PUBLIC WORKS DESIGN GUIDE

SCHERTZ

COMMUNITY • SERVICE • OPPORTUNITY

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Public Works Design Specifications

SECTION 1 – GENERAL

1.1 PURPOSE AND SCOPE

A) Every subdivision or development which requires the installation of private or public infrastructure improvements to serve the proposed subdivision or development is required to submit construction plans to ensure that the required improvements are constructed in accordance with all applicable standards of the City of Schertz Code of Ordinances, Unified Development Code (UDC), Public Works Specifications Manual, or any other codes of or manuals of the City pertaining to the construction and installation of the improvements are met. All public infrastructure construction plans shall be submitted and approved in accordance with the Unified Development Code Sec 21.4.15.

B) The purpose of this design manual and specifications is to establish standard principles, criteria, and practices for the design of infrastructure and to protect and preserve the public welfare. The design factors, coefficients, formulas, and procedures described in this document are intended to serve as guidelines for the solution and design of infrastructure.

C) Ultimate responsibility for the actual design remains with the design engineer. Applicability of the Design Guide Standards are subject to determination by the City Engineer or his/her designee.

1.2 APPEAL

A) Any departure from this manual must be approved by the City Manager or his/her designee, provided:

1) It is not detrimental to the public welfare.

2) It meets the requirements of the UDC or has an approved deviation.

3) It is based upon an engineering study performed by a Professional Engineer registered in the State of Texas.

SECTION 2 – REQUIRED SUBMISSIONS OF PLANS

2.1 PLAN REQUIREMENTS

A) PDF copy of plans and profiles for streets, alleys, sidewalks, water, sewage, and drainage shall be submitted, and bear the signature and seal of a Professional Engineer, registered in the State of Texas.

1) Construction plans shall be submitted to the City Engineer prior to or concurrently with a development application as indicated in the UDC.

2) Any set over 4 pages should include an index sheet. The preferred size of construction plans is 22” x 34” or 24” x 36” sheets (half sized plans will be 11” x 17”).

3) Plans must use and reference City of Schertz standard details.

B) The following are typical plans to be submitted. Each set of plans and what is contained in that set will be dependent upon the project scope.

1) Front end sheets should contain a cover sheet, index and quantity sheets, and City of Schertz General notes, project layout, and an Overall Utility Plan.

2) Streets and alleys will be shown in plan and profile sheets and cross-section sheets. Provide a plan sheet showing typical existing and proposed street sections detail with the proposed pavement width, type, thickness, and crown; the proposed curb or gutter type, location in relation to curbs and property lines, the proposed sidewalk dimensions, and location in relation to curbs and property lines, and the proposed parkway grading slopes. This information shall be given for each of the different types of streets and alleys in the subdivision.

3) Drainage channels, storm drain, and culverts will be shown in plan and profile sheets. Large drainage channel projects will include cross section sheets. Construction details of all drainage structures, including dimension, reinforcing and components, such as grates and manhole covers. Hydraulic grade line (HGL) will be indicated on profile. Drainage plans shall address interim (i.e. “during construction”) and final drainage plan.

4) If detention ponds or water quality ponds are part of the development or project, a plan indicating dimension, grading, outlet design, downstream protection, and stage-storage-discharge tables should be included.

5) Plans for erosion and sedimentation controls during construction shall be included as part of the construction plans and be in compliance with the Texas Pollutant Discharge Elimination System (TPDES) permitting requirements and specifications established by the City Manager or his/her designee. All land disturbing or land filling activities or soil storage shall be undertaken in a manner designed to minimize surface runoff, erosion, and sedimentation and to safeguard life, limb, property, and the public welfare.

6) Grading plan will include slab elevations, existing and proposed contours, retaining walls, spot elevations, and shall indicate drainage for all lots in the subdivision. Grading plans must include specific paths for the direction of drainage flow away from the building pads or the lots, as well as all trees to be preserved within the limits of construction. In addition, whenever drainage flow will impact existing developed land (residential, retail, or industrial), grading plans must show how the adjacent land will be impacted and how the adverse impact will be mitigated.

7) Retaining walls over four (4') feet (measured from the bottom of the foundation to top of the wall), or as required by other applicable City adopted code, require plans signed and sealed by a registered Professional Engineer registered in the State of Texas. Any retaining walls located on slope or retaining supercharged soils may require plans signed and sealed by a registered Professional Engineer registered in the State of Texas at the discretion of the City Engineer or his/her designee.

8) Utility plans for water mains less than twelve (12") inches in size will require plan sheets with associated details. Utility plans for water mains twelve (12") inches and greater will require plan and profile sheets. Section details only required at critical crossings of infrastructure. The City Engineer or his/her designee may waive this requirement or may require plan and profile sheets for smaller diameter lines in special circumstances.

9) Utility plans for sanitary sewers will require plan and profile sheets, and associated details.

2.2 ENGINEERING REPORTS

A) In addition to the plans, the following reports are to be submitted for review by the City Engineer or his/her designee. Except for the pavement design and SWPPP, these items should be submitted at the time of appropriate development application and updated for and prior to final plat, site plan, and construction plans approval. Pavement design shall be completed prior to final plat, site submittal, or construction plan submittal.

1) Geotechnical Engineering Report for pavement design.

2) Traffic Impact Analysis (TIA) as indicated in the current UDC.

3) Storm Water Management Plan Report (SWMP)

4) Storm Water Pollution Prevention Plan (SWPPP)

5) Engineering Design Report for the water system

6) Engineering Design Report for the wastewater system

B) The content and level of detail of the reports shall be as described in this manual, or as determined by the City Engineer or his/her designee. Format of submittal is a PDF file of each document.

2.3 PLAN SHEETS

A) In general, plan sheets should be oriented with north pointing up, left, or right on the sheet, with proper consideration given to existing and proposed conditions.

All plans shall require a scale, north arrow, and date. The preferred scale for plan view sheets is 1” = 20’ or 1” = 40’ or 1” = 50’. Deviation to the preferred scale may occur with the approval of the City Engineer or his/her designee.

B) A minimum of two benchmarks shall be established on and set to NAD 1983 State Plane Texas South Central FIPS 4204 feet coordinates and NAVD 1988 datum.

C) Plans sheets should include all pertinent property and right-of-way information, existing easements, proposed easements, topographical features, notes, and callout necessary for design and construction.

2.4 PLAN AND PROFILE SHEETS

The plan and profile sheets should, at the minimum, include the following:

A) All plans shall require *a* scale, north arrow, and date. The preferred scale for profile view sheets is 1" = 20' or 1" = 40' or 1" = 50' horizontal and 1" = 5' or 1" = 10' vertical. Deviation to the preferred scale may occur with the approval of the City Engineer or his/her designee.

B) A minimum of two benchmarks shall be established on and set to NAD 1983 State Plan Texas South Central FIPS 4204 feet coordinates and NAVD 1988 datum.

Indicate the location, description and elevation of benchmarks, the top of curb grade at each curb return; the centerline grade at each end and at each fifty (50') foot station of alleys and drainage ditches; the gradient of each tangent grade and the location and length of each vertical curve; the direction of storm drainage flow at each intersection; the flow line elevation of each storm sewer at each point of grade and each end and the intervening gradients.

C) The profiles of streets, alleys and drainage ditches shall show the natural ground at adjacent property lines and the proposed centerline.

D) Alignment of each street, alley, crosswalk way and drainage easement showing a beginning and ending station; each deflection angle of the centerline and the station of the point of intersection; the station of the point of curvature and the point of tangency of each curve; the station and angle of intersection of each intersection with another street, alley or drainage easement; the station and radius of each curb return; the location of adjacent right-of-way lines; the location and limits of sidewalks and curbs of each street; the location of each drainage structure; the location and size of all storm sewers; and the location of monuments.

E) All pertinent property and right-of-way information, easements, topographical features, notes, and callout necessary for design will be shown in the plan view.

2.5 SECTION SHEETS

A) When required, cross-sections shall be at every fifty-foot (50') station (minimum) drawn at a scale of 1" = 10' horizontal and vertical.

B) Section will include existing ground and existing utilities, and proposed finish ground and proposed utilities, right of way and easement limits.

SECTION 3 – STREET REQUIREMENTS

3.1 GENERAL

A) Plans for streets, alleys, sidewalks, and crosswalk ways shall be prepared in accordance with Public Works Specification Manual as well as the City's Master Thoroughfare Plan.

B) Any street design element not specifically addressed in this document shall be designed in accordance with:

1) Latest edition of Policy on Geometric Design of Highways and Streets, American Association of State Highway and Transportation Officials (AASHTO).

2) Latest edition of Highway Design Division Operations and Procedures Manual and the Standard specifications for Construction of Highways, Streets and Bridges, Texas Department of Transportation (TXDOT)

3) Latest edition of Texas Manual on Uniform Traffic Control Devices for Streets and Highways (TMUTCD)

3.2 PAVEMENT DESIGN

A) The City allows both flexible and rigid structures, as defined by the American Association of State Highway and Transportation Officials (AASHTO). Pavement design shall be based upon a geotechnical analysis of the project conditions, upon AASHTO design methods, and shall be designed by a Professional Engineer registered in the State of Texas.

B) Performance. Service life has been defined as the anticipated number of years that a pavement will be functionally and structurally acceptable with only routine maintenance. Flexible Pavements shall be designed for a 20-year service life; Rigid Pavements shall be designed for a 30-year service life.

C) Design Traffic Levels. Traffic load for the pavement design will be based upon the expected cumulative 18-Kip equivalent single axle load (ESAL) for the pavement's service life. A table of minimum values is shown below, but a pavement designer may increase the expected ESALS based on the results of a traffic study, or other unique situations as determined by the City Engineer or his/her designee.

Table 3.2A				
Flexible Pavement Design Parameters				
	18-kip ESAL	Reliability Factor, %	Std Dev	Serviceability Po/Pt
Arterials	3,000,000	90	0.45	4.2/2.5
Collectors	2,000,000	90	0.45	4.2/2.5
Local Type	1,000,000	70	0.45	4.2/2.0
Alleys/Low volume Private Streets/Fire Lane	100,000	70	0.45	4.2/2.0
Rigid Pavement Design Parameters				
	18-kip ESAL	Reliability Factor, %	Std Dev	Serviceability Po/Pt
Arterials	4,500,000	90	0.35	4.5/2.5
Collectors	3,000,000	90	0.35	4.5/2.5
Local Type	1,500,000	70	0.35	4.5/2.0
Alleys/Low volume Private Streets/Fire Lane	150,000	70	0.35	4.5/2.0

D) Resilient modulus (MR) is to be determined by the geotechnical engineer.

E) There are areas within the city limits and surrounding regions with expansive soil, water lenses, and drainage issues. It is expected that the pavement design will address those issues. Swelling soils (soils with a P.I. of 20 or more), may be treated by removal and replacement, or cement soil treatment, or drains/barriers, or combination as determined by a pavement design. Treated subgrade may be used as a structural layer in the pavement design.

F) Minimum thickness for hot mix asphalt concrete surface layer is three (3”) inches compacted depth. Minimum thickness for treated subgrade layer is six (6”) inches.

G) Minimum structural numbers will be as follows. These values are minimums, and actual values used in design will account for the design criteria above.

Table 3.2B Structural Number Level Roadway conditions		
Street Classification	Minimum	Maximum
Arterial	3.80	5.76
Collector Street	2.92	5.08
Local/Residential	2.58	4.20

3.3 STREETS LAYOUT

A) Adequate streets shall be provided by the Developer and the arrangement, character, extent, width, grade, and location of each shall conform to the City's Master Thoroughfare Plan and shall be considered in their relation to existing and planned streets, to be served by such streets, and to the topographical conditions. The location and type of traffic control device to be installed by the Developer or the City of Schertz shall be indicated on the plans. This shall include the proposal of all Stop, Yield, Speed, Parking and Movement Series signs and other devices in accordance with TMUTCD. The design of location of intersections shall take into account intersection site distance per AASHTO requirements. This specifically shall be utilized for location of intersections in relation to curves and cutbacks to prevent the location of sight barriers including signs, fences, and landscaping. See Tables 3.3G below.

B) The following specifications are required minimums. The analysis of supporting subsurface soils is to be determined and thickness of pavements to be designed by the Developer. Substitutes for street geometric or pavement thickness design shall not be less than the minimum design requirements. The minimum horizontal curve radii and vertical curves shall be assigned considering the service of the facility and the conditions of the location of the street in relation to existing and proposed features.

C) STREET GEOMETRICS

1) The following specifications are required minimums. They are not to be substituted as street geometric or pavement thickness design. The geotechnical borings and analysis of supporting subsurface soils is to be completed by the Developer and the design of the pavement structure shall be signed and sealed by a Professional Engineer registered in the State of Texas. Flexible and rigid pavements shall be designed for a twenty (20) year and thirty (30) year service life respectively. The minimum horizontal curve radii shall be designed considering the conditions of the location of the street in relation to existing and proposed features.

Table 3.3A Principal Arterials (Design Speed – 45 mph)	
Minimum right-of-way width	120-130 feet
Minimum pavement width (not including curb and gutter)	48 feet
Minimum horizontal curve radius	1200 feet
Minimum tangent between reverse curve	200 feet
Grades	Flexible Pavement 1% - 5% Rigid Pavement 0.5% - 5%
Daily Traffic Volume Limit (vehicles per day)	>34,000

Table 3.3B Secondary Arterials (including Secondary Rural Arterials) (Design Speed - 45 mph)	
Minimum right-of-way width	90 feet
Minimum pavement width (not including curb and gutter)	48feet
Minimum horizontal curve radius	750 feet
Minimum tangent between reverse curve	200 feet
Grades	Flexible Pavement 1% - 5% Rigid Pavement 0.5% - 5%
Daily Traffic Volume Limit (vehicles per day)	34,000

Table 3.3C Collectors (Design Speed – 30 mph)	
Minimum right-of-way width	70 feet
Minimum pavement width (not including curb and gutter)	38 feet
Minimum horizontal curve radius	400 feet
Minimum tangent between reverse curve	100 feet
Grades	Flexible Pavement 1% - 7% Rigid Pavement 0.5% - 7%
Daily Traffic Volume Limit (vehicles per day)	10,000

Table 3.3D Local Type Commercial/Industrial (Design Speed – 30 mph)	
Minimum right-of-way width	60 feet
Minimum pavement width (not including curb and gutter)	39 feet
Minimum horizontal curve radius	400 feet
Minimum tangent between reverse curve	100 feet
Grades	Flexible Pavement 1% - 7% Rigid Pavement 0.5% - 7%
Daily Traffic Volume Limit (vehicles per day)	5,000

Table 3.3E Local Type Residential Streets (Design Speed – 30 mph)	
Minimum right-of-way width	50 feet
Minimum pavement width (not including curb and gutter)	27 feet
Minimum horizontal curve radius	100 feet
Minimum tangent between reverse curve	50 feet
Minimum Grade	Flexible Pavement 1% - 7% Rigid Pavement 0.5% - 7%
Daily Traffic Volume Limit (vehicles per day)	1,000

2) Non-residential marginal access streets shall have a right-of-way width of at least fifty (50') feet and a pavement width of at least thirty (30') feet. Safety lanes shall have a right-of-way of at least thirty (30') feet and a pavement width of at least twenty-four (24') feet. All streets, alleys, non-residential driveways, and non-residential drive aisles shall have a minimum pavement width of twenty-four (24') feet.

3) Pavement Crown shall have a cross slope of 2% percent.

4) As allowable by State Law, the Developer shall be responsible for construction of pavement width and right-of-way dedication of streets forming part of the boundary of the subdivision adjacent as follows:

a) New adjacent collector or residential access streets shall conform to the specifications of this section.

b) Where the proposed subdivision abuts upon an existing minor arterial street or half street that does not conform to the specifications of this Section, the Developer shall be required to make the necessary dedication and improvements in conformance with the current UDC or any other applicable code of the City as allowable by State Law. With regard to paving the adjacent street, the City reserves the right to waive all or a portion of this requirement. In considering such waiver, the following factors shall be considered by the City:

1) Current condition of the roadway.

2) Current daily traffic on roadway.

3) Estimated additional daily traffic from proposed subdivision.

4) Total cost for widening roadway

5) Ability of City to finance road widening in the next several years

5) "Broken-Back" or compound curves shall not be permitted unless approved by the City Engineer or his/her designee. Reverse curves may be used provided due consideration for safe sight distance, has been shown.

6) Transitional Curves may be used where comfort and safety of the motorist will be enhanced.

7) Combination of horizontal and vertical curves shall be permitted provided sufficient sight distance is available for safe operation. Generally, horizontal curvature should be introduced on the upgrade of the vertical curve.

8) Superelevation of road is permissible when minimum horizontal curves are unattainable and when approved by City Engineer or his/her designee. Design of superelevation will follow standard engineering practices and the TXDOT Roadway Design Manual.

9) Before any pavement is laid to widen existing pavement, the existing pavement shall be cut back two (2') feet on each side to assure an adequate sub-base and pavement joint.

D) PROPERTY LINE AND CURB RETURNS

At each intersection the curb and the property line at each block corner shall be rounded with a radius, R, varying with the interior angle as specified in the following table:

Table 3.3F
Minimum Radii for Curb Returns (CR) and Property Line Returns (PLR)
Street Intersections

Interior Angles in Degrees	Two Local		Local and Collector		Two Collector		Local/Collector with Arterial		Two Arterial	
	CR	PLR	CR	PLR	CR	PLR	CR	PLR	CR	PLR
150-45	15	5	15	6	20	10	25	15	25	15
145-40	15	5	15	6	20	10	25	15	25	15
140-135	15	5	15	6	20	10	25	15	30	20
135-125	15	5	15	6	20	10	25	15	35	25
125-85	15	5	15	6	20	10	25	15	30	25
85-75	20	10	20	11	25	15	30	20	50	40
75-65	25	15	25	16	30	20	35	25	80	70
65-55	30	20	30	21	35	25	40	30	90	80
55-45	35	25	35	26	40	30	45	35	110	100
45-00	35	25	35	26	40	30	45	35	150	140

E) INTERSECTIONS

1) The preferred angle of intersection is ninety (90) degrees. Allowance for non-perpendicular intersecting angles between eighty (80) degrees and one hundred (100) degrees will be made on a case-by-case basis.

2) The following minimum sight distances shall be provided for a safe stopping and intersection operations. Development design shall be based upon actual conditions and speeds.

Table 3.3G
Minimum Stopping Sight Distance
Level Roadway Conditions

Street Classification	Sight Distance
Principal Arterial	300 ft.
Secondary Arterial and Secondary Rural Arterial	300 ft.
Collector Street	250 ft.
Local	200 ft.

3) The “sight triangle” at an intersection is that portion of a property over which motorists must see to safely judge and execute a driving maneuver into the intersection and onto the street. The distance to the approaching motorist is the “intersection sight distance”, which is one leg of the sight triangle.

The length of the required intersection sight distance shall be based on AASHTO Policy on Geometric Design of Highways and Streets. The driver’s eyes are considered to be three and one-half (3.5’) feet above pavement, and the object is considered to be four and one-half (4.5’) feet above pavement.

This applies to intersections of two (2) or more streets as well as junctions of driveways and streets.

4) Landscaping and Signing: No signs, walls or fences shall be placed in the median area other than approved traffic control devices unless approved by the City Engineer or his/her designee. No trees, shrubs or other ground cover shall be placed in the median, which will obstruct the driver’s sight distance. The area enclosed by the sight triangle must be free of visual obstructions.

5) At “T-intersections”, the minimum intersection offsets are one hundred twenty-five (125’) feet between center lines of local streets.

In the case of collector-street intersections, this offset shall not be less than two hundred (200’) feet or the minimum distance required to allow for left-turn storage between intersections, whichever is greater. The distance between intersection offsets is measured from the center line intersection of one intersecting roadway and the centerline intersection of the next intersecting roadway, measured along the centerline of the intersected roadway.

6) Right turn deceleration lanes shall be required when the daily entering right-turn traffic volume a peak hour volume greater than 50 vehicles per hour (VPH) and the approaching design hourly volume in the adjacent outside lane exceed five hundred (500) vehicle trips; at street and driveway intersections in TxDOT right-of-way at the option of TxDOT; or where unsafe conditions such as limited sight distance, high travel speed, uneven grade, etc. may exist, as determined in a TIA. Minimum turn lanes width is eleven (11’) feet.

7) Left turn lanes shall be required at all median openings on collector and arterial streets; at all driveways or streets with an average daily entering left-turn traffic volume of five hundred (500) vehicle trips; at street and driveway intersections in TxDOT right-of-way at the option of TxDOT; or where unsafe conditions such as limited sight distance, high speed, uneven grade, etc. may exist, as determined in a TIA. Minimum turn lanes width is eleven (11’) feet.

8) Turn lanes should accommodate the anticipated deceleration length and storage determined for the intersection. Lengths at signalized intersections should be determined in a TIA. Lengths at non-signalized intersections should be determined by the equation or below.

$L = (V/30) \times 2 \times S$

Where: L is storage length (ft), V is turning vehicles per hour, S is queue storage length in feet per vehicle (25).

The following table is a table of minimums values for storage and declaration; taper length may be considered part of the deceleration length. Preferred taper design is symmetrical reverse curve, per AASHTO.

Table 3.3F Minimum Deceleration and Storage for Left Turn Lanes				
Speed (mph)	Deceleration Length (ft)	Taper Length (ft)	Storage Length (ft)	
30	160	50	100	100
35	215	50	100	100
40	275	50	100	100
45	345	100	100	100
50	425	100	100	100
55	510	100	100	100

9) Site design shall take into account appropriate throat length for driveways and intersections for safe and efficient traffic operations for entry to and within the site.

F) VERTICAL CURVATURE

A gradual transition from one roadway grade to another shall be accomplished by means of a vertical parallel curve connecting two (2) intersecting tangents. The minimum length of vertical curve shall be computed from the following formula and table.

$$L = KA$$

Where: L = the length of vertical curve in feet, K = a constant related to sight distance and geometry of a parabolic curve (See Table 3.3H),
A = the algebraic difference in grades in percent.

Table 3.3G Design Value for Constant "K" Vertical Curvature		
Street Classification	"K" Crest Curves	"K" Sag Curves
Principal Arterial	70	60
Secondary Arterial	70	60
Collector Street	55	55
Local	30	40

G) CURB AND SIDEWALK REQUIREMENTS

1) PUBLIC CURB

a) With the exception of rural arterials, curb or curb and gutter shall be installed on all existing or proposed streets forming the boundary of the subdivision and internally on streets.

b) All curb or curb and gutter shall be non-reinforced unless otherwise stated. Cold joints shall be steel reinforced.

2) PUBLIC SIDEWALK

a) Sidewalks: A sidewalk or multiuse path, in accordance with the City's Master Thoroughfare Plan sections, meeting all requirements of the American Disability Act shall be required. All corner lots shall have such sidewalks on both the front and sides thereof. Concrete sidewalks having a width of not less than five (5') feet (or six (6') feet if abutting back of curb) and thickness of not less than four (4") inches shall be constructed on each side of each street within the subdivision. All curb ramps shall have a minimum thickness of six (6") inches. Said sidewalks shall allow for a minimum three (3') foot greenbelt behind back of curb, shall be one (1') foot inside of the right-of-way and shall extend along all street frontages, including the side of corner lots and block ends. Modifications to this standard are subject to approval by the City Engineer or his/her designee.

b) Where a new section of sidewalk is to connect with a sidewalk or concrete hike and bike trail previously constructed, or abuts on the curbing, an expansion joint must be made and filled as above. Reinforcing bars shall extend ten (10") inches beyond the expansion joint and the ends shall be wrapped with building paper so that the ten (10") inches shall not be bonded to the concrete. Approved types of slip joints may be used in place of wrapping ends of bars. When wire mesh reinforcing is used, three - 3/8" round smooth dowel bars not less than eighteen (18") inches in length, installed as specified above for bar reinforcing, shall be provided at each expansion joint.

c) Concrete shall have a minimum compressive strength of four thousand (4000) pounds per square inch at twenty-eight (28) days. Concrete will conform to material and proportion requirements for the concrete of Section 02751 of the Schertz Construction Specifications. Concrete, which has partially set, shall be disposed. All tests for ingredients and concrete shall be made in accordance with the applicable methods of tests of the American Society for Testing Materials (ASTM).

d) Sidewalks, curb ramps and crosswalks shall conform to all ADA requirements mandated at the time of construction. They shall have a monolithic finish and shall be floated and troweled to a uniform smooth surface, then finished with a fine-haired brush or wood float so as not to be left with a slick or glossy finish.

e) The completed sidewalks and drive approaches shall be cured in accordance with good engineering practices as approved by the design Engineer.

3) MEDIANS

a) The minimum width of a raised median is a function of purpose.

Table 3.3J
RECOMMENDED MEDIAN WIDTHS (FOC TO FOC)

Function	Minimum (feet)	Desirable (feet)
Separation of Opposing Traffic	4*	6*
Pedestrian Refuge and Space for Traffic Control	6*	16
Left-Turn, Speed Change and Storage	14	16
Crossing/Entering Vehicle Protection	20	23
U-Turns, Speed change and Storage	20	23
Channelized: “T”, Speed Change and Storage	25	23-30
*Cannot accommodate left-turn lanes, hence, such turns must be made from the through lanes.		

Source: City of Austin, Department of Public Works and Transportation Based on ITE, Guidelines for Urban Major Street Design

b) Raised median openings shall be at least twenty (20’) feet wider than the width of driveway which they are serving, with a minimum width of sixty (60’) feet.

c) Minimum separation distance between raised median openings on local roads should be based on functionality and proximity to street intersections; no closer than one hundred twenty-five (125’) feet. Minimum separation distance between raised median openings for collector and arterial streets, measured nose to nose, should provide sufficient storage and deceleration length for the rate of speed on the through traffic road.

H) ALLEYS

1) Alley right-of-way minimum shall be [twenty-four (24') feet wide and paved, see Section 21.14.4] in the UDC. Eight (8%) percent is the maximum sustained grade for an alley and shall not exceed three hundred (300') feet. Concrete pavement shall be a minimum of six (6") inches in depth – 4000 psi in commercial alleys and a minimum of five (5") inches in depth – 3000 psi in residential alleys. Alleys shall be designed based on a one hundred (100) year frequency to carry storm water from only the lots within the block abutting the alley.

2) Intersecting Alleys: Where two (2) alleys intersect or turn at right angle, a cutoff of not less than ten (10') feet shall be provided along each property or easement line.

3) Dead-end Alleys are not permitted.

I) DRIVEWAYS AND APPROACHES

1) Driveways shall be designed as a "lay-down" curb or curb and gutter or a straight driveway section. The driveway width at the property line shall not be greater than the width approved by the City Engineer or his/her designee.

2) Residential driveways ten (10') feet to twelve (12') feet in width for single, and not more than twenty-four (24') feet for double driveway apron. One (1) curb cut per residential property. Two (2) curb cuts may be allowed for circular if frontage is greater than one hundred (100') feet if approved by the City Engineer or his/her designee. No new residential driveway curb cut on collector or arterial streets will be allowed, unless lot size is greater than one (1) acre, frontage is greater than one hundred (100') feet, traffic study indicates no impact, and maneuvering is done off street for turn-around.

"Back out" driveway access to collector and arterial streets is not allowed.

3) Non-residential driveway access width should be between twenty-four (24') and forty (40') feet measured at the right-of-way.

4) Non-residential approaches shall have the minimum spacing requirements identified in UDC Article 14.5 Spacing of approaches shall be measured from the start of curve/taper to start of curve/taper along the curb line. If the minimum spacing cannot be achieved, then use of a common access easement will be required for adjacent properties to share drive approaches and minimize the number of drive approaches along collector and arterial streets.

5) Minimum distance of an approach from the corner/flare of an intersection shall be one hundred twenty-five (125') feet or the length of the turn lane for the intersection. The distance shall be measured from the curb return or start of taper/curve of the pavement as it widens next to the intersecting street to the edge of the driveway. A lesser distance may be approved by the City Engineer, or his/her designee provided a TIA demonstrates the lesser distance still maintains safe traffic flow on the street and site. If the minimum distance cannot be met, then use of a common access easement will be required.

6) Frontage measured from property line to property line, or from corner/flare of intersection to property line.

7) Drive approaches shall meet all criteria as minor intersection concerning sight distance and stopping distances to ensure a safe facility.

8) Driveway aprons within the City Limits shall be reinforced concrete per City standard details, unless otherwise approved by the City Engineer or his/her designee.

9) The site design shall take into account appropriate throat length for driveways and intersections for safe and efficient traffic operations for entry to and within the site.

J) FIRE LANES

1) A fire lane is interpreted as a private or public, hard-surfaced, all-weather material (asphalt or concrete), driving surface constructed specifically for the use of emergency vehicles.

2) Fire and safety lanes shall meet standards of the UDC Article 14.1.M.

3) Dead-end fire lanes are not permitted, unless approved by the Fire Chief or his/her designee.

K) CUL-DE-SAC TURNAROUND

1) Cul-de-sac turnarounds shall meet the criteria set forth in the UDC Section .14.1.E.

2) "Knuckle" or elbow intersections with bulbs herein and UDC requirements of intersection angles and curb return radii.

L) STREET LIGHTS

Street lights in new subdivisions within the City Limits and the annexed areas of the City shall be in accordance with the UDC Article 14.1.S.

M) STREET MARKERS

1) Two street name signs shall be erected at all street intersections in subdivisions for street markers:

a) The material of the street name signs, the method of attaching the sign to the post, the details of lettering, painting, and method of installation, as well as the location of the sign at the intersection, shall be in accordance with the specifications on file at the appropriate entity (i.e., City of Schertz, TxDOT, etc.)

b) Construction plans shall include layout of all traffic control devices in accordance with the TMUTCD.

c) All street signs in a new subdivision within the City limits, including street name, speed limit, stop and yield signs, etc. shall be paid for by the Developer and shall be provided by and installed by the City's Public Works Department in accordance with the Public Works Specifications Manual. Traffic Control Devices shall be installed in accordance with the latest revision of the Texas Manual on Uniform Traffic Control Devices for Streets and Highways. Street signs within TxDOT right-of-way shall be installed according to the appropriate standards by the Developer (as permitted by TxDOT).

2) All pavement markings shall be thermoplastic or preformed tape. Follow TMUTCD and TxDOT standards and guidance for marking standards. The following Pavement markings are required

a) Arterials: centerline striping, lane lines, turn bay islands, reflective pavement markers, edge lines for non-curbed streets, and bike lanes.

b) Collectors: centerline striping, lane stripping, edge lines for non-curbed streets, and bike lanes.

N) REMOVING AND REPLACING PAVEMENTS, CURBS, AND GUTTERS, DRIVEWAYS, AND SIDEWALKS

1) Scope: The Technical Specifications and Standard Details shall govern for all work necessary to complete the removing and replacement of all types of pavements, curbs and gutters, driveways, and sidewalks as required to complete the project.

2) Method of Cutting: The outline of the trench shall be marked on the surface to be cut. The cut shall be made as nearly vertical as possible. The excavated pavement or concrete shall be removed from the site and disposed of by the contractor.

3) Ashpaltic Pavement: Repair to be five (5') feet on each side wider than ditch excavation. Sawcut shall be vertical and perpendicular to flow of traffic for trenching across street. Any asphalt repair needed more than five (5') feet from the curb and gutter, or edge of payment will require the asphalt repair limits to extend the entire width of the roadway unless a smaller repair area is specifically permitted by the City Engineer or his/her designee.

3.4 MINIMUM TESTING REQUIREMENTS

A) GENERAL

All materials to be used in subdivision construction shall be subject to testing. The preponderance of testing to be performed in subdivisions is directly related to street construction. A series of laboratory tests normally associated with road and street construction will be required in subdivisions, with said tests being performed by an independent testing laboratory using qualified personnel. The design (or consulting) engineer or his designated representative shall be present at all testing activities. The Developer or his/her designee is responsible for scheduling and payment. The passing test results shall be received prior to commencing additional construction activities and after two (2) days of inactivity on the tested material, new testing may be required.

The Developer shall notify the City at least one (1) week prior to the contractor beginning construction. Contractor shall be required to notify the City a minimum of at least forty-eight (48) hours in advance of all testing being performed.

B) Sub-grade materials shall be compacted by approved mechanical tamping equipment to an apparent dry density as determined by the ASTM 698 or TEX-114-E compaction test made in accordance with the procedure outlined in the Texas Highway Department Testing Manual. If the material fails to meet the density specified, it shall be reworked as necessary to obtain the density required.

C) When a fill or embankment is required to achieve the prescribed sub- grade, or structural elevation, such fill shall be placed in uniform lifts covering the entire width of the cross-section. Prior to compaction, the layers shall not exceed a six (6") inch loose lift depth where pneumatic tire rolling is to be used and shall not exceed eight (8") inches in loose lift depth for rolling with

other types of rollers. Each lift shall be compacted to the required density before succeeding lifts are placed. Lifts shall be compacted to not less than ninety-five (95%) percent of the maximum dry density as determined by the ASTM 698 or TEX-114-E compaction test made in accordance with the procedure outlined in the Texas Highway Department Testing Manual

D) Swelling soils (soils with plasticity index of twenty (20) or more) shall be treated by removal and replacement, or cement or lime soil treatment, or drains/barriers, or combination as determined by a pavement design or other City requirements. Developers must provide the City with lab reports on soil conditions.

E) Flexible base materials shall be compacted by approved mechanical tamping equipment to an apparent dry density of the total material of not less than ninety-five (95%) percent of the maximum dry density as determined by the TEX-113-E compaction test made in accordance with the procedure outlined in the Texas Highway Department Testing manual. If the material fails to meet the density specified, it shall be reworked as necessary to obtain the density required.

F) Each course of six (6") inches or less shall be compacted to full required density before succeeding layers are placed.

Table 3.4A Ratio of Testing	
Subgrade	Minimum 1 per 100 ft. of street (each lift)
Under Curb/Gutter	Minimum 1 per 100 ft. of curb (each lift)
Base	Minimum 1 per 100 ft. of street (each lift)
Embankment (Street)	Minimum 1 per 100 ft. of street (each lift)
Embankment (Berm or Structural)	-1 per lift per 10,000 sq. ft. -1 per lift per 100 ft. berm
Proctors (Moisture-Density Relationship)	
Subgrade (raw) and Embankment	-1 per material type per source, minimum 2 per subdivision (NOT VALID AFTER 1 YEAR)
Note: Testing frequencies double for pavement widths wider than 38'	

Table 3.4B Atterberg Limits & Graduation Hot Mix Control	
Surface Course Design	1 per subdivision
Base Course Design	1 per subdivision
Extraction	2 per day/run minimum – 1 per 500 ton
Densities	1 per 1,000 ft. of street

G) CONCRETE PAVING

1) GENERAL

Plant Certification Required

Testing shall be as required in City Technical Specification Section 02751. In the event of failures, additional tests will be taken. If excessive rain occurs on a previously tested section, the City shall have the right to order retests as necessary.

2) The Developer shall notify the testing lab when tests are to be taken. If it is necessary to retest, such retesting shall be at the Developer's expense. The scope of testing of materials incorporated in subdivision construction is not necessarily limited to those tests outline above. In the event of unusual conditions or factors which may give the City reason to question the quality of the materials in any portion of the subdivision, the City will have the right to order such additional tests as are necessary.

3) All testing within these requirements will be performed in accordance with the American Society of Testing Materials (ASTM) latest revision, and/or as elsewhere provided in approved plans and specifications for the subdivision. The City will require all subdivision test reports to be certified by a professional engineer registered in the State of Texas and will further require that the City be furnished with copies for all testing reports.

SECTION 4 – STORM DRAINAGE REQUIREMENTS

4.1 GENERAL

A) All drainage facilities (including, but not limited to curb and gutter, inlets, pipes, and channels), shall be designed to intercept and transport runoff from a minimum twenty-five (25) year frequency storm. The drainage system shall also be designed to intercept and convey flows greater than a twenty-five (25) year frequency, up to and including a one hundred (100) year frequency storm within defined rights-of-way of drainage easements. All detention structures shall be designed to contain the one hundred (100) year frequency storm. Peak discharge flows shall not be increased from the pre-development flows for the 2-, 5-, 10-, 25-, and 100- year frequency storm. Channels with drainage areas over one hundred (100) acres or areas within a designated floodplain shall be designed for a one hundred (100) -year storm or a twenty-five (25)-year storm plus freeboard (see Table 4.5E) if that elevation is higher.

B) Three (3) development conditions shall be analyzed for each development.

1) Existing Conditions. This refers to current development conditions in the watershed and on-site. Use as the baseline analysis for determining the impact of development.

2) Proposed Conditions. This refers to existing conditions with the proposed development added. Use to determine if the increased runoff from the proposed development results in an adverse impact to other properties.

3) Ultimate Conditions. This refers to ultimate development conditions within the watershed used to design the drainage facilities. This condition may be used in-lieu of subsection (2) above, to determine if the increased runoff from the ultimate watershed development results in an adverse impact to other properties.

C) RESPONSIBILITY TO ACCEPT STORM WATER

The owner or Developer of property to be developed shall be responsible for the conveyance of all storm water flowing through the property. This responsibility includes the storm water flowing onto the property by any other developed property as well as the drainage naturally flowing through the property by reason of topography. Future upstream development shall be accounted for by assuming ultimate development when sizing drainage systems as specified in this section.

D) POSITIVE OVERFLOW PATHWAYS

Storm water management facilities for local drainage systems will be designed to ensure that a positive overflow pathway is provided to the nearest one hundred (100) year conveyance facility. The overflow pathway must be delineated on a plan that shows all existing structures in the vicinity impacted by the overflow pathway.

E) MAINTENANCE

1) Maintenance of publicly owned facilities will be the responsibility of the City. Maintenance of private facilities is the responsibility of the property owner or the community association and must be specified in the maintenance schedule submitted to the City. A maintenance schedule for privately owned facilities must be approved by the City Engineer or his/her designee. along with the approval of construction drawings.

2) Authorized personnel from the City may conduct periodic inspections of these facilities and structures. Any required repairs will be consistent with current construction standards. Maintenance issues identified by the City or State during inspections shall be the responsibility of the current owner.

F) DEVELOPMENT

Peak storm water runoff rates from all new development shall be less than or equal to the peak runoff rates from the site's predevelopment conditions for the 2-year, 5-year, 10-year, 25-year, and 100- year design storm events, except as provided in subsection A, above. Discharge from developed property shall mimic other pre-developed discharge flow characteristics as much as possible so as not to cause adverse impact to downstream property.

4.2 FLOOD HAZARDS

A) New development within the FEMA designated special flood hazard areas will follow the City's Flood Damage Prevention Ordinance, and the requirements of CFR 44.60.3 whichever is more stringent.

B) New subdivisions having a portion of that subdivision subject to the special flood hazards shall dedicate on the plat a drainage easement fully containing the one hundred (100)- year one (1%) percent annual chance) special flood hazard area. If not already determined, the new subdivision shall determine the base flood elevations of the 100-year event for that portion of the special flood hazard area within the subdivision. This must be based on a certified engineering study survey taking into consideration the full development of the watershed.

C) Proposed subdivisions shall be reviewed to assure that all such proposals are consistent with the need to minimize flood damage and that all public utilities and facilities such as sewer, gas, electrical and water systems are located, elevated, and constructed to minimize or eliminate flood damage and adequate drainage is provided so as to reduce exposure to flood hazards.

D) New or Replacement water supply systems and/or wastewater systems shall be designed to minimize or eliminate infiltration of flood waters into the system, discharges from the systems into flood water, and to require on-site waste disposal systems to be located above the base flood elevation so as to avoid impairment or contamination from them during flooding.

E) Preservation of the natural floodplain and native vegetation contained therein is encouraged. Understory growth which impedes flow may be

cleared within the bank of watercourses within the proposed development with City approval however, the alteration of natural vegetation or unique features with diameters greater than eight (8") inches is discouraged and shall follow the requirements for tree removal in the UDC Article 21.9.9.H. Lower branches of large trees may be trimmed to provide a vertical clearance of eight (8') feet. The alteration of natural vegetation or unique features within the floodplain of watercourses is discouraged and must be explicitly permitted.

F) Upon acceptance by the City of Schertz of Public Utilities, Streets and Drainage, it shall be the responsibility of the homebuilder and/or lot owner to maintain all erosion and sedimentation controls to prevent sedimentation onto any public right-of-way and/or adjacent owner's lots. Failure to comply shall result in a stop work order of all construction on lots owned by the landowner or homebuilder.

4.3 STORM WATER MANAGEMENT PLAN

A) As part of the subdivision platting and construction plan review process, an analysis of existing drainage conditions and the design of modifications or new drainage facilities is required. The owner of the property to be developed is required by the City Engineer or his/her designee to provide, at the owner's expense and as a condition of approval, a Storm Water Management Plan (SWMP) for the total development area to be ultimately constructed. The SWMP shall be submitted to the City Engineer or his/her designee prior to approval of any construction plans.

B) CONTENTS OF THE SWMP

The SWMP shall contain all necessary support data, methodologies used in calculations and conclusions. A checklist (at the end of this section) will be used by the City Engineer or his/her designee as a guide during the evaluation of all SWMP reports submitted to the City. The purpose of the checklist is to expedite the review process for both the engineer and the City, and to aid the engineer in the preparation of reports for the City's review.

A storm water management concept plan or preliminary drainage plan should be submitted with master development plan or preliminary plat. The concept plan should detail in concept how runoff and associated water quality impacts resulting from the development will be controlled or managed. It should address the pre, post and ultimate development conditions of the watershed. The plan should be labeled "Concept" or "Preliminary".

The final SWMP should be submitted with all other submittals including but not necessarily limited to, a final plat, minor plat, site plan, grading and clearing permit or building permit. In addition to the information from the preliminary or concept plan, shall include all information required in the final Storm Water Management Plan (SWMP) checklist (at the end of this section), including construction details.

C) In general, the Final Storm Water Management Plan should contain the following (for details see the checklist at the end of this section):

1) The contact information for the owner of the property or properties affected.

2) A vicinity map of the site and affected reach of the outfall channel.

3) On topographic base map, a detailed map of the area and the outfall channel(s) with all pertinent physiographic information, with two (2') foot contours.

4) A watershed map showing the existing and proposed drainage area boundary along with all sub area delineations and all areas of existing and proposed development; indicate locations of all rights-of-way and additional easements/rights-of-way required, flow path to nearest downstream 100-year structure.

5) All hydrologic and hydraulic calculations: specifying methodology and key assumptions used to include a table of discharges at key locations; hydraulic calculations specifying methodology used, assumptions and values of the design parameters.

6) Profiles of the affected channels, including water surface elevations for the specified design frequencies, all existing and proposed bridge, culvert, and pipeline crossings, the location of all tributary and drainage confluences, and the location of all hydraulic structures.

7) Detention basin design calculations, including those used for design of the control structure and construction details.

8) Additional back-water analysis data as described in the checklist.

9) Certification by a Professional Engineer registered in the State of Texas that the result of the proposed development will not produce an adverse impact to downstream properties, structures, drainage facilities, and public infrastructure.

10) Soils map indicating the type of soil and hydrologic group.

11) Maintenance and repair plan for permanent best management practices (BMPs) and a maintenance agreement for on-site storm water management measures.

12) Erosion and sediment control plans or A Storm Water Pollution Prevention Plan (SWPPP) including erosion and sediment control plans for construction.

13) Additional information as requested by the City Engineer or his/her designee, including but not limited to, digital copies of models and digital copies of detailed drawings (dxf or dwg format).

14) Other Environmental Permits as required by local, state, or federal rules.

4.4 WATER QUALITY

A) Post construction storm water quality will eventually be regulated for the quality of the water discharged. There are currently no quantitative limits for post construction water quality of discharge, however post construction BMPs are strongly encouraged, and consideration should be given to provide suitable designs to not prohibit the retrofitting of facilities to meet future water quality monitoring and discharge needs.

B) In accordance with the City of Schertz Construction Storm Water Management Ordinance and Section 01410 of the Construction Technical Specifications, no person shall be granted a Grading and Clearing Permit or Construction Permit for land-disturbing activity without the approval of a Storm Water Pollution Prevention Plan (SWPPP) report and plans.

1) The SWPPP follow the requirements of the Construction Storm Water Management Ordinance and shall include:

a) Each application shall bear the name(s) and address(es) of the owner or Developer of the site and of any consulting firm retained by the applicant together with the name of the applicant’s principal contact at such firm, and the designated operator as defined by TPDES General Permit.

b) A natural resources map identifying soils, forest cover, and resources protected by the local, state, and federal regulations.

c) A sequence of construction of the development site, including stripping and clearing, rough grading, construction of utilities, infrastructure, and buildings, and final grading and landscaping. Sequencing shall identify the expected date on which clearing will begin, the estimated duration of exposure of cleared areas, areas of clearing, installation of temporary erosion and sediment control measures, and establishment of permanent vegetation.

d) All erosion and sediment control measures necessary to meet the objectives of the City's regulations throughout all phases of construction and after completion of development of the site. Depending upon the complexity of the project, intermediate plans may be required at the close of each season.

e) Seeding mixtures and rates, types of sod, method of seedbed preparation, expected seeding dates, type and rate of lime and fertilizer application, and kind and quantity of mulching for both temporary and permanent vegetative control measure.

f) Provisions for maintenance of control facilities, including easements and estimates of the cost of maintenance, dust control and cleaning, stockpile protection, etc.

2) Major amendments of the SWPPP must be submitted for approval.

3) In addition to the report, appropriate details, and instructions to be included with the construction plan set.

4) Copies of all submittals to the Texas commission on Environmental Quality (TCEQ), including the notice of intent (NOI) and notice of termination (NOT) shall be submitted.

4.5 STORM DRAINAGE DESIGN CRITERIA

A) METHOD OF COMPUTING RUNOFF

1) The preferred method for computing storm water runoff shall be a unit hydrograph method such as WinTR-20, WinTR-55, HEC HMS models, or some other method provided it is acceptable to the City Engineer or his/her designee. The Modified Rational Method is not allowed.

2) For small urban drainage areas less than fifty (50) acres where hydrographs are not required, for storm sewer inlets, for roadside

ditches, for driveway culverts, or for “peak flow only” calculations, the basis for computing peak flow runoff may be the Rational Method. The Rational Method is not allowed for the design or detention ponds nor channels within the FEMA designated special flood hazard area. The Rational method may not be used if the time of concentration exceeds twenty (20) minutes.

3) Normal depth channel calculations are permissible for constructed open channels with a uniform geometric cross section where there is no potential for the water surface elevations to be controlled by backwater and the channel is not in a FEMA special flood hazard area.

4) Hydraulic calculations for open channels with non-uniform geometric cross sections shall be performed by using the HEC- RAS "River Analysis System" computer models, or other method approved by the City Engineer or his/her designee.

B) TIME OF CONCENTRATION

1) Sheet flow, shallow concentrated flow and channel flows are components that need to be considered in the calculation of time of concentration. The following methods are recommended for time of concentration calculation. The total time of concentration (the sum of the three (3) components described below) shall be a minimum of five (5) minutes.

a) Sheet flow - flow over plane surfaces based on NRCS method and roughness coefficients for sheet flow. Maximum allowable time is twenty (20) minutes for sheet flow, or a maximum distance of one hundred (100’) feet.

b) Shallow concentrated flow – Use NRCS method to estimate travel time for shallow concentrated flow.

c) Channel flow: Use existing computer models where available or Manning's equation if data is not available. Open channels are assumed to begin where surveyed cross section information has been obtained, where channels are visible on aerial photographs, or where blue lines (indicating streams) appear on USGS quadrangle sheets.

C) RUNOFF COEFFICIENTS

Runoff coefficients (C value) for use in the Rational formula shall not be less than the values shown in Tables 4.5A as appropriate.

Table 4.5A
Runoff Coefficients (C)

Character of Area	Slope			
	Up to 1%	1% to 3%	3 to 5%	Over 5%
Business or Commercial Area (90% or more Impervious), Existing Pavement/Buildings	.95	.96	.97	.97
Densely Developed Area (80% to 90% Impervious)	.85	.88	.91	.95
Closely Built Residential Area and School Sites	.75	.77	.80	.84
Large Lot Residential Area	.55	.57	.62	.64
Average Residential Area	.65	.67	.69	.72
Undeveloped Areas				
Undeveloped and Ultimate Land Use is Unknown	.68	.70	.72	.75
Cultivated or Range (Grass Cover <50% of Area)	.44	.47	.49	.53
Range (Grass Cover <50% of Area)	.37	.41	.49	.53
Forest or Range (Grass Cover >75% of Area)	.35	.39	.47	.52

1) In all cases, wet antecedent conditions shall be assumed. Runoff rates shall be computed based on the ultimate development of the entire watershed to the proposed subdivision. For determination of time for concentration, times shall be figured on the basis that there shall be an improved drainage system upstream from the point under consideration.

D) RAINFALL INTENSITY

National Oceanic and Atmospheric Administration (NOAA) Atlas 14 Precipitation frequency data should be used. Tables of rainfall intensity-duration-frequency for the precipitation areas across Schertz are provided in Appendix A of this document. If a site is located within more than one precipitation area, it is acceptable to use the higher intensities for the entire site.

E) NRCS/SCS CURVE NUMBERS

For the NRCS method, the rainfall distribution type III shall be used in the runoff model and shall be in accordance with the San Antonio River Basin standards for analysis. Design rainfalls values listed in Appendix A shall be used for hydrograph calculations. The NRCS/SCS curve numbers adopted for use by the City of Schertz are shown in Table 4.5B. The hydrologic soil groups are listed in the latest version of the United States Natural Resources Conservation Service, "Urban Hydrology for Small Watersheds", Technical Release No. 55 (TR 55), which document is hereby incorporated by this reference. Soil types that relate to the hydrologic soil group may be found in the latest version of the United States.

Natural Resources Conservation Service Soil Surveys for Bexar, Guadalupe and Comal Counties, Texas which documents are hereby incorporated by this reference. Soil types may also be based on a Geotechnical Engineering Report. Alternative curve numbers may be approved by the City Engineer or his/her designee.

Table 4.5B
NRCS (SCS) Curve Numbers

Cover Type and Description	Curve Number for Hydrologic Soil Group			
	A	B	C	D
Open Space (lawn, parks, golf courses, cemeteries, etc.)				
Poor condition (grass cover, < 50%)	68	79	86	89
Fair condition (grass cover 50% to 75%)	49	69	79	84
Good condition (grass cover > 75%)	39	61	74	80
Impervious areas				
Paved parking lots, roofs, driveways, etc., (excluding ROW)	98	98	98	98
Streets and roads				
Paved curbs and storm sewers (excluding ROW)	98	98	98	98
Paved open ditches (including ROW)	83	83	89	93
Gravel (including ROW)	76	85	89	91
Dirt (including ROW)	72	82	87	89
Pasture, grassland, or range – continuous forage for grazing, 50%–75% ground cover and not heavily grazed	49	69	79	84
Meadow – continuous grass, protected from grazing and generally mowed for hay	30	58	71	78
Brush – brush-weeds grass mixture with brush the major element > 75% ground cover	30	48	65	73
Woods -- grass combination (orchard or tree farm). CN's shown were computed for areas with 50% woods and 50% (grass/ pasture) cover	32	58	72	79
Woods – protected from grazing and forest litter and brush adequately cover the soil	30	55	70	77
Farmsteads -- Buildings, lanes, driveways, and surrounding lots	59	74	82	86

3) Percent Impervious Cover. The percent impervious cover for typical land use types (as opposed to lots) in Schertz are presented in Table 4.5C.

Table 4.5C
NRCS (SCS) Curve Numbers by Impervious Cover and Cover type

Cover Type and Description	Average % Impervious Cover	Curve Number for Hydrologic Soil Group			
		A	B	C	D
Commercial and business	85	89	92	94	95
Industrial	72	81	88	91	93
Residential: 1/8-acre lot or less (townhouses) average lot size	65	77	85	90	92
Residential: 1/ 4-acre average lot size	38	61	75	83	87
Residential: 1/3-acre average lot size	30	57	72	81	86
Residential: 1/2-acre average lot size	25	54	70	80	85
Residential: 1-acre average lot size	20	51	68	79	84
Residential: 2-acre average lot size	12	46	65	77	82

F) DESIGN RAINFALL DISTRIBUTION

1) Design Rainfall. A twenty-four-hour rainfall distribution shall be applied for runoff calculations. NOAA Atlas 14 Design Rainfall Values for the precipitation areas across Schertz are provided in Appendix A of this document and should be used for HEC-HMS input. If a site is within more than one precipitation area, it is acceptable to use the higher depth values for the entire site. The lag value for a subarea shall be calculated as 0.6 times the time of concentration. Facilities with watersheds greater than one hundred (100) acres must be designed for the 100-year frequency storm or the 25-year event plus freeboard (see Table 4.5E), unless otherwise stated below.

2) Routing of Runoff. Routing of the runoff hydrograph through the channel from one subarea calculation point to the next in the HEC-HMS shall be computed using one of the following methods:

a) Overbank/channel storage not significant: use normal depth channel routing.

b) Overbank/channel storage is significant: use the Muskingum method where a hydraulic model is not available. Use Modified Puls Storage method where a hydraulic model is available to develop storage/out flow relationship.

c) Kinematic wave method for channel reaches where inflow from overbank runoff or multiple point sources (Example: storm sewer outfalls) is significant and where hydrograph attenuation is insignificant. Channel routing methodologies currently being applied in the existing HEC-HMS model of the watershed shall not be replaced with a different methodology without approval or direction from the City Engineer or his/her designee.

G) STREETS

1) GENERALLY

a) Design of streets shall consider public safety and limit potential conflicts between storm water conveyance, traffic, parking, pedestrian access, ADA requirements, and bicycle traffic.

b) Streets and associated drainage facilities, draining a watershed greater than one hundred (100) acres must be designed for the 100-year frequency storm.

c) Streets may be used for storm water drainage only if the calculated storm water flow does not exceed the criteria herein and/or the velocity does not exceed ten (10') feet per second.

d) Where streets are not capable of carrying storm water, as outlined above, inlets or curb openings discharging to drainage channels or storm sewers shall be provided. Partial flow past the inlet will be allowed when the capacity of all downstream street systems can accommodate the flow.

e) Street width shall not be widened beyond the width as determined by the street classification for drainage purposes.

f) Storm water conveyance on streets shall be designed to account for the cumulative impact of peak flows and runoff volumes on the system as the storm water progresses downgrade.

g) Curb cuts for driveways on all streets shall be designed for compatibility with the storm water conveyance function of streets.

h) Potential flooding problems or conflicts at the connection points where new or modified drainage systems (including streets, storm sewers, etc.) and the existing portions of the downstream street system and storm water conveyance system shall be identified and resolved either in the design of the new or modified drainage system or in modifications to the existing system.

i) Structures located on the downhill side of a T- intersection shall be sited to avoid obstruction of the drainage discharge from the street (including the case of a blocked or otherwise ineffective inlet) or channel flow patterns.

2) An arterial street is a street designated as such on the City's Master Thoroughfare Plan. One (1) lane in each direction on arterial streets shall remain clear during a twenty-five (25)-year storm event. The maximum depth of water in the street section must not exceed seven (7") inches (the height of a standard city curb).

3) A collector street is a street designated as such on the City's Master Thoroughfare Plan. One (1) lane on collector streets shall remain clear during a twenty-five (25)-year storm event. The maximum depth of water in the street section must not exceed seven (7") inches (the height of a standard city curb).

4) Local Streets. Local streets shall be designed on a basis of a twenty-five (25) - year frequency. The maximum depth of water in the street section must not exceed seven (7") inches (the height of a standard city curb). A one hundred (100) -year frequency storm must be contained within the street right-of-way.

5) CULVERTS AND BRIDGES

a) Where streets cross existing or proposed watercourses, culverts or bridges shall be adequate to allow passage of twenty-five (25)-year design storm. In the instance the crossing conveys runoff from a watershed greater than one hundred (100) acres, then culverts or bridges shall be adequate to allow passage of the one hundred (100)-year design storm.

b) All crossings, culverts and bridges shall be designed for an HS—25 or equivalent loading.

H) CHANNELS

1) This section addresses proposed improvements or modifications to drainage channels and watercourses required to convey storm water runoff from or through the proposed development.

2) Except as authorized by a development plan approved by the City Engineer or his/her designee, no person shall place or cause to be placed any obstruction of any kind in any watercourse. The owner of any property within the city, through which any watercourse may pass, shall keep the watercourse free from any obstruction not authorized by a development plan.

3) CHANNEL MODIFICATIONS

a) Modifications to existing watercourses or newly created open channels may be designed as earth channels, sod channels or as concrete lined, or otherwise hard armored channels. Liners other than sod or concrete which enhance the aesthetics or habitat value of the watercourse, and which reduce future maintenance requirements are encouraged. Preliminary planning for the applicability of other channel liners shall be reviewed with the City Engineer or his/her designee prior to the submittal of construction plans for approval.

b) Runoff that results from upstream development and is discharged to an unimproved waterway can cause flood damage to properties adjacent to the waterway. Natural undeveloped waterways do not receive regular maintenance. Design of natural waterways shall take into consideration fluvial geomorphologic principles and practices. Consulting engineers and development review officials shall work to resolve potential downstream impact issues.

4) Design of new channels or alterations to existing channels shall consider future maintenance requirements. A maintenance schedule for any private channel shall be submitted to and approved by the City Engineer or his/her designee prior to approval of construction plans. Maintenance requirements of concrete channels consist of de-silting activities, prevention of vegetation establishment in construction joints, and repair of concrete as necessary. Maintenance of earthen channels includes regular observation and repair, as necessary, of erosion, scouring, and removal of silt deposits, as necessary to maintain design parameters. Developers shall be responsible for maintaining newly planted channels until

coverage is established throughout eighty- five (85%) percent of the area. This area shall include slopes, floor, and any attendant maintenance easement. New earthen channels shall be planted with drought resistant, low-growth, native species grasses, which will allow unobstructed passage of floodwaters. Johnson grass, giant ragweed and other invasive species shall not be allowed to promulgate in channels. Suggested species shall include, but not be limited to, common bermuda, buffalo grass, side oats grama, seep muhly, little bluestem, and Indian grass. Mowing frequencies vary with the vegetation growth rates but is required when the grass exceeds the design roughness coefficient of the channel.

5) Planned multiple use of a watercourse is allowed (e.g. bike paths or greenbelt). If multiple use of the watercourse is to be incorporated, the applicant shall form a community association that shall assume maintenance responsibility for private amenities. The appropriate government agency will be responsible for maintenance of public amenities. The applicant shall provide overlay easements for public or private use.

6) Table 4.5D shall be used to determine maximum permissible channel velocity.

Table 4.5D
Velocity Control

Velocity	Type Drain Required	Hydraulic Radius	Correction Factor	Max. Permissible Velocity
1 to 6 fps (Maximum Average Velocity = 6 fps)	Grass Lined Channel	0-1 ft 1-3 ft 3-5 ft 5-8 ft 8-10 ft Over 10 ft	0.8 0.9 1.05 1.15 1.225 1.25	5 fps 5.5 fps 6.3 fps 6.9 fps 7.35 fps 7.5 fps
6 to 8 fps	Concrete retards required	N/A	N/A	N/A
8 fps and over	Concrete lining or Drop Structures Required	N/A	N/A	N/A

a) Where velocities are in the supercritical range, allowance shall be made in the design for the proper handling of the water by the design of energy dissipaters at the outfall, and the lining of the channel, and the inclusion of freeboard.

b) Ensure that the channel will contain the hydraulic jump (sequent depth) throughout the extent of the supercritical profile. An exception to this criterion is where concrete lined lateral channels discharge down the side slopes of channels. These channels may be designed for normal depth plus freeboard provided velocity controls are established at the main channel flow line.

c) Ensure that the energy grade of the channel will not result in upstream flooding at existing or proposed lateral facility connections.

7) Retard spacing shall be computed as using the following equations and subject to the Velocity Control standards in Table 4.5D:

$L = 1.0 \div (S1 - S2)$

Where: L = Distance required between retards in feet.
S1 = Actual slope of channel in ft./ft.
S2 = Slope of proposed channel for maximum permissible velocity established from Table 4.5F. For example:
$S2 = [V \div (1.486 * n * R^{2/3})]^2$
Where:
V = maximum permissible velocity established from Table 4.5F
n = .035, manning's roughness coefficient for grass lined channel
R = area/wetted perimeter

8) Concrete Lined Channels. The design of concrete lined channels shall comply with the following general requirements:

a) Freeboard consistent with Table 4.5E will be applied to the twenty-five-(25) -year design.

Table 4.5E
Drainage Freeboard for Concrete Lined and Earth Channels for 25-Year Storm

Design Depth of Flow	Required Freeboard
0-5 ft	0.5 ft
Over 5 ft	1.0 ft

b) From the top of the concrete lining to the top of the ditch, a side slope not steeper than four (4) horizontal to one (1) vertical shall be required; nor shall the slope be less than twelve to one (12:1).

c) For normal conditions, the concrete lining shall be a minimum of five (5”) inches thick and reinforced with No. 3 round bars at twelve (12”) inches on center each way. Where surcharge, nature of ground, height, and steepness of slope, etc., become critical, design shall be in accordance with latest structural standards. All concrete lining shall develop a minimum compressive strength of not less than three thousand (3,000) pounds per square inch in twenty-eight (28) days. The depth of all toe downs shall be thirty-six (36) inches upstream, and eighteen (18) inches for side slopes. The City's Engineering Inspector may permit an eighteen (18”)-inch toe down in rock sub grade in lieu of the above toe down requirements. The horizontal dimensions of toe downs shall not be less than six (6”) inches.

d) Maximum concrete riprap side slopes shall be one and one-half (1-1/2) horizontal to one (1) vertical, unless soil tests made by a geotechnical engineer show that a greater slope, or a special design, will be stable. Where vehicular traffic may travel within a horizontal distance equal to one-half (1/2) the vertical rise of the slope, a two (2’)-foot surcharge load shall be included in the design.

e) Fencing (or other approved safety barrier) will be required adjacent to the channel where channel vertical wall heights exceed two (2’) feet. Fencing or barrier will also be required adjacent to the channel where channel side slopes exceed three to one (3:1) and the channel depth is greater than two (2’) feet. The barrier must not cause sight distance problems for motorists.

f) Easements or rights-of-way for concrete lined channels shall extend a minimum of two (2’) feet on both sides of the extreme limits of the channel. "Extreme limits" of the channel shall mean the side slope intercept with the natural ground or proposed finished ground elevation. This two (2’) foot space shall be constructed of concrete or some other maintenance free material.

g) A minimum "N" value of roughness coefficient of 0.015 shall be used in Manning's formula. Recommended “N” are available in Table 4.5F below. For approval to alter, contact the City Engineer or his/her designee.

h) Channel shall have a bottom width of eight (8') foot minimum with a vehicular access point of seven (7) horizontal to one (1) vertical slope at least every one thousand (1000') feet. For channels less than eight (8') foot bottom width, a fifteen (15') foot wide access road is required adjacent to the channel.

Table 4.5F Manning's Roughness Coefficient "N"	
Channel Description	"N" Value
Concrete Lined Channel	0.015
Grass Lined Channel with Regular Maintenance	0.035
Grass Lined Channel without Recent Maintenance	0.050
Vegetated Channel with Trees, Little or No Underbrush	0.055
Natural Channel with Trees, Moderate Underbrush	0.075
Natural Channel with Trees, Dense Underbrush	0.090
Natural Channel with Dense Trees and Dense Underbrush	0.100
Reinforced Concrete Pipe	0.013
Concrete Box Culverts	0.013
Overbank Description	"N" Value
Pasture	0.035-0.055
Trees, Vegetation, Multiple Fences and Structures	0.060-0.075
Dense Vegetation, Multiple Fences and Structures	0.075-0.090
Pipe	"N" Value
Corrugated Metal Pipe - ½" corrugations	0.024
Corrugated Metal Pipe - 1" corrugations	0.027
Concrete Pipe	0.013

9) Vegetated Earth Channels.

a) Freeboard consistent with Table 4.5E will be applied to the twenty- five (25)-year design

b) No earthen channels will be permitted with less than an eight (8') foot bottom width. All channels not meeting the minimum width shall be concrete channels (see Section 8 above). The side slope shall not be steeper than four (4) horizontal to one (1) vertical.

c) Easements or rights-of-way for improved earth channels shall conform to the requirements stated in subsection (d) of this section and shall extend a minimum of two (2') feet on one (1) side and fifteen (15') feet for an access road on the opposite side of the extreme limits of the channels when such channels do not parallel and adjoin an alley or roadway. When such channels do parallel and adjoin an alley or roadway, the easement or right-of-way shall extend a minimum of two (2') feet on both sides of the extreme limits of the channel. Where utilities are installed in the access road of the drainage right-of-way, the right-of-way shall extend two (2') feet on one (1)

side and seventeen (17') feet on the opposite side of the design limits of the channel. These seventeen (17') feet are to provide an access way along the channel with a maximum cross slope of one (1") inch per foot toward the channel. Where designed channel bottoms exceed one hundred (100') feet in width, fifteen (15')- foot extra width shall be provided on both sides of the channel. Interceptor drainage easements shall extend a minimum of two (2') feet on both sides of the extreme limits of the channel.

d) Channel shall have a bottom width of eight (8') foot minimum with a vehicular access point of seven (7) horizontal to one (1) vertical slope at least every one thousand (1000') feet. For easements crossing streets there shall be an access drive on both sides of the street right-of-way. Improved earthen channels will be vegetated by seeding or sodding. Eighty-five (85%) percent of the channel surface area must have established vegetation before the City of Schertz will accept the channel.

10) Channel Bends. Allowance for extra freeboard shall be made when the centerline radius of the channel is less than three (3) the bottom width. Where sharp bends or high velocities are involved, the applicant shall use the following formula for computing the extra freeboard:

$$d_2 - d_1 = V^2 * (T + B) \div (2*g*R)$$

Where: d_1 = depth of flow at the inside of the bend in feet. d_2 = depth of flow at the outside of the bend in feet.
B = bottom width of the channel in feet.
V = the average approach velocity in the channel in feet per second.
T = width of flow at the water surface in feet.
g = 32.2 feet/second squared.
R = the center line radius of the turn or bend in feet.

a) The quantity $d_2 - d_1$ divided by two (2) shall be added to the normal depth of flow before adding the required freeboard in calculating required right-of-way widths.

b) Where sharp turns are used without curved sections, the depth required shall be large enough to provide for all head losses. Allowance shall be made for any backwater head that may result.

c) For normal design conditions no extra freeboard is required. An accepted rule of thumb to follow is this: Centerline radius of channel should be at least three (3) times the bottom width.

11) Trickle Channel. All channels and detention basins with a bottom width of eight (8') feet or greater must have a trickle channel, a minimum of five (5') feet wide, following the centerline to facilitate positive drainage to the outfall or the entire length of the channel.

H) STORM SEWERS

1) For all ordinary conditions, storm sewers shall be designed on the assumption that they will flow full under the design discharge; however, whenever the system is placed under a pressure head, or there are constrictions, turns, submerged or inadequate outfall, etc., the hydraulic and energy grade lines shall be computed and plotted in profile. In all cases adequate outfalls shall be provided and the system adequately designed. Show the HGL in the profile.

2) No public storm sewers shall be less than twenty-four (24") inches in diameter, and all junctions shall have an access manhole a minimum of five (5') foot in diameter meeting the access criteria in the latest version of the Standard Construction Details and the Technical Specifications. All structures shall conform to the HS-25 loading standard within streets or along any potential vehicle route (including drainage easements)

3) Minimum easement widths for storm sewers will be the greater of fifteen (15') feet or six (6') feet on both sides of the extreme limits of the storm sewer width (e.g. the easement width for a three (3) barrel ten (10')-foot wide box culvert with six (6")-inch walls would be (3 x 10') + (4 x 0.5') + (2 x 6') = 44').

I) INLETS AND OPENINGS

1) Drop Curb Openings - Where drop curb openings are used to take storm water off the streets and into drains or swales, the length of the curb opening can be calculated from the weir formula using the coefficient of 3.087 in the following formula:

$L = Q \div (C_w * h^{3/2})$

Where:
L = the length of drop curb opening required in feet
Q = amount of flow in cubic feet per second (cfs) based on twenty-five-year design frequency
C = 3.087
h = head of weir in feet

Gutter line depressions will be permitted where such depressions will not hinder the flow of traffic. For amount of curb exposure, conform to Texas Department of Transportation San Antonio District Inlet Type I or II.

2) Curb or Drop Inlets. Where drop inlets are used, the City standard inlets with adequate reinforcing steel may be used. All other types or designs shall be subject to the approval of the City Engineer or his/her designee. The following formulas for inlet capacity are based on drop inlets in sag points. Inlet capacities on grades will be considered less, the amount of which depends on street grades, deflections, cross slopes, depressions, etc.

3) Grate Inlets. The flow of water through grate openings may be treated as the flow of water through a rectangular orifice. The following formula may be used for determining grate capacity:

$Q = C_o * A * (2*g*h)^{1/2}$

Where:
Q = discharge in cubic feet per second
C_o = orifice coefficient of discharge (taken as 0.70)
g = acceleration due to gravity (32.2 ft./sec^2)
h = head on the grate in feet
A = net area of the openings in the grate in square feet

This formula gives the theoretical capacity of the grate inlet. Since grate inlets are subject to considerable clogging, capacity of the grate inlet will be taken as one-half (1/2) on the value given by this formula.

4) Curb Opening Inlets. The capacity of curb opening inlets will depend on whether or not the opening is running partially full or submerged. If the depth of flow at the curb opening inlet is such as to cause a partially full opening, a weir effect will develop, and the following formula will apply:

$Q = C_w * L * h^{3/2}$

Where:
Q = the discharge of capacity in cubic feet per second
C_w = the weir coefficient of discharge (3.087)
L = the length of curb opening in feet
h = the head or depth of water at the opening in feet

If the depth of flow at the curb opening is such as to fully submerge the opening, the orifice effect will develop, and the formula used shall be identical to that given under grate inlets with the exception that the head, h, on the curb opening orifice shall be taken as the depth from the top of the water surface to the center of orifice or opening; one hundred (100%) percent efficiency will be allowed for curb opening inlets. In no case, shall a pedestrian facility be placed in an area to be inundated by water during the design storm event.

5) The pedestrian facility should be elevated so as to avoid inundation and adequate railing shall be provided as required per paragraph H.8.e of this section.

J) DETENTION BASINS

For projects with an increased impervious area of greater than 0.1 acres, for all new developments or redevelopment of individual parcels of property, detention basins may be used to mitigate peak flow rates to predevelopment or existing development conditions.

1) The maximum allowable outflow rate from the detention facility must be restricted to the flow rate from the undeveloped or existing development tract for the 2-year, 5-year, 10-year, 25-year and 100-year frequencies. Best management practices shall be used in the design of detention facilities in accordance with this section. The timing of the hydrograph released from the detention facility must be checked against the timing of the flow rate in the first open watercourse to prevent any increase in the peak flow rate in the receiving watercourse. For detention basins constructed in-line on an existing watercourse, the creation of the basin shall not increase flood elevations in the channel upstream of the new development boundaries.

2) On-site detention facilities must be privately owned and shall be maintained by the community or property owner association or property owner. A maintenance schedule shall be submitted to the City

Engineer or his/her designee prior to approval of construction plans. The City will have the right to do periodic inspections of privately owned and maintained detention facilities to ensure that the maintenance schedule is being implemented.

3) Multi-use facilities are encouraged, but not required (multi-use facilities allows for water quality, satisfy TPDES requirements, enhance around water recharge, provide open space, provide recreation or other amenities, and/or provide habitat) and may be utilized so long as the facility meets the standards set forth in subsection (F.1) of this section and does not increase the rate or volume of erosion above that which would result from the use of a facility without multiple uses. The use of multi-use detention facilities to alleviate existing flooding problems, enhance and provide amenities for older neighborhoods, and support the revitalization of economically depressed areas is encouraged in public and private redevelopment initiatives.

4) Maximum water depths over six (6') feet will not be allowed without prior approval of the City Engineer or his/her designee.

5) Fencing or other approved safety barrier is required when side slopes and total depth meet the criteria specified for channels in paragraph H.8.e. of this section.

6) Parking areas may be used as detention facilities provided the depth does not exceed eight (8") inches, and the impounding of storm water does not impact the adjacent buildings.

7) Stage- Storage- Discharge tables for basins and associated outlets will be required upon plans and within the SWMP.

8) Pumped detention systems will not be an acceptable method of storm water mitigation unless the facility will remain privately owned, operated, and maintained. The City will approve the use of a pumped facility for private use under the following conditions:

   a) A gravity system is not feasible from an engineering and reasonable economic standpoint.
   b) At least two (2) pumps are provided, each of which is sized to pump the design flow rate.
   c) The selected design outflow rate must not aggravate downstream flooding.
   d) Controls and pumps shall be designed to prevent unauthorized operation and vandalism.
   e) Adequate assurance is provided that the system will be operated and maintained appropriately on a continuous basis.

9) Storm water retention with permanent wet pool systems will not be an acceptable method of storm water mitigation unless the facility will remain privately owned, operated, and maintained. The City will approve the use of a wet pool system for private use under the following conditions:

   a) A gravity system is not feasible from an engineering and reasonable economic standpoint.
   b) The volume below the discharge invert shall not be considered for detention capacity.
   c) Mitigation measures must be included in the design of the facility to ensure water quality and prevent nuisances and environmental hazards.
   d) Facility shall not promote a bird hazard or any other hazard that would negatively impact Joint Base San Antonio (JBSA) or its mission.
   e) Adequate assurance is provided that the system will be operated and maintained appropriately on a continuous basis.

K) OUTFALLS/OUTLETS/TRANSITIONS

If the velocity at an outfall or outlet of a channel, storm drain, or detention pond to an earthen/grass lined channel is greater than six (6') feet per second (fps), provide energy dissipaters or other means to reduce velocity and prevent erosion.

Provide retard spacing and concrete transition length calculations to account for the effect of hydraulic jumps.

Adequate space shall be provided for the transition of flow from a concentrated point to Sheet Flow (to mimic predevelopment conditions) before the discharge leaves the developed Property.

4.6 STORM WATER CHECKLIST

City of Schertz Storm Water Management Plan (SWMP) Checklist		N/A	Complete	Incomplete
A.	**GENERAL**			
1.	Signed, sealed & bound SWMP			
	Introduction & Project description			
	Narrative of existing and proposed hydrology			
	Summary of calculations (indicate methodology and key assumptions, time of concentration calculation, Curve Number and Runoff Coefficient determination)			
	Table of runoff values			
2.	Certification by Engineer that the resulting impact of the proposed development will not produce a significant adverse impact to downstream properties, structures, drainage facilities, and public infrastructure.			
3.	Project Location Map			
4.	Flood Insurance Rate Map (FIRM) with site superimposed			
5.	Grading Plan (As required by City Engineer): Lots grading property according to FHA Lot Grading Type (A, B, C) An upstream watershed no more than the depth of 1 residential lot or 120 feet, whichever is greater, may drain to a platted lot unless an interceptor drain is provided.			
6.	Aerial map: Delineate site boundary, contributing watershed, downstream flow path to 100-year facility, flood plain and floodway location			
B.	**HYDROLOGY**			
1.	Drainage Area Map (to scale) for Existing and Ultimate Conditions			
	Show site boundaries, overall drainage areas and sub- areas, acreage of each of each drainage area, and discharge locations, downstream flow path to 100-year facility			
	Provide Existing & Design time of concentration flow paths with length & slope shown Table of runoff values at key locations			
	Existing and proposed topographic information with maximum two (2) foot contour elevations			
	Flood plain and floodway location, with BFE indicated			
2.	Detailed Q calculations include:			
	Time of Concentration (provide detailed calculations) (NRCS method): Minimum 5 minutes total Overland Sheet – Length, slopes, (max 20 minutes) max 100 feet Shallow Concentrated Flow – Length, slopes Concentrated Flow – Length, slopes, assumed v ≥ 6 fps			
	Rational Method: Rational Method for watersheds 0 to 50 Acres, Tc≤20 minutes, peak flow analysis only, no flow routing required, no floodplain analysis Verify Rainfall Intensities (i) & Runoff Coefficient (C)			
	Unit Hydrograph Method (TR 20 or HEC HMS, etc.): SCS or other Hydrograph Method for larger watershed or flow routing Required (detention pond) SCS curve number, CN value: provide detailed calculations & exhibit Routing Values (if used): Provide detailed calculations			
	Routing Method: Modified Puls or Muskingum Soil Survey Map of area (site delineated, soil type & acreage of each soil group)			

C. HYDRAULICS				
1.	General: For all storm water facilities with drainage area > 100ac, design for Q100 All storm water facilities shall be designed for Ultimate development			
2.	Street Capacity: Local: Q25 contained within curbs, Q100 contained within ROW Collector: Q25 contained within curbs AND one lane shall remain clear Arterial: Q25 within curbs AND one lane in each direction shall remain clear			
	Streets draining a watershed greater than one hundred (100) acres must be designed for the one hundred (100) year frequency storm			
	Velocity <10 fps			
	Street draining to unpaved surface runoff velocity < 6fps			
	Lateral curb opening sized as weir			
3.	Channels: (provide detailed calculations) If Drainage area < 100ac: Q25 plus freeboard If Drainage area > 100ac: the greater of Q100 or Q25 plus freeboard			
	Slope Conveyance Method (Mannings) – for small channels (BW≤20) not floodplain, nor affected by backwater. Provide section of channel Indicating normal depth, velocity, Froude number			
	Standard Step Back Water Model (HEC RAS or similar) – for large channels (BW>20'), channels within floodplain, or channels controlled by backwater. Provide plan and profile indicating HGL and EGL			
	Concrete channel: Manning's "n" minimum of 0.015 Hydraulic jump calculations			
	Earthen channel: Appropriate Manning's "n" Velocity < 6 fps			
	Channel bend extra freeboard calculations			
	Turf Reinforcement Matting: 6 fps < Vel < 12 fps If > 12 fps, engineer's report should certify that material is appropriate for velocity. Include manufacturer spec's & installation instructions. Engineer to certify at final inspection that material was installed correctly.			
	Interceptor Channel: Easement width calculation			
	Floodplain Submittal is required if property is within or next to a FEMA designed special flood hazard area			
4.	Storm Sewer			
	Inlet designed for 25-yr capacity			
	HGL/EGL: provide detailed calcs (including junction losses). Show in profiles of pipe EGL: below top of junction box or, if approved by City, specify bolted manhole covers. HGL: below gutter			
	Downstream tail water depth calculation			
	Min storm sewer pipe diameter = 24 inches. Pipe velocity between 2 fps and 12 fps			
5.	Culverts			
	Culvert design for 25-year event unless upstream watershed is greater than 100 acres, then it shall convey the 100-year runoff.			
	Designed according to FHWA HDS-5			
	Headwater does not overtop road			
	Box culvert, headwalls and wingwalls to conform to TxDOT design standards			
6.	Detention Basins			
	Indicate area to drain to detention basin			

	Provide inflow and outflow hydrographs for 2-yr, 5-yr, 10-yr, 25-yr, and 100-yr (proposed, ultimate)			
	Provide required storage for the 2-yr, 5-yr, 10-yr, 25-yr, and 100-yr (proposed, ultimate)			
	Check tailwater conditions on outlet structure			
	Include a stage/storage/discharge table			
	Provide details on outlet structure (invert, sizes, slopes, details on plan sheet) indicate depth per rainfall event.			
	Verify pond height is 6' high or less from toe on downstream side of embankment (existing grade) to the top of the structure. If not, overflow spillway must have capacity for 100% of the ultimate development probable maximum flood (PMF) and TCEQ approval may be required.			
	Modified rational is not accepted			
	Provide maintenance schedule			
	Provide results in tabular format with detailed calculations for allowable/existing, proposed, and ultimate discharges from the structure. Provide Electronic files of model			
7	Outfalls/Outlets/Transitions			
	If velocity > 6fps at transition to earthen channel, provide energy dissipaters or other means to reduce velocity. Provide retard spacing and concrete transition length calculations (hydraulic jump)			
	Receiving facility (street, channel, culvert, etc.) capacity to accept runoff.			
8.	Easements			
	Widths include freeboard and access			
9.	Storm Water Pollution Prevention Plan			
10.	Maintenance agreement/plan			
D. ADDITIONAL ITEMS IF FLOODPLAIN WORK IS PROPOSED				
1.	Narrative Table of Contents and abstract or executive summary Introduction that includes project description and history, location, scope and objective of analysis, previous and related studies that may affect this analysis. Summary, conclusions, vicinity map and recommendations. Include the Impact on the floodplain's Q, WSEL & velocity.			
2.	Provide detailed Hydrology calculations for changes in hydrology or for unstudied stream reach, see SWMP above (with electronic copy of model)			
3.	Provide detailed Hydrology calculations for changes in hydrology or for unstudied RAS or standard step backwater analysis model: 25 year existing and ultimate development condition hydraulic analysis 100 year existing and ultimate development condition hydraulic analysis			
4.	Provide plans and calculations for channel outfalls perpendicular to the floodplain. Channel outfall must be taken to the invert of the receiving channel or show the velocity to be less than 6 fps going down the side slope.			
5.	Plotted water surface profiles for the 100-year flows (if applicable)			
6.	Provide channel cross sections (existing superimposed on proposed) show the drainage easement, Manning numbers, property lines, structures, etc.)			
7.	Provide a summary table of the hydraulic model (HECRAS) of the floodplain within the platted area			
8.	Copy of all permits needed under the authority of USACE, TCEQ, or any other applicable regulatory authority			
9.	Current Effective dFIRM of project area			
10.	Grading Plan (existing and finished contours)			
11.	Provide Topographic Work Map: show plan view of project limits, cross sections, existing/proposed contours, proposed development, current and revised flood plain limits, property lines, drainage easement, engineers signature and seal			

12.	Provide U.S.G.S. Quadrangle maps showing overall drainage areas, runoff coefficients, time of concentration, intensity.			
13.	Floodplain Development Permit			
14.	Elevation Certificated (if applicable)			
15.	FEMA CLOMR / LOMR/LOMRa/LOMRf			
	Provide the applicable items listed above			
	MT-2 Form 1 Sec D: Provide Owners and Engineer's original signature			
	MT-2 Form 2 Sec A: Provide an attached explanation if sediment transport is not considered			
	MT-2 Form 2 Sec B 4: Model names in this section must match the models listed in the CD			
	For Map Revision Detail study includes 10, 50, 100, and 500-year Analysis			
	If applicable, provide As Built Grading Plan with engineer's seal and signature			
	Recommend providing Check-RAS output			
	Provide existing and proposed FEMA FIRM Maps with the following: **Existing** – Label Map "Current" and show the site boundaries. **Proposed** – Label Map "Revised", show site boundaries, show only the proposed floodplain limits, floodplain must be in the existing floodplain upstream and downstream, show the proposed streets centerline only and label, show the upstream and downstream limits of study.			

SECTION 5 – SANITARY SEWER REQUIREMENTS

5.1 GENERAL

All subdivisions shall be provided with an approved sewage disposal system. An Engineering Design Report for wastewater shall be submitted for review by the City Engineer or his/her designee. The report should contain a map of the service area, development LUE count, design flow rates and calculations (Average Dry Weather, Peak Wet Weather flow), design capacity of the sewer, minimum and maximum velocities, and a statement declaring that minimum velocities and pipe capacities have been met. If the project is to require a lift station and force main, the sizing of the wet well, pumps, controls, and force main shall be included in the report. The sanitary sewer collection system shall be designed in accordance with the standards and specifications set forth hereinafter.

A) The Developer shall dedicate, at their own cost, such right-of-way and construct such sanitary sewer main and appurtenance of such size as to adequately serve the area being subdivided as determined by the City or the utility company under whose jurisdiction the subdivision falls.

5.2 MINIMUM STANDARDS

A) Design Criteria: All gravity sewers shall be PVC gravity sewer pipe and fittings meeting the requirements of ASTM Specifications D 3034 and shall be SDR 26. All structures shall conform to the HS-25 loading standard within streets or along any potential vehicle route (including sewer easements).

B) Minimum size of sewer mains shall be eight (8") inches in diameter and all house connections in streets or alleys must be six (6") inches in diameter belonging to the owner of the lot. The minimum and maximum pipe slopes and velocities shall be in accordance with TCEQ standards (30 TAC Ch 217.53(1)(2)(A) table C.2). All sanitary sewer collection mains shall be of sufficient size to serve the peak dry weather flow from the service area plus infiltration and inflow. Provide flow calculations including the details of the average dry weather flow, the dry weather flow peaking factor, and the infiltration and inflow. The flow calculations must include the flow expected in the facility immediately upon completion of construction and at the end of a fifty (50) year life. The line must conform to the City's current Sanitary Sewer Master Plan.

C) The following criteria shall be used in formulas in the design of sewer system:

1) Average Dry Weather Daily Flow is based on 245 gpd/LUE (living unit equivalent).

2) Peak Dry Weather Daily Flow is based on a peaking factor of 3.0.

3) Peak Wet Weather Flow is Equal to Peak Dry Weather Flow plus Inflow/Infiltration.

Table 5.2A
Flow From Contributing Population (245 gpd/LUE)

Residential	LUE/each	1
Apartments & Extended Living	LUE/unit	3/5
Hotel/Motel	LUE/unit	1/3
Business	LUE/person	20/245
School	LUE/student	15/245
Unknown future development	LUE/acre	4

Rates for other non-residential development may be obtained from actual water usage, TCEQ, Wastewater Usage Rates (30 TAC §285.91 Table III (use rates without water saving devices for existing facilities and rates with water saving devices for future facilities) or other method approved by City Engineer.

Table 5.2B
Infiltration

Source of Infiltration	Amount of Infiltration In Gallons Per Day Acre
Residential Area – Level to 7% slope	700
Residential Area – 7% To 15% Slope	500
Totally Undeveloped Areas	360
High Water Table (Creek Beds, Lake Areas)	1450
Business and Industrial Areas	1000

D) The Developer shall furnish lift stations with Supervisory Control and Data Acquisition (SCADA) equipment where necessary. These shall be constructed only after approval by the City.

E) Sewage treatment plants and sewer systems must conform to the requirements of Texas State Department of Health.

F) Manholes: All manholes shall be a minimum of five (5') foot in diameter for all Base and riser sections (no cones less than five (5') in diameter) with watertight manhole ring and cover meeting the Current Standard Specification and Standard Detail criteria and minimum of thirty (30") inch diameter opening.

1) Precast concrete manhole sections with steel reinforced concrete base with confined O-ring joints in conformance with ASTM C-443.

2) Base shall be manufactured in accordance with ASTM C-478. The precast base may have formed smooth invert channels cast at the angles. The invert channel shall have ¼" = 1' fall toward the outlet and inverts shall be designed to prevent reverse flow.

3) Resilient joint connectors for a watertight seal between the manhole base and specified line pipe shall be provided. This joint shall comply with ASTM C-923.

G) Construction methods shall be in strict accordance with the manufacturer's installation procedures and recommendations. The items below are listed for emphasis:

1) The City shall be advised forty-eight (48) hours before any construction is started for adequate scheduling inspection to be provided.

2) Sewers shall be located in the centerline of streets and four (4') feet from the north or east lines where in alleys or as otherwise approved. Mains within earthen channels/drainage ways shall be protected from scour; a scour analysis may be required.

3) All sewer lines shall be placed on line and grade as directed by the Design Engineer.

4) Manholes shall be placed at all deflection, intercept and terminating points on the public system and spaced not more than five hundred (500') feet apart.

5) Manholes shall be provided at intersecting streets or alleys where there is a possibility of future extensions.

6) Drop Manholes should be used sparingly and generally, only when it is not economically feasible to steepen the incoming sewer, in no case should a drop be used for a fall less than two (2') feet and all shall be interior drop manholes.

7) Sewer laterals shall be terminated in a cleanout at the property line. A sewer lateral may only serve a single customer. No cleanouts may be used on any public sewer main.

8) All non-residential service customers shall provide a sample port meeting the current City of Schertz specifications or approved by the City Engineer or his/her designee on all service laterals within the property. The sample port should be in an area readily accessible to City and/or sewer service provider's representative and clear of pedestrian and vehicular traffic.

9) Manholes located in the area to be paved shall be left covered below sub-grade until the street contractor has completed the street and then it shall be reset to finished grade.

10) Compaction of sewer trench and lateral backfill shall be according to Section 02317 – Excavation and Backfill for Utilities of Schertz Technical Specifications. Each lift of backfill shall be tested and pass density requirements prior to the next lift of material being placed.

11) Construction over the Edwards Aquifer: For subdivisions constructed over Edwards and associated limestone formation, all construction shall meet the latest revision and requirement of the Texas Commission on Environmental Quality.

12) All manhole section joints shall be wrapped with an external seal wrap meeting Technical Specification 02082 and installed according to manufacturer's recommendations.

13) Encapsulate manholes with flowable fill from bottom of base, minimum of one (1') foot around walls, up to bottom of concrete collar.

5.3 MINIMUM SANITARY SEWER TESTING REQUIREMENTS

A) PUBLIC SANITARY SEWER LINE AIR TESTING

1) Description: This item shall cover the testing of completed sections of installed sewer pipe using low-pressure air tests on all completed sections of sanitary sewer mains.

2) The air test will be used to evaluate materials and construction methods on the pipeline sections and successful air tests shall be mandatory for the acceptance of the lines.

B) MATERIALS FOR TESTING

1) Compressor Air Supply: Any source which will provide at least three hundred (300) cubic feet per minute at one hundred (100 psi) pounds per square inch.

2) Plugs, Valves, Pressure Gauges, Air Hoses, Connections, and other equipment necessary to conduct the air test, shall be furnished by the contractor. The test equipment for air testing will consist of valves, plugs and pressure gauges used to control the rate at which air flows to the test section and to monitor the air pressure inside the plugs. Test equipment shall be assembled as follows:

a) Hose connection
b) Shut-off valve
c) Throttle valve
d) Pressure-reduction valve
e) Gage cock
f) Monitoring pressure gauge

3) Test Procedures:

a) Determine and isolate section of line to be tested
b) Apply air pressure until the pressure inside the pipe reaches 4 psig.
c) Maintain 4 psig for duration of test length and record.

If no decrease for the duration shown in the allowable table, the pipe shall be presumed to be free from problems If any pressure decrease is detected, or pipe breakage, joint leakage or leaking plugs are indicated, an inspection must be made to determine the cause.

The contractor shall make such repairs as may be required to accomplish a successful air test. If repairs are needed an additional thirty (30) day waiting period for final backfill will be required before follow-up deflection and pressure testing (see Section 4 below).

See Section 02533 – Acceptance Testing for Sanitary Sewers. City of Schertz Technical Specifications for a table of time allowed for pressure loss.

4) Deflection by testing

Flexible gravity sewer lines shall be tested for deflections by use of a go-no-go testing mandrel calibrated for five (5%) percent maximum deflection of the inside diameter to the pipe. No deflection testing can occur until a minimum of thirty (30) days after final (density-tested) backfill.

5) Additional Testing and Criteria

See Section 02533 – Acceptance Testing for Sanitary Sewers. City of Schertz Technical Specifications for a table of mandrel sizes, as well as vacuum testing of manhole procedures and requirements for filming of sewer mains. No vacuum testing on manholes or sewer mains shall be performed before final pavement is laid or final backfill and grading is complete. If any additional work is done in the vicinity of the manholes or sewer mains after testing is completed, an additional round of testing may be required at the Developer's expense.

SECTION 6 – WATER REQUIREMENTS

6.1 GENERAL

All subdivisions within the City and its ETJ shall be provided with water supply and water distribution systems constructed in compliance with an approved water system. An Engineering Design Report for the water system will be submitted for review by the City Engineer or his/her designee. The report should contain a map of the area to be served, development LUE count, design flow rates and calculations, available local pressures, and a statement declaring that minimum pressures and flow rates will be provided. If additional storage of pressure will be needed the sizing and design of the pumps and storage facilities will be included in the report.

A) Facilities Required: Every lot in a subdivision shall be provided with an approved supply of water, either by the construction of a supply and distribution system connected to an adequate approved public water system or, if such public source is not available, by construction of a complete water system, including a safe, adequate water source, proper treatment facilities, pumps, storage facilities and distribution system, approved by the TCEQ.

B) The Developer shall dedicate, at his own cost, such right-of-way or easement and construct such water main, water lines, fire hydrants and appurtenance as such size as to adequately serve the area being subdivided as determined by the City or the utility company under whose jurisdiction the subdivision falls.

6.2 MINIMUM WATER STANDARDS

A) FIRE HYDRANTS

1) Hydrant location must follow both of two rules:

a) No structure should be further away than four hundred (400') feet from a fire hydrant as a fire house would lay (or as required by the Fire Marshal)

b) Hydrant spacing along a water main should not exceed five hundred (500') feet in single-family residential areas or three hundred (300') feet in any non-residential, multifamily dwelling, or heavily congested residential area.

2) Fire Hydrants branch lines shall connect to an eight (8") -inch water main and in no case be longer than one hundred (100') feet.

3) Any new fire hydrant along a roadway is required to have a hydrant locator Type II blue reflector installed in the roadway or fire lane, perpendicular to the hydrant two (2') feet off centerline.

4) No private fire lines shall exceed one thousand (1000') feet in length without redundant connections to public main and shall meet all the design criteria and construction specifications required within the most current editions of the Technical Specifications Manual, NFPA 24, and the most current, adopted International Fire Code. See additional criteria in Section 6.3.G below.

B) WATER MAINS

1) Design Specifications: The water distribution system design shall include the minimum requirements of the Texas State Fire Insurance commission for residential, mercantile, and industrial areas in addition to the requirements for a peak hour customer demand a determined by the City Engineer or his/her designee.

2) Supply Mains: Supply mains in the distribution system shall be looped and have a minimum size of twelve (12") inches diameter. Supply mains should be located generally where shown on the City of Schertz Water Master Plan but should be sited so the length between cross connecting supply mains does not exceed six thousand (6000') feet.

3) Distribution Mains: Mains shall be looped between supply mains and shall have a minimum of eight (8") inches in diameter. The maximum length between distribution main cross connections shall be the shorter of the two following lengths: three thousand (3,000') feet, or a length that would by fluid friction render the line incapable of producing the flows and pressure set out herein for the type of area to be served considering pressure and flows that exist at the supply main's connections as determined by the City Engineer or his/her designee.

a) Mercantile and Industrial Mains: Mains in all mercantile areas shall be located in rights-of-way or water easements and shall be sized to provide minimum fire flow from any single hydrant of not be less than one thousand five hundred (1,500 gpm) gallons per minute with twenty (20 psi) pounds per square inch residual pressure.

b) Residential Mains: Domestic mains shall be installed in dedicated street right-of-way or water easements and sized so that the minimum fire flow at any single fire hydrant shall not be less than seven hundred fifty (750 gpm) gallons plus two (2 gpm) per minute for every lot in the subdivision with thirty (30 psi) pounds per square inch residual pressure.

4) One LUE (Living Unit Equivalent) produces a water demand of:

c) 2 gpm peak hour flow demand

d) 1 gpm peak day flow demand

e) 300 gpd (0.208 gpm) average daily flow

f) Peak Flow Factor formula:

$PFF = (18+ (0.0144*F)^{0.5}) / (18+ (0.0144*F)^{0.5})$
Where, F = avg flow (gpm) = 70*gpcd*population/1440

5) Connections for combination domestic and fire service lines are not permitted. Separate connections to the main are required for domestic and private fire lines.

6.3 DESIGN CRITERIA

A) Water Mains within the City's Jurisdiction shall be ANSI/AWWA C900 or C905 PVC DR 14 or as allowed in Sections 02511, 02501, 02502, 02506 of the Technical Specifications or other material as approved by the City Engineer or his/her designee.

1) Minimum Working Pressure in any part of the system shall be twenty (20psi) pounds per square inch during fire flow conditions and two thirds (2/3) of the normal water use domestic or commercial. This pressure pertains to the point of delivery of water to the consumer at the house service line, and for residences not exceeding two stories. A minimum working pressure of thirty-five (35) psi should be provided wherever possible.

2) Normal Working Pressure under average conditions of flow should range between thirty-five (35) psi and seventy (70) psi.

3) Maximum Pressures in excess of one hundred (100) psi should be avoided. Anything over 80 psi shall be protected with pressure release valve to be owned and maintained by the homeowner.

4) No Private Water Supply shall be installed in any subdivision in the City limits or City of Schertz service area without City Council approval and a water franchise agreement.

B) The depth of cover of the main shall be not less than forty-eight (48”) inches from the top of pipe. Any mains with less than forty-eight (48”) inches of cover from the top of pipe shall be lowered to meet the minimum depth of cover. Mains within earthen channels shall be protected from scour (a scour analysis may be required).

1) Any new water mains to be placed under a non-residential driveway shall be cased in steel pipe. Exceptions to the requirement for casing will be determined by the City Engineer and will be based on conditions such as depth of planned or existing main, availability of other site access, type of facility accessed by driveway, and other site constraints.

2) Water mains crossing existing thoroughfare right-of-way (collector class and larger) shall be encased in steel pipe.

3) Utility trench backfill shall be in accordance with Section 02317 – Excavation and Backfill for Utilities of the Technical Specifications. Each lift of backfill shall be tested and pass density requirements prior to the next lift of material being placed.

4) The practices of water jetting or ponding backfill in roadways, drainage right-of-way, driveways, concrete or paved easements are NOT ACCEPTABLE

C) Water Service Lines shall be constructed using an approved double strapped saddle copper service line with suitable brass CC threaded compression gasket and compression stops. Developers will also be required to install the angle stop and meter box before acceptance by the City. Meter boxes are to be as shown in standard details and shall be installed at the finish grade of the property to be served. A blue painted dot on the curb over and "x" etching shall mark location of new meters.

D) AIR RELIEF AND BLOW-OFF VALVES AND DEAD-END MAINS

1) Air relief valves and blow-off valves should not be used except in locations where fire hydrants are not practical or at true dead-end mains. Air relief valves shall be located at high points on the line and blow-off valves shall be placed at low points. Air release valves shall be cast-iron stainless-steel screens and have a two (2") inch operating nut and a PVC plug.

2) No new dead-end mains shall be installed except as temporary stub-outs to future development or along ROWs to undeveloped properties as approved by the City Engineer or his/her designee. No dead-end water main providing domestic service shall be permitted. Looping is required for redundancy and water quality. In no case shall a dead-end main be longer than five hundred (500') feet. No new blow-offs will be accepted except at the end of a temporary dead-end main to be extended with further development. No blow-offs will be allowed at the end of cul-de-sacs. Mains should be looped at the end of the cul-de-sacs through water easements. A reduced main size (less than 8") may be approved if line is only provided to connect the end of a cul-de-sac within a subdivision. Water easements should not cross single family residential lot lines unless approved by the City Engineer or his/her designee.

E) GATE VALVES

1) Location of the valves shall be uniformly located in a standard area such as street curb line extension to facilitate location. A valve box, with its cover at the finish grade, shall always be placed over a buried valve. A sufficient number of valves should be placed in the distribution system so that a short section of main may be repaired or serviced without interruption of service of more than one block. A minimum of three (3) vales shall be used as crosses and two (2) valves at tees. Generally, valves shall be placed along a main at every other fire hydrant or at maximum one thousand (1000') foot spacing. Valves shall also be installed on each side of thoroughfare streets, railroad crossings and drainage channels.

2) Material for gate valve construction shall comply with the current AWWA Standard C-509-80 Resilient Seat Gate Valves Per Technical Specification Section 02521. All valves shall be left open (counterclockwise).

3) A blue painted “V” shall be etched into curb face to mark valves.

4) Operation of Valves: No existing valves in the City’s water distribution system shall be operated by the contractor without prior permission from the Public Works Department. The contractor shall notify the Public Works Department, Engineering Inspector, all affected customers a minimum of two (2) working days or forty-eight (48) hours in advance of any outage. Contractors shall not operate a valve outside the presence of the City’s representative.

F) FIRE HYDRANTS: Five and one fourth (5 ¼”) inch steamer outlet (storz connection), NST and two and a half (2 ½) outlets, NST fire hydrants shall be installed as part of the water distribution system per the City design standards. Fire hydrants shall be installed with a separate gate valve and valve box shall be per Technical Specification Section 02520. Public hydrant bodies to be factory painted red with the bonnets and caps factory painted white. Private hydrants shall be factory painted all red.

G) Private fire lines shall meet the City’s specifications for pipe material and trench backfill.

1) A Double Check Assembly (DCA) if metered, or a Double Check Detector Assembly (DCDA) backflow device if not metered, shall be provided within one hundred (100’) feet of the City’s water main on private fire lines.

2) The DCA or DCDA may be installed in a vault if proper consideration is given for drainage and clearance to vault walls for access and repair in accordance with manufacturer’s specifications.

H) PROTECTION OF WATER MAINS

1) Horizontal Separation: Whenever possible, water mains shall be laid at least nine (9’) feet, radially, from any existing or proposed sewer. Should local conditions prevent a lateral separation of nine (9’) feet, a water main may be laid closer than nine (9’) feet to a sewer if it complies with 30 Texas Administrative Code (TAC) (or TCEQ rules) Chapter 217: Rule 217.53.d.

2) Vertical Separation: Whenever sewers cross under water mains, the water main shall be laid at such an elevation that at the bottom of the water main is a least nine (9') feet above the top of the sewer. The vertical separation shall be maintained for that portion of the water located within ten (10') feet horizontally of any sewer it crosses.

3) Special: When it is impossible to obtain proper horizontal and vertical separation, both the water main and sewer shall be constructed in accordance to 30 TAC Chapter 217: Rule 217.53.d.

4) Relation to Sewer Manholes: No water main shall pass through, or come in contact with, any part of a sewer manhole. All sewer design shall meet 30 TAC Chapter 217: Rule 217.53.d.

5) Cross Connections: There shall be no physical connection between the distribution system and any pipe, pumps, hydrant, or tanks, which are supplied, or may be supplied, with water that is, or maybe, lesser standards or contaminated.

6) Water Mains Near or Crossing Obstructions: Water mains within ten (10') feet of railroad tracks or crossing under railroad tracks shall be Ductile Iron Pipe equipped with restrained clamps or other acceptable provisions to minimize the effect of vibration. For mains crossing under waterways, a valve shall be placed at both ends of such crossing to permit isolation for repair and testing of the section.

7) Sampling taps shall be provided to facilitate sanitary control, typically one (1) per subdivision. These taps shall not be subject to flooding.

I) Disinfection of Water Mains: The mains shall be disinfected in accordance with AWWA Standard for Disinfecting Water Mains – C651, the requirements of the TCEQ, and the City of Schertz Technical Specifications Section 02514 – Disinfection of Water Lines. This applies to newly laid mains or after main system repairs are made.

J) Asbestos Cement (AC) Mains: AC mains shall be replaced with currently acceptable pipe materials a minimum of five (5') feet from the limits of any new taps including fire line, domestic, and irrigation taps. Regardless of where that five (5') foot distance falls, any AC main removal must be done from collar to collar (whole pipe lengths only). AC mains shall also be replaced where any grading work removes any depth of cover from the water main.

6.4 MINIMUM WATER TESTING REQUIREMENTS

Flushing, hydrostatic testing and chlorination of the City water main shall be in accordance with the City of Schertz Technical Specifications Section 02515 – Hydrostatic Testing of Pipelines, current AWWA standards as well as TCEQ rules and regulations.

For all water lines, expel air and apply minimum test pressure of 200 psi for four (4) hours. During the test, pressures shall not vary more than ±5 psi.

SECTION 7 – INSPECTIONS AND TESTING

7.1 LABORATORY TESTING:

A) The sub-divider shall notify the City at least one week prior to the contractor beginning construction. Contractor shall be required to notify the City a minimum of at least forty-eight (48) hours in advance of all testing being performed.

B) All materials to be used in subdivision construction shall be subject to testing if warranted. The preponderance of testing to be performed in subdivisions is directly related to ensure quality of construction. Street construction and a series of laboratory tests normally associated with road and street construction will be required in subdivisions with said tests being performed by an independent testing laboratory using qualified personnel. The design (or consulting) engineer or his designated representative and the City Inspector shall be present at all testing.

Whenever a Developer, contractor or engineer needs an inspection of any street or utility improvement, the City Engineer or his/her designee shall be contacted first a minimum of at least forty-eight (48) hours in advance of the inspection. The design engineer or his designated representative shall be present at all inspections.

Regarding testing of water and sewer lines, all testing will be done according to American Water Works Association (AWWA), ASTM and ASCE Standards.

In addition, the following procedures for testing of these lines will be as follows:

1) No new water lines will be connected directly to an existing City line. A backflow preventer with a hand valve (jumper) shall be used between old and new lines for loading.

2) No new sewer lines will be installed in a manner that would prevent testing of any part of the new line. All new sewer lines will be tested. No connection to or work on the existing system shall begin until testing has been completed satisfactorily and notice has been given to the City.

3) Pre-testing of water and sewer lines will be conducted by contractor prior to calling for an inspection to assure all lines will hold required pressure.

C) With regard to street inspection: Streets shall be checked by contractor, to ensure readiness; prior to calling for an inspection. No streets covered with debris, vehicles or equipment will be inspected.

D) Minimum test spacing set out shall be not less than five hundred (500') feet. No piecemeal inspection of parts of lines or small sections of streets will be made. However, with regard to subgrade inspections, sections of the street can be inspected when needed to protect the subgrade from bad weather or other conditions that may deteriorate the sub-grade. No more than three (3) subgrade inspections will be made in any one (1) subdivision unit.

E) The City staff, or an authorized inspector, may at the direction of the City, inspect all subdivision site work at any time and any stage. The City shall bear the cost of all inspections and the sub-divider shall bear the cost of all re-inspections. The judgment of the City and/or the City Engineer as to the need for any re-inspections of any part thereof, at any stage, shall be final.

F) Testing will be performed by an approved, independent testing laboratory. The following test schedule will be adhered to:

1) Streets: subgrade moisture, density test at the rate of one per one hundred (100') feet of street.

2) Flexible Base: P.L., L.L., P.I. and gradation of material used; moisture, density test on same spacing as subgrade.

3) Concrete Structures: Concrete cylinders, one/100 cy placed or for each pour is less than 100 cy shall be taken for curbs, drainage structures and sidewalks.

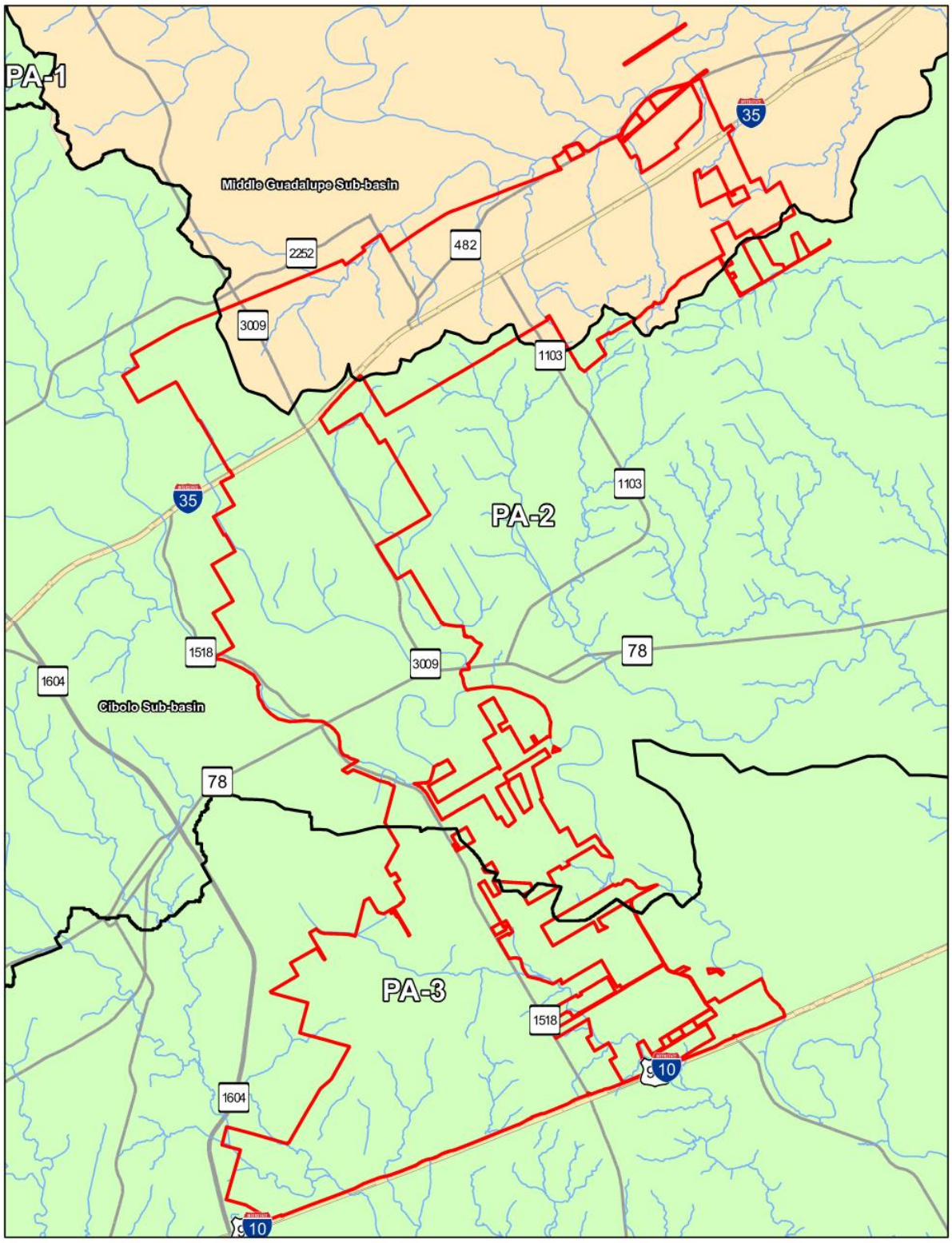
4) All testing is the responsibility of the Developer. Copies of all test results shall be furnished to the City as soon as possible. All results are to be provided before final acceptance of the subdivision by the City.

G) Before acceptance of a subdivision by the City for street or utility work, the consulting engineer responsible for the design of said work shall issue a letter to the City stating that he/she has inspected such improvements and that said improvements were constructed in accordance with the approved construction plans. Submitted along with the letter shall be “As Built” drawings showing the work to be accepted for use by the City as one (1) PDF and one (1) CAD format. These should include final surveyed coordinates and elevations of valves, curb returns, left and right gutter VPIs and all other appurtenances.

H) Guarantee of Material and Workmanship: The Developer shall be responsible for guaranteeing that all materials required under this Code and workmanship in connection with such improvements are free of defects for a period of two (2) year after such acceptance of the improvements by the City. The responsibility for all costs of the in-place improvements shall be borne by the sub-divider, and all criteria of Section 21.4.15 of the Schertz UDC shall be met before acceptance.

Appendix A

Rainfall Data



National Oceanic and Atmospheric Administration Atlas 14
City of Schertz Precipitation Areas

Precipitation Area PA-1

Intensity-Duration-Frequency (IDF) Values for PA-1

Time		Atlas 14 Rainfall Intensity (inches/hour) by Storm Frequency PA-1									
Minutes	Hours	1-year	2-year	5-year	10-year	25-year	50-year	100-year	200-year	500-year	1000-year
5	0.083	5.34	6.34	7.96	9.31	11.22	12.72	14.26	15.91	18.19	19.99
6	0.100	5.03	5.98	7.53	8.81	10.64	12.06	13.53	15.06	17.14	18.76
7	0.117	4.79	5.70	7.17	8.40	10.16	11.52	12.91	14.36	16.30	17.79
8	0.133	4.58	5.45	6.87	8.05	9.74	11.04	12.37	13.75	15.58	16.99
9	0.150	4.40	5.24	6.61	7.73	9.36	10.60	11.88	13.20	14.95	16.29
10	0.167	4.24	5.05	6.36	7.44	9.00	10.20	11.43	12.69	14.38	15.67
11	0.183	4.09	4.87	6.13	7.17	8.66	9.82	11.00	12.22	13.85	15.10
12	0.200	3.96	4.70	5.92	6.91	8.34	9.46	10.59	11.77	13.35	14.57
13	0.217	3.83	4.54	5.71	6.67	8.03	9.11	10.19	11.33	12.88	14.08
14	0.233	3.70	4.39	5.51	6.43	7.73	8.77	9.81	10.92	12.43	13.61
15	0.250	3.58	4.24	5.32	6.20	7.44	8.44	9.43	10.51	11.99	13.16
16	0.267	3.47	4.10	5.14	5.99	7.18	8.14	9.10	10.14	11.57	12.71
17	0.283	3.36	3.98	4.98	5.80	6.95	7.88	8.80	9.81	11.20	12.31
18	0.300	3.27	3.86	4.84	5.63	6.75	7.64	8.53	9.51	10.86	11.94
19	0.317	3.18	3.76	4.71	5.47	6.56	7.42	8.29	9.24	10.56	11.62
20	0.333	3.10	3.66	4.58	5.33	6.39	7.22	8.07	8.99	10.28	11.32
21	0.350	3.03	3.58	4.47	5.20	6.23	7.04	7.86	8.76	10.03	11.04
22	0.367	2.96	3.50	4.37	5.08	6.08	6.87	7.67	8.56	9.79	10.79
23	0.383	2.90	3.42	4.27	4.96	5.95	6.71	7.50	8.36	9.57	10.55
24	0.400	2.84	3.35	4.18	4.86	5.82	6.57	7.34	8.18	9.37	10.33
25	0.417	2.78	3.28	4.10	4.76	5.70	6.43	7.19	8.01	9.18	10.13
26	0.433	2.73	3.22	4.02	4.67	5.59	6.31	7.04	7.86	9.01	9.93
27	0.450	2.68	3.16	3.94	4.58	5.49	6.18	6.91	7.71	8.84	9.75
28	0.467	2.63	3.10	3.87	4.49	5.39	6.07	6.78	7.57	8.68	9.58
29	0.483	2.58	3.05	3.81	4.42	5.29	5.96	6.66	7.43	8.53	9.42
30	0.500	2.54	3.00	3.74	4.34	5.20	5.86	6.55	7.31	8.39	9.27
31	0.517	2.50	2.95	3.68	4.27	5.11	5.76	6.44	7.19	8.25	9.12
32	0.533	2.46	2.90	3.62	4.20	5.03	5.67	6.33	7.07	8.12	8.98
33	0.550	2.42	2.85	3.56	4.13	4.95	5.58	6.23	6.96	8.00	8.85
34	0.567	2.38	2.81	3.51	4.07	4.88	5.49	6.14	6.86	7.88	8.72
35	0.583	2.34	2.77	3.45	4.01	4.80	5.41	6.05	6.76	7.77	8.60
36	0.600	2.31	2.72	3.40	3.95	4.73	5.33	5.96	6.66	7.66	8.48
37	0.617	2.27	2.68	3.35	3.89	4.66	5.25	5.87	6.56	7.55	8.36
38	0.633	2.24	2.65	3.30	3.83	4.60	5.18	5.79	6.47	7.45	8.25
39	0.650	2.21	2.61	3.25	3.78	4.53	5.11	5.71	6.39	7.35	8.15
40	0.667	2.18	2.57	3.21	3.73	4.47	5.04	5.63	6.30	7.26	8.04
41	0.683	2.15	2.53	3.16	3.68	4.41	4.97	5.56	6.22	7.17	7.94
42	0.700	2.12	2.50	3.12	3.63	4.35	4.90	5.48	6.14	7.08	7.85

Time		Atlas 14 Rainfall Intensity (inches/hour) by Storm Frequency PA-1									
Minutes	Hours	1-year	2-year	5-year	10-year	25-year	50-year	100-year	200-year	500-year	1000-year
43	0.717	2.09	2.46	3.08	3.58	4.29	4.84	5.41	6.06	6.99	7.75
44	0.733	2.06	2.43	3.04	3.53	4.24	4.78	5.34	5.98	6.90	7.66
45	0.750	2.03	2.40	3.00	3.48	4.18	4.72	5.28	5.91	6.82	7.57
46	0.767	2.00	2.36	2.96	3.44	4.13	4.66	5.21	5.84	6.74	7.48
47	0.783	1.97	2.33	2.92	3.39	4.08	4.60	5.15	5.77	6.66	7.40
48	0.800	1.95	2.30	2.88	3.35	4.02	4.54	5.08	5.70	6.58	7.31
49	0.817	1.92	2.27	2.84	3.31	3.97	4.48	5.02	5.63	6.51	7.23
50	0.833	1.89	2.24	2.80	3.27	3.92	4.43	4.96	5.56	6.43	7.15
51	0.850	1.87	2.21	2.77	3.22	3.88	4.38	4.90	5.50	6.36	7.07
52	0.867	1.84	2.18	2.73	3.18	3.83	4.32	4.84	5.43	6.29	6.99
53	0.883	1.82	2.15	2.70	3.14	3.78	4.27	4.79	5.37	6.22	6.92
54	0.900	1.79	2.12	2.66	3.11	3.73	4.22	4.73	5.31	6.15	6.84
55	0.917	1.77	2.10	2.63	3.07	3.69	4.17	4.68	5.25	6.08	6.77
56	0.933	1.74	2.07	2.59	3.03	3.64	4.12	4.62	5.19	6.02	6.70
57	0.950	1.72	2.04	2.56	2.99	3.60	4.07	4.57	5.13	5.95	6.63
58	0.967	1.70	2.01	2.53	2.95	3.56	4.02	4.51	5.07	5.89	6.56
59	0.983	1.67	1.99	2.49	2.92	3.51	3.98	4.46	5.02	5.82	6.49
60	1.000	1.65	1.96	2.46	2.88	3.47	3.93	4.41	4.96	5.76	6.42
120	2.000	0.99	1.21	1.55	1.85	2.29	2.64	3.03	3.48	4.13	4.67
180	3.000	0.72	0.90	1.16	1.40	1.77	2.07	2.41	2.80	3.37	3.84
240	4.000	0.57	0.72	0.93	1.13	1.44	1.70	2.00	2.33	2.82	3.23
360	6.000	0.41	0.53	0.69	0.85	1.09	1.30	1.54	1.81	2.21	2.55
720	12.000	0.23	0.30	0.40	0.50	0.64	0.77	0.92	1.09	1.35	1.57
1440	24.000	0.13	0.17	0.23	0.29	0.37	0.45	0.54	0.64	0.80	0.93

Design Rainfall Values – PA-1

Depth-Duration-Frequency (DDF) Values for PA-1											
Duration		Atlas 14, Volume 11 Design Storm Depth (inches) by Storm Frequency									
Period	hr	1-year	2-year	5-year	10-year	25-year	50-year	100-year	200-year	500-year	1000-year
5-min:	0.0833	0.45	0.53	0.66	0.78	0.94	1.06	1.19	1.33	1.52	1.67
10-min:	0.1667	0.71	0.84	1.06	1.24	1.50	1.70	1.90	2.12	2.40	2.61
15-min:	0.2500	0.90	1.06	1.33	1.55	1.86	2.11	2.36	2.63	3.00	3.29
30-min:	0.5000	1.27	1.50	1.87	2.17	2.60	2.93	3.27	3.65	4.19	4.63
60-min:	1.0000	1.65	1.96	2.46	2.88	3.47	3.93	4.41	4.96	5.76	6.42
2-hr:	2	1.98	2.42	3.09	3.69	4.57	5.28	6.07	6.96	8.26	9.34
3-hr:	3	2.15	2.69	3.48	4.21	5.30	6.21	7.24	8.40	10.10	11.52
6-hr:	6	2.46	3.16	4.15	5.09	6.54	7.80	9.23	10.86	13.26	15.29
12-hr:	12	2.78	3.62	4.80	5.94	7.70	9.25	11.02	13.10	16.23	18.90
24-hr:	24	3.11	4.10	5.49	6.85	8.93	10.76	12.88	15.34	19.12	22.37
2-day:	48	3.58	4.72	6.36	7.94	10.41	12.37	14.88	17.78	21.92	25.62
3-day:	72	3.90	5.11	6.88	8.58	11.27	13.17	15.92	19.03	23.13	27.00
4-day:	96	4.18	5.44	7.32	9.13	12.02	13.75	16.72	20.04	23.99	28.03
7-day:	168	4.79	6.19	8.23	10.15	13.03	15.44	18.19	21.31	25.99	29.89
10-day:	240	5.24	6.70	8.85	10.84	13.80	16.25	19.02	22.12	26.78	30.61
20-day:	480	6.67	8.33	10.73	12.99	16.24	18.81	21.63	24.68	29.35	32.93
30-day:	720	7.99	9.84	12.39	14.91	18.45	21.14	24.00	27.01	31.79	35.14
45-day:	1080	9.76	11.89	14.44	17.36	21.33	24.20	27.14	30.07	35.25	38.24
60-day:	1440	11.26	13.68	15.97	19.29	23.69	26.74	29.75	32.61	38.45	41.07

Precipitation Area PA-2

Intensity-Duration-Frequency (IDF) Values for PA-2

Time		Atlas 14 Rainfall Intensity (inches/hour) by Storm Frequency PA-2									
Minutes	Hours	1-year	2-year	5-year	10-year	25-year	50-year	100-year	200-year	500-year	1000-year
5	0.083	5.35	6.34	7.94	9.29	11.14	12.60	14.01	15.56	17.68	19.36
6	0.100	5.04	5.98	7.52	8.80	10.53	11.94	13.30	14.73	16.67	18.16
7	0.117	4.79	5.70	7.17	8.39	10.03	11.40	12.69	14.05	15.85	17.22
8	0.133	4.59	5.45	6.87	8.04	9.61	10.92	12.16	13.45	15.15	16.44
9	0.150	4.41	5.24	6.60	7.73	9.23	10.48	11.68	12.91	14.54	15.76
10	0.167	4.25	5.05	6.36	7.44	8.88	10.08	11.23	12.42	13.98	15.16
11	0.183	4.10	4.87	6.13	7.17	8.56	9.70	10.81	11.95	13.46	14.61
12	0.200	3.97	4.70	5.92	6.91	8.25	9.34	10.41	11.51	12.98	14.10
13	0.217	3.84	4.54	5.71	6.67	7.96	8.99	10.02	11.08	12.52	13.62
14	0.233	3.72	4.39	5.51	6.43	7.67	8.65	9.64	10.67	12.08	13.17
15	0.250	3.61	4.24	5.32	6.20	7.40	8.32	9.27	10.27	11.65	12.73
16	0.267	3.49	4.10	5.14	5.99	7.14	8.03	8.94	9.91	11.24	12.30
17	0.283	3.39	3.98	4.98	5.79	6.91	7.77	8.64	9.58	10.88	11.91
18	0.300	3.29	3.86	4.83	5.62	6.71	7.53	8.38	9.29	10.55	11.55
19	0.317	3.21	3.76	4.69	5.46	6.52	7.32	8.14	9.03	10.26	11.23
20	0.333	3.13	3.66	4.57	5.32	6.35	7.12	7.92	8.78	9.99	10.94
21	0.350	3.05	3.58	4.46	5.19	6.19	6.94	7.72	8.56	9.74	10.68
22	0.367	2.98	3.50	4.35	5.06	6.04	6.78	7.53	8.36	9.51	10.43
23	0.383	2.92	3.42	4.26	4.95	5.91	6.62	7.36	8.17	9.30	10.20
24	0.400	2.86	3.35	4.17	4.84	5.78	6.48	7.20	7.99	9.10	9.99
25	0.417	2.80	3.28	4.08	4.74	5.66	6.34	7.05	7.83	8.92	9.79
26	0.433	2.75	3.22	4.00	4.65	5.55	6.22	6.91	7.67	8.74	9.61
27	0.450	2.70	3.16	3.93	4.56	5.44	6.10	6.78	7.53	8.58	9.43
28	0.467	2.65	3.10	3.85	4.48	5.34	5.99	6.65	7.39	8.43	9.26
29	0.483	2.60	3.05	3.79	4.40	5.25	5.88	6.53	7.26	8.28	9.11
30	0.500	2.56	3.00	3.72	4.32	5.16	5.78	6.42	7.13	8.14	8.96
31	0.517	2.52	2.95	3.66	4.25	5.07	5.68	6.31	7.02	8.01	8.82
32	0.533	2.48	2.90	3.60	4.18	4.99	5.59	6.21	6.90	7.89	8.68
33	0.550	2.44	2.85	3.54	4.11	4.91	5.50	6.11	6.80	7.77	8.55
34	0.567	2.40	2.81	3.49	4.05	4.84	5.42	6.02	6.69	7.65	8.43
35	0.583	2.36	2.77	3.43	3.99	4.76	5.34	5.93	6.59	7.54	8.31
36	0.600	2.33	2.72	3.38	3.93	4.69	5.26	5.84	6.50	7.43	8.20
37	0.617	2.29	2.68	3.33	3.87	4.63	5.18	5.76	6.41	7.33	8.09
38	0.633	2.26	2.64	3.28	3.81	4.56	5.11	5.68	6.32	7.23	7.98
39	0.650	2.22	2.61	3.24	3.76	4.50	5.04	5.60	6.23	7.14	7.88
40	0.667	2.19	2.57	3.19	3.71	4.43	4.97	5.52	6.15	7.04	7.78
41	0.683	2.16	2.53	3.14	3.65	4.37	4.90	5.45	6.07	6.95	7.68
42	0.700	2.13	2.50	3.10	3.60	4.31	4.83	5.38	5.99	6.87	7.58

Time		Atlas 14 Rainfall Intensity (inches/hour) by Storm Frequency PA-2									
Minutes	Hours	1-year	2-year	5-year	10-year	25-year	50-year	100-year	200-year	500-year	1000-year
43	0.717	2.10	2.46	3.06	3.56	4.26	4.77	5.31	5.91	6.78	7.49
44	0.733	2.07	2.43	3.02	3.51	4.20	4.71	5.24	5.84	6.70	7.40
45	0.750	2.04	2.40	2.98	3.46	4.15	4.65	5.17	5.77	6.62	7.32
46	0.767	2.01	2.36	2.94	3.42	4.09	4.59	5.11	5.70	6.54	7.23
47	0.783	1.98	2.33	2.90	3.37	4.04	4.53	5.04	5.63	6.46	7.15
48	0.800	1.95	2.30	2.86	3.33	3.99	4.48	4.98	5.56	6.39	7.07
49	0.817	1.93	2.27	2.82	3.29	3.94	4.42	4.92	5.49	6.31	6.99
50	0.833	1.90	2.24	2.79	3.24	3.89	4.37	4.86	5.43	6.24	6.91
51	0.850	1.87	2.21	2.75	3.20	3.84	4.31	4.80	5.36	6.17	6.83
52	0.867	1.85	2.18	2.72	3.16	3.79	4.26	4.75	5.30	6.10	6.76
53	0.883	1.82	2.15	2.68	3.12	3.75	4.21	4.69	5.24	6.03	6.69
54	0.900	1.80	2.12	2.65	3.08	3.70	4.16	4.64	5.18	5.97	6.61
55	0.917	1.77	2.09	2.61	3.05	3.66	4.11	4.58	5.12	5.90	6.54
56	0.933	1.75	2.06	2.58	3.01	3.61	4.06	4.53	5.06	5.84	6.47
57	0.950	1.72	2.04	2.55	2.97	3.57	4.01	4.48	5.01	5.77	6.41
58	0.967	1.70	2.01	2.51	2.93	3.53	3.96	4.42	4.95	5.71	6.34
59	0.983	1.67	1.98	2.48	2.90	3.48	3.92	4.37	4.90	5.65	6.27
60	1.000	1.65	1.96	2.45	2.86	3.44	3.87	4.32	4.84	5.59	6.21
120	2.000	0.99	1.21	1.54	1.84	2.26	2.60	2.98	3.40	4.02	4.53
180	3.000	0.71	0.89	1.15	1.39	1.75	2.04	2.37	2.74	3.28	3.73
240	4.000	0.56	0.71	0.93	1.13	1.42	1.67	1.96	2.28	2.75	3.14
360	6.000	0.41	0.52	0.69	0.84	1.07	1.28	1.51	1.77	2.15	2.47
720	12.000	0.23	0.30	0.40	0.49	0.63	0.76	0.90	1.06	1.31	1.52
1440	24.000	0.13	0.17	0.23	0.28	0.36	0.44	0.52	0.62	0.77	0.90

Design Rainfall Values – PA-2

Depth-Duration-Frequency (DDF) Values for PA-2											
Duration		Atlas 14, Volume 11 Design Storm Depth (inches) by Storm Frequency									
Period	hr	1-year	2-year	5-year	10-year	25-year	50-year	100-year	200-year	500-year	1000-year
5-min:	0.0833	0.45	0.53	0.66	0.77	0.93	1.05	1.17	1.30	1.47	1.61
10-min:	0.1667	0.71	0.84	1.06	1.24	1.48	1.68	1.87	2.07	2.33	2.53
15-min:	0.2500	0.90	1.06	1.33	1.55	1.85	2.08	2.32	2.57	2.91	3.18
30-min:	0.5000	1.28	1.50	1.86	2.16	2.58	2.89	3.21	3.57	4.07	4.48
60-min:	1.0000	1.65	1.96	2.45	2.86	3.44	3.87	4.32	4.84	5.59	6.21
2-hr:	2	1.97	2.41	3.08	3.67	4.52	5.20	5.95	6.80	8.03	9.06
3-hr:	3	2.14	2.67	3.46	4.18	5.24	6.12	7.10	8.21	9.84	11.20
6-hr:	6	2.44	3.13	4.11	5.05	6.45	7.66	9.04	10.59	12.90	14.84
12-hr:	12	2.76	3.58	4.75	5.87	7.58	9.06	10.76	12.74	15.73	18.27
24-hr:	24	3.10	4.04	5.44	6.76	8.74	10.45	12.47	14.85	18.45	21.51
2-day:	48	3.53	4.65	6.23	7.73	10.06	12.13	14.27	17.00	21.09	24.55
3-day:	72	3.83	5.03	6.75	8.35	10.85	13.09	15.12	18.03	22.34	25.97
4-day:	96	4.10	5.37	7.20	8.87	11.52	13.93	15.73	18.83	23.37	27.16
7-day:	168	4.72	6.08	8.04	9.87	12.58	14.86	17.39	20.28	24.56	28.16
10-day:	240	5.17	6.58	8.64	10.55	13.34	15.68	18.21	21.11	25.35	28.93
20-day:	480	6.58	8.18	10.48	12.65	15.73	18.24	20.82	23.71	27.84	31.39
30-day:	720	7.88	9.67	12.09	14.52	17.89	20.56	23.20	26.09	30.09	33.74
45-day:	1080	9.61	11.69	14.07	16.90	20.70	23.62	26.33	29.22	33.04	37.06
60-day:	1440	11.07	13.44	15.53	18.75	22.99	26.16	28.94	31.83	35.48	40.11

Precipitation Area PA-3

Intensity-Duration-Frequency (IDF) Values for PA-3

Time		Atlas 14 Rainfall Intensity (inches/hour) by Storm Frequency PA-3									
Minutes	Hours	1-year	2-year	5-year	10-year	25-year	50-year	100-year	200-year	500-year	1000-year
5	0.083	5.34	6.30	7.88	9.20	11.00	12.36	13.79	15.24	17.20	18.71
6	0.100	5.03	5.95	7.45	8.73	10.43	11.75	13.08	14.43	16.21	17.56
7	0.117	4.78	5.66	7.11	8.33	9.95	11.24	12.49	13.76	15.41	16.65
8	0.133	4.58	5.42	6.81	7.98	9.54	10.78	11.97	13.17	14.74	15.90
9	0.150	4.40	5.21	6.54	7.67	9.17	10.35	11.49	12.65	14.14	15.24
10	0.167	4.24	5.02	6.30	7.38	8.82	9.96	11.05	12.16	13.60	14.66
11	0.183	4.10	4.85	6.08	7.11	8.50	9.58	10.64	11.70	13.10	14.13
12	0.200	3.97	4.68	5.86	6.85	8.19	9.22	10.24	11.27	12.62	13.63
13	0.217	3.84	4.53	5.66	6.60	7.89	8.87	9.85	10.85	12.17	13.17
14	0.233	3.73	4.38	5.47	6.36	7.60	8.53	9.48	10.45	11.74	12.73
15	0.250	3.62	4.24	5.28	6.12	7.32	8.20	9.12	10.06	11.33	12.31
16	0.267	3.50	4.10	5.10	5.91	7.07	7.91	8.79	9.70	10.93	11.88
17	0.283	3.39	3.97	4.94	5.72	6.84	7.66	8.50	9.38	10.58	11.50
18	0.300	3.30	3.86	4.80	5.55	6.63	7.42	8.24	9.10	10.26	11.16
19	0.317	3.21	3.75	4.66	5.40	6.45	7.21	8.00	8.84	9.97	10.85
20	0.333	3.13	3.66	4.54	5.26	6.28	7.02	7.79	8.60	9.71	10.57
21	0.350	3.06	3.57	4.43	5.13	6.12	6.84	7.59	8.38	9.46	10.31
22	0.367	2.99	3.49	4.33	5.01	5.98	6.68	7.41	8.18	9.24	10.07
23	0.383	2.92	3.41	4.23	4.90	5.84	6.53	7.24	8.00	9.04	9.85
24	0.400	2.86	3.34	4.14	4.79	5.72	6.39	7.08	7.82	8.84	9.65
25	0.417	2.81	3.27	4.06	4.70	5.60	6.26	6.93	7.66	8.66	9.45
26	0.433	2.75	3.21	3.98	4.60	5.49	6.13	6.80	7.51	8.50	9.27
27	0.450	2.70	3.15	3.90	4.52	5.38	6.02	6.66	7.37	8.34	9.10
28	0.467	2.65	3.09	3.83	4.43	5.28	5.91	6.54	7.23	8.19	8.94
29	0.483	2.60	3.04	3.76	4.35	5.19	5.80	6.42	7.10	8.04	8.79
30	0.500	2.56	2.98	3.70	4.28	5.10	5.70	6.31	6.98	7.91	8.65
31	0.517	2.52	2.93	3.64	4.21	5.01	5.60	6.21	6.87	7.78	8.51
32	0.533	2.48	2.89	3.58	4.14	4.93	5.51	6.11	6.76	7.66	8.38
33	0.550	2.44	2.84	3.52	4.07	4.85	5.43	6.01	6.65	7.54	8.25
34	0.567	2.40	2.79	3.47	4.01	4.78	5.34	5.92	6.55	7.43	8.13
35	0.583	2.36	2.75	3.41	3.95	4.71	5.26	5.83	6.45	7.32	8.02
36	0.600	2.32	2.71	3.36	3.89	4.64	5.18	5.74	6.36	7.22	7.91
37	0.617	2.29	2.67	3.31	3.83	4.57	5.11	5.66	6.27	7.12	7.80
38	0.633	2.25	2.63	3.26	3.78	4.50	5.04	5.58	6.18	7.02	7.70
39	0.650	2.22	2.59	3.22	3.72	4.44	4.97	5.50	6.10	6.93	7.60
40	0.667	2.19	2.55	3.17	3.67	4.38	4.90	5.43	6.01	6.84	7.50
41	0.683	2.16	2.52	3.13	3.62	4.32	4.83	5.35	5.93	6.75	7.41
42	0.700	2.12	2.48	3.08	3.57	4.26	4.77	5.28	5.86	6.66	7.31

Time		Atlas 14 Rainfall Intensity (inches/hour) by Storm Frequency PA-3									
Minutes	Hours	1-year	2-year	5-year	10-year	25-year	50-year	100-year	200-year	500-year	1000-year
43	0.717	2.09	2.45	3.04	3.52	4.20	4.70	5.21	5.78	6.58	7.23
44	0.733	2.06	2.41	3.00	3.48	4.15	4.64	5.15	5.71	6.50	7.14
45	0.750	2.03	2.38	2.96	3.43	4.09	4.58	5.08	5.64	6.42	7.06
46	0.767	2.00	2.35	2.92	3.39	4.04	4.52	5.02	5.57	6.35	6.97
47	0.783	1.98	2.32	2.88	3.34	3.99	4.47	4.96	5.50	6.27	6.89
48	0.800	1.95	2.28	2.84	3.30	3.94	4.41	4.89	5.43	6.20	6.81
49	0.817	1.92	2.25	2.81	3.26	3.89	4.36	4.83	5.37	6.13	6.74
50	0.833	1.89	2.22	2.77	3.21	3.84	4.30	4.78	5.31	6.06	6.66
51	0.850	1.87	2.19	2.73	3.17	3.79	4.25	4.72	5.24	5.99	6.59
52	0.867	1.84	2.16	2.70	3.13	3.74	4.20	4.66	5.18	5.92	6.52
53	0.883	1.81	2.13	2.66	3.09	3.70	4.15	4.61	5.12	5.85	6.44
54	0.900	1.79	2.11	2.63	3.05	3.65	4.10	4.55	5.06	5.79	6.37
55	0.917	1.76	2.08	2.59	3.02	3.61	4.05	4.50	5.00	5.72	6.31
56	0.933	1.74	2.05	2.56	2.98	3.56	4.00	4.45	4.95	5.66	6.24
57	0.950	1.71	2.02	2.53	2.94	3.52	3.95	4.39	4.89	5.60	6.17
58	0.967	1.69	1.99	2.49	2.90	3.47	3.90	4.34	4.84	5.54	6.11
59	0.983	1.66	1.97	2.46	2.87	3.43	3.86	4.29	4.78	5.48	6.04
60	1.000	1.64	1.94	2.43	2.83	3.39	3.81	4.24	4.73	5.42	5.98
120	2.000	0.98	1.19	1.52	1.81	2.22	2.55	2.90	3.30	3.88	4.35
180	3.000	0.71	0.88	1.14	1.37	1.71	1.99	2.30	2.65	3.15	3.57
240	4.000	0.56	0.70	0.91	1.11	1.39	1.63	1.90	2.20	2.64	3.00
360	6.000	0.40	0.51	0.67	0.82	1.05	1.24	1.46	1.70	2.06	2.36
720	12.000	0.23	0.29	0.39	0.48	0.61	0.73	0.86	1.02	1.25	1.45
1440	24.000	0.13	0.17	0.22	0.27	0.35	0.42	0.50	0.59	0.73	0.85

Design Rainfall Values – PA-3

Depth-Duration-Frequency (DDF) Values for PA-3											
Duration		Atlas 14, Volume 11 Design Storm Depth (inches) by Storm Frequency									
Period	hr	1-year	2-year	5-year	10-year	25-year	50-year	100-year	200-year	500-year	1000-year
5-min:	0.0833	0.45	0.53	0.66	0.77	0.92	1.03	1.15	1.27	1.43	1.56
10-min:	0.1667	0.71	0.84	1.05	1.23	1.47	1.66	1.84	2.03	2.27	2.44
15-min:	0.2500	0.90	1.06	1.32	1.53	1.83	2.05	2.28	2.51	2.83	3.08
30-min:	0.5000	1.28	1.49	1.85	2.14	2.55	2.85	3.16	3.49	3.96	4.32
60-min:	1.0000	1.64	1.94	2.43	2.83	3.39	3.81	4.24	4.73	5.42	5.98
2-hr:	2	1.96	2.38	3.04	3.62	4.44	5.10	5.81	6.60	7.75	8.70
3-hr:	3	2.12	2.64	3.43	4.11	5.14	5.98	6.91	7.95	9.46	10.72
6-hr:	6	2.42	3.08	4.05	4.95	6.31	7.45	8.74	10.20	12.36	14.17
12-hr:	12	2.73	3.53	4.66	5.73	7.36	8.76	10.36	12.22	14.99	17.36
24-hr:	24	3.07	3.96	5.31	6.56	8.46	10.06	12.00	14.20	17.51	20.35
2-day:	48	3.49	4.55	6.06	7.49	9.69	11.62	13.60	16.15	19.95	23.18
3-day:	72	3.77	4.91	6.55	8.07	10.42	12.51	14.37	17.07	21.09	24.46
4-day:	96	4.02	5.23	6.97	8.55	11.03	13.29	14.90	17.77	21.99	25.52
7-day:	168	4.67	5.96	7.85	9.57	12.13	14.25	16.60	19.27	23.24	26.52
10-day:	240	5.12	6.46	8.44	10.23	12.88	15.04	17.42	20.08	24.05	27.29
20-day:	480	6.53	8.07	10.25	12.29	15.22	17.53	19.98	22.64	26.69	29.75
30-day:	720	7.83	9.55	11.84	14.11	17.33	19.78	22.30	24.97	29.21	32.10
45-day:	1080	9.56	11.57	13.78	16.42	20.07	22.73	25.36	28.03	32.77	35.42
60-day:	1440	11.02	13.33	15.21	18.20	22.29	25.17	27.90	30.57	36.08	38.47