5. Assist in minimizing damage caused by floods
6. Satisfy criteria adopted by the United States Department of Housing and Urban Development (HUD) pursuant to the National Flood Insurance Program (NFIP), the National Flood Insurance Act, and other applicable Federal Emergency Management Agency (FEMA) regulations relating to floodplain management
7. Engage in floodplain management and adopt enforcing permanent land use and control measures that improve the long-range management and use of flood-prone areas

This manual is intended to supplement the *Hunt County Subdivision and Land Development Regulations* with procedures and technical criteria to meet the County's adopted policies. If any policies and requirements set forth herein conflict with, or are inconsistent with, criteria outlined elsewhere, the more stringent criteria shall apply.

1.3 Applicability of Stormwater Criteria

These regulations apply for all subdivision activity in any unincorporated area of Hunt County, Texas, and those areas where Hunt County maintains the rights-of-way. Floodplain development activity is regulated in NFIP-designated areas under the provisions outlined in **Chapter 5** and the County's *Flood Damage Prevention Ordinance*.

Development that does not meet the applicability requirements outlined above will not require a drainage plan submittal. However, all subdivision applications shall comply with the *Hunt County Subdivision and Land Development Regulations* and development permitting requirements, including but not limited to: building permits, floodplain development permits, SWPPP, and grading permits.

1.4 Drainage Plan Requirements

A drainage plan is required for every Preliminary Plat, Final Plat, and Construction Plans submission as required under **Section 4** of the *Hunt County Subdivision and Land Development Regulations*. The drainage plan shall include sufficient information to determine the quantity of runoff traveling to, through, and from the proposed subdivision or roadway. The drainage plan shall provide calculations and other supporting data which shall be sufficiently detailed to demonstrate conformance with the technical standards and criteria of this manual, including demonstrating no adverse impacts to downstream or adjacent properties, as detailed in **Section 2.3**.

1.4.1 Acceptable Modeling Software

The design of storm drainage facilities can be aided by and sometimes requires the use of hydrologic and hydraulic modeling programs. **Table 1** lists several widely used modeling software which are acceptable to the County. The use of a program that is not included in the list requires prior approval by the County's engineering representative.

Table 1: Acceptable Hydrologic and Hydraulic Modeling Programs

Software	Hydrologic Calculations	Hydraulic Calculations	FEMA Approved	Water Quality Features
HEC-HMS	X		X	
HEC-RAS		X	X	
HydroCAD	X	X		X
Bentley Suite – CulvertMaster, FlowMaster, PondPack, StormCAD, GEOPAK Drainage	X	X	(X)	

The most recent version of the program should generally be used unless utilizing an approved effective model developed using a previous version, and in other instances as approved by the County's engineering representative. Only Federal Emergency Management Agency (FEMA) approved software can be used for design within NFIP-designated areas.

1.5 Permitting Requirements

Developments subject to these requirements may also be subject to other federal, state, and local regulations and permits. The engineer is responsible for coordinating with the appropriate regulatory agencies to ensure compliance with these requirements. Potential applicable regulations and permits may include, but are not limited to:

1. Section 404 of the Clean Water Act (CWA)
2. Section 106 of the National Historic Preservation Act
3. Water Rights
4. Section 303(d) Impaired Waters
5. Migratory Bird Treaty Act
6. Water Well Drilling
7. Threatened and Endangered Species Act
8. The Texas Archeological and Research Laboratory Requirements
9. The Antiquities Code of Texas
10. Air Quality
11. Texas Commission on Environmental Quality (TCEQ) Dam Safety Requirements

1.6 Maintenance of Permanent Drainage Facilities

For the purposes of this manual, “private water” refers to runoff which is generated on private property and flowing within the property or from one property or another. “Public water” refers to runoff flowing through or from public land or right-of-way. “Public” and “private” drainage systems and facilities refer to systems and facilities managing public and private water, respectively.

1.6.1 Drainage Easements

Easements are required for all public drainage systems that convey stormwater runoff across a development and shall be required for both on-site and off-site public stormwater drainage improvements, including standard engineered channels, storm drain systems, detention and retention facilities, and other stormwater controls. All drainage easements shall be recorded on the plat. The drainage easement must include sufficient area for operation and maintenance of the drainage system, and the developer shall obtain downstream drainage easements until adequate outfall is determined in accordance with **Section 2.3**.

Minimum easement requirements are discussed in the following sections. Special circumstances may require additional easement allocation at the discretion of the County’s engineering representative or their designee. Easements shall be kept free and clear of encroachments, unless otherwise approved by the County’s engineering representative or their designee.

1.6.1.1 Open Channels

Existing creeks or other open drainage channels within subdivisions will remain as open channels and will be maintained by the individual owners of properties that are traversed by or adjacent to the drainage channels. Open channels constructed as part of a roadway improvement project shall be fully contained within the public right-of-way and/or a drainage easement of sufficient width. Except for those channels contained within the right-of-way, the County will not be responsible for the maintenance and operation of open drainage ways.

Development within an NFIP regulated floodplain is regulated under the provisions of **Chapter 5** of this manual and the County's *Flood Damage Prevention Ordinance*.

1.6.1.2 Storm Sewer Easements

The minimum width of the storm sewer easement shall be the outside diameter of the storm sewer pipe or horizontal dimension of the storm sewer box plus 10 feet. Easement widths will be rounded up to the nearest 5-foot increment. For pipes or boxes in parallel, the minimum easement shall be equal to the width of the parallel storm drain system plus 10 feet. The minimum storm sewer easement that shall be provided in any case is 15 feet. Storm sewers shall be centered within the limits of the easement.

1.6.1.3 Other Public Stormwater Facilities

Drainage easements for structural overflows, swales, and berms shall be of sufficient width to encompass the structure or graded area. The proposed centerline of overflow swales shall normally coincide with the centerline of the easement. Drainage easements will generally extend at least 25 feet past an outfall headwall to provide an area for maintenance operations.

Easements for other public stormwater controls, including detention basins, sediment traps, and retention ponds, shall be negotiated between the County and the developer but will normally include essential access to all embankment areas and inlet and outlet controls. Essential access is defined as access in at least one location. The entire reach or each section of any drainage facility must be readily accessible to maintenance equipment. Additional easement(s) shall be required at the access point(s), and the access points shall be appropriately designed to restrict access by the public.

1.6.2 Operations and Maintenance

The County will provide for perpetual maintenance, in accordance with adopted County maintenance standards, of all public drainage facilities located within dedicated easements and constructed to the County standards. Access shall be provided and dedicated by the developer to all public drainage facilities in developments for maintenance and inspection by the County.

Maintenance of all private drainage facilities constructed within a development and any existing or natural drainage systems to remain in use by the development shall be the responsibility of the private property owner. In the case of a drainage facility servicing multiple lots in a residential subdivision, the Homeowners Association (HOA) shall bear the maintenance responsibility. Maintenance shall be provided to the degree and at the frequency as is necessary to ensure long- term functionality of the stormwater drainage facility as designed. The maintenance responsibility shall be recorded on the plat, and these provisions shall remain in-force upon sale of transfer of the property.

1.6.3 Inspections

The County maintains the right to inspect public and privately owned stormwater drainage facilities and enforce provisions of this manual and the *Hunt County Subdivision and Land Development Regulations*.

CHAPTER 2. DRAINAGE DESIGN GUIDELINES

2.1 Design Frequency for Drainage Features

The level of service provided by drainage infrastructure is most often presented as a design frequency. The frequency of a rainfall event is the recurrence interval of storms having the same duration and volume (depth). Table 2 lists the minimum design frequencies to be used in the design of drainage facilities.

Table 2: Design Frequency for Drainage System Design

Type of Facility	Minimum Design Frequency
Storm Drains (Closed Systems)	50-Year**
Streets*	100-Year
Roadside Ditches	50-Year**
Culverts and Bridges	See **Section 4.5.1**
Modified Natural Channels	100-Year

**in combination with closed storm drains and roadside ditches, as applicable*

***allowances made for instances where capacity is limited by ROW or existing downstream drainage infrastructure*

As noted, storm drains and roadside ditches shall generally be designed with capacity for the 50-year event. However, in instances where capacity of these systems is limited by the available right-of-way in a standard street section and/or by the capacity of existing downstream drainage infrastructure, the County's engineering representative or their designee may approve a lower level of service. In all cases, the provisions of the County's *Flood Damage Prevention Ordinance* and the no adverse impacts criteria outlined in **Section 2.3** must be met.

2.2 Drainage Calculations and Roughness Coefficients

Calculations must be submitted to support design of drainage facilities. Where applicable, maximum permissible velocities and "n" coefficient for use in Manning's Formula applications shall conform to the values outlined in Table 3.

Table 3: Roughness Coefficients and Permissible Velocities

Type of Section/Feature	Roughness Coefficient "n"	Maximum Permissible Velocity (fps)
Natural Streams		
Stream Section		6
Some Grass and Weeds; Little or No Brush	0.045	
Dense Growth of Grass or Brush	0.055	
Dense Brush and Trees	0.065	
Floodplain/Overbank Areas		6
Grass, Weeds; Some Brush and Trees	0.045	
Dense Grass, Weeds or Brush	0.055	
Dense Brush and Trees	0.080	
Buildings	0.500	N/A
Constructed/Modified Open Channels		
Grass Lined Ditches	0.035	6
Concrete Lined Channels	0.015	15
Streets		
Finished Concrete	0.015	N/A
Rough Concrete	0.018	
Asphalt	0.015	
Pipes and Culverts		
Reinforced Concrete Pipe (RCP)	0.013	15
Corrugated Metal Pipe	0.022	
High-Density Polyethylene Pipe (HDPE)	0.011	
Concrete Box Culvert	0.015	

2.3 Downstream Impact Analysis

The design of a storm drainage system must account for offsite flows, flows generated by the development or roadway, and the impacts on the downstream drainage system. To determine the effects of the proposed development on the downstream watershed, the County requires a downstream impact analysis to be provided. The analysis methodology shall be consistent with the procedures outlined in the North Central Texas Council of Governments (NCTCOG) integrated Stormwater Management (iSWM) *Technical Manual for Hydrology*.

2.3.1 Applicable Criteria

The process of evaluating downstream impacts requires an assessment of the downstream watershed from the outfall of a development through the site's zone of influence to an adequate outfall downstream. The zone of influence is the point downstream where the discharge from a proposed development no longer has a significant impact upon the receiving stream or storm drainage system. An adequate outfall is a structure or location that is adequately designed as to not cause adverse impacts to adjacent or downstream properties or facilities. An adequate outfall shall have capacity to convey any increased stormwater runoff from the site. The requirements for demonstrating an adequate outfall are listed in Table 4.

Table 4: Adequate Outfall (Adverse Impact) Determination

Item	Parameter	Adverse Impact Determination
1	**Inhabitable Structures**	• No new or increased flooding (0.00 feet) of existing insurable (FEMA) structures (inhabitable buildings).
2	**Flood Elevations**	• No increase (0.00 feet) in the 2-, 10-, 25-, and 100-year water surface elevations unless contained within the owner's property or within an existing channel, roadway, drainage easement, and ROW. • Dry lane and gutter capacity requirements set forth in Table 8 shall also be met.
3	**Floodplain Regulations**	• Where provisions of the County's *Flood Damage Prevention Ordinance* may be more restrictive, the floodplain regulations shall have authority over the above provisions.
4	**Channel Velocities**	• Proposed channel velocities for 2-, 10-, 25-, and 100-year storms cannot exceed the applicable maximum permissible velocity shown in Table 3. • If existing channel velocities exceed maximum permissible velocities shown in Table 3, no more than a 5% increase in velocities will be allowed. • Exceptions to these criteria will require certified geotechnical/ geomorphologic studies that provide documentation that the higher velocities will not create additional erosion.
5	**Downstream Discharges**	• No increase in downstream discharges caused by the proposed development that, in combination with existing discharges, exceeds the existing capacity of the downstream storm drainage system or existing right-of-way.

It shall be the responsibility of the engineer to contact the County and inquire about other proposed or approved developments within the zone of influence. At the direction of the County's engineering representative or their designee, these developments shall be accounted for in the downstream assessment.

2.3.2 Guidance

Generally, the zone of influence will be defined by a detailed hydrologic and hydraulic analysis. For watersheds of 100 acres or less at any proposed outfall, the 10% rule of thumb may be used in order to determine the zone of influence. The 10% rule states the zone of influence is considered to be the point where the drainage area controlled by the drainage facility comprises 10% of the total drainage area. If a portion of a larger property is being developed, the zone of influence shall be determined based on the entire property. A detailed study may be required for any drainage area regardless of size at the discretion of the County's engineering representative or their designee.

In most cases, the downstream analysis will begin with a comparison of pre- and post-development hydrology. In some cases, the engineer may be able to demonstrate no adverse impacts through a hydrological study by demonstrating no increases in peak flow rates through the zone of influence. If the development or roadway includes fill or alteration to an existing floodplain or other natural drainage course, a hydraulic analysis will be required to evaluate water surface impacts and channel velocities, even if the post-development peak flows through the zone of influence do not exceed the peak flows under pre-development conditions. A full hydraulic analysis may be required at the discretion of the County's engineering representative or their designee.

2.4 Drainage Considerations for Site Grading

2.4.1 Grading Plans

The natural flow of surface waters shall not be diverted or impounded in a manner that damages adjacent property. The County also restricts lot-to-lot drainage for small lots. No lot less than 1 acre may receive drainage from more than 1 additional lot.

To demonstrate compliance with these and other site grading criteria, grading plans shall be submitted for any land disturbance activities. Existing (pre-project) and proposed (post-project) contours shall be shown. If an existing site has been cleared and/or graded within the prior five years of the date of the developer's initial application submittal, the developer may consider the land conditions prior to the clearing and grading to be the existing site conditions.

2.4.2 Concentrated Runoff from Development

Site runoff due to development shall not cause adverse impacts. Generally, stormwater runoff from the development or roadway must match the runoff flow characteristics including peak flow, flow velocity, and flow type (sheet flow, concentrated flow, etc.) of pre-development conditions. When offsite grading is required or when the development or roadway discharges concentrated flow on an adjacent property, off-site conveyance to reach an adequate outfall shall be contained within a drainage easement of sufficient width obtained from the affected property owner(s).

2.4.3 Minimum Finished Floor Elevations

Any inhabitable structure shall have a finished floor elevation that meets the criteria of the County's *Flood Damage Prevention Ordinance*. For developments outside of the floodplain, minimum finished floor elevations shall be at or above the edge of pavement or rear property line, whichever is lower, unless otherwise approved by the County's engineering representative or their designee. For lots adjacent to or in the influence of a sump area and a positive overflow, the lot elevation will be at or above the sump area edge of pavement or the possible maximum pool elevation when the positive overflow is functioning, whichever elevation is higher. Refer to **Section 4.2.4** for additional information on positive overflow requirements.

CHAPTER 3. DESIGN DISCHARGE DETERMINATION

Determination of design discharges for drainage facilities shall be made considering the existing development conditions and land use of the contributing watershed. The appropriate hydrologic methodology shall be employed. See **Section 3.4** for further guidance.

3.1 Rainfall Intensities

The National Oceanic and Atmospheric Administration (NOAA) *Atlas 14, Volume 11 Precipitation-Frequency Atlas of the United States, Texas (2018)* is recognized as the best available set of rainfall data for the State of Texas. *Atlas 14* provides point precipitation frequency values, with rainfall intensity values varying slightly across the County. A single coordinate (33.1333,-96.0880) has been selected to define standard rainfall intensity values throughout the County. The standard rainfall intensities are listed in Table 5.

Table 5: Design Rainfall Intensities

Duration		Rainfall Intensity (in/hr) by Return Period						
Min	Hr	1-Year	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
5	**0.083**	5.32	6.06	7.31	8.33	9.71	10.74	11.77
10	**0.167**	4.25	4.85	5.85	6.66	7.80	8.64	9.42
15	**0.25**	3.54	4.04	4.84	5.52	6.44	7.12	7.80
30	**0.5**	2.48	2.82	3.38	3.84	4.46	4.92	5.38
60	**1**	1.62	1.85	2.23	2.53	2.95	3.27	3.58
120	**2**	1.00	1.16	1.42	1.63	1.92	2.14	2.37
180	**3**	0.74	0.87	1.07	1.24	1.48	1.65	1.84
360	**6**	0.44	0.52	0.65	0.76	0.91	1.03	1.15
720	**12**	0.26	0.31	0.39	0.45	0.55	0.62	0.70
1440	**24**	0.15	0.18	0.23	0.26	0.32	0.36	0.41

3.2 Drainage Areas

Drainage area maps and runoff calculations shall include all drainage areas contributing to the site. Separate drainage area maps and runoff calculations shall be prepared for both the existing (pre-project) drainage area and the proposed (post-project) drainage area. Drainage areas shall follow natural drainage features if future land disturbance is unknown or existing areas will not be changing under proposed conditions.

Drainage area determinations shall be based on site survey and proposed grading plans, supplemented by recent aerial imagery and topographic maps. Delineations shall be performed utilizing a maximum 2-foot contour interval for existing drainage areas and a maximum 1-foot contour interval for proposed drainage areas. The performance of topographic survey used to delineate drainage areas is the responsibility of the engineer designing the drainage facility.

3.3 Time of Concentration

The time of concentration (T_c) is defined as the longest time, without interruption of flow by detention devices, that will be required for water to flow from the upper limit of a drainage area to the point of concentration. Times of concentration can often be assumed based on the minimum inlet times shown in Table 6.

Alternatively, T_c may be calculated using the National Resource Conservation Service (NRCS, formerly known as the Soil Conservation Service, SCS) methodology. The use of NRCS methodology in lieu of standard inlet times may be at the discretion of the County's engineering representative or their designee. This method separates the flow through the drainage area into sheet flow, shallow concentrated flow, and open channel flow. The T_c is the sum of travel times for sheet flow, shallow flow and open channel flow. Time of concentration calculations shall be provided by the engineer along with flow path delineations.

Computations for travel time (T_t) for sheet flow, shallow flow, and open channel flow shall adhere to the following methodology.

1. **Sheet Flow:** Sheet flow is the initial flow over the ground surface. The maximum allowable length for sheet flow is 300 feet for undeveloped drainage areas and 100 feet for developed areas. The travel time (T_t) in hours for sheet flow is determined using the following equation:

$$T_t = \frac{0.007(nL)^{0.8}}{(P_2)^{0.5}(S)^{0.4}}$$

T_t = travel time (hours)
n = Manning's roughness coefficient (Table 3)
L = flow length (feet)
P_2 = 2-year, 24-hour rainfall, 4.3 inches
S = longitudinal slope (feet/foot)

2. **Shallow Concentrated Flow:** Shallow concentrated flow begins where sheet flow ends. A projected average slope should be established along the flowline for the shallow concentrated flow length. The travel time (T_t) in hours for shallow concentrated flow is determined by the following equation:

$$T_t = \frac{L}{3600V}$$

V = average velocity (feet/second), calculated as follows:
Unpaved Surfaces = $16.1345 \times S^{0.5}$ or Paved Surfaces = $20.3282 \times S^{0.5}$

3. **Open Channel Flow:** Open channel flow is where the runoff is located within a defined channel or in some cases, closed storm systems. The travel time (T_t) for open channel flow is determined using the equation for shallow concentrated flow and using Manning's Equation to determine average velocity (V):

$$V = \frac{1.49R^{\frac{2}{3}}S^{\frac{1}{2}}}{n}$$

V = average velocity (feet/second)
R = hydraulic radius (A/P) (feet), where:
A = cross-sectional area (square feet)
P = wetted perimeter (feet)
S = longitudinal slope (feet/foot)
n = Manning's roughness coefficient (Table 3)

3.4 Allowable Hydrologic Methods

Peak discharge data from an existing flood study or drainage studies may be used subject to the approval of the County's engineering representative or their designee. When such data is unavailable, peak discharges shall be determined by the engineer. All discharge values shall be based on existing development and land use conditions of the drainage basin.

There are a number of empirical hydrologic methods available to estimate runoff characteristics for a site or drainage subbasin. The following methods have been selected to support hydrologic site analysis for the design methods and procedures included in this manual:

1. Rational Method
2. Modified Rational Method
3. Unit Hydrograph Method

The procedures and approved applications of each method are described in the following sections.

3.4.1 Rational Method

The rational method is a simple procedure for estimating peak flows from small drainage areas. The use of the rational method is limited to drainage areas of less than 100 acres, unless otherwise approved by the County's engineering representative or their designee. The formula for calculation of runoff by the rational method is:

$$Q = CiA$$

Q = peak discharge (cfs)
C = runoff coefficient
i = rainfall intensity (in/hr) for a period equal to the time of concentration
A = contributing drainage area (acres)

The runoff coefficient "C" shall be based on the proposed development conditions of the property. Existing development conditions may be considered for off-site drainage areas. Table 6 gives values for runoff coefficients to be used in applications of the rational method.

For mixed-use areas, the most intense land use shall be used to determine the runoff coefficient. In some cases, it may be desirable to develop a composite runoff coefficient based in part on the percentage of different types of surfaces in the drainage area. Composite "C" values and other deviations from the coefficients provided in Table 6 are subject to the approval of the County's engineering representative or their designee.

Table 6: Runoff Coefficients and Typical Inlet Times by Land Use Type

Land Use Type	Runoff Coefficient	Minimum Inlet Time (Minutes)
Residential		
Single Family		
Lots > 1/2 acre	0.35	15
Lots 1/4 – 1/2 acre	0.45	15
Lots < 1/4 acre	0.55	15
Multifamily		
< 20 DU/acre	0.65	15
≥ 20 DU/acre	0.80	10
Business Districts	0.80	10
Commercial/Industrial		
Light	0.65	10
Heavy	0.75	10
Parks/Open Space	0.18	15

3.4.2 Modified Rational Method

The modified rational method is allowed for the design of detention facilities serving small drainage areas less than 100 acres. Analysis shall conform to the methodology outlined in the iSWM hydrology manual. For further guidance, see **Section 4.6.1**.

3.4.3 Unit Hydrograph Method

The County generally requires the use of the NRCS unit hydrograph method for drainage areas larger than 100 acres. The unit hydrograph method requires drainage area, a runoff factor, time of concentration, rainfall, and methodology to consider initial and constant losses. Details of the methodology and additional guidance can be found in the NRCS *National Engineering Handbook, Hydrology* and the iSWM hydrology manual.

The County requires the use of HEC-HMS to perform the computations and to develop runoff hydrographs for a drainage area. Additional software may be accepted at the discretion of the County's engineering representative or their designee. Typical inputs required for development of a HEC-HMS hydrograph are described below.

3.4.3.1 Curve Numbers

Use of the runoff curve number (CN) methodology outlined in *Urban Hydrology for Small Watersheds – NRCS Technical Release (TR)-55* is required. Curve numbers indicate the runoff potential of the land cover, considering the combined hydrologic effects of the soil type, land use, hydrologic condition of the soil cover, and the antecedent soil moisture. The NRCS Soil Survey for Hunt County may be used to identify the soil group within the watershed subbasins. For computation of design events, an assumption of Antecedent Moisture Condition (AMC) II is required.

The runoff CN values for urban areas provided in *TR-55* are recommended for use. When open space is used as the cover type, fair condition shall generally be assumed. Other CN values may be approved by the County's engineering representative or their designee. Table 7 shows the land use categories and corresponding impervious percentages. These values do not supersede the existing conditions. For instance, if a business district is currently 95% paved, 95% is the impervious condition that shall be used.

Table 7: Impervious Percentages by Land Use Type

Land Use	Impervious Condition (%)
Residential:	
Single Family	
Lots > 1/2 acre	25
Lots 1/4 – 1/2 acre	41
Lots < 1/4 acre	47
Multi-Family	
< 20 DU/acre	70
≥ 20 DU/acre	70
Business Districts	85
Commercial/Industrial:	
Light	90
Heavy	95
Parks/Open Space	6
Streets, Drives, Walks, and Roofs	95
Agricultural	3
Forest	0
Streams, Lakes, Water Surfaces	100

3.4.3.2 Design Storm Rainfall

Use of the 24-hour storm duration and SCS Type II distribution is required for peak flow calculations, unless otherwise approved by the County's engineering representative or their designee.

3.4.3.3 Hydrologic Stream Routing

Routing may be needed within the hydrologic model to account for the storage effects of detention facilities or significant channel reaches that are not accounted for in a hydraulic model. Detention and ponding areas shall be modeled using Modified Puls routing with explicit depth-area curves determined from topographic contours. Channel segments shall be modeled using either Modified Puls or Muskingum Cunge methods based on cross sections taken from available topography. For unsteady flow modeling, the routing is accounted for by the hydraulic software being used.

[This Page Intentionally Left Blank for Double-Sided Printing]

CHAPTER 4. DRAINAGE SYSTEM DESIGN

4.1 Streets

4.1.1 Street Capacity Requirements

Streets may be used in combination with roadside ditches to convey the runoff resulting from the 100-year storm and to meet the street drainage criteria outlined in Table 8. The allowable flow depth and spread requirements outlined in Table 8 shall be applied at the edge of pavement.

Table 8: Street Design Criteria

Type of Street	Allowable Spread	Maximum Water Surface Elevation
Major Thoroughfare	One traffic lane in each direction to remain open	6”
Collector Street	One moving traffic lane to remain open	6”
Residential Street	n/a	6”

Roadside ditches shall be included in the street right-of-way section. Curb and gutter systems with storm sewer inlets and storm drain pipe may also be approved in lieu of parallel ditches by the County’s engineering representative or their designee, provided the other design requirements of this manual are met.

Additional street drainage considerations are listed below:

1. The maximum allowable spread shall not exceed the limits of the public right-of-way or drainage easement.
2. The maximum allowable concentrated flow to a street including flow from driveways and flumes is 3 cfs. Discharges of point flows exceeding 3 cfs are allowed into the side drainage features of the street but may require permanent erosion control mechanisms at the discretion of the County’s engineering representative or their designee.

3. At any intersection, only one street shall be crossed with surface drainage, and this shall be the lower classified street.

4.1.2 Street and Gutter Flow Calculations

Surface drainage along streets is a function of transverse and longitudinal pavement slope, pavement roughness, inlet spacing, and inlet capacity. The design of these elements is dependent on storm frequency and the allowable spread of stormwater. Flow in streets and gutters is governed by Manning's equation for open channel flow:

$$Q = \frac{1.486}{n} A\, R^{2/3}\, S^{1/2}$$

Q = average velocity (fps)
A=cross-sectional flow area (ft^2)
R = hydraulic radius (ft), as defined previously
S = longitudinal slope (ft/ft)
n = Manning's roughness coefficient (Table 3)

The iSWM *Technical Manual for Hydraulics* provides alternate forms of the Manning's equation with tables and nomographs to be used in the calculation of drainage capacities of streets with triangular, composite, and parabolic sections, as well as streets with curb splits.

4.2 Inlets

4.2.1 Inlet Design Considerations

Inlets must be spaced to serve the runoff calculated using the appropriate hydrologic method. Curb inlets shall be spaced so that the maximum travel distance of water in the gutter will not exceed 700 feet one way for residential streets and 300 feet one way on major thoroughfares and streets within commercial developments. It is preferable that curb inlets be located on intersecting side streets instead of major thoroughfares on all original designs or developments. Do not place inlets in circular portion of cul-de-sac streets unless special conditions warrant otherwise. Place inlets at the end of proposed pavement, if drainage will enter or leave pavement. Special conditions warranting other locations of curb inlets shall be determined on a case by case basis by the County's engineering representative or their designee.

4.2.2 Roadway Inlets

Inlets are drainage structures used to collect surface drainage and to convey this water to storm drains or direct outlet to culverts. The capacity of an inlet depends upon its geometry and the cross slope, longitudinal slope, total gutter flow, depth of flow, and pavement roughness. Inlets servicing roadway drainage can be divided into three major classes:

1. Curb Inlets
2. Grate Inlets
3. Combination (Grate and Curb-Opening) Inlets

Inlets may be classified as being on a continuous grade or in a sump. The term "on grade" refers to an inlet located on the street with a continuous slope past the inlet with water entering from one direction. The "sump" condition exists when the inlet is located at a low point and water enters from both directions.

Artificial low points created by "seesaw" of street grades will not be permitted. All low point inlets shall be designed in accordance with additional standards outlined in **Section 4.2.4**.

The procedures and technical criteria outlined in the iSWM hydraulic manual shall be used for the hydraulic design of stormwater inlets. Additional criteria for various inlet types are summarized in the following sections. Refer to the Texas Department of Transportation (TxDOT) *Bridge Standards* for inlet construction and material requirements.

4.2.3 Drop Inlets

The County allows for the installation of drop inlets to collect water in nonpaved areas, such as ditches and swales. If used, grading plans to direct flow into drop inlets shall be included in the construction plans. Drainage interceptor swales or berms shall be used, as required, to direct runoff to the drop inlets. Where swales or other means of collecting and directing runoff into drop inlets are needed, they shall be contained in drainage easements according to the requirements outlined in **Section 1.6.1**.

Drop inlet capacity shall be designed using a 50% clogging factor due to the tendency of these inlets to collect debris. Flow into drop inlets shall be calculated using either the weir flow formula for an unsubmerged inlet or the orifice flow formula when depth of flow exceeds the depth of the opening.

The capacity of an unsubmerged inlet operating as a weir is:

$$\frac{Q}{P} = 2.5y^{3/2}$$

Q = flow capacity (cfs)
2.5 = weir coefficient (3.1) adjusted for 50% clogged inlet throat
P = perimeter of opening (ft)
y = head/depth (ft)

and the capacity of a submerged inlet operating as an orifice is:

$$Q = 0.6A(2gH)^{0.5}$$

Q = flow capacity (cfs)
0.6 = orifice discharge coefficient
A = area of inlet opening (ft^2)
g = acceleration due to gravity = 32.2 (ft/s^2)
H = head above centerline of inlet opening height (ft)

Both conditions should be evaluated, and the capacity shall be determined from the condition that produces the more conservative value. The capacity calculations for drop inlets will be limited to a maximum head of 1 foot above the flowline of the inlet throat.

4.2.4 Positive Overflow Requirements

Inlets are required at all low points in the gutter profile. Additionally, the drainage system shall provide for positive overflow at all low points. The term "positive overflow" means that when the inlets do not function properly, or when the design capacity of the conduit is exceeded, the excess flow can be conveyed overland along an open course. Generally, positive overflow is provided along a street, but certain circumstances may require the dedication of drainage easement and construction of a concrete flume sized to carry the overflow. Reasonable judgment should be used to limit the easements on private property to a minimum.

In areas where positive overflow is not feasible, flanking inlets are required on each side of the low point inlet to act in relief of the inlet at the low point if it should become clogged. Flanking inlets shall be located to function before water spread exceeds the allowable spread at the sump location and shall be designed with a combined capacity to match the capacity of the primary sump inlet.

4.3 Storm Drains (Closed Systems)

4.3.1 Flow in Storm Drains

4.3.1.1 Hydraulic Grade Line

Storm sewers shall be constructed to flow in subcritical hydraulic conditions unless otherwise approved by the County's engineering representative or their designee. A plan and profile sheet and calculations of the hydraulic gradient shall be furnished by the design engineer.

The hydraulic gradient shall be calculated assuming the top of the outfall pipe as the starting water surface. At drops in pipe invert, should the upstream pipe be higher than the hydraulic grade line, then the hydraulic grade line shall be recalculated assuming the starting water surface to be at the top of pipe at that point. For the design storm, the hydraulic gradient shall be below the gutter line for all newly developed areas. For approved streets with ditch sections, the hydraulic gradient shall be 0.5 feet below the edge of pavement or natural ground elevation, whichever is lower.

4.3.1.2 Velocities

Storm sewers shall be designed to have a minimum velocity of 3 feet/second when flowing full. Maximum velocities shall not exceed 15 feet/second. Maximum discharge velocities shall not exceed 6 feet/second without use of energy dissipation downstream.

4.3.1.3 Head Losses

Head losses at structures shall be determined for manholes, junction boxes, wye branches, bends, curves, and changes in pipe sizes in the design of closed conduits. Head losses must be incorporated into the gradient profile. Minimum head loss used at any structure shall be one-tenth (0.10) foot. Refer to the iSWM hydraulic manual for the equations to calculate energy losses at pipe junctions, bends, manholes, inlets, and other situations.

Pipe direction changes will be curves using radius pipe unless approved by the County's engineering representative or their designee. Ninety-degree turns on storm sewers or outfalls are prohibited. Laterals shall intersect the trunk line at 60 degrees.

4.3.2 Pipe Size and Material

The pipe size shall be a minimum of 15 inches for all public systems. Storm sewers shall be constructed with Class III reinforced concrete pipe, either precast pipe, box conduits or cast in place pipe. Refer to the pipe manufacturer specifications for cover requirements. Higher classes of pipe shall be required where the ultimate D-load of Class III pipe is exceeded, and in other situations as required by the County's engineering representative or their designee.

The use of High-Density Polyethylene Pipe (HDPE) is allowed in unpaved areas. The use of corrugated galvanized metal pipe or HDPE may be approved at the storm sewer outfall into unlined channels.

4.3.3 Storm Drain Alignments

Match crowns of pipe at any size change unless severe depth constraints prohibit. Pipe size shall generally increase downstream except in the following specific cases or where otherwise allowed by the County's engineering representative or their designee:

1. Where construction constraints prohibit the use of a larger pipe downstream;
2. Where the improvements are outfalling into an existing system; or,
3. Where the upstream system is intended for use in detention.

Headwalls or sloped end treatments shall be constructed at the pipe ends of all storm drain systems. Sloped end treatments are required along streets when the drainage feature is adjacent and parallel to traffic flow. The sloped end treatment shall be a minimum 6:1 (horizontal to vertical) end section.

Storm drain systems that outfall to a stream, natural channel, or pond shall conform to the existing side slope of the channel and be connected to a headwall. Discharge flowlines of storm sewers are to be 6 inches above the flowline of creeks and channels, unless channel lining is present. Hard armor protection and energy dissipation shall be provided when discharge velocities exceed the maximum allowable velocity in Table 3 and when specified by the County's engineering representative or their designee.

4.4 Channels and Ditches

4.4.1 Hydraulic Evaluation

The County requires a hydraulic analysis for any proposed open channels or ditches. Normal depth (uniform flow) calculations using the Manning's equation are to be used only for initial sizing. Exceptions for small outfall channels and ditches will be made at the discretion of the County's engineering representative or their designee.

The hydraulic analysis shall generally be performed using HEC-RAS. The analysis will be used to determine the headwater and tailwater elevations, head losses, capacity, freeboard, and floodplain impacts. For systems discharging into natural creeks, channels, or ponds, the tailwater shall be assumed to be the 100-year water surface elevation. If an approved flood hydrograph is available to provide a coincident flow elevation for the system's peak, the table of coincident design frequencies in the iSWM hydraulic manual can be used to assist with tailwater determination. Alternatively, a detailed hydrologic and hydraulic study may be provided.

For channels that require a flood study, a hydrologic routing model and hydraulic analysis will be required to determine impacts on existing floodplains and/or adjacent properties. If a stream or channel has an effective FEMA model and/or a County-adopted watershed model, the engineer will be required to use those models for the analysis.

Supercritical flow will not be allowed for designed channels. However, for lined channels, the HEC-RAS analysis shall include a mixed-flow regime analysis, to make sure no supercritical flow occurs for the designed channel. Mixed or supercritical flow may be allowed for analysis of existing conditions when required.

Upstream or downstream transitions from natural to modified channels along with channel outfalls will require a design based on a hydraulic study and will provide a non-erosive environment. Refer to the iSWM hydraulic manual for design of channel transitions and energy dissipation.

4.4.2 Allowable Depth and Freeboard

The 50-year hydraulic gradient shall be shown for each drainage ditch section and shall be below the edge of pavement or natural ground elevation, whichever is lower. The 100-year hydraulic gradient shall also be shown on the plans to confirm that flows are contained within the right-of-way and/or drainage easement. Freeboard must also be provided to meet the requirements for minimum finished floor elevations outlined in **Section 2.4.3**.

4.4.3 Setbacks

The minimum distance between the edge of the roadway shoulder and the adjacent edge of ditch bank shall be as shown on the County's Typical Roadway Sections.

4.4.4 Geometry

The following standards for the geometry of constructed channels and ditches shall apply:

1. The minimum bottom width for roadside ditches shall be 3 feet.
2. The minimum grade or slope of roadside ditches shall be 0.50%. In situations where the minimum slope cannot be achieved, concrete lining may be required by the Count's engineering representative or their designee. For grass lined sections, the maximum design velocity shall be 6 feet per second.
3. The minimum preferred unlined or unimproved roadside ditch section shall have a side slope no steeper than 3:1 (horizontal to vertical) configuration. Steeper slopes may be approved by the County's engineering representative or their designee when the existing right-of-way is limited or other construction features dictate the design.
4. Bank stabilization may be required at the discretion of the County's engineering representative or their designee.

4.5 Bridges and Culverts

4.5.1 Bridge and Culvert Capacity

The hydraulic design of bridges and culverts for roadway crossings of drainage feature shall conform to the methodology outlined in the TxDOT *Hydraulic Design Manual*. The minimum design frequencies of bridge and culvert facilities shall conform to the recommended design flood and check flood standards presented in the manual. Driveway culverts in roadside ditch sections shall be provided to allow sufficient cross drainage to meet the ditch capacity and freeboard requirements.

All bridge and culvert facilities must be evaluated to the 100-year storm, to ensure conformance with the County's downstream impacts and floodplain development criteria. Bridge and culvert design must meet the no adverse impacts standards outlined in **Section 2.3.1**.

4.5.2 Bridge Design Considerations

A hydrologic and hydraulic analysis using HEC-RAS is required for designing all new bridges, bridge widening, bridge replacement, and roadway profile modifications that may adversely affect the floodplain, even if no structural modifications are necessary.

4.5.3 Bridge Scour Analysis

A scour analysis shall be submitted with bridge design plans. Scour analysis shall be performed in accordance with the latest edition of the TxDOT *Geotechnical Manual*, based on the guidelines and procedures outlined in *HEC-18 Evaluating Scour at Bridges (5th Ed.)*. The HEC-RAS scour routines shall generally be used to perform bridge scour computations.

Scour revetment shall be provided as needed and shall be designed using the methodology outlined in *HEC-23 Bridge Scour and Stream Instability Countermeasures: Experience, Selection, and Guidance*. Alternative methodologies for scour analysis and revetment may be approved at the discretion of the County's engineering representative or their designee.

4.5.4 Culvert Design Considerations

Culverts with headwalls will be placed at all driveway and roadway crossings, and other locations where appropriate. All driveways crossing open drainage ditches are required to be serviced by culverts; no paved dips will be permitted.

Culverts will be designed assuming inlet control. For safety reasons, headwater depth/culvert diameter ratio (HW/D) for road crossings shall not exceed 1.5 for the 100-year event peak flow. Variance to this criteria may be permitted by the County if justification is provided and sufficient measures are taken to reasonably avoid any safety impacts. Assessment of the impacts caused by exceeding the design headwater depth should account for:

1. Hazard to human life and safety.
2. Potential damage to the culvert, embankment stability and roadway.
3. Traffic interruption in the event of roadway overtopping.
4. Anticipated upstream and downstream flood risks, for a range of return frequencies.

If the culvert outlet is operating with a free outfall, the critical depth and equivalent hydraulic grade line shall be determined. If an upstream culvert outlet is located near a downstream culvert inlet, the headwater elevation of the downstream culvert will establish the design tailwater depth for the upstream culvert. For culverts discharging into natural creeks, channels, or ponds, the tailwater shall be assumed to be the 100-year water surface elevation. If an approved flood hydrograph is available to provide a coincident flow elevation for the system's peak, the table of coincident design frequencies in the iSWM hydraulic manual can be used to establish the tailwater elevation. Alternatively, a detailed hydrologic and hydraulic study can be performed to establish the tailwater elevation.

4.5.5 Culvert Size and Material

The minimum size culvert shall have a cross-sectional area equal to or greater than a 15-inch inside diameter pipe. Roadside culverts are to be sized based on drainage area. Calculations are to be provided for each block based on drainage calculations. All proposed and reasonably expected future culverts shall be included in the hydraulic profile. The size of culvert used shall not create an additional head loss of more than 0.2 feet greater than the normal water surface profile prior to placement of the culvert.

Pipe culverts shall conform to ASTM Specifications C-76, Class III, for reinforced concrete pipe. Higher classes of pipe shall be required where the ultimate D-load of Class III pipe is exceeded, and in other situations as required by the County's engineering representative or their designee.

4.6 Stormwater Storage Facilities

4.6.1 Storage Volume Calculation

The modified rational method is allowed only for detention facilities serving watersheds of 100 acres and less. The modified rational method is not acceptable for basins in series. Detention basins draining watersheds over 100 acres shall be designed using unit hydrograph methodology. The unit hydrograph method is also allowed for basins with watersheds less than 100 acres and may be required at the discretion of the County's engineering representative or their designee.

A calculation summary shall be provided on construction plans. For detailed calculations of unit hydrograph studies, a separate report shall be provided to the County for review and referenced with date, engineer, and title on the construction plans. Stage-storage-discharge values shall be tabulated, and flow calculations for discharge structures shall be shown on the construction plans. Reservoir routing calculations must be used to demonstrate that the storage volume and outlet structure configuration are adequate.

4.6.2 Pond and Spillway Geometry

The following criteria shall apply:

1. Detention basin embankments shall have a 10-foot crown width. For access to the pond bottom, provide a maintenance ramp of at least 10 feet wide with a maximum slope of 15%. Twelve (12) feet in width is required next to vertical walls.
2. Detention basins shall be designed with at least one 10-foot-wide maintenance access location, with a 15% maximum grade.
3. A freeboard of 1 foot based on the 100-year design depth will be required for all detention ponds.
4. Grassed side slopes shall be 4:1 or flatter and less than 20 feet in height. Slopes protected with concrete riprap shall be no steeper than 2:1. A detailed geotechnical investigation and slope stability analysis is required for grass and concrete slope pavement slopes greater than 12 feet in height. A concrete-lined or structural embankment can be steeper with County approval.
5. An emergency spillway shall be provided at the 100-year maximum storage elevation with sufficient capacity to convey the 100-year storm assuming blockage of the closed conduit portion of the outlet works with 6 inches of freeboard. Spillway requirements must also meet all appropriate state and federal criteria. Design calculations will be provided for all spillways.

6. Dry detention basins are sized to temporarily store the volume of runoff required to provide flood protection up to the 100-year storm, if required. Dry detention basin design should consider multiple uses, such as recreation. As such, pilot channels should follow the edges of the basin to the extent practical. The bottom of the basin shall have a minimum grade of 1%, although swales may have minimum grades of 0.5%. Concrete flumes shall be provided for slopes less than 0.5% and may have slopes as shallow as 0.2%. They shall be at least 6 feet wide.
7. Safety fencing is required around the detention area if any of the following criteria are met:
    a. Where side slopes of the facility are steeper than 4:1.
    b. Where the 100-year design depth of the facility exceeds 4 feet.
    c. Where the facility is likely to experience significant exposure to children or the elderly (i.e. adjacent to schools, parks, or adult care facilities)
    d. In other instances, as directed by the County's engineering representative or their designee.
8. Safety fencing shall be a minimum of 6-feet in height and shall be chain link. Maintenance access must be provided. Alternative materials or other means of preventing public egress (i.e. decorative fencing or privacy hedges) may be approved by the County's engineering representative or their designee.

4.6.3 Permitting and Dam Safety Requirements

All federal, state, and local laws pertaining to the impoundment of surface water relating to the design, construction, and safety of the impounding structure shall apply. Criteria established by the State of Texas for dam safety (*TAC Title 30, Part 1, Chapter 299*) and impoundment of state waters (*Texas Water Code Chapter 11*) shall apply where required by the state. The engineer is responsible for coordinating with the appropriate regulatory agencies to ensure compliance with these requirements.

[This Page Intentionally Left Blank for Double-Sided Printing]

CHAPTER 5. FLOODPLAIN DEVELOPMENT

5.1 General

The following information is included for reference and to supplement the provisions outlined in the County's *Flood Damage Prevention Ordinance*. Where codified flood protection provisions conflict with the provisions of this manual, the more stringent of the criteria shall apply.

The County regulates development within the FEMA Special Flood Hazard Area (SFHA). Any land disturbance that includes impacts to the SFHA or could have impacts on floodplain limits for an associated stream shall require a hydraulic analysis (flood study) to determine drainage easements, establish minimum finished floors for insurable structures, and evaluate proposed modifications to existing floodplains or floodways.

5.2 Floodplain Development Permit

A *Floodplain Development Permit* includes an authorization by the County for any work to be performed within areas of the SFHA as required by the County's *Flood Damage Prevention Ordinance*. Applications for a *Floodplain Development Permit* shall be submitted to the County with the flood study that evaluates existing conditions and proposed project impacts. Depending upon the proposed project, location, and type of stream, the project may also require a FEMA Letter of Concurrence/Approval and/or a USACE Section 10 and Section 404 Permit. The County's Floodplain Administrator will coordinate with the engineer if any such additional conditions apply.

[This Page Intentionally Left Blank for Double-Sided Printing]

CHAPTER 6. EROSION CONTROL

6.1 Permanent Erosion Control

Permanent erosion control methods acceptable to the County's engineering representative or their designee shall be utilized where the velocities of surface flow are calculated to be greater than 6 feet/second or where soil conditions indicate their need. Final stabilization measures that provide a protective cover must be initiated immediately in portions of the site where construction activities have permanently ceased. Final stabilization consists of soil cover such as vegetation, geo-textiles, mulch, rock, or placement of pavement or concrete. For stabilizing vegetated drainage ways, sod or seeded soil retention blankets shall be used. Hydromulch will not be allowed in vegetated swales, channels, or other drainage ways.

6.2 Site Erosion Control During Construction

Construction activities shall comply with all applicable federal (EPA), state (TCEQ), and local (County) stormwater pollution prevention regulations. When this manual and other applicable regulations are in conflict, the most stringent requirements shall apply.

6.2.1 Erosion Control Plan (ECP)

An Erosion Control Plan (ECP) is required for all sites regardless of size. The ECP shall consider areas where development activities or channel improvements occur and shall protect these areas from site erosion. Sediment carried by stormwater runoff through these areas shall be prevented from entering storm drain systems and natural watercourses through applicable Best Management Practices (BMPs). Some acceptable forms of site erosion control BMPs include silt fences, silt traps, geo-netting, and geo-textiles.

BMPs shall comply with the latest edition of the iSWM *Criteria Manual for Site Development and Construction* and *Technical Manual for Construction Controls*. It is the responsibility of the engineer to select and design appropriate construction controls for each site. The minimum design storm for temporary BMPs is the 2-year, 24-hour storm event. All temporary BMPs must be removed prior to final stabilization of the construction site.

6.2.2 Stormwater Pollution Prevention Plan (SWPPP)

For all construction projects that will disturb 1 acre or more of land area, or projects that are part of a larger common plan of development that will disturb 1 acre or more, the TCEQ requires operators to obtain Texas Pollutant Discharge Elimination System (TPDES) General Permit (TXR150000) coverage for the project. This requires the preparation of a Storm Water Pollution Prevention Plan (SWPPP) bearing the seal of a Professional Engineer licensed in the State of Texas. The SWPPP shall be provided to the County and approved prior to the start of any construction. The contractor is responsible for implementing and maintaining the SWPPP, as well as posting and submitting construction site notifications, the Notice of Intent, and the Notice of Termination.

[This Page Intentionally Left Blank for Double-Sided Printing]

CHAPTER 7. STREETS

7.1 Traffic Impact Analysis (TIA) Standards

The Traffic Impact Analysis Standards supplement the requirements established in the Hunt County Subdivision Regulations. These standards outline the County's expectations and facilitate a coordination of the scope, analysis contents, parameters and assumptions of a TIA.

7.1.1 Purpose

The purpose of a TIA is to assess the effects of specific development activity on the existing and planned roadway system.

7.1.2 When a TIA is Required

7.1.2.1 A TIA is required with every application for a proposed development that generates traffic in excess of one thousand (1,000) average daily trips based on data published in the latest edition of the Institute of Transportation Engineers (ITE) Trip Generation Manual; or,

7.1.2.2 When the Commissioners Court Engineering Representative determines that the characteristics of the proposed subdivision necessitate analysis.

7.1.2.3 When a new subdivision exceeds more than fifty (50) lots or seventy-five (75) gross acres.

7.1.2.4 An updated TIA is required with submittal of a final plat if, in the opinion of the Commissioners Court Engineering Representative, the final plat changes significantly (i.e., adds lots, modifies or adds street connections, etc.) from an approved Preliminary Plat.

7.1.2.5 All or a portion of the requirement for the TIA may be waived by the Commissioners Court Engineering Representative depending upon the size and potential impact of the proposed subdivision and the traffic to be generated. Waivers will be considered on a case-by-case basis upon submittal of a waiver request and corresponding Commissioners Court Engineering Representative review. Technical justification must be provided by the applicant when requesting the waiver.

7.1.3 TIA Requirements

7.1.3.1 All elements of the TIA must be prepared under direct supervision of and signed, stamped and dated by a Professional Engineer licensed to practice in the State of Texas with specific expertise in transportation and traffic engineering, preferably certified as a Professional Traffic Operations Engineer.

7.1.3.2 The analysis is required to contain at a minimum, the following:

(a) Traffic Analysis Map
(b) Land Use, Site and Study Area Boundaries, as defined
(c) Existing and Proposed Site Uses
(d) Proposed Land Uses on both sides of boundary streets for all parcels within the study area for TIAs where land use is the basis for estimating projected and existing traffic volumes
(e) Existing and Proposed Roadways and Intersections of boundary streets within the study area of the subject property, including geometrics, traffic signal control, and volumes
(f) All major driveways and intersecting streets adjacent to the property will be illustrated in sufficient detail to serve the purposes of illustrating traffic function. This may include showing lane widths, traffic islands, medians, sidewalks, curbs, traffic control devices (traffic signs, signals, and pavement markings), and a general description of the existing pavement condition.
(g) Photographs of adjacent streets of the development and an aerial photograph showing the study area

7.1.4 Trip Generation and Design Hour Volumes

7.1.4.1 A trip generation summary table listing each type of land use, the building size assumed, average trip generation rates used (total daily traffic and a.m./p.m. peaks), and total trips generated shall be provided. Trip generation information is to be based on data published in Trip Generation, latest edition, by the Institute of Transportation Engineers (ITE).

7.1.4.2 Vehicular trip generation may be discounted in recognition of other reasonable and applicable modes, e.g., transit, pedestrian or bicycles. Trip generation estimates may also be discounted through the recognition of pass by trips and internal site trip satisfaction. All such estimates shall be subject to the approval of Hunt County Commissioners Court.

7.1.4.3 Proposed trip generation calculations for single-story commercial properties shall be based on a floor-to-area (building size to parcel size) ratio of 0.25 or more.

7.1.4.4 Trip Distribution (provide figure by Site Exit/Entrance). The estimates for percentage distribution of trips by turning movements to/from the proposed development.

7.1.4.5 Trip Assignment (provide figure by site entrance and boundary street). The direction of approach of site-attracted traffic via the area's street system.

7.1.4.6 Existing and Projected Traffic Volumes (provide figure for each item). Existing traffic volumes are the numbers of vehicles on the streets of interest during the time periods listed below, immediately prior to the beginning of construction of the land development project. Projected traffic volumes are the number of vehicles, excluding the site-generated traffic, on the streets of interest during the time periods listed below, in the build-out year.

(a) A.M. peak hour site traffic (including turning movements) if significant impact

(b) P.M. peak hour site traffic (including turning movements)

(c) Weekend peak hour site traffic (including turning movements)

(d) A.M. peak hour total traffic including site-generated traffic and projected traffic (including turning movements)

(e) P.M. peak hour total traffic including site-generated traffic and projected traffic (including turning movements)

(f) Weekend peak hour total traffic including site-generated traffic and projected traffic (including turning movements)

(g) For special situations where peak traffic typically occurs at non- traditional times, e.g., major sporting venues, entertainment venues, large specialty Christmas stores, etc., any other peak hour necessary for complete analysis (including turning movements)

(h) Total daily existing traffic for street system in study area

(i) Total daily existing traffic for street system in study area and new site traffic

(j) Total daily existing traffic for street system in study area plus new site traffic and projected traffic from build-out of study area land uses

7.1.5 Capacity Analysis (provide Analysis Sheets in Appendices)

7.1.5.1 A capacity analysis shall be conducted for all public or private streets, intersections and junctions of major driveways with public or private streets, which are significantly impacted (as designated by the County), by the proposed development within the previously defined study boundary.

7.1.5.2 Capacity analysis will follow the principles established in the latest edition of the Transportation Research Board's Highway Capacity Manual (HCM), unless otherwise directed by the County. Capacity will be reported in quantitative terms as expressed in the HCM and in terms of traffic level of service.

7.1.5.3 Capacity analysis will include traffic queuing estimates for all critical applications where the length of queues is a design parameter, e.g., auxiliary turn lanes and at traffic gates.

7.1.6 Level of Service Determination

7.1.6.1 A table indicating the level of service for near-term and long-term traffic projections for all streets within the study area shall be included.

7.1.6.2 Level of service "C" is the design objective for all movements. Under no circumstances shall the level of service be less than "D" unless deemed acceptable for site and non-site traffic by the Commissioner Court engineering representative.

7.1.7 Conclusions and Recommendations

7.1.7.1 The TIA must include a summary of the findings regarding impacts of the proposed development on the existing and proposed street system.

7.1.7.2 If the analysis indicates unsatisfactory levels of service or safety problems, a detailed description of proposed improvements to remedy deficiencies and a sketch of each improvement showing pertinent geometric features shall be included. Assumptions regarding future capacity recommendations shall be approved by the Commissioners Court Engineering Representative.

7.1.7.3 For phased construction projects, implementation of traffic improvements must be accomplished prior to the completion of the project phase for which the capacity analyses show that they are required. Plats for project phases subsequent to a phase for which a traffic improvement is required may be approved only if the traffic improvements are completed or bonded.

7.1.8 Other Items

The Commissioners Court Engineering Representative may require other items be included in the TIA in addition to those listed above.

7.2 Functional Classification and Street Dimensions

This section further defines the functional classifications, street types, and design dimensions defined in the Hunt County Subdivision Regulations.

7.2.1 Street Classification

Street classifications and standard dimensions for each street section designation are listed in **Table 9**.

Table 9: Classifications and Standard Dimensions

Functional Classification	Area Type	Lanes	Spacing (miles)	ROW	Pavement Width (ft)	Design Speed (mph)	Median
Major Arterial (A)	Rural	4	1	100	2 @ 32	35 - 45	No
Minor Arterial (B)	Rural	2	0.5	80	40	30 - 35	No
Collector (C)	Rural	2	0.5	60	32	30 - 35	No
Local (Residential)	Rural	2	0.25	60	28	15 - 25	No
	Urban	2	0.25	50	30	15 - 25	No

7.2.2 Standard Street Dimensions

For typical street cross sections, see Chapter 8. Typical Cross Sections.

7.3 Access Control

The following standards shall be used in the location of street intersections, and driveway approaches which affect access to streets from adjoining properties. **Section 7.4.7 Street Design Elements** provides the geometric design requirements for streets, medians, and driveway approaches.

7.3.1 Intersections and Intersection Requirements

7.3.1.1 All street intersections along one side of an existing cross-street must, wherever practical, align with existing intersections on the opposite side of the cross street.

7.3.1.2 There shall be a minimum of 2,000 feet between intersections of arterial streets and/or collector streets.

7.3.1.3 Block lengths shall be in accordance with the Subdivision Regulations.

7.3.2 Drive Approaches

7.3.2.1 Streets shall be designed to conform to existing or proposed driveway openings.

7.3.2.2 Where a residential subdivision will abut or contain an existing or proposed arterial street, driveway access to the thoroughfare is prohibited.

7.3.2.3 To the greatest extent possible, no more than 20 percent of the total centerline length of a residential collector street may have residential lots fronting onto the collector on each side of the street without construction of a wider alternative section.

7.3.2.4 Driveway approaches including turnout curb transitions shall be located entirely within the frontage of the property served by the approach.

7.4 Geometric Design

7.4.1 Design Criteria

All engineering designs shall be based on national standards and best practices. The American Association of State Highway and Transportation Officials (AASHTO) published A Policy on Geometric Design of Highways and Streets, referred to as the AASHTO Green Book. This manual is updated periodically and contains design considerations and criteria applicable to roadway design. The AASHTO Green Book shall be used for guidance for designing geometrics, including intersection design, and other street features. The National Association of City Transportation Officials (NACTO) Urban Street Design Guide shall be considered where AASHTO does not fully address street issues. Roadway designs should comply with the following standards.

7.4.2 Intersections Standards

7.4.2.1 An intersection shall not have more than four street approaches.

7.4.2.2 No offset is permitted at intersections of two thoroughfares.

7.4.2.3 When conditions require the centerlines of local streets to be offset, a minimum of 125 feet offset distance is required for local street intersections and 200 feet offset distance for thoroughfare street intersections. Centerline offsets less than the minimum must be approved by the Commissioners Court Engineering Representative. Offsets greater than the minimum may be required by the Commissioners Court Engineering Representative when necessary for traffic safety.

7.4.2.4 No street intersecting an arterial street should vary from a 90-degree angle of intersection by more than 5 degrees. Streets intersecting collector streets should not vary from a 90-degree angle of intersection by more than 10 degrees. All other street intersections should not vary from a 90-degree angle of intersection by more than 15 degrees.

7.4.3 Design Speed

All streets shall be designed to accommodate the design speeds in table 2.1.

7.4.4 Horizontal and Vertical Control

7.4.4.1 Horizontal Control - All plans submitted to the County shall be prepared using the NAD83 State Plane Grid Coordinate System.

7.4.4.2 Vertical Control - Vertical control shall be tied to NGVD 29.

7.4.5 Minimum Radius

The required radius for curb returns at intersections shall be as shown in **Table 10**:

Table 10: Required Curb Return Radius

Street Types	Min Radius
Arterial / Arterial	30 feet
Arterial / Collector	30 feet
Arterial / Local	30 feet
Collector / Collector	30 feet
Collector / Local	30 feet
Local / Local	20 feet

The minimum radius from the face of curb on a cul-de-sac shall be 45 ft.

7.4.6 Sight Distance

7.4.6.1 At controlled or uncontrolled intersections of any public or private street, sight triangles (visibility triangles) are required. The dimensions of the sight triangle shall be in accordance with the County's subdivision regulations. Within this triangle there shall be no tree, shrub, plant, sign, soil, fence, retainer wall or other view obstruction having a height greater than 2 feet. This height shall be measured above a line drawn between the top of curb or edge of pavement of both streets at the point where the referenced line intersects the top of curb or edge of pavement.

7.4.6.2 An intersection sight distance analysis in accordance with the latest edition of the AASHTO Green Book (the chapter titled Intersections) should be undertaken to confirm that sufficient stopping distance is available.

7.4.6.3 Additional sight distance may be required based on topography, roadway curvature, vegetation or other sight hindrance. The AASHTO Green Book describes the process the designer should follow to determine whether a vehicle entering or crossing an intersection from a minor road can see, and be seen by, a vehicle on the major road when there is an obstruction, such as a change in the vertical profile of the road, in time to avoid a collision (section titled Identification of Sight Obstructions within Sight Triangles).

7.4.6.4 Deviations from the minimum intersection sight distance requirements may be allowed provided that the owner has demonstrated that the area proposed will provide adequate sight distance based on AASHTO standards. All deviations must be approved by the Commissioners Court Engineering Representative.

7.4.7 Street Design Elements

7.4.7.1 Horizontal Alignment

(a) The curvilinear requirements in the Subdivision Regulations must be accommodated.

(b) The minimum centerline radii shown in **Table 11** shall be used in the design of all street construction.

Table 11: Minimum Centerline Radius

Street Type	Min Centerline Radius
Arterial (Major)	1040 ft
Arterial (Minor)	1040 ft
Collector	510 ft
Local	335 ft
Cul-de-sac	50 ft to right-of-way

(c) Reverse curves shall be separated by a tangent section in accordance with **Table 12**:

Table 12: Minimum Centerline Radius (Reverse Curves)

Street Type	Min Curve Separation
Arterial (Major)	100 ft
Arterial (Minor)	100 ft
Collector	50 ft
Local	As approved by Commissioners Court Engineering Representative

(d) Major collector or arterial roadways intersecting other major collector/arterial roadways shall have the following minimum horizontal centerline approach tangent section length shown in **Table 13** as measured from the nearest right-of-way line of the intersecting street, unless such requirement is waived by the Commissioners Court Engineering Representative.

Table 13: Minimum Centerline Approach Tangent

Street Type	Intersecting With	Min Centerline Radius
Arterial (Major)	Arterial (Major)	200 ft
Arterial (Minor)	Arterial (Minor)	200 ft
Collector	Arterial	150 ft
Collector	Collector	100 ft

7.4.7.2 Vertical Alignment

(a) All streets shall be designed and constructed to a minimum grade of 0.5%; unless the required geotechnical report indicates the soil has a PI greater than or equal to 40, a minimum grade of 1% shall be required. All streets shall have a maximum grade as shown in **Table 14**:

Table 14: Maximum Vertical Grade

Street Type	Maximum Grade
Arterial	6.0%
Collector	8.0%
Local	10.0%

(b) In order to maintain adequate sight distance, all streets shall be designed and constructed to comply with the minimum vertical curve length in **Table 15** for each algebraic percent difference in grade K, where K = curve length (L) / algebraic difference in grade (A). Grade changes where the algebraic percent difference is one percent or less are not required to use vertical curves for design speeds less than or equal to 45 mph.

Table 15: Minimum Vertical Curve Length

Street Type	Design Speed	Crest Curves K	Sag Curves (K)
Arterial (Major)	45	65	80
Arterial (Minor)	45	65	80
Collector	35	30	50
Local	30	20	40

(c) The maximum intersection grades involving arterial and collector roadways shall be used at controlled intersections as shown in Table 16.

Table 16: Maximum Intersection Grades

Design Street Type	Intersecting With	Design Street Maximum Grade	Distance
Arterial	Arterial	2%	300 ft
Collector	Arterial	3%	200 ft
Collector/Local	Collector	4%	150 ft

(d) No valleys across arterials or collectors will be allowed. To accomplish a smooth transition, cross-fall toward the median of one lane of each thoroughfare may be required. The use of storm drainage inlets in the median shall be avoided if possible.

7.4.7.3 Street Cross Section

For curbed streets, the right-of-way shall be graded to drain to the street at a typical slope of 1/4 inch per foot. Street back slopes and embankment slopes shall not be steeper than 3:1. Streets shall typically be rooftop crowned with two percent (2%) cross slope unless otherwise approved by the Commissioners Court Engineering Representative.

7.4.7.4 Sidewalks

(a) All sidewalks shall conform to state regulations for barrier free construction.
(b) Sidewalks shall be at least 4 feet wide in residential subdivisions and at least 5 feet wide in non-residential subdivisions and along arterials and collectors.
(c) Sidewalks shall not be located within ditches.
(d) One foot of width shall be added to all sidewalks abutting retaining walls.

7.4.7.5 Driveway and Curb Openings

Design of driveways shall comply with applicable requirements of the Hunt County Subdivision Regulations and this manual.

(a) Driveways should intersect streets at or near 90 degrees.
(b) The driveway edge should be located equal to or greater than 5 feet from each side of the property line.
(c) No portion of any driveway should be located within 3 feet of any fire hydrant, electrical pole, or any other surface public utility.
(d) Driveways shall be designed with a sidewalk crossing meeting accessibility requirements.
(e) The minimum driveway grade within the street right-of-way is set using 1/4 inch per foot (2 percent) rise above the top of curb to the property line. The elevation of a driveway at the right-of-way line shall be no lower than the top of curb to ensure proper street drainage is maintained.
(f) The grade break at the gutter line, and at any point within 10 feet of the gutter line, must not exceed 12 percent in order to avoid car bumper drag from occurring. Streets with a 1/4 inch per foot crossfall to the gutter (-2 percent) will limit the maximum approach grade to 10 percent.
(g) Driveway connections to rural road sections across bar ditches (see Chapter 8) shall be installed in accordance with the following: The culvert shall be sized by the owner's engineer. The minimum culvert size is 15 inches and shall be reinforced concrete or corrugated metal pipe. For thoroughfares, the maximum slope from the edge of driveway to the top of culvert pipe shall be 6:1 and the end of the pipe shall have sloped end treatment. Positive grading shall be provided upstream and downstream so that drainage can flow through the culvert without ponding. Rural driveways shall have a minimum width along the pavement edge of 18 feet to facilitate turning movements.
(h) Throat width at right-of-way shall conform to the subdivision regulations Section 5.02 E
(i) Minimum curb radius shall conform to the subdivision regulations Section 5.02 E
(j) Minimum centerline spacing of driveways shall conform to the subdivision regulations Section 5.02 D
(k) Minimum driveway spacing from intersections shall conform to the subdivision regulations Section 5.02 C.

7.4.7.6 Accessibility Requirements

All plans and specifications for the construction or alteration of public buildings and facilities, privately owned buildings and facilities and pedestrian facilities must be in compliance with the Texas Accessibility Standards (TAS) and must conform to the standards required by regulations issued by the Texas Department of Licensing and Regulation (TDLR), under the Architectural Barriers Act, codified as Article 9102, Texas Civil Statutes.

7.5 Pavement Structure Design

7.5.1.1 Pavement Design

All new roadways within Hunt County shall be constructed of reinforced Portland cement concrete or hot mix asphalt concrete pavements. The use of RAP (Reclaimed Asphalt Pavement) and RAS (Recycled Asphalt Shingles) is not allowed. Work and materials shall be in accordance with the North Central Texas Council of Governments Public Works Construction Standards, current edition. Thickness minimums listed in **Table 17** are the minimum required pavement thickness for pavement and subgrade requirements for certain soil conditions for various street and thoroughfare types. Alternative pavement designs, if used, shall be performed in accordance with the Texas Department of Transportation (TXDOT) Pavement Manual, current edition. Other pavement thicknesses may be considered and approved by the Commissioners Court Engineering Representative based on traffic volume loads and soils report recommendations for road pavement sections. Construction means and methods shall conform to NCTCOG standards and specifications. Oil sand and seal coat may be used with approval of the Precinct Commissioner.

Table 17: Minimum Pavement and Subgrade Thickness

Facility Type	Concrete Pavement			Asphalt Pavement			
	Concrete Thickness[1]	Subgrade Thickness		Asphalt Thickness[4]	Subgrade Thickness		
		if P.I. ≤ 15, Cement Treat[2]	if P.I. ≤ 15, Lime Treat[3]		Flex Base[5]	if P.I. ≤ 15, Cement Treat[2]	if P.I. ≤ 15, Lime Treat[3]
Major Arterial (A)	9”	10”	10”	3.5”	14”	10”	10”
	8”	10”	10”	3.5”	12”	10”	10”
Minor Arterial (B)	8”	10”	10”	3.5”	12”	10”	10”
Collector (C)	7”	8”	8”	3”	10”	8”	8”
	6”	6”	6”	2”	8"	8"	8"
Local	6”	6”	6”	n/a	n/a	n/a	n/a
Driveways	6”	6”	6”	n/a	n/a	n/a	n/a

1NCTCOG Class C with 3,600 psi 28-day compressive strength.

2Minimum 3% by dry unit weight of Portland cement.

3Minimum 7% by dry unit weight of hydrated lime.

4NCTCOG Type D asphaltic concrete fine surface course.

5Crushed limestone compacted to 95% standard proctor density at optimum moisture.

7.5.1.2 Geotechnical Investigation

A geotechnical investigation must be performed for all new developments containing public or private streets. The investigation must be based on samples obtained from drilling or from excavations on the site. The geotechnical investigation must be performed by a qualified geotechnical firm. A report with findings and recommendations must be prepared and shall bear the seal of a Professional Engineer licensed in the State of Texas. As a minimum, the study must address the following:

(a) General soil and groundwater conditions;
(b) Earthwork recommendations;
(c) Recommendations for pavement subgrade treatment type, depth, and concentration;
(d) Guidelines for concrete and / or HMAC pavement construction; and
(e) Existence of Sulfites

7.5.1.3 Samples must be tested in a laboratory. Tests must include as a minimum:

(a) Moisture content and soil identification;
(b) Liquid and plastic limit determination;
(c) Unit weight determination;
(d) Eades and Grim lime series tests; and
(e) Soluble sulfate tests

7.5.1.4 Pavement Widening

Pavement widening projects may require a special pavement analysis and alternate pavement subgrade design. If the subgrade soil P.I. exceeds 20, a special pavement analysis shall be performed by the designer and, if warranted, the designer shall perform a special pavement subgrade design. When existing pavement sections are widened or when old pavement is removed and replaced with a widened section, differential upward pavement deflections can occur over short distances in a transverse direction (across the width) due to non-uniformity of subgrade moisture conditions.

(a) Sample borings shall be drilled along the proposed alignment to determine the differential in potential vertical rise (PVR) value between the existing paved and unpaved areas.
(b) Sample borings shall be drilled on 1,000 foot spacing along the existing pavement and 500 foot spacing along the proposed (unpaved) area.
(c) Moisture content tests, hand penetrometer tests and swell tests shall be performed to determine the differential soil PVR along the proposed alignment.
(d) If the differential PVR exceeds 2 inches, the designer shall propose an alternate pavement subgrade design that shall reduce the differential PVR to less than two 2 inches.

7.5.1.5 Pavers and Other Materials

Special paving treatments can be selected from a range of options including unit concrete pavers, bricks, textured and colored concrete, natural stone pavers, and concrete with exposed or special aggregate or other finish treatments. Design detailing must address the needs of ADA and TAS compliance in areas of crosswalks or walkways. In all locations within public rights-of-way, the materials must perform for the serviceable life of the street without significant degradation or requiring ongoing maintenance by the County.

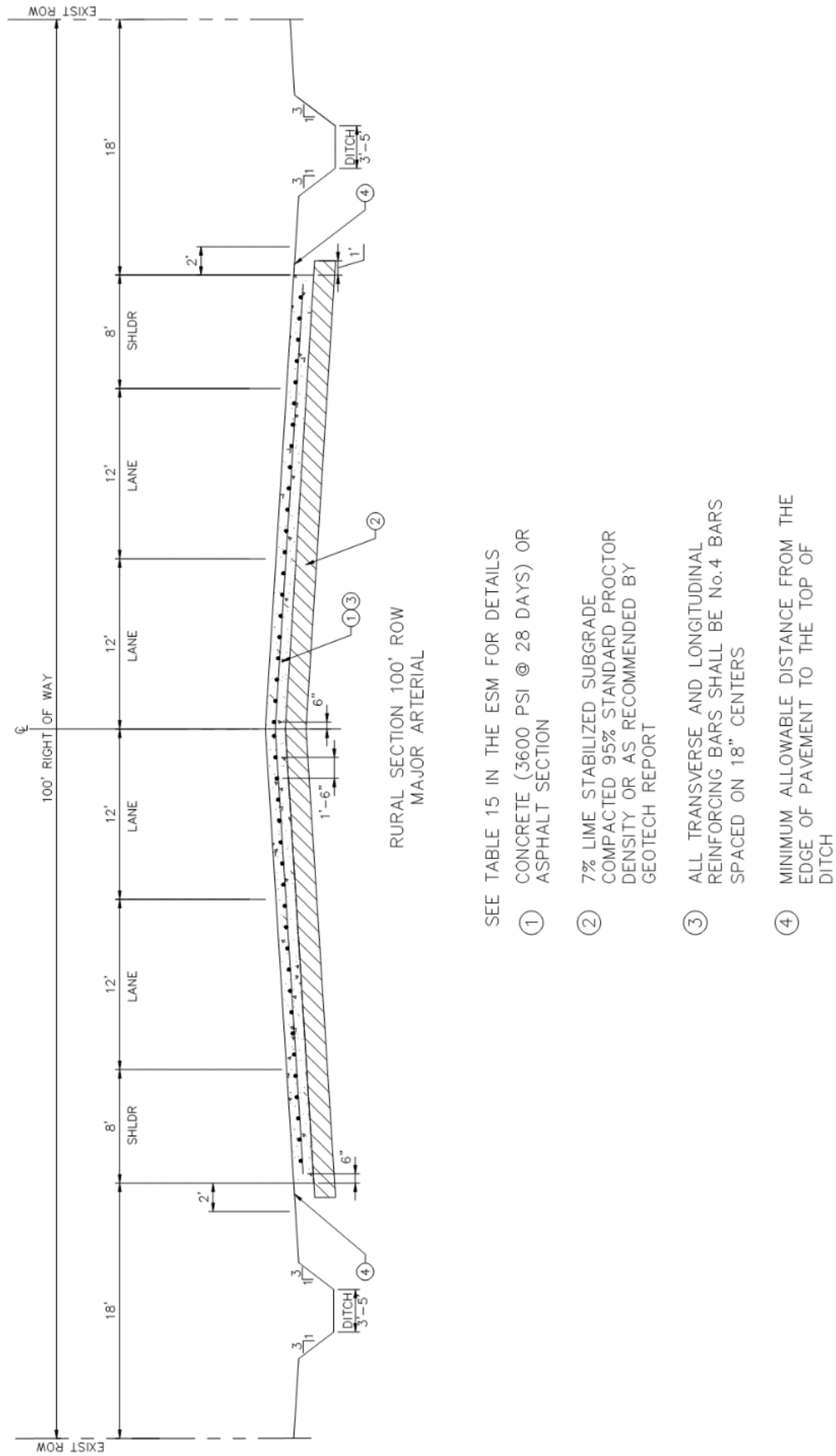
7.5.2 Permanent Pavement Markings and Signage

Permanent pavement markings and signage shall be installed in accordance with the Texas Manual on Uniform Traffic Control Devices (TMUTCD), current edition, and the direction of the Hunt County Commissioners Court.

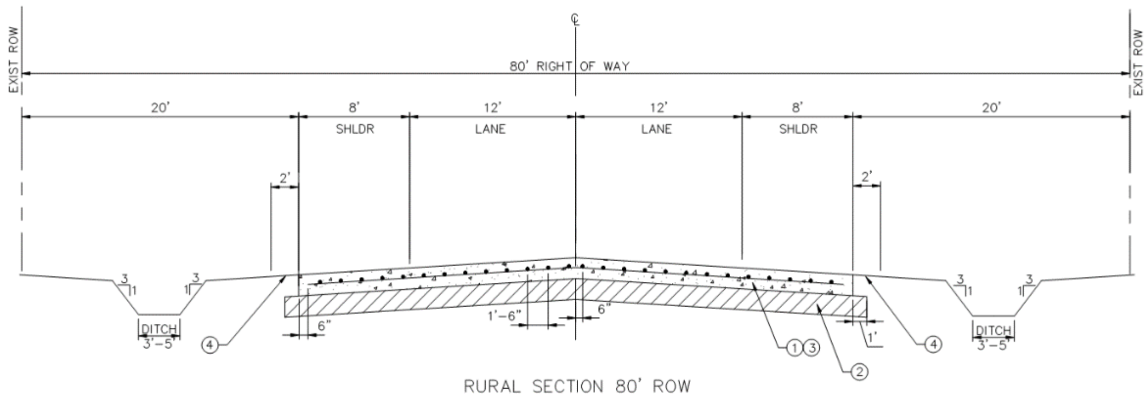
[This Page Intentionally Left Blank for Double-Sided Printing]

CHAPTER 8. TYPICAL CROSS SECTIONS

8.1 Major Arterial



8.2 Minor Arterial



RURAL SECTION 80' ROW
MINOR ARTERIAL

SEE TABLE 15 IN THE ESM FOR DETAILS

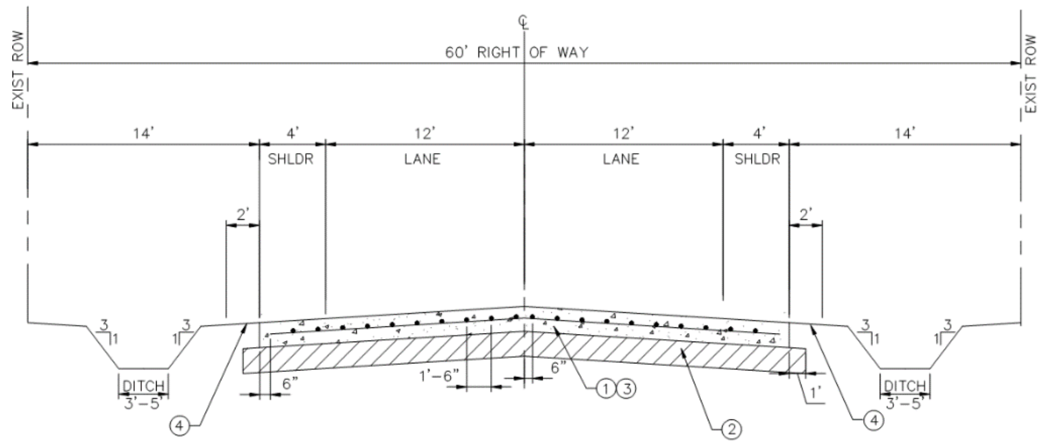
① CONCRETE (3600 PSI @ 28 DAYS) OR ASPHALT SECTION

② 7% LIME STABILIZED SUBGRADE COMPACTED 95% STANDARD PROCTOR DENSITY OR AS RECOMMENDED BY GEOTECH REPORT

③ ALL TRANSVERSE AND LONGITUDINAL REINFORCING BARS SHALL BE No.4 BARS SPACED ON 18" CENTERS

④ MINIMUM ALLOWABLE DISTANCE FROM THE EDGE OF PAVEMENT TO THE TOP OF DITCH

8.3 Collector



RURAL SECTION 60' ROW
COLLECTOR

SEE TABLE 15 IN THE ESM FOR DETAILS

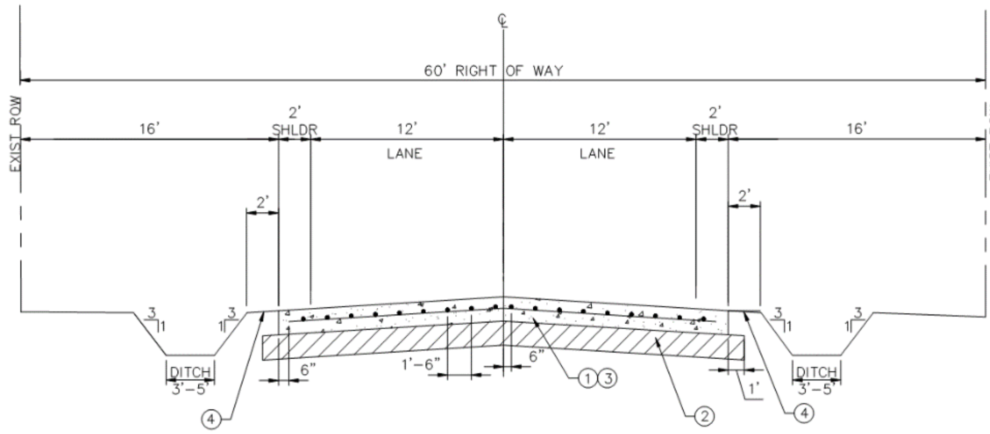
① CONCRETE (3600 PSI @ 28 DAYS) OR ASPHALT SECTION

② 7% LIME STABILIZED SUBGRADE COMPACTED 95% STANDARD PROCTOR DENSITY OR AS RECOMMENDED BY GEOTECH REPORT

③ ALL TRANSVERSE AND LONGITUDINAL REINFORCING BARS SHALL BE No.4 BARS SPACED ON 18" CENTERS

④ MINIMUM ALLOWABLE DISTANCE FROM THE EDGE OF PAVEMENT TO THE TOP OF DITCH

8.4 Rural Local



RURAL SECTION 60' ROW
LOCAL (RESIDENTIAL)

SEE TABLE 15 IN THE ESM FOR DETAILS

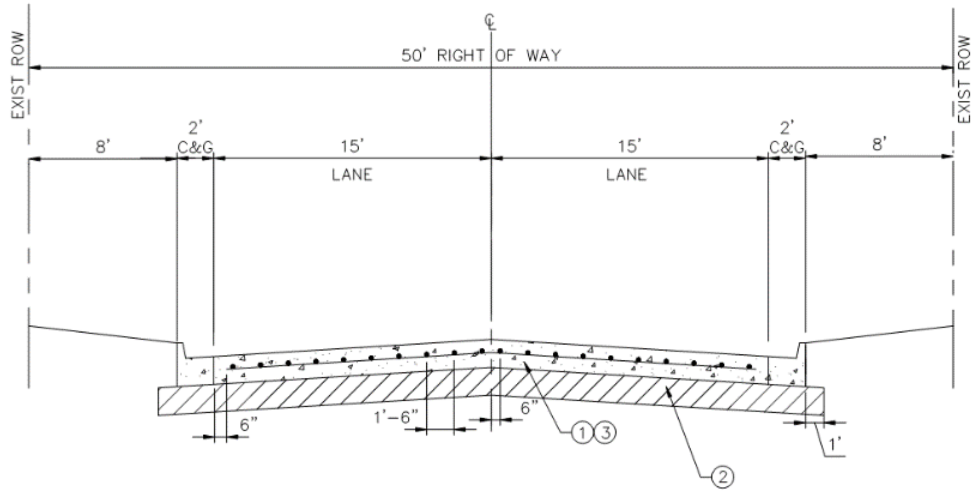
① CONCRETE (3600 PSI @ 28 DAYS) OR ASPHALT SECTION

② 7% LIME STABILIZED SUBGRADE COMPACTED 95% STANDARD PROCTOR DENSITY OR AS RECOMMENDED BY GEOTECH REPORT

③ ALL TRANSVERSE AND LONGITUDINAL REINFORCING BARS SHALL BE No.4 BARS SPACED ON 18" CENTERS

④ MINIMUM ALLOWABLE DISTANCE FROM THE EDGE OF PAVEMENT TO THE TOP OF DITCH

8.5 Urban Local



URBAN SECTION 50' ROW
LOCAL (RESIDENTIAL)

SEE TABLE 15 IN THE ESM FOR DETAILS

① CONCRETE AND INTEGRAL CURB & GUTTER (3600 PSI @ 28 DAYS) OR ASPHALT SECTION

② 7% LIME STABILIZED SUBGRADE COMPACTED 95% STANDARD PROCTOR DENSITY OR AS RECOMMENDED BY GEOTECH REPORT

③ ALL TRANSVERSE AND LONGITUDINAL REINFORCING BARS SHALL BE No.4 BARS SPACED ON 18" CENTERS

[This Page Intentionally Left Blank for Double-Sided Printing]