ENGINEERING STANDARDS MANUAL

THE CITY OF STEPHENVILLE TEXAS

PUBLIC WORKS

WATER - SEWER - STREETS - DRAINAGE

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CITY OF STEPHENVILLE

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PART I - GENERAL

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1.1 PURPOSE

The purpose of the Engineering Standards Manual (ESM) is to provide a set of guidelines for designing water, sewer, streets, and drainage facilities and other public improvements and for preparing construction plans for such facilities which are to be owned, operated and/or maintained by the City of Stephenville, Texas. These guidelines shall be used by the City, Consulting Engineers for both public and private developments in the City of Stephenville and its extra-territorial jurisdiction (ETJ) as well as for plat approval, and the issuance of building and earthwork / grading permits, approval of construction plans by the City, site plan approval, and for other construction within public rights-of-way and easements subject to Section 245 of the Texas Local Government Code. The design criteria may be modified by administrative action and subsequent City Ordinance at such times as may be appropriate. The standard construction details may be modified by administrative action in keeping with the most up-to-date construction materials and techniques. All water, sewer, street and drainage installations shall be performed in accordance with the City Standards and Specifications and all projects shall meet state and federal requirements.

1.2 AUTHORIZATION

The Standards shall be in full force and effective immediately upon adoption by the City Council. Projects will be required to comply with all requirements. The standards include the various design criteria defined in this ESM, Standard Construction Details, technical specifications, the current versions of the North Central Texas Council of Governments (NCTCOG) Specifications for Public Works Construction, as amended from time to time, and the City's supplements to the NCTCOG specifications which are considered minimum requirements for the design and construction of adequate public facilities within the City. The Engineer of Record shall bear the sole responsibility for meeting the Engineering Standard of Care for all aspects of the design and providing a design that's required by the site-specific conditions and intended use of the facilities, while at a minimum meeting the City's design and construction requirements.

1.3 SCOPE

The scope of this section of the Engineering Standards Manual includes the various design elements, criteria, standards and instructions required for the design of streets and arterials, drainage facilities, water lines, wastewater lines, and other public improvements.

1.4 STANDARD CONSTRUCTION DETAILS

In addition to the guidelines contained in this manual, the City maintains drawings entitled "STANDARD CONSTRUCTION DETAILS", which are to be used in conjunction with this Design Manual in the preparation of engineering plans.

1.5 CORRELATION OF MANUAL AND STANDARD CONSTRUCTION DETAILS

The Engineering Standards Manual and Standard Construction Details are complementary and what is called for by one shall be binding as if called for by both.

In case of conflict between the Engineering Standards Manual and Standard Construction Details, the City reserves the right to make the interpretation that is in the best interest of the City.

1.6 UTILITY ASSIGNMENTS

Utilities are to be located in public rights-of-way in the location shown in Appendix "A". The City shall determine the location of utilities where special circumstances prevent the standard utility assignments from being used.

1.7 GENERAL NOTES

All construction plans for the projects described above shall contain the applicable general notes listed in Appendix "B".

1.8 CORRELATION OF MANUAL AND SUBDIVISION ORDINANCE

The Engineering Standards Manual (ESM) and the Subdivision Ordinance are complementary and what is called for by one shall be binding as if called for by both.

In case of conflict between the ESM and the Subdivision Ordinance the more stringent criteria shall take precedence.

1.9 VARIANCE PROCEDURE

The City of Stephenville City Administrator will consider variance requests on an individual basis when, due to geographic or topographic limitations of the site on which the facilities are to be constructed, there are circumstances which warrant an individual design. In considering whether or not a variance should be granted, the City Administrator shall consider the following factors:

a. The extent to which the proposed design meets the spirit and intent of this Ordinance through the use of materials, design criteria and engineering which will protect the health, safety and general welfare of the public; and

b. The extent to which the proposed design meets the spirit and intent of this Ordinance through the use of materials, design criteria and engineering which will protect the health, safety and general welfare of the public; and

c. The positive or negative impact of the proposed design on surrounding property uses and property values, in comparison to the expected impact of the facilities if same were built in strict conformity with the standards of this Ordinance; and

d. The extent to which the proposed design accomplishes the purposes of the City's Engineering Standards Manual and Standard Construction Details.

A variance shall not be granted to serve as a convenience to the applicant or for reasons related to economic hardship.

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PART II – WATER AND SEWER

PART II - WATER AND SEWER LINES

I WATER MAINS

1.1 GENERAL

Water mains shall generally be placed on the north and east sides of a street, in accordance with the utility assignments in Appendix A. Where applicable, line sizes shall comply with the City's Water Master Plan or subsequent revisions.

a. Water lines in the City of Stephenville are categorized as:

   1. Distribution Lines – sizes 12-inch and less.
   2. Transmission Mains – sizes greater than 12-inches.

b. Lines shall be minimum 6-inch diameter pipe in residential neighborhoods. A minimum 8-inch diameter pipe shall be used in commercial and industrial districts and shall be a minimum of 12-inch diameter pipe if the line is over 600 feet in length.

c. Dead end lines shall not be allowed.

d. Fire hydrant lead lines shall be 6-inch diameter pipe and no greater than 50 feet in length. Any fire hydrant lead line over 20 feet may be required to be 8-inch diameter pipe.

e. Water lines shall be shown with a profile view, on plan sheets, to confirm separation distances from other utility lines. Stationing and elevations to 0.01 feet shall be provided for all water lines.

1.2 WATER LINE MATERIAL

a. Water mains 24-inches in diameter and smaller shall be AWWA C900-07 Class 235 (DR 18) PVC, mechanical joint, or a bell and spigot joint unless otherwise approved by the City. A recession in the bell shall have a single rubber gasket. Ductile iron fittings with polywrap shall be used unless otherwise approved by the City.

b. Water mains greater than 24 inches in diameter and larger shall generally be Ductile Iron Pipe, (DIP) complying with AWWA C151, with bituminous coating outside and mortar-lining inside in accordance with AWWA C104. Mechanical joint fittings shall be used and shall conform to ASTM C111. The minimum Pressure Class shall be 150 psi. All pipe and fittings shall be encased in polyethylene in conformance with ASTM C105.

c. Water lines shall be minimum pressure Class 150.

d. Water mains shall be standard sizes that are readily available, such as 6-inch 8-inch, 12-inch, 16-inch, 18-inch, 20-inch, 24-inch, 30-inch, and 36-inch.

1.3 LOCATION

Water mains shall be constructed with extensions to the development boundary to allow for direct connection by future developments. Water mains shall generally be located in accordance with Utility Location Requirements for the City of Stephenville. See Appendix ”A”.

1.4 WATER VALVES

Valves, 16-inch diameter and smaller, shall be placed on or near street property lines and shall be spaced at a maximum of 800 feet apart in residential areas and 500 feet in all other districts and shall be placed in such a manner as to require, preferably two, but not more than three valves to shut down each City block, or as may be required to prevent shutting off more than one fire hydrant. On cross-feed mains without services, a maximum of four valves shall be used to shut down each block. Also, valves shall be placed at or near the ends of mains in such manner that a shut-down can be made for a future main extension without causing loss of service on the existing main. The location of valves larger than 16-inches will be as approved by the Director of Public Works. Valves 16-inches and smaller shall be Resilient Seat Gate Valves (RSGV). Restrained joints shall be used in all installations. All valves will be gate valves, unless otherwise approved by the City and shall be manufactured by one of the following companies: American, Mueller or City-approved equal.

1.5 FIRE HYDRANTS

a. Number and Locations

A sufficient number of fire hydrants shall be installed to provide hose stream protection for every point on the exterior wall of the building. There shall be sufficient hydrants to concentrate the required fire flow, as recommended by the publication "GUIDE FOR DETERMINATION OF REQUIRED FIRE FLOW" published by the Insurance Service Office, as required by the adopted version of the International Fire Code by the City of Stephenville, or as approved by the Fire Marshal, around any building with an adequate flow available from the water system to meet this required flow. Fire hydrant markers shall be provided at each hydrant. In addition, the following guidelines shall be met or exceeded:

1. SINGLE FAMILY AND DUPLEX RESIDENTIAL - As the property is developed, fire hydrants shall be located at all intersecting streets and at intermediate locations between intersections at a maximum spacing of 500 feet between fire hydrants as measured along the route that fire hose is laid by a fire vehicle. All buildings shall be within a 500 foot radius of a fire hydrant.

2. MULTIFAMILY RESIDENTIAL - As the property is developed, fire hydrants shall be located at all intersecting streets and at intermediate locations between intersections at a maximum spacing of 400 feet as measured along the length of the center line of the roadway, and the front of any structure at grade and shall be no further than 400 feet from a minimum of two fire hydrants as measured along the route that a fire hose is laid by a fire vehicle. All buildings shall be within a 400 foot radius of a fire hydrant.

3. OTHER DISTRICTS - As the property is developed, fire hydrants shall be located at all intersecting streets and at intermediate locations between intersections at a maximum spacing of 300 feet as measured along the length of the center line of the roadway, and the front of any structure at grade and shall be no further than 400 feet from a minimum of two fire hydrants as measured along the route that a fire hose is laid by a fire vehicle. All buildings shall be within a 300 foot radius of a fire hydrant.

4. PROTECTED PROPERTIES - Fire hydrants required providing a supplemental water supply for automatic fire protection systems shall be within 100 feet of the fire department connection for such system.

5. Fire hydrants shall be installed along all fire lane areas as follows:

   (a) Non-Residential Property or Use

      (1). Within 150 feet of the main entrance.

      (2). Within 100 feet of any fire department connection.

      (3). At a maximum intermediate spacing of 300 feet as measured along the length of the fire lane.

   (b) Apartment, Townhouse, or Cluster Residential Property or Use

      (1). Within 100 feet of any fire department connection.

      (2). At maximum intermediate spacing of 400 feet as measured along the length of the fire lane.

6. Generally, no fire hydrant shall be located closer than fifty (50) feet to a non-residential building or structure unless approved by the City.

7. In instances where access between the fire hydrant and the building that the hydrant is intended to serve may be blocked, extra fire hydrants shall be provided to improve the fire protection. Railroads, expressways, major thoroughfares and other man-made or natural obstacles are considered as barriers.

8. Along divided roadways, fire hydrants shall be installed on both sides of the roadway so as to preclude the need for laying hose across the roadway.

b. Restrictions

1. All public fire hydrants shall be the type indicated on the approved plans and shall be placed on water mains of no less than six inches (6") in diameter. Fire hydrants shall be manufactured by one of the following companies and meet the City's standard; East Jordan, Mueller, or City-approved equal.

2. Gate valves shall be placed on all fire hydrant leads.

3. Required fire hydrants shall be installed so the breakaway point will be no less than three (3") inches, and no greater than five (5") inches above the grade surface.

4. Fire hydrants shall be located a minimum of two (2') feet and a maximum of six (6') feet behind the curb line, depending on the location of the sidewalk. The fire hydrant shall not be located in the sidewalk.

5. All required fire hydrants placed on private property shall be adequately protected by either curb stops or concrete filled steel posts or other methods as approved by the City and shall be in easements. Installation and maintenance of stops or posts shall be the responsibility of the landowner on whose property said private fire hydrant is placed.

6. All required fire hydrants shall be installed so that the steamer connection will face the fire lane or street, or as directed by the City.

7. Fire hydrants, when placed at intersections or access drives to parking lots, when practical, shall be placed so that no part of the fire truck will block the intersection or parking lot access when connections are made to the fire hydrant.

8. Fire hydrants, required by this article, and located on private property, shall be accessible to the Fire Department at all times.

9. Fire hydrants shall be located at street or fire lane intersections, when feasible.

10. Fire hydrant barrels shall arrive at the job site after being painted by the manufacturer enameled in Silver. Bonnets shall be painted according to Standard Details.

1.6 FIRE LINE METERING

The City of Stephenville will own and maintain all public fire lines serving public fire hydrants. Sprinkler service lines, fire line connections and other fire lines which are not maintained by the City shall be equipped with either a City-approved water meter or a detector check assembly having a capacity equal to the required fire flow. Water meters and detector check assemblies shall be constructed in accordance with City standards.

1.7 MINIMUM COVER

The minimum cover to the top of the pipe must vary with the valve stem. In general, the minimum cover below the street grade should be as follows: 12-inch and smaller, 3.0 feet. Lines larger than 12-inches shall have 4.0 to 6.0 feet of cover. Water lines with more than 6.0 feet of cover shall be approved by the City.

1.8 CLEARANCES BETWEEN WATER AND WASTEWATER LINES:

Clearances between water and wastewater lines shall meet TCEQ requirements. The minimum clearances for water and wastewater lines crossing storm drains shall be two (2) feet or one-half (0.5) feet when the water or wastewater line is encased per City standards.

1.9 METER BOX AND SERVICE

A water service with a meter box is constructed from the main to a point just behind the curb line, usually in advance of paving. The location of the meter box is generally as shown on the Utility Assignments detail sheets and as shown on the City of Stephenville Details. On multiple apartments and business properties, the desired size and location is usually specified by the owners. Minimum requirements for water service sizes are:

a. ¾ or one-inch min. single water services are required to serve all single-family residential lots.

b. Each residence shall have dedicated meter and service line on single-family residential lots.

c. The size of apartment, condominium, or multi-family services will depend on the number of units served with a minimum of one meter per building.

1.10 SERVICE CONNECTIONS

a. Service shall generally not be connected to fire hydrant leads unless approved by the City.

b. Service connections shall not be allowed to transmission mains.

II. WASTEWATER

2.1 MINIMUM SIZE

The minimum size of wastewater mains in the City of Stephenville shall be 8-inch diameter. 6-inch lines may be used to connect to existing 6-inch mains subject to City approval. Line sizes shall convey peak flows as shown on the City's Wastewater Master Plan or subsequent revisions. All wastewater lines shall be one of the following standard sizes such as 8-inch, 10-inch, 12-inch, 15-inch, 18-inch, 21-inch, 24-inch, 30-inch, and 36-inch.

2.2 LOCATION

Wastewater mains shall generally be placed on the south and west sides of a street, in accordance with the utility assignments in Appendix A. Where applicable, line sizes shall comply with the City's Wastewater Master Plan or subsequent revisions.

1. For Planned Developments, ALL necessary sanitary sewer services must be constructed up to the right-of-way. In areas outside of Planned Developments, sanitary sewer stub outs must be provided to allow future developments to connect service lines.

2.3 MINIMUM COVER

Minimum cover over all wastewater mains shall be a minimum of 2.0 feet unless approved by the City. Approved mains with less than 3.0 feet of cover may be required to be capped as per the "Cap Detail" on the Wastewater Standard Details. See City Standard Details.

2.4 WASTEWATER FLOWS, SIZE AND GRADES

Wastewater lines shall be designed to convey flows from all upstream areas based on ultimate development of the sewershed basin. Wastewater main sizes shall be obtained from the City's Wastewater Master Plan. Subbasin flow shall be computed in accordance with the following formula:

$$Q = \frac{C^{0.89}}{295}$$

Where:

Q = Peak wastewater flow (million gallons per day)
C = Equivalent single family connections

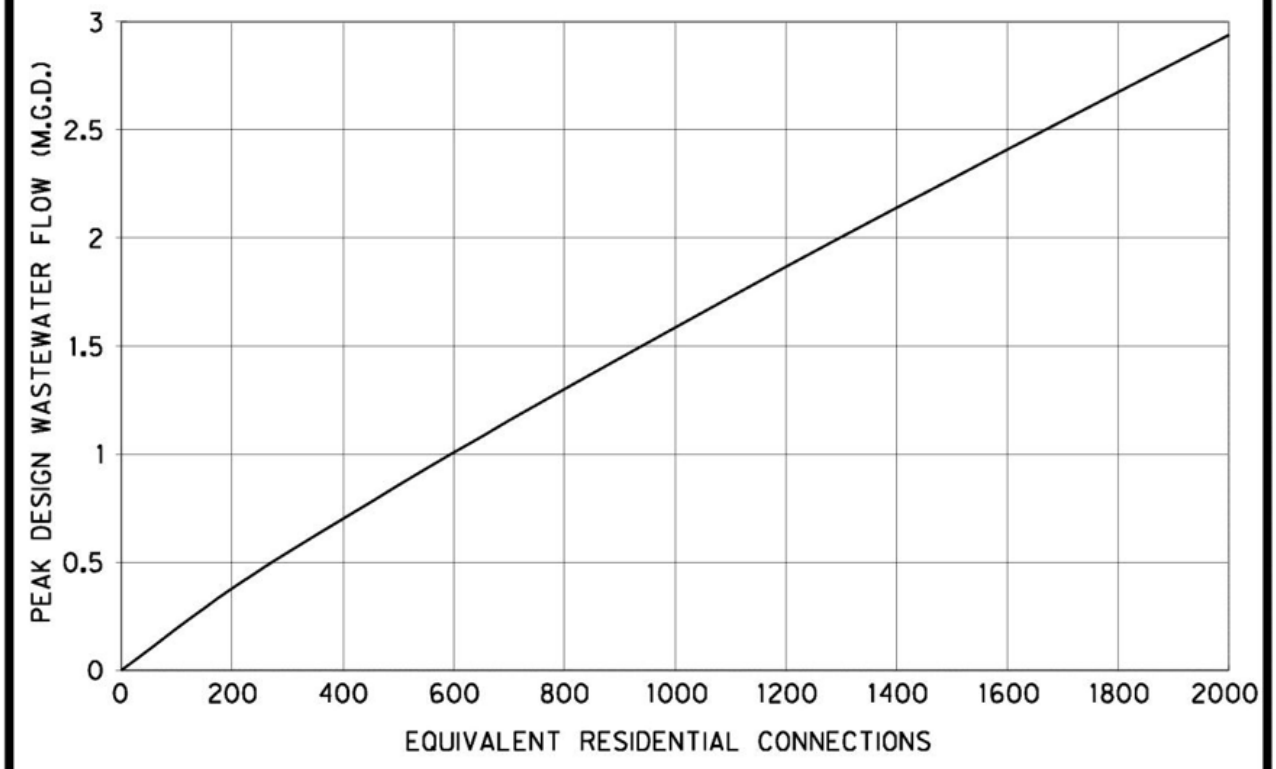
This equation is graphically displayed in Figure II-1. Equivalent single family connections are based on a density of 3.1 persons per dwelling unit. Densities for other residential uses shall be determined by the City. Wastewater flow for non-residential uses shall be evaluated by the design engineer and submitted to the City for approval.

Pipes should be placed on such a grade that the velocity when flowing full is not less than two feet per second or more than ten feet per second. Minimum grades shall be as follows:

6" - 0.50%	8" - 0.33%	10" - 0.26%	12” - 0.20%
15" - 0.14%	18" - 0.12%	21" - 0.10%	24" - 0.08%

All grades shall be shown to the nearest 0.01 foot with P.I. stationing. A manhole is required at all pipe slope changes and horizontal direction changes. No vertical curves will be allowed in wastewater lines.

FIGURE II-1
PEAK WASTEWATER FLOW RATES



2.5 MANHOLES

Manhole sizes shall be as designated on the Wastewater Standard Details. In general, manholes shall be placed at all three-way and four-way connections as well as line size changes and in accordance with spacing requirements. In floodplains and areas of local drainage, sealed manhole covers shall be used. Inside drop manholes shall be required when the inflow elevation exceeds the outflow elevation by more than eighteen inches (18"). All manholes shall have a minimum 30-inch rim opening or as required by the Texas Commission on Environmental Quality (TCEQ) or governing agency at the time of installation.

TABLE II-1
MINIMUM MANHOLE SIZES

Largest Main Size	Manhole Diameter
8"	4' 0"
12" – 24"	5' 0"
Greater than 24"	6' 0"

Manholes more than eight (8) feet deep shall be a minimum of five (5) feet in diameter.

Manholes shall be provided at all points of directional change (vertical and horizontal), "tee" intersections of pipe, force main outfalls, and at changes in pipe grade and/or pipe size. Maximum spacing between manholes on mains 21-inch in diameter and smaller shall be 500 linear feet. Maximum spacing for manholes on mains larger than 21-inch diameter shall be 800 feet.

2.6 LATERALS

For single family dwellings, the minimum lateral size shall be 4-inch diameter; for multiple units, apartments, local retail and commercial; 6-inch diameter minimum; for manufacturing and industrial, the size should be determined by the Engineer. House laterals should generally be located nine feet (9') downstream from the center of the lot and shall have a minimum lateral separation of nine feet (9') from the water service. Manholes will be required on 6-inch diameter and larger laterals where laterals connect to the main line. Laterals may only be connected to sewer mains with a depth of ten feet (10') or greater with approval of the City Engineer. A minimum of one lateral per residential lot shall be required. Duplexes shall have a separate lateral to each unit.

A cleanout shall be installed in each lateral and located at the right-of-way or easement line. Developers are encouraged to set a double cleanout(s) for access to the private portion of the lateral.

2.7 WASTEWATER LINE MATERIALS

a. All wastewater lines up to 15-inch diameter shall be PVC SDR 35 for depths less than 14 feet and SDR 26 for deeper installation in accordance with manufacturer recommendations. Allowable pipe types for larger mains shall be as shown on the Wastewater Details or as otherwise approved by the City.

b. For wastewater lines crossing under creeks, rivers, streams, and/or major drainage ways with a minimum cover of five feet (5') or less to the water flowline, wastewater lines shall be fusible PVC (or city-approved jointless pipe) with appropriate encasement per City Wastewater Details.

III. UTILITY EASEMENTS

3.1 REQUIREMENTS

All public utilities shall be installed in a utility easement. Utility easements shall be dedicated on plats or by separate instrument if the property is not platted.

No structure, building, wall or pool shall be located or constructed within a Utility Easement (UE). Only the following facilities may be allowed in a UE upon written approval of the City:

a. Fences
   1. Fence types must be approved by the City Engineer.
      A. Privacy fences will not be permitted.
      B. Livestock fencing may be permitted on a case-by-case basis in non-residential settings.

b. Facilities transverse to the easement such as roads, streets and private utilities;

c. Parking lots and driveways subject to written approval of the City. UE's shall be shown, labeled and described on the plat or described by metes and bounds when provided by separate instrument.

UE's shall have the following minimum widths unless otherwise approved in writing by the City Engineer.

a. No UE shall be less than 15 feet in width.

b. UE's with public water and wastewater lines shall have a minimum width of 20 feet.

c. When more than two utility lines or a single line is greater than 12-inches in diameter, the width of the UE will be determined by the City. Typical easement widths with a single line are:
   1. Less than 16-inch diameter = 15 feet wide easement min.
   2. 16-inch to 20-inch diameter = 20 feet wide easement min.
   3. 24-inch to 27-inch diameter = 25 feet wide easement min.
   4. 30-inch and greater diameter = 30 feet wide easement min.

3.2 LANDSCAPING IN UTILTIY EASEMENTS

Landscaping in utility easements shall be limited to grass. Water features and trees shall not be permitted in utility easements. Planters should be avoided when possible.

IV. EXTENSION OF UTILITY SERVICES BEYOND CITY LIMITS

4.1 EXTENSION OF UTILITY SERVICES – CONTIGUOUS TO CITY LIMITS

When city water and/or wastewater service is sought for property contiguous to the existing city limits, the property shall be voluntarily annexed into the city as a condition of receiving such utility service.

a. As part of the voluntary annexation process, a Municipal Services Agreement will be completed to define the terms of service.

4.2 EXTENSION OF UTILITY SERVICES – NOT CONTIGUOUS TO CITY LIMITS

For property not contiguous to the existing city limits, conformity with the city's general plan, building, zoning, and other codes, regulations, ordinances, and policies as well as future maintenance costs may be considered prior to granting such utility service.

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PART III - STREETS

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PART III - STREETS

I. STREET FUNCTIONAL CLASSIFICATIONS

1.1 GENERAL

City streets are classified into types according to their use and locations as indicated in Table III-1. The basic types include the local streets which provide direct access and frontage to adjacent properties, collectors which serve as the distributor-collector routes and provide direct access to adjacent properties, and minor and major arterials which carry high volumes of traffic. Each roadway is made up of elements which are related to the use of that particular facility. These elements include right-of-way, pavement width, median width if required, arrangement of traffic lanes, curb radii at intersections and other characteristics. The City of Stephenville intends to maintain the rural character of certain areas of the City as per the City's 2030 Comprehensive Plan. Toward that end, rural roadway standards will be permitted in rural residential areas. Rural standards employ concrete paved shoulders or roll-over curbs, in lieu of using standard curbs and gutters, with the use of bar ditches for drainage.

II. STREET DIMENSIONS

2.1 GENERAL

Geometrics of streets may be defined as the geometry of the curbs or pavement areas which governs the movement of traffic within the confines of the right-of-way. Included in the geometrics are the pavement widths, degree of curvature, width of traffic lanes, shoulders, turning lanes, median width separating opposing traffic lanes, median nose radii, curb radii at street intersections, crown height, cross fall, geometric shapes of islands separating traffic movements and other features.

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TABLE III-1
STREET CLASSIFICATIONS AND DIMENSIONS

STREET TYPE	CLASSIFICATION DESCRIPTION	PVMT WIDTH	MIN ROW WIDTH	LANES	SHOULDER WIDTH	MIN PARKWAY WIDTH	MEDIAN WIDTH	DESIGN SPEED (MPH)
Alley	Commercial - Industrial	24’	25’	NA	NA	NA	NA	10
L2U-U	Local	31’	50’	2-9’	NA	9.5’	NA	30
C2U-U	Collector	44’	70’	2-12’	NA	13’	NA	35
M4D-U	Minor Arterial (divided)	54’	100’	2-11’ & 2-12’	NA	16’	14’	40
P4D-U	Major Arterial (divided)	56’	120’	4-12’	NA	24’	16’	45
P6D-U	Major Arterial (divided)	76’	130’	4-11’ & 2-12’	NA	19’	16’	45
L2U-R	Local (HMA Alt)	26’	60’	2-11’	2-2’	18’	NA	30
C2U-R	Collector	40’	80’	2-12’	2-8’	15’	NA	35
M3U-R	Rural Arterial (undivided)	48’	100’-120’	3-12’	2-6’	26’	NA	45
Note: All pavement and median width dimensions are to the back of curb or edge of pavement								

2.2 DESIGN VEHICLES

The geometrics of City street intersections vary with the classification of intersecting streets. Criteria for the geometric design of intersections must be based on certain vehicle operating characteristics, and vehicle dimensions. The American Association of State Highway and Transportation Officials (AASHTO) has standardized vehicle criteria into three general designs which is published in the AASHTO Publication, "A Policy on Geometric Design of Highways and Streets", dated 2011 or current edition. In the design of street and thoroughfare intersections for the City, these vehicle designs are adopted for use. Table III-2, Intersection Design Standards, shall be used for intersection design.

TABLE III-2
INTERSECTION DESIGN STANDARDS
(All dimensions are minimums)

	A_1*	A_1+	A_1#	A_2*	A_3	B	C	D	E	F	R_1	R_2	Corner Clip
P4D-U & P6D-U	275'	150'	100'	150'	150'	150'	10'	330'	600'	60'	50'	50'	25 X 25
M4D-U	200'	150'	100'	150'	150'	150'	10'	330'	600'	60'	50'	50'	25 X 25
M3U-R	200'	150'	100'	150'	150'	150'	N/A	330'	N/A	N/A	40'	40'	20 X 20
C2U-U & C2U-R	100'	150'	100'	100'	150'	150'	N/A	270'	N/A	N/A	30'	30'	15 X 15
L2U-U & L2U-R	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	30'	30'	10 X 10
	A_1*	A_1+	A_1#	A_2*	A_3	B	C	D	E	F	R_1	R_2	Corner Clip

* When intersecting street is a principal or minor arterial.
+ When intersecting street is a collector or a rural road.
# When intersecting street is a local street.
** For dual left-turn standards, consult the City
A_1 and A_2 may be increased to allow for stacking truck traffic.
Corner clip based on 90 degree intersection, may be adjusted for angled intersection.
Radius and corner clip are based on highest classification street at intersection.

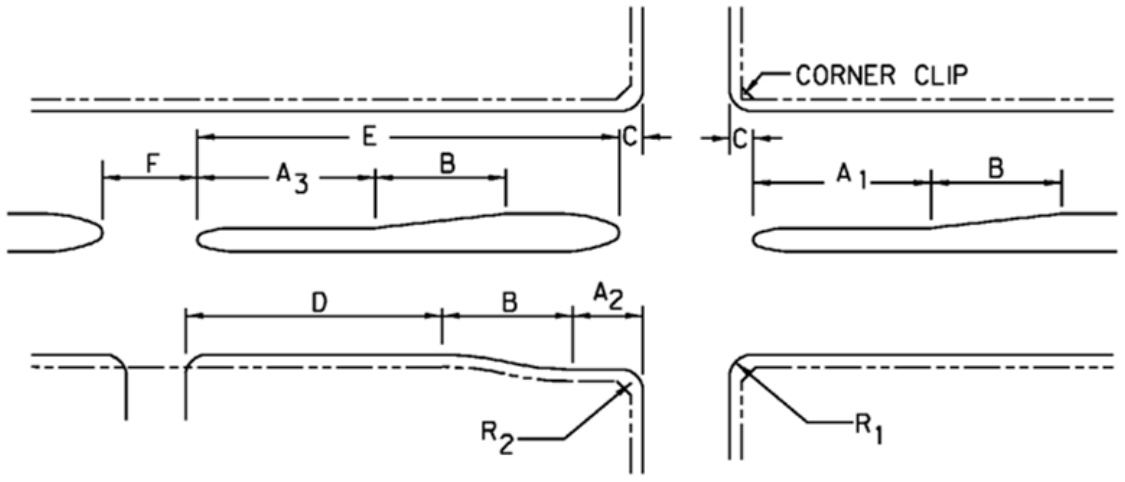


FIGURE III-1
INTERSECTION DESIGN DIAGRAM

2.3 DESIGN SPEED

The design speed is a primary factor in the horizontal and vertical alignment on City streets. Design features such as curvature, superelevation, radii for turning movements and sight distance are directly related to the design speed. The design speed also affects features such as lane width, pavement width, pavement cross-fall, pavement crown, and clearance.

The design speed is defined as the approximate maximum speed that can be maintained safely by a vehicle, traveling over a given section of pavement, when conditions are such that the design features of the roadway govern. The assumed design speed should correlate logically with respect to the topography, anticipated operating speed, the adjacent land use, and the functional classification of the street. On city streets, designers should select a design speed to use in geometric decisions based on safe operating speeds in a complex environment.

The speed limit or posted speed is the maximum legal speed set by local authorities for a certain roadways or areas. The design speed should always be greater than the likely legal speed limit for arterials.

The various street classifications, which make up the system within the City, require different design speeds according to use and location. The minimum design speeds for the various classifications within the City of Stephenville are presented in Table III-1. Lower design speeds may be required for all classifications with unusual conditions of terrain or alignment.

2.4 HORIZONTAL GEOMETRICS

a. General

The horizontal geometrics of City streets and arterials include the segment of geometric design associated with the alignment, intersections, pavement widths, and related geometric elements. The various classifications, utilizing the design speed as a control, must have certain horizontal and vertical geometrics to provide a safe economical facility for use by the public. All curves shall provide proper sight distances.

b. Horizontal Curves and Superelevation

The alignment of City streets and arterials is usually determined by the alignment of the existing right-of-way or structures which cannot be relocated. Changes in the direction of a street or arterial are minimized by constructing a simple curve having a radius compatible with the speed of vehicular traffic. To increase the safety and reduce discomfort to drivers traversing a curved portion of a street or thoroughfare, the pavement may be superelevated. Curvature in the alignment of arterials and collectors is allowed, but greater traffic volume and higher vehicle speeds which accompany these facilities tend to increase crashes on curving roadways. Curves in the alignment of residential streets usually provide aesthetic values to the residential neighborhoods without affecting the orderly flow of traffic or sacrificing safety.

A recommended minimum radius of curvature for vehicle design speed and pavement cross-slopes is shown in Table III-3. These are based on traffic consisting of typical present day automobiles operating under optimum weather conditions. There are other important considerations in the design of curves on City streets and arterials including the location of intersecting streets, drives, bridges and topographic features. When superelevation is required on collectors and arterials, the following basic formula shall be used:

$$R = \frac{V^2}{15(e+f)}$$

where:

e = rate of roadway superelevation, foot per foot

f = Side friction factor (See Table II-3)

V = vehicle design speed, mph

R = radius of curve in feet

TABLE III-3

MINIMUM CENTERLINE RADIUS FOR ROADWAYS

Rate of Superelevation (In./Ft.)	Residential	Collector/Minor Arterial		Principal Arterial
	DESIGN SPEED (MPH)			
	30 mph	35 mph	40 mph	45 mph
-1/2	500 ft	710 ft	930 ft	1290 ft
-3/8	465 ft	655 ft	855 ft	1175 ft
-1/4	430 ft	605 ft	790 ft	1080 ft
-1/8	400 ft	565 ft	740 ft	1000 ft
0	375 ft	530 ft	690 ft	935 ft
+1/8	355 ft	495 ft	650 ft	875 ft
+1/4	335 ft	470 ft	610 ft	820 ft
+3/8	320 ft	445 ft	580 ft	775 ft
+1/2	300 ft	420 ft	550 ft	730 ft

Street Classification	Side Friction Factor (f)
Residential Streets	0.160
Collector Streets	0.155
Arterials	0.145

c. Turning Lanes

Turning lanes are provided at intersections to accommodate left-turning and right-turning vehicles. The primary purpose of these turning lanes is to provide storage for the turning vehicles. The secondary purpose is to provide space to decelerate from normal speed to a stopped position in advance of the intersection or to a safe speed for the turn in case a stop is unnecessary. Left turn lanes at intersections are 11-12 feet in width. When turning traffic is too heavy for a single lane and the cross street is wide enough to receive the traffic, two turning lanes may be provided.

The location of the median nose at the end of the left turn lane should be located so that left turning traffic will clear the median nose while making a left turn. Other considerations include adequate clearance between the median nose, thru traffic on the intersecting thoroughfare and locations of the median nose to properly clear the pedestrian crosswalks.

Minimum length of left turn lanes for major thoroughfares shall be as specified in Table III-2.

The actual length shall be approved by the City based upon projected left turn volume.

d. Street Intersections

The intersection at grade of arterials, collector streets, and local streets shall be at ninety (90) degree angles. Intersections which are not a ninety (90) degree angle may be approved by the City. Lanes shall be aligned for safe passage through the intersection.

e. Sidewalks

The purpose of public sidewalks is to provide a safe area for pedestrians. The Subdivision Ordinance requires sidewalks be constructed with the paving of streets, when building construction occurs, in all urban, residential areas and wherever pedestrian traffic may be generated. All sidewalks shall conform to state laws for barrier free construction.

The standard concrete sidewalk is four feet (4') in width for residential areas and five feet (5') in width for commercial areas. Special sidewalk designs to include a sidewalk six feet (6') in width located adjacent to the street will be considered for approval where warranted. Rural paving section sidewalks shall be located in sidewalk easements adjacent to right-of-way lines. Sidewalks shall not be located in ditches. One foot of width shall be added to all sidewalks abutting retaining walls.

Sidewalk alignments may be varied to avoid the removal of trees or the creation of excessive slopes when approved by the City Engineer. A waiver for deletion of the requirement for sidewalks shall be submitted in writing and will become effective only upon City Council approval.

2.5 VERTICAL ALIGNMENT

a. Street Grades

The vertical alignment of City streets and arterials should be designed to insure the safe operation of vehicles and should allow easy access to adjacent property. A safe travelway for vehicles is dependent on criteria which considers operating speeds, maximum grades, vertical curves and sight distance. In addition to these considerations, other factors related to vertical alignment include storm drainage, crown and cross slope and the grade and right-of-way elevation relationship.

1. Minimum Grades

Minimum longitudinal grades for streets are required to insure proper flow of surface drainage toward inlets and to provide minimum ditch grades. Minimum grades are five tenths percent (0.5%) for all urban roadways. Valleys gutters across intersections shall be a minimum of five tenths percent (0.5%).

2. Maximum Grades

Maximum longitudinal grades shall be compatible with the type of facility and the accompanying characteristics including the design speed, traffic conditions and sight distance.

Arterials must move large volumes of traffic at faster speeds and flatter grades will better accommodate these characteristics. Truck and bus traffic on these type facilities often controls traffic movement, particularly if steep grades prevent normal speeds. The normal maximum street grades allowed are shown in Table III-4. Steeper grades may be permitted for short lengths where topographical features or restricted alignment require.

TABLE III-4

MAXIMUM STREET GRADES

Street Types	Normal Maximum Grade In Percent
Residential	8%
Collector	6%
Arterial	6%

b. Vertical Curves

When two longitudinal street grades intersect at a point of vertical intersection (PVI) and the algebraic difference in the grades is greater than one percent (1%) for design speed less than 45 mph or one-half percent (0.5%) for design speeds greater than 45 mph, a vertical curve is required. Vertical curves are utilized in roadway design to effect a gradual change between tangent grades and should result in a design which is safe, comfortable in operation, pleasing in appearance and adequate for drainage. The vertical curve shall be formed by a simple parabola and may be a crest vertical curve or a sag vertical curve.

c. Stopping Sight Distance

1. Crest Vertical Curve

When a vertical curve is required, it must not interfere with the ability of the driver to see length of street ahead. This length of street, called the stopping sight distance, should be of sufficient length to enable a person in a vehicle having a height of 3.50 feet above the pavement and traveling at design speed to stop before reaching an object in his path that is 0.5 feet in height.

The minimum stopping sight distance is the sum of two distances: first, the distance traversed by a vehicle from the instant the driver sights an object for which a stop is necessary, to the instant the brakes are applied; and second, the distance required to stop the vehicle after the brake application begins.

The minimum safe stopping sight distance and design speeds are shown in Table III-5. These sight distances are based on each design speed shown and based on a wet pavement. The length of crest vertical curve required for the safe stopping sight distance of each street type may be calculated using the formula L = KA and the values of K for a crest vertical curve shown in Table III-5.

2. Sag Vertical Curve

When a sag vertical curve is required, the vertical curve shall be of sufficient length to provide a safe stopping sight distance based on headlight sight distance. The minimum length of sag vertical curve required to provide a safe stopping sight distance may be calculated using the formula L = KA and values of K for a sag vertical curve are shown on Table III-5.

TABLE III-5

MINIMUM LENGTH OF VERTICAL CURVE

CREST VERTICAL CURVE	SAG VERTICAL CURVE
L = KA where	L = KA where
L = Minimum Length Vertical Curve required for safe stopping	L = Minimum Length Vertical Curve required for Headlight Control
K = Horizontal Distance in feet requires to affect a one percent change in gradient	K = Horizontal Distance in feet required to affect a one percent change in gradient
A = Algebraic Difference in grade	A = Algebraic Difference in grade

Street Type	Design Speed	Safe Stopping Sight Distance	Normal Crest Vertical Curve K	Normal Sag Vertical Curve K	Minimum Length of Curve
Local	30	200	19	37	60
Collector	35	250	29	49	100
Minor Arterial	40	305	44	64	100
Major Arterial	45	360	61	79	120

d. Intersection Grades

The grade of an intersecting street with the principal street gutter should not generally be more than two percent (2%) either up or down within the first 20 feet beyond the curb line of the principal street. Grade changes greater than one percent (1%) will require vertical curves.

The grade of street or arterial, particularly at its intersections with another street, is of prime importance in providing a safe, comfortable riding surface. The intersection design of two arterials shall include grades which will result in a plane surface or at least a surface which approximates a plane surface. Grades in excess of 3% should be avoided. A maximum grade of 2% is desirable. A vehicle traveling on either thoroughfare should be able to traverse the intersection at the design speed without discomfort. For intersections involving streets of different classifications, the profile of street with the lesser classification shall be adjusted to meet the profile of the street with the higher classification. No valleys across major thoroughfares or collectors will be allowed. To accomplish a smooth transition, crossfall 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.

In drawing the grades of intersecting thoroughfares in the profile view of plan/profile sheets, profiles of all four profiles shall be shown as a continuous line through the intersection. All intersections where any street is classified as a collector or arterial shall be contour graded with minimum contour intervals of 0.2 feet.

e. Street Cross Section

For curbed streets, the right-of-way shall be graded to drain to the street at a slope of 1/4" per foot. Street back slopes and embankment slopes shall not be steeper than 4:1.

2.6 SIGHT DISTANCE AT INTERSECTIONS

An important consideration in the design of City streets is the vehicle attempting to cross the street or thoroughfare from the side street or drive. The operator of the vehicle attempting to cross should have an unobstructed view of the whole intersection and a length of the thoroughfare to be crossed sufficient to permit control of the vehicle to avoid collisions. The minimum sight distance considered safe under various assumptions of physical conditions and driver behavior is related directly to vehicle speeds and to the resultant distance traversed during perception and reaction time and during braking. This sight distance, which is termed intersection sight distance, can be calculated for different street or thoroughfare widths and for various grades upwards and downwards. Intersection sight by AASHTO publication "A Policy on Geometric Design of Highways and Streets", 2011 or current edition. Sight distance requirements are defined by Table III-6 and Figure II-2. As a minimum visibility triangles shall be provided as shown in Figure III-3.

TABLE III-6

SIGHT DISTANCE REQUIREMENTS

Design Speed (mph)	Stopping Sight Distance (feet)	Intersection Sight Distance for passenger Cars (feet)
30	200	335
35	250	390
40	305	445
45	360	500
55	495	610

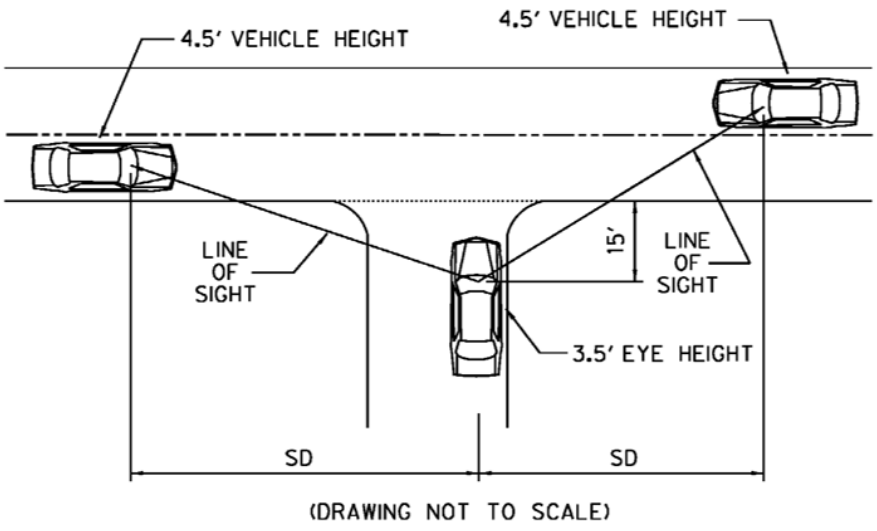


FIGURE III-2
SIGHT DISTANCE REQUIREMENTS

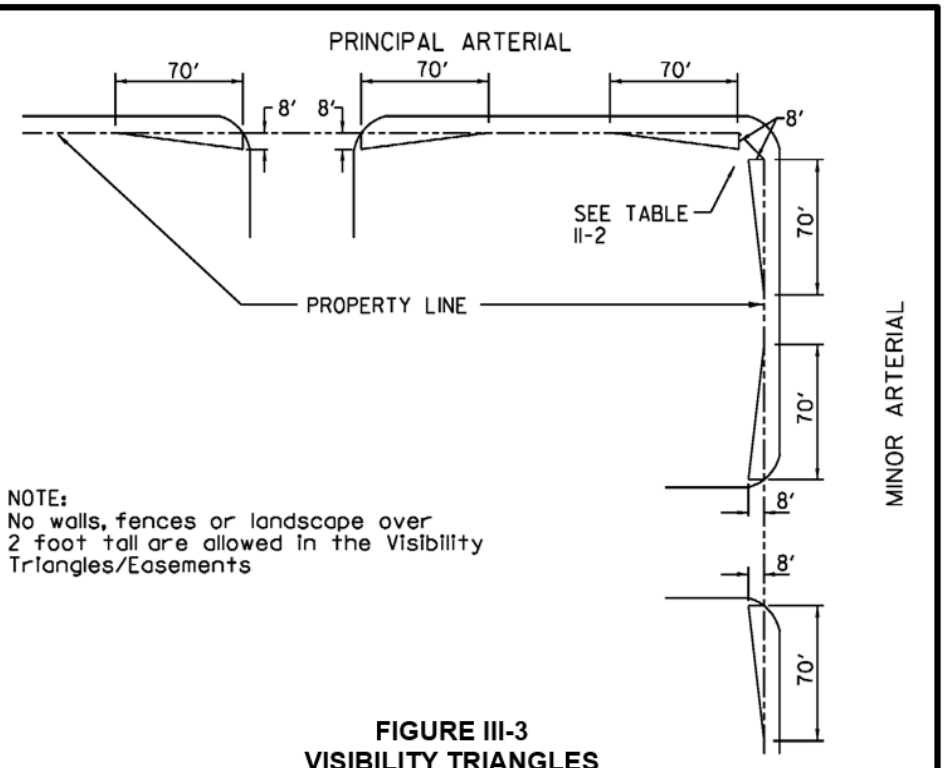


FIGURE III-3
VISIBILITY TRIANGLES

2.7 MEDIAN OPENINGS

The following standards for median openings are established to facilitate traffic movement and promote traffic safety:

Major Streets

Median openings will normally be permitted at all intersections with dedicated City streets. Exceptions would be at certain minor streets where due to unusual conditions a hazardous situation would result.

Midblock median openings or other openings with turns permitted into adjacent property will not normally be permitted unless all the following conditions exist:

a. The property to be served is a significant traffic generator with demonstrated or projected trip generation of not less than two hundred and fifty (250) vehicles in a twelve-hour period.

b. The median opening is not less than 600 feet from another median opening.

2.8 CUL-DE-SACS

The maximum length of any cul-de-sac shall be 500 feet measured from curb line of the intersecting street to the radius point of turn around. The right-of-way radius shall be 50 feet and the curb radius 40 feet within the cul-de-sac turn around. All cul-de-sac turnarounds shall be visible from the intersecting street.

III. DRIVEWAY STANDARDS

3.1 DRIVEWAY REQUIREMENTS

Driveways shall be governed by Tables III-7 and III-8. Refer to Figures III-1 and III-4.

TABLE III-7

DRIVEWAY REQUIREMENTS

	Residential (Min) (Max)	Industrial (Min) (Max)	Commercial (Min) (Max)
A - Driveway Throat Width			
Local	18 - 28 ft	40 ft	24 - 40 ft
Collector	18 - 28 ft	40 - 60 ft *	24 - 40 ft
Minor Arterial	N/A	40 - 60 ft *	24 - 60 ft
Major Arterial	N/A	40 - 60 ft *	24 - 60 ft
Driveway Curb Radius			
Local	5 ft	30 ft	20 ft
Collector	5 ft	40 ft	25 ft
Minor Arterial	N/A	40 ft	30 ft
Major Arterial	N/A	50 ft	35 ft
B - Minimum Centerline Driveway Spacing Along			
Local	30 ft	110 ft	70 ft
Collector	40 ft	110 ft	120 ft
Minor Arterial	N/A	160 ft	170 ft
Major Arterial	N/A	250 ft **	230 ft
Driveway Angle	90°	90°	90°
C - Minimum Distance from Driveway to Intersection			
Local	50 ft	100 ft	100 ft
Collector	50 ft	100 ft	120 ft
Minor Arterial	N/A	175 ft	150 ft
Major Arterial	N/A	175 ft	150 ft
Maximum Approach Grade			
Local / Collectors	10%	6%	6%
All Others	10%	6%	6%
Right Turn Requirement	10%	6%	6%

* Can be wider based on site requirements.

** Driveways should be used jointly at median openings.

Based on 40 mph.

Driveway width plus radius must be contained within the property frontage, between the extended property lines.

State Standards, if more restrictive, shall apply to State maintained roadways.

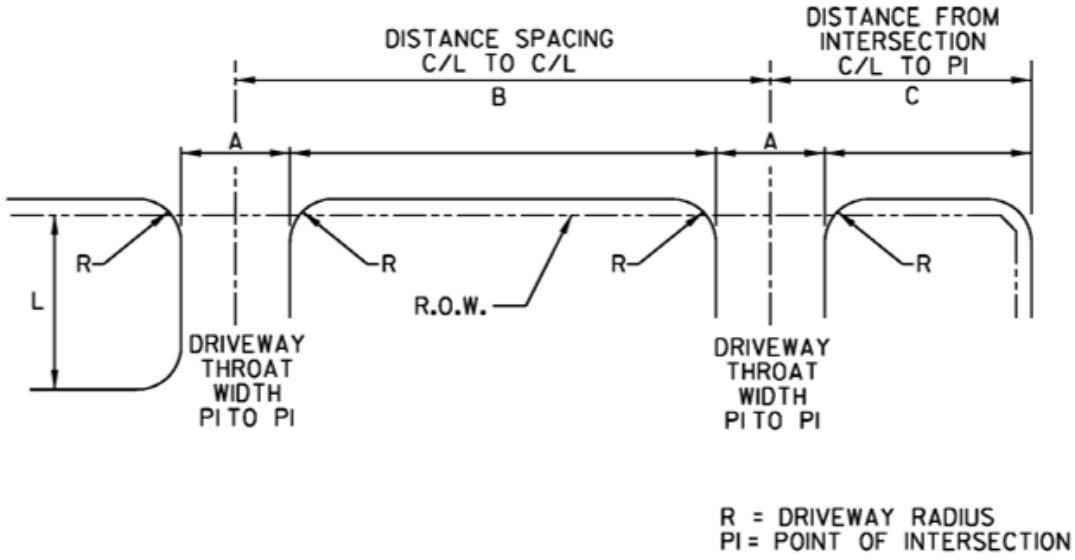


FIGURE III-4
DRIVEWAY REQUIREMENTS

TABLE III-8

MINIMUM DRIVEWAY STORAGE LENGTH (L)
(See Figure III-4)

Number of Parking Spaces per Driveway	Minimum Storage Length (L)*
Less than 50	18 ft
50 to 200	50 ft
More than 200	78 ft

* Storage length is defined as the distance between the street right-of-way line and the first intersecting aisleway on the side.

IV. TRAFFIC IMPACT ANALYSIS GUIDELINES

4.1 DEFINITIONS - THE FOLLOWING TERMS ARE USED IN THIS ARTICLE

a. Projected traffic volumes - The number of vehicles that are expected/calculated to exist on streets after completion of the project.

b. Study area - The boundaries in which the study is conducted.

c. TIA (Traffic Impact Analysis) - An in-depth analysis of traffic.

d. Traffic queuing - A line of waiting vehicles.

e. Trip distribution - Estimates of percentage distribution of trips by turning movements from the proposed development.

f. Trip generation summary - A table summarizing the trip generation characteristics of the development for the entire day including AM and PM peak periods, rates and units used to calculate the number of trips.

g. Non-site traffic - Traffic not created or associated with the traffic generated by the project.

4.2 PURPOSE

The purpose of a Traffic Impact Analysis (TIA) is to assess the effects of specific development activity on the existing and planned roadway system. It is the intent of this ordinance to make traffic access planning an integral part of the development process.

4.3 APPLICABILITY

a. A Traffic Impact Analysis (TIA) will be required at the time of platting for land developments that are expected to meet a threshold level of change as described in Section 4.4 below, "When Traffic Impact Analysis (TIA) is Required". The City reserves the right to require a TIA for land developments that do not meet the threshold requirements, but that may impact a sensitive area with traffic issues or may be a known public concern.

b. A Traffic Impact Analysis (TIA) will be required when there is a request to amend the Thoroughfare Plan.

4.4 WHEN TRAFFIC IMPACT ANALYSIS (TIA) IS REQUIRED

a. A TIA will be required of the property owner (or designated agent) when an activity or change to the property occurs and any of the following occur:

1. Threshold is reach as defined in Section 6.5.D.1.a. of the Subdivision Ordinance.
2. More than 100 acres of property is involved
3. Any changes or alterations to the City Thoroughfare Plan

b. The property owner (or designated agent) shall perform and submit to the City of Stephenville a TIA performed at a minimum as established in Section 4.6, "Traffic Impact Analysis Requirements". The TIA must be signed and sealed by a professional engineer, licensed in Texas, with experience in Transportation Engineering sufficient to assess traffic impacts.

c. The engineer conducting the study must be approved by the City prior to performing the study. The City of Stephenville Public Works Department must approve all TIA's before final acceptance. After acceptance of the TIA, the review process will determine further actions.

4.5 ROLES OF APPLICANT AND CITY

A TIA that is required of the applicant by the City of Stephenville is part of the development review and approval process. The primary responsibility for assessing the traffic impacts associated with a proposed development rest with the applicant. The City serves in a review capacity for this process.

4.6 TRAFFIC IMPACT ANALYSIS (TIA) REQUIREMENTS

a. The Traffic Impact Analysis (TIA) must be prepared and evaluated by a consultant possessing the qualifications described in Section 4.4 (b) to perform such studies.

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

1. Traffic Analysis Map

   a. Land Use, Site and Study Area Boundaries, as defined (provide map).

   b. Existing and Proposed Site Uses.

   c. For TIA's where land use is the basis for estimating projected traffic volumes and existing and Proposed Land Uses on both sides of boundary streets for all parcels within the study area (provide map).

   d. Existing and Proposed Roadways and Intersections of boundary streets within the study area of the subject property, including traffic conditions (provide map).

   e. 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.

   f. Photographs of adjacent streets of the development and an aerial photograph showing the study area.

2. Trip Generation and Design Hour Volumes (provide table).

   a. 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.

   b. 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 passby trips and internal site trip satisfaction. All such estimates shall be subject to the approval of the City.

c. 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.

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

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

3. 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.

4. Capacity Analysis (provide Analysis Sheets in Appendices).

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

b. 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 City. Capacity will be reported in quantitative terms as expressed in the HCM and in terms of traffic Level of Service.

c. 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.

5. Conclusions and Requirements.

a. Roadways and intersections, within the Study Area, that are expected to operate at Level of Service D, E, or F, under traffic conditions including projected traffic plus site-generated traffic must be identified and viable recommendations made for raising the traffic conditions to Level of Service C or better (Level of Service A or B).

b. Level of Service "C" is the design objective for all movements and under no circumstances will less than Level of Service "D" be deemed acceptable for site and non-site traffic including existing traffic at build-out of the study area. The City must approve a Level of Service " D".

c. 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.

d. Voluntary efforts, beyond those herein required, to mitigate traffic impacts are encouraged as a means of providing enhanced traffic handling capabilities to users of the land development site as well as others.

e. Traffic mitigation tools include, but are not limited to, pavement widening, turn lanes, median islands, access controls, curbs, sidewalks, traffic signalization, traffic signing, pavement markings, etc.

f. The applicant will provide five (5) copies of the Draft Report for review and nine (9) copies of the Final Report for submittal.

6. Other Items

a. The City Engineer may require other items be included in the TIA above those listed above.

V. PAVEMENT DESIGN

5.1 STANDARD STREET AND ARTERIAL PAVEMENT DESIGN

All new roadways within the City of Stephenville 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. Pavement design shall be in in accordance with the PAVEMENT DESIGN GUIDE, Texas Department of Transportation, current edition. Work and materials shall be in accordance with the STANDARD SPECIFICATIONS FOR CONSTRUCTION AND MAINTENANCE OF HIGHWAYS, STREETS AND BRIDGES adopted by the Texas Department of Transportation, current edition. Table III-9 shows the minimum required pavement thickness for pavement and the subgrade requirements for certain soil conditions for various street and thoroughfare types within the City. The procedure for using this table requires that a soils investigation be made including obtaining soil auger borings, classifying the soils encountered and determining the strength and physical properties of the underlying and supporting soils system in moisture content, and unit dry weight (see 5.2 - Geotechnical Investigation Required). For each soil classification encountered, the plasticity index shall be calculated and depending whether the P.I. is less or more than the critical percentage shown, the subgrade design shall consist of the specified thickness of a lime or cement treated subgrade as shown in Table III-9. Use of Table III-9 does not preclude the required pavement design, but presents the minimum pavement thickness of portland cement concrete pavement and hot mix asphalt pavement for the various street and arterial types.

5.2 GEOTECHNICAL INVESTIGATION REQUIRED

A geotechnical investigation must be performed for all new developments within the City of Stephenville containing public streets. As a minimum, the study must address the following:

- general soil and groundwater conditions
- earthwork recommendations
- recommendations for pavement subgrade type, depth, and concentration
- guidelines for concrete pavement design

The investigation must be based on samples obtained from drilling or from excavations on the site. Samples must be tested in a laboratory. Tests must include as a minimum:

- moisture content and soil identification
- liquid and plastic limit determination
- unit weight determination
- Eades and Grim lime series tests
- soluble sulfate tests

The geotechnical investigation must be performed by a qualified geotechnical firm. A report with findings and recommendations must be prepared. The report shall bear the seal of a Professional Engineer licensed in the State of Texas.

5.3 GUIDELINES FOR STABILIZATION OF SUBGRADE SOILS CONTAINING SULFATES

Lime induced heaving has been a cause of pavement failures in the North Texas area. There are four components which are the culprits in sulfate induced stress in stabilized soils: calcium, aluminum, water, and sulfates. Together, and in the proper combination, these components will produce calcium-aluminate-sulfate-hydrate minerals with an expansion potential as large as 250%.

The best approach when dealing with lime stabilization of clay with significant soluble sulfate content is to force the formation of the deleterious minerals prior to compaction. If these minerals form during the mellowing period before placement and compaction, no damage will be done to the pavement. This can be done by providing adequate mellowing time (time delay between application of stabilizer and compaction of the stabilized soil) and with addition of adequate water.

Generally if the total level of soluble sulfates is below 2,000 ppm, by weight of soil, then lime stabilization is not of significant concern.

Sulfate levels of moderate to high risk are those between 2,000 ppm and 10,000 ppm. These soils should be treated by the double lime application method. In this method one-half of the lime is mixed with the soil and excess water. Mixing water should be applied to bring the soil to at least 3% to 5% above optimum for compaction and maintained at that level through the mellowing period. The mellowing period should be at least 72 hours. After that time, the second half of the required lime is mixed followed by compaction. Double treatment does not require twice the required lime, but rather the required lime placed in two separate treatments.

Sulfate levels of high risk, between 8,000 ppm and 10,000 ppm, should be treated with a double application of lime as required for moderate to high risk soils, but the mellowing period should be extended to a minimum of 7 days.

Soils with a sulfate level higher than 10,000 ppm are not suitable for lime stabilization. Other strategies for dealing with these soils may include removal and replacement or blending with other soils to reduce the concentration of sulfates. The geotechnical report must recommend alternative strategies for subgrades with high levels of sulfates. Alternative strategies are subject to approval by the City Engineer.

The above guidelines were obtained from a paper and sponsored by the Lime Association of Texas, dated August 2000, and titled "Guidelines for Stabilization of Soils Containing Sulfates".

5.4 ALTERNATE PAVEMENT DESIGN

The Department of Public Works will consider an alternate pavement design in lieu of selecting a design from Table III-9, particularly when there are circumstances which warrant an individual design.

TABLE III-9

STANDARD STREET AND THOROUGHFARE MINIMUM PAVEMENT THICKNESS

Facility Type	Concrete Pavement			Asphalt Pavement			
	Concrete Thickness (3)	Cement Treat P.I. ≤ 15 (1)	Lime Treat P.I. > 15 (2)	Type "D" Asphalt Thickness (5)	Flex Base Thickness (4)	Cement Treat P.I. ≤ 15 (1)	Lime Treat P.I. > 15 (2)
Fire Lane	6"	6"	6"	2"	8"	6"	6"
Driveways	6"	6"	6"	NA	NA	NA	NA
Alleys Local	6"	6"	6"	2"	10"	6"	6"
Local							
L2U-U and R	6"	6"	6"	2"	10"	6"	6"
Collector							
C2U-U and R	7"	8"	8"	3"	10"	8"	8"
Minor Arterial							
M4U-U and R	8"	10"	10"	3.5"	12"	10"	10"
M4D-U and R	8"	10"	10"	3.5"	12"	10"	10"
Major Arterial							
P6D-U and R	8"	10"	10"	3.5"	12"	10"	10"

NOTE: 1) Minimum 3% by dry unit weight of Portland cement.
2) Minimum 6% by dry unit weight of hydrated lime.
3) Twenty-eight day concrete compressive strength shall not be less than 3,600 psi.
4) Crushed limestone compacted to 95% standard proctor density at optimum moisture.
5) Asphaltic concrete surface course meeting TxDOT specification, Type "D".

VI. PERMANENT LANE MARKINGS

6. 1 PAVEMENT MARKINGS PLAN

Permanent lane markers shall be installed in accordance with the pavement markings plan and Pavement Marking Standard Details.

VII. LANDSCAPING IN PUBLIC RIGHT-OF-WAY

7.1 GENERAL

All unpaved public medians and parkways shall be landscaped with a minimum of four inches of topsoil, sodded or seeded in accordance with seeding requirements in the standard details and irrigated with a properly designed and installed system.

7.2 METERING

All water usage shall be metered and paid for by the developer until landscaping is accepted by the City. Developers shall pay administrative fees, meter costs, and meter deposits, but shall be exempt impact fees for meters installed on City right-of-way. Within medians, no plantings or irrigation facilities shall be permitted within areas five feet or less in width or in median noses.

Those areas shall be covered with brick pavers in accordance with the Standard Details.

7.3 OTHER REQUIREMENTS

a. Minimum landscape requirements will be established by the City.

b. *Trees* or upright plantings must not be planted within 30 feet of intersections or utility poles. The City may require greater setback for safety based on line of sight issues.

c. An 8-inch wide concrete mow strip shall be installed between all planting beds and grassed areas.

d. Seeded or sodded areas of medians shall be bermed a minimum of 6 inches.

e. Only trees with a mature height less than 30 feet may be planted closer than 20” either side of an overhead line. No trees shall be directly under utility lines.

f. Trees to be planted within the medians of divided roadways that are ultimately planned for widening by constructing additional lanes in the median shall not be planted within the path of future lanes. Trees shall not be planted within five (5) feet of existing or proposed curbs. Future lane widening shall be shown on the landscape plans.

g. Trees shall not be planted within five feet of existing or proposed water lines.

h. Irrigation systems shall be designed to meet all other City Ordinances.

7.4 PLAN SUBMITTAL REQUIREMENTS

Landscape construction plans shall be submitted as part of the overall construction plans associated with the related project. Plans shall bear license seal of the designer. The plans shall include the following:

a. A scale drawing (1 inch = 40 ft or 1 inch = 20 ft), prepared on 22 inch by 34 inch sheets clearly indicating the location, type, size and description of all proposed landscape materials and existing utilities.

b. The name of the project, name and address of the Developer, north arrow, scale, and legend.

c. The configuration, location, type and size of all irrigation, piping heads and controllers.

d. All details necessary to provide a constructible installation.

7.5 OWNERSHIP AND MAINTENANCE

a. Upon final acceptance, all landscape and irrigation materials within medians way shall become the property of the City. The property owner shall be responsible for maintenance of landscaped areas in the rights of way joining the property.

b. Landscaped median areas shall be maintained by the Developer or owner for a minimum of one year. Within one year the City will assume responsibility if 80% grass cover is obtained and all plantings are in a healthy condition. Developer maintenance will continue until adequate coverage is obtained.

VIII. STREET LIGHT REQUIREMENTS

8.1 GENERAL

Street lights shall be installed in all new subdivisions. The Developer shall pay the costs for all street lighting. Street light luminaries shall be of a type approved by the City. Street light materials and design shall be approved by the City.

8. 2 STREET LIGHT REQUIREMENTS BY STREET CLASSIFICATION

Street light installations will vary according to the classification of street. In general installations will be as follows:

a. Residential Streets: For residential streets, street lights shall be installed at each intersection, at major curves, at ends of cul-de-sacs, and at intervals of between 200 and 400 feet. Luminaires shall be either 50 Watt equivalent Light Emitting Diode (LED) or 100 Watt equivalent LED or City-approved equivalent and shall mounted on poles at least 11 feet high as shown on standard details for street lights.

b. Collector Streets: For collector streets, street lights shall be installed at each intersection, at major curves, and at intervals of between 200 and 400 feet. Luminaires shall be either 100 Watt equivalent LED or City-approved equivalent and mounted on poles at least 11 feet high with pole type to be approved by the City.

c. Major Arterials: For major arterial streets, street lights shall be installed at each intersection, at major curves, and at intervals of between 200 and 300 feet. Luminaires shall be 250 Watt equivalent LED or City-approved equivalent directional lights and mounted on poles at least 30 feet high with pole type to be approved by the City. Where a major arterial traverses a single-family neighborhood light fixtures shall be either 100 Watt equivalent LED or 250 Watt equivalent LED or City-approved equivalent directional lights and mounted on poles at least 11 feet high for 100 Watt equivalent and 30 feet high for 250 Watt equivalent lights with pole type to be approved by the City.

8.3 STREET LIGHT LOCATIONS

Street lights shall be installed in the public right-of-way, in a location at least three (3) feet behind the face of curb. Where there is no curb, street lights shall be installed at least eight (8) feet from the edge of pavement. Street lights on major arterials shall be installed in the median, where a median exists. In conjunction with the development of any subdivision, street light location and installation shall be coordinated with the local Franchise Electric utility and the City. Installations in state right-of-ways shall be coordinated with TxDOT and the City.

8.4 PLAN SUBMITTAL REQUIREMENTS

Street light plans shall be submitted as part of the overall construction plans associated with the related project. The plans shall include the following:

a. A layout of the entire subdivision showing the proposed location of each street light.

b. A plan for the location of underground conduits. All street lights shall be served by underground electric unless approved in writing by the City. All wiring shall be placed in minimum two (2) inch schedule 40 PVC conduit unless otherwise approved by the City.

c. Comply with standard street light details.

8.5 COSTS

The developer shall be responsible for all engineering and plan preparation costs required for installation of street lights.

IX. TEXAS ACCESSIBILITY STANDARDS

9.1 GENERAL

A. All plans and specifications for the construction or alteration of public buildings and facilities, privately owned buildings and facilities leased or occupied by state agencies, places of public accommodation, pedestrian facilities within public right-of-way, and commercial facilities must be in compliance with the Texas Accessibility Standards (TAS) for individuals with disabilities 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.

B. Projects with a total estimated construction cost of $50,000 or more are required to submit a full set of construction documents in accordance with Administrative Rule 68.20 (Buildings and Facilities Subject to Compliance with the Texas Accessibility Standards) to TDLR for registration and review. For Public Right-of-Way projects, the estimated cost for the project shall be based on pedestrian elements only in accordance with Administrative Rule 68.102 (Public Right-of-Way Projects). If a project's total estimated construction cost is less than $50,000, it is not required to be submitted to TDLR for registration and review; however, the project is still required to comply with TAS. An architect, engineer, interior designer, or landscape architect with overall responsibility for the design of a building or facility subject to subsection 5(j) of the Architectural Barriers Act, shall mail, ship, or hand-deliver the project registration form, review and inspection fees, and construction documents to the TDLR, a registered accessibility specialist, or a contract provider not later than thirty (30) business days after the design professional seals and signs the construction documents. An Architectural Barriers Project Registration Form must be completed for each subject building or facility.

CITY OF STEPHENVILLE

ENGINEERING STANDARDS MANUAL

PART IV – DRAINAGE

CITY OF STEPHENVILLE

ENGINEERING STANDARDS MANUAL

PART IV - DRAINAGE

I. INTRODUCTION

1.1 Purpose

The purpose of Part IV – Drainage of the Engineering Standards Manual is to provide design guidance and a framework for incorporating effective and environmentally sustainable stormwater management into the site development and construction processes within the City of Stephenville and the ETJ. The primary motivation for this section is to guide the community in drainage policy and criteria so that new development does not increase flooding, erosion, and/or water quality problems.

Part IV is intended to provide a guideline for the most commonly encountered stormwater or flood control designs in the City of Stephenville. It can also be used as a guide for watershed master plans and for design of remedial measures for existing facilities. The standards herein were developed for users with knowledge and experience in the applications of standard engineering principles and practices of stormwater design and management. There will be situations not completely addressed or covered by these guidelines. Any variations from the practices established in Part IV must have the approval of the City. Close coordination with the City staff is recommended and encouraged during the planning, design and construction of all storm water facilities.

1.2 Relationship of City of Stephenville Manual to Regional *integrated* Stormwater Management (*iSWM*^{TM}) Criteria Manual for Site Development and Construction

The City of Stephenville hereby adopts and incorporates herein the iSWM Criteria Manual for Site Development and Construction, developed by the North Central Texas Council of Governments (NCTCOG). The adoption is the same as if the same is set forth fully herein, with such clarifications and Local Provision modifications as are indicated. The Manual shall be used for all development within the boundary of the City and within its extraterritorial jurisdiction (ETJ). The digital version of Criteria Manual is included on the City of Stephenville website (http://www.stephenvilletx.gov/). Copies of these documents can be downloaded from the respective City and NCTCOG websites or ordered from the respective agencies for the cost of reproduction.

1.3 Notes and Abbreviations

Notes and abbreviations used in the Local Provisions Section:

1. City - City of Stephenville
2. Criteria Manual - References are made to the Regional *i*SWM^{TM} Criteria Manual for Site Development and Construction

1.4 Contact Information

Contacts for the City of Stephenville Storm Water Management Design Manual can be reached at the Public Works Department at: 254-918-1292 or at the website: http://www.stephenvilletx.gov/.

1.5 References

integrated Stormwater Management Criteria Manual for Site Development and Construction, December 2009, Revised 1/14/15. NCTCOG, Arlington, TX.
http://iswm.nctcog.org/criteria_manual.asp

integrated Stormwater Management Technical Manual, April 2010, NCTCOG, Arlington, TX.
http://iswm.nctcog.org/technical_manual.asp

Note: Additional references are included in individual chapters or appendices.

II. GOALS AND OBJECTIVES OF THE STEPHENVILLE STORMWATER MANAGEMENT PROGRAM

2.1 Establish and implement drainage policy and criteria to ensure new development does not create or increase flooding problems, cause erosion or pollute downstream water bodies.

2.2 Facilitate the continuation of comprehensive watershed planning to promote orderly growth in order to result in an integrated system of public and private storm water infrastructure.

2.3 Minimize flood risks to citizens and properties and stabilize or decrease streambank and channel erosion on creeks, channels, and streams.

2.4 Improve storm water quality in creeks, rivers, and other water bodies, remove pollutants, enhance the environment and mimic the natural drainage system to the extent practicable in conformance with the Texas Pollutant Discharge Elimination System (TPDES) permit requirements.

2.5 Support multi-use functions of storm water facilities for trails, green space, parks, greenways or corridors, storm water quality treatment, and other recreational and natural features, provided they are compatible with the primary functions of the storm water facility.

2.6 Encourage a more standardized, integrated land development process by bringing storm water planning into the conceptual stages of land development.

III. CITY OF STEPHENVILLE STORMWATER POLICY STATEMENTS

3.1 All development within the City of Stephenville City Limits or Extra-territorial Jurisdiction (ETJ) shall include planning, design, and construction of storm drainage systems in accordance with the iSWM Criteria Manual for Site Development and Construction as well as Planning Commission Rules and Regulations.

3.2 Conceptual, Preliminary and Final Drainage Studies and Plans may be required for proposed developments within the Stephenville City Limits or its ETJ, in conformance with the iSWM Criteria Manual. Specific submittal requirements depend on the individual project and the requirements of the Subdivision Ordinance. Drainage Studies are required only as a part of a "Concept Plan" as defined by the Subdivision Ordinance. The checklists for each stage of this three-tier process are included in the *i*SWM™ Manual.

3.3 All drainage related plans and studies shall be prepared and sealed by a Licensed Professional Engineer with a valid license from the State of Texas. The Engineer shall attest that the design was conducted in accordance with the iSWM Criteria Manual.

3.3.1 All drainage studies shall bear the following certification.

I, *(PRINTED NAME)*, a Professional Engineer registered in the State of Texas and in good standing, have prepared the enclosed drainage study in compliance with the latest published requirements and criteria of the City of Stephenville, Texas, and have verified that the topographic information used in this study is in compliance with said requirements and is otherwise suitable for developing this workable Plan of Drainage which can be implemented through proper subsequent detailed construction planning.

Signature_____, P.E., Date_____ (Seal)

3.4 For currently developed areas within the City of Stephenville with planned re-development, storm water discharges and velocities from the project should not exceed discharges established by procedures presented in the Criteria Manual but also shall not exceed discharges and velocities from current (existing) developed conditions, unless the immediate downstream storm drainage system is designed (or adequate) to convey the future (increased) discharges and velocities.

3.5 All drainage studies and design plans shall be formulated and based upon ultimate, fully developed watershed or drainage area runoff conditions. In certain circumstances where regional detention is in place or a master plan has been adopted, a development may plan to receive less than ultimate developed flow from upstream areas with the approval of the City. The rainfall frequency criteria for storm water facilities, as enumerated within the iSWM Criteria Manual shall be utilized for all drainage studies and design plans.

3.6 Proposed storm water discharge rates and velocities from a development shall not exceed the runoff from existing, pre-development conditions, unless a detailed study is prepared that demonstrates that no unacceptable adverse impacts will be created. Adverse impacts include: new or increased flooding of existing structures, significant increases in flood elevations over existing roadways, unacceptable rises in base flood elevations or velocities, and new or increased stream bank erosion or increased occurrence of nuisance flows.

3.7 If a proposed development drains into an improved channel or storm water drainage system designed under a previous City of Stephenville drainage policy, then the hydraulic capacities of downstream facilities must be checked to verify that increased flows, caused by the new development, will not exceed the capacity of the existing system or cause increased downstream structure flooding. If there is not sufficient capacity to prevent increased downstream flooding, then detention or other acceptable measures must be adopted to accommodate the increase in runoff due to the proposed development.

3.8 Stormwater runoff may be stored in detention and retention basins to mitigate potential downstream problems caused by a proposed development. Proposed detention or retention basins shall be analyzed both individually and as a part of the watershed system, to assure compatibility with one another and with the City's storm water management master plans for that watershed (if available). Storage of storm water runoff, near points of rainfall occurrence, such as the use of parking lots, ball fields, property line swales, parks, road embankments, borrow pits and on-site ponds is desirable and encouraged.

3.9 Alternatives to detention or retention for mitigation of potential downstream problems caused by proposed development include: acquisition of expanded drainage easements, ROW, or property owner agreements; downstream channel and/or roadway bridge/culvert improvements or stream bank erosion protection; and financial contributions to the City Storm Water Program for future improvements. These alternatives will be considered by the City on a case-by-case basis.

3.10 All proposed developments within the Stephenville City Limits or its Extra Territorial Jurisdiction (ETJ) shall comply with all local, county, state and federal regulations. All required permits or approvals shall be obtained by the developer.

3.11 The policy of the City is to avoid substantial or significant transfer of storm water runoff from one basin to another and to maintain historical drainage paths whenever possible. However, the transfer of storm water from basin to basin may be necessary in certain instances and will be reviewed and a variance can be made by the City in accordance with established variance procedures. TCEQ approval may be required for significant transfer of storm water.

3.12 City Maintenance - The City will provide for perpetual maintenance, in accordance with adopted City maintenance standards, of all public drainage facilities (those facilities located within dedicated easements, rights of way and constructed to City standards). Access shall be provided and dedicated by the developer to all public storm water facilities in developments for maintenance and inspection by the City.

3.13 Private Maintenance - Private drainage facilities (those facilities entirely on private property) include those drainage improvements which are located on private property and which handle only private water. Private drainage facilities may also include detention or retention ponds, dams, and other stormwater controls which collect public water, as well as drainage ways not constructed to City standards but which convey public water. Such facilities must be designed in accordance with sound engineering practices and reviewed and inspected by the City. An agreement for perpetual maintenance of private drainage facilities serving public stormwater shall be executed with the City prior to acceptance of the final plat. This agreement shall remain with the land and can be tied to commercial property or to an owner's association, but not to individual residential lots. Access shall be provided by the developer/owner to all private drainage facilities where there may be a public safety concern for inspection by the City.

CITY OF STEPHENVILLE

ENGINEERING STANDARDS MANUAL

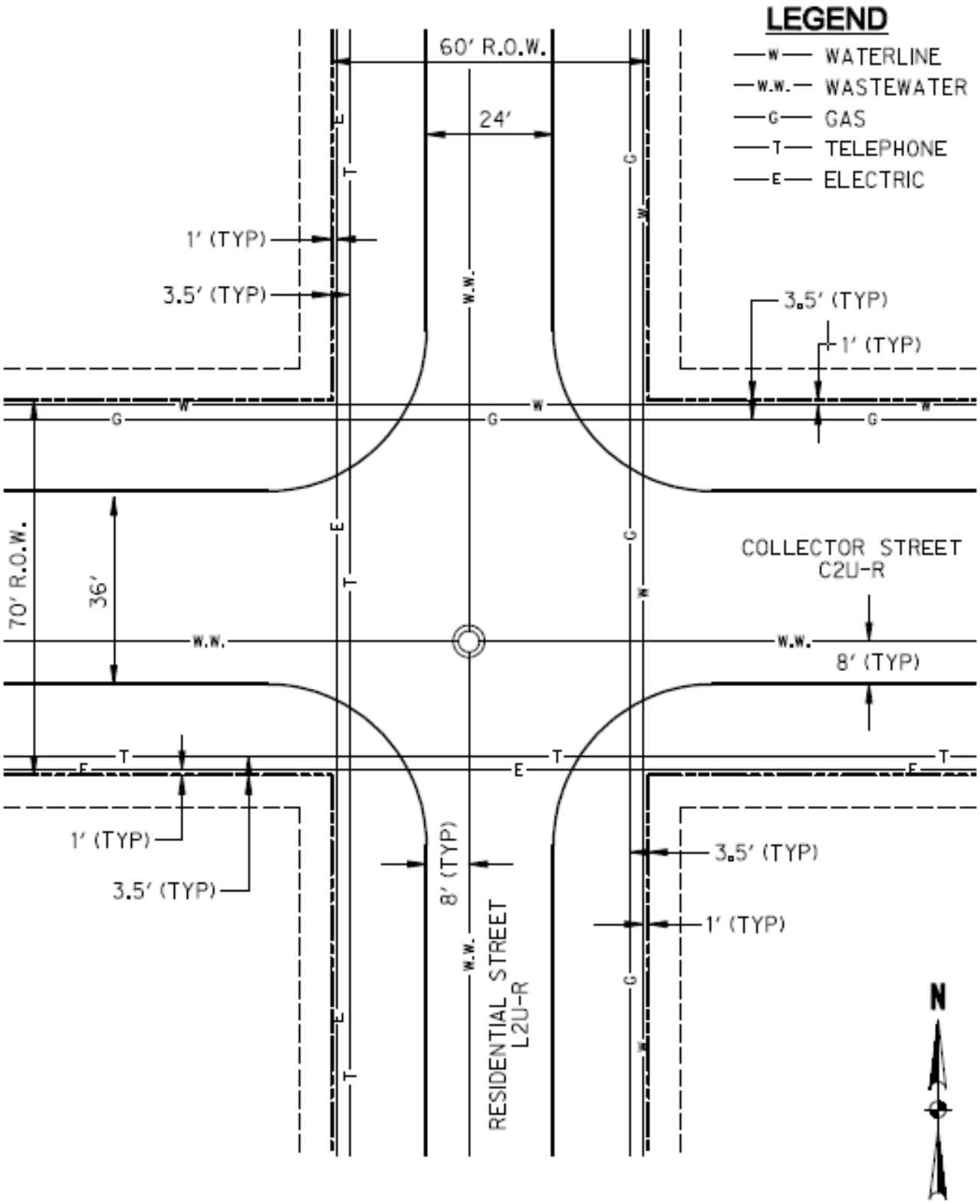
APPENDICIES

.

APPENDIX “A”

UTILITY ASSIGNMENTS

UTILITIES LOCATION PLAN WITHIN STREET R.O.W.



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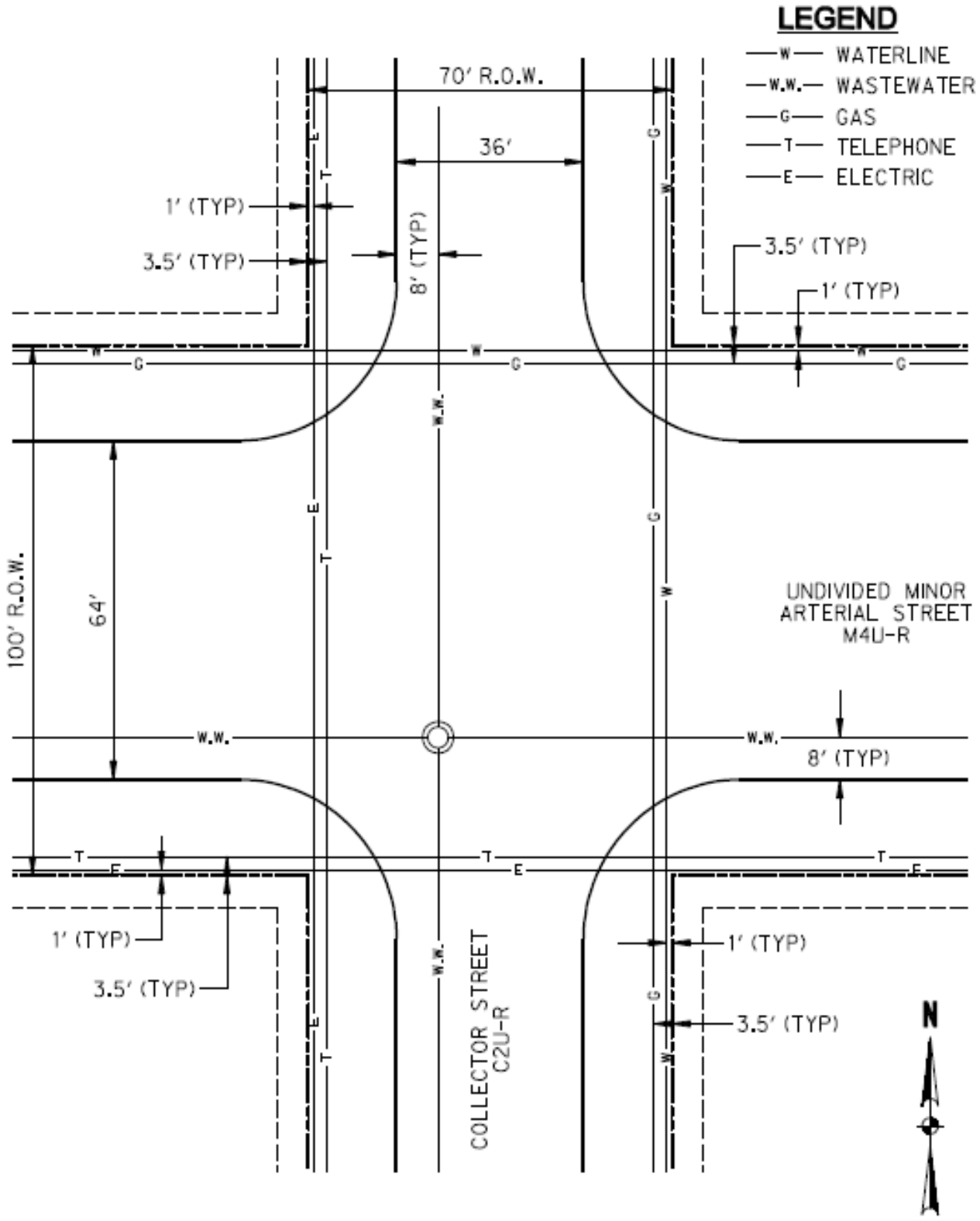
APPENDIX A
SHEET 1 OF 6

RESIDENTIAL STREET – COLLECTOR STREET INTERSECTION

UTILITIES LOCATION PLAN WITHIN STREET R.O.W.



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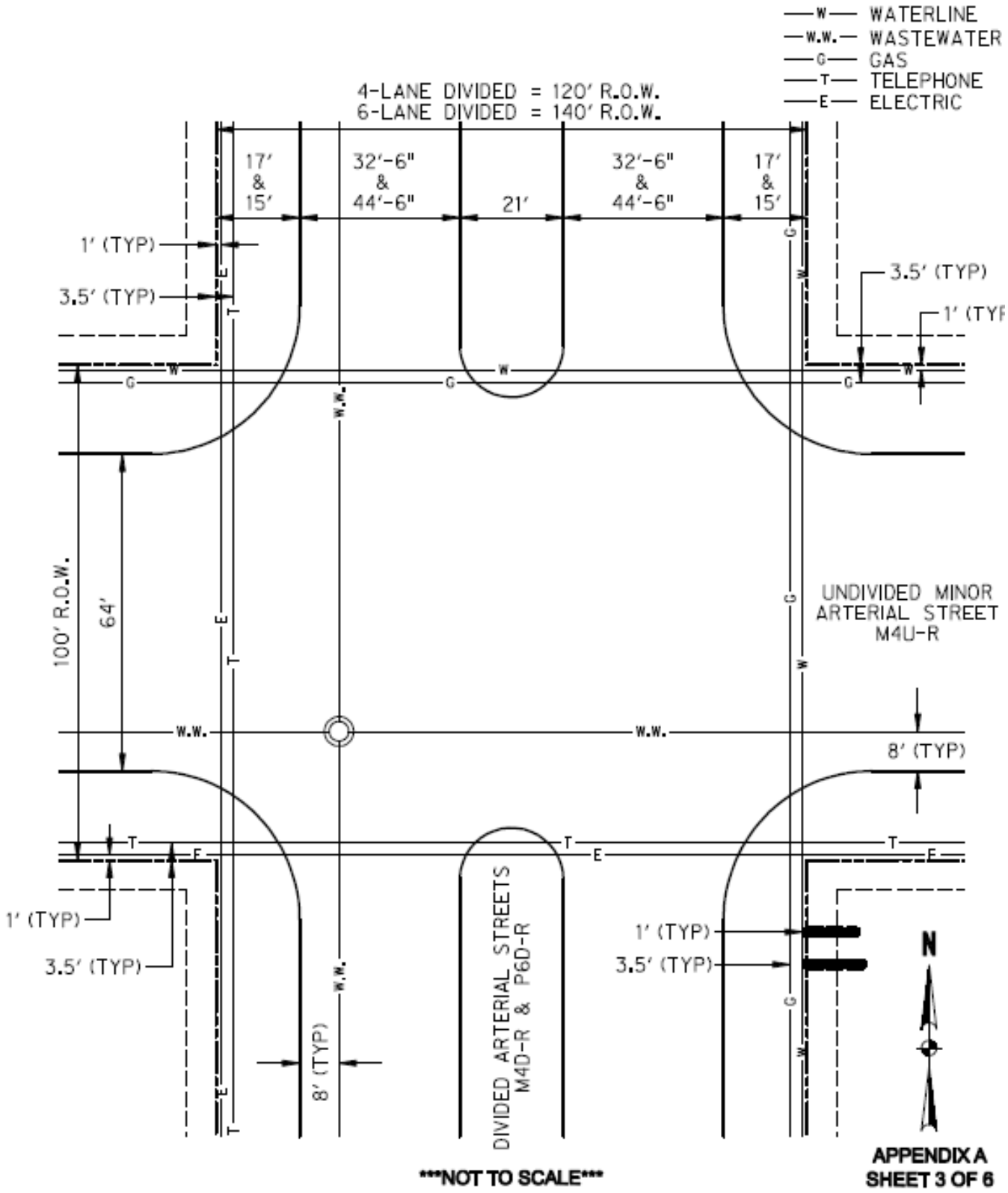
APPENDIX A
SHEET 2 OF 6

COLLECTOR STREET – UNDIVIDED MINOR ARTERIAL INTERSECTION

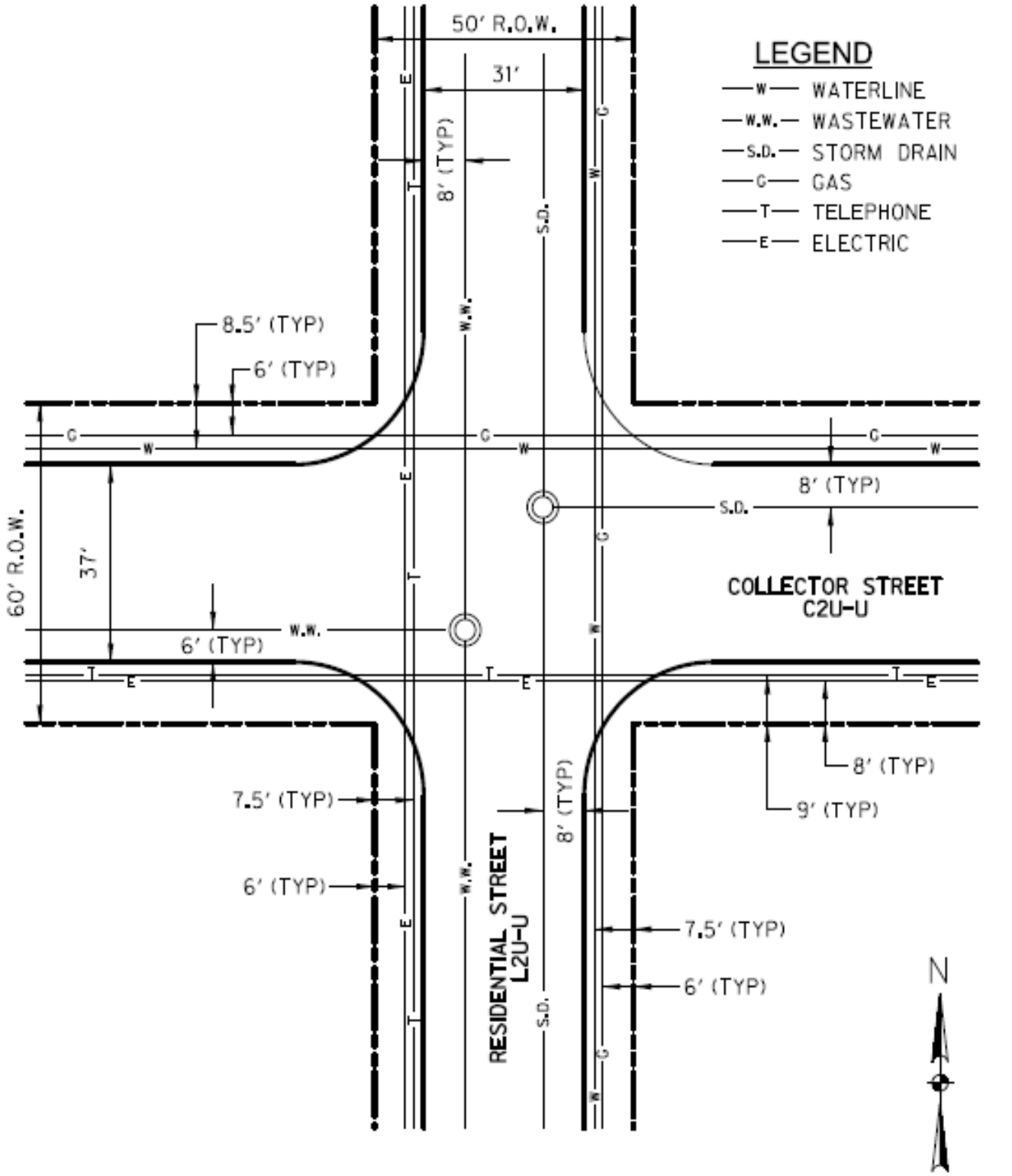
UTILITIES LOCATION PLAN WITHIN STREET R.O.W.



APPENDIX A
SHEET 3 OF 6

UNDIVIDED MINOR ARTERIAL – DIVIDED ARTERIAL INTERSECTION

UTILITIES LOCATION PLAN WITHIN STREET R.O.W.



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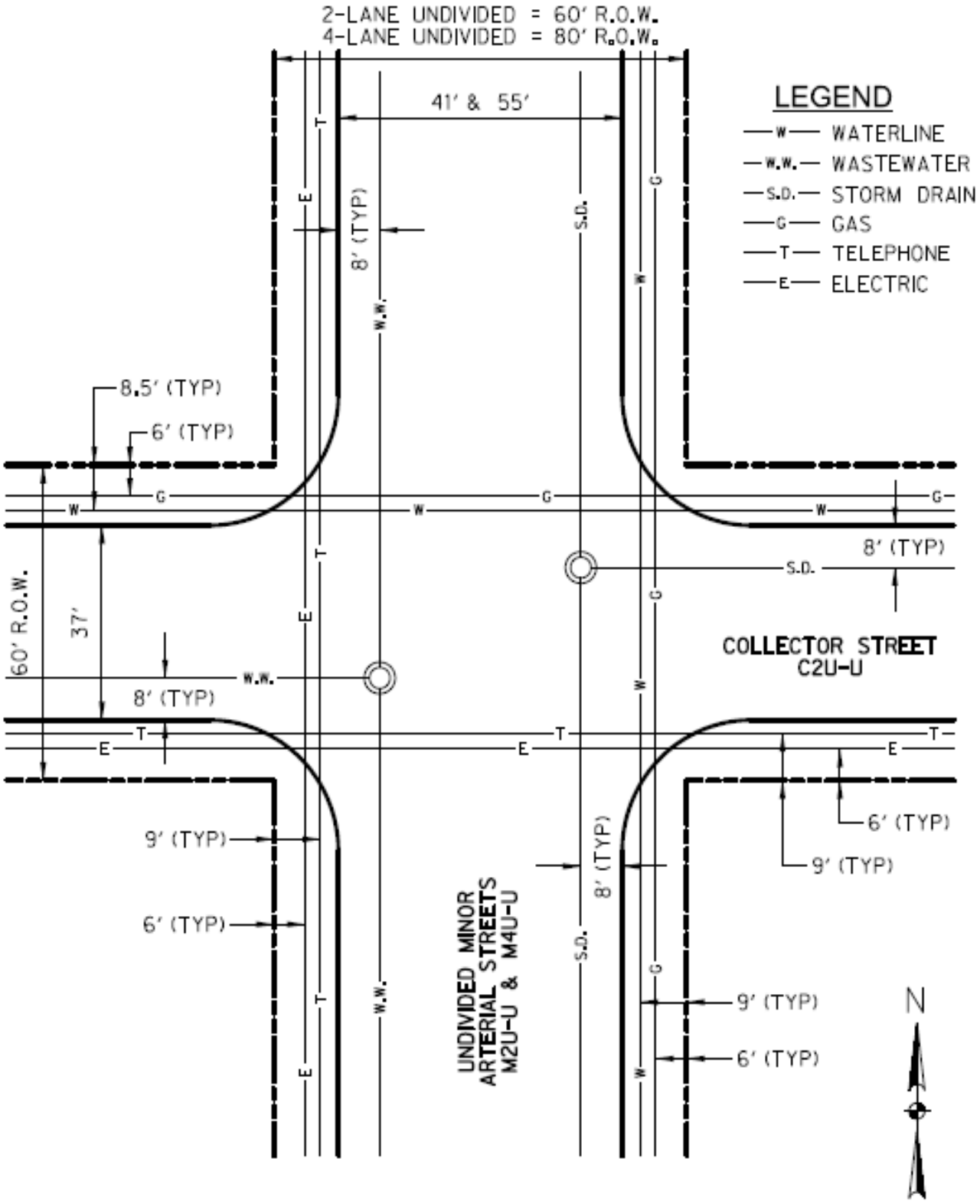
APPENDIX A
SHEET 4 OF 6

COLLECTOR STREET – RESIDENTIAL STREET INTERSECTION

UTILITIES LOCATION PLAN WITHIN STREET R.O.W.



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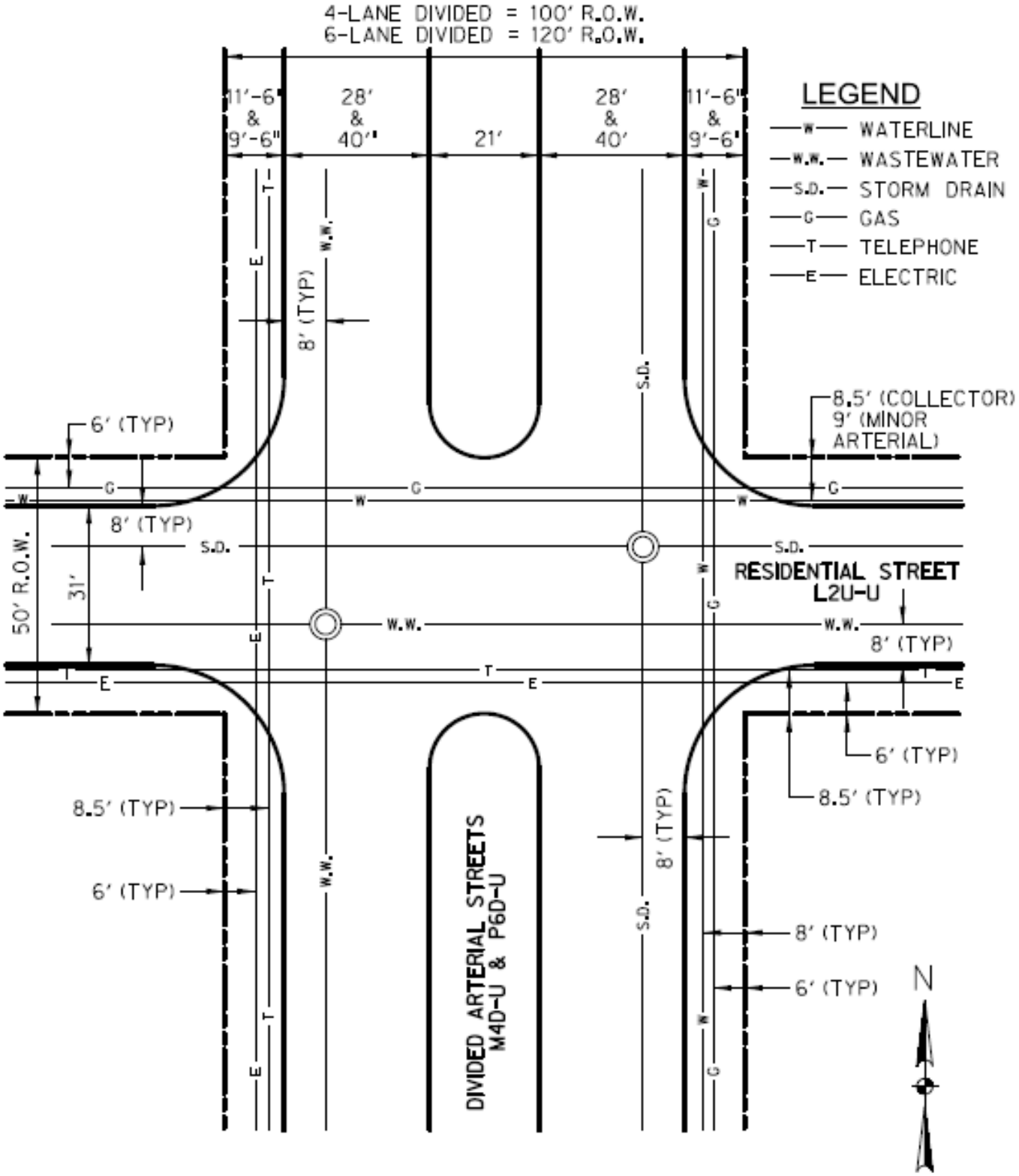
COLLECTOR – UNDIVIDED MINOR ARTERIAL STREET INTERSECTION

UTILITIES LOCATION PLAN WITHIN STREET R.O.W.



NOT TO SCALE

APPENDIX A
SHEET 6 OF 6

RESIDENTIAL STREET – DIVIDED ARTERIAL STREET INTERSECTION

APPENDIX “B”

PRIVATE DEVELOPMENT GENERAL NOTES
FOR
CONSTRUCTION PLANS

CITY OF STEPHENVILLE

ENGINEERING STANDARDS MANUAL

APPENDIX "B"

PRIVATE DEVELOPMENT GENERAL NOTES

1. All work shall be performed in accordance with the City of Stephenville standard details and specifications which has adopted the North Central Texas Council of Governments (NCTCOG) "STANDARD SPECIFICATIONS FOR PUBLIC WORKS CONSTRUCTION", as modified from time to time. Copies may be obtained from the "NORTH CENTRAL COUNCIL OF GOVERNMENTS", PO Drawer 5888, Arlington, Texas, 76005-5888, Phone (817) 640-3300; also available at www.publicworks.dfwinfo.com. A copy of the approved contract documents, plans and specifications shall be available on-site at all times by the Contractor.

2. The location and depth of all utilities shown on the plans are approximate and there may be other unknown existing utilities not shown on the plans. All existing utilities shall be field verified and protected by the Contractor prior to the start of construction. Also see General Note No. 3(d). The contractor shall contact the below utility companies minimum 72 hours prior to any work in the area:

Utility	**Phone Number**
DIGTESS	800-DIG-TESS or 811
City of Stephenville	(254) 918-1235
City of Stephenville – After Hours	(254) 918-1220
Oncor Electric	(254) 977-1903
United Cooperative Electric	(254) 918-6105
Atmos Energy	(254) 918-2345
Century Link	(254) 968-1267
Northland Cable	(254) 968-4189

3. It shall be the responsibility of the Contractor to perform the following:

   a. Prevent any property damage to property owner's poles, fences, shrubs, mailboxes, etc.

   b. Provide access to all drives during construction.

   c. Protect all underground and overhead utilities and repair any damages.
      1. See General Note No. 2.

   d. Notify all Utility Companies and verify location of all utilities prior to the start of construction.

   e. Cooperate with the Utility Companies where utilities are required or specified to be relocated.

   f. Work in close proximity to and protect existing Utility Mains, traffic lights and poles.

   g. Any item not specifically called out to be removed shall be brought to the attention of the Engineer prior to removing that item or it shall be replaced at the Contractor's own expense.

   h. Any tree, shrub, or grassed areas damaged by the Contractor's work shall be repaired at the Contractor's expense.

4. In the preparation of the plans and specifications, the Engineer has endeavored to indicate the location of existing underground utilities. It is not guaranteed that all lines or structures have been shown on the plans.

5. The Contractor shall verify, locate, and protect existing water, sanitary sewer, storm sewer, gas, electric, telephone mains and services and shall effect restoration of service in case of any damage.

6. The Contractor shall provide proper barricades and maintain traffic flow as per the current Manual on Uniform Traffic Control Devices (MUTCD) at all times.

7. The location for the disposal of construction material shall be approved by the City of Stephenville prior to the start of construction.

8. All phases of construction must be coordinated with the Engineer. Also, the Contractor is required to coordinate with the surrounding and affected property owners in order to minimize conflicts.

9. Field adjustments may be necessary and will be carried out as directed by the Engineer.

10. The Contractor shall contact the City of Stephenville prior to any sign removal. See General Note No. 3. Sign removal and reinstallation/relocation shall be in good condition of equal to or better than existing condition, and as per the Engineer's specifications.

11. All fences, signs, and property corner monuments removed for, or damaged during construction shall be replaced with new material as per the Engineer's specifications.

12. The Contractor shall relocate existing mailboxes in conflict with the proposed improvements and as specified on the plans, in good condition of equal to or better than existing condition, complete in place. Mailboxes shall be accessible at all times for mail delivery.

13. The Contractor shall be responsible for taking all precautions to protect existing trees inside and outside the scope of this Project.

14. The Contractor shall be responsible for repairing any damage caused by the Contractor outside of the designated work area with new quality material at the Contractor's expense.

15. The Contractor shall locate, verify working condition and protect all existing sprinkler systems lines and heads (if any). Remove, adjust and reinstall in good condition equal to or better than existing condition; replace, if in direct conflict, with the same or better quality material and appurtenances.

16. All existing grades shown on the plans are approximate and shown based on the best information available.

17. All backfill for ditch lines are to be mechanically tamped to 95% STD Proctor density (ASTM D698), at a moisture content near optimum (-1% to +3%).

18. Contractor to fill all voids under existing pavement when installing new line. Also all ditch lines must be filled at the end of each day’swork.

19. All pipe shall be kept free of trash and dirt at all time. At the end of each day, the pipe shall be temporarily connected/sealed.

20. The Contractor shall keep the existing fire hydrants in service at all times.

21. The Contractor shall maintain the existing water mains in service during all phases of construction. Leaks caused by the Contractor shall be repaired immediately at the Contractor's expense. Leaks along the existing water main close to the working area, caused by vibration, etc. (during working hours) shall be repaired by the Contractor with the City only providing the required parts. The City will repair all leaks if the Contractor is not on the job-site (primarily after working hours); if the leak is directly caused by the Contractor and not repaired, all charges incurred shall be billed to the Contractor.

22. All cutting and plugging of the existing water main where specified on the plans, shall include all labor, fittings and appurtenances required to perform this work. The cost for this work is incidental to the project.

23. The Contractor shall maintain the existing sanitary sewer mains and services in operation when installing the proposed sanitary sewer main. This shall include any temporary connections, if required.

24. Clearances on water and wastewater lines shall meet Texas Commission on Environmental Quality (TCEQ) requirements. Minimum clearances for water and wastewater lines crossing each other storm drains shall be two (2) feet or one-half (0.5) feet when the water or wastewater line is concrete encased. When running in **parallel**, water and wastewater lines shall be no closer than 9' from the outside edge of each pipe.

25. Street closing requests shall be submitted to the City of Stephenville in writing, a minimum of two weeks in advance of any street closing for notifications to Police, Fire, Mail, Garbage and School. There are no guarantees that street closings will be approved by the City.

26. Seed/sod shall be furnished to establish ground cover over all disturbed areas as an erosion control measure. The Contractor shall not wait until the completion of the entire project before doing this work. The project shall not be accepted by the City prior to the establishment of ground cover.

27. Sheeting, shoring, and bracing: The contractor will abide by all applicable federal, state, and local laws governing excavation, Trench' s side slopes shall meet Occupational Safety and Health Administration (OSHA) standards that are in effect at the time of construction. Sheeting shoring and bracing shall be required if side slope standards are not met. A pull box, meeting OSHA standards, will be acceptable. The Contractor will submit detailed plans and specifications for trench safety systems that meet OSHA standards that are in effect at the time of development of project when trench excavation will exceed a depth of five (5) feet. These plans will be sealed by an Engineer registered by the State of Texas and submitted to the City before obtaining a construction permit.

28. Contractor shall conform activities to the SWPPP as specified, including installing, maintaining, and removing pollution controls, conducting and documenting inspections of pollution controls, sprinkling for dust control, maintaining spill response equipment on-site, and "good housekeeping". Pollution controls include silt fences (or straw bales), stabilized construction entrance, establishing grass, sprinkling for dust control. The Contractor shall also be responsible for submitting Notice of Intent (NOI) and Notice of Termination (NOT) to the Texas Commission on Environmental Quality (TCEQ).

29. The Contractor shall maintain the existing water mains and services in operation when installing the proposed water main. This shall include any temporary connections, if required in areas of conflict.

30. Contractor must notify each property owner 24 hours prior to shutting off water for connection to new main.

31. The Contractor shall contact the City at (254) 918-1235 for the operation of all water valves.

32. The cost of replacing all pavement markers, traffic buttons, striping, utilities, curbs, etc., disturbed during the construction shall be Contractor' s responsibility to maintain, repair or replace at the direction of and to the satisfaction of the City.

33. The Contractor shall maintain the flow of traffic at all times and provide access to all drives unless otherwise approved by the City.

34. The maximum deflection of pipe joints shall not exceed that recommended by the pipe manufacturer. If it is necessary to deflect the pipe (greater that the recommended amount) the Contractor shall provide fittings or specials.

35. The Contractor shall notify the City for inspection a minimum of two (2) regular business days in advance for all requests for water or wastewater locates or turnoffs of water.

36. Prior to the start of construction on Water/Wastewater utility connections the Contractor shall coordinate with City to insure, to the extent possible, that the utility can be found and secured.

37. Work may not be backfilled until it has been inspected by the City if specifically requested by the City. Work backfilled without inspection is done at the risk of the Contractor.

APPENDIX “C”

INTEGRATED STORMWATER MANAGEMENT (ISWM) CRITERIA MANUAL FOR SITE DEVELOPMENT AND CONSTRUCTION

NCTCOG
North Central Texas Council of Governments

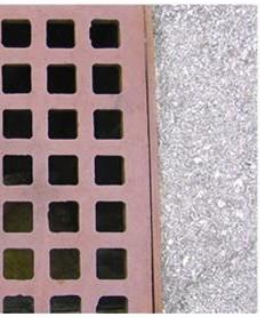
iSWM

iSWM Criteria Manual for Site Development and Construction

City of Stephenville

January 2018



integrated Stormwater Management iSWM

December 2009

Revised 1/14/15

Overview of the iSWM Program

The iSWM Program for Construction and Development is a cooperative initiative that assists municipalities and counties to achieve their goals of water quality protection, streambank protection, and flood mitigation, while also helping communities meet their construction and post-construction obligations under state stormwater permits.

Development and redevelopment by their nature increase the amount of imperviousness in our surrounding environment. This increased imperviousness translates into loss of natural areas, more sources for pollution in runoff, and heightened flooding risks. To help mitigate these impacts, more than 60 local governments are cooperating to proactively create sound stormwater management guidance for the region through the *integrated* Stormwater Management (iSWM) Program.

The success of the iSWM Program provides persuasive evidence that the quality and quantity issues associated with urban environment are among the top priorities for our member local governments. The focus of iSWM has followed the development of stormwater regulations and rulemaking on site development, but also acknowledges that the impact of linear projects like transportation and other infrastructure has on our communities.

The iSWM Program is comprised of four types of documentation and tools as shown in Figure 1. These are used to complement each other and to support the development process.

The four parts of iSWM are:

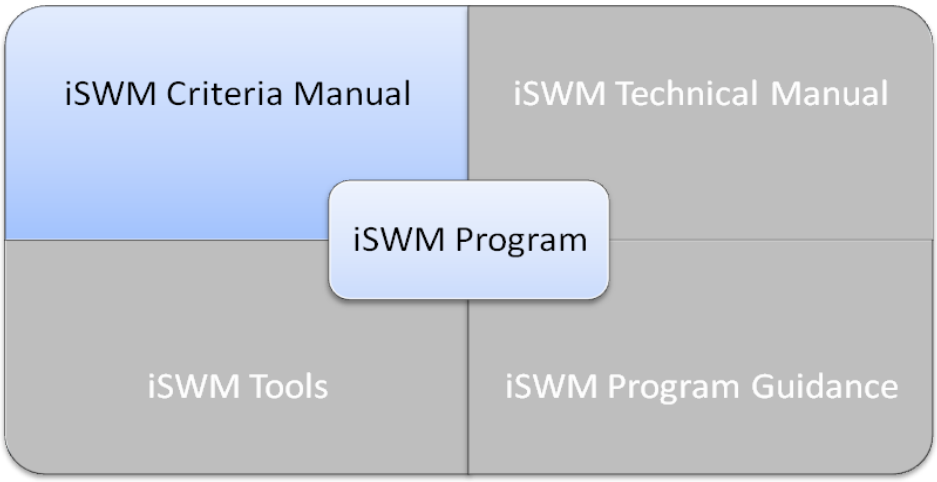


Figure 1: iSWM Program Support Documents and Tools

- iSWM Criteria Manual –This document provides a description of the development process, the iSWM focus areas and locally adopted design criteria allowing municipalities a flexible approach to apply at a local level. The Transportation *integrated* Stormwater Management (TriSWM) Appendix is provided for use by cities, counties, and transportation agencies for the planning and design of stormwater management systems associated with the construction of public transportation infrastructure (streets, roads, and highways).
- iSWM Technical Manual – This set of documents provides technical guidance including equations, descriptions of methods, fact sheets, etc. necessary for design.
- iSWM Tools – This includes web-served training guides, examples, design tools, etc. that could be useful during design.
- iSWM Program Guidance – This includes reference documents that guide programmatic planning rather than technical design.

Table of Contents

List of Figures

1.0 Overview of iSWM Criteria Manual

This Chapter discusses the criteria aspects of iSWM and lays out the framework and specific requirements. Local governments may modify this section to meet any local provisions.

1.1 Introduction

The purpose of this manual is to provide design guidance and a framework for incorporating effective and environmentally sustainable stormwater management into the site development and construction processes and to encourage a greater regional uniformity in developing plans for stormwater management systems that meet the following goals:

- Control runoff within and from the site to minimize flood risk to people and properties;
- Assess discharges from the site to minimize downstream bank and channel erosion; and
- Reduce pollutants in stormwater runoff to protect water quality and assist communities in meeting regulatory requirements.

Following criteria provided in the manual will help to meet sustainable development goals. There are many ways that sustainable development may be achieved while following these criteria. For example, a development that reduces individual lot imperviousness and a development that has high lot density in one area and a large open space in another can both meet sustainable requirements.

Chapter Summary

The iSWM Criteria Manual consists of five chapters:

Chapter 1 – Introduction and Summary

Chapter 2 – *integrated* Development Process

Chapter 3 – *integrated* Design Criteria

Chapter 4 – *integrated* Construction Criteria

Chapter 5 – Additional Local Provisions

Transportation *integrated* Stormwater Management (TriSWM) Appendix[1]

1. The Transportation *integrated* Stormwater Management (TriSWM) Appendix is for use by cities, counties, and transportation agencies for the planning and design of stormwater management systems for public infrastructure projects including streets, roads, and highways. When utilized, the TriSWM Appendix is used in place of certain chapters or sections of the iSWM Criteria Manual as indicated in the appendix. Note that the TriSWM Appendix does not apply to local or residential classified streets within residential subdivisions, unless required by the local jurisdiction. Typically, runoff from residential streets is managed as part of the stormwater management system for the entire development and designed in accordance with Chapters 1 through 5 of the iSWM Criteria Manual. However, when a city or county cooperates with a developer in the construction of a Collector or Arterial Street for access, the local government may require use of the TriSWM Appendix for that portion of the project.

Local Provisions:
This Criteria Manual has been adopted by the City of Stephenville under the conditions stated in the Local Provision Boxes throughout and the additional information provided in Chapter 5.

For the Technical Manual and other iSWM tools, please visit http://iswm.nctcog.org/.

In the event that the City of Stephenville subdivision or zoning ordinances conflict with this iSWM Criteria Manual, the City's ordinances supersede this manual.

Note: "Local Provisions" boxes may be used by a local government to add, delete, or modify sections of the criteria and specify the options allowed and/or required by the local government. Additional local information may be found in Chapter 5 (if used).

Applicability

iSWM is applicable under the following conditions for development and redevelopment that will ultimately disturb one or more acres as illustrated below and in Figure 1.1:

Table 1.1 iSWM Applicability

Applicable for iSWM Site Design:	Applicable for iSWM Construction:
Land disturbing activity of 1 acre or more **OR** land disturbing activity of less than 1 acre where the activity is part of a common plan of development that is one acre or larger.	Land disturbing activity of 1 acre or more **OR** land disturbing activity of less than 1 acre where the activity is part of a common plan of development that is one acre or larger.

A common plan of development consists of construction activity that is completed in separate stages, separate phases, or in combination with other construction activities.

Development and redevelopment are not specifically defined in this manual. The applicability is based on land disturbance activities. If an existing site has been cleared and graded, but not developed, within five years of the date of the developer's initial application submittal, the developer must consider the land conditions prior to the clearing and grading to be the existing site conditions.

New development or redevelopment in critical or sensitive areas, or as identified through a watershed study or plan, may be subject to additional performance and/or regulatory criteria as specified by the local government. Furthermore, these sites may need to utilize certain structural controls in order to protect a special resource or address certain water quality or drainage problems identified for a drainage area or watershed.

Site Design below Applicable Criteria

Site developments that do not meet the applicability requirements are not subject to the regulatory water quality or streambank protection requirements. However, it is recommended that these criteria still be used and that temporary controls be provided during construction. Flood mitigation and conveyance criteria still apply. The planning process is also simplified for sites below the applicable criteria to an optional pre-development review before the final submittal of the engineering plans.

Local Provisions:

Water Quality

An iSWM Water Quality Plan is NOT required for new development or redevelopment, but is encouraged when;

1) Land disturbing activity of one acre or more results in impervious area, or
2) If a one acre or larger lot has any increase in total impervious area on the site.

Flood Mitigation for New Development and Redevelopment

An iSWM submittal is required for all new development and redevelopment. In general, stormwater detention facilities are required for new development and redevelopment except:

1) Single-family residential properties less than one acre, and
2) Properties less than 0.5 acres where there is no land use change and where all drainage will go to the adjacent street and not cross any other adjacent properties.
3) Where development can be shown to not cause adverse downstream impacts.

Local Provisions:

iSWM requirements must be addressed for all new development and redevelopment. All iSWM Plans and stormwater management plans must be prepared and sealed by a Licensed Professional Engineer with a valid license from the State of Texas. The Engineer must attest in writing that the design and subsequent construction was conducted in accordance with the iSWM Design Manual.

Does iSWM apply to my Project?

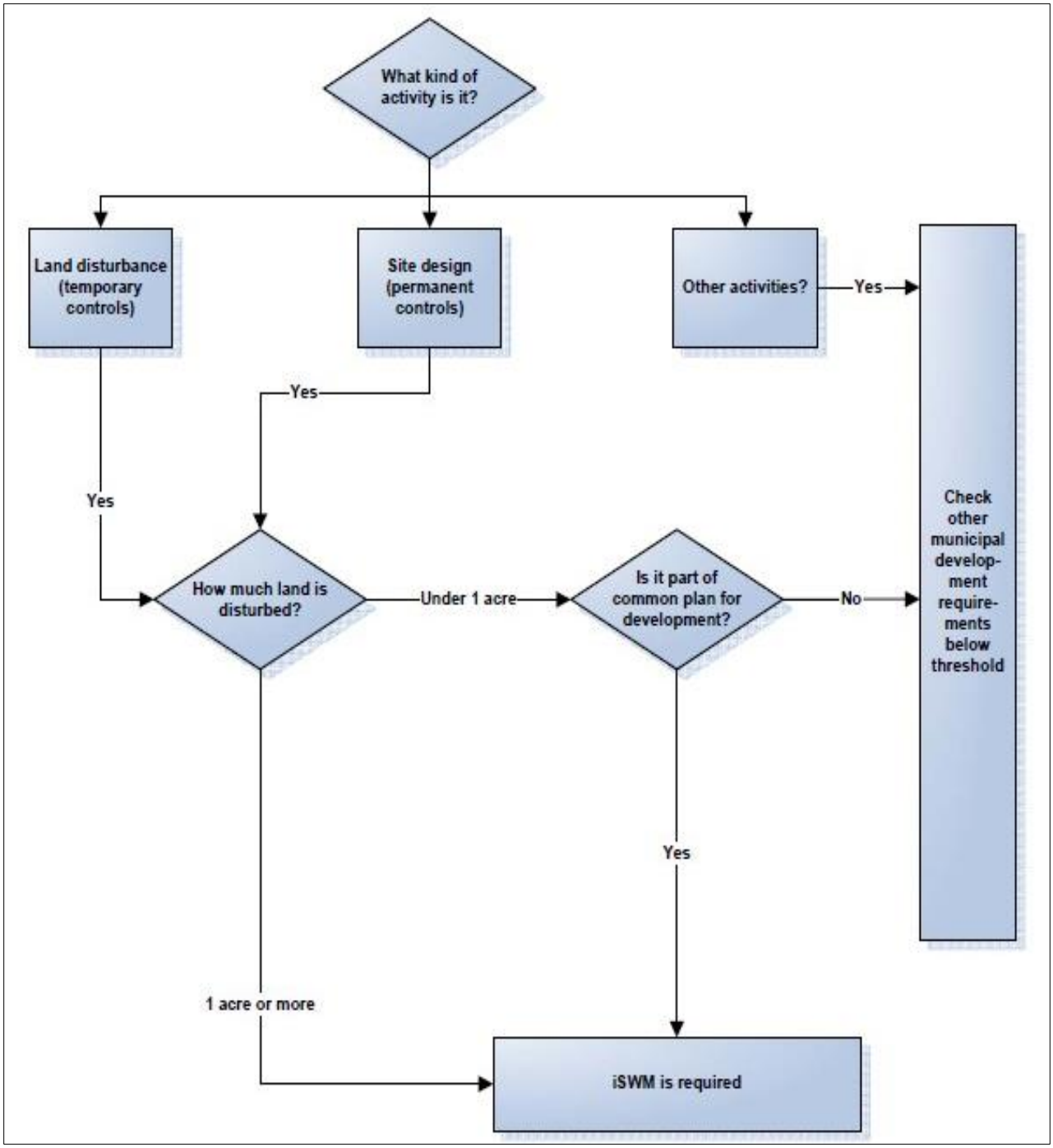


Figure 1.1 iSWM Applicability Flowchart

1.2 *integrated* Development Process

Chapter 2 of this manual presents details for completing the full iSWM development process which consists of five steps. Each of the steps builds on the previous steps to result in Final iSWM Site Design Plans and Construction Plans.

Step 1 – Review Local Requirements and Municipality's Processes

Step 2 – Collect Data and Perform Site Analysis

Step 3 – Prepare Concept/Preliminary iSWM Plans

Step 4 – Prepare Final iSWM Plans and iSWM Construction Plan

Step 5 – Prepare Operation and Maintenance Plans

Local Provisions: NONE

1.3 *integrated* Design Criteria

Chapter 3 of this manual presents an *integrated* approach for meeting stormwater runoff quality and quantity management goals by addressing the key adverse impacts of development on stormwater runoff. Its framework consists of three focus areas, each with options in terms of how the focus area is applied.

Design Focus Areas

The stormwater management focus areas and goals are:

- **Water Quality Protection:** Remove pollutants in stormwater runoff to protect water quality.
- **Streambank Protection:** Regulate discharge from the site to minimize downstream bank and channel erosion.
- **Flood Mitigation and Conveyance:** Control runoff within and from the site to minimize flood risk to people and properties for the conveyance storm as well as the 100-year storm.

Each of the Design Focus Areas must be used in conjunction with the other Design Focus Areas to address the overall stormwater impacts from a development site. When used as a set, the Design Focus Areas control the entire range of hydrologic events, from the smallest runoff-producing rainfalls up to the 100-year, 24-hour storm.

Local Provisions: NONE

Design Storms

Integrated design is based on the following four (4) storm events.

Table 1.2 Storm Events

Storm Event Name	Storm Event Description
"Water Quality"	Criteria based on a volume of 1.5 inches of rainfall, not a storm frequency
"Streambank Protection"	1-year, 24-hour storm event
"Conveyance"	25-year, 24-hour storm event
"Flood Mitigation"	100-year, 24-hour storm event

Throughout the manual the storms will be referred to by their storm event names.

Local Provisions:

The adopted storm events are the 1-year, 5-year, 25-year and 100-year, 24-hour storm events.

It is required that the Streambank Protection storm, the Conveyance storm, and the Flood Mitigation storm are all analyzed for downstream assessments and design of detention outfalls.

Enclosed pipe systems may be required for the Flood Mitigation storm which is the 100-year, 24-hour storm event.

Design Focus Area Application Options

There are multiple options provided to meet the required criteria for water quality protection, streambank protection, and flood mitigation. These design options are summarized in Table 1.3.

Design criteria for streambank protection and flood mitigation are based on a **downstream assessment**. The purpose of the downstream assessment is to protect downstream properties and channels from increased flooding and erosion potential due to upstream development. A downstream assessment is required to determine the extent of improvements necessary for streambank protection and flood mitigation. Downstream assessments shall be performed for streambank protection, conveyance, and flood mitigation storm events. More information on downstream assessments is provided in Section 3.3.

If a development causes no adverse impacts to existing conditions, then it is possible that little or no mitigation would be required.

Table 1.3 Summary of Options for Design Focus Areas

Design Focus Area	Reference Section	Required Downstream Assessment	Design Options
Water Quality Protection	3.2	no	**Option 1:** Use *integrated* Site Design Practices for conserving natural features, reducing impervious cover, and using the natural drainage systems
			Option 2: Treat the Water Quality Protection Volume (WQ_V) by reducing total suspended solids from the development site for runoff resulting from rainfalls of up to 1.5 inches (85^{th} percentile storm)
			Option 3: Assist in implementing off-site community stormwater pollution prevention programs/activities as designated in an approved stormwater master plan or TPDES Stormwater permit
Streambank Protection	3.4	yes	**Option 1:** Reinforce/stabilize downstream conditions
			Option 2: Install stormwater controls to maintain or improve existing downstream conditions
			Option 3: Provide on-site controlled release of the 1-year, 24-hour storm event over a period of 24 hours (Streambank Protection Volume, SP_V)
Flood Mitigation and Conveyance	3.5 and 3.6	yes	**Flood Mitigation** **Option 1:** Provide adequate downstream conveyance system
			Option 2: Install stormwater controls on-site to maintain or improve existing downstream conditions
			Option 3: In lieu of a downstream assessment, maintain existing on-site runoff conditions
			Conveyance Minimize localized site flooding of streets, sidewalks, and properties by a combination of on- site stormwater controls and conveyance systems

Local Provisions:

For Streambank Protection, Options 1 and 2 are allowed by the City but will require all the necessary supporting documents and calculations. Option 3 is more common practice in Stephenville.

For Flood Mitigation, Options 1 and 2 are allowed by the City but will require all the necessary supporting documents and calculations. Option 3 is more common practice in Stephenville.

1.4 *integrated* Construction Criteria

Chapter 4 of this manual presents an *integrated* approach for reducing the impact of stormwater runoff from construction activities on downstream natural resources and properties. The purpose is to provide design criteria for temporary controls during construction that protect water quality by:

- Preventing soil erosion;
- Capturing sediment on-site when preventing erosion is not feasible due to construction activities; and
- Controlling construction materials and wastes to prevent contamination of stormwater.

Temporary controls to protect water quality are known as Best Management Practices (BMPs). The design of the BMPs is to be coordinated with and done at the same time as the Preliminary and Final iSWM Plans. Construction BMPs complement and work with the site grading and drainage infrastructure.

Erosion Control BMPs are designed to minimize the area of land disturbance and to protect disturbed soils from erosion. Protection can be accomplished by diverting stormwater away from the disturbed area or by stabilizing the disturbed soil. Erosion control BMPs are most important on disturbed slopes and channels where the potential for erosion is greatest. The design of erosion control BMPs must be coordinated with related grading, drainage and landscaping elements. (e.g. channel armoring, velocity dissipaters, etc.)

Sediment Control BMPs are temporary structures or devices that capture soil transported by stormwater. The BMPs are designed to function effectively with the site drainage patterns and infrastructure. An effective design ensures that the sediment control BMPs do not divert flow or flood adjacent properties and structures. Some types of permanent drainage structures, such as retention basins, can also be designed to function as a sediment control BMP during construction.

Material and Waste Control BMPs prevent construction materials and wastes from coming into contact with and being transported by stormwater. These BMPs consist of a combination of notes to direct contractor and temporary construction controls.

The iSWM Construction Criteria are the minimum requirements for temporary controls during construction. The state permit and requirements for stormwater discharges associated with construction activities must also be followed. More information on state requirements is provided in Section 4.2.

Local Provisions: NONE

1.5 Transportation *integrated* Stormwater Management (TriSWM) Criteria

The TriSWM Appendix presents an *integrated* approach for reducing the impact of stormwater runoff associated with public linear transportation infrastructure projects. The TriSWM Appendix has been incorporated as an expansion of the iSWM Criteria Manual for Site Development and Construction for use by cities, counties, and transportation agencies (and in some cases private developers) in the planning and design of stormwater management systems for public streets, roads, and highways.

Transportation design, construction and operation practices are unique when contrasted with site/parcel development and require equally unique approaches to stormwater management. New public roadway, street, and highway projects are distinct from private site development and they require some specific strategies to more fully integrate stormwater design. In the larger context, the interrelation between parcel

development and transportation projects represent important challenges and opportunities to truly integrate stormwater management in urban areas and infrastructure.

The process of coordinating more effective stormwater management for new public transportation infrastructure projects, as well as significant expansion projects, starts with a full integration into the project planning and design process. This involves a comprehensive planning approach and a thorough understanding of the physical characteristics and natural resources in proximity to the proposed route.

The information presented in the TriSWM Appendix provides design guidance and a framework for incorporating effective and environmentally sensitive stormwater management into the public street and highway project development process in order to meet the following goals:

- Provide safe driving conditions
- Minimize the upstream and downstream flood risk to people and properties
- Minimize downstream bank and channel erosion
- Reduce pollutants in stormwater runoff to protect water quality.

Note: Stormwater runoff from residential streets should be managed as part of the overall stormwater management system for the entire site. Chapters 1 through 5 of the iSWM Criteria Manual for Site Development and Construction should be used for the planning and design of stormwater management facilities for residential subdivisions and internal residential streets. The TriSWM Appendix does not apply to streets within residential subdivisions, unless required by the local jurisdiction. However, when a city or county cooperates with a developer in the construction of a collector or arterial street for access, the local government may require the use of the TriSWM Appendix for that portion of the project.

Local Provisions:

The TriSWM Appendix is NOT applicable. However, if and/or when the City cooperates with a developer in the construction of a collector or arterial street for access, the use of the TriSWM Appendix for that portion of the project is encouraged and may be included in developer agreement.

2.0 *integrated* Development Process

This Chapter discusses the five-step development process. Local governments will integrate these processes into their current process by the addition of local provisions.

2.1 Planning

A formal *integrated* Stormwater Management Development Process shall be implemented to meet the stormwater management goals and to see that local stormwater guidelines and requirements are implemented. The process shall include the steps, meetings, and documents that must be met by the developer. The five-step process described herein includes the following:

- The iSWM Plans: The iSWM Plans are the documents that summarize the data collected in steps 1 and 2 and are shown on the conceptual/preliminary and final plans that must be submitted to the municipality as part of steps 3, 4, and 5. Each submittal must follow the criteria outlined in Chapters 2 and 3. Submittals shall include information in accordance with the checklists that are included in Chapter 5.
- The iSWM Construction Plan: The iSWM Construction Plan is the document that uses data collected in steps 1 and 2 to protect water quality during construction. It is submitted to the municipality with the Final iSWM Plans in Step 4. An overview of the iSWM construction plan content is covered in Section 2.2. More detailed criteria for the iSWM Construction Plan are outlined in Chapter 4.

The iSWM Plans and iSWM Construction Plan are a subset of the overall development process that occurs throughout the planning and development cycle of a project and then continues after construction is completed via regular inspection and maintenance of the stormwater management system.

In addition to these plans, stormwater master plans are an important tool used to assess and prioritize both existing and potential future stormwater problems and to consider alternative stormwater management solutions. Local governments may have individual watershed plans, or several governments may work cooperatively to develop a unified approach to watershed planning, development controls, permit compliance, multi-objective use of floodplain and other areas, and property protection. Refer to the Local Provisions in Step 1 under Section 2.2 where regional approaches (if any) are identified.

2.2 Steps in the Development Process

This section describes the typical contents and general procedure for preparing iSWM Plans and the iSWM Construction Plan. The level of detail involved in the plans will depend on the project size and the individual site and development characteristics. Figure 2.1 lays out the five-step process. Each of the following steps builds on the previous steps to result in the Final iSWM Site and Construction Plans:

Step 1 – Review Local Requirements and Municipality's Processes

Step 2 – Collect Data and Perform Site Analysis

Step 3 – Prepare Concept/Preliminary iSWM Plans

Step 4 – Prepare Final iSWM Plans and iSWM Construction Plan

Step 5 – Prepare Operation and Maintenance Plans

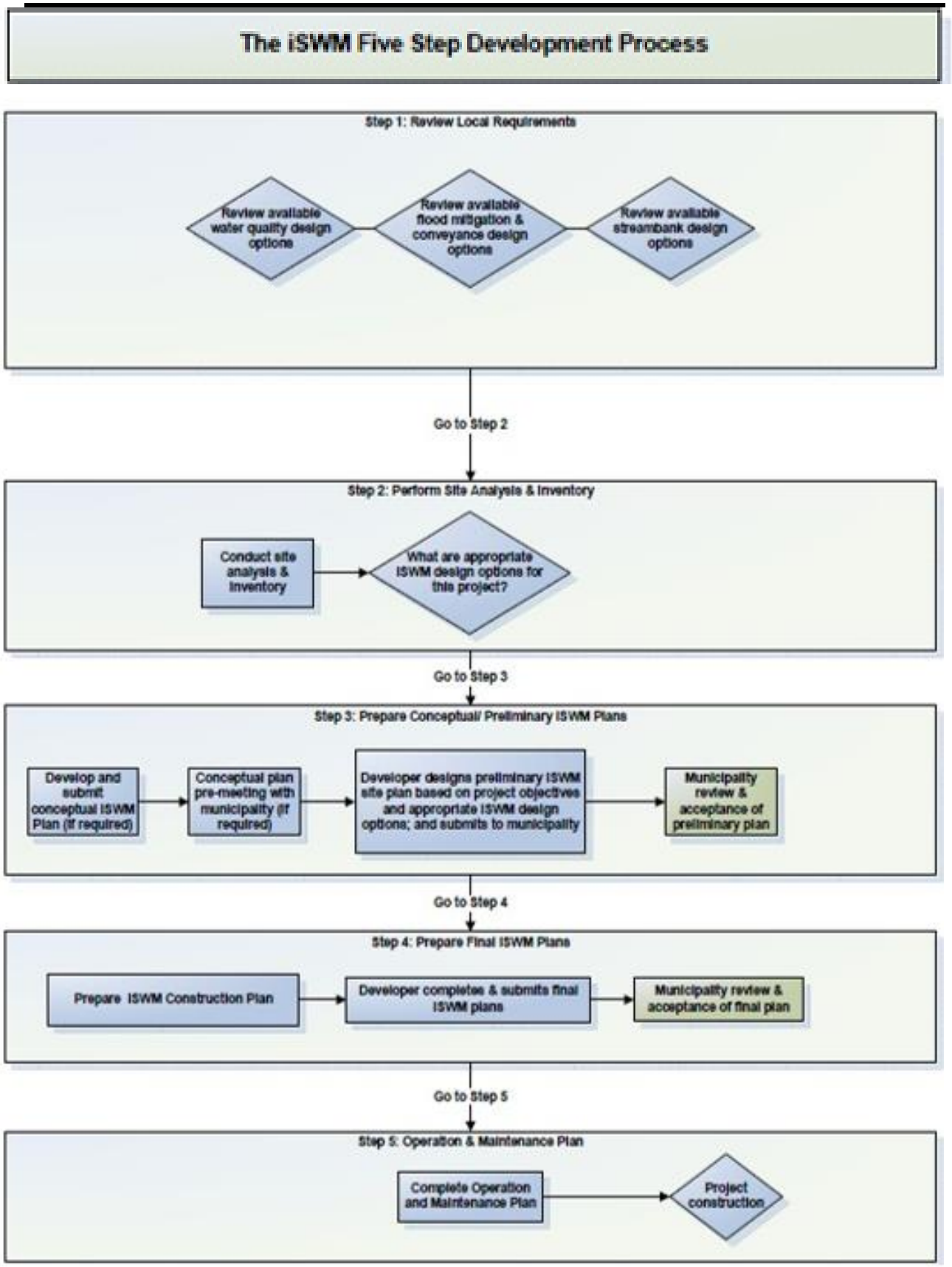


Figure 2.1 iSWM Flowchart

Step 1 – Review Local Requirements and Municipality Processes

The site developer shall become familiar with the local stormwater management, development requirements and design criteria that apply to the site. These requirements include:

- iSWM Criteria Manual for Site Development and Construction (this manual including all local provisions)
- Available online iSWM Program documents
  - iSWM Technical Manual
  - iSWM Tools
  - iSWM Program Guidance
- State and Federal Regulatory Requirements
- Other Local Municipal Ordinances and Criteria
  - Platting Procedures
  - Zoning Requirements
  - Development Codes and Procedures
  - Tree and Landscape Requirements
  - Special Use Permits
  - Drainage Master Plans and Watershed Plans
  - Erosion Control Plans
  - Floodplain Ordinances
  - Grading Plan Requirements
  - Construction/Building Permit Notifications and Requirements

Information regarding the above items can be obtained from this manual or at a pre-submittal (or similar) meeting with the municipality.

A critical part of any project involves the proposed development working closely with various departments within the municipality. Integrating the stormwater practices with other regulatory requirements will promote a sustainable development.

Opportunities for special types of development (e.g., clustering) or special land use opportunities (e.g., conservation easements or tax incentives) must be investigated. In addition, there may be an ability to partner with a local community for the development of greenways or other riparian corridor or open space developments.

All applicable State and Federal regulatory requirements must be met.

Local Provisions:
See Chapter 5, Figure 1 for a flowchart of the City of Stephenville development process. Information regarding the above items is available on the City of Stephenville website. If additional information is needed, it may be requested by the developer and will be provided by the City.

Step 2 – Collect Data and Perform Site Analysis

Using field and mapping techniques approved by the municipality, the site engineer shall collect and review information on the existing site conditions and map the following site features:

- Topography
- Drainage patterns and basins
- Intermittent and perennial streams on-site and off-site waters that will receive discharges from the proposed development
- Property lines, adjacent areas and easements
- Wetlands and critical habitat areas
- Boundaries of wooded areas and tree

- Soil types and their susceptibility to erosion
- Ground cover and vegetation, particularly unique or sensitive vegetation areas to be protected during development
- Existing development
- Existing stormwater facilities on-site and off-site facilities that will receive discharges from the proposed development
- clusters
- Floodplain boundaries
- Steep slopes
- Required buffers and setbacks along water bodies
- Proposed stream crossing locations
- Other required protection areas

The site analysis shall be summarized in the conceptual/preliminary iSWM Plans along with any other supporting documents. The data collected and analyzed during this step of the development process shall be used as the starting point for preparing the iSWM Plans and the iSWM Construction Plan.

Local Provisions:
Data collected under Step 2 shall be shown on an Existing Features Plan required to be submitted at the Pre-Application Conference during Step 3. The Pre-Application Checklist in Chapter 5 provides a list of items that must be shown at the Pre-Application Conference.

Step 3 –Prepare Conceptual/Preliminary iSWM Plans

Conceptual iSWM Plan

Based on the review of existing conditions and site analysis, the design engineer shall develop and submit a Conceptual iSWM Plan for the project. The Conceptual iSWM Plan allows the design engineer to propose a potential site layout and gives the developer and local review authority a “first look” at the stormwater management system for the proposed development.

The following steps shall be followed in developing the Conceptual iSWM Plan with the help of the Checklist for Conceptual iSWM Plans found in Chapter 5 of this manual:

1. Use *integrated* Site Design Practices (Section 3.2.2) as applicable to develop the site layout, including:
   - Preserving the natural feature conservation areas defined in the site analysis
   - Fitting the development to the terrain and minimizing land disturbance
   - Reducing impervious surface area through various techniques
   - Preserving and utilizing the natural drainage system wherever possible
2. Determine the credits for *integrated* Site Design (Section 3.2.2) and water quality volume reduction (Section 3.2.3) as applicable, to be accounted for in the design of structural and non-structural stormwater controls on the site.
3. Calculate conceptual estimates of the locally required focus area design requirements for water quality protection, streambank protection, and flood mitigation (Sections 3.2, 3.4, 3.5) based on the conceptual plan site layout.
4. Perform screening and conceptual selection of appropriate temporary and permanent structural stormwater controls (Section 3.8 and Section 4.0) and identification of potential site locations.

It is extremely important at this stage that stormwater system design is integrated into the overall site design concept in order to best and most cost-effectively reduce the impacts of the development as well as provide for the most cost-effective and environmentally sensitive approach. Using hydrologic calculations, the goal of mimicking pre-development conditions can serve a useful purpose in planning the stormwater management system.

Local Provisions:

The Conceptual iSWM Plan will be incorporated into the Existing Features Plan that will be submitted during the Pre-Application Conference. The Pre-Application Checklist in Chapter 5 provides a list of items that must be shown at the Pre-Application Conference.

Conceptual iSWM Site Plans shall be prepared and submitted to the City of Stephenville in the initial planning stages of a land development project. In general, the engineer and planner will follow the conceptual iSWM Site Plan guidelines, as applicable to Stephenville. A conceptual drainage study and Conceptual iSWM Site Plan for any proposed development shall include at a minimum the information listed in the Engineer's Checklist for Conceptual iSWM Site Plan shown in Chapter 5, Appendix A – City of Stephenville Detailed Checklists and Forms.

A Grading Permit is required prior to any construction or grading activity. Grading Permits will be approved for earthwork only, will be at the risk of the owner/developer, and will require compliance with any other required permits or approvals including floodplain and SWPPP, as applicable.

Preliminary iSWM Plans

The Preliminary iSWM Plan ensures that requirements and criteria are complied with and opportunities are taken to minimize adverse impacts from the development. This step builds on the data developed in the Conceptual iSWM Plan by refining and providing more detail to the concepts identified. If no Conceptual Plan is submitted, it shall be part of the Preliminary iSWM Plan. The checklist for Preliminary iSWM Plan in Chapter 5 outlines the data that shall be included in the preliminary iSWM Plan.

The Preliminary iSWM Plan shall consist of maps, plan sheets, narrative, and supporting design calculations (hydrologic and hydraulic) for the proposed stormwater management system. The completed Preliminary iSWM Plan shall be submitted to the local review authority for review and comment.

Local Provisions:

The submission of a Preliminary Site Plan that includes preliminary iSWM information is required. The Preliminary Site Plan Checklist in Chapter 5 provides a list of items that must be shown on the Preliminary Site Plan. A Preliminary Drainage study and iSWM Site Plan for any proposed development must accompany a preliminary plat submitted for development review, and shall include at a minimum the information listed in the Engineer's Checklist for Preliminary iSWM Site Plan shown in Chapter 5, Appendix A – City of Stephenville Detailed Checklists and Forms. The study will include a downstream assessment of properties that could be impacted by the development. These studies will include adequate hydrologic analysis to determine the existing, proposed, and fully-developed runoff for the drainage area that is affected by the proposed development and will include hydraulic studies that define the "adequate outfall". The study, as part of the development of the iSWM Site Plan, shall address existing downstream, off-site drainage conveyance system(s) and define the discharge path from the outlet of the on-site stormwater facilities, to the off-site drainage system(s) and/or appropriate receiving waters. It will include a capacity analysis of all existing constraint points such as pipes, culverts/bridges, or channels from the point of stormwater discharge of the development downstream to an "adequate outfall". For drainage areas of 50 acres or less, the downstream assessment will be limited to an "adequate outfall point", determined by the study, or the 10% rule (see the iSWM Hydrology Technical Manual, Section 2.4).

For drainage areas larger than 50 acres, the "adequate outfall point" will be defined by the detailed hydrologic and hydraulic analyses. This preliminary drainage study and Preliminary iSWM Site Plan will include:

Local Provisions: (Cont.)

1. A topographical map of the entire watershed (not just the area of the proposed development) generally not smaller than 1"=200' (or other such scale approved by City of Stephenville), delineating the watershed boundary(s) and runoff design point(s), existing and proposed land use and zoning, and the size and description of the outfall drainage facilities and receiving streams.
2. Computation tables showing drainage areas, runoff coefficients, time of concentration, rainfall intensities and peak discharge for the required design storms, for both existing and proposed (ultimate development) conditions, at all design points for each component of the stormwater system (streets, pipes, channels, detention ponds, etc.).
3. Any proposed changes to watershed boundaries (i.e. by re-grading, where permissible by Texas Water Code). If significant changes to watershed boundary are made, more extensive analyses of downstream impact and mitigating detention will be required and a variance obtained from the City.
4. FEMA Flood Hazard Areas, if applicable.
5. In addition any required Corps of Engineers' Section 404 permits, Conditional Letters of Map Revision (CLOMR), Letters of Map Revision (LOMR) or other permits relating to lakes and streams required by any federal, state or local authorities. These must be documented in the Drainage Study.
6. Detailed off-site outfall information. This shall include the presence of existing or proposed drainage structures, bridges or culverts; documentation of existing versus proposed developed site as well as ultimate runoff, identification of downstream properties which might be impacted by increased runoff, and proposed detention or other means of mitigation. Downstream impacts shall generally be delineated identified to a point where the drainage from the proposed development has no impact on the receiving stream or on any downstream drainage systems within the "zone of influence".
7. Report with technical documentation.

Step 4 – Prepare Final iSWM Plans and iSWM Construction Plan

The Final iSWM Plans and iSWM Construction Plan shall be prepared together and submitted to the local review authority for approval prior to any soil disturbance or other construction activities on the development site. The Final iSWM Plans add further detail to the Preliminary iSWM Plan and reflect changes that are requested or required by the local review authority.

The Final iSWM Plans and iSWM Construction Plan, as outlined in the final iSWM Plan checklist in Chapter 5, shall include all of the revised elements of the Preliminary iSWM Plans as well as a landscape plan, operation and maintenance plan, and any permits/waiver requests.

Local Provisions:

The final iSWM plan will be submitted as part of the Final Site Plan submittal. The iSWM construction plan will be incorporated into the Erosion Control Plan for the site. A checklist for the iSWM related items, including items for the iSWM construction plan, that will be required within the Final Site Plan is provided in Chapter 5 as the Final iSWM Plan Checklist.

Local Provisions: (Cont.)

A Final Drainage Study and iSWM Site Plan for development of all or a portion (i.e. phase one or phase two, etc.) of the overall development shall be prepared and submitted to the City of Stephenville. This submittal shall include at a minimum the information listed in the Engineer's Checklist for the Final iSWM Site Plan shown in Chapter 5, Appendix A – City of Stephenville Detailed Checklists and Forms, including:

1. Conformance with the Preliminary iSWM Site Plan and Study.
2. Submission of detailed drainage calculations and detailed design plans.
3. Final drainage studies shall be reviewed for approval based on the submission of an engineer-signed cover sheet and drainage map with calculations from the approved engineering construction drawings. Where City approval of construction plans is not required, the above information required for preliminary drainage studies, as well as construction plans for any drainage improvements, shall be submitted for City records.
4. Note that unless specifically approved in a Grading Permit issued by the City of Stephenville, no work may be performed in the FEMA regulatory floodway without a FEMA-approved Conditional Letter of Map Revision (CLOMR).
5. An iSWM Construction Plan must be prepared by a Licensed Professional Engineer; such plan shall provide for erosion and sediment control during construction, and must be submitted as an integral part of the final engineering documents.
6. A Storm Water Pollution Prevention Plan (SWPPP) must be prepared by the engineer or another qualified professional prior to construction in accordance with TCEQ and EPA requirements. The iSWM Construction Plan submitted with the final engineering documents should normally be incorporated into the SWPPP as its erosion and sediment control plan component.

Construction Phase

1. Pre-construction Meeting - Where possible, a pre-construction meeting shall occur before any clearing or grading is initiated on the site. This step ensures that the owner-developer, contractor, engineer, and inspector can be sure that each party understands how the plan will be implemented on the site.
2. Periodic Inspections - Periodic inspections during construction by City of Stephenville representatives. Inspection frequency may vary with regard to site size and location; however, monthly inspections are a minimum target.
3. Final Inspection - A final inspection is required to ensure that the construction conforms to the intent of the approved design. Prior to accepting the infrastructure components, issuing an occupancy permit, and releasing any applicable bonds, the Engineer of Record shall certify in writing that: (a) temporary erosion control measures have been removed; (b) stormwater controls are unobstructed and in good working order; (c) permanent vegetative cover has been established in exposed areas; (d) any damage to natural feature protection and conservation areas has been mitigated; (e) conservation areas and buffers have been adequately marked or signed; and (f) any other applicable conditions have been met.
4. Record Drawings - Record drawings of the structural stormwater controls, drainage facilities, and other infrastructure components will be provided to the City of Stephenville by the developer.
5. Final Grading Certificate - (Form CITY OF STEPHENVILLE -11) in Appendix A must be prepared by an engineer or the contractor which certifies that grading and stormwater infrastructure have been completed in substantial compliance with the Grading Permit, the iSWM Site Plan, and the SWPPP including revegetation and filing of Notice of Termination (NOT).

Step 5 – Complete Operations and Maintenance Plan

An Operations and Maintenance Plan shall be developed in accordance with this section. The plan shall be included in the Final iSWM Plan. It needs to clearly state which entity has responsibility for operation and maintenance of temporary and permanent stormwater controls and drainage facilities to ensure they function properly from the time they are first installed.

The Operations and Maintenance Plan shall include but is not limited to:

- Responsible party for all tasks in the plan
- Inspection and maintenance requirements
- Maintenance of permanent stormwater controls and drainage facilities during construction
- Cleaning and repair of permanent stormwater controls and drainage facilities before transfer of ownership
- Frequency of inspections for the life of the permanent structures
- Funding source for long-term maintenance
- Description of maintenance tasks and frequency of maintenance
- Access and safety issues
- Maintenance easements
- Reviewed and approved maintenance agreements
- Testing and disposal of sediments
- Life span of structures and replacement as needed

Guidance for development of Operations and Maintenance Plans has been provided with each temporary and permanent Best Management Practice (BMP) included in the *Stormwater Controls Technical Manual* sections.

Local Provisions:

An Operations and Maintenance Plan shall be shown on the engineering plans at the submittal of the Final Site Plan. The requirements of the Operations and Maintenance Plan are dependent on the permanent controls on the site. A list of items to be included on the Operations and Maintenance Plan is provided in Chapter 5 as part of the Final iSWM Plan Checklist.

A Stormwater Facility Maintenance Agreement must be prepared by the developer and/or engineer for each stormwater control to be wholly maintained by the property owner. This agreement must be a formal, written agreement signed by the developer and City and filed in the Erath County Courthouse and must outline both preventive maintenance tasks as well as major repairs, identify the schedule for each task, assign clear roles to affected parties, and provide a maintenance checklist to guide future owners including an annual self-inspection to be provided to the City of Stephenville. The obligation to maintain the facility will remain with the land and notes regarding the maintenance responsibility shall be shown in the notes on the plat.

3.0 *integrated* Design Criteria

This chapter gives details on criteria to meet the three focus areas of water quality, stream bank protection and flood mitigation, as well as information supportive of hydrology and stormwater conveyance.

3.1 Hydrologic Methods

3.1.1 Types of Hydrologic Methods

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

- Rational Method
- SCS Unit Hydrograph Method
- Snyder's Unit Hydrograph Method
- USGS & TXDOT Regression Equations
- iSWM Water Quality Protection Volume Calculation
- Water Balance Calculations

Table 3.1 lists the hydrologic methods and the circumstances for their use in various analysis and design applications. Table 3.2 provides some limitations on the use of several methods.

In general:

- The Rational Method is acceptable for small, highly impervious drainage areas, such as parking lots and roadways draining into inlets and gutters.
- The U.S. Geological Survey (USGS) and Texas Department of Transportation (TXDOT) regression equations are acceptable for drainage areas with characteristics within the ranges given for the equations shown in Table 3.2. These equations should not be used when there are significant storage areas within the drainage basin or where other drainage characteristics indicate general regression equations are not appropriate.

Local Provisions:
The City of Stephenville does not use USGS & TXDOT Regression Equations. All other hydrologic methods listed above are acceptable.

Table 3.1 Applications of the Recommended Hydrologic Methods

Method	Rational Method	SCS Method	Modified Rational	Snyder's Unit Hydrograph	USGS / TXDOT Equations	iSWM Water Quality Volume Calculation
Water Quality Protection Volume (WQ_v)						✓
Streambank Protection Volume (SP_v)		✓		✓		
Flood Mitigation Discharge (Q_f)		✓		✓	✓	
Storage Facilities		✓	✓	✓		
Outlet Structures		✓		✓		
Gutter Flow and Inlets	✓					
Storm Drain Pipes	✓	✓		✓		
Culverts	✓	✓		✓	✓	
Bridges		✓		✓		
Small Ditches	✓	✓		✓		
Open Channels		✓		✓	✓	
Energy Dissipation		✓		✓		

Local Provisions:

The City of Stephenville allows the use of the Rational Method for Flood Mitigation Discharge, outlet structures, bridges, open channels, and energy dissipation in addition to the items checked in Table 3.1 for acreage limitations shown on Table 3.2 and the accompanying Local Provisions.

Table 3.2 Constraints on Using Recommended Hydrologic Methods

Method	Size Limitations[1]	Comments
Rational	0 – 100 acres	Method can be used for estimating peak flows and the design of small site or subdivision storm sewer systems.
Modified Rational[2]	0 – 200 acres	Method can be used for estimating runoff volumes for storage design.
Unit Hydrograph (SCS)[3]	Any Size	Method can be used for estimating peak flows and hydrographs for all design applications.
Unit Hydrograph (Snyder's)[4]	1 acre and larger	Method can be used for estimating peak flows and hydrographs for all design applications.
TXDOT Regression Equations	10 to 100 mi^2	Method can be used for estimating peak flows for rural design applications.
USGS Regression Equations	3 – 40 mi^2	Method can be used for estimating peak flows for urban design applications.
*i*SWM Water Quality Protection Volume Calculation	Limits set for each Structural Control	Method can be used for calculating the Water Quality Protection Volume (WQ_v).

[1] Size limitation refers to the drainage basin for the stormwater management facility (e.g., culvert, inlet).
[2] Where the Modified Rational Method is used for conceptualizing, the engineer is cautioned that the method could underestimate the storage volume.
[3] This refers to SCS routing methodology included in many readily available programs (such as HEC-HMS or HEC-1) that utilize this methodology.
[4] This refers to the Snyder's methodology included in many readily available programs (such as HEC-HMS or HEC-1) that utilize this methodology.

Local Provisions:

The adjusted size limitations on hydrologic methods for the City of Stephenville are as follows:

Rational Method: 0 – 100 acres
Modified Rational Method: 0 – 25 acres
Unit Hydrograph (SCS): any size acreage
Unit Hydrograph (Snyder's): 1 sq. mi. and larger with prior City approval.

3.1.2 Rainfall Estimation

Rainfall intensities are provided in *Section 5.0 of the Hydrology Technical Manual* for the nine (9) counties within the North Central Texas Council of Governments. The intensities are based on a combination of data from Hydro-35 and USGS. These intensities shall be used for all hydrologic analysis within the applicable county.

Local Provisions:

For Rational and Modified Rational the rainfall intensity shall be determined using the Erath County rainfall intensity tables in Section 5.0 of the Hydrology Technical Manual.

For the SCS Unit Hydrograph method a Type II rainfall distribution shall be used as defined in the NRCS TR-55 for Erath County or a frequency-based hypothetical storm developed from rainfall depths for multiple durations.

3.2 Water Quality Protection

3.2.1 Introduction

iSWM requires the use of *integrated* Site Design Practices as the primary means to protect the water quality of our streams, lakes, and rivers from the negative impacts of stormwater runoff from development. The *integrated* Site Design Practices shall be designed as part of the iSWM Plans. In addition to the *integrated* Site Design Practices, required water quality protection can be achieved by two additional options: (1) by treating the water quality protection volume and (2) assisting with off-site pollution prevention activities. These three approaches are described below.

Local Provisions:

Water Quality Protections Requirements are not adopted by the City of Stephenville at this time.

3.2.2 Option 1: integrated Site Design Practices and Credits

The *integrated* Site Design Practices are methods of development that reduce the "environmental footprint" of a site. They feature conservation of natural features, reduced imperviousness, and the use of the natural drainage system. In this option, points are awarded for the use of different Site Design Practices. A minimum number of points are needed to meet the iSWM requirements for Water Quality. Additional points can be gained to qualify for development incentives.

List of *integrated* Site Design Practices and Techniques

Twenty *integrated* Site Design Practices are grouped into four categories listed below. Not all practices are applicable to every site.

- **Conservation of Natural Features and Resources**
  1. Preserve Undisturbed Natural Areas
  2. Preserve Riparian Buffers
  3. Avoid Floodplains
  4. Avoid Steep Slopes
  5. Minimize Siting on Porous or Erodible Soils
- **Lower Impact Site Design Techniques**
  6. Fit Design to the Terrain
  7. Locate Development in Less Sensitive Areas
  8. Reduce Limits of Clearing and Grading
  9. Utilize Open Space Development
  10. Consider Creative Designs

- **Reduction of Impervious Cover**
  11. Reduce Roadway Lengths and Widths
  12. Reduce Building Footprints
  13. Reduce the Parking Footprint
  14. Reduce Setbacks and Frontages
  15. Use Fewer or Alternative Cul-de-Sacs
  16. Create Parking Lot Stormwater "Islands"
- **Utilization of Natural Features for Stormwater Management**
  17. Use Buffers and Undisturbed Areas
  18. Use Natural Drainageways Instead of Storm Sewers
  19. Use Vegetated Swale Instead of Curb and Gutter
  20. Drain Rooftop Runoff to Pervious Areas

More detail on each site design practice is provided in the *integrated* Site Design Practice Summary Sheets in *Section 2.2 of the Planning Technical Manual*.

Local Provisions:
NONE

Integration of Site Design Practices into Site Development Process

During the site planning process described in Chapter 2, there are several steps involved in site layout and design, each more clearly defining the location and function of the various components of the stormwater management system. To be most effective and easier to incorporate, *integrated* Site Design Practices should be part of this overall development process as outlined in Table 3.3.

Table 3.3 Integration of Site Design Practices with Site Development Process	
Site Development Phase	**Site Design Practice Activity**
Site Analysis	• Identify and delineate natural feature conservation areas (natural areas and stream buffers) • Perform site reconnaissance to identify potential areas for and types of credits • Determine stormwater management requirements
Conceptual Plan	• Preserve natural areas and stream buffers during site layout • Reduce impervious surface area through various techniques • Identify locations for use of vegetated channels and groundwater recharge • Look for areas to disconnect impervious surfaces • Document the use of site design practices
Preliminary and Final Plan	• Perform layout and design of credit areas – integrating them into treatment trains • Ensure *integrated* Focus Areas are satisfied • Ensure appropriate documentation of site design credits according to local requirements
Construction	• Ensure protection of key areas • Ensure correct final construction of areas needed for credits • Inspect and maintain implementation of BMPs during construction
Final Inspection	• Develop maintenance requirements and documents • Ensure long term protection and maintenance • Ensure credit areas are identified on final plan and plat if applicable

Point System

All sites that meet iSWM applicability must provide on-site enhanced water quality protection. Under the *integrated* Site Design Practice option, sites that accumulate a minimum number of points by incorporating *integrated* Site Design Practices are considered to have provided enhanced water quality protection.

The point system is made up of three components:

1. The initial percentage of the site that has been previously disturbed sets the minimum requirement. This is shown in the left-hand column of Table 3.4.
2. A minimum required total of Water Quality Protection (WQP) points is needed to meet the basic water quality criteria. This minimum is shown in the center column of Table 3.4.
3. Optional additional points can be accumulated through additional use of Site Design Practices to be eligible for developer incentives. Each developer incentive attained requires ten (10) additional Site Design Practice points above the minimum required points as shown in the right-hand column of Table 3.4.

As shown in Table 3.4, the initial percentage of site disturbance sets the minimum required points necessary to meet Water Quality Protection criteria. If a developer wishes to go beyond this minimum then the number of additional points required to attain specific development incentives is also given.

Table 3.4 *integrated* Site Design Point Requirements

Percentage of Site(by Area) with Natural Features Prior to Proposed Development	Minimum Required Points for Water Quality Protection (WQP)	Additional Points Above WQP for Development Incentives
> 50%	50	10 points each
20 - 50%	30	10 points each
< 20%	20	10 points each

The minimum number of points required to achieve WQP, as shown in the center column of Table 3.4, depends on the proportion of undisturbed natural features that exist on the site before it is developed. It is assumed that disturbing a site that has little previously disturbed area will cause more relative environmental impact than a site that has already incurred significant site disturbance. Therefore, disturbing a "pristine" site carries a higher restoration/preservation requirement.

For the purpose of this evaluation, undisturbed natural features are areas with one or more of the following characteristics:

- Unfilled floodplain
- Stand of trees, forests
- Established vegetation
- Steep sloped terrain
- Creeks, gullies, and other natural stormwater features
- Wetland areas and ponds

The number of points credited for the use of *integrated* Site Design Practices is shown in Table 3.5. To determine the qualifying points for a site, the developer must reference Table 3.5 and follow the guidance for each practice in the *Planning Technical Manual*.

Using the area of the site that is eligible for a practice as a basis, points are given for the percent of that area to which the *integrated* Site Design Practice is applied. For example, if a planned site has four (4) acres of riparian buffer and the developer proposes to preserve two (2) acres, then the site would qualify for 50 percent of the 8 credit points for iSWM Site Design Practice 2 (Preserve Riparian Buffers), because 50 percent of the site design practice was incorporated. The actual points earned for iSWM Site Design Practice 2 would be 4 points (0.50 * 8 pts = 4 pts). To comply with water quality protection and to apply for site design credits, the developer must submit the completed table and associated documentation or calculations to the review authority.

Table 3.5 Point System for *integrated* Site Design Practices				
***i*SWM Practice No.**	**Practice**	**Percent of Eligible Area Using Practice**	**Maximum Points**	**Actual Points Earned (% practice used * max. points)**
Conservation of Natural Features and Resources				
1	Preserve/Create Undisturbed Natural Areas		8	
2	Preserve or Create Riparian Buffers Where Applicable		8	
3	Avoid Existing Floodplains or Provide Dedicated Natural Drainage Easements		8	
4	Avoid Steep Slopes		3	
5	Minimize Site on Porous or Erodible Soils		3	
Lower Impact Site Design				
6	Fit Design to the Terrain		4	
7	Locate Development in Less Sensitive Areas		4	
8	Reduce Limits of Clearing and Grading		6	
9	Utilize Open Space Development		8	
10	Incorporate Creative Design (e.g. Smart Growth, LEED Design, Form Based Zoning)		8	
Reduction of Impervious Cover				
11	Reduce Roadway Lengths and Widths		4	
12	Reduce Building Footprints		4	
13	Reduce the Parking Footprint		5	
14	Reduce Setbacks and Frontages		4	
15	Use Fewer or Alternative Cul-de-Sacs		3	
16	Create Parking Lot Stormwater “Islands”		5	
Utilization of Natural Features				
17	Use Buffers and Undisturbed Areas		4	
18	Use Natural Drainageways Instead of Storm Sewers		4	
19	Use Vegetated Swale Design		3	
20	Drain Runoff to Pervious Areas		4	
Subtotal – Actual site points earned			**100**	
Subtract minimum points required (Table 3.4) -				
Points available for development incentives				
Add 1 point for each 1% reduction of impervious surface +				
Total Points for Development Incentives				

Local Provisions:

The Water Quality Protection Volume requirement is not required at this time.

Development Incentives

The developer can use *integrated* Site Design Practice points in excess of the minimum required for water quality protection to qualify for development incentives provided by the municipality. Additional points can be earned for redevelopment sites. Each reduction of one (1) percent imperviousness from existing conditions qualifies for one (1) site design point. The total points available for development incentives shall be calculated per Table 3.5. Each incentive requires ten (10) additional points above the minimum point required to meet water quality criteria, as stated in Table 3.4.

A list of available development incentives includes:

1. Narrower pavement width for minor arterials
2. Use of vegetated swales in lieu of curb and gutter for eligible developments
3. Reduced ROW requirements, i.e. Sidewalk/Utility Easements
4. Increased density in buildable area, floor area ratios, or additional units in buildable area
5. Expedited Plans review and inspection
6. Waiver or reduction of fees
7. Local government public-private partnerships
8. Waiver of maintenance, public maintenance
9. Stormwater user fee credits or discounts
10. Rebates, local grants, reverse auctions
11. Low interest loans, subsidies, tax credits, or financing of special green projects
12. Awards and recognition programs
13. Reductions in other requirements

Local Provisions:
The Development Incentives and Integrated Design point system described above are not adopted by the City of Stephenville. The development policies, however, encourage the incorporation of stormwater controls for achieving stormwater quality goals through the acceptance of perpetual, limited maintenance of preserved streams and by affording flexibility in placing stormwater quality treatment controls in land required for other purposes such as parks of commercial landscape areas.

3.2.3 Option 2: Treat the Water Quality Protection Volume

Treat the Water Quality Protection Volume by reducing total suspended solids from the development site for runoff resulting from rainfall of 1.5 inches (85th percentile storm). Stormwater runoff equal to the Water Quality Protection Volume generated from sites must be treated using a variety of on-site structural and nonstructural techniques with the goal of removing a target percentage of the average annual total suspended solids.

A system has been developed by which the Water Quality Protection Volume can be reduced, thus requiring less structural control. This is accomplished through the use of certain reduction methods, where affected areas are deducted from the site area, thereby reducing the amount of runoff to be treated. For more information on the Water Quality Volume Reduction Methods see *Section 1.3 of the Water Quality Technical Manual*.

Water Quality Protection Volume

The Water Quality Protection Volume (WQ_v) is the runoff from the first 1.5 inches of rainfall. Thus, a stormwater management system designed for the WQ_v will treat the runoff from all storm events of 1.5 inches or less, as well as a portion of the runoff for all larger storm events. For methods to determine the WQ_v, see *Section 1.2 of the Water Quality Technical Manual*.

Local Provisions:
For reference only.

Recommended Stormwater Control Practices

Below is a list of recommended structural stormwater control practices. These structural controls are recommended for use in a wide variety of applications and have differing abilities to remove various kinds of pollutants. It may take more than one control to achieve a certain pollution reduction level. A detailed discussion of each of the controls, as well as design criteria and procedures, can be found in the *Site Development Controls Technical Manual*. Refer to Table 3.6 for details regarding primary and secondary controls.

- Bioretention
- Enhanced swales (dry, wet, wetland)
- Alum treatment
- Detention
- Filter strips
- Sand filters, filter boxes, etc
- Infiltration wells and trenches
- Ponds
- Porous surfaces
- Proprietary systems
- Green roofs
- Rainwater harvesting
- Wetlands
- Submerged gravel wetlands

Local Provisions:
For design guidance and technical reference.

Using Other or New Structural Stormwater Controls

Innovative technologies will be allowed and encouraged. Any such system will be required to provide sufficient documentation as to its effectiveness and reliability. Communities can allow controls not included in this manual at their discretion. However, these communities shall require third party proof of performance, maintenance, application requirements, and limitations.

More specifically, new structural stormwater control designs will not be accepted for inclusion in the manual until independent performance data shows that the structural control conforms to local and/or State criteria for treatment, conveyance, maintenance, and environmental impact.

Suitability of Stormwater Controls to Meet Stormwater Management Goals

The stormwater control practices recommended in this manual vary in their applicability and ability to meet stormwater management goals:

Primary Controls

Primary Structural Stormwater Controls have the ability to fully address one or more of the Steps in the *integrated* Focus Areas if designed appropriately. Structural controls are recommended for use with a wide variety of land uses and development types. These structural controls have a demonstrated ability to effectively treat the Water Quality Volume (WQv) and have been shown to be able to remove 70% to 80% of the annual average total suspended solids (TSS) load in typical post-development urban runoff when designed, constructed, and maintained in accordance with recommended specifications. Several of these structural controls can also be designed to provide primary control for downstream streambank protection (SPv) and flood mitigation. These structural controls are recommended stormwater management facilities for a site wherever feasible and practical.

Secondary Controls

A number of structural controls are recommended only for limited use or for special site or design conditions. Generally, these practices either: (1) do not have the ability on their own to fully address one or more of the Steps in the *integrated* Focus Areas, (2) are intended to address hotspot or specific land use constraints or conditions, and/or (3) may have high or special maintenance requirements that may preclude their use. These types of structural controls are typically used for water quality treatment only. Some of these controls can be used as pretreatment measures or in series with other structural controls to meet pollutant removal goals. Such structural controls are not recommended for residential developments.

Table 3.6 summarizes the stormwater management suitability of the various stormwater controls in addressing the *integrated* Focus Areas. The *Site Development Controls Technical Manual* provides guidance on the use of stormwater controls as well as how to calculate the pollutant removal efficiency for stormwater controls in series. The *Site Development Controls Technical Manual* also provides guidance for choosing the appropriate stormwater control(s) for a site as well as the basic considerations and limitations on the use of a particular stormwater control.

Table 3.6 Suitability of Stormwater Controls to Meet *integrated* Focus Areas

Category	*integrated* Stormwater Controls	TSS/ Sediment Removal Rate	Water Quality Protection	Streambank Protection	On-Site Flood Control	Downstream Flood Control
Bioretention Areas	Bioretention Areas	80%	P	S	S	-
Channels	Enhanced Swales	80%	P	S	S	S
	Channels, Grass	50%	S	S	P	S
	Channels, Open	-	-	-	P	S
Chemical Treatment	Alum Treatment System	90%	P	-	-	-
Conveyance System Components	Culverts	-	-	-	P	P
	Energy Dissipation	-	-	P	S	S
	Inlets/Street Gutters	-	-	-	P	-
	Pipe Systems	-	-	P	P	P
Detention	Detention, Dry	65%	S	P	P	P
	Detention, Extended Dry	65%	S	P	P	P
	Detention, Multi-purpose Areas	-	-	P	P	P
	Detention, Underground	-	-	P	P	P
Filtration	Filter Strips	50%	S	-	-	-
	Organic Filters	80%	P	-	-	-
	Planter Boxes	80%	P	-	-	-
	Sand Filters, Surface/Perimeter	80%	P	S	-	-
	Sand Filters, Underground	80%	P	-	-	-
Hydrodynamic Devices	Gravity (Oil-Grit) Separator	40%	S	-	-	-
Infiltration	Downspout Drywell	80%	P	-	-	-
	Infiltration Trenches	80%	P	S	-	-
	Soakage Trenches	80%	P	S	-	-
Ponds	Wet Pond	80%	P	P	P	P
	Wet ED Pond	80%	P	P	P	P
	Micropool ED Pond	80%	P	P	P	P
	Multiple Ponds	80%	P	P	P	P
Porous Surfaces	Green Roof	85%	P	S	-	-
	Modular Porous Paver Systems	[2]	S	S	-	-
	Porous Concrete	[2]	S	S	-	-
Proprietary Systems	Proprietary Systems [1]	[1]	S/P	S	S	S
Re-Use	Rain Barrels	-	P	-	-	-
Wetlands	Wetlands, Stormwater	80%	P	P	P	P
	Wetlands, Submerged Gravel	80%	P	P	S	-

P = Primary Control: Able to meet design criterion if properly designed, constructed and maintained.

S = Secondary Control: May partially meet design criteria. Designated as a Secondary control due to considerations such as maintenance concerns. For Water Quality Protection, recommended for limited use in approved community-designated areas.

- = Not typically used or able to meet design criterion.

[1] = The application and performance of proprietary commercial devices and systems must be provided by the manufacturer and should be verified by independent third-party sources and data, if used as a primary control. Third-party sources could include Technology Acceptance Reciprocity Partnership, Technology Assessment Protocol – Ecology, or others.

[2] = Porous surfaces provide water quality benefits by reducing the effective impervious area.

3.2.4 Option 3: Assist with Off-Site Pollution Prevention Programs and Activities

Some communities have implemented pollution prevention programs/activities in certain areas to remove pollutants from the runoff after it has been discharged from the site. This may be especially true in intensely urbanized areas facing site redevelopment where many of the BMP criteria would be difficult to apply. These programs will be identified in the local jurisdiction's approved TPDES stormwater permit and/or in a municipality's approved watershed plan. In lieu of on-site treatment, the developer can request to simply assist with the implementation of these off-site pollution prevention programs/activities.

Developers should contact the municipality to determine if there are any plans to address runoff pollutants within the region of proposed development. If no plans exist, consider proposing regional alternatives that would address pollution prevention.

Local Provisions:
Off-site pollution prevention activities are not currently required by the City of Stephenville.

3.3 Acceptable Downstream Conditions

As part of the iSWM Plan development, the downstream impacts of development must be carefully evaluated for the two focus areas of Streambank Protection and Flood Mitigation. The purpose of the downstream assessment is to protect downstream properties from increased flooding and downstream channels from increased erosion potential due to upstream development. The importance of the downstream assessment is particularly evident for larger sites or developments that have the potential to dramatically impact downstream areas. The cumulative effect of smaller sites, however, can be just as dramatic and, as such, following the *integrated* Focus Areas is just as important for the smaller sites as it is for the larger sites.

The assessment shall extend from the outfall of a proposed development to a point downstream where the discharge from a proposed development no longer has a significant impact, in terms of flooding increase or velocity above allowable, on the receiving stream or storm drainage system. The local jurisdiction shall be consulted to obtain records and maps related to the National Flood Insurance Program and the availability of Flood Insurance Studies and Flood Insurance Rate Maps (FIRMs) which will be helpful in this assessment. The assessment shall be a part of the preliminary and final iSWM plans, and must include the following properties:

- Hydrologic analysis of the pre- and post-development on-site conditions
- Drainage path that defines extent of the analysis
- Capacity analysis of all existing constraint points along the drainage path, such as existing floodplain developments, underground storm drainage systems culverts, bridges, tributary confluences, or channels
- Offsite undeveloped areas are considered as "full build-out" for both the pre- and post-development analyses
- Evaluation of peak discharges and velocities for three 24-hour storm events
    - Streambank protection storm
    - Conveyance storm
    - Flood mitigation storm
    - Separate analysis for each major outfall from the proposed development.

Once the analysis is complete, the designer must answer the following three questions at each determined junction downstream:

- Are the post-development discharges greater than the pre-development discharges?
- Are the post-development velocities greater than the pre-development velocities?
- Are the post-development velocities greater than the velocities allowed for the receiving system?
- Are the post-development flood heights more than 0.1 feet above the pre-development flood heights?

These questions shall be answered for each of the three storm events. The answers to these questions will determine the necessity, type, and size of non-structural and structural controls to be placed on-site or downstream of the proposed development.

Section 2.0 of the Hydrology Technical Manual gives additional guidance on calculating the discharges and velocities, as well as determining the downstream extent of the assessment.

Local Provisions:

Downstream Assessment

Offsite undeveloped areas may be considered as “fully built-out” for post-development calculations only in lieu of fully built out for pre & post-development conditions. Downstream impacts due to a development must be analyzed and mitigated for the 1-yr, 5-yr, 25-yr and 100-yr floods for the entire Zone of Influence, as determined by the development engineer’s analysis. The Zone of Influence for any proposed development must be defined by the development engineer, based on a drainage study that determines the specific location along the drainage route where “no adverse impacts” from the new development exist. Storm drainage from a development must be carried to an "adequate outfall" or "acceptable outfall."

Zone of Influence

A “zone of influence” from a proposed development extends to a point downstream where the discharge from a proposed development no longer has a significant impact upon the receiving stream or storm drainage system. The Zone of Influence for any proposed development must be defined by the development engineer by a drainage study that: (1) determines the extent of the downstream drainage route subject to impacts from a proposed development, and (2) delineates what existing conditions are in place or what proposed mitigation is planned so that “no adverse impacts” from the new development will occur.

A drainage study will include the necessary hydrologic and hydraulic analyses to clearly demonstrate that the limits of the Zone of Influence have been identified, and that along the drainage route to that location, these parameters are met:

- No new or increased flooding of existing insurable (FEMA) structures (habitable buildings),
- No significant (0.1’) increases in flood elevations over existing roadways for the 1-yr, 5-yr, 10-yr, 25-yr and 100-yr floods.
- No significant rise (0.1’ or less) in 100-year flood elevations, unless contained in existing channel, roadway, drainage easement and/or R.O.W.
- Where provisions of the City’s floodplain ordinance may be more restrictive, the floodplain ordinance shall have authority over the above provisions.
- No significant increases (maximum of 5%) in channel velocities for the 1-yr, 5-yr, 10-yr, 25-yr and 100-yr floods. Post-development channel velocities cannot be increased by more than 5% above predevelopment velocities, nor exceed the applicable maximum permissible velocity shown in Table 3.3 in the Hydraulics Technical Manual. Exceptions to these criteria will require certified geotechnical/geomorphologic studies that provide documentation that the higher velocities will not create additional erosion. If existing channel velocities exceed six (6) feet per second, no additional increase in velocities will be allowed.
- No increases in downstream discharges caused by the proposed development that, in combination with existing discharges, exceeds the existing capacity of the downstream storm drainage system.
- For watersheds of 100 acres or less at any proposed outfall, the downstream assessment may use the ten percent rule of thumb (as delineated in Section 2.0 of the Hydrology Technical Manual) or a detailed study in order to determine the Zone of Influence (ZOI).
- For all other watersheds, the ZOI will be defined by a detailed hydrologic & hydraulic analysis.

Local Provisions:
Adequate Outfall
Storm drainage from a development must be carried to an "adequate outfall" or "acceptable outfall." **An adequate outfall is one that does not create adverse flooding or erosion conditions downstream and is, in all cases, subject to the City of Stephenville's approval.**

No development may divert, concentrate, or impound runoff in a manner that damages a downstream property in accordance with Section 11.086 of the Texas Water Code. Discharge of water onto an adjacent property requires an easement or notarized letter of consent from the downstream property owner.

3.4 Streambank Protection

The second focus area is in streambank protection. There are three options by which a developer can provide adequate streambank protection downstream of a proposed development. The first step is to perform the required downstream assessment as described in Section 3.3. If it is determined that the proposed project does not exceed acceptable downstream velocities or the downstream conditions are improved to adequately handle the increased velocity, then no additional streambank protection is required. If on-site or downstream improvements are required for streambank protection, easements or right-of-entry agreements will need to be obtained in accordance with Section 3.7. If the downstream assessment shows that the velocities are within acceptable limits, then no streambank protection is required. Acceptable limits for velocity control are contained in Tables 3.10 and 3.11.

Option 1: Reinforce/Stabilize Downstream Conditions

If the increased velocities are greater than the allowable velocity of the downstream receiving system, then the developer must reinforce/stabilize the downstream conveyance system. The proposed modifications must be designed so that the downstream system is protected from the post-development velocities. The developer must provide supporting calculations and/or documentation that the downstream velocities do not exceed the allowable range once the downstream modifications are installed.

Allowable bank protection methods include stone riprap, gabions, and bio-engineered methods. *Sections 3.2 and 4.0 of the Hydraulics Technical Manual* give design guidance for designing stone riprap for open channels, culvert outfall protection, riprap aprons for erosion protection at outfalls, and riprap basins for energy dissipation.

Local Provisions:

NONE

Option 2: Install Stormwater Controls to Maintain Existing Downstream Conditions

The developer must use on-site controls to keep downstream post-development discharges at or below allowable velocity limits. The developer must provide supporting calculations and/or documentation that the on-site controls will be designed such that downstream velocities for the three storm events (Streambank Protection, Conveyance, and Flood Mitigation) are within an allowable range once the controls are installed.

Local Provisions:
NONE

Option 3: Control the Release of the 1-yr, 24-hour Storm Event

Twenty-four hours of extended detention shall be provided for on-site, post-developed runoff generated by the 1-year, 24-hour rainfall event to protect downstream channels. The required volume for extended detention is referred to as the Streambank Protection Volume (denoted SP_v). The reduction in the frequency and duration of bankfull flows through the controlled release provided by extended detention of the SP_v will reduce the bank scour rate and severity.

To determine the SP_v refer to *Section 3.0 of the Hydrology Technical Manual*.

Local Provisions:
This option protects a stream from increased runoff discharge rates and velocities that tend to occur with development.

3.5 Flood Mitigation

3.5.1 Introduction

Flood analysis is based on the design storm events as defined in Section 1.3: for conveyance storm and the flood mitigation storm.

The intent of the flood mitigation criteria is to provide for public safety; minimize on-site and downstream flood impacts from the three storm events; maintain the boundaries of the mapped 100-year floodplain; and protect the physical integrity of the on-site stormwater controls and the downstream stormwater and flood mitigation facilities.

Flood mitigation must be provided for on-site conveyance system, as well as downstream outfalls as described in the following sections.

3.5.2 Flood Mitigation Design Options

There are three options by which a developer may address downstream flood mitigation. These options closely follow the three options for Streambank Protection. When on-site or downstream modifications are required for downstream flood mitigation, easements or right-of-entry agreements will need to be obtained in accordance with Section 3.7.

The developer will provide all supporting calculations and/or documentation to show that the existing downstream conveyance system has capacity (Q_f) to safely pass the full build-out flood mitigation storm discharge.

Option 1: Provide Adequate Downstream Conveyance Systems

When the downstream receiving system does not have adequate capacity, then the developer shall provide modifications to the off-site, downstream conveyance system. If this option is chosen the proposed modifications must be designed to adequately convey the full build-out stormwater peak discharges for the three storm events. The modifications must also extend to the point at which the discharge from the proposed development no longer has a significant impact on the receiving stream or storm drainage system. The developer must provide supporting calculations and/or documentation that the downstream peak discharges and water surface elevations are safely conveyed by the proposed system, without endangering downstream properties, structures, bridges, roadways, or other facilities.

Option 2: Install Stormwater Controls to Maintain Existing Downstream Conditions

When the downstream receiving system does not have adequate capacity, then the developer shall provide stormwater controls to reduce downstream flood impacts. These controls include on-site controls such as detention, regional controls, and, as a last resort, local flood protection such as levees, floodwalls, floodproofing, etc.

The developer must provide supporting calculations and/or documentation that the controls will be designed and constructed so that there is no increase in downstream peak discharges or water surface elevations due to development.

Option 3: In lieu of a Downstream Assessment, Maintain Existing On-Site Runoff Conditions

Lastly, with Option 3, on-site controls shall be used to maintain the pre-development peak discharges from the site. The developer must provide supporting calculations and/or documentation that the on-site controls will be designed and constructed to maintain on-site existing conditions.

It is important to note that Option 3 does not require a downstream assessment. It is a detention-based approach to addressing downstream flood mitigation after the application of the *integrated* site design practices.

For many developments however, the results of a downstream assessment may show that significantly less flood mitigation is required than "detaining to pre-development conditions". This method may also exacerbate downstream flooding problems due to timing of flows. The developer shall confirm that detention does not exacerbate peak flows in downstream reaches.

3.6 Stormwater Conveyance Systems

3.6.1 Introduction

Stormwater system design is an integral component of both site and overall stormwater management design. Good drainage design must strive to maintain compatibility and minimize interference with existing drainage patterns; control flooding of property, structures, and roadways for design flood events; and minimize potential environmental impacts on stormwater runoff.

Stormwater collection systems must be designed to provide adequate surface drainage while at the same time meeting other stormwater management goals such as water quality, streambank protection, habitat protection, and flood mitigation.

Design

Fully developed watershed conditions shall be used for determining runoff for the conveyance storm and the flood mitigation storm.

Local Provisions: NONE

3.6.2 Hydraulic Design Criteria for Streets and Closed Conduits

Introduction

This section is intended to provide criteria and guidance for the design of on-site flood mitigation system components including:

- Street and roadway gutters
- Stormwater inlets
- Parking lot sheet flow
- Storm drain pipe systems

Streets and Stormwater Inlets

Design Frequency

- Streets and roadway gutters: conveyance storm event
- Inlets on-grade: conveyance storm event
- Parking lots: conveyance storm event
- Storm drain pipe systems: conveyance storm event
- Low points: flood mitigation storm event
- Street ROW: flood mitigation storm event
- Drainage and Floodplain easements: flood mitigation storm event

Local Provisions:

The iSWM Inlet Design Methodology (iSWM Hydraulics Technical Manual) is adopted. Under the City of Stephenville classification system, inlets have been classified into two major groups namely: Inlets in Sumps and Inlets on Grade with Gutter Depression. The only curb inlets that are allowed by the City of Stephenville are those in sumps and depressed inlets on grade. Grate inlets and combination inlets are not allowed.

Figures presented in Chapter 5 can be used to document all closed conduit calculations even if calculations are performed on an acceptable computer program unless otherwise approved by the City.

A "rooftop" section should be used for concrete streets and a parabolic section for asphalt streets. Please note that the nomograph in Figure 1.2 of the iSWM Hydraulics Technical Manual does not completely address cases where the crown elevation is lower that the top of curb elevation. For those cases a combination of Figure 1.2 and 1.3 can be used or a standard hydraulics program such as EPASWMM, HEC-RAS or FlowMaster can be applied.

The design storms presented in the regional portion of Section 1.3 of this document are replaced by the design storms required by the City of Stephenville as follows:

Storm Sewer System

The design storm is a minimum of the 100-year storm for the combination of the closed conduit and surface drainage system.

Runoff from the 5-year storm must be contained within the permissible spread of water in the gutter.

The 100-year storm flow must be contained within the ROW. Adequate inlet capacity shall be provided to intercept surface flows before the street ROW capacity is exceeded.

Note: The capacity of the underground system may be required to exceed the 5-year storm in order to satisfy the 100-year storm criteria.

The closed conduit HGL must be equal to or below the gutter line for pipe systems and one (1) foot or more below the curb line at inlets. For situations where no ROW exists, the 100-year HGL must be below finished ground. The 100-year HGL will be tracked carefully throughout the system and described in the hydraulic calculations tables in Chapter 5 and in the construction drawings.

Inlets in Sumps

Curb opening inlets in sumps (Type CO-S) are addressed in Section 1.2.7 of the Hydraulics Technical Manual. Drop inlets in sumps (Y Inlet) are addressed in Section 1.2.9 of the Hydraulics Technical Manual.

In sag or sump conditions, the storm drain and sump inlets should be sized to intercept and convey a minimum of the 25-year storm and a positive structural overflow is required to provide for the remainder of the 100-year storm. The positive overflow structure must be concrete or other acceptable nonearthen structure with a minimum bottom width of 4 feet extending from the sump inlet to the storm sewer outfall. It must be designed to pass at least 20 cfs with 1 foot of freeboard from the top of curb to the adjacent finish floor elevations (minimum finish floor elevations for all lots adjacent to said overflows must be shown on the plat).

All flumes that pass through sidewalks shall have a bolted-down, rust-proof, 3/8-inch thick (min.) steel plate with a pedestrian-rated walking surface. The plate shall be recessed into the concrete sidewalk from face of curb to the property line. The plate must be secured to the concrete with bolts and flush with the top of sidewalk. A center support maybe added depending on the width of the flume. Fences must be kept behind the curb line of the flume. Where a structural overflow is not feasible, a variance must be requested from the City. If no structural overflow is constructed, the sump inlets must be designed with a 50% clogging factor. In a cul-de-sac where no structural overflow is feasible, additional on-grade inlet capacity may be provided upstream of the sump in lieu of additional sump inlets.

Local Provisions: (Cont.)

Inlets on Grade with Gutter Depression (Type CO-D)
The hydraulic efficiency of storm-water inlets varies with gutter flow, street grade, street crown, and with the geometry of the inlet depression. The design flow into any inlet can be greatly increased if a small amount (5 to 10 percent) of gutter flow is allowed to flow past the inlet. When designing inlets, freedom from clogging or from interference with traffic often takes precedence over hydraulic considerations. See Sections 5.3.1 for computation sheet for Type CO-D inlet.

Recessed depressed inlets should be used on all arterials.

The capacity of a depressed curb inlet on grade will be based on the methodology presented in Section 1.2.7 of the iSWM Hydraulics Technical Manual.

Drop Inlets (Area Drains)

1. Drop inlets serving a drainage area of 10 to 25 acres will be designed with a 50% clogging factor.
2. Grading plans to direct flow into drop inlets will be included in the construction plans. Where earthen swales or other means of collecting and directing runoff into drop inlets are needed, they should be contained in appropriately sized drainage easements.
3. Consideration should be given to a structural overflow in the same manner as described for sump inlets.
4. Drop inlets shall be located where they can be easily accessed for inspection and maintenance by the City.

Headwalls

1. A headwall will be used in lieu of an inlet to collect a drainage area of 25 acres or more flowing to one spot.
2. Areas that have been channelized or discharged from a storm drain system will use a headwall to reintroduce the flow to a new storm drain system. These provisions do not apply to special multistage outlet structures draining detention facilities.

Design Criteria

Streets and ROW

Depth in the street shall not exceed top of curb or maximum flow spread limits for the conveyance storm. The flood mitigation storm shall be contained within the right-of-ways or easements.

Parking Lots

Parking lots shall be designed for the conveyance storm not to exceed top of curb with maximum ponding at low points of one (1) foot. The flood mitigation storm shall be contained on-site or within dedicated easements.

Flow Spread Limits

Inlets shall be spaced so that the spread of flow in the street for the conveyance storm shall not exceed the guidelines listed below, as measured from the gutter or face of the curb:

Table 3.7 Flow Spread Limits

Street Classification	Allowable Encroachment
Collectors, Arterial, and Thoroughfares (greater than 2-lanes)	• 8 feet or one travel lane, both sides for a divided roadway
Residential Streets	• curb depth or maximum 6 inches at gutter

Local Provisions:

Spread of water refers to the amount of water that is allowed to collect in streets during a storm of 5-year design frequency. In order that excess stormwater will not collect in streets or thoroughfares during a storm of the design frequency, the following spread of water values shall be used for the various types of streets.

Arterials (Divided)

1. Permissible Spread of Water - The permissible spread of water in gutters of major divided thoroughfares shall be limited so that one traffic lane on each side remains clear during the 5-year storm.
2. Conditions - Inlets shall preferably be located at street intersections, at low points of grade or where the gutter flow exceeds the permissible spread of water criteria. Inlets shall be located, when possible, on side streets when grades permit. In no cases shall the gutter depression at inlets exceed the standard. In super-elevated sections, inlets placed against the center medians shall have no gutter depression and shall intercept gutter flow at the point of vertical curvature to prevent flow from crossing the thoroughfares on the surface in valley gutters or otherwise.

Arterials (Not Divided)

1. Permissible Spread of Water - The permissible spread of water in gutters of major undivided thoroughfares shall be limited so that two traffic lanes will remain clear during the 5-year storm. The 100-year storm shall be contained within the R.O.W.
2. Conditions - Inlets shall preferably be located at street intersections, low points of grades, or where the gutter flow exceeds the permissible spread of water criteria. Inlets shall be located, when possible, on the side streets when grades permit. In no case shall the gutter depression at inlets exceed the standard.
3. Super-elevated Sections - Intercept gutter flow at points of vertical curve, points of vertical tangency, pointes of vertical intersection (PVC, PVT, PVI) to prevent flow from crossing thoroughfare. Unless expressly approved by the City of Stephenville, stormwater will not be allowed to cross major thoroughfares on the surface in valley gutters or otherwise.

Collector Streets

1. Permissible Spread of Water - The permissible spread of water in gutters of collector streets shall be limited so that one standard lane of traffic will remain clear during the 5-year storm. The 100- year storm shall be contained within the R.O.W.
2. Conditions - Inlets shall preferably be located at street intersections, low points of grade or where the gutter flow exceeds the permissible spread of water criteria. Inlets shall be located, when at all possible, on the side streets when grade permits. Inlets with the standard gutter depression shall be used. In no case shall the gutter depression at inlets exceed the standard.

Local Streets

1. Permissible Spread of Water - The permissible spread of water in gutters for minor streets shall be limited by the height of the curb for 5-year storms. The 100-year storm shall be contained within the R.O.W.
2. Conditions - Inlets shall be located at street intersections, low points of grade or where the gutter flow exceeds the permissible spread of water criteria. Inlets with depressed standard gutter depression shall be used in all cases unless special grading problems are involved. In no case shall the gutter depression at inlets exceed the standard.

Storm Drain Pipe Design

Design Frequency

- Pipe Design: conveyance storm event within pipe with hydraulic grade line (HGL) below throat of inlets
- ROW and Easements: flood mitigation storm event must be contained within the ROW or easement

Local Provisions:

The pipe capacity design frequency is the 100-year, 24 hour storm less any gutter, roadway, and flume flows.

Design Criteria

- For ordinary conditions, storm drain pipes shall be sized on the assumption that they will flow full or practically full under the design discharge but will not be placed under pressure head. The Manning Formula is recommended for capacity calculations.

- The maximum hydraulic gradient shall not produce a velocity that exceeds 15 feet per second (fps). Table 3.8 shows the desirable velocities for most storm drainage design. Storm drains shall be designed to have a minimum mean velocity flowing full at 2.5 fps.

Table 3.8 Desirable Velocity in Storm Drains

Description	Maximum Desirable Velocity
Culverts (All types)	15 fps
Storm Drains (Inlet laterals)	No Limit
Storm Drains (Collectors)	15 fps
Storm Drains (Mains)	12 fps

- The minimum desirable physical slope shall be 0.5% or the slope that will produce a velocity of 2.5 feet per second when the storm sewer is flowing full, whichever is greater.

- If the potential water surface elevation exceeds one (1) foot below ground elevation for the design flow, the top of the pipe, or the gutter flow line, whichever is lowest, adjustments are needed in the system to reduce the elevation of the hydraulic grade line.

- Access manholes are required at intermediate points along straight runs of closed conduits. Table 3.9 gives maximum spacing criteria.

Table 3.9 Access Manhole Spacing Criteria
(HEC 22, 2001)

Pipe Size (inches)	Maximum Spacing (feet)
12-24	300
27-36	400
42-54	500
60 and up	1000

Local Provisions:

Additional or Revised Storm Drain Pipe Design Criteria for the City of Stephenville:

1. Maximum manhole spacing for all pipe sizes is 500 feet unless approved otherwise by the City.
2. The minimum diameter size allowed for storm water lateral pipes is 18 inches.
3. The minimum diameter pipe size allowed for storm water mains is 18 inches.
4. Pipe sizes must not decrease in size in the downstream direction unless approved by the City.
5. When connecting to an existing system, the starting hydraulic gradeline shall be equivalent to the 100-year HGL elevation of the receiving pipe. If the 100-year HGL elevation of the receiving pipe is not available then the starting HGL elevation must start one foot below grade.
6. The 100-year HGL of the pipe system must remain below the throat of the inlet.

Materials
Only reinforced concrete pipe, seamless, jointless HDPE and/or seamless, jointless PVC materials, of acceptable structural integrity as pre-approved by the city, are allowed under pavement for public storm drains. Corrugated metal piping is not allowable and shall not be used in a public storm drain system except where approved by the City for use under private, residential driveways, in which case, the property owner shall be responsible for maintenance, repair or replacement.

3.6.3 Hydraulic Design Criteria for Structures

Introduction

This section is intended to provide design criteria and guidance on several on-site flood mitigation system components, including culverts, bridges, vegetated and lined open channels, storage design, outlet structures, and energy dissipation devices for outlet protection.

Open Channels

Design Frequency

- Open channels, including all natural or structural channels, swales, and ditches shall be designed for the flood mitigation storm event
- Channels shall be designed with multiple stages. A low flow channel section containing the streambank protection flows and a high flow section that contains the conveyance and flood mitigation storms will improve stability and better mimic natural channel dimensions.

Local Provisions:

100-year design storm for fully developed watershed conditions. Channels may be designed with multiple stages (e.g., a “low-flow” or “trickle” channel section for common recurring flows, and a high flow section that contains the design discharge). The “low-flow” or “trickle” channel shall convey 2% of the design 100-year discharge.

Design Criteria

- Trapezoidal channels shall have a minimum channel bottom width of 6 feet.
- Channels with bottom widths greater than 6 feet shall be designed with a minimum bottom cross slope of 12 to 1 or with compound cross sections.
- Channel side slopes shall be stable throughout the entire length and the side slope shall depend on the channel material. Channel side slopes and roadside ditches with a side slope steeper than 3:1 shall require detailed geotechnical and slope stability analysis to justify slopes steeper than 3:1. However, any slope that is less than 3:1 needs a detailed analysis to prove that it can be done.
- Trapezoidal or parabolic cross sections are preferred over triangular shapes.
- For vegetative channels, design stability shall be determined using low vegetative retardance conditions (Class D). For design capacity, higher vegetative retardance conditions (Class C) shall be used.
- For vegetative channels, flow velocities within the channel shall not exceed the maximum permissible velocities given in Tables 3.10 and 3.11.
- If relocation of a stream channel is unavoidable, the cross-sectional shape, meander, pattern, roughness, sediment transport, and slope shall conform to the existing conditions insofar as practicable. Energy dissipation will be necessary when existing conditions cannot be duplicated.
- Streambank stabilization shall be provided, when appropriate, as a result of any stream disturbance such as encroachment and shall include both upstream and downstream banks as well as the local site.
- HEC-RAS, or similarly capable software approved by the entity with jurisdiction, shall be used to confirm the water surface profiles in open channels.
- The final design of artificial open channels shall be consistent with the velocity limitations for the selected channel lining. Maximum velocity values for selected lining categories are presented in Table 3.10. Seeding and mulch shall only be used when the design value does not exceed the allowable value for bare soil. Velocity limitations for vegetative linings are reported in Table 3.11. Vegetative lining calculations and stone riprap procedures are presented in *Section 3.2 of the Hydraulics Technical Manual*.
- For gabions, design velocities range from 10 fps for 6-inch mattresses up to 15 fps for 1-foot mattresses. Some manufacturers indicate that velocities of 20 fps are allowable for basket installations. The design of stable rock riprap lining depends on the intersection of the velocity (local boundary shear) and the size and gradation of the riprap material. More information on calculating acceptable riprap velocity limits is available in *Section 3.2.7 of the Hydraulics Technical Manual*.

Local Provisions: General Criteria

Earthen Channels

1. An earthen channel shall have a trapezoidal shape with side slopes not steeper than a 4:1 ratio and a channel bottom at least four (4) feet in width for ease of maintenance.
2. One (1) foot of freeboard above the 100-year frequency ultimate development water surface elevation must be available within all designed channels at all locations along the channel.
3. The side slopes and bottom of an earthen channel shall be smooth, free of rocks, and contain a minimum of six (6) inches of topsoil. The side slopes and channel bottom shall be re-vegetated with grass. Publicly dedicated channels may be accepted for maintenance only when a uniform (e.g., evenly distributed, without large bare areas) vegetative cover with a density of 70% has been established.
4. The City may require channels to have a ramp(s) for maintenance access. Ramps shall be at least ten (10) feet wide and have 15% maximum grade. Twelve-foot (12') channel width is required if a ramp is deemed necessary by the City.
5. Minimum channel slope is 0.0020 ft/ft unless approved by the City.
6. Erosion protection to be provided at all outfalls to the receiving stream.

Lined Channels

1. Channels shall be trapezoidal in shape and lined with reinforced concrete in accordance with City Standards and Specifications with maximum side slopes of two (2) foot horizontal to one (1) foot vertical or otherwise to such standards, shape and type of lining as may be approved by the City. The lining shall extend to and include the water surface elevation of the 100 year design storm plus one foot of freeboard above the 100 year water surface elevation.
2. The channel bottom must be a minimum of four (4) feet in width.
3. Whenever flow changes from supercritical to subcritical, channel protection shall be provided to protect from the hydraulic jump that is anticipated (see comment in Item 3).
4. The design of the channel lining shall take into account the superelevation of the water surface around curves and other changes in direction.
5. A chain link fence six (6) feet in height or other approved fence, with access gates for maintenance, may be required by the City and shall be constructed on each side of the concrete or gabion channel lining.
6. The City may require a geotechnical analysis and /or an underground drainage system design for concrete lined channels.

Local Provisions: General Criteria (Cont.)

Roadside Ditches

Design Storms

1. A roadside ditch ("rural") street section is permissible only as specifically approved by the City.
2. Median ditches will not be permitted.
3. The design storm for roadside ditches shall be the 100-year storm. The 100-year flow shall not exceed the right-of-way capacity defined as the natural ground at the right-of-way line or top of roadside ditch.

Design Considerations

1. For grass lined sections, the maximum design velocity shall be 6.0 feet per second during the 100-year design storm (Higher velocities shall justified by a sealed geotechnical analysis).
2. A grass lined or unimproved roadside ditch shall have minimum 2 foot bottom width and side slopes no steeper than four horizontal to one vertical. There shall be a minimum four-foot wide area at a maximum 2% cross slope between the edge of pavement and the beginning of the ditch.
3. Minimum grades for roadside ditches shall be 0.0050 foot/foot (0.50%).
4. Manning's roughness coefficient for analysis and design of roadside ditches are presented in Section 3.2.3 in the iSWM Hydraulics Technical Manual.
5. Erosion protection will be provided at the upstream and downstream ends of all culverts.
6. Maximum depth will not exceed 4 feet from center-line of pavement except as specifically approved by the City.
7. If the ditch extends beyond the right-of-way line, an additional drainage easement shall be dedicated extending at least 2 feet beyond the top of bank. Utility easements must be separate and beyond any drainage easements.

Culverts in Roadside Ditches

1. Culverts will be placed at all driveway and roadway crossings and other locations where appropriate.
2. Erosion protection will be provided at all driveway and roadway crossings and other locations where appropriate.
3. Roadside culverts are to be sized based on drainage area, assuming inlet control. Drainage calculations shall be provided for each block. The size of culvert used shall not create a head loss of more than 0.20 feet greater than the normal water surface profile without the culvert.
4. Roadside ditch culverts will be no smaller than 24 inches inside diameter or equivalent for roadway crossings and 18 inches for driveway culverts.
5. A driveway culvert schedule shall be included on the face of the plat. It shall include for each lot approximate culvert flowline depth below top of pavement, number and size of pipe(s) required, and horizontal distance from edge of pavement to center of culvert (based on horizontal control requirements above).

Table 3.10 Roughness Coefficients (Manning's n) and Allowable Velocities for Natural Channels

Channel Description	Manning's n	Max. Permissible Channel Velocity (ft/s)
MINOR NATURAL STREAMS		
Fairly regular section		
1. Some grass and weeds, little or no brush	0.030	3 to 6
2. Dense growth of weeds, depth of flow materially greater than weed height	0.035	3 to 6
3. Some weeds, light brush on banks	0.035	3 to 6
4. Some weeds, heavy brush on banks	0.050	3 to 6
5. Some weeds, dense willows on banks	0.060	3 to 6
For trees within channels with branches submerged at high stage, increase above values by	0.010	
Irregular section with pools, slight channel meander, increase above values by	0.010	
Floodplain – Pasture		
1. Short grass	0.030	3 to 6
2. Tall grass	0.035	3 to 6
Floodplain – Cultivated Areas		
1. No crop	0.030	3 to 6
2. Mature row crops	0.035	3 to 6
3. Mature field crops	0.040	3 to 6
Floodplain – Uncleared		
1. Heavy weeds scattered brush	0.050	3 to 6
2. Wooded	0.120	3 to 6
MAJOR NATURAL STREAMS		
Roughness coefficient is usually less than for minor streams of similar description on account of less effective resistance offered by irregular banks or vegetation on banks. Values of "n" for larger streams of mostly regular sections, with no boulders or brush	Range from 0.028 to 0.060	3 to 6
UNLINED VEGETATED CHANNELS		
Clays (Bermuda Grass)	0.035	5 to 6
Sandy and Silty Soils (Bermuda Grass)	0.035	3 to 5
UNLINED NON-VEGETATED CHANNELS		
Sandy Soils	0.030	1.5 to 2.5
Silts	0.030	0.7 to 1.5
Sandy Silts	0.030	2.5 to 3.0
Clays	0.030	3.0 to 5.0
Coarse Gravels	0.030	5.0 to 6.0
Shale	0.030	6.0 to 10.0
Rock	0.025	15
For natural channels with specific vegetation type, refer to Table 3.11 for more detailed velocity control.		

Table 3.11 Maximum Velocities for Vegetative Channel Linings		
Vegetation Type	**Slope Range (%)[1]**	**Maximum Velocity[2] (ft/s)**
Bermuda grass	0-5	6
Bahia		4
Tall fescue grass mixtures[3]	0-10	4
Kentucky bluegrass	0-5	6
Buffalo grass	5-10 >10	5 4
Grass mixture	0-5[1] 5-10	4 3
Sericea lespedeza, Weeping lovegrass, Alfalfa	0-5[4]	3
Annuals[5]	0-5	3
Sod		4
Lapped sod		5

[1] Do not use on slopes steeper than 10% except for side-slope in combination channel.
[2] Use velocities exceeding 5 ft/s only where good stands can be maintained.
[3] Mixtures of Tall Fescue, Bahia, and/or Bermuda
[4] Do not use on slopes steeper than 5% except for side-slope in combination channel.
[5] Annuals - used on mild slopes or as temporary protection until permanent covers are established.

Source: Manual for Erosion and Sediment Control in Georgia, 1996.

Vegetative Design

- A two-part procedure is required for final design of temporary and vegetative channel linings.
  - Part 1, the design stability component, involves determining channel dimensions for low vegetative retardance conditions, using Class D as defined in Table 3.12.
  - Part 2, the design capacity component, involves determining the depth increase necessary to maintain capacity for higher vegetative retardance conditions, using Class C as defined in Table 3.12.

If temporary lining is to be used during construction, vegetative retardance Class E shall be used for the design stability calculations.

- If the channel slope exceeds 10%, or a combination of channel linings will be used, additional procedures not presented below are required. References include HEC-15 (USDOT, FHWA, 1986) and HEC-14 (USDOT, FHWA, 1983).

Local Provisions:

For Reference Only

Table 3.12 Classification of Vegetal Covers as to Degrees of Retardance		
Retardance Class	**Cover**	**Condition**
A	Weeping Lovegrass	Excellent stand, tall (average 30")
	Yellow Bluestem Ischaemum	Excellent stand, tall (average 36")
B	Kudzu	Very dense growth, uncut
	Bermuda grass	Good stand, tall (average 12”)
	Native grass mixture Little bluestem, bluestem, blue gamma other short and long stem Midwest grasses	Good stand, unmowed
	Weeping lovegrass	Good stand, tall (average 24”)
	Laspedeza sericea	Good stand, not woody, tall (average 19”)
	Alfalfa	Good stand, uncut (average 11”)
	Weeping lovegrass	Good stand, unmowed (average 13”)
	Kudzu	Dense growth, uncut
	Blue gamma	Good stand, uncut (average 13”)
C	Crabgrass	Fair stand, uncut (10 – 48”)
	Bermuda grass	Good stand, mowed (average 6”)
	Common lespedeza	Good stand, uncut (average 11”)
	Grass-legume mixture: summer (orchard grass redtop, Italian ryegrass, and common lespedeza)	Good stand, uncut (6 – 8 “)
	Centipede grass	Very dense cover (average 6”)
	Kentucky bluegrass	Good stand, headed (6 – 12”)
D	Bermuda grass	Good stand, cut to 2.5”
	Common lespedeza	Excellent stand, uncut (average 4.5”)
	Buffalo grass	Good stand, uncut (3 – 6”)
	Grass-legume mixture: fall, spring (orchard grass, redtop, Italian ryegrass, and common lespedeza)	Good stand, uncut (4 – 5”)
	Lespedeza serices	After cutting to 2” (very good before cutting)
E	Bermuda grass	Good stand, cut to 1.5”
	Bermuda grass	Burned stubble

Note: Covers classified have been tested in experimental channels. Covers were green and generally uniform.
Source: HEC-15, 1988.

Culverts

Design Frequency

Culverts are cross drainage facilities that transport runoff under roadways or other improved areas.

- Culverts shall be designed for the flood mitigation storm or in accordance with TxDOT requirements, whichever is more stringent. Consideration when designing culverts includes: roadway type, tailwater or depth of flow, structures, and property subject to flooding, emergency access, and road replacement costs.
- The flood mitigation storm shall be routed through all culverts to be sure building structures (e.g., houses, commercial buildings) are not flooded or increased damage does not occur to the highway or adjacent property for this design event.

Local Provisions:

The design storm event for culverts is the 100-year, 24 hour Flood Mitigation storm event for fully developed watershed conditions.

Multiple barrel culverts are acceptable with the placement of one barrel at the flowline of the stream and the other barrels set at a higher elevation to encourage a single flow path for lower flow and reduce sediment and debris accumulation. Where practical, the low-flow portion of the low barrel(s) should convey 2% of the designed 100-year discharge.

Design Criteria

Velocity Limitations

- The maximum velocity shall be consistent with channel stability requirements at the culvert outlet.
- The maximum allowable velocity for corrugated metal pipe is 15 feet per second. There is no specified maximum allowable velocity for reinforced concrete pipe, but outlet protection shall be provided where discharge velocities will cause erosion conditions.
- To ensure self-cleaning during partial depth flow, a minimum velocity of 2.5 feet per second is required for the streambank protection storm when the culvert is flowing partially full.

Length and Slope

- The maximum slope using concrete pipe is 10% and for CMP is 14% before pipe-restraining methods must be taken.
- Maximum vertical distance from throat of intake to flowline in a drainage structure is 10 feet.
- Drops greater than 4 feet will require additional structural design.

Headwater Limitations

- The *allowable headwater* is the depth of water that can be ponded at the upstream end of the culvert during the design flood, which will be limited by one or more of the following constraints or conditions:
    1. Headwater will be non-damaging to upstream property.
    2. Culvert headwater plus 12 inches of freeboard shall not exceed top of curb or pavement for low point of road over culvert, whichever is lower.
    3. Ponding depth will be no greater than the elevation where flow diverts around the culvert.
    4. Elevations will be established to delineate floodplain zoning.
- The headwater shall be checked for the flood mitigation storm elevation to ensure compliance with flood plain management criteria and the culvert shall be sized to maintain flood-free conditions on major thoroughfares with 12-inch freeboard at the low-point of the road.
- Either the headwater shall be set to produce acceptable velocities or stabilization/energy dissipation shall be provided where these velocities are exceeded.

- In general, the constraint that gives the lowest allowable headwater elevation establishes the criteria for the hydraulic calculations.

Tailwater Considerations

- If the culvert outlet is operating with a free outfall, the critical depth and equivalent hydraulic grade line shall be determined.
- For culverts that discharge to an open channel, the stage-discharge curve for the channel must be determined. See *Section 2.1.4 of the Hydraulics Technical Manual* on methods to determine a stage-discharge curve.
- 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.
- If the culvert discharges to a lake, pond, or other major water body, the expected high water elevation of the particular water body will establish the culvert tailwater.

Other Criteria

- In designing debris control structures, the Hydraulic Engineering Circular No. 9 entitled *Debris Control Structures* or other approved reference is required to be used.
- If storage is being assumed or will occur upstream of the culvert, refer to *Section 2.0 of the Hydraulics Technical Manual* regarding storage routing as part of the culvert design.
- Reinforced concrete pipe (RCP), pre-cast and cast in place concrete boxes are recommended for use (1) under a roadway, (2) when pipe slopes are less than 1%, or (3) for all flowing streams. RCP and fully coated corrugated metal pipe or high-density polyethylene (HDPE) pipe may also be used in open space areas.
- Culvert skews shall not exceed 45 degrees as measured from a line perpendicular to the roadway centerline without approval.
- The minimum allowable pipe diameter shall be 18 inches.
- Erosion, sediment control, and velocity dissipation shall be designed in accordance with *Section 4.0 of the Hydraulics Technical Manual*.

Local Provisions: NONE

Bridges

Design Frequency

Bridges are cross drainage facilities with a span of 20 feet or larger.

- Flood mitigation storm for all bridges

Local Provisions:
The design storm event for bridges is the 100-year, 24 hour Flood Mitigation storm event for fully developed watershed conditions.

Design Criteria

- A freeboard of two feet shall be maintained between the computed design water surface and the low chord of all bridges.
- The contraction and expansion of water through the bridge opening creates hydraulic losses. These losses are accounted for through the use of loss coefficients. Table 3.13 gives recommended values for the Contraction (K_c) and Expansion (K_e) Coefficients.

Table 3.13 Recommended Loss Coefficients for Bridges

Transition Type	Contraction (K_c)	Expansion (K_e)
No losses computed	0.0	0.0
Gradual transition	0.1	0.3
Typical bridge	0.3	0.5
Severe transition	0.6	0.8

Additional design guidance is located in *Section 3.4 of the Hydraulics Technical Manual*.

Local Provisions: NONE

Detention Structures

Design Frequency

Detention structures shall be designed for the three storms (streambank protection, conveyance, and flood mitigation storms) for the critical storm duration that results in the maximum (or near maximum) peak flow.

Local Provisions:

Design frequencies of 1-yr, 5-yr, 10-yr, 25-yr and 100-yr storms for the critical storm duration (i.e. 3 hour, 6 hour or 24 hour duration) that results in the maximum (or near maximum) peak flow shall be used. Analysis should consider both existing watershed plus developed site conditions and fully developed watershed conditions.

Design Criteria

- Dry detention basins are sized to temporarily store the volume of runoff required to provide flood protection up to the flood mitigation storm, if required.
- Extended detention dry basins are sized to provide extended detention of the streambank protection volume over 24 hours and can also provide additional storage volume for normal detention (peak flow reduction) of the flood mitigation storm event.
- Routing calculations must be used to demonstrate that the storage volume and outlet structure configuration are adequate. See *Section 2.0 of the Hydraulics Technical Manual* for procedures on the design of detention storage.
- Detention Basins shall be designed with an 8 foot wide maintenance access.
- No earthen (grassed) embankment slopes shall exceed 4:1.
- A freeboard of 1 foot will be required for all detention ponds.
- A calculation summary shall be provided on construction plans. For detailed calculations of unit hydrograph studies, a separate report shall be provided to the municipality for review and referenced on the construction plans. Stage-storage-discharge values shall be tabulated and flow calculations for discharge structures shall be shown on the construction plans.
- An emergency spillway shall be provided at the flood mitigation maximum storage elevation with sufficient capacity to convey the flood mitigation storm assuming blockage of the outlet works with six inches of freeboard. Spillway requirements must also meet all appropriate state and Federal criteria.
- A landscape plan shall be provided for all detention ponds.
- All detention basins shall be stabilized against significant erosion and include a maintenance plan.
- Design calculations will be provided for all spillways and outlet structures.
- Maintenance agreements shall be included for all detention structures.
- Storage may be subject to the requirements of the Texas Dam Safety Program (see iSWM Program Guidance) based on the volume, dam height, and level of hazard.
- Earthen embankments 6 feet in height or greater shall be designed per Texas Commission on Environmental Quality guidelines for dam safety (see iSWM Program Guidance).
- Vegetated slopes shall be less than 20 feet in height and shall have side slopes no steeper than 2:1 (horizontal to vertical) although 3:1 is preferred. Riprap-protected slopes shall be no steeper than 2:1. Geotechnical slope stability analysis is recommended for slopes greater than 10 feet in height. Vegetated slopes with a side slope steeper than 2:1 shall require detailed geotechnical and slope stability analysis to justify slopes steeper than 2:1.
- Areas above the normal high water elevations of the detention facility should be sloped toward the basin to allow drainage and to prevent standing water. Careful finish grading is required to avoid creation of upland surface depressions that may retain runoff. The bottom area of storage facilities should be graded toward the outlet to prevent standing water conditions. A low flow or pilot channel across the facility bottom from the inlet to the outlet (often constructed with riprap) is recommended to convey low flows and prevent standing water conditions.

Local Provisions: NONE

Outlet Structures

Extended detention (ED) orifice sizing is required in design applications that provide extended detention for downstream streambank protection or the ED portion of the water quality protection volume. The release rate for both the WQ_v and SP_v shall discharge the ED volume in a period of 24 hours or longer. In both cases an extended detention orifice or reverse slope pipe must be used for the outlet. For a structural control facility providing both WQ_v extended detention and SP_v control (wet ED pond, micropool ED pond, and shallow ED wetland), there will be a need to design two outlet orifices – one for the water quality control outlet and one for the streambank protection drawdown.

Design Frequency

Water quality storm
Streambank protection storm
Conveyance storm
Flood mitigation storm

Local Provisions: The multiple design storm events for outfall structures include the 1-year, 5-year, 10-year, 25-year, and 100-year, 24 hour storm events.

Design Criteria

- Estimate the required storage volumes for water quality protection, streambank protection, conveyance storm, and flood mitigation.
- Design extended detention outlets for each storm event.
- Outlet velocities shall be within the maximum allowable range based on channel material as shown in Tables 3.10 and 3.11.
- Design necessary outlet protection and energy dissipation facilities to avoid erosion problems downstream from outlet devices and emergency spillway(s).
- Perform buoyancy calculations for the outlet structure and footing. Flotation will occur when the weight of the structure is less than or equal to the buoyant force exerted by the water.

Additional design guidance is located in *Section 2.2 of the Hydraulics Technical Manual*.

Local Provisions: NONE

Energy Dissipation

Design Frequency

All drainage system outlets, whether for closed conduits, culverts, bridges, open channels, or storage facilities, shall provide energy dissipation to protect the receiving drainage element from erosion.

- Conveyance storm
- Flood mitigation storm

Local Provisions: NONE

Design Criteria

- *Energy dissipaters* are engineered devices such as rip-rap aprons or concrete baffles placed at the outlet of storm water conveyance systems for the purpose of reducing the velocity, energy and turbulence of the discharged flow.
- Erosion problems at culvert, pipe and engineered channel outlets are common. Determination of the flow conditions, scour potential, and channel erosion resistance shall be standard procedure for all designs.
- Energy dissipaters shall be employed whenever the velocity of flows leaving a stormwater management facility exceeds the erosion velocity of the downstream area channel system.
- Energy dissipater designs will vary based on discharge specifics and tailwater conditions.
- Outlet structures shall provide uniform redistribution or spreading of the flow without excessive separation and turbulence.
- Energy dissipaters are a required component of the *i*SWM Construction Plan.

Recommended Energy Dissipaters for outlet protection include the following:

- Riprap apron
- Riprap outlet basins
- Baffled outlets
- Grade Control Structures

The reader is referred to *Section 4.0 of the Hydraulics Technical Manual* and the Federal Highway Administration Hydraulic Engineering Circular No. 14 entitled, Hydraulic Design of Energy Dissipaters for Culverts and Channels, for the design procedures of other energy dissipaters.

Additional design guidance is located in *Section 4.0 of the Hydraulics Technical Manual.*

Local Provisions: NONE

3.7 Easements, Plats, and Maintenance Agreements

Easements

Easements are required for all drainage systems that convey stormwater runoff across a development and must include sufficient area for operation and maintenance of the drainage system. Types of easements to be used include:

- Drainage easements - are required for both on-site and off-site public storm drains and for improved channels designed according to current municipality standards.
- Floodplain easements - shall be provided on-site along drainageways that are in a Special Flood Hazard Area as designated on the effective FEMA FIRM maps. No construction shall be allowed within a floodplain easement without the written approval of the municipality.
- Temporary drainage easements are required off-site for temporary channels when future off-site development is anticipated to be enclosed underground or follows an altered alignment. Temporary drainage easements will not be maintained by the municipality and will not terminate until permanent drainage improvements meeting municipality standards are installed and accepted. Temporary drainage easements will require written approval from the municipality.
- Drainage and utility easements can be combined for underground storm drains and channels, subject to adequate easement width as approved by the municipality.
- Drainage easements shall include adequate width for access and maintenance beyond the top of bank for improved channels.
- Retaining walls are not permitted within or adjacent to a drainage easement in a residential area in order to reduce the easement width. Retaining walls adjacent to the channel are allowed in non-residential areas only if the property owner provides an agreement for private maintenance.
- The minimum finished floor elevation for structures adjacent to a Special Flood Hazard Area shall be a minimum of one (1) foot above the fully-developed flood mitigation storm water surface elevation or two (2) feet above the effective FEMA base flood elevation.
- Improved channels shall have drainage easements dedicated to meet the requirements of the width of the channel, the one-foot freeboard, any perimeter fencing, and any underground tie-backs or anchors.
- Easements for detention ponds and permanent control BMPs shall be negotiated between the municipality and the property owner.
- 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 (including motorcycles).

Minimum easement width requirements for storm drain pipe are shown in Table 3.14 and shall be as follows:

- The outside face of the proposed storm drain line shall be placed five (5) feet off either edge of the storm drain easement. The proposed centerline of overflow swales shall normally coincide with the centerline of the easement.
- For pipe sizes up to 54”, a minimum of five (5) additional feet shall be dedicated when shared with utilities.
- Box culvert minimum easement width shall be determined using Table 3.14 based on an equivalent box culvert width to pipe diameter.
- For parallel storm drain systems with a combined width greater than 8 feet the minimum easement shall be equal to the width of the parallel storm drain system plus twenty (20) additional feet.

- Drainage easements will generally extend at least twenty-five (25) feet past an outfall headwall to provide an area for maintenance operations. Drainage easements along a required outfall channel or ditch shall be provided until the flowline reaches an acceptable outfall. The minimum storm drain shall not be on property line, except where a variance has been granted.

Table 3.14 Closed Conduit Easements

Pipe Size	Minimum Easement Width Required
39” and under	15 Feet
42” through 54”	20 Feet
60” through 66”	25 Feet
72” through 102”	30 Feet

Local Provisions:

Additional Easement Criteria:

1. The City of Stephenville does not have a fully-developed floodplain model. Therefore, the minimum finished floor elevation for structures adjacent to a Special Flood Hazard Area shall be a minimum of twelve inches (12”) above the effective FEMA base flood elevation. The engineer also has the option to complete an analysis and determine a fully-developed floodplain model in lieu of using a finished floor with a minimum of twelve inches (12”) above the effective FEMA base flood elevation.
2. A private drainage easement is required when a detention pond is constructed to collect runoff from more than one lot. Other private drainage easement requirements will be at the discretion of the City Engineer on a case-by-case basis to match the unique characteristics of each development.
3. Private drainage easements must be filed by separate instrument and are not considered to be part of the plat. The plat shall include the recording number of the private drainage easement if applicable.
4. **All residential lots must drain to an abutting street, easement, right-of-way, and/or alley.**
   a. **Lot-to-lot drainage plans will not be permitted unless in an approved easement.**
   b. Any exceptions or variations to this rule must be approved by the Director of Public Works.

Easements for Open Channels and Detention Ponds:

1. Drainage easements 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. (Public Water).
2. Drainage easements shall include a buffer of ten feet (10’) in width on both sides beyond actual top of bank for improved earthen channels. The buffer shall be part of the floodplain easement itself and not a separate easement.
3. Retaining walls are not permitted within or adjacent to a drainage easement in a residential area in order to reduce the easement width. Retaining walls adjacent to the channel are allowed in nonresidential areas only if the property owner provides an agreement for private maintenance.
4. Floodplain easements shall be provided on sites along natural or improved earthen drainageways (other than standard engineered channels); to encompass the ultimate developed 100-year floodplain plus a buffer of ten feet (10’) in width on either side. The buffer shall be part of the floodplain easement itself and not a separate easement. Floodplain easements are not routinely maintained by the City.
5. Natural creeks shall have a dedicated floodplain easement containing the inundation area of a 100 year frequency storm based on ultimate developed conditions, plus a ten-foot wide buffer horizontally adjacent to the inundation area. The developer’s engineer shall provide calculations to support the location of the inundation area along the creek, if unknown, prior to development. The ultimate condition may be estimated by adding twelve inches (12”) to the Base Flood Elevation.
6. Concrete Lined Channels and Gabion Lined Channels shall have drainage easements dedicated to meet the requirements of the width of the channel and a minimum of one-foot of freeboard. Additionally, fencing may be required by the City.

Local Provisions: (Cont.)

7. Private drainage easements, not dedicated to the City, may be required for private stormwater drainage improvements serving single lots, multiple lots or for stormwater controls on a property.
8. Access easements shall be provided for access to public stormwater drainage improvements where necessary for maintenance.
9. Dam easements shall be provided, to encompass any proposed dams (including any dams already existing or modifications to existing dams) and spillway structures. The 100-year water surface of any impounded lake shall be covered by a floodplain easement as described above. Dams and spillways shall comply with applicable local and state regulations.
10. No construction shall be allowed within a floodplain easement without the written approval (floodplain permit) of the City of Stephenville, and then only after detailed engineering plans and studies are submitted to the City by the developer to show that no flooding will result, and that no obstruction to the natural flow of water will result.
11. Any parallel utility easements must be separate and outside of drainage easements for channels.
12. Drainage and utility easements may be combined for underground storm drains, subject to the easement width requirements provided in this section and Table 3.14.
13. Easements for stormwater controls including detention basins, sediment traps and retention ponds, shall be negotiated between the City and the Property Owner, but will normally include essential access to all embankment areas and inlet and outlet controls.
14. 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 (including ATV's and motorcycles).
15. Drainage easements for structural overflows, swales, or berms shall be of sufficient width to encompass the structure or graded areas.

Plats

All platting shall follow established development standards established by the local municipality. Plats shall include pertinent drainage information that will be filed with the plat. Elements to be included on the plat include:

- All public and private drainage easements not recorded by separate instrument
- Easements to be recorded by separate instrument shall be documented on the plat
- All floodplain easements
- Legal disclosure for drainage provisions upon sale or transfer of property
- Documentation of maintenance responsibilities and agreements including transfer of responsibility upon sale of the property

Local Provisions: NONE

Maintenance Agreements and Plans

All drainage improvements and permanent structural controls constructed within a development and any existing or natural drainage systems to remain in use shall require a maintenance agreement and plan that identifies responsible parties, required maintenance activities, and frequency of inspections. Both private and public maintenance responsibility shall be negotiated between the municipality and the owner and documented in the agreement. The maintenance agreement and plan shall be written such that it remains in force upon sale or transfer of the property and must be filed in the real property records of the county in which the property is located. Documentation of required inspections and maintenance activities must be retained on site and made available for review.

Local Provisions:

1. Drainage improvements constructed and installed by private developers shall remain the responsibility of the developer to operate and maintain unless or until the private improvement is dedicated to and accepted by the City. Acceptance for maintenance of drainage facilities will be as shown on the approved plans on a case-by-case basis.

2. Access shall be provided by the developer/owner to all private drainage facilities where there may be a public safety concern for inspection by the City.

3.8 Stormwater Control Selection

3.8.1 Control Screening Process

Outlined below is a screening process for structural stormwater controls that can effectively treat the water quality volume, as well as provide water quantity control. This process is intended to assist the site designer and design engineer in the selection of the most appropriate structural controls for a development site and to provide guidance on factors to consider in their location. This information is also contained in the *Site Development Controls Technical Manual*.

The following four criteria shall be evaluated in order to select the appropriate structural control(s) or group of controls for a development:

- Stormwater treatment suitability
- Water quality performance
- Site applicability
- Implementation considerations

In addition, the following factors shall be considered for a given site and any specific design criteria or restrictions need to be evaluated:

- Physiographic factors
- Soils
- Special watershed or stream considerations

Finally, environmental regulations shall be considered as they may influence the location of a structural control on site or may require a permit.

The following steps provide a selection process for comparing and evaluating various structural stormwater controls using a screening matrix and a list of location and permitting factors. These tools are provided to assist the design engineer in selecting the subset of structural controls that will meet the stormwater management and design objectives for a development site or project.

Step 1 Overall Applicability

The following are the details of the various screening categories and individual characteristics used to evaluate the structural controls.

Table 3.15 - Stormwater Management Suitability

The first category in the matrix examines the capability of each structural control option to provide water quality treatment, downstream streambank protection, and flood control. A blank entry means that the structural control cannot or is not typically used to meet an *integrated* Focus Area. This does not necessarily mean that it should be eliminated from consideration, but rather it is a reminder that more than one structural control may be needed at a site (e.g., a bioretention area used in conjunction with dry detention storage).

> *Ability to treat the Water Quality Volume (WQ_v):* This indicates whether a structural control provides treatment of the water quality volume (WQ_v). The presence of “P” or “S” indicates whether the control is a Primary or Secondary control, respectively, for meeting the TSS reduction goal.

Ability to provide Streambank Protection (SP_v): This indicates whether the structural control can be used to provide the extended detention of the streambank protection volume (SP_v). The presence of a "P" indicates that the structural control can be used to meet SP_v requirements. An "S" indicates that the structural control may be sized to provide streambank protection in certain situations, for instance on small sites.

Ability to provide Flood Control (Q_f): This indicates whether a structural control can be used to meet the flood control criteria. The presence of a "P" indicates that the structural control can be used to provide peak reduction of the flood mitigation storm event.

Table 3.16 - Relative Water Quality Performance

The second category of the matrix provides an overview of the pollutant removal performance for each structural control option when designed, constructed, and maintained according to the criteria and specifications in this manual.

Ability to provide TSS and Sediment Removal: This column indicates the capability of a structural control to remove sediment in runoff. All of the Primary structural controls are presumed to remove 70% to 80% of the average annual TSS load in typical urban post-development runoff (and a proportional removal of other pollutants).

Ability to provide Nutrient Treatment: This column indicates the capability of a structural control to remove the nutrients nitrogen and phosphorus in runoff, which may be of particular concern with certain downstream receiving waters.

Ability to provide Bacteria Removal: This column indicates the capability of a structural control to remove bacteria in runoff. This capability may be of particular concern when meeting regulatory water quality criteria under the Total Maximum Daily Load (TMDL) program.

Ability to accept Hotspot Runoff: This last column indicates the capability of a structural control to treat runoff from designated hotspots. Hotspots are land uses or activities that produce higher concentrations of trace metals, hydrocarbons, or other priority pollutants. Examples of hotspots might include: gas stations, convenience stores, marinas, public works storage areas, garbage transfer facilities, material storage sites, vehicle service and maintenance areas, commercial nurseries, vehicle washing/steam cleaning, landfills, construction sites, industrial sites, industrial rooftops, and auto salvage or recycling facilities. A check mark indicates that the structural control may be used on hotspot site. However, it may have specific design restrictions. Please see the specific design criteria of the structural control for more details in the *Site Development Controls Technical Manual*. Local jurisdictions may have other site uses that they designate as hotspots. Therefore, their criteria should be checked as well.

Table 3.17 - Site Applicability

The third category of the matrix provides an overview of the specific site conditions or criteria that must be met for a particular structural control to be suitable. In some cases, these values are recommended values or limits and can be exceeded or reduced with proper design or depending on specific circumstances. Please see the specific criteria section of the structural control for more details.

Drainage Area: This column indicates the approximate minimum or maximum drainage area considered suitable for the structural control practice. If the drainage area present at a site is slightly greater than the maximum allowable drainage area for a practice, some leeway can be permitted if more than one practice can be installed. The minimum drainage areas indicated for ponds and wetlands should not be considered inflexible limits and may be increased or decreased depending on water availability (baseflow or groundwater), the mechanisms employed to prevent outlet clogging, or design variations used to maintain a permanent pool (e.g., liners).

Space Required (Space Consumed): This comparative index expresses how much space a structural control typically consumes at a site in terms of the approximate area required as a percentage of the impervious area draining to the control.

Slope: This column evaluates the effect of slope on the structural control practice. Specifically, the slope restrictions refer to how flat the area where the facility is installed must be and/or how steep the contributing drainage area or flow length can be.

Minimum Head: This column provides an estimate of the minimum elevation difference needed at a site (from the inflow to the outflow) to allow for gravity operation within the structural control.

Water Table: This column indicates the minimum depth to the seasonally high water table from the bottom or floor of a structural control.

Table 3.18 - Implementation Considerations

The fourth category in the matrix provides additional considerations for the applicability of each structural control option.

Residential Subdivision Use: This column identifies whether or not a structural control is suitable for typical residential subdivision development (not including high-density or ultra-urban areas).

Ultra-Urban: This column identifies those structural controls appropriate for use in very high-density (ultra-urban) areas, or areas where space is a premium.

Construction Cost: The structural controls are ranked according to their relative construction cost per impervious acre treated, as determined from cost surveys.

Maintenance: This column assesses the relative maintenance effort needed for a structural stormwater control, in terms of three criteria: frequency of scheduled maintenance, chronic maintenance problems (such as clogging), and reported failure rates. It should be noted that **all structural controls** require routine inspection and maintenance.

Local Provisions:

The Site Development Controls iSWM Technical Manual contains an exhaustive discussion and detailed examples of stormwater controls that can be implemented in land development to meet the goals of protecting water quality, minimizing streambank erosion, and reducing flood volumes. It should be viewed as a planning and design resource document with valuable design examples that the City of Stephenville encourages local developers to consider in site planning. Although it is primarily oriented toward water quality issues, these stormwater controls bring additional and valuable benefits for flood control and streambank protection.

Many of the listed stormwater control features and techniques enhance the aesthetics and value of land developments, as well as provide a drainage function.

The City of Stephenville is currently emphasizing, but not requiring, the streambank protection and flood control components of the integrated stormwater management approach, the Stormwater Control Section (Section 3.8), of applicable features that may be implemented in local developments and redevelopments.

The City of Stephenville does not mandate the use of any of these stormwater controls, but recognizes the inherent values of their application in overall stormwater management.

The design guidance and technical reference sections of the iSWM Technical Manual are adopted. There are, however, at this time, no City of Stephenville requirements for achieving Stormwater Quality or Channel Protection volumes.

Table 3.15 Stormwater Treatment Suitability

Category	*integrated* Stormwater Controls	Stormwater Treatment Suitability			
		Water Quality Protection	Streambank Protection	On-Site Flood Control	Downstream Flood Control
Bioretention Areas	Bioretention Areas	P	S	S	-
Channels	Enhanced Swales	P	S	S	S
	Channels, Grass	S	S	P	S
	Channels, Open	-	-	P	S
Chemical Treatment	Alum Treatment System	P	-	-	-
Conveyance System Components	Culverts	-	-	P	P
	Energy Dissipation	-	P	S	S
	Inlets/Street Gutters	-	-	P	-
	Pipe Systems	-	P	P	P
Detention	Detention, Dry	S	P	P	P
	Detention, Extended Dry	S	P	P	P
	Detention, Multi-purpose Areas	-	P	P	P
	Detention, Underground	-	P	P	P
Filtration	Filter Strips	S	-	-	-
	Organic Filters	P	-	-	-
	Planter Boxes	P	-	-	-
	Sand Filters, Surface/Perimeter	P	S	-	-
	Sand Filters, Underground	P	-	-	-
Hydrodynamic Devices	Gravity (Oil-Grit) Separator	S	-	-	-
Infiltration	Downspout Drywell	P	-	-	-
	Infiltration Trenches	P	S	-	-
	Soakage Trenches	P	S	-	-
Ponds	Wet Pond	P	P	P	P
	Wet ED Pond	P	P	P	P
	Micropool ED Pond	P	P	P	P
	Multiple Ponds	P	P	P	P
Porous Surfaces	Green Roof	P	S	-	-
	Modular Porous Paver Systems	S	S	-	-
	Porous Concrete	S	S	-	-
Proprietary Systems	Proprietary Systems [1]	S/P	S	S	S
Re-Use	Rain Barrels	P	-	-	-
Wetlands	Wetlands, Stormwater	P	P	P	P
	Wetlands, Submerged Gravel	P	P	S	-

P = Primary Control: Able to meet design criterion if properly designed, constructed and maintained.
S = Secondary Control: May partially meet design criteria. May be a Primary Control but designated as a Secondary due to other considerations. For Water Quality Protection, recommended for limited use in approved community- designated areas.
- = Not typically used or able to meet design criterion.
[1] = The application and performance of proprietary commercial devices and systems must be provided by the manufacturer and should be verified by independent third-party sources and data if used as a primary control.

Table 3.16 Water Quality Performance

Category	*integrated* Stormwater Controls	Water Quality Performance			
		TSS/ Sediment Removal Rate	Nutrient Removal Rate (TP/TN)	Bacteria Removal Rate	Hotspot Application
Bioretention Areas	Bioretention Areas	80%	60%/50%	-	✓
Channels	Enhanced Swales	80%	25%/40%	-	✓
	Channels, Grass	50%	25%/20%	-	
	Channels, Open	-	-	-	
Chemical Treatment	Alum Treatment System	90%	80%/60%	90%	✓
Conveyance System Components	Culverts	-	-	-	
	Energy Dissipation	-	-	-	
	Inlets/Street Gutters	-	-	-	
	Pipe Systems	-	-	-	
Detention	Detention, Dry	65%	50%/30%	70%	✓
	Detention, Extended Dry	65%	50%/30%	70%	✓
	Detention, Multi-purpose Areas	-	-	-	
	Detention, Underground	-	-	-	
Filtration	Filter Strips	50%	20%/20%	-	
	Organic Filters	80%	60%/40%	50%	✓
	Planter Boxes	80%	60%/40%	-	
	Sand Filters, Surface/Perimeter	80%	50%/25%	40%	✓
	Sand Filters, Underground	80%	50%/25%	40%	✓
Hydrodynamic Devices	Gravity (Oil-Grit) Separator	40%	5%/5%	-	
Infiltration	Downspout Drywell	80%	60%/60%	90%	
	Infiltration Trenches	80%	60%/60%	90%	
	Soakage Trenches	80%	60%/60%	90%	
Ponds	Wet Pond	80%	50%/30%	70%	✓
	Wet ED Pond	80%	50%/30%	70%	✓
	Micropool ED Pond	80%	50%/30%	70%	✓
	Multiple Ponds	80%	50%/30%	70%	✓
Porous Surfaces	Green Roof	85%	95%/16%	-	✓
	Modular Porous Paver Systems	[2]	80%/80%	-	
	Porous Concrete	[2]	50%/65%	-	
Proprietary Systems	Proprietary Systems [1]	[1]	[1]	[1]	
Re-Use	Rain Barrels	-	-	-	
Wetlands	Wetlands, Stormwater	80%	40%/30%	70%	✓
	Wetlands, Submerged Gravel	80%	40%/30%	70%	✓

✓ = Meets suitability criteria

\- = Not typically used or able to meet design criterion.

[1] = The application and performance of proprietary commercial devices and systems must be provided by the manufacturer and should be verified by independent third-party sources and data if used as a primary control.

[2] = Porous surfaces provide water quality benefits by reducing the effective impervious area.

Table 3.17 Site Applicability

Category	*integrated* Stormwater Controls	Site Applicability				
		Drainage Area (acres)	Space Req'd (% of Tributary imp. Area)	Site Slope	Minimum Head Required	Depth to Water Table
Bioretention Areas	Bioretention Areas	5 max[3]	5-7%	6% max	5 ft	2 ft
Channels	Enhanced Swales	5 max	10-20%	4% max	1 ft	Below WT
	Channels, Grass					
	Channels, Open					
Chemical Treatment	Alum Treatment System	25 min	None			
Conveyance System Components	Culverts					
	Energy Dissipation					
	Inlets/Street Gutters					
	Pipe Systems					
Detention	Detention, Dry		2-3%	15% across pond	6 to 8 ft	2 ft
	Detention, Extended Dry		2-3%	15% across pond	6 to 8 ft	2 ft
	Detention, Multi-purpose Areas	200 max		1% for Parking Lot; 0.25 in/ft for Rooftop		
	Detention, Underground	200 max				
Filtration	Filter Strips	2 max[3]	20-25%	2-6%		
	Organic Filters	10 max[3]	2-3%		5 to 8 ft	
	Planter Boxes		6%			
	Sand Filters, Surface/Perimeter	10 max[3] / 2 max[3]	2-3%	6% max	5 ft per 2-3 ft	2 ft
	Sand Filters, Underground	5 max	None			
Hydrodynamic Devices	Gravity (Oil-Grit) Separator	1 max[3]	None			
Infiltration	Downspout Drywell					
	Infiltration Trenches	5 max	2-3%	6% max	1 ft	4 ft
	Soakage Trenches	5 max	27 ft per 1000 ft^2 imp. area	6% max	1 ft	4 ft
Ponds	Wet Pond		2-3%	15% max	6 t 8 ft	2 ft, if hotspot or aquifer
	Wet ED Pond	25 min[3]				
	Micropool ED Pond	10 min[3]				
	Multiple Ponds	25 min[3]				
Porous Surfaces	Green Roof					
	Modular Porous Paver Systems	5 max	Varies			
	Porous Concrete	5 max	Varies			
Proprietary Systems	Proprietary Systems [1]	[1]	[1]			
Re-Use	Rain Barrels					
Wetlands	Wetlands, Stormwater	25 min	3-5%	8% max	3 to 5 ft (shallow) 6 to 8 ft (pond)	2 ft, if hotspot or aquifer
	Wetlands, Submerged Gravel	5 min			2 to 3 ft	Below WT

- = Not typically used or able to meet design criterion.
1 = The application and performance of proprietary commercial devices and systems must be provided by the manufacturer and should be verified by independent third-party sources and data if used as a primary control.
2 = Porous surfaces provide water quality benefits by reducing the effective impervious area.
3 = Drainage area can be larger in some instances

Table 3.18 Implementation Considerations

Category	*integrated* Stormwater Controls	Implementation Considerations			
		Residential Subdivision Use	High Density/Ultra Urban	Capital Cost	Maintenance Burden
Bioretention Areas	Bioretention Areas	✓	✓	Moderate	Low
Channels	Enhanced Swales	✓		High	Low
	Channels, Grass	✓		Low	Moderate
	Channels, Open	✓		Low	Low
Chemical Treatment	Alum Treatment System	✓	✓	High	High
Conveyance System Components	Culverts	✓	✓	Low	Low
	Energy Dissipation	✓	✓	Low	Low
	Inlets/Street Gutters	✓	✓	Low	Low
	Pipe Systems	✓	✓	Low	Low
Detention	Detention, Dry	✓		Low	Moderate to High
	Detention, Extended Dry	✓		Low	Moderate to High
	Detention, Multi-purpose Areas	✓	✓	Low	Low
	Detention, Underground		✓	High	Moderate
Filtration	Filter Strips	✓		Low	Moderate
	Organic Filters		✓	High	High
	Planter Boxes		✓	Low	Moderate
	Sand Filters, Surface/Perimeter		✓	High	High
	Sand Filters, Underground		✓	High	High
Hydrodynamic Devices	Gravity (Oil-Grit) Separator		✓	High	High
Infiltration	Downspout Drywell	✓	✓	Low	Moderate
	Infiltration Trenches	✓	✓	High	High
	Soakage Trenches	✓	✓	High	High
Ponds	Wet Pond	✓		Low	Low
	Wet ED Pond	✓		Low	Low
	Micropool ED Pond	✓		Low	Moderate
	Multiple Ponds	✓		Low	Low
Porous Surfaces	Green Roof		✓	High	High
	Modular Porous Paver Systems		✓	Moderate	High
	Porous Concrete		✓	High	High
Proprietary Systems	Proprietary Systems [1]	[1]	✓	High	High
Re-Use	Rain Barrels	✓	✓	Low	High
Wetlands	Wetlands, Stormwater	✓		Moderate	Moderate
	Wetlands, Submerged Gravel	✓	✓	Moderate	High

✓ = Meets suitability criteria
\- = Not typically used or able to meet design criterion.
[1] = The application and performance of proprietary commercial devices and systems must be provided by the manufacturer and should be verified by independent third-party sources and data if used as a primary control.

Step 2 Specific Criteria

The last three categories in the Structural Control Screening matrix provide an overview of various specific design criteria and specifications, or exclusions for a structural control that may be present due to a site's general physiographic character, soils, or location in a watershed with special water resources considerations.

Table 3.19 - Physiographic Factors

Three key factors to consider are low-relief, high-relief, and karst terrain. In the North Central Texas, low relief (very flat) areas are primarily located east of the Dallas metropolitan area. High relief (steep and hilly) areas are primarily located west of the Fort Worth metropolitan area. Karst and major carbonaceous rock areas are limited to portions of Palo Pinto, Erath, Hood, Johnson, and Somervell counties. Special geotechnical testing requirements may be needed in karst areas. The local reviewing authority should be consulted to determine if a project is subject to terrain constraints.

- Low relief areas need special consideration because many structural controls require a hydraulic head to move stormwater runoff through the facility.
- High relief may limit the use of some structural controls that need flat or gently sloping areas to settle out sediment or to reduce velocities. In other cases, high relief may impact dam heights to the point that a structural control becomes infeasible.
- Karst terrain can limit the use of some structural controls as the infiltration of polluted waters directly into underground streams found in karst areas may be prohibited. In addition, ponding areas may not reliably hold water in karst areas.

Table 3.20 - Soils

The key evaluation factors are based on an initial investigation of the NRCS hydrologic soils groups at the site. Note that more detailed geotechnical tests are usually required for infiltration feasibility and during design to confirm permeability and other factors.

Table 3.21 - Special Watershed or Stream Considerations

The design of structural stormwater controls is fundamentally influenced by the nature of the downstream water body that will be receiving the stormwater discharge. In addition, the designer should consult with the appropriate review authority to determine if their development project is subject to additional structural control criteria as a result of an adopted local watershed plan or special provision.

In some cases, higher pollutant removal or environmental performance is needed to fully protect aquatic resources and/or human health and safety within a particular watershed or receiving water. Therefore, special design criteria for a particular structural control or the exclusion of one or more controls may need to be considered within these watersheds or areas. Examples of important watershed factors to consider include:

High Quality Streams (Streams with a watershed impervious cover less than approximately 15%). These streams may also possess high quality cool water or warm water aquatic resources or endangered species. The design objectives are to maintain habitat quality through the same techniques used for cold-water streams, with the exception that stream warming is not as severe of a design constraint. These streams may also be specially designated by local authorities.

Wellhead Protection: Areas that recharge existing public water supply wells present a unique management challenge. The key design constraint is to prevent possible groundwater contamination by preventing infiltration of hotspot runoff. At the same time, recharge of unpolluted stormwater is encouraged to maintain flow in streams and wells during dry weather.

Reservoir or Drinking Water Protection: Watersheds that deliver surface runoff to a public water supply reservoir or impoundment are a special concern. Depending on the available treatment, a greater level of pollutant removal may be necessary for the pollutants of concern, such as bacteria pathogens, nutrients, sediment, or metals. One particular management concern for reservoirs is ensuring stormwater hotspots are adequately treated so they do not contaminate drinking water.

Local Provisions: NONE

Table 3.19 Physiographic Factors

Category	*integrated* Stormwater Controls	Physiographic Factors		
		Low Relief	High Relief	Karst
Bioretention Areas	Bioretention Areas	Several design variations will likely be limited by low head		Use poly-linear or impermeable membrane to seal bottom
Channels	Enhanced Swales	Generally feasible. However, slope <1% may lead to standing water in dry swales	Often infeasible if slopes are 4% or greater	
	Channels, Grass			
	Channels, Open			
Chemical Treatment	Alum Treatment System			
Conveyance System Components	Culverts			
	Energy Dissipation			
	Inlets/Street Gutters			
	Pipe Systems			
Detention	Detention, Dry		Embankment heights restricted	Require poly or clay liner, Max ponding depth, Geotechnical tests
	Detention, Extended Dry			
	Detention, Multi-purpose Areas			
	Detention, Underground			GENERALLY NOT ALLOWED
Filtration	Filter Strips			
	Organic Filters			
	Planter Boxes			
	Sand Filters, Surface/Perimeter	Several design variations will likely be limited by low head		Use poly-linear or impermeable membrane to seal bottom
	Sand Filters, Underground			
Hydrodynamic Devices	Gravity (Oil-Grit) Separator			
Infiltration	Downspout Drywell	Minimum distance to water table of 4 ft		GENERALLY NOT ALLOWED
	Infiltration Trenches	Minimum distance to water table of 2 ft	Maximum slope of 6%; trenches must have flat bottom	GENERALLY NOT ALLOWED
	Soakage Trenches	Minimum distance to water table of 4 ft	Maximum slope of 6%; trenches must have flat bottom	GENERALLY NOT ALLOWED
Ponds	Wet Pond	Limit maximum normal pool depth to about 4 ft (dugout) Providing pond drain can be problematic	Embankment heights restricted	Require poly or clay liner Max ponding depth Geotechnical tests
	Wet ED Pond			
	Micropool ED Pond			
	Multiple Ponds			
Porous Surfaces	Green Roof			
	Modular Porous Paver Systems			
	Porous Concrete			
Proprietary Systems	Proprietary Systems [1]			
Re-Use	Rain Barrels			
Wetlands	Wetlands, Stormwater		Embankment heights restricted	Require poly-liner Geotechnical tests
	Wetlands, Submerged Gravel			

[1] = The application and performance of proprietary commercial devices and systems must be provided by the manufacturer and should be verified by independent third-party sources and data if used as a primary control.

Table 3.20 Soils

Category	*integrated* Stormwater Controls	Soils
Bioretention Areas	Bioretention Areas	Clay or silty soils may require pretreatment
Channels	Enhanced Swales	
	Channels, Grass	
	Channels, Open	
Chemical Treatment	Alum Treatment System	
Conveyance System Components	Culverts	
	Energy Dissipation	
	Inlets/Street Gutters	
	Pipe Systems	
Detention	Detention, Dry	Underlying soils of hydrologic group "C" or "D" should be adequate to maintain a permanent pool. Most group "A" soils and some group "B" soils will require a pond liner.
	Detention, Extended Dry	
	Detention, Multi-purpose Areas	
	Detention, Underground	
Filtration	Filter Strips	
	Organic Filters	
	Planter Boxes	Type A or B
	Sand Filters, Surface/Perimeter	Clay or silty soils may require pretreatment
	Sand Filters, Underground	
Hydrodynamic Devices	Gravity (Oil-Grit) Separator	
Infiltration	Downspout Drywell	Infiltration rate > 0.5 inch/hr
	Infiltration Trenches	Infiltration rate > 0.5 inch/hr
	Soakage Trenches	Infiltration rate > 0.5 inch/hr
Ponds	Wet Pond	"A" soils may require pond liner "B" soils may require infiltration testing
	Wet ED Pond	
	Micropool ED Pond	
	Multiple Ponds	
Porous Surfaces	Green Roof	
	Modular Porous Paver Systems	Infiltration rate > 0.5 inch/hr
	Porous Concrete	
Proprietary Systems	Proprietary Systems [1]	
Re-Use	Rain Barrels	
Wetlands	Wetlands, Stormwater	"A" soils may require pond liner
	Wetlands, Submerged Gravel	

[1] = The application and performance of proprietary commercial devices and systems must be provided by the manufacturer and should be verified by independent third-party sources and data if used as a primary control.

Table 3.21 Special Watershed Considerations

Category	*integrated* Stormwater Controls	Special Watershed Considerations		
		High Quality Stream	Aquifer Protection	Reservoir Protection
Bioretention Areas	Bioretention Areas	Evaluate for stream warming	Needs to be designed with no exfiltration (ie. outflow to groundwater)	
Channels	Enhanced Swales		Hotspot runoff must be adequately treated	Hotspot runoff must be adequately treated
	Channels, Grass			
	Channels, Open			
Chemical Treatment	Alum Treatment System			
Conveyance System Components	Culverts			
	Energy Dissipation			
	Inlets/Street Gutters			
	Pipe Systems			
Detention	Detention, Dry			
	Detention, Extended Dry			
	Detention, Multi-purpose Areas			
	Detention, Underground			
Filtration	Filter Strips			
	Organic Filters			
	Planter Boxes			
	Sand Filters, Surface/Perimeter	Evaluate for stream warming	Needs to be designed with no exfiltration (ie. outflow to groundwater)	
	Sand Filters, Underground			
Hydrodynamic Devices	Gravity (Oil-Grit) Separator			
Infiltration	Downspout Drywell			
	Infiltration Trenches		Maintain safe distance from wells and water table. No hotspot runoff	Maintain safe distance from bedrock and water table. Pretreat runoff
	Soakage Trenches			
Ponds	Wet Pond	Evaluate for stream warming	May require liner if "A" soils are present Pretreat hotspots 2 to 4 ft separation distance from water table	
	Wet ED Pond			
	Micropool ED Pond			
	Multiple Ponds			
Porous Surfaces	Green Roof			
	Modular Porous Paver Systems			
	Porous Concrete			
Proprietary Systems	Proprietary Systems [1]			
Re-Use	Rain Barrels			
Wetlands	Wetlands, Stormwater	Evaluate for stream warming	May require liner if "A" soils are present Pretreat hotspots 2 to 4 ft separation distance from water table	
	Wetlands, Submerged Gravel			

[1] = The application and performance of proprietary commercial devices and systems must be provided by the manufacturer and should be verified by independent third-party sources and data if used as a primary control.

Step 3 Location and Permitting Considerations

In the last step, a site designer assesses the physical and environmental features at the site to determine the optimal location for the selected structural control or group of controls. Table 3.22 provides a condensed summary of current restrictions as they relate to common site features that may be regulated under local, state, or federal law. These restrictions fall into one of three general categories:

- Locating a structural control within an area when expressly prohibited by law
- Locating a structural control within an area that is strongly discouraged, and is only allowed on a case by case basis. Local, state, and/or federal permits shall be obtained, and the applicant will need to supply additional documentation to justify locating the stormwater control within the regulated area.
- Structural stormwater controls must be setback a fixed distance from a site feature.
- This checklist is only intended as a general guide to location and permitting requirements as they relate to siting of stormwater structural controls. Consultation with the appropriate regulatory agency is the best strategy.

Local Provisions: NONE

Table 3.22 Location and Permitting Checklist

Site Feature	Location and Permitting Guidance
Jurisdictional Wetland (Waters of the U.S) U.S. Army Corps of Engineers Regulatory Permit	• Jurisdictional wetlands must be delineated prior to siting structural control. • Use of natural wetlands for stormwater quality treatment is contrary to the goals of the Clean Water Act and should be avoided. • Stormwater should be treated prior to discharge into a natural wetland. • Structural controls may also be *restricted* in local buffer zones. Buffer zones may be utilized as a non-structural filter strip (i.e., accept sheet flow). • Should justify that no practical upland treatment alternatives exist. • Where practical, excess stormwater flows should be conveyed away from jurisdictional wetlands.
Stream Channel (Waters of the U.S) U.S. Army Corps of Engineers Section 404 Permit	• All Waters of the U.S. (streams, ponds, lakes, etc.) should be delineated prior to design. • Use of any Waters of the U.S. for stormwater quality treatment is contrary to the goals of the Clean Water Act and should be avoided. • Stormwater should be treated prior to discharge into Waters of the U.S. • In-stream ponds for stormwater quality treatment are highly discouraged. • Must justify that no practical upland treatment alternatives exist. • Temporary runoff storage preferred over permanent pools. • Implement measures that reduce downstream warming. • Section 401 certification reviews by the Texas Commission on Environmental Quality are required for projects needing a Section 404 Permit.
Water Quality Certification Texas Commission on Environmental Quality (TCEQ)	• TCEQ conducts Section 401 water quality certification reviews of projects requiring a Section 404 permit from the U.S. Army Corps of Engineers for the discharge of dredged or fill material into waters of the U.S., including wetlands. • Specific stream and reservoir buffer requirements. • May be imperviousness limitations • May be specific structural control requirements that may overlap with requirements in this manual. • Mitigation will be required for impacts to existing aquatic and terrestrial habitat.
Impaired Water Bodies Texas Commission on Environmental Quality	• Determine if the project will discharge pollutants of concern into any downstream receiving waters that have been designated as impaired water bodies on TCEQ's *Texas Integrated Report of Surface Water Quality for Clean Water Act Sections 305(b) and 303(d)*. • Stormwater runoff discharges containing pollutants of concern to impaired water bodies will be governed by an entity's Municipal Separate Storm Sewer System (MS4) permit, if applicable.

Table 3.22 Location and Permitting Checklist (continued)

Site Feature	Location and Permitting Guidance
Texas Commission on Environmental Quality Groundwater Management Areas	• Conserve, preserve, protect, recharge, and prevent waste of groundwater resources through Groundwater Conservation Districts • Groundwater Conservation District pending for Middle Trinity. • Detailed mapping available from Texas Alliance of Groundwater Districts.
Floodplain Areas National Flood Insurance Program / Local Floodplain Administrator	• Grading and fill for structural control construction is generally discouraged within the 100-year floodplain, as delineated by FEMA flood insurance rate maps, FEMA flood boundary and floodway maps, or more stringent local floodplain maps. • Floodplain fill cannot raise the floodplain water surface elevation by more than limits set by the appropriate jurisdiction.
Stream Buffer Check with appropriate review authority whether stream buffers are required	• Consult local authority for stormwater policy. • Structural controls are discouraged in the streamside zone (within 25 feet or more of streambank, depending on the specific regulations).
Utilities Local Review Authority	• Call appropriate agency to locate existing utilities prior to design. • Note the location of proposed utilities to serve development. • Structural controls are discouraged within utility easements or rights of way for public or private utilities.
Roads TxDOT or DPW	• Consult TxDOT for any setback requirement from local roads. • Consult DOT for setbacks from State maintained roads. • Approval must also be obtained for any stormwater discharges to a local or state-owned conveyance channel.
Structures Local Review Authority	• Consult local review authority for structural control setbacks from structures. • Recommended setbacks for each structural control group are provided in the performance criteria in this manual.
Septic Drain fields Local Health Authority	• Consult local health authority. • Recommended setback is a minimum of 50 feet from drain field edge or spray area.
Water Wells Local Health Authority	• 100-foot setback for stormwater infiltration. • 50-foot setback for all other structural controls.

Local Provisions:
The City of Stephenville does not mandate the use of any of these stormwater controls, but recognizes the inherent values of their application in overall stormwater management.

The design guidance and technical reference sections of the iSWM Technical Manual are adopted. There are, however, at this time, no City of Stephenville requirements for achieving Stormwater Quality or Channel Protection volumes.

4.0 *integrated* Construction Criteria

The chapter lays out the criteria and methods to be employed during construction to limit erosion and the discharge of sediment and other pollutants from construction sites.

4.1 Applicability

Requirements for temporary controls during construction are applicable to the following projects:

- Land disturbing activity of one acre or more or
- Land disturbing activity of less than one acre, where the activity is part of a common plan of development that is one acre or larger.

A common plan of development refers to a construction activity that is completed in separate stages, separate phases, or in combination with other construction activities.

Local Provisions: Erosion controls are required for all construction sites. Sediment and material and waste controls are required for land disturbing activities of one acre or more. The iSWM Technical Manual gives details of the types of controls and the criteria for each control. Construction activities shall comply with the SWPPP requirements in the effective TPDES General permit relating to Stormwater Discharges from Construction Activities, of the Stormwater Pollution Control Ordinance and the appropriate federal (Environmental Protection Agency) and state (Texas Commission on Environmental Quality) regulations. When the ordinance and applicable regulations are in conflict, the most stringent requirements shall apply.

4.2 Introduction

iSWM requires the use of temporary controls during construction to prevent or reduce the discharge of sediment and other pollutants from the construction site. The temporary controls are known as Best Management Practices (BMPs). BMPs may be activities, prohibitions, maintenance procedures, structural controls, operating procedures and other measures to prevent erosion and control the discharge of sediment and other pollutants.

Construction BMPs shall be considered when developing the Preliminary iSWM Plan and shall be coordinated with the Final iSWM Plans. Construction BMPs fall into three general categories: Erosion Control, Sediment Control, and Material and Waste Control. The first category prevents erosion, and the second catches soil from erosion that does occur. It is generally more effective and less expensive to prevent erosion than to treat turbid runoff. Material and waste controls are for other sources of stormwater pollutants on a construction site.

The following priorities shall be applied to the selection of construction BMPs:

- Retain native topsoil and natural vegetation in an undisturbed state by incorporating natural drainage features and buffer areas into the site design.
- Limit the area of disturbance and vehicle access to the site.
- Limit the extent of clearing operations, and phase construction operations to minimize the area disturbed at any one time.
- Stabilize disturbed areas as soon as possible (not at the end of construction), particularly in channels and on cut/fill slopes.
- Minimize the disturbance of steep slopes during construction, and minimize slope length and steepness.

- Coordinate stream crossings, and minimize the construction of temporary stream crossings.
- Provide sediment controls, including but not limited to perimeter controls, where stormwater discharges will occur from disturbed areas.
- Prevent tracking of sediment off-site through the establishment of stabilized construction entrances and exits.
- Control sediment and other contaminants from dewatering activities.
- Control discharges of construction materials and wastes.

State Requirements

In addition to the municipality requirements outlined in this chapter, land disturbing activities must comply with the Texas Commission on Environmental Quality (TCEQ) requirements under General Permit Number TXR150000, commonly referred to as the "Construction General Permit." This permit contains requirements for a Storm Water Pollution Prevention Plan (SWP3), state and local notifications, and installation, maintenance, and inspection of best management practices on construction sites. The *Water Quality Technical Manual* contains guidance for preparing a SWP3. However, compliance with the Construction General Permit is beyond the scope of this iSWM Criteria Manual and is the sole responsibility of the construction site operator(s).

Local Provisions: NONE

4.3 Criteria for BMPs during Construction

The iSWM Construction Plan shall include, but shall not be limited to, the following:

- Topography;
- Limits of all areas to be disturbed by construction activity, including off-site staging areas, utility lines, batch plants, and spoil/borrow areas;
- Location and types of erosion control, sediment control, and material and waste control BMPs;
- Construction details and notes for erosion control, sediment control, and material and waste control BMPs; and
- Inspections and maintenance notes.

BMPs and notes shall be provided for all the elements listed in this section, unless site conditions render an element not applicable. BMPs shall be selected and designed according to the technical criteria in the *Construction Controls Technical Manual*. Site data gathered and analyzed in Step 2 of the *integrated* Development Process shall be the basis for selecting BMPs.

The minimum design storm for temporary BMPs is the 2-year, 24-hour duration storm event.

Plans for temporary BMPs shall be prepared by a Certified Professional in Erosion and Sediment Control (CPESC) or a licensed engineer or registered landscape architect in the State of Texas who has documented experience in hydrology and hydraulics and erosion and sediment control.

Local Provisions: Capacity calculations shall be included in the iSWM Construction Plan. It is the responsibility of the engineer to design appropriate BMP's for each site. If the most appropriate BMP is not in the NCTCOG BMP Manual, the engineer shall submit calculations and references for design of the BMP to City.

4.3.1 Erosion Controls

Erosion control is first line of defense and the primary means of preventing stormwater pollution. They shall be designed to retain soil in place and to minimize the amount of sediment that has to be removed from stormwater runoff by other types of BMPs. Fact Sheets for different types of Erosion Control BMPs are in *Section 2.0 of the Construction Controls Technical Manual*.

Limits of Disturbance

On the iSWM Construction Plans, clearly show the limits of the area to be disturbed.

Design Criteria

- Minimize the disturbance of steep slopes.
- Constrain the disturbed area to the minimum necessary to construct the project.
- Include the contractor's staging area, borrow/spoil area, utilities and any other areas on or off site that will be disturbed in support of the construction activity.
- Specify construction fencing or similar protective measures to prevent disturbance of natural drainage features, trees, vegetative buffers and other existing features to be preserved.

Slope Protection

Slope protection shall be provided for disturbed or cut/fill slopes that are one vertical on three horizontal (3H:1V) or steeper, 50 feet in length or longer, or on highly erodible soils. Show the location and type of BMPs to on the plans.

Design Criteria

- Where feasible, add notes that prohibit disturbing the slope until final site grading.
- Where a stabilized discharge point is available, provide temporary berms or swales to direct stormwater away from the slope until the slope is stabilized.
- Check dams shall be used within swales that are cut down a slope.
- Temporary terraces, vegetated strips or equivalent linear controls shall be specified at regular intervals to break-up slopes longer than 50 feet until the slope is stabilized.
- Specify final stabilization measures to be initiated immediately upon completing work on the slope.
- Hydromulch is prohibited for slope stabilization unless the slope is one vertical on five horizontal (5H:1V) or less.

Channel Protection

Show the location and type of BMPs used to prevent the erosion of channels, drainage ways, streambanks, and outfalls until permanent structures and final stabilization measures are installed.

Design Criteria

- Provide temporary energy dissipaters at discharge points.
- If final channel stabilization consists of vegetation, anchored erosion control blankets, turf reinforcement mats, or an equivalent BMP that is resistant to channel flow shall be installed until the vegetation is established.
- If the BMPs include check dams, velocity dissipaters or other structures that extend into the channel, the BMPs shall be designed by a licensed engineer to function under the flow conditions produced by the design storm. The engineer shall verify that the BMPs will not divert flow or cause flooding of adjacent properties and structures.
- Specify final stabilization measures to be initiated immediately upon completing work on the channel.

Temporary Stabilization

Temporary stabilization practices shall be specified to be initiated immediately for disturbed portions of the site where work is anticipated to stop for 14 days or more.

Design Criteria

- Stabilization measures shall be appropriate for the time of year, site conditions, and estimated duration of use.
- Stabilization BMPs shall be provided for soil stockpiles.

Final Stabilization

Final stabilization practices shall be specified for disturbed areas that are not covered by buildings, pavement or other permanent structures upon completion of construction. Final stabilization measures shall be coordinated with the site's landscaping plan.

Design Criteria

- Final stabilization shall be specified to be initiated immediately upon completing soil disturbing activities.
- If space is available, top soil shall be stockpiled during construction and distributed onto the surface of disturbed areas prior to final stabilization.
- If top soil has not been stockpiled, soil amendments (compost, fertilizer, etc.) shall be specified with the final stabilization measures.
- Final stabilization measures must provide a perennial vegetative cover with a uniform density of 70% of the native background vegetative cover or equivalent permanent measures (riprap, gabion, or geotextiles).
- Include notes requiring temporary BMPs be removed within 30 days of establishing final stabilization.

Local Provisions: Erosion controls are required for all constructions sites.

4.3.2 Sediment Controls

Sediment control BMPs shall be designed to capture sediment on the site when preventing erosion is not feasible due to on-going construction activity. Sediment control BMPs and their locations shall be designed to change with the different phases of construction as site conditions and drainage patterns change. Sediment controls for the initial phase of construction shall be installed before any site disturbing activities begin. Fact Sheets for different types of Sediment Control BMPs are in *Section 3.0 of the Construction Controls Technical Manual*.

Sediment Barriers

Sediment barriers may be linear controls (silt fence, compost socks, sediment logs, wattles, etc.), check dams, berms, sediment basins, sediment traps, active treatment systems and other structural BMPs designed to capture sediment suspended in stormwater.

Design Criteria

- Sediment barriers shall be designed to treat the volume of runoff from the design storm.
- Sediment barriers are not required for areas of the site that are undisturbed.
- If linear controls are used as the only sediment barrier for a project, the linear control shall be provided at a rate of 100 linear feet per quarter-acre of disturbed area. A series of linear controls may be needed throughout the site and are not limited to the perimeter.
- Linear controls shall not be used across areas of concentrated flow, such as drainage ditches, swales and outfalls.
- A sediment basin shall be provided where stormwater runoff from 10 acres or more of disturbed area flows to a common drainage location, unless a basin is infeasible due to site conditions or public safety. The basin shall be designed for the volume of runoff from the total area contributing (on-site and off-site) to the common drainage location, not just the volume from the disturbed portion of the contributing area. Stormwater diversion BMPs may be used to divert stormwater from upslope areas away from and around the disturbed area to minimize the design volume of the sediment basin.
- Both existing topography and graded topography shall be evaluated when determining if ten (10) acres or more discharges to a common location.
- If a sediment basin is infeasible on a site of ten (10) acres or more, a series of smaller sediment traps and/or linear controls shall be provided throughout the site to provide an equivalent level of protection.
- Permanent detention and retention basins may be used as a sediment basin during construction if all sediment is removed upon completion of construction.

Perimeter Controls

A linear BMP shall be provided at all down slope boundaries of the construction activity and side slope boundaries where stormwater runoff may leave the site. Linear sediment barriers may be used to satisfy the requirement for perimeter controls.

Storm Drain Inlet Protection

Storm drain inlet protection shall not be used as a primary sediment control BMP unless all other primary controls are infeasible due to site configuration or the type of construction activity. Inlet protection is intended to be a last line of defense in the event of a temporary failure of other sediment controls.

Design Criteria

- Municipality approval is required before installing inlet protection on public streets.
- Inlet protection shall only be specified for low point inlets where positive overflow is provided.
- Drainage patterns shall be evaluated to ensure inlet protection will not divert flow or flood the roadway or adjacent properties and structures.

Construction Access Controls

BMPs shall be provided to prevent off-site vehicle tracking of soil and pollutants.

Design Criteria

- Limit site access to one route during construction, if possible; two routes for linear projects.
- Design the access point(s) to be at the upslope side of the construction site. Do not place the construction access at the lowest point on the construction site.
- Specify rock stabilization or an equivalent BMP for all access points.
- Include notes requiring soil tracked onto public roads be removed at a frequency that minimizes site impacts and prior to the next rain event, if feasible.
- Using water to wash sediment from streets is prohibited.

Dewatering Controls

Water pumped from foundations, vaults, trenches and other low areas shall be discharged through a BMP or treated to remove suspended soil and other pollutants before the water leaves the site. The plans shall include notes that prohibit discharging the water directly into flumes, storm drains, creeks or other drainage ways. Where state or local discharge permit requirements exist for the pollutant(s) suspected of being in the water, the plan shall include the discharge permit conditions.

Local Provisions: NONE

4.3.3 Material and Waste Controls

Notes shall be placed on the iSWM Construction Plan for the proper handling and storage of materials and wastes that can be transported by stormwater. At a minimum, notes shall be provided for the materials and wastes in Table 4.1. Additional notes and BMPs shall be provided if other potential pollutants are expected to be on-site. Construction details shall be provided when necessary to ensure proper installation of a material or waste BMP.

All material and waste sources shall be located a minimum of 50 feet away from inlets, swales, drainage ways, channels and waters of the U.S., if the site configuration provides sufficient space to do so. In no case shall material and waste sources be closer than 20 feet from inlets, swales, drainage ways, channels and waters of the U.S.

Table 4.1 Requirements for Materials and Wastes

Material or Waste Source	Requirements
Sanitary Facilities	Sanitary facilities shall be provided on the site, and their location shall be shown on the *i*SWM Construction Plan. The facilities shall be regularly serviced at the frequency recommended by the supplier for the number of people using the facility.

Table 4.1 Requirements for Materials and Wastes

Material or Waste Source	Requirements
Trash and Debris	Show the location of trash and debris storage on the *i*SWM Construction Plan. Store all trash and debris in covered bins or other enclosures. Trash and debris shall be removed from the site at regular intervals. Containers shall not be allowed to overflow.
Chemicals and Hazardous Materials	The amount of chemicals and hazardous materials stored on-site shall be minimized and limited to the materials necessary for the current phase of construction. Chemicals and hazardous materials shall be stored in their original, manufacturer's containers inside of a shelter that prevents contact with rainfall and runoff. Hazardous material storage shall be in accordance with all Federal, state and local laws and regulations. Storage locations shall have appropriate placards and secondary containment equivalent to 110% of the largest container in storage. If an earthen pit or berm is used for secondary containment, it shall be lined with plastic. Containers shall be kept closed except when materials are added or removed. Materials shall be dispensed using drip pans or within a lined, bermed area or using other spill/overflow protection measures.
Fuel Tanks	On-site fuel tanks shall be provided with a secondary enclosure equivalent to 110% of the tank's volume. If the enclosure is an earthen pit or berm, the area shall be lined with plastic. Show the location of fuel tanks and their secondary containment on the iSWM Construction Plan.
Concrete Wash-out Water	An area shall be designated on the iSWM Construction Plan for concrete wash-out. A pit or bermed area, lined with plastic, or an equivalent containment measure shall be provided for concrete wash-out water. The containment shall be a minimum of 6 CF for every 10 CY of concrete placed plus a one foot freeboard. The discharge of wash-out water to drainage ways or storm drain infrastructure shall be prohibited.
Hyper-chlorinated Water from Water Line Disinfection	Hyper-chlorinated water shall not be discharged to the environment unless the chlorine concentration is reduced to 4 ppm or less by chemically treating to dechlorinate or by on-site retention until natural attenuation occurs. Natural attenuation may be aided by aeration. Water with measurable chlorine concentration of less than 4 ppm is prohibited from being discharged directly to surface water. It shall be discharged onto vegetation or through a conveyance system for further attenuation of the chlorine before it reaches surface water. Alternatively, permission from the sanitary sewer operator may be obtained to discharge directly to the sanitary sewer.
Vehicle/Equipment Wash Water	Vehicle and equipment washing is prohibited on the site unless a lined basin is provided to capture 100% of the wash water. The wash water may be allowed to evaporate or hauled-off for disposal.
Soil Stabilizers	Lime or other chemical stabilizers shall be limited to the amount that can be mixed and compacted by the end of each working day. Stabilizers shall be applied at rates that result in no runoff. Stabilization shall not occur immediately before and during rainfall events. Soil stabilizers stored on-site shall be considered a hazardous material and shall meet all the requirements for chemicals and hazardous materials.

Table 4.1 Requirements for Materials and Wastes	
Material or Waste Source	**Requirements**
Concrete Saw-cutting Water	Slurry from concrete cutting shall be vacuumed or otherwise recovered and not be allowed to discharge from the site. If the pavement to be cut is near a storm drain inlet, the inlet shall be protected by sandbags or equivalent temporary measures to prevent the slurry from entering the inlet.

Local Provisions: NONE

4.3.4 Installation, Inspection and Maintenance

The iSWM Construction Plan shall include details and notes that specify the proper installation, inspection and maintenance procedures for BMPs. The BMPs for the initial phase of construction must be implemented before starting any activities that result in soil disturbance, including land clearing. Notes shall indicate the sequence of BMP installation for subsequent phases of construction.

Notes on the iSWM Construction Plan shall indicate the frequency of inspections and the areas to be inspected. Inspections shall include:

- Inspecting erosion and sediment controls to ensure that they are operating correctly;
- Inspecting locations where vehicles enter or exit the site for evidence of off-site tracking;
- Inspecting material and waste controls to ensure they are effective; and
- Inspecting the perimeter of disturbed areas and discharge points for evidence of sediment or other pollutants that may have been discharged.

Erosion, sediment, and material and waste controls shall be repaired, replaced, modified and/or added if inspections reveal the controls were not installed correctly, are damaged, or are inadequate or ineffective in controlling their targeted pollutant.

Notes for maintenance of BMPs shall require the removal of sediment from BMPs when the sediment reaches half of the BMP's capacity or more frequently. Sediment discharged from the site shall be removed prior to the next rain event, where feasible, and in no case later than seven days after it is discovered. Upon completion of construction, sediment shall be removed from all storm drain infrastructure and permanent BMPs before the temporary BMPs are removed from the site.

Local Provisions: NONE

5.0 Additional Local Requirements

- Figure 5.1 - City of Stephenville Development Process
- City of Stephenville Development Review Checklists (Pre-Application Conference, Preliminary Site Plan, Final iSWM Plan)

5.1 City of Stephenville Development Process

For complete subdivision standards and procedures please go to:
http://www.stephenvilletx.gov/departments/community-development/

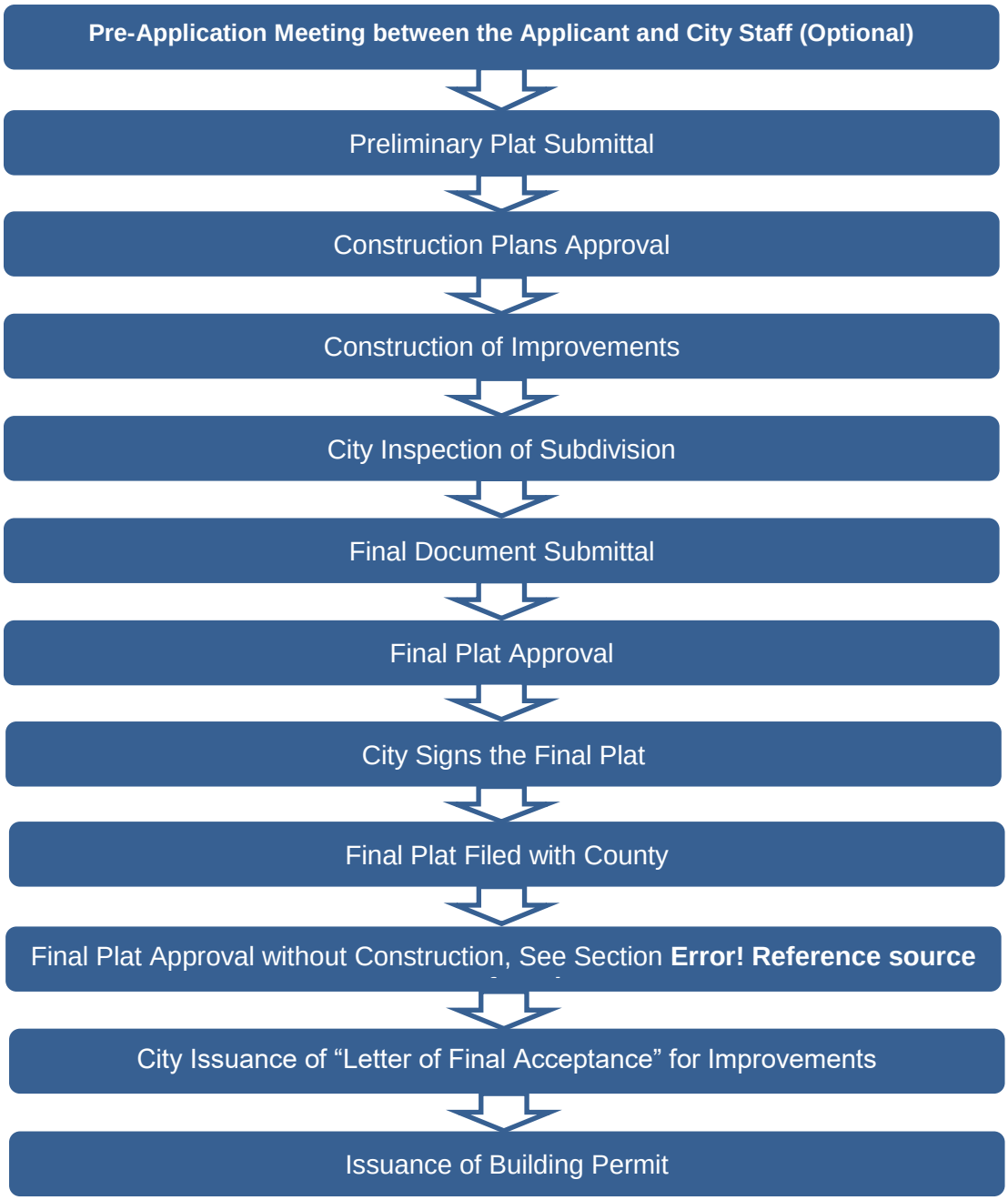


Figure 5.1 City of Stephenville Development Process

Checklist for Conceptual iSWM Plan Preparation and Review

	Included?		
	Yes	No	Comments
Mapping and plans which illustrate at a minimum:			
(recommended scale of 1" = 50' or greater)			
1. Project Description			
A. Name, legal address and telephone number of applicant			
B. Name, legal address and telephone number of preparer			
C. Common address and legal description of site			
D. Vicinity map			
E. Proposed land use with Standard Industrial Code No.			

	Yes	No	Comments
2. Planning Concerns			
A. Have any previous drainage or watershed plans been completed in the watershed? (If yes, describe)			
B. Is there any known history of flooding downstream? (If yes, describe conditions and locations)			
C. Is there any known history of excessive erosion downstream? (If yes, describe conditions and locations)			
D. Are there any known downstream drainage constrictions such as undersized culverts or channels? Size?			
E. Are there any known or suspected wetland areas, mitigation areas, 404 permit areas, or other natural habitat features which require special consideration?			
F. Are there any existing dams over six feet in height which are or will be subject to TCEQ regulations?			
G. Are there any existing impoundments subject to TCEQ water rights permitting? (Livestock ponds are not exempt when converted to other uses.)			
H. Are there any existing environmental concerns on the site requiring special treatment or design consideration (i.e. fuel stations, vehicle maintenance, auto recycling, illeal dump sites, landfills, etc.)?			

Checklist for Conceptual iSWM Plan Preparation and Review (continued)

	Yes	No	Comments
3. Existing Conditions			
A. Copy of applicable digital orthophoto showing proposed project boundaries			
B. Best available existing topography (no greater than 2-foot contours recommended)			
C. Total Site Area and Total Impervious Area (acres)			
D. Benchmarks used for site control if available			
E. Perennial and intermittent streams			
F. Predominant soils from USDA soil surveys and/or on site soil borings			
G. Boundaries of existing predominant vegetation			
H. Location and boundaries of natural feature protection and conservation areas such as wetlands, lakes, ponds, and other setbacks (e.g., stream buffers, drinking water well setbacks, septic setbacks, etc.)			
I. Location of existing roads, buildings, parking lots and other impervious areas			
J. Location of existing utilities (e.g., water, sewer, gas, electric) and easements			
K. Location of existing conveyance systems such as storm drains, inlets, catch basins, channels, swales, and areas of overland flow			
L. Flow paths			
M. Location of floodplain/floodway limits and relationship of site to upstream/downstream properties and drainages			
N. Location and dimensions of existing channels, bridges or culvert crossings			
4. Conceptual Site Layout			
A. Complete the iSWM Conceptual Plan Worksheet			
B. Hydrologic analysis to determine conceptual runoff rates, volumes and velocities to support selection of Stormwater Controls			
C. Conceptual site design identifying *integrated* site design practices used			
D. Identification and calculation of stormwater site design credits			

Checklist for Conceptual iSWM Plan Preparation and Review (continued)

	Yes	No	Comments
E. Approximate downstream assessment limits for all outfalls			
F. Conceptual estimates of *integrated* Design Focus Area requirements			
G. Conceptual selection, location and size of proposed structural stormwater controls			
H. Conceptual limits of proposed clearing and grading			

Checklist for Preliminary iSWM Plan Preparation and Review

	Included?		
	Yes	No	Comments
Mapping and plans which illustrate at a minimum:			
(recommended scale of 1" = 50' or greater)			
1. Existing Conditions Hydrologic Analysis			
A. Existing and proposed topography (no greater than 2-foot contours recommended)			
B. Total Site Area and Total Impervious Area (acres)			
C. Perennial and intermittent streams			
D. Predominant soils from USDA soil surveys or soil borings			
E. Boundaries of existing predominant vegetation and proposed limits of clearing and grading			
F. Location and boundaries of natural feature protection and conservation areas such as wetlands, lakes, ponds, and other setbacks (e.g., stream buffers, drinking water well setbacks, septic setbacks, etc.)			
G. Location of existing and proposed roads, buildings, parking lots and other impervious areas			
H. Location of existing and proposed utilities (e.g., water, sewer, gas, electric) and easements			
I. Preliminary selection and location of stormwater controls			
J. Location of existing and proposed conveyance systems such as storm drains, inlets, catch basins, channels, swales, and areas of overland flow			
K. Flow paths			
L. Location of floodplain/floodway limits and relationship of site to upstream/downstream properties and drainages			
M. Preliminary location and dimensions of proposed channel modifications, such as bridge or culvert crossings			
N. Existing conditions hydrologic analysis for runoff rates, volumes and velocities showing methodologies used and supporting calculations			

Checklist for Preliminary iSWM Plan Preparation and Review (continued)

	Included? Yes	No	Comments
2. Project Description and Design Considerations (updated information from Conceptual Plan)			
A. Name, legal address and telephone number of applicant			
B. Name, legal address and telephone number of preparer			
C. Common address and legal description of site			
D. Vicinity Map			
E. Discussion of *integrated* Site Design Practices			
F. Discussion of Credits for *integrated* Site Design			
G. Discussion of stormwater controls			
H. Discussion of groundwater recharge considerations			
I. Discussion of hotspot land uses and runoff treatment			

	Yes	No	Comments
3. Post-Development Hydrologic Analysis			
A. Proposed (post-development) conditions hydrologic analysis for runoff rates, volumes, and velocities showing the methodologies used and supporting calculations			
B. Preliminary estimates of *integrated* Design Focus Area requirements			
C. Preliminary identification and calculation of credits for *integrated* site designs			
D. Location and boundary of proposed natural feature protection areas			
4. Downstream Assessments			
A. Preliminary analysis of potential downstream impact/effects of project, where necessary			

Checklist for Preliminary iSWM Plan Preparation and Review (continued)

	Yes	No	Comments
5. Stormwater Management System Design			
A. Hydrologic and hydraulic analysis of the stormwater management system for all applicable design storms			
B. Preliminary sizing calculations for stormwater controls including contributing drainage area, storage, and outlet configuration			
C. Narrative describing the selected stormwater controls			

Checklist for Final iSWM Plan Preparation and Review

	Included? Yes	No	Comments
1. Existing Conditions Hydrologic Analysis			
A. Updated checklist from **Preliminary iSWM Site Plan**.....			
2. Project Description and Design Considerations			
A. Updated checklist from **Preliminary iSWM Site Plan**.....			
3. Post-Development Hydrologic Analysis			
A. Updated checklist from **Preliminary iSWM Site Plan**.....			
B. Final sizing calculations for stormwater controls including contributing drainage area, storage, and outlet configuration.....			
C. Stage-discharge or outlet rating curves and inflow and outflow hydrographs for storage facilities.....			
D. Final analysis of potential downstream impact/effects of project, where necessary.....			
E. Dam safety and breach analysis, where necessary			
4. Downstream Assessments			
A. Update checklist from **Preliminary iSWM Site Plan**.....			
5. Stormwater Management System Design			
A. Update checklist from **Preliminary iSWM Site Plan**.....			
B. Existing and proposed structural elevations (e.g., invert of pipes, manholes, etc.).....			
C. Design water surface elevations.....			

Checklist for Final iSWM Plan Preparation and Review (continued)

	Yes	No	Comments
D. Structural details and specifications of structural control designs, outlet structures, embankments, spillways, grade control structures, conveyance channels, etc.			
E. Professional Engineer seal, signature and date			

6. iSWM Construction Plan

A. Existing topography and natural drainage features and post-development topography and drainage features			
B. Limits of disturbance, including off-site areas that will be disturbed and natural features to be protected within the disturbed areas			
C. Location, details, BMP design calculations (if applicable), and notes for erosion controls			
D. Locations, details, BMP design calculations (if applicable), and notes for sediment controls			
E. Location, details, BMP design calculations (if applicable), and notes for material and waste controls			
F. Inspection and maintenance notes			
G. Sequence of BMP installation based on sequence of construction phases			
H. Schedule and phasing of temporary and permanent stabilization on different area of the site			
I. Temporary structures that will be converted into permanent storm water controls			
J. Prepared by CPESC, PE or RLA			

Checklist for Final iSWM Plan Preparation and Review (continued)

	Yes	No	Comments
7. Landscaping Plan			
A. Arrangement of planted areas, natural areas, and other landscaped features			
B. Information required to construct landscaping elements			
C. Descriptions and standards for the methods, materials and vegetation that are to be used			
8. Operations and Maintenance Plan			
A. Name, legal address and phone number of responsible parties for maintenance activities			
B. Description and schedule of maintenance tasks			
C. Description of applicable easements			
D. Description of funding source			
E. Access and safety issues			
F. Procedures for testing and disposal of sediments, if required			
G. Expected service life of structures and estimated cost to replace			
H. Executed Maintenance Agreement(s) and Plan(s),			
I. Record of Maintenance Plan filed in county property records for the property			
9. Evidence of Acquisition of Applicable Federal, State, and Local Permits			
A. USACE Regulatory Program permits			
B. 401 water quality certification			
C. TPDES Construction permit			
D. Other _____			
E. Other _____			
10. Waiver Requests			
A. Evidence of acquisition of all necessary legal agreements (e.g., easements, covenants, land trusts, etc.)			