City of Gonzales

Engineering Standards Manual

October 2013

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A. DRAINAGE DESIGN CRITERIA

A.1.0 Introduction

1.1 Purpose and Scope

A. The purpose of this design criteria is to establish standard principles and practices for the design and construction of storm drainage, flood protection, and erosion control facilities within the City of Gonzales, Texas and within its extraterritorial jurisdiction.

B. The design factors, formulas, graphs, and procedures described in the following pages are intended to serve as guidelines for the solution of drainage problems involving the volume and rate of flow, method of collection, storage, conveyance and disposal of stormwater and erosion protection from stormwater flows. Ultimate responsibility for actual design, however, remains with the design engineer. Any deviation from the requirements of this manual shall be approved by the Designated Official of the City of Gonzales.

C. Section 4.0 and beyond are concerned with issues related to the Drainage Plan and Drainage Report required for a Type 3 Development.

D. **In cases where the owner has negotiated monies instead of on-site or off-site drainage improvements, the development standards will be tailored within the terms of the negotiations.**

1.2 References

At certain points in the text, the reader will encounter numbers enclosed in parentheses, for example (1). These numbers correspond to the references listed in Appendix A.

1.3 Acknowledgments

This design criteria is based on a similar manual produced by the City of New Braunfels, Texas.

A.2.0 Drainage Policy And Criteria

2.1 Development Categories

In an effort to facilitate development while applying drainage rules, a tier system is established requiring different submittals and different development actions depending on the probable impact on the drainage basin. In all cases, properly sized easements shall be granted across all contiguous property owned by the applicant; and a comprehensive Drainage Plan and Drainage Report shall be provided for all property on the subject plat whether developed by this application or not. Best Management Practices (BMPs) shall be exercised in the design process.

2.1.1 Type 1 Development

A. A Type 1 Development is any development or redevelopment in the following categories.

1. Disturbs less than one acre of land;
2. Creates less than 1,000 square feet of additional impervious cover; or
3. Creates additions to single family or duplex residential structure.

B. Submittals for a Type 1 Development include: location and contact information (e.g. name, address, phone number, property location), site drawing for the proposed disturbance, review of applicable BMP's and temporary erosion control techniques. For a Type 1 Development:

1. Drainage easements may be required to accommodate future or existing development

2.1.2 Type 2 Development

A. A Type 2 Development is any development or redevelopment in the following categories:

1. Agriculture (not including feedlots), or

2. Single family or duplex residential not in a major subdivision (three or more lots) with more than 1,000 square feet of additional impervious cover, or

3. Non-residential developments of less than 5,000 square feet of additional impervious cover, or

4. Development not meeting criteria for a Type 3 Development.

B. Submittals for a Type 2 Development include: location and contact information, site drawing or sketch for the proposed disturbance (a scaled drawing (scale 1" = (50' or less)) on 11" x 17" paper showing existing drainageways, flow directions, floodplain boundaries, proposed grading and development, and proposed drainage, and erosion control facilities with a copy of the survey plat showing the lot layout, streets, and utility and drainage easements), review of applicable BMP's and temporary erosion control techniques, agreement letter specifying BMP's to be included in the project. For a Type 2 Development:

1. If any on-site and off-site stormwater structure is known to be at or below design capacity, the owner/developer shall be responsible for increasing the size of the structure to accommodate the development.

2. Drainage easements may be required to accommodate future or existing development.

2.1.3 <u>Type 3 Development</u>

A. A Type 3 Development is any development or redevelopment in the following categories.

1. Non-residential development with more than 5,000 square feet of additional impervious cover,

2. Residential subdivision with other than single family and duplex units,

3. Major subdivisions (three or more lots),

4. Disturbs more than one acre of land,

5. Development within a FEMA designated flood hazard area or adjacent to a major watercourse, or

6. Agricultural feedlots

B. Submittals for a Type 3 Development include: location and contact information, Drainage Report, Erosion Control Plan, agreement letter specifying BMP's to be included in the project or other site specific requirements. For a Type 3 Development:

1. Mitigation through detention, retention, or some other technique must be designed, constructed, and maintained to reduce the post-development discharge rate to below that of pre-development for the 2- year, 10-year, 25-year and 100-year design storms. Participation in neighborhood or regional mitigation is an acceptable option when available.

2. In cases where adequate detention is not available and an In-lieu-of negotiation is in place, all on-site and off-site stormwater structures must be sized to convey the additional stormwater from the property to the first major stream. For existing structures, see paragraph 3 below.

3. If any encountered structures are at or below design capacity, the owner/developer shall be responsible for increasing the size of the structure to accommodate the development, at their own expense or demonstrating cause why the city should partner in the project.

4. On-site drainage easements may be required to accommodate future or existing development. Off-site drainage easements may also be required if the increase in water quantity impacts existing water storage capacity and increases the possibility of flooding.

C. The Drainage Plan and Drainage Report containing the proposed storm drainage and flood protection system must be submitted as part of the vesting platting process or application for a Building Permit. A revised Drainage Plan and Drainage Report shall be submitted after all issues have been resolved with the Designated Official.

2.2 Water Quality

Stormwater discharge from developments may eventually be regulated for the quality of the water discharged. Standards for water quality of discharge are not currently being enforced. When the responsibilities of administering EPA/TCEQ NPDES/TPDES Phase II fall to the City, additional requirements will be enforced.

2.3 Drainage Structure Aesthetics

A. Drainage design in the urban environment must also consider appearance as an integral part of the design and structures should generally blend with the natural surroundings as much as possible to maintain the aesthetics of the natural area. The City of Gonzales strongly encourages preservation of the natural floodplains.

B. The protection of existing trees and vegetation should be maximized during development of drainage plans. Whenever possible, the replacement of the trees destroyed by drainage and flood protection procedures is encouraged.

2.4 Drainage Design Computations

Computations to support all drainage designs shall be submitted to the Designated Official for review as part of the Drainage Report. Computer programs used to perform computations shall be limited to those referenced in this manual unless approved by the Designated Official. On-site pre-development stormwater runoff computations shall be based upon conditions representing the existing land conditions with respect to soil type, percentage cover, and cover type as of October, 2013. Undeveloped conditions must be assumed unless documentation is presented establishing the level of development prior to October, 2013. Design of structures shall use fully developed sub-basin conditions for the prescribed design storms.

2.5 Criteria for Design of Drainage Facilities

2.5.1 General

A. The planning and design of drainage systems should ensure that problems are not transferred from one location to another. Grading and other construction activities may not change the terrain to cause damage to public or private property from drainage or flood problems, increased runoff, or increased erosion or sediment movement.

B. Lot to lot drainage of sheet flows should be avoided in subdivision design. Typically, not more than one lot will be allowed to drain across another before drainage enters a street or storm drain.

C. The Designated Official shall not approve any Drainage Report pertaining to proposed construction, platting or other development where the proposed activity or change in the land would result in post-development discharge from the site exceeding discharge under natural conditions (prior to grading or other development), immediately downstream of the proposed site. Downstream capacity shall not be exceeded as a result of development. Exemptions from this provisions are as follows:

1. Additional drainage improvements are not required if drainage improvements have been provided for the fully developed condition, which includes the proposed development.

2. A fee may be utilized in place of a detention/retention system, at the request of affected persons, when it can be clearly demonstrated that detention/retention at the site does not provide off-site flood relief due to the parcel size, location, or other factors. The fees collected will be used to construct public flood control improvements, which will be designed to mitigate the potential damage of floodwaters associated with the property from which the fees are contributed. The amount of the fee shall be proportional to the cost of the otherwise required detention/retention system.

2.5.2 <u>Stormwater retention or detention facilities</u>

A. Stormwater retention or detention facilities must reduce peak flows from the 2-year, 24-hour storm, 10-year, 24hour storm, 25-year, 24-hour storm and the 100-year, 24-hour storm, such that these peak flows are no greater than under pre-development conditions.

B. The method(s) of retention or detention shall be appropriate to the type of development, topography, and amount of control needed. Suggested measures include the following:

   1. basins or swales – single or multiple

   2. check dams in gullies to slow runoff and trap sediment

   3. leach fields, infiltration chambers, dry wells, rain barrels, French drains

   4. granular fill under permeable paving blocks

   5. contour terracing, improved vegetation cover.

C. Detention/retention facilities may be incorporated into parks, open space areas and landscaping designs. Parking areas may be used as detention or retention facilities provided that maximum depths of ponding do not exceed eight inches, and ponding is in the areas most remotely situated from structures.

D. Stormwater infiltration systems are not permitted in any development where there is a potential for pollutants to adversely affect ground water quality.

E. No detention or retention basin shall retain standing water longer than 36 hours unless it is designed and constructed to be a permanent pond with appropriate health, safety, and water quality measures, and water rights requirements for such a body of water.

F. Individual lot basins within subdivisions may be approved for lots of one acre or more with slopes under 5% (five percent).

G. Specific requirements for retention/detention facilities are as follows:

1. Facilities shall be located such that the edge of the 100-year water surface is at least 10 feet from the edge of any public road. Finished floors of adjacent structures should be a minimum of 1 foot above the 100-year water surface in the facility. Facilities should preferably be located such that the invert of the outlet structure is above the 100-year flood level in the receiving body; but in all cases facilities shall be designed to function properly during conditions where the outlet is submerged by the tailwater of the receiving stream.

2. Drainage easements or open space designations may be required for retention/detention facilities. Easement boundaries shall contain the berms, inlet and outlet structures, access ramps, permanent erosion control facilities, the 100-year water surface and any additional area needed for access and maintenance.

3. Ponding below natural grade (depressed storage) is encouraged.

4. Detention facilities shall be designed with one or more outlet structures to allow safe passage of the 100-year post-development design storm runoff. In addition, an emergency spillway shall be provided with sufficient capacity to pass at least the 25-year design storm runoff assuming the pond is full. Spillways and outlets shall be protected from erosion with riprap, grouted riprap, or other method or erosion control to adequately protect the structure and downstream channel. Outflows shall be conveyed to an appropriate receiving drainage facility in a manner such that roadways, buildings, etc. are not damaged.

5. In the event a detention facility empties into another storage facility downstream, the effect of the facility's outflow hydrograph (volume and peak flow) on that facility shall be evaluated.

6. Side slopes of earthen embankments shall be designed for stability and safety, with the following minimum requirements for facilities with unrestricted access: in facilities with ponding depths of 18 inches to 3 feet, side slopes of earthen banks shall be 2.5:1 or flatter; side slopes shall be 3:1 or flatter in facilities with maximum ponding depths over 3 feet; a benched configuration is required for facilities with ponding depths over 6 feet. Bench widths shall be at least 4 feet, spaced at least every 3 feet vertically. The above slope criteria may be waived if security barriers and erosion control measures are provided, with Designated Official approval. Barriers may consist of chain-link, masonry, wood, vegetation or other materials, but must not restrict the hydraulic capacity of drainage facilities. Minimum barrier height is 48". Vegetative barriers must be of a width equal to or greater than the total height, with density sufficient to restrict access. All constructed stormwater structures of earthen material shall be revegetated to mature growth.

7. Maximum water depths over 6 feet shall not be allowed without prior approval from the Designated Official.

8. All earthen drainage structures or facilities shall be compacted in lifts not to exceed eight inches during construction to 90% Standard Proctor.

2.5.3 <u>Culvert or bridge crossings</u>

A. Arterial streets shall meet the stricter of the most recent Texas Department of Transportation criteria for crossings on urban highways, or;

   1. 50-year design storm runoff, with headwater one foot below the top of the culvert structure.

   2. 100-year water surface shall not encroach through half of roadway lanes

   3. Minimum culvert size 24” circular pipe

B. All other streets shall meet the following criteria for crossings, as a minimum:

   1. 50-year design storm runoff, with headwater one foot below the top embankment

   2. 50-year water surface shall leave at least one lane open.

   3. 100-year design storm runoff no more than 6” over top of roadway

   4. Allowance shall be made for conveyance of the 100-year runoff across the road and into the downstream channel without damage to the road or adjacent property

   5. Minimum culvert size 18” circular pipe

C. Temporary crossings shall be designed to safely pass the 2-year design storm runoff, minimum.

D. The backwater created by a culvert or bridge during the 100-year design storm runoff shall not cause damage to public or private property.

E. Culvert outlets will be designed to minimize damage caused by erosion.

F. Culverts and bridges shall be aligned with natural drainageways in grade and direction whenever practical. Minimum slopes by culvert type must be observed to reduce sediment accumulation.

G. Larger culvert sizes, bridges and/or box culverts or smooth-walled pipe are recommended for crossings where heavy debris or sediment accumulations are anticipated. Trash racks may be required.

H. All headwalls shall be constructed of reinforced concrete.

2.5.4 <u>Surface use of streets and alleys for drainage</u>

A. General requirements for streets are:

1. The roadway or paved alley must be able to contain the 100-year flow within the right of way. Runoff shall not enter private property from a street except in recorded drainage easements or rights-of-way, or in historic watercourses where easements or rights-of-way have not been obtained.

2. 100-year design storm depth of water shall not exceed 10" at any point within the street right-of-way and the product of maximum depth (feet) times average cross-section velocity (feet per second) at any point shall not exceed 6.5.

3. Rundowns shall be designed to convey and contain drainage carded by the roadway to ensure the 100-year event is contained within the right-of-way. If a storm drain system is present, rundowns shall be designed for the difference between the storm drain capacity and the 100-year runoff, with a 25-year minimum design assuming all of the flow bypasses the storm drain system.

4. Driveways should be constructed to allow the 25-year design storm runoff to pass under the driveway in a culvert (18" minimum) or over the driveway on a concrete apron. Concrete aprons or box culverts are preferred in areas of heavy sediment transport.

5. The side slope of a ditch or swale on the side adjacent to the road shall be no steeper then 4:1 (6:1 TxDOT)

C. Water Spread limits for Roadways is as indicated in Table 2-1. No lowering of the standard height of street crown shall be allowed for the purposes of obtaining additional hydraulic capacity. Where additional hydraulic capacity is required, the proposed street gradient must be increased or curb inlets and storm sewers installed to remove a portion of the flow. For non-curbed streets, the 100-year frequency flows shall be contained within available rights-of-way.

Table 2-1

Water Spread Limits for Roadways

Street Classification	**1O-Year Permissible Water Spread**
Arterial Streets	One 11-foot traffic lane must remain open in each direction.
Collector Streets	One 11-foot traffic lane must remain open.
Residential Streets	Water flow must not exceed the top of either curb.

2.5.5 Storm drain systems

A. General requirements for storm drain systems are:

1. Storm drain pipes, inlets, and roadside drainage swales shall be designed for the 25year design storm runoff with the design HGL of the system at or below the level of the street subgrade.

2. Pipe. Typically, reinforced concrete pipe shall be used within street rights of way. If corrugated metal pipe is used, the manufacturer's design guidelines shall be followed. Concrete lining shall be used with corrugated metal pipes with diameters of 36 inches or greater. Plastic pipe can be used only if authorized by the Designated Official and in no case shall plastic be used under roadways.

3. Connections. Concrete pipe collars or manufactured transition pieces must be used at all pipe size changes on trunk lines. For all pipe junctions other than manholes and junction boxes, manufactured wye connections should be used, and the angle of intersection shall not be greater than 45 degrees. This includes discharges into box culverts and channels. Special circumstances may require cut-ins instead of manufactured wye connections; the use of cut-ins must be approved by the Designated Official. Laterals shall be connected to trunk lines using manholes or manufactured wye connections. Special situations may require laterals to be connected to the trunk lines by a cut-in (punch-in), and such cut-ins must be approved by the Designated Official. Inlet laterals will normally connect only one inlet to the trunk line. Special circumstances requiring multiple inlets to be connected with a single lateral shall be approved by the Designated Official. Vertical curves in the conduit will not be permitted, and horizontal curves must meet manufacturer's requirements for offsetting of the joints.

4. The maximum manhole or junction box spacing for storm drain systems is shown in Table 8-2. Junction boxes must also be located at:

   a. Pick up points having three or more laterals;
   b. Trunk line size changes for pipes with diameter differences greater than 24 inches;
   c. Vertical alignment changes;
   d. Future collection points.

5. The cover over the crown of circular pipe should be at least two feet and should be based on the type of pipe used, the expected loads and the supporting strength of the pipe. Box sections should normally have a minimum of one foot of cover; however, box sections may be designed for direct traffic in special situations with the approval of the Designated Official.

6. Grates for drop inlets should be designed with grate units weighing 250 to 300 pounds to facilitate removal for maintenance, but minimize vandalism. Design shall consider traffic loading and bicycle and pedestrian safety.

7. The minimum storm drainpipe diameter shall be 18 inches. Manholes should be located at junctions, changes in pipe size, sharp changes in direction or grade, and at regular intervals of 300 feet, maximum. The requirement for manholes may be waived if the pipe size allows direct access into the pipe by maintenance personnel and equipment. More stringent criteria may be imposed by the Designated Official to reduce or facilitate maintenance.

8. A bypass flow of not more than 10% of the 10-year flow will be allowed on streets with grades of three percent or greater. No bypass flow will be allowed for inlets on streets with grades less than three percent.

9. For storms of a 10-year frequency or less, water flowing in arterial streets shall be intercepted by an inlet prior to super-elevated sections, to prevent water from flowing across the roadway. In critical circumstances, this requirement can be waived by the Designated Official.

10. All storm sewer conduits to be dedicated to the City of Gonzales shall be located in the drainage easements dedicated to the City of Gonzales at the time of filing plat approval. Storm sewer easements shall be at least 15 feet wide. Wider easements may be required for multiple box culverts, other multiple storm sewer designs or for extremely wide single-line storm sewers as outlined in the Drainage Design Manual.

B. Connections from Buildings to Storm Sewers. Drainage from residential areas, such as rooftops, should be allowed to flow overland before joining the storm sewer system. Seepage into basements that is pumped to ground level, seepage from springs and runoff from roof drains on nonresidential buildings that would flow onto or across driveways, sidewalks or other areas commonly crossed by pedestrians can create hazards or nuisances to pedestrians. Thus, if hazards or nuisances would be created, the basement and rooftop drains shall be tied directly to the nearest storm sewer. Pumped lines from basements shall have backflow preventers.

2.5.6 <u>Channels</u>

A. The City of Gonzales encourages the preservation of natural channels and drainage patterns. Concentrated drainage flows must enter and depart from a developed area in the same manner and location as under pre-development conditions.

B. Easements or drainage right-of-ways shall be provided for all channels (artificial and natural) and shall be labeled as drainage easements on plats for recording. For properties with existing structural development on previously platted lots, setbacks of the same dimensions may be used in place of easements. The requirement for a setback or easement may be waived by the Designated Official. Easements, setbacks and FEMA floodways shall not be encroached upon with fill materials or structures, which would reduce the channel's ability to carry the 100-year flood.

1. Easement width shall be at least the width of the water surface from the 100year design storm runoff under post-development conditions. In addition, an additional 12 feet, minimum, shall be allowed for access.

2. Additional easement width should be provided to allow for channel meandering near bends of channels.

3. Easement width should be measured outward from the centerline of the watercourse, 1/2 of the dimension to the right and 1/2 to the left of center, additional access easement shall be 10 feet on one side and two on the other.

C. Artificial channels and swales:

1. Artificial channels and swales shall be designed to contain the 100-year design storm runoff with the water surface at the top of the structure or within the easement whichever is more restrictive. Freeboard along the outside of channel bends shall include the increased water surface due to superelevation (refer to Section 9.6).

2. For large channels where exposure to the wind may cause wave action, additional freeboard must be included to accommodate 75 mph winds without washover.

3. Fencing and/or warning signs shall be required to prevent public access where flowing water would pose a safety hazard as determined by the Designated Official.

4. Unlined improved channels that contain bends shall be designed such that erosion at the bends is minimized. Erosion protection at bends shall be determined based on the velocity along the outside of the channel bend (refer to Section 9.5).

D. Flumes. Sidewalks crossing flumes shall be A.D.A. compatible so as to minimize danger to pedestrians (e.g. covered, flared, or bridged flumes; handrails on sidewalks). Applicants shall dedicate drainage easements for flumes.

E. Channels shall be designed to be stable and to not create safety hazards. Lined slopes should be no steeper than 1:1. Side slopes of artificial earthen channels should be 3:1 or flatter in channels with depths greater than 2 feet. Recommended maximum water velocities for earthen channels are given in Section 9. Erosion control or energy dissipation devices should be used to control velocities such that channel degradation does not occur. Bank stabilization measures shall not reduce channel capacity and shall follow sound engineering practices.

F. Should diversion of a natural drainageway be required, sufficient work shall be done upstream and/or downstream to provide all affected properties at least the same level of flood protection and erosion control that existed prior to the diversion. The time length of a diversion channel must be at least as long as the segment of natural channel being replaced so that velocity is not increased.

G. Maintenance Access Requirements. Access roads and/or ramps shall be provided for all channels to allow vehicular access for maintenance. The location and design of access roads and ramps shall be approved by the Designated Official. Access roads shall have a width of at least twelve feet and a cross slope no greater than two percent. Ramps on access roads shall have a vertical grade no steeper than ten percent.

2.6 Freeboard

Table 2-2 provides the required freeboard for fully developed watersheds.

2.7 Maintenance of Drainage Facilities

The hydraulic integrity of drainage systems dedicated to and accepted by the City of Gonzales, will be maintained by the City of Gonzales. The hydraulic integrity of drainage systems not dedicated with approval of the Designated Official to the City of Gonzales, shall be maintained by the property owner. Floodplain and drainage easements shall be maintained by the property owner.

Table 2-2
Freeboard

Storm Drainage Facility	Frequency	Freeboard
Street right-of-way	100-year	None
Channels and Creek Improvements	100-year	Wave action level****
Swales and Ditches*	25-year	None
Reservoirs	100-year	1 foot
Culverts and Bridges	25-year	**
Floodways and Floodplains	100-year	2 feet (in accordance with FEMA)
Levees	SPF***	4 feet

* In all cases, the 100-year event shall be contained in natural drainage channels, drainage easements, or public rights-of-way

** The culverts and bridges are designed to withstand the 100-year event, but the water level may reach roadway level at the 25-year design level if no public safety issues are involved.

*** SPF - Standard Project Flood

**** There are currently no known conditions in the City where wave action level is a consideration.

2.8 Drainage Report Requirements

A. An electronic media copy of drainage construction and topography in AutoCAD is required in addition to the paper file copy.

B. The construction of all improvements shall be in accordance with the current specifications and regulations adopted by the City of Gonzales.

C. The applicant shall submit a preliminary Drainage Report with the submittal of any vesting plat of a proposed Type 3 Development. A preliminary Drainage Report may also be required by the City when reviewing the merits of a change in zoning. Approval of the vesting plat or zoning change may be contingent on the acceptability of the solutions proposed by the Drainage Report.

D. The applicant shall submit a final Drainage Report with the submittal of any Record Plat, Plat Revision, or Plat showing a proposed development. Approval of the above mentioned plats shall be contingent on the acceptability of the solutions proposed by the final Drainage Report.

E. Drainage Reports shall be prepared by a Professional Engineer licensed in the State of Texas, experienced in Civil Engineering, and having a thorough knowledge of the study of drainage issues. Drainage Reports shall be signed, sealed, and dated by the person responsible for the study.

F. The Designated Official may waive the requirement of the Drainage Report or may limit certain requirements where the Designated Official determines that such requirements are not necessary for a proper review of the development.

G. Requirements for Drainage Report submittals: Drainage Area Map

1. Use a scale of one-inch equals 200 feet for the development and a scale of up to one-inch equals 2,000 feet for creeks and off-site areas, provided that the scale is adequate for review, and show match lines between any two or more maps.

2. Show existing and proposed storm sewers and inlets.

3. Indicate subareas for each alley, street, inlets, off-site areas, etc.

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

5. Indicate zoning on drainage area.

6. Show points of concentration of design points.

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

8. Provide runoff calculations for all areas showing acreage, runoff coefficient, inlet time and storm frequency.

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

H. Requirements for Drainage Report submittals: Drainage Report

* Calculations

1. Show hydraulic grade lines with computations.
2. Provide table with input parameters for all models and formulas.
3. Indicate all assumptions.

* Storm Drain Plan and Profile Sheets (or spec page)

1. Show plan and profile of all drainage elements on separate sheets from paving plans.
2. Indicate concrete cushions where applicable.
3. Specify the type of storm drain pipe to be used.
4. Indicate property lines along storm sewer and show easements with dimensions.
5. Show all existing utilities in plan view, and show those existing utilities in profile where possible conflicts may occur with the storm sewer.
6. Indicate existing and proposed ground line and improvements on all street, alley and storm sewer profiles.
7. Show laterals on trunk profile with stations.
8. Number inlets according to the number designation given for the area or subarea contributing runoff to the inlet.
9. Indicate size and type of inlet on plan view, lateral size and flow line, paving station and top-of-curb elevation.
10. Indicate quantity and direction of flows at all inlets, stubouts, pipes and intakes.
11. Show future streets and grades, where applicable.
12. Show water surface at outfall of storm sewer, velocity and typical section of receiving water body.
13. Where fill is proposed for trench cut in creeks or outfall ditches, specify compacted fill and compaction criteria.
14. Show size of pipe, length of each pipe size, and stationing at 100-foot intervals in the plan
15. Begin and end each sheet with even or 50-foot stationing.
16. Show diameter of pipes, physical grade, discharge, capacity of pipe, slope of hydraulic grade line and velocity in the pipe in the profile view.
17. Show elevation of flow lines at 100-foot intervals on the profile.
18. Give benchmark information.
19. Show capacities, flows, velocities, etc., of the existing system into which the proposed system is being connected.
20. Show details of all connection boxes, headwalls on storm sewer, times or any other item not in a standard detail sheet.
21. Provide profile where existing utility is crossed.
22. Show headwalls and specify type for all storm sewers at outfall.
23. Show if curbing in alleys is needed to add extra capacity.
24. Runoff from alleys and other paved areas are not to cause street capacity to be exceeded.
25. Show horizontal and vertical curve data for all drainage elements.

26. Tie storm sewer stationing with paving stations.
27. On all dead-end streets and alleys, show grades for drainage overflow path on the plan and profile sheets, and show erosion controls.
28. Specify concrete strength for all structures.
29. Provide sections for road, railroad and other ditches with profiles and hydraulic computations. Show design water surface on profile.

I. Requirements for Drainage Report submittals: Bridge Plans

1. Show the elevation of the lowest member of the bridge and 100-year water surface elevation.
2. Indicate borings on plans.
3. Provide soils report.
4. Show a section at the bridge.
5. Provide hydraulic calculations on all sections.
6. Provide structural details and calculations with dead load deflection diagram.
7. Provide vertical and horizontal alignment.
8. Provide calculations and details for all erosion protection.

* Creek Alteration and Channel Plans

1. Show stationing in plan and profile.
2. Indicate flow line, banks, design water surface. Show hydraulic computations.
3. Indicate the nature of banks, such as rock, earth, etc.
4. Provide cross sections with ties to property lines and easements.
5. Show side slopes of creeks, channels, etc.
6. Specify compacted fill, where fill is proposed.
7. Indicate any adjacent alley or street elevations on creek profile.
8. Show any temporary or permanent erosion controls.
9. Indicate existing and proposed velocities.
10. Show access and/or maintenance easements.
11. Identify the datum, benchmarks and date of re-leveling the benchmarks to which the flood and ground elevations are referenced.
12. Show existing Finished Floor (F.F.), or proposed minimum F.F. of all structures, existing or proposed adjacent to creek or channel alternations.

* Environmental Effects and Required Regulatory Permits Report

1. The preliminary submittal of plans is to identify all permits that, in the design engineer's opinion, will or may be required by regulatory agencies. Such permits and agencies include, but are not limited to, NPDES, Section 404 permit from the U.S. Army Corps of Engineers, the Environmental Protection Agency (EPA), and Texas Commission on Environmental Quality (TCEQ).
2. The final submittal of plans is to provide a list of all required permits necessary to construct the project and a copy of the approved permits.

* Detention and Retention Facilities

1. Show plan view of detention/retention area and outlet structure.
2. Delineate limits of conservation pool, sediment storage area, flood storage pool and/or freeboard.
3. Indicate size, dimensions, total capacity and design discharge velocity of the outlet structure.
4. Show erosion control features at the discharge point of the outlet structure.
5. Specify side slopes of facility and outlet structure.
6. Show existing or proposed structures or other facilities downstream of the outlet structure and emergency spillway, and provide information sufficient to show that the adjacent facilities will not be subjected to inundation (or increased inundation) or otherwise affected by the discharge from the facility.
7. Indicate locations and quantities of all inflows to the facility.
8. State the design time to empty the facility.

2.9 Erosion Hazard Setback Regulation

Erosion hazard setback zone determination is necessary for the banks of streams in which the natural channel is to be preserved. The purpose of the setbacks is to reduce the amount of structural damage caused by the erosion of the bank. With the application of streambank erosion hazard setbacks, an easement is dedicated to the city such that no structure can be located, constructed, or maintained in the area encompassing the erosion hazard setback. The City of Gonzales allows for streambank stabilization as an alternative to dedicating the erosion hazard setback zone. Streambank erosion hazard setbacks may extend beyond the limits of the regulatory floodplain. Recommendations by a qualified geotechnical engineer or geologist should be presented to the Designated Official for review.

2.10 Finished Floor Elevations

The elevation of the lowest floor shall be at least 10 inches above the finished grade of the surrounding ground, which shall be sloped in a fashion so as to direct stormwater away from the structure. Properties adjacent to stormwater conveyance structures must have floor slab elevation or bottom of floor joists a minimum of one foot above the 100-year water flow elevation in the structure. Driveway serving houses on the downhill side of the street shall have properly sized swale before entering the garage.

A.3.0 City of Gonzales Comprehensive Storm Drainage Flood Protection And Erosion Control Ordinance

The City of Gonzales' Code of Ordinances contains requirements for the design of storm drainage, flood protection, and erosion control facilities. Where there is any conflict between this manual and the current Ordinance, the Ordinance shall take precedence. It is the intent of this Manual, in concert with the Drainage and Erosion Control Ordinance, to provide all development under its jurisdiction the options of: 1) mitigation; 2) demonstrating that no mitigation is in the best interest of the watershed; or, 3) paying a share of the cost of increased regional detention required because of the development.

A.4.0 Design Rainfall

4.1 Rainfall Intensity - Duration-Frequency – Rational Method

A. Rainfall rates for drainage design purposes shall be estimated in accordance with standard technical information provided by the Texas Department of Transportation (TXDOT)). The information, guidelines and procedures contained in these publications should be utilized by the design engineer. Rainfall information from these sources is provided in this manual for the convenience of the Engineer. If there are any discrepancies between the data in this manual and these references, the Designated Official should be contacted for clarification.

Point rainfall intensities can be calculated utilizing the equations listed in Tables 4-1 and 4-2. The design of storm drainage facilities within the City of Gonzales and Gonzales County shall be based on rainfall information from either of the tables depending on the location.

Table 4-1
City of Gonzales Rainfall Intensity Constants

Intensity for Durations of 5 Min to 7 Days I=b/(Tc+d)^e			
Year	b	d	e
2	61	8.4	0.801
5	74	8.6	0.788
10	77	8.6	0.763
25	89	8.6	0.760
50	95	8.6	0.747
100	104	8.4	0.745

Note: I is rainfall intensity in inches per hour.

Table 4-2
Gonzales County Rainfall Intensity Constants

Intensity for Durations of 5 Min to 7 Days I=b/(Tc+d)^e			
Year	b	d	e
2	61	8.4	0.801
5	74	8.6	0.788
10	77	8.6	0.763
25	89	8.6	0.760
50	95	8.6	0.747
100	104	8.4	0.745

Note: I is rainfall intensity in inches per hour.

4.2 Hydrographs – TR-20, TR-55 or HEC-HMS

The model of choice for the City is HEC-HMS because of its compatibility with existing City studies and FEMA. When models such as in TR-20, TR-55 or HEC-HMS are used to evaluate drainage, the design storm distribution shall be the standard Type III storm defined with the data from Table 4-3.

Table 4-3
Gonzales Area Depth-Duration Values

Year	5-Min	15-Min	1-Hr	2-Hr	3-Hr	6-Hr	12-Hr	24-Hr	2-day	3-day
2	0.64	1.22	2.07	2.5	2.75	2.75	3.73	4.30	4.95	5.37
5	0.79	1.53	2.64	3.22	3.57	3.57	4.93	5.74	6.66	7.26
10	0.88	1.73	3.06	3.79	4.24	4.24	6.05	7.16	8.46	9.32
25	1.02	2.01	3.58	4.44	4.98	4.98	7.13	8.46	10.01	11.04
50	1.13	2.24	4.04	5.05	5.69	5.69	8.29	9.92	11.85	13.14
100	1.25	2.48	4.47	5.59	6.30	6.30	9.20	11.03	13.19	14.63

4.3 Rainfall Loss Rate

The method used to calculate the rainfall losses will depend on the method used to compute the design discharge. The Rational Method accounts for rainfall losses with the C coefficient, as described in Section 5.3.2. For the unit hydrograph methods described in Section 5.4, the method used is described in the respective user manual with SCS values for selected conditions are provided for standardization.

A.5.0 Determination of Design Discharge

5.1 General

The selection of an appropriate method for calculating runoff depends upon the size and time of concentration of the drainage area contributing runoff to the most downstream point of a project.

5.2 Impact of Runoff on Downstream Facilities

No proposed development shall be constructed that impedes or constricts runoff from an upstream watershed based on fully developed conditions. No proposed development shall adversely impact downstream properties or facilities. The developer is responsible for any downstream improvements required resulting from his development. The City may partner on downstream improvements if it can be shown that improvements are needed that are not a result of the proposed development.

5.3 Procedure for the Rational Method

Rational Method equation is based on the following assumptions:

A. Rainfall intensity is constant over the time it takes to drain the watershed (time of concentration)
B. The runoff coefficient remains constant during the time of concentration.

C. The watershed area does not change.

Computation of stormwater runoff for drainage areas less than 150 acres may be by the Rational Method. The discharge computed by the Rational Method is the peak discharge for a given frequency on the watershed in question, and is given by the following relationship:

$$Q=K*C*I*A \qquad \text{(Eq. 5-1)}$$

where:

- Q is the peak design discharge in cubic feet per second for a given frequency on the watershed at the desired design point.
- K is a dimensionless coefficient to be used for storms with recurrence intervals of 25, 50 and 100-years. (See Table 5-1.)
- C is a dimensionless weighted runoff coefficient, representing ground cover conditions and/or land use within the watershed area. (See Table 5-2.)
- I is the average rainfall intensity in inches per hour at a rainfall duration equal to the time of concentration, associated with the desired design frequency. (See Tables 4-1 and 4-2.)
- A is the drainage area in acres contributing runoff to the desired design point.

5.3.1 Antecedent Precipitation Coefficient

The runoff computations should include the antecedent precipitation coefficient "K", as identified in Table 5-1. This coefficient is intended to reflect the additional runoff that results from saturated ground conditions. In no case should the product of the runoff coefficient and the antecedent precipitation coefficient exceed 1.0.

5.3.2 Runoff Coefficient

A. The American Society of Civil Engineers (ASCE) has compiled average runoff coefficients used in the Rational Method for various surface conditions (6). For the pre-development case, runoff coefficients shown in Table 5-2 are available. For the post-developed case, runoff coefficients shown in Table 5-7 are recommended.

Table 5-1
Values of Antecedent Precipitation Coefficient "K"

Frequency	Value of K
10-year or less	1.0
25-year	1.1
50-year	1.20
100-year	1.25

Table 5-2
Runoff Coefficients

Area (Developed)	"C"	Area (Undeveloped)	"C"
Grass (Lawns, Parks) Poor<50% cover		Cultivated	
Flat 0-2%	0.37	Flat 0-2%	0.36
Average 2-7%	0.43	Average 2-7%	0.41
Steep, >7%	0.45	Steep, >7%	0.41
Grass (Lawns, Parks) Fair 50%-75% cover		Pasture/Range	
Flat 0-2%	0.30	Flat 0-2%	0.30
Average 2-7%	0.38	Average 2-7%	0.38
Steep, >7%	0.42	Steep, >7%	0.42
Grass (Lawns, Parks) Good>50% cover		Forest/Woodlands	
Flat 0-2%	0.25	Flat 0-2%	0.28
Average 2-7%	0.35	Average 2-7%	0.36
Steep, >7%	0.40	Steep, >7%	0.41
Asphaltic	0.81		
Concrete/Roof	0.83		

B. The drainage area under investigation may consist of several different drainage surfaces or zoning classifications. In such cases, an average coefficient weighted in accordance with the respective areas should be used, as outlined in equation 5-2.

$$C_w = (A_1 * C_1 + A_2 * C_2 + \ldots. + A_n * C_n) \;/\; A_1 + A_2 + A_3 + \ldots A_n) \qquad \text{(Eq. 5-2)}$$

5.3.3 <u>Time of Concentration</u>

A. The time of concentration (t_c) is the amount of time required for surface runoff to travel from the most hydraulically remote point within the drainage basin to the drainage point under consideration. The most hydraulically remote drainage point refers to the route requiring the longest drainage travel time and not necessarily the greatest linear distance. The flow routes used in determining the time of concentration must take into consideration fully developed conditions as proposed by thoroughfare plans, zoning maps, etc.

B. When computing the t_c, the maximum length of overland flow shall be 300 feet, at which point flow shall be considered shallow concentrated flow or channelized flow. The flow route may consist of several segments. The total time of concentration is determined as follows:

$t_c = t_{t1} + t_{t2} + \ldots + t_{tn}$ Eq. 5-3

C. Overland flow velocity can be calculated by using Table 5-4 in the following equations:

Sheet Flow

$T_t = (L*n)/(42*S^{0.5})$ Eq. 5-4a

Shallow Concentrated Flow

$T_t = (L*n)/(60*S^{0.5})$ Eq. 5-4b

Channel or Sewer Flow

$T_t = (L*A)/(60*Q)$ Eq. 5-4c

where:

T_t Segment Time of concentration (min)

Q Design discharge (cfs)

n Manning “n” from Table 5-4

S Slope of the land over which the runoff will flow (ft/ft)

V Average velocity (ft/s)

A Cross-sectional area (ft)

5.4 Alternative Procedure

A. For drainage areas in excess of 150 acres, or in instances of sizing large open channels, reclaiming floodplains, creating lakes or building other types of drainage-related facilities on major drainage courses where the use of the Rational Method does not provide reliable results, a unit hydrograph method shall be used.

B. FEMA’s flows shall not be used.

C. The preferred unit hydrograph in general is the Natural Resource Conservation Service (SCS/NRCS) Dimensionless Unit Hydrograph.

5.4.1 SCS/NRCS Unit Hydrograph

A. The procedures for the Soil Conservation Service (SCS) method are outlined in Section 4 of the National Engineering Handbook (13) and in numerous hydrology textbooks. The designer is responsible for obtaining a copy of the user manual for the SCS method. The SCS method uses a dimensionless unit hydrograph applied to the peak discharge computed for a given watershed.

B. Runoff Coefficient. The runoff curve number used in developing the pre-development discharge shall be documented. The runoff curve number and contributing area shall reflect the fully developed sub-basin or watershed. Table 5-5 contains runoff curve numbers. Antecedent Moisture Condition III (AMC III) shall be used for the 100-year event (9, 14). For a listing an applicable soil types, refer to the United States Department of Agriculture, Soil Conservation Service, Soil Survey of Tom Green County, Texas (15).

Table 5-4
Manning's "n" for Overland Flow and Shallow Concentrated Flow

Condition	"n"
Concrete (rough or smoothed finish)	0.016
Asphalt	0.02
0-50% vegetated ground cover, remaining bare soil or rock outcrops, minimum brush or tree cover	0.10
50-90% vegetated ground cover, remaining bare soil or rock outcrops, medium brush or tree cover	0.20
100% vegetated ground cover, medium – dense grasses (lawns, grassy fields, etc) medium brush or tree cover	0.30
100% vegetated ground cover with areas of heavy vegetation (parks, greenbelts, riparian areas, etc) dense undergrowth with medium to heavy tree growth	0.60

Table 5-5A
General SCS Runoff Curve Numbers

Cover Type*		CN (AMC III)	
		C	D
Open space – lawns, parks, golf courses	Poor condition (grass cover <50%)	86	89
	Fair condition (grass cover 50-75%)	79	84
	Good condition (grass cover >75%)	74	80
Impervious	Paved	98	98
	Gravel	89	91
	Dirt	87	89
Urban	Commercial and business	94	95
	Industrial	91	93
Residential	⅛ acre lot size	90	92
	¼ acre lot size	83	87
	½ acre lot size	80	85
	1 acre lot size	79	84
	2 acre lot size	77	82
Pasture, grassland, or range-continuous Forage	Poor	86	89
	Fair	79	84
	Good	74	80
Meadow-continuous generally mowed for hay		71	78
Brush-brush, weed, grass mix	Poor	77	83
	Fair	70	77
	Good	65	73
Woods-grass combination (orchard, tree Farm)	Poor	82	86
	Fair	76	82
	Good	72	79
Woods	Poor	77	83
	Fair	73	79
	Good	70	77
Farmstead		82	86

Table 5-5B
Farming SCS Runoff Curve Numbers

Cover Type*			CN (AMC III)	
			C	D
Fallow	Base soil		91	94
	Crop residue cover (CR)	Poor	90	93
		Good	88	90
Row crops	Straight row (SR)	Poor	88	91
		Good	85	89
	SR+ CR	Poor	87	90
		Good	82	85
	Contoured (C)	Poor	84	88
		Good	82	86
	C + CR	Poor	83	87
		Good	81	85
Small grain	SR	Poor	84	88
		Good	85	89
	SR + CR	Poor	83	86
		Good	80	84
	C	Poor	82	85
		Good	81	84
	C + CR	Poor	81	84
		Good	80	83
Close seeded or broadcast Or rotation meadow	SR	Poor	85	89
		Good	81	85
	C	Poor	83	85
		Good	78	83

*From 210-VI_TR-55, Second Ed., June 1986.

C. Time of concentration. Time of concentration shall be computed using the same techniques as for the Rational Method.

5.5 Fully Developed Runoff Conditions

Table 5-7 provides the runoff coefficients for the fully developed watershed case by zoning category.

Table 5-7
Fully Developed Runoff Coefficients

Zone	"C"	CN (AMCII)	
		C	D
R-1/R-1A Single family	0.53	83	87
R-2/R-2A Single and two family	0.59	90	92
R-3/R-3L Multi family high density	0.67	92	94
R-3/R-3H Multi family low density	0.55	90	92
B-1/B-1A Convent & mobile homes	0.53	83	87
TH/TH-A Townhouse	0.67	92	92
ZH/ZH-A Zero lot line homes	0.55	87	90
C-1/C1A Neighborhood business	0.67	92	93
C-2/C-1B General Business	0.68	93	94
C-3 Commercial	0.80	94	95
C-4/C-4A Resort commercial / PUD*			
M-1/M1A Light industry	0.72	87	90
M-2/M-2A Heavy industry	0.78	94	95

*must use composite values based on % impervious.

5.6 Hydrologic Computer Programs

A. The recognized computer models are T-20, TR-55 and HEC-HMS. When using any model, use the procedures outlined in the respective user's manual. Data generated with the model and the results of the program shall be summarized on the drainage plans.

B. In using the Soil Conservation Service's TR-20 program for hydrograph analysis, use the procedures outlined in Technical Release No. 20 (17).

A.6.0 Street Flow

6.1 Lot-to-Lot Drainage

Existing drainage between developed lots will remain the responsibility of the affected property owners. New developments may drain a maximum of one lot across another lot, but then are required to drain surface runoff from the second lot to a public right-of-way or to a drainage system contained in public easement.

6.2 Positive Overflow

The approved drainage system shall provide for positive overflow at all low points. The term “positive overflow” means that, when the inlets do not function properly or when the design capacity of the conduit or roadway ditch is exceeded, the excess flow can be conveyed overland along an open course. Normally, this would mean along a street or alley, but it can be constructed on private property within the dedication of a special drainage easement.

6.3 Street Flow Calculations

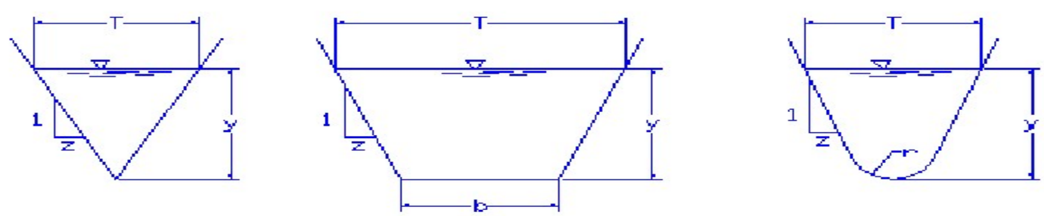
Evaluation of street flow is based upon open channel hydraulics theory, with the Manning’s equation modified to allow direct solution, based on the street cross section. Generally, the street will have a straight or parabolic section. These street flow calculations are dependent on the shape of the street. Street flow calculations shall be provided to show that flow spread in the streets does not exceed the allowance as defined in Table 2-1.

6.4 Alley Flow Limitations

Figure 6-2 shows the various typical sections. Alley capacities shall be checked at all alley turns and “T” intersections to determine if curbing is needed or grades should be flattened. Curbing shall be required for at least 10 feet on either side of an inlet in an alley and on the other side of the alley so that the top of the inlet is even with the high edge of the alley pavement. Alleys adjacent to drainage channel shall be required to have curbs for the full length of the channel.

6.5 Alley Flow Calculations

Flow in alleys is also based upon open channel hydraulic theory, with the Manning equation modified to allow direct solution, with regard to the alley cross section.



a. Triangular b. Trapezoidal c. round

Figure 6-2 Typical Alley Cross Sections

6.6 Computer Models

Computer models such as Bentley Flow Master may be used when appropriate to the situation.

A.7.0 Inlet Design

7.1 Inlet Design Considerations

A. Inlets shall be located as necessary to remove the flow based on the 10-year storm. The hydraulic efficiency of storm drain inlets varies with the amount of gutter flow, street grade, street crown and the geometry of the inlet opening. The following are some considerations which must be given attention during inlet design:

1. Inlets must be located where the allowable street flow capacities are exceeded, at low points (sumps or sags) and upstream of transition between normal and super-elevated street sections.

2. In super-elevated sections of divided arterial streets, inlets placed against the center medians shall have no gutter depression. Interior gutter flow (flow along the median) shall be intercepted at the point of super-elevation transition, to prevent pavement cross flow.

3. At bridges with curbed approaches, gutter flow shall be intercepted prior to flowing onto the bridge, to prevent ice from developing during cold weather.

4. The maximum approved vertical inlet opening is six inches. Openings larger than six inches require approval of the Designated Official and if approved, must contain a bar or other form of restraint to prevent entry by a child.

5. The design and location of all inlets must take into consideration pedestrian and bicycle traffic.

6. Combination curb inlets (with opening in curb and grate opening in gutter) may be used only where space behind the curb prohibits the use of other inlet types.

7. Where recessed inlets are required, they shall not decrease the width of the sidewalk or interfere with utilities.

8. Recessed inlets must also be depressed, unless otherwise approved by the Designated Official. The maximum allowable inlet depression for recessed inlets shall be seven inches.

9. Non-recessed, depressed inlets shall have a maximum allowable inlet depression of five inches.

10. The use of slotted drains is not allowed except in instances where there is no alternative, in which case approval must be obtained from the Designated

Official. If slotted drains are used, the inlet capacity shall be the lesser of the calculated capacity from this manual or the manufacturer's design guidelines.

7.2 Inlet Types and Descriptions

Stormwater inlets are used to remove surface runoff and convey it to a storm drainage system. For the purposes of this manual, inlets are divided into four classes:

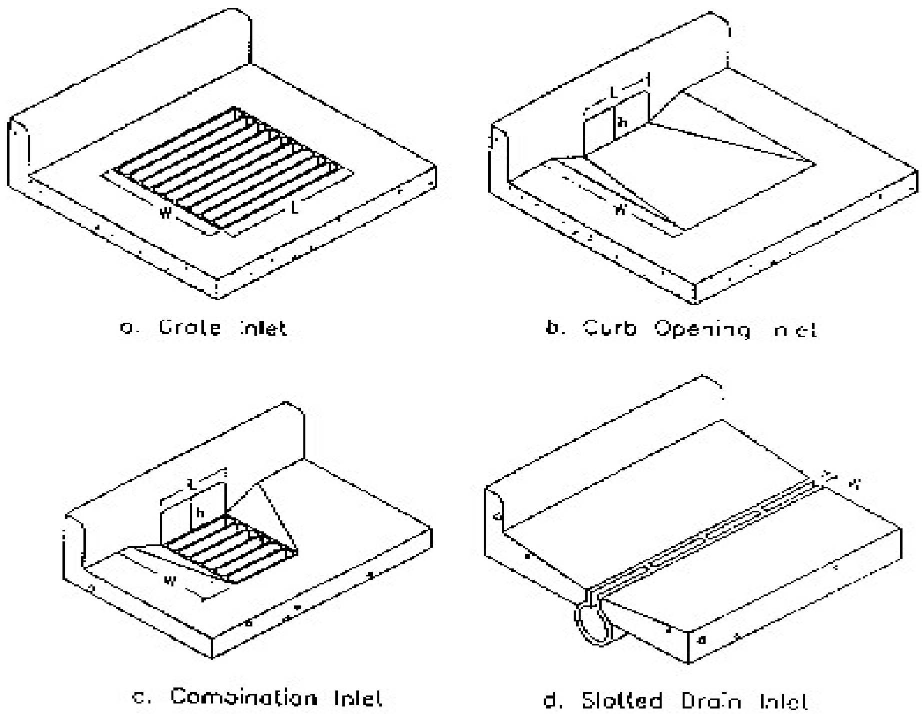


Figure 7-1. Inlet Types

a. grate inlets
b. curb-opening inlets and type y-inlets
c. combination inlets
d. slotted inlets

A. Grate Inlets: Although grate inlets may be designed to operate satisfactorily in a range of conditions, they may become clogged by floating debris during storm events. In addition, they can produce a hazard to wheel chair and bicycle traffic and must be designed to be safe for both. For these reasons, they may be used only at locations where space restriction prohibit the use of other types of inlets, should be designed to be twice as large as the theoretical required area, to compensate for clogging, and must be approved by the Designated Official.

B. Curb Inlets: Curb inlets are the most effective type of inlet on slopes flatter than 3%, in sag locations, and with flows, which typically carry large amounts of debris. Similar to grate inlets, curb inlets also tend to lose capacity as street grades increase, but to a lesser degree than grate inlets. Curb inlets are recommended in grades less than 3% and in sag locations.

Combination Inlets. A combination inlet consists of both the grate inlet and the curb inlet. This configuration provides many of the advantages of both inlet types. The combination inlet also reduces the chance of clogging by debris with flow into the curb portion of the inlet. If a curb opening is extended on the upstream side of the combination inlet it will act as a "Sweeper", and remove debris before it reaches the grate portion of the inlet.

C. Slot inlets. Although slotted drains can be used to intercept sheet flow, or flow in wide sections, they are not recommended for use in the City of Gonzales since they are very susceptible to clogging from debris. Slot inlets may only be used with the permission of the Designated Official. If slot inlets are allowed, the inlet capacity shall be calculated by both equations for a curb inlet, Grate Inlets on Grade, and the manufacturer's design guidelines, and the lesser inlet capacity, or more conservative method, shall be used for design.

A.8.0 <u>Storm Drain Design</u>

8.1 <u>Storm Drain Design Standards</u>

A. Storm sewer conduit shall be sized to flow full, and Manning's Equation shall be used to determine the conduit size. The coefficients of roughness listed in Table 8-1 are for use in Manning's Equation.

B. The minimum velocity in a conduit shall be 2.5 feet per second (25-year design storm). This minimum velocity is required to minimize or prevent the accumulation of sediment in the system. Such sediment accumulation can severely reduce to ability of the system to convey the design flow. The minimum slopes for various pipe sizes required to maintain this minimum velocity and the recommended maximum velocities of flow in a conduit.

C. Maximum velocities in conduits are important because of the possibility of excessive erosion of the storm drainpipe material. Table 8-3 lists the maximum velocities allowed. Maximum flow velocities at the downstream end of pipe systems shall be consistent with the maximum allowable velocities for the receiving channel (refer to Section 9, Open Channels). Erosion protection is required for disturbed banks of natural channels.

D. The maximum discharge velocities in the pipe shall not exceed the design velocity of the receiving channel or conduit at the outfall. The maximum outfall velocity of a conduit in partial flow shall be computed for partial depth and shall not exceed the maximum permissible velocity of the receiving channel unless controlled by an appropriate energy dissipater.

E. When establishing the hydraulic gradient of a storm sewer, entrance and exit losses, expansion losses, manhole and bend losses, junction losses, and minor head losses at points of turbulence shall be calculated and included in the computation of the hydraulic gradient.

F. Outfalls to Open Channels and Lakes. The flow lines of storm sewer conduits that discharge into open channels shall match the flow line of the channel.

G. Pipe diameters shall increase downstream, unless otherwise approved by the Designated Official. Select pipe size and slope so that the velocity of flow will increase progressively down the system or at least will not appreciably decrease at inlets, bends or other changes in geometry or configuration.

H. At points of change in storm drain size, pipe crowns (soffits) shall be set at the same elevation.

8.2 Calculation of the Hydraulic Grade Line

The 25-year and 100-year frequency hydraulic grade lines (HGL) shall be computed and plotted for all storm drain systems. The 25-year frequency hydraulic grade line shall be calculated throughout the system and shall be at least at or below the street subgrade at the entrance to the inlet. For designs that contain sumps, the 100-year hydraulic grade line is required from the system outfall to the most upstream sump. The determination of friction losses and minor losses are required for these calculations.

8.2.1 Starting Tailwater Conditions

The designer must determine the tailwater conditions at the downstream end of the proposed storm drain system when calculating the hydraulic performance of the system. When proposed storm drains are to discharge into existing watercourses, the tailwater elevation used in hydraulic calculations of the proposed storm drain system will be determined by the design engineer and approved by the Designated Official. The tailwater elevation shall be the greater of the water surface of the receiving stream and the minimum outlet water surface, y_m, both in feet above mean sea level (ft msl).

Table 8-1
Roughness Coefficient "N" for Storm Drains

Materials of Construction	**Minimum Roughness Coefficient "n"**
Concrete Pipe	0.013
Corrugated-metal pipe*	
Plain or coated	0.024
Concrete Lined	0.013
Plastic pipe*	
Smooth	0.011
Corrugated	0.024

*Requires approval

Table 8-2
Maximum Spacing of Manholes and Junction Boxes

Pipe Diameter (in)	Max. Spacing (ft)
18-24	400
27-39	800
42-60	1,000
Larger than 60	1,200

Table 8-3
Maximum Velocity in Storm Drains

Storm Drain Type	Maximum Velocity
Inlet Laterals (shorter than 30 feet)	No Limit
Inlet Laterals (longer than 30 feet)	20 fps
Trunk Lines	20 fps

8.2.2 Friction Losses

Friction losses shall be computed using Manning's equation, below, with the Manning's "n" values consistent with Table 8-1.

$$Q = (1.486 / n) * A^{(5/3)} / P^{(2/3)} * S^{1/2} \qquad \text{(Eq. 8-1)}$$

$$Q = (1.486 / n) * A*R^{(2/3)} * S^{1/2} \qquad \text{(Eq. 8-2)}$$

$$V = (1.486 / n) * R^{(2/3)} * S^{1/2} \qquad \text{(Eq. 8-3)}$$

$$S = ((Q * n) / (1.486 * A*R^{(2/3)}))^2 \qquad \text{(Eq. 8-4)}$$

$$R = A/P \qquad \text{(Eq. 8-5)}$$

Where:

Q Is the flow in the conduit (cfs)
V Is the velocity of the flow in the conduit (ft/sec)
S Is the slope of the conduit in the direction of flow (ft/ft)
N Is the Manning's roughness coefficient from Table 8-1
A Is the cross sectional area of the flow from the equations found in Table 8-4 (ft^2)
P Is the wetted perimeter of the flow determined from the equations in Table 8-4 (ft).
R Is the Hydraulic Radius (ft)

Table 8-4
Hydraulic Geometric Elements of Storm Drain Conduits

Conduit Shape	Flow Area A	Wetted Perimeter P	Top Width T	Hydraulic Depth D
Circular	1/8 (q - sin θ) d_0^2	½ θ d_0	(sin ½ θ) d_0	$1/8 * d_0 * \frac{(\theta - \sin\theta)}{\sin \frac{1}{2}\theta}$
Box, y < 0.99* d_0	Y * b	y * 2 + b	b	y
y>= 0.99* d_0	y * b	(y + b) *2	b	y

Note: $\theta = \pi + 2 * (\arcsin((y-d_0/2)/(d_0/2))$

8.2.3 Junction Losses, Without a Manhole or Junction Box

Junction losses, losses incurred when a lateral or trunk line flow into a trunk line, without the use of a manhole or junction box, shown in Figure 8-1, shall be computed using the following equation:

$$Hj = \frac{(Q_o * V_o) - (Q_i * V_i) - (Q_l * V_l \cos\theta)}{0.5 * g * (A_o + A_i)} + h_i - h_o \qquad \text{(Eq. 8-6)}$$

Where:

Hj	Is the head loss incurred in junction (ft)
Q_o, Q_i, Q_l	Is the outlet, inlet and lateral flows respectively (ft^3/sec)
V_o, V_i, V_l	Is the outlet, inlet and lateral velocities respectively (ft/sec)
h_I, h_o	Is the outlet and inlet velocity heads respectively (ft)
A_o, A_I	Is the outlet and inlet cross-sectional areas respectively (ft^2)
θ	Is the angle between the inflow and outflow pipes
g	Is the acceleration due to gravity (32.2 ft/sec^2)

8.2.4 Junction Losses, With a Manhole or Junction Box

Junction losses incurred when a lateral or trunk line flows into a trunk line, concurrent with the use of a manhole or junction box, shown in Figure 8-2, shall be computed using the following equations:

$$H_{ah} = K_j (V_o^2 / 2g) \qquad \text{(Eq. 8-7)}$$
$$K_j = K_o * C_D * C_Q \qquad \text{(Eq. 8-8)}$$

Where:

H_{ah}	Is the head loss incurred in the junction (ft)
V_o	Is the velocity of the flow in the outlet pipe (ft/sec)

	g	Is the acceleration due to gravity (32.2 ft/sec^2)
	K_j	Is the adjusted loss coefficient
	K_o	Is the initial head loss coefficient based on relative access hole size
	C_D	Is the correction factor for pipe diameter and pipe depth
	C_Q	Is the correction factor for relative flow

The coefficient of head loss due to relative access hole size, K_o, is determined by the following equation:

$$K_o = 0.1 (b / D_o) * (1 – \sin \theta) + 1.4 (b / D_o) 0.15 \sin \theta \quad \text{(Eq. 8-9)}$$

Where:	K_o	Is the coefficient of head loss due to relative access hole size
	b	Is the manhole of junction box diameter
	D_o	Is the outlet pipe diameter (ft)
	θ	Is the angle between the inflow and outflow pipes

A head loss due to pipe diameter is only significant in pressure flow, likewise head loss due to flow depth is only significant in non-pressure flow. Therefore, the coefficient of head loss for pipe diameter and pipe depth, C_D, is determined by the following equations:

If $d_{aho} / D_o => 3.2$; then $C_D = (D_o / D_i)^3$ (Eq. 8-10)
If $d_{aho} / D_o < 3.2$; then $C_D = 0.5 * (d_{aho} / D_o)^{0.6}$ (Eq. 8-11)

Where:	C_D	Is the coefficient of head loss due to for pipe diameter and pipe depth
	d_{aho}	Is the water depth in the access hole above the outlet pipe invert (ft)
	D_o	Is the outlet pipe diameter (ft)
	D_i	Is the inflowing pipe diameter (ft)

A coefficient of head loss due to the flow relative to an incoming pipe, C_Q, is a function of the angle of the incoming flow as well as the ratio of the flow from the inflow pipe to the total outflow. The coefficient is given by the following equation:

$$C_Q = (1 – 2 \sin \theta) * (1 – (Q_i / Q_o))^{0.75} + 1 \quad \text{(Eq. 8-12)}$$

Where: C_Q Is the coefficient of head loss due to the flow relative to an incoming pipe
Q_I and Q_o Is the inlet and outlet flows respectively (ft^3/sec)
θ Is the angle between the inflow and outflow pipes

If the flow line of the inflow lateral or trunk line is above the hydraulic grade line of the outflow pipe, then the initial depth is equivalent to the minimum depth, y_m, of the inflow pipe and is determined by the Equation 8-2.

8.2.5 Losses in a Bend

The head loss at pipe bends is related to the velocity head and can be computed using the following equation:

$h_b = K_a * K_r * V^2 / 2g$ (Eq. 8-13)

Where:		
	h_b	Is the head loss at the bend (ft)
	K_a	Is the bend loss coefficient due to the angle of the bend, Table 8-5
	K_r	Is the bend loss coefficient due to the diameter of the radius the bend is pulled, Table 8-5
	$V^2 / 2g$	Is the velocity head using the velocity at the downstream end of the bend

The coefficients K_a and K_r vary with the angle of the bend. Table 8-5 and Figure 8-3 contain different K_r coefficients used in bend losses calculations.

8.2.6 Losses Due to Transitions (Sudden Expansion or Contraction)

The head losses due to sudden enlargements and contractions are calculated using the same equation as for junction losses, Equation 8-7. The values for K_j for sudden enlargements and contractions are in Table 8-6.

Table 8-5
Coefficients of Loss Due to a Bend K_a and K_b

Bend Angel Degrees	Angle Bend Loss Coefficient, K_a	Radius / Diameter	Radius Bend Loss Coefficient, K_r
$\theta \leq 15°$		R/D<2	1.000
$15° < \theta \leq 22.5°$	0.20	2≤R/D<4	0.500
$22.5° < \theta \leq 45°$	0.35	4≤R/D<6	0.433
$45° < \theta \leq 60°$	0.43	6≤R/D<8	0.367
$60° < \theta$	0.50	8≤R/D<20 20≤R/D	0.300 -

Note: Minimum radius of bend shall be specified by the manufacture.

Table 8-6
Head Loss Coefficients Due to Sudden Expansion and Contraction

D_2/D_1*	Sudden Expansion K_j	Sudden Contractions K_j
1.2	0.10	0.08
1.4	0.23	0.18
1.6	0.35	0.25
1.8	0.44	0.33
2.0	0.52	0.36
2.5	0.65	0.40
3.0	0.72	0.42
4.0	0.80	0.44
5.0	0.84	0.45
10.0	0.89	0.46
	0.91	0.47

*D_2/D_1 = Ratio of larger to smaller diameter

A.9.0 Open Channels

9.1 Hydraulics

9.1.1 Gradually Varied Flow

Calculations of water surface profiles can be accomplished by using standard backwater methods, Standard Step Method, or acceptable computer routines. Water surface profiles for the design frequency floods shall be computed for all channels and shown on all final drawings. The Corps of Engineers or HEC-RAS Water Surface Profile Programs may also be used to perform standard step backwater calculations, and if used, a summary table shall be submitted to the City. Losses due to changes in velocity, drops, bridge openings, and other obstructions shall be considered in the backwater computations, as described in the HEC-RAS User's Manuals.

$$S_f = \frac{n^2V^2}{2.22\ R^{4/3}} = S_e \qquad \text{(Eq. 9-1)}$$

9.1.2 Normal Flow

Any of several computer programs or nomographs are acceptable. Manning's "n" for various conditions are in Table 9-1 and 9-2.

9.2 Design Parameters

A. Where possible, channels should have sufficient gradient, depending upon the type of soil or channel lining material, to provide velocities that will be self-cleaning (greater than 2 feet per second) but will not be so great as to create erosion. Maximum permissible velocities are shown in Table 9-3.

B. Appropriate energy dissipating structures may be used to control erosion due to high velocities at pipe system outfalls and steep grades and shall be designed in accordance with accepted design practices such as outlined by the Soil Conservation Service, the Corps of Engineers, the Bureau of Land Reclamation, or TxDOT.

9.3 Supercritical Flow

A. The Froude Number provides a relationship between flow velocity and the hydraulic depth of flow, and gravitational action and shall be calculated for all channel improvements designs. Subcritical flow conditions occur when the Froude Number is less than 1.0 and supercritical flow conditions exist in lined channels when the Froude Number exceeds 1.0. The Froude Number may be calculated by the following equations:

$$Fr = V / (g * D)^{0.5} \qquad \text{(Eq. 9-2)}$$

Where:
- V Is velocity of flow (ft/sec)
- g Is the acceleration due to gravity (ft/sec^2)
- D Is the hydraulic depth (ft)

And

$$D = A / T \qquad \text{(Eq. 9-3)}$$

Where:
- A Is the cross-sectional area of the flow (ft^2)
- T Is the top of the flow (ft)

B. Each channel cross section has two flow depths, the normal depth and the alternate depth. Although the depths, velocities, and Froude Number differ, the specific energy of the two depths are equivalent. Figure 9-1 shows the relationship of specific energy to depth. If a channel's normal depth is supercritical, its alternate depth is a deeper subcritical depth. Obstructions that may enter a stream during a storm event may cause supercritical flows to experience a hydraulic jump and become subcritical flows. Due to this fact, channels that are designed for supercritical conditions must have freeboard equal to the alternate depth. Supercritical flow must be contained in straight reinforced concrete lined sections of the channel with no bends.

Table 9-1
Roughness Coefficients of New or Altered Channels

Type of Channel	Manning's "n"	
Grass lined		
Bermuda	0. 04	
St. Augustine	0. 045	
Soils		Velocity (fps)
Cobbles	0.035	5.5
Coarse gravel	0.025	6
Graded silts to gravel	0.030	5.5
Graded loam to cobbles	0.030	5
Fine gravel	0.020	5
Shale & hardpan	0.025	6
Alluvial silts, colloidal	0.025	3.75
Stiff clay, very colloidal	0.025	3.75
Firm loam	0.020	2.5
Alluvial silts, non-colloidal	0.020	2
Silt loam, non-colloidal	0.020	2
Sandy loam, non-colloidal	0.020	1.75
Fine sand, colloidal	0.020	1.5

Concrete	
Rough finish	0. 02
Smooth finish	0. 015
Exposed rubble	0. 025
Gabion	0. 035
Rock-cut	0. 025

Table 9-2
Computation of Composite Roughness Coefficient for Excavated and Natural Channels
For use with $n = (n_0 + n_1 + n_2 + n_3 + n_4) * m$

	Channel Conditions	Qualifiers	Values
n_0	Material	Earth	0.02
		Fine Gravel	0.024
		Course Gravel	0.028
n_1	Degree of Irregularity	Smooth	0.0
		Minor	0.005
		Moderate	0.010
		Severe	0.02
n_2	Relative Effect of Channel Cross Section	Gradual	0.0
		Alternating Occasionally	0.005
		Alternating Frequently	0.013
N_3	Relative Effect of Obstructions	Negligible	0.0
		Minor	0.013
		Appreciable	0.025
		Severe	0.05
n_4	Vegetation	Low	0.008
		Medium	0.018
		High	0.038
		Very High	0.075

m	Degree of Member	Minor	1.0-1.02
		Appreciable	1.2-1.5
		Severe	1.5 or greater

In selecting the value of n_1, the degree of irregularity is considered smooth for surfaces comparable to the best attainable for the materials involved; minor for good dredged channels, slightly eroded or scoured side slopes of canals or drainage channels; moderate for fair to poor dredged channels, moderately sloughed or eroded side slopes of canals or drainage channels, and unshaped, jagged and irregular surfaces of channels excavated in rock.

In selecting the value of n2, the character of variations in size and shape of cross section is considered gradual when the change in size or shape occurs gradually; alternating occasionally when large and small sections alternate occasionally or when shape changes cause occasional shifting of main flow from side to side; and alternating frequently when large and small sections alternate frequently or when shape changes cause frequent shifting of main flow from side to side.

In selection of the value of n3 is based on the presence and characteristics of obstructions such as debris deposits, stumps, exposed rots, boulders and fallen and lodged logs. One should recall that conditions considered in other steps must not be reevaluated or double-counted in this selection. In judging the relative effect of obstructions, consider the following: the extent to which the obstruction occupy or reduce the average water area, the obstruction characteristics (sharp-edged or angular objects induce greater turbulence than curved, smooth-surfaced objects) and the position and spacing of obstructions transversely and longitudinally in the reach under consideration.

In selecting the value of n4, the degree of effect of vegetation is considered in the following way:

1. Low for conditions comparable to: 1) dense growths of flexible turf grasses or weeds, of which Bermuda and blue grasses are examples; where the average depth of flow is two to three time the height of vegetation and 2) supple seeding tree switches, such as willow, cottonwood or salt cedar where the average depth of flow is three to four times the height of the vegetation.

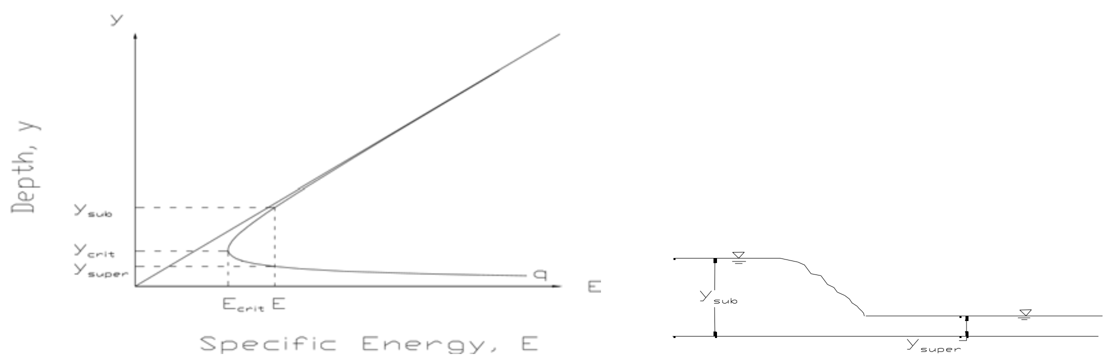
2. Medium for conditions comparable to: 1) turf grasses where the averaged depth of flow is one to two times the height of vegetation, 2) stemmy grasses, weed or tree seedlings with moderate cover where the average depth of flow is two to three times the height of vegetation and 3) brush growth, moderately dense, similar to willows one to two years old, dormant season, along the side of a channel with no significant vegetation along the channel bottom, where the hydraulic radius is greater than two feet.

3. High for conditions comparable to: 1) turf grasses where the average depth of flow is about equal to the height of vegetation, 2) dormant season – willow or cottonwood trees eight to ten years old, inter-grown with some weeds and brush, where none of the vegetation is in foliage along side slopes, no significant vegetation along channel bottom, where hydraulic radius is greater that two feet.

4. Very high for conditions comparable to: 1) turf grasses where the average depth of flow is less than one-half the height of vegetation, 2) growing season – bushy willows about one year old, inter-grown with weeds in full foliage along side slope, or dense growth of cattails along channel bottom, with any value of hydraulic radius up to ten or 15 feet and 3) growing season trees inter-grown with weed and brush, all in full foliage, with any value of hydraulic radius up to ten or 15 feet.

In selecting the value of m, the degree of meandering depends on the ratio of the meander length to the straight length of the channel reach. The meandering is considered minor for ratios of 1.0 to 1.2, appreciable for rations of 1.2 to 1.5, and severe for rations of 1.5 and greater.

B. Subcritical flow conditions are recommended for all channel designs, as supercritical flow tends to have high velocities and high potential for channel erosion. Supercritical flow conditions will not be allowed in unlined channels. Subcritical flow conditions may be achieved by using energy dissipaters in unlined channels in areas where the existing topography will not allow subcritical flow conditions to occur naturally. In all cases, the channel improvements shall be designed to avoid the unstable transitional flow conditions that occur when the Froude Number is between 0.9 and 1.1.



$$E = V_{2sub} / 2g + y_{sub} = V_{2super} / 2g + y_{super}$$

Figure 9-1. Alternate Depths on the Specific Energy Curve.

9.4 Flow in Bends

A. When a channel changes direction, the depth of flow along the outside edge of the curve is higher than the average channel flow depth, or the water surface is super-elevated. Therefore, additional freeboard must be provided to prevent the channel bank from being overtopped. The amount of super-elevation along the outside of the bend can be estimated using (18):

$$\Delta H = \frac{C^2}{2gr_o^2 r_i^2} (r_o^2 - r_i^2) \qquad \text{(Eq. 9-4)}$$

Where: ΔH Is the increase in water surface elevation along the outside of the channel bend due to super-elevated in feet

C Is the circulation constant (ft^2/sec)

r_o Is the outside radius of the channel bend in feet

r_i Is the inside radius of the channel bend in feet

g Is the acceleration due to gravity (32.2 ft/sec)

B. If the discharge, depth of flow at the approach to the bend, average flow velocity in the approach to the bend, and the inner and outer radii of the bend are known, the value of the circulation constant can be approximately by solving for C:

$$Q = C \left[y_a + \frac{V_a^2}{2g} - \frac{C2}{2gr_o r_I} \right] \ln (r_o / r_i) \qquad \text{(Eq. 9-5)}$$

Where: Q Is the total flow in the channel (cfs)

V_a Is the average velocity in the bend approach (fps)

y_a Is the depth of flow in the approach to the bend in feet.

Table 9-3
Maximum Velocity in Open Channels

Channel Material*	Channel Slope	Velocity (fps) erosion resistant soil	Velocity (fps) erosion resistant soil
Grass Line Earth			
Bermuda	0-5	8	6
	5-10	7	5
	>10	6	4
Buffalo grass, Kentucky bluegrass, smooth brome, blue grama	0-5	7	5
	5-10	6	4
	>10	5	3
Weeping lovegrass, alfalfa, annuals	0-5**	3.5	2.5
Rock (Native)***			10
Gabion lined			12
Reinforced concrete lining			20
Rock riprap (placed rock)			Use U.S. Army Corps of Engineers Guidelines
Prefabricated lining products			Use 90% of Manufacturer's Recommended Velocity Limits

* Uniform, in well-maintained condition

** Not recommended for channels >5% except for channel side slopes

*** Depends on size (d_{50}) and velocity C.

The flow velocity along the outside of the bend, V_o (in feet per second), can then be approximated:

$$V_o = C / r_o \qquad \text{(Eq. 9-6)}$$

V_o shall not exceed the maximum values established in Table 9-1.

C. Super-elevation may also be determined using:

$$\Delta H = \frac{V^2 T_w}{g r_c} \qquad \text{(Eq. 9-7)}$$

Where: T_w Top width of channel (ft)
r_c Centerline radius of curvature (ft)

9.5 Drop Structures

A. The function of a drop structure is to reduce flow velocities by dissipating some of the kinetic energy of the flow at the drop structure, and also providing flatter channel slopes upstream and downstream of the drop structure. Sloping channel drops and vertical channel drops are two commonly used drop structure types.

An apron shall be constructed immediately upstream and downstream of a drop structure to protect against turbulence. The upstream apron shall extend at least ten feet upstream from the point where flow becomes supercritical and shall include a concrete toe into the ground. The downstream apron shall extend a minimum of twenty feet beyond the anticipated location of the jump and shall include a concrete toe into the ground. The toe at each end shall extend a minimum of twenty-four inches into the ground to minimize scour at the transition to natural ground.

Table 9-4
Length of Downstream Apron

Maximum Unit Discharge (cfs/ft)	Length of Downstream Apron (ft)
0-14	10
15	15
20	20
25	23
30	25

B. All drop structures shall be constructed of reinforced concrete, and the bottom and walls (if any) shall have a minimum thickness of six inches. To facilitate maintenance, drop structures should be located near bridges or culverts if possible.

9.5.1 Vertical Drop Structures

The drop length and the hydraulic jump length of the drop structure should be calculated to determine the length of the downstream apron required to prevent erosion. (18,19). In order to utilize a vertical drop structure vehicular access must be provided to both the upstream and downstream ends of the structures.

9.5.2 Sloping Drop Structures

The location of the hydraulic jump should be determined based on the upstream and downstream flow depths and channel slopes (18, 19). When utilizing a sloping drop structure, a minimum slope of 6:1 shall be used to allow vehicular access from one end across the structure. If the slope of the drop structure is less than 6:1, vehicular access must be provided to both the upstream and downstream ends of the structures.

9.6 Energy Dissipaters

Although hydraulic jumps can be used as energy dissipaters, impact dissipaters are recommended for their predictability, efficiency, and economy. The Baffled Apron is used to dissipate the energy in the flow at a drop. It requires no initial tailwater to be effective, although scour is reduced with tailwater. The chute of the Baffle Apron is constructed on a 2:1 or flatter slope extending below the channel bottom. See Examples.

A.10.0 Bridge and Culvert Design

10.1 Applicable Design Criteria

Bridge design shall be on a case-by-case basis to establish design requirements. Headwalls and necessary erosion protection shall be provided at all culverts and shall comply with TxDOT standard.

10.2 Design Parameters

A. Alignment, location and grade of proposed culverts must be consistent with planned development of the drainage system for that watershed. In the event the particular watershed or waterway is not covered by a planned storm drainage system, the designer should proceed with the design from the nearest downstream control (i.e. bridge, culvert dam, etc.) and design the proposed drainage system improvements anticipating future system expansion due to fully developed watershed conditions.

B. Wingwalls, if used, may be either straight parallel, flared, or tapered. Approach and discharge aprons shall be provided for all culvert headwall designs. The guidelines listed in Table 10-1 are intended to aid in determining when to use various types of wingwalls.

Precast headwalls and endwalls may be used if all other criteria are satisfied; generally precast headwalls/endwalls are available for smaller culverts (18 inches to 24 inches diameter).

Table 10-1
Guidelines for Wingwall Use

Conditions	Wingwall Type
Small culverts with flat slopes	Straight (parallel), flared of tapered.
Abrupt change in flow direction is necessary	Straight with one perpendicular wingwall (not recommended for large culverts) or flared.
Approach velocities below 6 fps, approach channel undefined, formation of backwater pools acceptable	Straight, flared or tapered
Approach velocities 6-10 fps, approach channel well defined	Flared (wingwalls located with respect to axis of the approach channel)

10.3 Culvert Outlet Protection

High discharge velocities from culverts can cause eddies or other turbulence which could damage unprotected downstream channel banks and roadway embankments. To prevent damage from scour and erosion in these conditions, culvert outlet protection is needed. The outlet protection should extend downstream to a point where non-erosive channel velocities are established in accordance with Table 9-1. The outlet protection should be placed sufficiently high on the adjacent banks to provide protection from wave wash under design flow conditions.

Table 10-2
Culvert Entrance Loss Coefficients

Type of Culvert	K_e
Reinforced concrete pipe:	
Projecting from fill, socket end (groove end)	0.2
Projecting from fill, square cut end headwall or headwall with wingwalls	0.5
Socket end of pipe (groove end)	0.2
Square edge	0.5
Rounded edge (radius ≥ 0.0833D)	0.2
Mitered to conform to fill slope	0.7
Beveled edges, 33.7° or 45° bevels	0.2
Side or slope tapered inlet	0.2

Corrugated metal pipe or arch-pipe:	
Projecting from fill (no headwall)	0.9
Headwall or headwall with wingwalls, square edge	0.5
Mitered to conform to fill slope, paved or unpaved slope	0.7
Beveled edges, 33.7° or 45° bevels	0.2
Side or slope tapered inlet	0.2
Reinforced concrete box:	
Headwall parallel to embankment (no wingwalls)	
Square-edged on three sides	0.5
Rounded on three sides to radius of 1/12 barrel dimension, or beveled edges on three sides	0.2
Wingwalls at 30°-70° to barrel square-edged at crown	0.4
Crown edge rounded to radius of 1/12 barrel dimension, or beveled top edge	0.2
Wingwall at 10°-25° to barrel, square-edged at crown	0.5
Wingwalls parallel (extension of sides), square-edged at crown	0.7
Side or slope-tapered inlet	0.2

10.4 Culvert Hydraulics

A. The hydraulic design of culverts shall be based upon design guidelines set forth by TxDOT, the U.S. Department of Transportation, or other suitable material. Computer programs are available such as FHWA's "HY-8" model (FHWA, 1985). Table 10-2 contains the culvert entrance loss coefficients (K_e).

B. In general, there are two categories of flow through culverts: inlet control and outlet control.

1. Inlet Control. The flow is controlled by the cross-sectional area of the culvert, inlet configuration, and headwater depth. Slope, roughness and length of culvert are of no importance. Inlet control can generally be assumed when the slope of the culvert is greater than the critical slope as defined below with culvert diameter (D) in feet:

$$So\% = 2.04 / D^{0.333} \qquad \text{(Eq. 10-1)}$$

2. Outlet control. The flow is controlled by the cross-section area of the culvert, inlet configuration, and headwater depth and, slope, roughness and length of

culvert. Culverts will be outlet controlled if the culvert slope is relatively flat, the tailwater sufficiently deep, or the culvert is quite long. It is also possible, where the water enters the culvert under inlet control, but the culvert slope or tailwater conditions cause a hydraulic jump near the outlet. This situation should be avoided because damage can occur to the culvert pipe. Unstable conditions are most likely when the culvert is placed at a near-critical slope.

3. The typical procedure is to calculate for both outlet and inlet control and use the smaller flow rate to design the system.

10.5 Debris Fins

A. For conditions where more than one box culvert is required, the upstream face of the structure shall incorporate debris deflector fins to prevent debris buildup. For multiple pipe or single box in critical situations, installations of debris fins may be used but are not required. The debris fin is an extension of the interior walls of a multiple-box culvert. The wall thickness shall be designed to satisfy structural requirements and reduce impact and turbulence to the flow.

B. A debris fin is constructed to the height of the culvert with a fin length of one and one half times the height of the box culvert. Since the debris fins are subject of the same erosive forces as bridge piers, care must be taken in the design of the footing. A toe wall at the upstream end of the debris fin and the apron is recommended.

10.6 Energy Dissipation

A. Material requirements for outlet protection are indicated in Table 10-3.

Table 10-3
Material Requirements

Culvert Outlet Velocity (fps)	Outlet Protection
<4	None, grass
4-10	Dumped rock riprap
10-15	Wire-enclosed or grouted rock riprap
>15	Energy dissipation structure

B. Riprap run out apron length for pipe diameter (D) and water depth at outlet (d) can be determined using:

$$\text{Riprap length (ft)} = 1.7d * Q / D^{2.5} + 8 \qquad \text{(Eq. 10-6)}$$

C. Median stone diameter (d_{50}) can be determined (ASCE 1992) as:

$$d_{50} = 0.02 * Q^{(4/3)} / TW * D$$ or by HEC-15 (FHWA, 1988)

A.11.0 Detention Basin Design

11.1 Design Criteria

A. Stormwater detention basins are used to temporarily impound (detain) excess stormwater, thereby reducing peak discharge rates.

B. Detention basins without upstream detention areas where the design rainfall was determined using the Rational Method can be designed using the Modified Rational Method to determine the critical duration. The detention volume for a given duration in this method is calculated as the difference between the trapezoidal inflow hydrograph and the triangular outflow hydrograph. A range of storm durations is required to determine the critical duration for the detention basin. See Appendix D for example of this calculation method. The “C” for the Rational Method shall be a minimum of 0.60. Time of concentration shall provide a conservative choice.

C. Computations performed for detention pond sizing using a unit hydrograph shall use a minimum curve number of 67, 79, 86 and 89 for soil types A, B, C and D, respectively. Time of concentration shall provide a conservative choice. If computer models utilizing HEC-HMS, or commercially available programs such as Bentley Pond Pack are used, summary tables of the results shall be included in the drainage report and on the plans.

11.2 Minimum Requirements for Detention Pond Design

A. The following criteria shall serve as minimum requirements for detention pond design:

1. Detention basins to be excavated shall provide positive drainage through the pond with a minimum slope of 0.25%.

2. When the outflow structure discharges flow into a natural stream or unlined channels, it shall do so at a non-erosive rate in accordance with Section 9 of this Manual.

3. Earthen embankments used to impound a required detention volume must have a minimum top-width of 4 feet, shall contain a non-permeable core, and shall be based on a geotechnical investigation for the site. Compaction of al earthen drainage structures shall be to 90% standard proctor. Earthen embankments higher than 6 feet shall conform to Permanent Rule 31, Texas Administrative Code (TAC) Chapter 299 and other applicable dam safety requirements.

4. Security fencing with a minimum height of six feet may be required to encompass the detention storage area if the location, velocity, depth, or slopes justify restricted access to the general public as determined by the Designated

Official. The fence shall be designed to allow access for maintenance as well as not to restrict stormwater flow into or out of the detention basin.

5. A maintenance ramp shall be provided for vehicular access in detention basin design for periodic desiliting and debris removal. The slope of the ramp shall not exceed 6:1 and the minimum width shall be 12 feet.

6. Basins with permanent storage must include dewatering facilities to provide for maintenance.

7. The design of detention facilities shall include provisions for collecting and removing sediment deposited after collecting and releasing stormwater.

8. A non-erodible pilot channel shall be provided to convey runoff from entry points of concentrated flow into the pond to the outlet structure of the pond during low flow conditions. Erosion protection must be provided adjacent to the pilot channel to prevent undermining of the pilot channel due to scour.

11.3 Outlet Structure Design

A. Design and construction information for outlet works is contained in the publication "Stormwater Detention Outlet Control Structures (ASCE, 1985). Multi-level outlet structures may be necessary to reduce the 2-year, 10-year, 25-year and 100-year design storm runoff to pre-development levels, and provide for an emergency spillway.

B. For small slick pipes flush with the upstream embankment and a free outfall, the orifice equation can be used (H = height of water above center of pipe, ft):

$$\text{Outflow (cfs)} = 4.8 * (\text{area of opening, sq ft}) * H^{0.5}$$

C. Standard culvert design techniques are appropriate for larger pipes.

D. Spillway size should generally be estimated using a broad-crested weir equation such as:

$$\text{Outflow (cfs)} = 2.7 * L * H^{1.5}$$

E. The spillway should be heavily protected from erosion with concrete, rock, grouted riprap, gabions, geotextile, geogrids, concrete block or other material, as selected by the designer.

F. Documentation on retention or detention structures should include design hydrographs, calculation of stage-storage-discharge tables, drawings of the basin, spillway and outlet size and location, and erosion control measures.

A.12.0 Site Erosion Control During Construction

12.1 Applicable Properties or Construction Sites

Private property owners, developers or builders shall be accountable for any erosion of their property or construction site which results in measurable accumulation of sedimentation in dedicated streets, alleys, any waterway or other private properties. Any accumulation or deposit of soil material beyond the limits of the property or in City streets, alleys or drainage facilities in an amount sufficient to constitute a threat to public safety and comfort as determined by the Designated Official shall constitute a violation. Sediment carried by stormwater runoff through these acres shall be prevented from entering storm drain systems and natural watercourses.

12.2 General Guidelines for Erosion Control Plan

A. Maximum use shall be made of vegetation to minimize soil loss.

B. Natural vegetation should be retained wherever possible.

C. Where inadequate natural vegetation exists, or where it becomes necessary to remove existing natural vegetation, temporary controls should be installed promptly to minimize soil loss and ensure that erosion and sedimentation does not occur. The developer is responsible for maintenance of site erosion control devices until a sufficient vegetation cover has been provided or replaced as determined by the Designated Official. Periodic maintenance shall be performed by the developer to remove accumulated sediment that would otherwise inhibit the proper functioning of the erosion control devices.

D. Wherever possible during construction, erosion controls shall be used on hillsides to slow drainage flow rate.

E. Erosion control elements should be implemented as soon as practical in the development process.

F. Waste or disposal areas and construction roads should be located and constructed in a manner that will minimize the amount of sediment entering streams.

G. Frequent fording of live streams will not be permitted; therefore, temporary bridges or other structures shall be used wherever an appreciable number of crossings of a stream is necessary.

H. When work areas or material sources are located in or adjacent to live streams, such areas shall be separated from the stream by a dike or other barrier to keep sediment from entering a flowing stream. Care shall be taken during the construction and removal of such barriers to minimize the sediment transport into a stream.

I. Should preventative measures fail to function effectively, the applicant shall act immediately to bring the erosion and/or siltation under control by whatever additional means are necessary.

J. Erosion control devices shall be placed to trap any losses from stockpiled topsoil. Some acceptable forms of site erosion control devices include, but are not limited to, silt fences, silt traps, hay bale barriers, geonetting and geotextiles. Hay bale barriers, if used, shall be replaced with new hay bales as a part of the regular maintenance program.

K. The selection and timing of the installation of erosion controls shall be based upon weather and seasonal conditions that could make certain controls not practicable.

L. Vegetation used for vegetative cover shall be suitable for local soil and weather conditions. Ground cover plants shall comply with listings from the Texas Agricultural Extension Service.

M. Runoff shall be diverted away from construction areas as much as possible.

N. Stripping of vegetation from project sites shall be phased so as to expose the minimum amount of area to soil erosion for the shortest possible period of time. Phasing shall also consider the varying requirements of an erosion control plan at different stages of construction.

O. Developers, builders, or owners of property shall install all utilities, including franchise utilities, before final acceptance of a subdivision, property and/or structure. Final acceptance will also be contingent upon having all necessary erosion control measures installed to minimize off-site sediment. At the discretion of the Designated Official; a site may be accepted without erosion control measures if perennial vegetative cover is actively growing.

12.3 Applicable Best Management Practices

Published Best Management Practices for erosion control for many different activities are available through libraries, Internet, and through the Designated Official.

12.4 Stream Bank Erosion

Erosion control will be provided along streams and drainage channels. Where bank stabilization or other erosion protection measures are required to protect streams and channels, the stream bank protection and erosion damage mitigation measures provided in this Manual shall be utilized as approved by the Designated Official.

B. WATER AND WASTEWATER DESIGN CRITERIA

B.1.0 Design Requirements For Water And Wastewater Systems

1.1 Introduction

These guidelines are intended to establish the minimum basic design requirements for water and wastewater systems within the City of Gonzales and its Extra Territorial Jurisdiction (ETJ), but do not address major facilities such as water and wastewater treatment plants. Generally, these systems will be operated and maintained by the City of Gonzales.

All project manuals shall include appropriate Specifications. All projects are required to be built in accordance with the Specifications, which will include other requirements not addressed here. All variations are subject to the approval of the city. Additional requirements for specific projects may be established where the conditions of service to the tract and related system operation and maintenance needs warrant.

The following information is provided to assist engineers and the general public in the design and construction of water and wastewater facilities within the City of Gonzales and its Extra Territorial Jurisdiction. All drawings for such facilities shall be prepared by or under the supervision of a Registered Professional Engineer, licensed in the State of Texas. It will be the responsibility of the engineer to ensure that the plans are in compliance with the latest versions of all applicable federal, state and local ordinances, rules and regulations.

These include, but are not limited to, the following:

A. Design Criteria for Domestic Wastewater Systems - Texas Commission on Environmental Quality. (TCEQ)

B. Rules and Regulations for Public Water Systems - TCEQ.

C. The Code of the City of Gonzales.

D. City of Gonzales Standard Specifications.

E. The City of Gonzales Water and Wastewater Criteria.

B.2.0 Water Systems

2.1 Size/Capacity/Determination

A. General.

1. Hazen Williams Friction Coefficient C = 110, higher C coefficient may be used for new mains only upon approval by the City with sufficient documentation to show effects of long-term use.

2. Average day demand = 200 gal/person/day.

3. Peak day demand = 530 gal/person/day.

4. Peak hour demand = 900 gal/person/day.

5. If the maximum static pressure exceeds 80 psi, a pressure-reducing valve (PRV) will be required on the property owner's side of the water meter and should be shown on the plan view.

6. Minimum operating pressure is 35 psi at the highest elevation meter location using average day demand.

B. Peak Hour Demand Requirements.

1 The maximum allowable velocity shall not exceed 5 feet per second (fps).

2. The minimum pressure at any point in the affected pressure zone must not be less than 35 psi.

C. Emergency Demand (Fire Flow) Requirements.

1. The maximum allowable velocity shall not exceed 10 fps.

2. The minimum residual pressure at any point in the affected pressure zone at peak day plus fire flow must not be less than 20 psi

D. Sizing of Water Mains - Computer modeling is preferred for sizing water mains. However, for water mains less than 16 inches in diameter other engineering calculation methods may be accepted. The largest size, as determined by comparing the service area’s peak hour demand and peak day plus fire flow demand, shall be used.

E. Storage Requirements - If it is determined by the City of Gonzales that additional storage is required, the following criteria shall be used:

Effective Storage = 100 gal/person

Emergency Storage = 100 gal/person

TOTAL STORAGE = 200 gal/person

Effective Storage is defined as storage, which will provide a minimum of 35 psi of pressure at the highest service elevation in pressure zone.

The Engineer may be required to provide computer simulations as determined on a case-by-case basis.

2.2 Mains

A. Minimum main size shall be 8 inches with consideration for 6-inch or 4-inch pipe in cul-de-sacs less than 200 feet in length. Provision must be made in these cases for a flush valve at the end of the 6-inch or 4-inch line. The minimum size for any street type, however, will be governed by various factors which include fire protection requirements, high density land usage, and the designer's consideration of general system gridding, future transmission mains, neighboring developments and area configuration. Looped systems are required. Transmission line sizes will be determined on a case-by-case basis.

While looped systems are required, it is recognized that in certain situations, short sections of dead end pipe may be more practical. When a dead end section of watermain, containing more than 100 gallons of water, is approved for installation, the following requirements must be met:

1. If a dead end section is installed for future connection or extension, and no service will be taken from the stub prior to the future connection or extension, a valve must be placed at the location where the main becomes a dead end (ie at the tee).

2. If a dead end is installed and service is to be provided via the dead end

   a. The water demand from the service (or services) must be sufficient to turn over the water every 72 hours.

   b. If the service(s) do not provide sufficient demand to turn over the water every 72 hours, an approved automatic flushing device must be installed and programmed such that the 72 hour criterion is met.

B. Water mains should be located, where maintenance can be accomplished with the least interference with traffic, structures, and other utilities.

   The separation between water and wastewater mains must comply with TCEQ rules or have a variance approved by TCEQ before submittal to the City. A minimum horizontal separation distance of five (5) feet, measured from OD of pipe to OD of pipe, shall be maintained between existing or proposed water mains and all other utilities and/or conduits in order to maintain trench integrity.

   Mains should normally be located on the high side of the street and per the City's standard locations. However, mains shall be installed on both sides of all divided road/highways. Roads/highways, where opposing lanes of traffic are separated by a vehicle obstruction, shall be considered a divided road/highway. In major collector and arterial roadways, mains should be located outside the pavement, curbs, etc., wherever feasible. When mains are located outside of the right-of-way, they shall be within a dedicated utility easement.

C. Piping materials and appurtenances shall conform to City of Gonzales Standard Specifications. Typically, PVC water pipe materials shall meet the requirements of AWWA C900 DR14 for sizes 4 inches to 12 inches, and AWWA C905 DR 18 for sizes greater than 12 inches. Ductile Iron pipe shall meet the requirements of AWWA C151 Class 350 (4" to 12") and Class 250 (14" & 16"). All fittings shall be ductile iron meeting the requirements of AWWA C153. Valves shall be Mueller Resilient Wedge Gate Valves or approved equal meeting the requirements of AWWA C509.

D. Minimum depth of cover over the uppermost projection of the pipe and all appurtenances shall be as follows:

   1. Water piping installed in undisturbed ground in easements of undeveloped areas, which are not within existing or planned streets, roads, or other traffic areas, shall be laid with at least 36 inches of cover.

   2. Water piping installed in existing streets, roads, or other traffic areas shall be laid with at least 48 inches of cover below finished grade.

   3. Unless approved by the City of Gonzales, installation of water piping in proposed new streets will not be permitted until paving and drainage plans have been approved and the roadway traffic areas excavated to the specified or standard paving subgrade, with all parkways and sidewalk areas graded according to any applicable provisions of the

drainage plans or sloped upward from the curb line to the right of way at minimum slope of ¼ inch per foot. Piping and appurtenances installed in such proposed streets shall be laid with at least 36 inches of cover below the actual subgrade. The maximum depth will be as approved by the Utility for the specific materials, application, and conditions.

E. For mains 16 inches in diameter and larger and on smaller mains where appropriate, hydrants or drain valves shall be placed at low points and on the up-slope side of all valve locations.

F. All fire lines shall have a gate valve on the line at the connection to the main line and a backflow preventer inside the property line, but accessible for inspection by City personnel. All unmetered fire lines shall have a Utility approved flow detection device. This flow detection service shall be located such that no more than 100 gallons of water is contained between the device and the point where the fire line is connected to the City's main.

G. On water mains 16 inches in diameter and larger and on smaller mains where appropriate, combination air valves will be placed at all high points and air/vacuum valves shall be placed at the down-slope side of all valve locations. Air/vacuum and vacuum release valves shall be approved on a case-by-case basis. All mains twenty-four (24) inches and larger will include an 18" outlet with blind flange installation at high points where the installation of an air release valve (ARV) would be necessary. In the absence of an ARV requirement, an 18" outlet with blind flange shall be placed every 2500 feet.

H. Joint restraint for pipes larger than 16 inch diameter shall be by use of integral, factory joint restraint systems, or by restraint gaskets. In addition, the city may require additional thrust blocking if deemed appropriate.

I. Joint restraint shall be provided for all pipe bends, valves and fittings, and where necessary when joint deflection is utilized. When joint restraint is required in intersections, extend the joint restraint, at a minimum, to the point of curvature (PC) of the curb line. Notes shall be placed in both plan and profile views and shall include at a minimum the type of restraint to be utilized and the beginning and ending stations of the restraint. In addition, the city may require additional thrust blocking if deemed appropriate. The proximity of other utilities and structures must be taken into account when specifying the use of thrust blocking.

J. Allowable pipe sizes:

The following sizes will be the only sizes allowed for use in the system: (4" and 6" see item 1. above), (6" fire-hydrant leads and services only), 8", 12", 16", 24", 30", 36", and 42". Larger sizes may be approved on a case by case basis.

K. Connections of new mains to existing mains shall be made by cutting in a tee. Tapping sleeves may be allowed in lieu of cutting in a tee on a case-by-case basis. Full-body tapping sleeves shall be used. A tapping sleeve will not be allowed if the materials and conditions of the existing main preclude tapping. "Size on size" taps will not be permitted, unless made by use of an approved full bodied mechanical joint tapping sleeve.

2.3 Valves

A. There shall be a valve on each fire hydrant lead restrained to the main. These and all valves twenty-four (24) inches and smaller shall be resilient seated gate valves.

B. Valves shall be located at the intersection of two or more mains and shall be spaced so that no more than thirty (30) customers will be without water during a shutout. For lines smaller than twenty-four (24) inches, typical spacing should be 500 feet in high-density areas and 1,200 feet in residential area. Mains twenty-four (24) inches and larger shall be valved at intervals not to exceed 2,000 ft.

C At dead ends, gate valves shall be located one (1) pipe length ten (10-ft. minimum) from the end points of the main. The Engineer shall provide - and show drawings – complete restraint for all such valves, pipe extensions and end caps.

D. Branch piping (both new and future branches) shall be separated from the main with gate valves.

E. For all mains, valves at intersections shall be placed at point of curvature (p.c.) of the curb line.

F. Valves shall be located so that isolating any segment of water main requires closing of no more than three (3) valves.

G. The operating nut or extension of any valve shall be between eighteen (18) inches and twenty-four (24) inches below finished grade.

H. Valves with valve extensions and those at pressure zone boundaries shall be equipped with a locking type debris cap.

I. All vertical gate valves larger than sixteen (16) inches shall have the bonnet located in a vault or manhole. All horizontal gate valves larger than sixteen (16) inches shall have the valve actuator (gearing) located in a vault or manhole.

J. Valves having "push on" joints are not permitted for fire hydrant leads and laterals.

K. Butterfly valves shall not be allowed.

L. Water mains shall be designed so that valves can be installed vertically unless conditions dictate otherwise.

2.4 Fire Hydrants

A. Hydrants shall be installed at the intersection of two (2) streets and between intersections where necessary, at distances not in excess of 300 feet between hydrants in commercial or other high-density areas and not more than 500 feet in residential areas.

B. Hydrants shall be installed on both sides of all divided road/highways to provide adequate firefighting coverage. Roads/highways where opposing lanes of traffic are separated by a vehicle obstruction shall be considered a divided road/highway.

C. The entire fire hydrant assembly shall have restrained joints, and thrust blocking.

D. Fire hydrants shall not be designed to be within nine feet in any direction of any wastewater main, lateral, or service regardless of material of construction.

E. Fire hydrants shall be designed so as not to interfere with sidewalk ramps, trash receptacles, and street light and signal pole foundations.

F. When new water lines are installed along with new fire hydrant leads, the drawings shall indicate existing fire hydrants are to be replaced with a new one, if it is older than 10 years old.

2.5 Services

A. Water services shall be in accordance with City of Gonzales Standard Details. More than two meters on a single service line will be considered on a case-by-case basis.

B. Individual meter services and fire lines will not be taken from transmission lines. Transmission lines are generally considered to be 24 inches in diameter or larger.

C. Water meters shall be placed within the public right-of-way (ROW) or in an easement. Water meter boxes are not allowed in sidewalks or driveways.

D. Service taps to the main shall have a minimum separation distance of 3 feet.

E. Service taps, regardless of type, shall not be made in vaults.

F. Contractor shall install the meter box, and the service from the main to the angle stop at the meter box.

2.6 Water Meters for Multi-Family and Commercial Customers

A. Properties with two, three, or four living units shall have an individual water meter serving each living unit.

B. Commercial and multi-family properties shall purchase and install a separate meter or meters to measure water used for all common areas and outdoor purposes, including swimming pools, fountains, permanently installed irrigation systems, and irrigation with quick-coupler hose bibbs.

C. All multi-family, manufactured home rental community, or multiple-use facility, in order to provide for the measurement of the quantity of water, if any, consumed by the occupants of each unit, shall install:

   1. Submeters, owned by the property owner or manager, for each dwelling unit or rental unit, or

   2. Individual meters for each dwelling unit or rental unit.

2.7 Easements

A. Easements for water mains shall be a minimum of 15 feet wide, or twice the depth of the main, measured from finished grade to pipe flowline, whichever is greater. Mains shall be centered on the easement. Narrower easements will be considered where the Engineer provides evidence, to the satisfaction of the City of Gonzales, that maintenance activities will not be hindered by the reduced width.

B Easement documents and the metes and bounds shall be reviewed and approved by the City of Gonzales prior to recordation in the real property records of the county. Easement recordation in the real property records of the county is required prior to the City of Gonzales' approval of construction plans.

B.3.0 Wastewater Systems

3.1 Determination of Wastewater Flow

A. Residential single-family units shall be assumed to produce an average wastewater flow of 250 gallons/day.

B. Industrial wastewater flows will be evaluated on a case-by-case basis.

C. Inflow/Infiltration.

In sizing sewers, external contributions are accounted for by including 750 gallons per day per acre served for inflow and infiltration. Strict attention shall be given to minimizing inflow and infiltration.

D. Peak Dry Weather Flow.

The peak dry weather flow is derived from the formula:

$$Qpd = [(18+(0.0206 \times F)^{0.5}) / (4+(0.0206 \times F)^{0.5})] \times F$$

where: F = 70 gal./person/day x population/1440

= average dry-weather flow in gpm

E. Peak Wet Weather Flow.

The peak wet weather flow is obtained by adding inflow and infiltration to the peak dry weather flow. In designing for an existing facility, flow measurement shall be used in lieu of calculations for the preexisting developed area.

3.2 Determination of Pipe Size

A. Minimum Size.

The minimum diameter of all gravity sewer mains shall be eight (8) inches. Six (6) inch mains will be considered on a case by case basis. For service line sizes, refer to the City of Gonzales Standard Details.

B. Design Requirements.

For sewer mains, fifteen (15) inches in diameter or smaller, use the larger size as determined below:

1. The main shall be designed such that the Peak Dry Weather Flow shall not exceed 65% of the capacity of the pipe flowing full.

2. The main shall be designed such that the Peak Wet Weather Flow shall not exceed 85% of the capacity of the pipe flowing full.

3. For sewer mains, eighteen (18) inches in diameter or larger, the main shall be designed such that the peak Wet Weather Flow shall not exceed 80% of the capacity of the pipe flowing full.

C. Design Velocities.

The minimum design velocity calculated using the Peak Dry Weather Flow shall not be less than two (2) feet per second (fps). The maximum design velocity calculated using the Peak Wet Weather Flow should not exceed ten (10) fps. Velocities in excess of 10 fps may be considered under special conditions where no other options are available. In such cases, proper consideration shall be given to pipe material, abrasive characteristics of the wastewater flows, turbulence and displacement by erosion or shock.

D. Minimum Slope.

The minimum allowable slope for eight (8) inch mains within the service area of the City of Gonzales shall be 0.0035 ft/ft (0.35 percent grade). The minimum allowable slope for six (6) inch mains when allowed within the service area of the City of Gonzales shall be 0.005 ft/ft (0.50 percent grade).

E. Allowable pipe sizes.

The following sizes will be the only sizes allowed for use in the gravity system: 6” (on a case by case basis only), 8”, 12”, 15”, 18”, 21”, 24”, 30” 36”, 42”. Larger sizes may be approved on a case by case basis.

3.3 Design Considerations

A. Materials and Standards.

All materials and appurtenances shall conform to the City of Gonzales Standard Specifications. Pipe material for gravity sewer mains shall typically be PVC meeting the requirements of ASTM D3034 SDR 26 for pipe sizes 4” though 15”, and ASTM F679 SDR 26 (PS115) for pipe sizes 18” and larger.

B. Protecting Public Water Supply.

No physical connection shall be made between a drinking water supply and a sewer or any appurtenance thereof. An air gap of a minimum of two inlet pipe diameters between the potable water supply and the overflow level connected to the sewer shall be provided.

C. Location.

The location of the wastewater main shall be in conformance with the City of Gonzales Standard Details. Alternative assignments must be approved by the City of Gonzales. Outside the City Limits, the design engineer shall coordinate utility assignments with both the City of Gonzales and the appropriate county authority.

D. Separation Distance.

The separation between wastewater mains and other utilities shall be in accordance with the Rules adopted by the Texas Commission on Environmental Quality.

E. Steep grades.

Maximum pipe grades shall typically be the lesser of 8 percent, or that grade which creates a full flow velocity of 10 feet per second. Grades in excess of this may be considered under special conditions where no other options are available.

F. Depth of Cover.

The minimum depth of cover over the upper-most projection of the main shall be as follows:

1. Wastewater piping installed in natural ground in easements or other undeveloped areas which are not within existing or planned streets, roads or other traffic areas, shall be laid with at least 36 inches of cover.

2. Wastewater piping installed in existing streets, roads or other traffic areas shall be laid with at least 48 inches of cover.

3. Wastewater piping installed in proposed streets shall be laid with at least 48 inches of cover below the actual subgrade. The maximum depth shall be as approved by the Utility for the specific material, application, and conditions.

G. Turbulence.

Wastewater lines shall be designed to minimize turbulence to prevent release of sulfide gases and subsequent corrosion.

H. Curved wastewater mains are discouraged, and will be considered on a case by case basis only.

3.4 Manholes

A. Location.

Manholes shall be located and spaced so as to facilitate inspection and maintenance of the wastewater main. All manholes must be accessible to maintenance equipment, including 2½ ton straight trucks, dump trucks, vacuum trucks, and standard (not compact) sizes of backhoes and loaders. Manholes shall be placed at the following locations:

1. Intersections of mains.

2. Horizontal alignment changes.

3. Vertical grade changes.

4. Change of pipe size.

5. Change of pipe material.

6. The point of discharge of a force main into a gravity wastewater main.

7. Intersection of service lines to main lines 24 inches and larger.

8. A manhole is required at the point of connection of a building service line to the public wastewater service stub for multi-family projects exceeding fifteen (15) dwelling units and for commercial developments {containing more than 4,000 square feet} requiring a water meter greater than 2".

9. At the upstream end of mains.

B. Spacing.

Manhole spacing for lines smaller than 24 inches should not exceed 500 ft.; for larger mains, spacing may be increased, subject to approval by the City.

C. Covers.

All manholes located in paved areas shall have hinged, watertight covers.
All manholes not located in paved areas shall have bolted, watertight covers.

D. All lines into manholes, including drop connections, shall match crown-to-crown where feasible. Any deviation must be approved in advance by the City.

E. Drop manholes will have a maximum of 8 foot of drop and are not allowed where the main size exceeds 15 inches.

F. Minimum inside manhole diameters shall be as indicated in the following table:

	Depth		
Main Size	Less than 20’	20’ – 30’	Greater than 30’
Up to 15”	48”	60”	72”
18”-24”	60”	60”	72”
30” & 36”	72”	72”	72”

Note 1: In the event a structure is utilized inside a manhole, the clear space between the structure and the manhole wall shall be a minimum of 48”.

Note 2: If more than two pipes connect to a manhole, or if two pipes connect to a manhole at an angle other than 180 degrees from each other, larger diameters may be required in order to accommodate mandrel insertion and hydraulically efficient flow.

Note 3: Access to mains 42" and larger shall be by junction boxes designed by a structural engineer.

Note 4: New pipe connections to existing manholes shall provide a minimum of 12" clearance between the existing pipe ID and the new core hole ID measured on the inside surface of the manhole, regardless of the orientation of the pipes with respect to one another. New precast manholes shall have holes for pipe penetrations separated far enough apart to ensure the structural integrity of the manhole wall.

G. Where a separation of nine feet between a water main and a manhole cannot be achieved, as approved by the City of Gonzales, the joints in the wastewater manhole shall be made watertight using externally applied joint wraps.

H. All manhole bases, for manholes to be constructed on existing lines, shall be cast in place.

I. Manhole and junction box inverts shall have a minimum slope of 2.5% between the inlet and outlet pipe inverts or have a minimum difference of 0.10 feet between the inlet and out pipe inverts, whichever provides the maximum difference in invert elevation between the inlet and outlet pipes.

J. Manholes and junction boxes located below ground water

    1. Manhole joints below the ground water level shall be sealed by installing a joint wrap material over the joint on the manhole exterior.

    2. Construction joints in cast-in-place junction boxes shall be water proofed using water stops.

3.5 <u>Ventilation</u>

Ventilation shall be provided as required by TCEQ Rules and Regulations.

3.6 <u>Inverted Siphons</u>

Siphons shall have a minimum of two barrels. The minimum pipe size shall be six (6) inches with a minimum flow velocity of 3.0 fps at peak dry weather flow. The minimum dry weather flow shall be used to size the smallest barrel. Three-barrel siphons shall be designed to carry the capacity of the incoming gravity wastewater mains(s) with one barrel out of service.

An additional corrosion resistant pipe shall be designed to allow for the free flow of air between the inlet and outlet siphon boxes. The diameter of this air jumper shall not be smaller than one-half the diameter of the upstream sewer. Air jumper pipe design shall provide for removal of condensate water that will collect in the pipe.

Siphon inlet and outlet structures shall be manufactured with approved corrosion resistant material and shall provide for siphon cleaning and maintenance requirements.

3.7 <u>Service Lines</u>

A. Wastewater service lines, between the main and property line, shall conform to the City of Gonzales Wastewater Service Connection Details.

B. Usually wastewater services are placed along the common property line between two lots where there is no conflict with other utilities' services. All other Utility service is usually located at the other lot corner. For details, see the City of Gonzales Standard Details.

C. Wastewater clean-outs are not allowed in sidewalks or driveways.

D. Large Diameter Cleanouts are required for service lines that are 8" in diameter and when industrial waste monitoring is required. They shall be located at the property line within the public right-of-way (ROW) or utility easement line to indicate the line of responsibility of the utility. They shall not be located in traffic areas, paved parking areas or sidewalks.

E. Manholes are required for services larger than 8" in diameter. They shall be located within the public ROW or utility easement line to indicate the line of responsibility of the utility.

3.8 Easements

A. Easements for wastewater mains shall be a minimum of 15 feet wide, or twice the depth of the main, measured from finished grade to pipe flowline, whichever is greater. Mains shall be centered on the easement. Narrower easements will be considered where the Engineer provides evidence, to the satisfaction of the City of Gonzales, that maintenance activities will not be hindered by the reduced width.

B. Easement documents and the metes and bounds shall be reviewed and approved by the City of Gonzales prior to recordation in the real property records of the county. Easement recordation in the real property records of the county is required prior to the City of Gonzales' approval of construction plans.

C. ROADWAY AND STREET DESIGN CRITERIA

C.1.0 General

This section provides guidelines for the assignment of street classifications and their respective design criteria.

C.2.0 Classifications and Functional Characteristics

2.1 General Street Classifications

Street classifications are used to categorize streets according to their functions. There are three (3) major street classifications for urban roadways: local streets, collector streets and arterial streets.

Each of the three (3) major classifications when appropriately planned, combine to create an effective overall street network.

2.2 Functional Characteristics

The following reflect general functional characteristics for each street classification. In addition, Figure 1-2 contained in Appendix H of this manual illustrates the access versus mobility characteristic as it pertains to each street classification.

A. Alley. An alley is a passageway designed primarily to provide access to or from the rear or side of property otherwise abutting on a public street.

B. Local Street. The primary function of a local street is to serve abutting land use and traffic within a neighborhood or limited residential district. A local street is not generally continuous through several districts.

C. Collector Street. The primary function of a collector street is to intercept traffic from intersecting local streets and expedite the movement of this traffic in the most direct route to an arterial street or other collector street.

D. Arterial Street. Arterial streets are designed to carry high volumes of through traffic. Access is usually limited to intersections and major driveways. Arterial streets serve as a link between major activity centers within the urban area.

The functional classification for each street shall be identified upon the time of the submittal of preliminary plans.

TABLE 1-1

Functional Classification	ROW	Paving Width LOG-LOG	Curb Basis	Design Speed (mph)	Min Centerline Radius	Side walk
Alley	20	20	0	25	180	NA
Local	50	29	8.5	30	300	4
Collector	60	37	10	40	725	4
Arterial	120	57	29.5	Varies	Varies	5 or 6

C3.0 Geometric Design Criteria

3.1 General Design Criteria

A. Grades. The following design criteria is based on material from the Institute of Transportation Engineers Report, Guidelines for Urban Major Street Design, 1983, Sections 6.1, 6.3 and 6.4.

1. Maximum Grades.

Maximum grades are determined primarily by the operation characteristics of vehicles on grades. Maximum grades of seven (7) to eight (8) percent should typically be used.

2. Minimum Grades.

Minimum grades are governed by drainage conditions. With curbed pavements, longitudinal grades should be provided to facilitate surface drainage. A minimum grade of 0.4 percent should typically be used.

3. General Controls for Vertical Alignment.

The following are general design controls which should be addressed in determining vertical alignments:

a. The grade line should be smooth flowing.

b. Undulating grade lines should be appraised for their effect upon traffic operations.

c. A broken-back grade line (successive vertical curves in the same direction) generally should be avoided.

d. It is desirable to reduce the grade through intersections on roadways with moderate to steep grades.

e. Steep downgrades should be avoided, whenever practicable, at the approach to traffic signals and stop signs.

4. Vertical Curves.

Vertical curves should be simple in application and should result in a design that is safe, comfortable in operation, pleasing in appearance and adequate for drainage.

For simplicity, the parabolic curve with an equivalent axis center on the vertical point of intersection is recommended in roadway profile design.

Maximum grade breaks of 0.8 percent or less may be used without a vertical curve.

B. Minimum Horizontal Radii.

The following design criteria is based on material from the American Association of State Highway and Transportation Officials (AASHTO) Manual, <u>A Policy on Geometric Design of Highways and Streets</u>, 1984, Chapters III, V, VI and VII.

The minimum radius of a roadway is directly related to a roadway's design speed. The 1984 AASHTO Manual, Figure III-17, "Maximum Safe and Comfortable Speed for Horizontal Curves on Low-speed Urban Streets," was utilized in establishing the following radii:

A design speed of:

20 mph relates to a minimum allowable radius of 100 ft.
25 mph relates to a minimum allowable radius of 180 ft.
30 mph relates to a minimum allowable radius of 300 ft.
35 mph relates to a minimum allowable radius of 470 ft.
40 mph relates to a minimum allowable radius of 725 ft.
45 mph relates to a minimum allowable radius of 1,000 ft.
50 mph relates to a minimum allowable radius of 1,400 ft.

C. Cross Slope.

The following design criteria were adapted from the American Association of State Highway and Transportation Officials (AASHTO) Manual, A Policy of Geometric Design of Highways and Streets, 2001, Chapter IV.

Minimum Cross Slope shall be 1.5 percent.
Typical Cross Slope shall be 2.0 percent.
Maximum Cross Slope shall be 3.0 percent.

D. Intersection Design.

The following design criteria was adapted from the Institute of Transportation Engineers reports, Recommended Guidelines for Subdivision Streets.

1. Vertical Alignment within Intersection Area.

Intersection areas should be designed with a flat grade. In the more difficult terrains, this becomes economically impractical.

The design speed for the major street at any intersection shall be maintained through the intersection approaches. The minor street may be designed with a change in grade based on reduced design speeds between the maximum grade in the approach and the cross-slope of the intersected street not to exceed eight (8) percent for local streets and six (6) percent for collector streets. The change in grade shall be accomplished by means of a vertical curve of length equal to the minimum length for that approach.

2. Horizontal Alignment within Intersection Area.

The horizontal approach to an intersection should be tangent for a length of 50-100 feet. Note that these tangent lengths are minimum. Longer tangents are highly desirable. The tangent distance is measured from the curb line of one (1) street to the first point of curvature on the intersecting street. In this regard, radii greater or equal to 1000 feet may be considered tangent.

It is desirable for all intersections to meet at approximately a 90 degree angle. However, necessary sight distance for streets intersecting from the outside of a curve is generally attainable. Skewed intersections should be avoided and in no case should the angle be less than 80 degrees or greater than 100 degrees.

3. Minimum Curb Radius.

As curb radius is increased, paving costs and intersection area required for a pedestrian to traverse are increased and higher turning speeds are encouraged. Substandard radii result in unnecessary lane encroachment and increased traffic conflict and accident potential.

a. Local to Local Streets – Curb Return radius should be minimum of 15 feet and maximum of 20 feet

b. Local to Collector Streets – Curb Return radius should be minimum of 15 feet and maximum of 20 feet

c. Collector to Collector Streets – Curb Return radius should be minimum of 20 feet and maximum of 25 feet

d. Collector to Arterial Streets – Curb Return radius should be minimum of 25 feet and maximum of 30 feet

e. Arterial to Arterial Streets – Curb Return radius should be a 30 feet

4. Minimum Centerline Offset of Adjacent Intersection.

The distance between intersection offsets is measured from the center line intersection of one (1) intersecting street and the centerline intersection of the next intersecting street, measured along the centerline of the intersected roadway. Offsets in street intersections will be evaluated on a case by case basis. Offsets to the left are more desirable than offsets to the right because of the reduction of left turn conflicts along the intersected roadway.

a. Local Streets – Offsets of Local Streets should be a minimum of 150 feet.

b. Collector Streets – Offsets of Collector Streets should be a minimum of 300 feet.

5. Drainage Structures.

The location of drainage structures, inlets, catch basins, etc., should be consistent with the intended use of the roadway.

Inlets or catch basins should not be located within the corner curb return or within ten (10) feet from the point of curvature of the curb return. Clearance is needed to allow space for street lights, street name signs, utility poles, pedestrians, sidewalk ramps, etc.

Valley gutters should not be designed across streets with collector or higher classification.

6. Sight Distance.

Intersections should be planned and located to provide as much sight distance as possible. A basic requirement for all controlled intersections is that drivers must be able to see the control device well in advance of performing the required action. Stopping sight distance on all approaches is needed as a minimum. Obstruction-free sight triangles are desirable, in both the horizontal and vertical planes as related to assumed driver eye height and position.

The stopping sight distance (SSD) in feet is determined from the formula:

$$SSD = 1.47\,PV + \frac{V^2}{30\,(f \pm g)} \qquad \text{(eq. 1-2)}$$

Where V = Design speed in miles per hour

P = Perception-reaction time in seconds (2.5 seconds)

f = Coefficient of friction for wet pavement (.30 to .40)

g = Percent of grade divided by 100 (+ for upgrade; - for downgrade)

APPENDIX A
LIST OF REFERENCES

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APPENDIX B
LIST OF ABBREVIATIONS

Θ	Slope of inlet gutter depression
a	Gutter depression
ac	Acres
A	Area
AMC	Antecedent moisture condition
ASCE	American Society of Civil Engineers
b	Width of partial flow in circular conduit
C	Dimension less weighted runoff coefficient used in the Rational Method to account for ground cover and/or land use within the watershed
CA	Product of runoff coefficient and drainage area used in Rational Method
cfs	Cubic feet per second
CLOMR	Conditional letter of map revision
Cp	Coefficient of peak discharge used in Snyder's unit hydrograph method to account for flood wave and storage conditions
Ct	Dimension less coefficient used in Snyder's unit hydrograph method related to the watershed slopes and storage
D	Diameter
d_c	Critical depth
FEMA	Federal Emergency Management Agency
fps	Feet per second
Ft	Feet
g	Acceleration due to gravity (32.2 fps)
SASMMP	San Angelo Stormwater Management Master Plan
h,H	Head
h_b	Headloss at a bend
H_j	Headloss at a junction
H_L	Total headloss
HW	Headwater depth
I	Rainfall intensity
K	Dimension less coefficient used in the Ration Method to account for antecedent precipitation
K_b	Headloss coefficient at a bend
K_e	Entrance loss coefficient
K_j	Headloss coefficient at a junction
L	Length
L_a	Length of curb inlet require for 100% interception
L_{ca}	River mileage from design point to center of gravity of drainage area
L_g	Gutter flow length
L_o	Overland flow length
Min.	Minimum or minutes
MSL	Mean sea level
n,N	Roughness coefficient used in Manning's formula

P	Wetted perimeter of flow
PMF	Probable maximum flood
q	Peak design discharge per unit area
Q, Q_p	Peak design discharge
Qa	Approach flow in gutter upstream of curb inlet
q_p	Peak rate of discharge of unit hydrograph for unit rainfall duration, t_r
q_{pR}	Peak rate of discharge of unit hydrograph for unit rainfall duration, t_R
ROW	Right-of-way
S, S_o, S_g	Ground slope, overland ground slope, or gutter flow ground slope.
SCS	Soil Conservation Service
Se	Slope of energy gradient
S_f	Slope of frictional gradient
S_p	Spread of water from curb toward the street centerline for peak flow
S_W	Slope of hydraulic gradient
t_c	Time of concentration
t_p	Hydrograph lag time from midpoint of rainfall duration, t_r, to peak of unit hydrograph
t_{pR}	Lag time from midpoint of unit rainfall duration, t_R, to peak of unit hydrograph
t_r	Standard unit rainfall duration
t_R	Unit rainfall duration in hours other than the standard unit t_r
T	Top width of flow
v,V	Velocity
w, W	Width
y, Y	Flow depth
z	Reciprocal of street cross slope

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APPENDIX C
DEFINITIONS OF TERMS

Abstractions.	The fractions of precipitation lost to evaporation, transpiration, interception, depression storage and infiltration.
Abutment.	A wall supporting the end of a bridge or span, and sustaining the pressure of the abutting earth.
Apron.	A floor or lining of concrete, timber, or other suitable material at the toe of a dam, entrance or discharge side of spillway, a chute, or other discharge structure, to protect the waterway from erosion from falling water or turbulent flow.
Arterial street.	Any major street defined as an arterial street in the City of Gonzales Comprehensive Traffic Plan, or as designated on official maps of the City of Gonzales.
Backwater.	The rise of the water level upstream due to an obstruction or constriction in the channel.
Backwater Curve.	The term applied to the longitudinal profile of the water surface in an open channel when flow is steady but non-uniform.
Baffle Chute.	A drop structure in a channel with baffles for energy dissipation to permit the lowering of the hydraulic energy gradient in a short distance to accommodate topography.
Baffles.	Deflector vanes, guides, grids, gratings, or similar devices constructed or placed in flowing water, to: (a) check or effect a more uniform distribution of velocities; (b) absorb energy; (c) divert, guide, or agitate the liquids; and (d) check eddy currents.
Base Flood.	The base flood for the City of San Angelo is defined as the 100-year frequency flood based on fully developed watershed conditions. The base flood elevation is the water surface elevation developed using the base flood as defined in part II of this manual. The City of San Angelo base flood elevation will not necessarily correspond FEMA base flood elevation.
Calibration.	Process of checking, adjusting, or standardizing operating characteristics of instruments and model appurtenances on a physical model or coefficients in a mathematical model. The process of evaluating the scale readings of an instrument in terms of the physical quantity to be measured.
Channel.	Any arroyo, stream, wash, swale, gully, ditch, diversion, or watercourse that conveys storm runoff, including manmade facilities.

Channel Roughness.	Irregularities in channel configuration which retard the flow of water and dissipate its energy.
Channel stability.	A condition in which a channel neither degrades to the degree that structures, utilities or private property are endangered, nor aggrades to the degree that flow capacity is significantly diminished as a result of one or more storm runoff events or moves laterally to the degree that adjacent property is endangered.
Channel treatment measure.	A physical alteration of a channel for any purpose.
Chute.	An inclined conduit or structure used for conveying water to a lower level.
Designated Official.	City of Gonzales staff individual responsible for administration, processing and compliance with provisions of this ordinance or his/her designated representative.
Comprehensive plan.	The City of Gonzales Comprehensive Plan and amendments thereto.
Conduit.	Any open or closed device for conveying flowing water.
Contaminants.	Contaminating agents such as oil wastes, sewage, chemicals, etc.
Continuity.	Continuity of flow exists between two sections of a pipe or channel when the same quantity of water passes the two cross sections and all intermediate cross sections at any one instant.
Critical Flow.	The state of flow which exhibits the following characteristics: (a) the specific energy is a minimum for a given discharge; (b) the discharge is a maximum for a given specific energy; (c) the specific force is a minimum for a given discharge; (d) the velocity head is equal to half the hydraulic depth in a channel of small slope; (e) the Froude Number is equal to unity.
Crown.	(a) The highest point on a transverse section of conduit; (b) the highest point of a roadway cross section.
Culvert.	Large pipe or other conduit through which a stormwater flows under a road or street.
Curb.	A vertical or sloping rim along the edge of a roadway, normally constructed integrally with the gutter, which strengthens and protects the pavement edge and clearly defines the pavement edge to vehicle operators.
Curb Inlet.	A vertical opening in a curb through which the gutter flow passes. The gutter may be undepressed or depressed in the area of the curb opening.
Curb Split Dam.	The elevation difference between curbs on opposite sides of a street.

Dam.	A barrier constructed across a watercourse for the purposes of (a) creating a reservoir; (b) diverting water from a conduit or channel.
Degradation.	The progressive general lowering of a stream channel by erosion.
Depression Storage.	Collection and storage of rainfall in natural depressions (small puddles) after exceeding infiltration capacity of the soil.
Design Storm or Flood.	The storm or flood which is used as the basis for design, i.e., against which the structure is designed to provide a stated degree of protection or other specified result.
Detention.	The storage of storm runoff for a controlled release during or immediately following the design storm. a. Off-site detention - A detention pond located outside the boundary of the area it serves. b. On-site detention - A detention pond which is located within and serves only a specific site or subdivision. c. On-stream detention - Detention facilities provided to control excess runoff based on a watershed-wide hydrologic analysis.
Developed land.	Any lot or parcel of land occupied by any structure intended for human occupation, including structures intended for commercial or industrial enterprise.
Developer.	Any individual, estate, trust, receiver, cooperative association, club, corporation, company, firm, partnership, joint venture, syndicate or other entity engaging in platting, subdivision, filling, grading, excavating, or construction of structures.
Downstream capacity.	The ability of downstream drainage facilities to accept and safely convey runoff generated upstream.
Drainage way.	Any path of concentrated flow which drains more than 1/4 acre. Watercourse is typically used for larger drainage ways. Channel is a more general term.
Drainage basin.	The storm water catchment area above a point on a channel to which waters drain and collect. Watershed has the same meaning.
Drainage control.	The treatment and/or management of surface runoff.
Drainage easement.	A platted area reserved for the primary purpose of stormwater drainage and maintenance.
Drainage System.	Drainage systems shall include streets, alleys, storm drains, drainage channels, culverts, bridges, overflow swales and any other facility through which or over which storm water flows.

Drop Inlet.	A storm drain intake structure typically located in unpaved areas. The inlet may extend above the ground level with openings on one or more sides or it may be flush with the ground with a grated cover.
Drop Structures.	A sloping or vertical section of a channel designed to reduce the elevation of flowing water without increasing its velocity.
Entrance Head.	The head required to cause flow into a conduit or other structure; it includes both entrance loss and velocity head.
Entrance Loss.	Head lost in eddies or friction at the inlet to a conduit, headwall or structure.
Erosion control.	Treatment measures for the prevention of damages due to soil movement and to deposition.
Evaporation.	Process by which water is transferred from land and water masses to the atmosphere.
Excavation.	Digging and removal of earth by mechanical means.
Exceedance Probability.	The statistical probability that an event will equal or exceed a specific magnitude.
Fill.	The placement of material such as soil or rock to replace existing material, or to create an elevated embankment. Fill also refers to the material which is placed.
Flash Flood.	A flood of short duration with a relatively high peak rate of flow, usually resulting from high intensity rainfall over a small area.
Flexible Pipe.	Any corrugated metal pipe, pipe-arch, sectional plate pipe, sectional plate pipe-arch or plastic (polyethylene) pipe.
Flood or Flooding.	A general and temporary condition of inundation of normally dry land areas by surface runoff. The 100-year flood is the flow rate with a 1% probability of being equaled or exceeded in any one year.
Flood Control.	The elimination or reduction of flood damage by the construction of flood storage reservoirs, channel improvements, dikes and levees, bypass channels, or other engineering works.
Flood Hazard Area.	Area subject to flooding by 100-year frequency floods.
Flood Hazard Mitigation.	See Stormwater Management.
Flood Management.	See Stormwater Management.

Floodplain. Geographically the entire area subject to flooding. In usual practice, it is the area subject to flooding by the 100-year frequency flood. In this manual, the "100-year floodplain" refers to the floodplain resulting from a 100-year flood based on ultimate watershed development conditions. The "FEMA floodplain" shall refer to the area subject to flooding resulting from the 100-year flood for current watershed development conditions.

Floodway. The channel of a river or other watercourse and the adjacent land areas that must be reserved in order to discharge the base flood without cumulatively increasing the water surface elevation by more than a designated height. In this manual, the floodway refers to the floodway resulting from a 100-year flood event based on ultimate development conditions with a cumulative increase of no more than one foot.

Floodway Fringe. Part of the flood hazard area within the floodplain but outside of the floodway.

Freeboard. The distance between the normal operating level and the top of the side of an open conduit left to allow for wave action, floating debris, or any other condition or emergency without overtopping the structure.

Frequency. Average recurrence interval of a given flood event over long periods of time. Mathematically, frequency is the reciprocal of the exceedance probability.

Froude Number. A flow parameter which is a measure of the extent to which gravitational action affects the flow. A Froude number greater than one indicates supercritical flow and a value less than one indicates subcritical flow. The simplest form of the Froude number is given by the equation:

$F = V/(gD)^{0.5}$

where: V=Velocity in ft/sec

g = the acceleration due to gravity (32.2f t/see2)

D = depth in ft

Fully developed watershed. A hydrologic condition in which all areas upstream and downstream of a point in question are assumed completely developed, including any undeveloped areas which are assumed to be developed in accordance with development densities established in the Comprehensive Zoning Map of the City of Gonzales.

Gabion. A wire basket containing earth or stones, deposited with others to provide protection against erosion.

Grade. (a) The inclination or slope of a channel, canal, conduit, etc., or natural ground surface, usually expressed in terms of the percentage of number of units of vertical rise (or fall) per unit of horizontal distance. (b) The elevation of the bottom of a conduit, canal, culvert, sewer, etc. (c) The finished surface of a canal bed, road bed, top of an embankment, or bottom of excavation.

Grading.	Any movement of soil, rock or vegetation by artificial means, to include any or all of the following acts: clearing, grubbing, excavating, placement of fill material, or grading of land.
Grate Inlet.	An opening in the gutter covered by one or more grates through which the water falls. As with all inlets, grated inlets may be either depressed or undepressed and may be located either on a continuous grade of in a sump.
Gutter.	A generally shallow waterway adjacent to a curb, used or suitable for drainage of water.
Head.	The amount of energy per pound of fluid.
Headwater.	(a) The upper reaches of a stream near its sources; (b) the region where ground waters emerge to form a surface stream; (c) the water upstream from a structure.
High Intensity Node.	Areas of existing or proposed development that contain a large concentration of buildings and large amounts of pavement. High Intensity nodes typically generate large volumes of storm water runoff.
Histogram.	Representation of statistical data by means of rectangles whose widths represent rainfall, runoff, etc. and whose height represents frequency.
Hydraulic Control.	The hydraulic characteristic which determines the stage- discharge relationship in a flowing stream or conduit. The control is usually critical depth, tailwater depth or uniform depth.
Hydraulic Grade Line.	A line representing the pressure head available at any given point within the system.
Hydraulic Gradient.	A hydraulic profile of the piezometric level of the water, representing the sum of the depth of flow and the pressure head. In open channel flow it is the water surface.
Hydraulic Jump.	The hydraulic jump is an abrupt rise in the water surface which occurs in an open channel when water flowing at supercritical velocity is retarded by water flowing at subcritical velocity. The transition through the jump results in a marked loss of energy, evidenced by turbulence of the flow within the area of the jump. The hydraulic jump is sometimes used as a means of energy dissipation.
Hydraulics.	A branch of science that deals with practical applications of the mechanics of water movement.
Hydrograph.	A graph showing flow (or sometimes stage, velocity or other properties of water) versus time at a given point on a stream or conduit.

Hydrology.	The science that deals with the processes governing the depletion and replenishment of the water resources of the land areas of the earth.
Hyetograph.	A histogram or graph of rainfall intensity versus time usually during a storm.
Impervious.	A term applied to a material through which water cannot pass, or through which water passes with great difficulty.
Infiltration.	(a) The entering of water through the interstices or pores of a soil or other porous medium; (b) the quantity of groundwater which leaks into a sanitary or combined sewer or drain through defective joints, breaks or porous walls; (c) The absorption of water by soil, either as it falls as precipitation or from a stream flowing over the surface.
Inlet.	(a) An opening into a storm sewer system for the entrance of surface storm runoff, more completely described as a storm sewer inlet; (b) a structure at the diversion end of a conduit; (c) the upstream connection between the surface of the ground and a drain or sewer, for the admission of surface or storm water.
Intensity.	As applied to rainfall, a rate usually expressed in inches per hour.
Interception.	As applied to hydrology, refers to the process by which precipitation is caught and held by foliage, twigs, and branches of trees, shrubs and buildings, never reaching the surface of the ground, and then lost by evaporation.
Invert.	The floor, bottom, or lowest portion of the internal cross-section of a conduit. Used particularly with reference to storm drains, sewers, tunnels, channels and swales.
Lag Time.	The time difference between two occurrences, such as between rainfall and runoff or pumping of a well and effect on the stream. See Time of Concentration.
Lining.	Impervious material such as concrete, clay, grass, plastic, etc., placed on the sides and bottom of a ditch, channel, and reservoir to prevent or reduce seepage of water through the sides and bottom and/or to prevent erosion.
Lip.	A small wall on the downstream end of an apron, to break the flow from the apron.
Maintenance.	The cleaning, shaping, grading, repair and minor replacement of drainage, flood control and erosion facilities, but not including the cost of power consumed in the normal operation of pump stations.
Major facility.	Any facility, including a street or alley, which would collect, divert, or convey a peak discharge of more than 50 cubic feet per second (50 cfs) or store more than 2.0 acre-feet of runoff in the event of a 50-year design storm.
Manning Coefficient.	The coefficient of roughness used in the Manning Equation for flow in open channels.

Manning Equation.	A uniform flow equation used to relate velocity, hydraulic radius and the energy gradient.
Minor facility.	Any facility which would collect, divert or convey a peak discharge of 50 cubic feet per second (50 cfs) or less, or store 2-acre feet of water or less in the event of the 50-year design storm.
Model.	Mathematical systems analysis by computer, applied to evaluate rainfall-runoff relationships; simulate watershed characteristics; predict flood and reservoir routings; or for other aspects of planning.
Multiple use facility.	A drainage control, flood control or erosion control facility in which other secondary uses are planned or allowed, including but not limited to recreation, open space, transportation, and utility location.
Nappe.	The sheet or curtain of water overflowing a weir or dam. When freely overflowing any given structure, it has a well- defined upper and lower surface.
100-year Event.	Event (rainfall or flood) that statistically has a one percent chance of being equaled or exceeded in any given year.
Open Channel.	A conduit in which water flows with a free surface.
Orifice.	(a) An opening with closed perimeter and regular form in a plate, wall, or partition, through which water may flow; (b) the end of a small tube, such as a Pitot tube, piezometer, etc.
Peak Flow.	The maximum rate of runoff during a given runoff event.
Percolation.	To pass through a permeable substance such as ground water flowing through an aquifer.
Permeability.	The property of a material which permits movement of water through it when saturated and actuated by hydrostatic pressure.
Pervious.	Applied to a material through which water passes relatively freely.
Porosity.	(a) An index of the void characteristics of a soil or stratum as pertaining to percolation; degree of perviousness; (b) the ratio, usually expressed as a percentage, of the volume of the interstices in a quantity of material to the total volume of the material.
Post-development.	The condition of the given site and drainage area after the anticipated development has take place.
Precipitation.	Any moisture that falls from the atmosphere, including snow, sleet, rain and hail.

Pre-development. The condition of the given site and drainage area prior to development.

Prismatic Channel. A channel with unvarying cross-section and constant bottom slope.

Probable Maximum Flood (PMF). The flood that may be expected from the most severe meteorological and hydrologic conditions that are reasonably possible in the region.

Probable Maximum Precipitation (PMP). The critical depth-duration-area rainfall relationship for a given area during a storm containing the most critical meteorological conditions considered probable of occurring.

Rainfall Duration. The length of time over which a single rainfall event occurs.

Rainfall Frequency. The average recurrence interval of rainfall events, averaged over long periods of time.

Rainfall Intensity. The rate of accumulation of rainfall, usually in inches or millimeters per hour.

Rational Formula. A traditional means of relating runoff from a drainage basin to the intensity of the storm rainfall, the size of the basin, and the characteristics of the basin (such as land use, impervious cover).

Reach. Any length of river or channel. Normally refers to sections which are uniform with respect to discharge, depth, area or slope, or sections between gagging stations.

Recurrence Interval. The average interval of time within which a given event is statistically predicted to be equaled or exceeded once. For an annual series (as opposed to a partial duration series), it is the probability of occurrence interval. Thus a flood having a recurrence interval of 100 years has a one percent probability of being equaled or exceeded.

Return Period. See Recurrence Interval

Reynold's Number. A flow parameter which is a measure of the viscous effects on the flow. Typically defined as:

Re = VD/

where, V = Velocity
D = Depth
v = Kinematic viscosity of the fluid

Rigid Pipe. Any concrete, clay or cast iron pipe.

Riprap (Revetment). Forms of bank channel protection, usually using rock or concrete. Riprap is a term sometimes applied to stone which is dumped rather than placed more carefully.

Routing. Routing is a technique used to predict the temporal and spatial variations of a flood wave as it traverses a river reach or reservoir. Generally, routing technique may be classified into two categories - hydrologic routing and hydraulic routing.

ROW (Right-of-Way). A strip of land dedicated for public streets and/or related facilities, including utilities, drainage systems and other transportation uses.

ROW Width. The shortest horizontal distance between the lines which delineate the limits of right-of-way of a street.

Runoff. That part of the precipitation that exceeds abstractions and reaches a stream or storm drain.

Runoff Coefficient. A decimal number used in the Rational Formula, which defines the runoff characteristics (i.e., land use impervious cover) of the drainage area under consideration. It may be applied to an entire drainage basin as a composite representation or it may be applied to a small individual area such as one residential lot.

Runoff Total. The total volume of flow from a drainage area for a definite period of time such as a day, month, year, or for the duration of a particular storm.

Scour. The erosive action of running water in streams or channels in excavating and carrying away material from the bed and banks.

SCS Runoff Curve Number. Index number used by the Soil Conservation Service as a measure of the tendency of rainfall to run off into streams rather than evaporate or infiltrate.

Sediment. Material of soil and rock origin transported, carried, or deposited by flowing water.

Sidewalk. A paved area within the street right-of-way specifically designed for pedestrians and/or bicyclists.

Slope, Critical. (a) The slope or grade of a channel that is exactly equal to the loss of head per foot resulting from flow at a depth that will give uniform flow at critical depth; (b) the slope of a conduit which will produce critical flow.

Slope, Friction. The friction head or loss per unit length of channel or conduit. For uniform flow the friction slope coincides with the energy gradient. Where a distinction is made between energy losses due to bends, expansions, impacts, etc., a distinction must also be made between the friction scope and the energy gradient. The friction slope is equal to the bed or surface slope only for uniform flow in uniform open channels.

Soffit. The top of the inside of a pipe. In a pipe, the uppermost point on the inside of the structure.

Spillway. A waterway in or about a darn or other hydraulic structure for the escape of excess water.

Steady Flow. Open channel flow is said to be steady if the depth of flow does not change and can be assumed to be constant during the time interval under consideration.

Stilling Basin. Pool of water conventionally used, as part of a drop structure or other structure, to dissipate energy.

Storm Hydrology. The branch of hydrology that concentrates on the calculation of runoff from storm rainfall.

Stormwater Management. The control of storm runoff by means of land use restrictions, detention storage, erosion control, and/or drainage systems

Stormwater Model. Mathematical method of solving stormwater problems by computer technology.

Street Classifications:

Alley- An alley is a passageway designed primarily to provide access to or from the rear or side of property otherwise abutting on a public street.

Arterial Street- Arterial streets are designed to carry high volumes of through traffic. Arterial streets serve as a link between major activity centers within the urban area.

Collector Street- The primary function of a collector street is to serve abutting traffic from intersecting local streets and expedite the movement of this traffic in the most direct route to an arterial street or other collector street.

Freeway- Freeways are divided arterial highways designed with full control of access and grade separations at all intersections. Freeways provide movement of high volumes of traffic at relatively high speeds. This system carries most of the trips entering and leaving the urban area, as well as most of the through movements bypassing the central city.

Local- The primary function of a local street is to serve abutting land use and traffic within a neighborhood or limited residential district. A local street is not generally continuous through several districts.

Parkway- (a) a freeway which does not have continuous frontage roads; (b) greenspace buffer between the roadway and adjacent development.

Subcritical Flow. Relatively deep, tranquil flow with low flow velocities. The Froude Number is less than 1.0 for subcritical flow conditions.

Supercritical Flow. Relatively shallow, turbulent flow with high velocities. The Froude Number is greater than 1.0 for supercritical flow conditions.

Tailwater. The depth of flow in the stream directly downstream of a drainage facility or other man-made control structure.

Temporary drainage Facility. A non-permanent drainage control, flood control or erosion control facility constructed as part of a phased project or to serve until such time that a permanent facility is in place, including but not limited to desilting ponds, berms, diversions, channels, detention ponds, erosion control measures, bank protection and channel stabilization measures.

Time of Concentration. The estimated time in minutes required for runoff to flow from the most hydraulically remote section of the drainage area to the point at which the flow is to be determined. Hydraulically remote refer to the travel path with the longest flow travel time, not necessarily the longest linear distance.

Total Head Line. A line representing the energy in flowing water. The elevation of the energy line is equal to the elevation of the flow line plus the depth plus the velocity head plus the pressure head.

Trash Rack. Racks, gratings, or mesh designed so as to prevent tree limbs, water-borne debris and rubbish from plugging the outlets from a dam or detention basin.

Trunk Line. The main line of a storm drain system, extending from manhole to manhole or from manhole to outlet structure.

Ultimate Development. The condition of the watershed after the entire watershed has undergone development.

Uniform Channel. A channel with a constant cross section, slope and roughness.

Uniform Flow. Open channel flow is said to be uniform if the depth of flow is the same at every section of the channel.

Unit Hydrograph. The direct runoff hydrograph resulting from one inch of precipitation excess, distributed uniformly over a watershed for a specified duration.

Velocity Head. The energy per unit weight of water due to its velocity. The velocity head also represents the vertical distance water must all freely under gravity to reach its velocity. The velocity head can be computed from:

$$H_v = V^2/2g$$

where, H_v = Velocity head in ft
V = Velocity in ft/sec
g = acceleration due to gravity 32,2 ftJsec2)

Warped Headwall.	The wingwalls are tapered from vertical at the abutment to a stable bank slope at the end of the wall.
Water Year.	The water year commonly used in the United States is the period from October 1 of the previous calendar year to September 30 of the numbered calendar year.
Watershed.	The area contributing storm runoff to a stream or drainage system. Other terms are drainage area, drainage basin and catchment area.

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APPENDIX D
EXAMPLES

1. Sizing drainage basin using Rational Method:

SIZING DRAINAGE BASIN USING RATIONAL METHOD

GIVEN: A 10-acre site, currently agricultural use, is to be developed for townhouses. The entire area is the drainage area of the proposed detention basin.

DETERMINE: Maximum release rate and required detention storage.

SOLUTION:

1. Determine 100-year peak run-off rate prior to site development. This is the maximum release rate from site after development.

2. Determine inflow hydrograph for storms of various durations in order to determine maximum volume required with release rate determined in Step 1. NOTE: Incrementally increase durations by 10- minutes to determine maximum required volume. The duration with a peak inflow less than maximum release rate or where required storage is less than storage for the prior duration is the last increment.

STEP 1. Calculate Peak Discharge for Present Conditions

Q = KCIA
K = 1.25
C = 0.30
T_c = 20 minutes
il00 = 7.0 in./hr
Q100 = 1.25 * 0.30 * (7.0) * 10 = 26.25 cfs (Maximum release rate)

STEP 2. Future Conditions (Townhouses)

K = 1.25
C = 0.80
T_c = 15 minutes
il00 = 7.7 in./hr.
Q100 = 1.25 * 0.80 * ( ) * 10 = cfs

Check various duration storms:

15 minutes	i =	Q = 1.25 * 0.80 * ( ) * 10 = cfs
20 minutes	i =	Q = 1.25 * 0.80 * ( ) * 10 = cfs
30 minutes	i =	Q = 1.25 * 0.80 * ( ) * 10 = cfs
40 minutes	i =	Q = 1.25 * 0.80 * ( ) * 10 = cfs
50 minutes	i =	Q = 1.25 * 0.80 * ( ) * 10 = cfs

60 minutes	i =	Q = 1.25 * 0.80 * ( ) * 10 = cfs
70 minutes	i =	Q = 1.25 * 0.80 * ( ) * 10 = cfs
80 minutes	i =	Q = 1.25 * 0.80 * ( ) * 10 = cfs
90 minutes	i =	Q = 1.25 * 0.80 * ( ) * 10 = cfs

Maximum Storage Volume is determined by deducting the volume of runoff released during the time of inflow from the total inflow for each storm duration.

Inflow = T_c * Q * 60 sec/min
Outflow = 0.5 * (T_i + T_o) * Q_0 * 60 sec/min
Storage = Inflow - Outflow
where: Tc = Time of concentration, (min) for that duration
Q = Flow for that T_o, (cfs)
T_i = Time of concentration of the basin
Q_0 = Original flow, pre-development conditions

15 min. Storm	Inflow 15 * (61.6) * 60 sec/min	=	55,440 cf
	Outflow (0.5) * (15+15) * (21.0) * 60 sec/min	=	<u>18,900 cf</u>
	Storage	=	36,540 cf
20 min. Storm	Inflow 20 * (56.0) * 60 sec/min	=	67,200 cf
	Outflow (0.5) * (15+20) * (21.0) * 60 sec/min	=	<u>22,050 cf</u>
	Storage	=	45,150 cf
30 min. Storm	Inflow 30 * (46.4) * 60 sec/min	=	83,520 cf
	Outflow (0.5) * (15+30) * (21.0) * 60 see/rain	=	<u>28,350 cf</u>
	Storage	=	55,170 cf
40 min. Storm	Inflow 40 * (40.0) * 60 sec/min	=	96,000 cf
	Outflow (0.5) * (15+40) * (21.0) * 60 sec/min	=	<u>34,650 cf</u>
	Storage	=	61,350 cf
50 min. Storm	Inflow 50 * (35.2) * 60 sec/min	=	105,600 cf
	Outflow (0.5) * (15+50) * (21.0) * 60 sec/min	=	<u>40,950 cf</u>
	Storage	=	64,650 cf
60 min. Storm	Inflow 60 * (32.0) * 60 sec/min	=	115,200 cf
	Outflow (0.5) * (15+60) * (21.0) * 60 sec/min	=	<u>47,250 cf</u>
	Storage	=	67,950 cf
70 min. Storm	Inflow 70 * (29.6) * 60 sec/min	=	124,320 cf
	Outflow (0.5) * (15+60) * (21.0) * 60 see/rain	=	<u>53,550 cf</u>
	Storage	=	70,770 cf

80 min. Storm	Inflow 80 * (27.2) * 60 sec/min	=	130,560 cf
	Outflow (0.5) * (15+80) * (21.0) * 60 see/rain	=	59,850 cf
	Storage	=	70,710 cf
90 min. Storm	Inflow 90 * (24.8) * 60 sec/min	=	133,920 cf
	Outflow (0.5) * (15+90) * (21.0) * 60 sec/min	=	66,150 cf
	Storage	=	67,770 cf

Maximum volume required is 70,770 cfs at the 70 min. storm duration.

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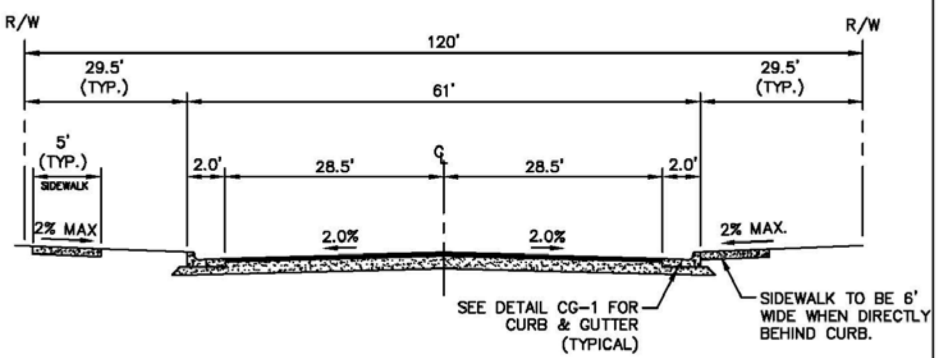
APPENDIX E
FIGURES

E.1 Arterial Street



*MINIMUM PAVEMENT DESIGN
3.5" SURFACE COURSE
12" BASE MATERIAL
6" LIME STABALIZED SUBGRADE

* REFER TO NOTE TWO.

120' RIGHT OF WAY
60' ROADWAY SECTION

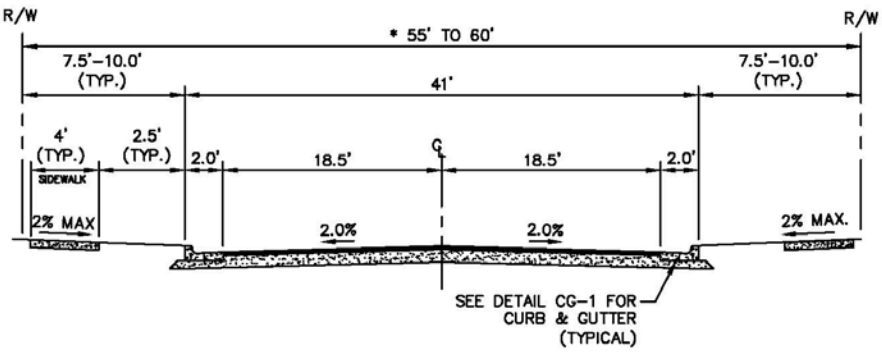
SECTION VIEW

NOTES:

1. NORMAL CROWN OF 0.02 FEET PER FOOT UNLESS OTHERWISE DIRECTED BY THE ENGINEER.
2. ALL PAVEMENT MUST BE DESIGNED BY A GEOTECHNICAL ENGINEER ACCORDING TO SPECIFIC SITE CONDITIONS. THE TOP 6"–8" OF SUBGRADE SOILS WITH PI'S GREATER THAN 20, MUST BE LIME STABILIZED TO REDUCE PI TO 20 OR LESS.

CITY OF GONZALES	ARTERIAL STREET DETAIL

E.2 Collector Street



* SEE NOTE 3 BELOW

***MINIMUM PAVEMENT DESIGN**
2.5" SURFACE COURSE
10" BASE MATERIAL
6" LIME STABALIZED SUBGRADE

* REFER TO NOTE TWO.

60' RIGHT OF WAY
40' ROADWAY SECTION

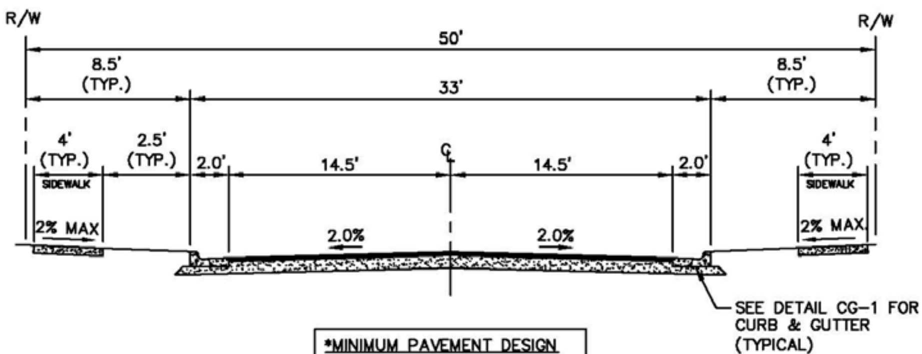
SECTION VIEW

NOTES:

1. NORMAL CROWN OF 0.02 FEET PER FOOT UNLESS OTHERWISE DIRECTED BY THE ENGINEER.
2. ALL PAVEMENT MUST BE DESIGNED BY A GEOTECHNICAL ENGINEER ACCORDING TO SPECIFIC SITE CONDITIONS. THE TOP 6"–8" OF SUBGRADE SOILS WITH PI'S GREATER THAN 20, MUST BE LIME STABILIZED TO REDUCE PI TO 20 OR LESS.
3. EXISTING RIGHTS OF WAY 55 FEET IN WIDTH OR GREATER MAY BE USED FOR COLLECTOR STREETS. NEW RIGHTS OF WAY DEDICATED FOR COLLECTOR STREETS MUST BE A MINIMUM OF 60 FEET.

CITY OF GONZALES	**COLLECTOR STREET DETAIL**

E.3 Local Street



***MINIMUM PAVEMENT DESIGN**
2.5" SURFACE COURSE
8" BASE MATERIAL
6" LIME STABALIZED SUBGRADE

* REFER TO NOTE TWO.

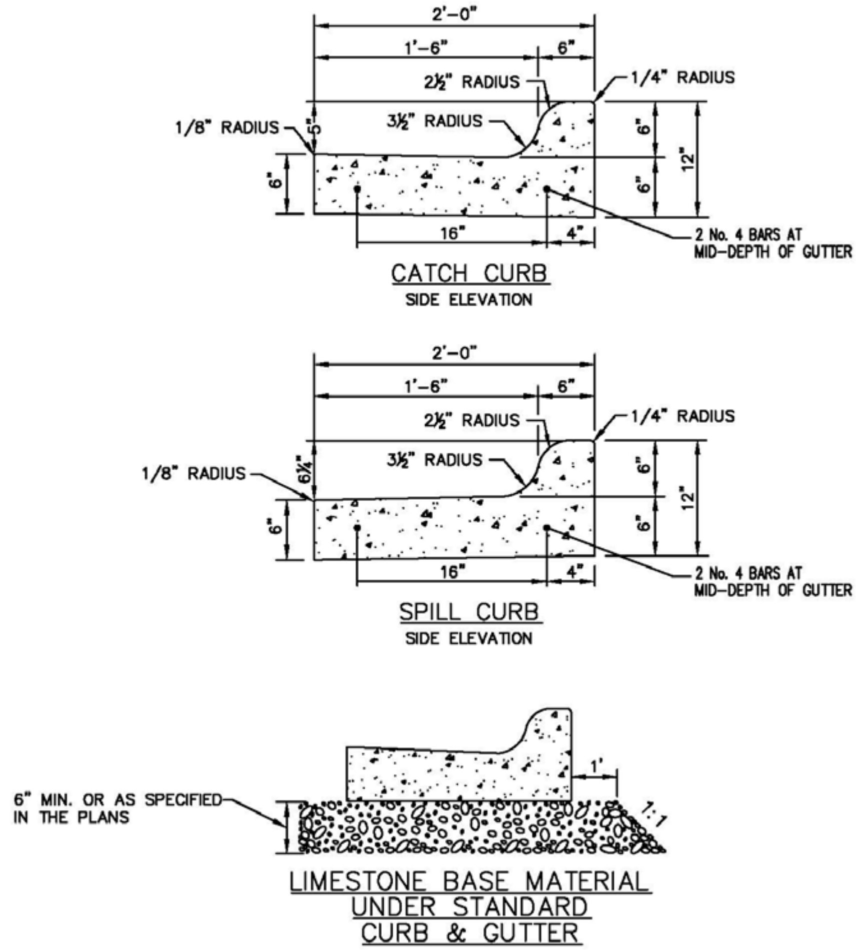
50' RIGHT OF WAY
32' ROADWAY SECTION
SECTION VIEW

NOTES:

1. NORMAL CROWN OF 0.02 FEET PER FOOT UNLESS OTHERWISE DIRECTED BY THE ENGINEER.
2. ALL PAVEMENT MUST BE DESIGNED BY A GEOTECHNICAL ENGINEER ACCORDING TO SPECIFIC SITE CONDITIONS. THE TOP 6"-8" OF SUBGRADE SOILS WITH PI'S GREATER THAN 20, MUST BE LIME STABILIZED TO REDUCE PI TO 20 OR LESS.

CITY OF GONZALES	LOCAL STREET

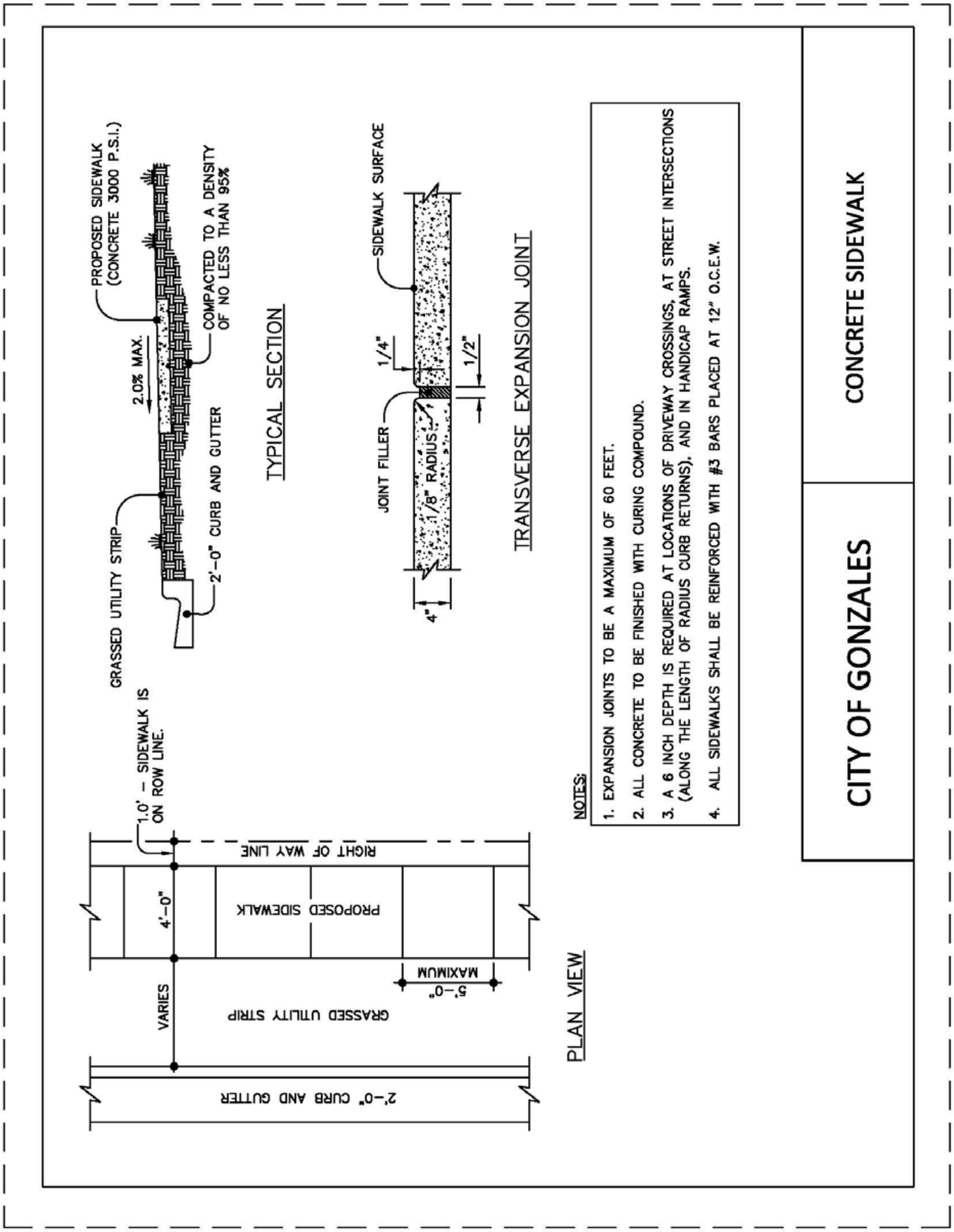
E.4 Curb and Gutter



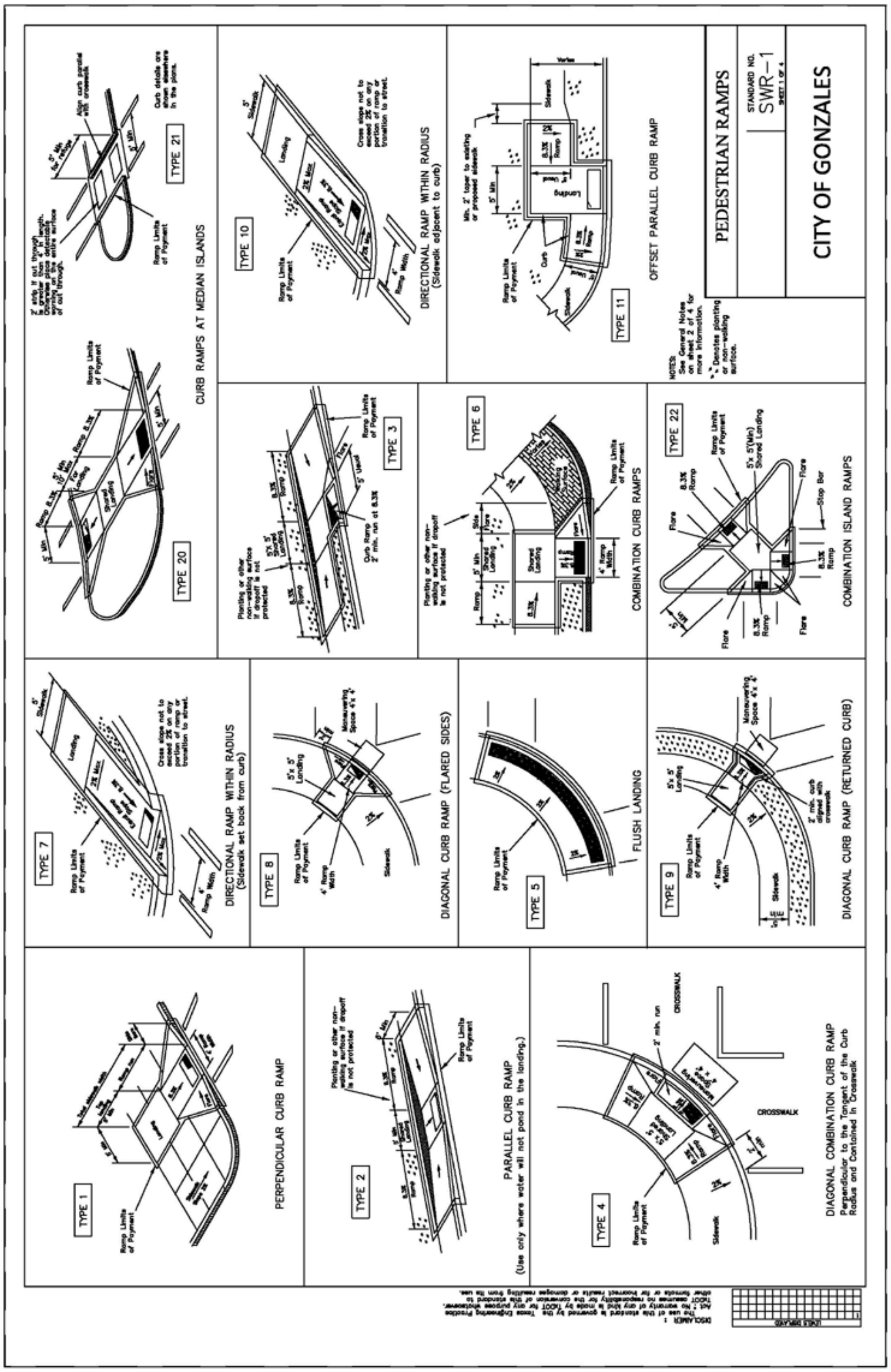
NOTES:
1. CONCRETE SHALL BE 3,000 P.S.I.
2. CONTROL JOINTS SHALL BE SPACED AT 10' INTERVALS.
3. EXPANSION JOINTS SHALL BE SPACED AT 100' MAX. INTERVALS.
4. FINISH ALL CONCRETE WITH CURING COMPOUND.

CITY OF GONZALES	CURB AND GUTTER DETAIL

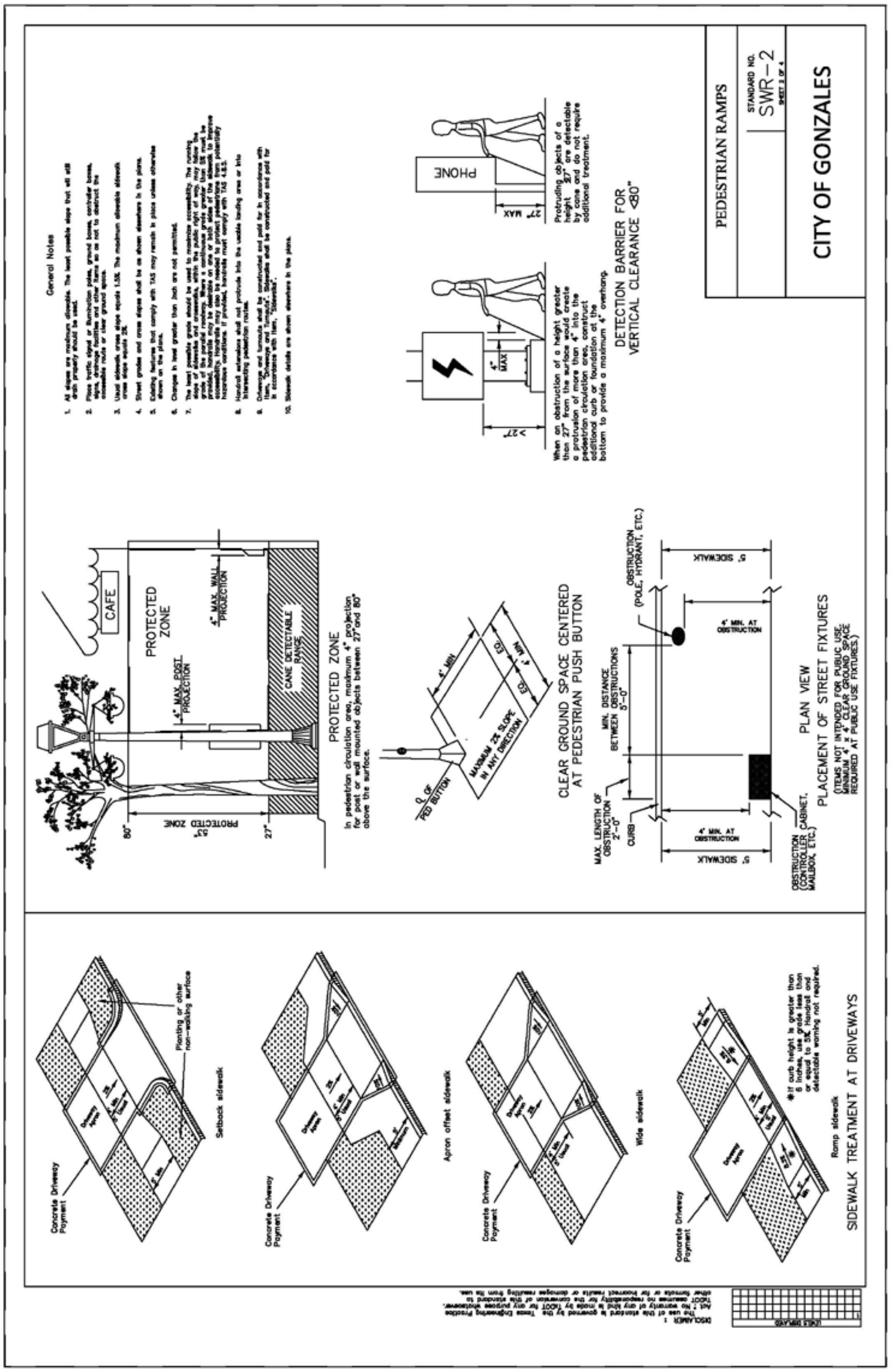
E.5 Sidewalk


PROPOSED SIDEWALK (CONCRETE 3000 P.S.I.)
2.0% MAX.
COMPACTED TO A DENSITY OF NO LESS THAN 95%
GRASSED UTILITY STRIP
2'-0" CURB AND GUTTER
TYPICAL SECTION
SIDEWALK SURFACE
JOINT FILLER
1/4"
1/2"
1/8" RADIUS
4"
TRANSVERSE EXPANSION JOINT
1.0' - SIDEWALK IS ON ROW LINE.
RIGHT OF WAY LINE
PROPOSED SIDEWALK
4'-0"
VARIES
5'-0" MAXIMUM
GRASSED UTILITY STRIP
2'-0" CURB AND GUTTER
PLAN VIEW
NOTES:
1. EXPANSION JOINTS TO BE A MAXIMUM OF 60 FEET.
2. ALL CONCRETE TO BE FINISHED WITH CURING COMPOUND.
3. A 6 INCH DEPTH IS REQUIRED AT LOCATIONS OF DRIVEWAY CROSSINGS, AT STREET INTERSECTIONS (ALONG THE LENGTH OF RADIUS CURB RETURNS), AND IN HANDICAP RAMPS.
4. ALL SIDEWALKS SHALL BE REINFORCED WITH #3 BARS PLACED AT 12" O.C.E.W.
CITY OF GONZALES
CONCRETE SIDEWALK

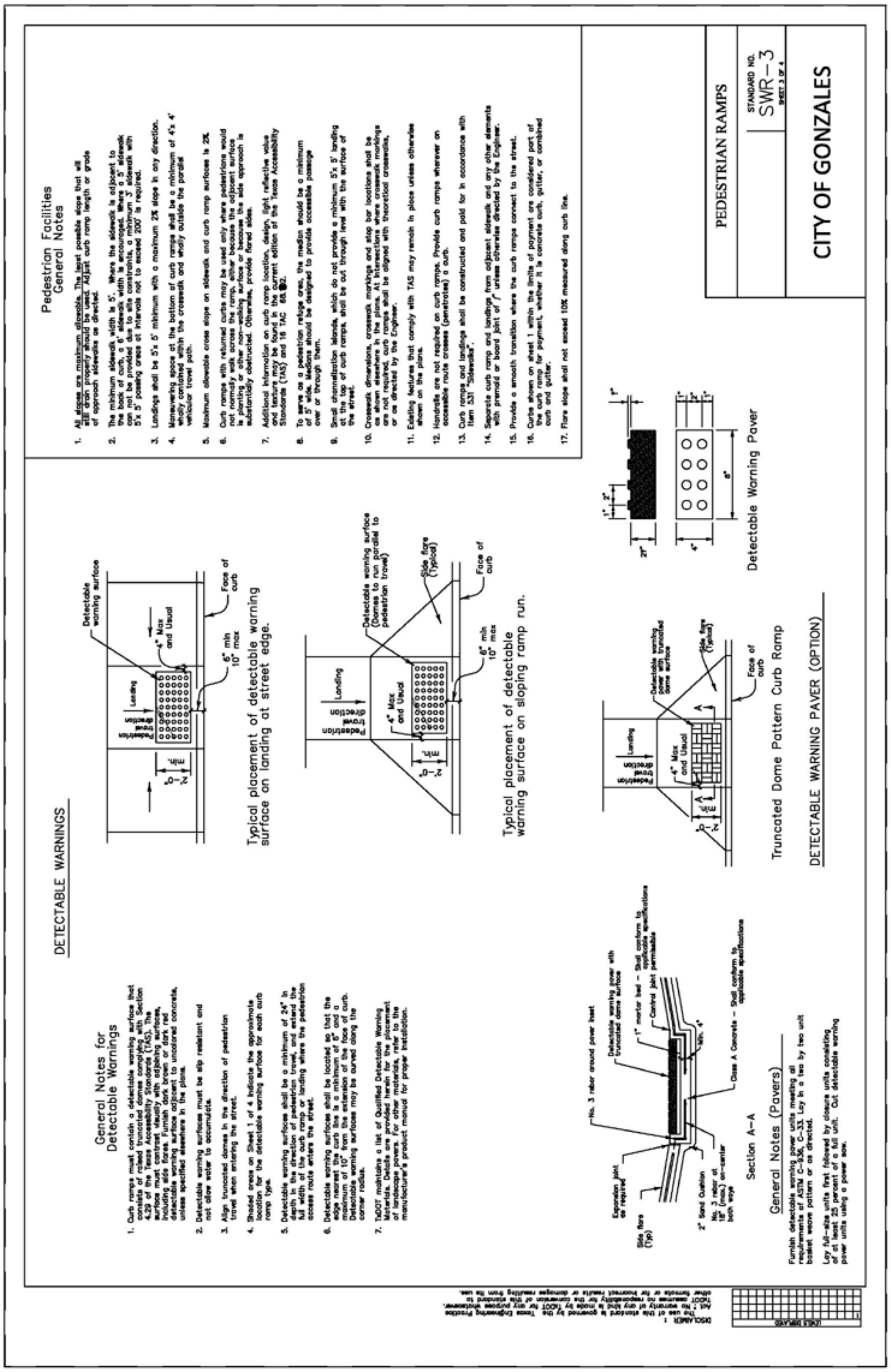
E.6 Ramp Details-1



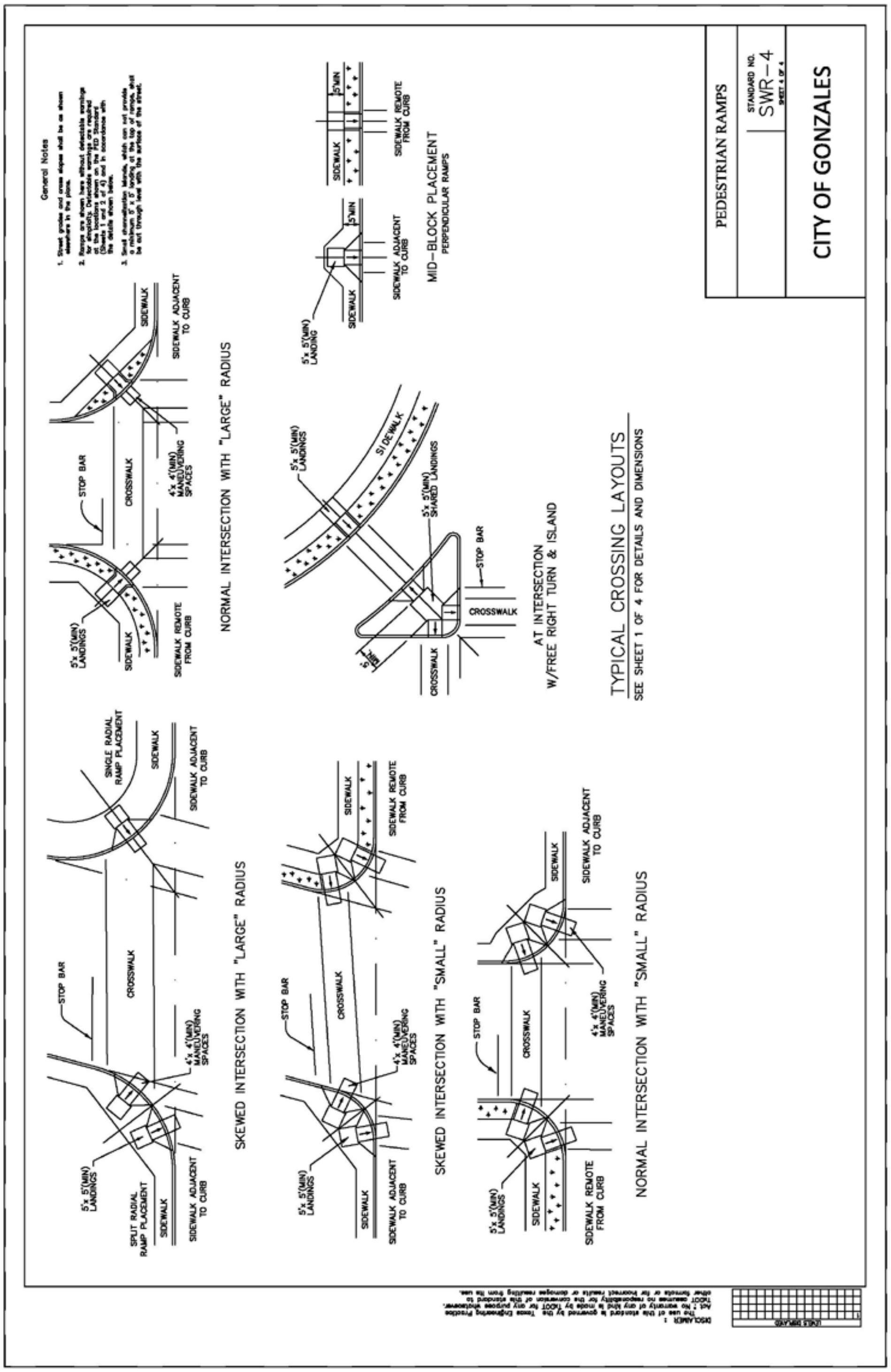
E.7 Ramp Details-2



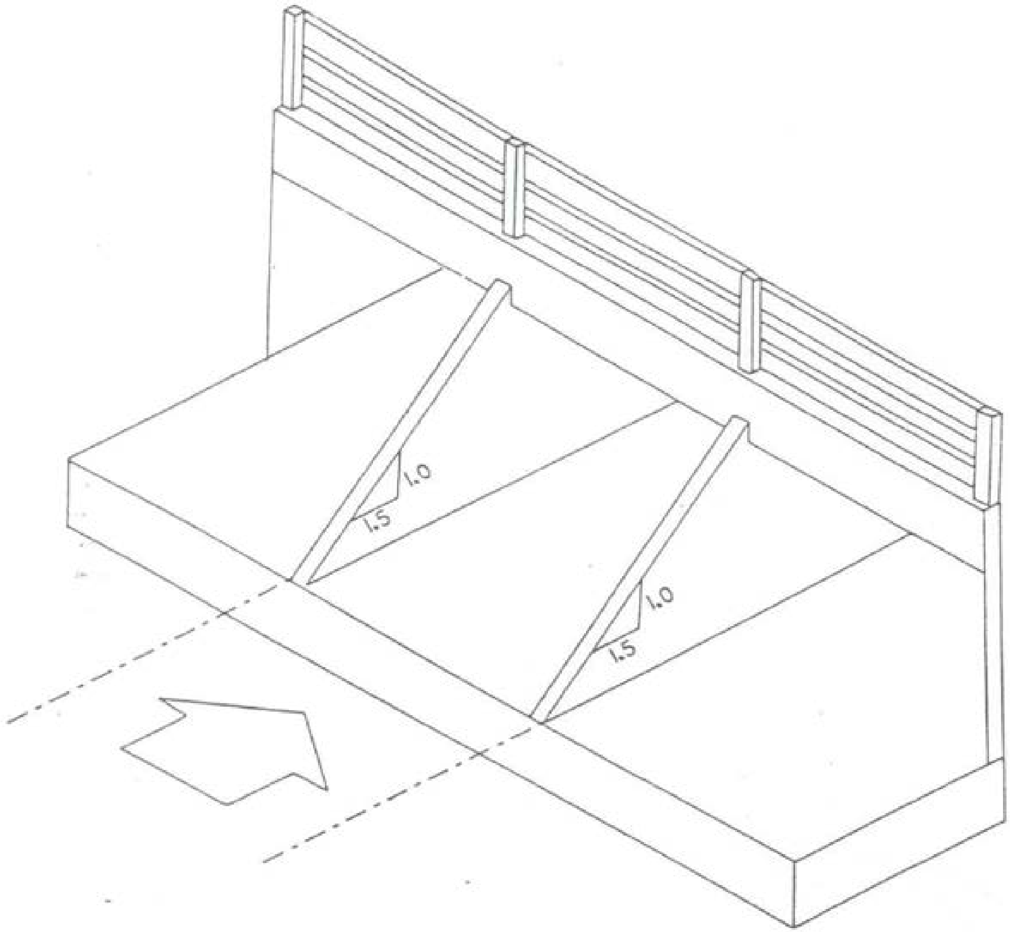
E.8 Ramp Details-3



E.9 Ramp Details-4

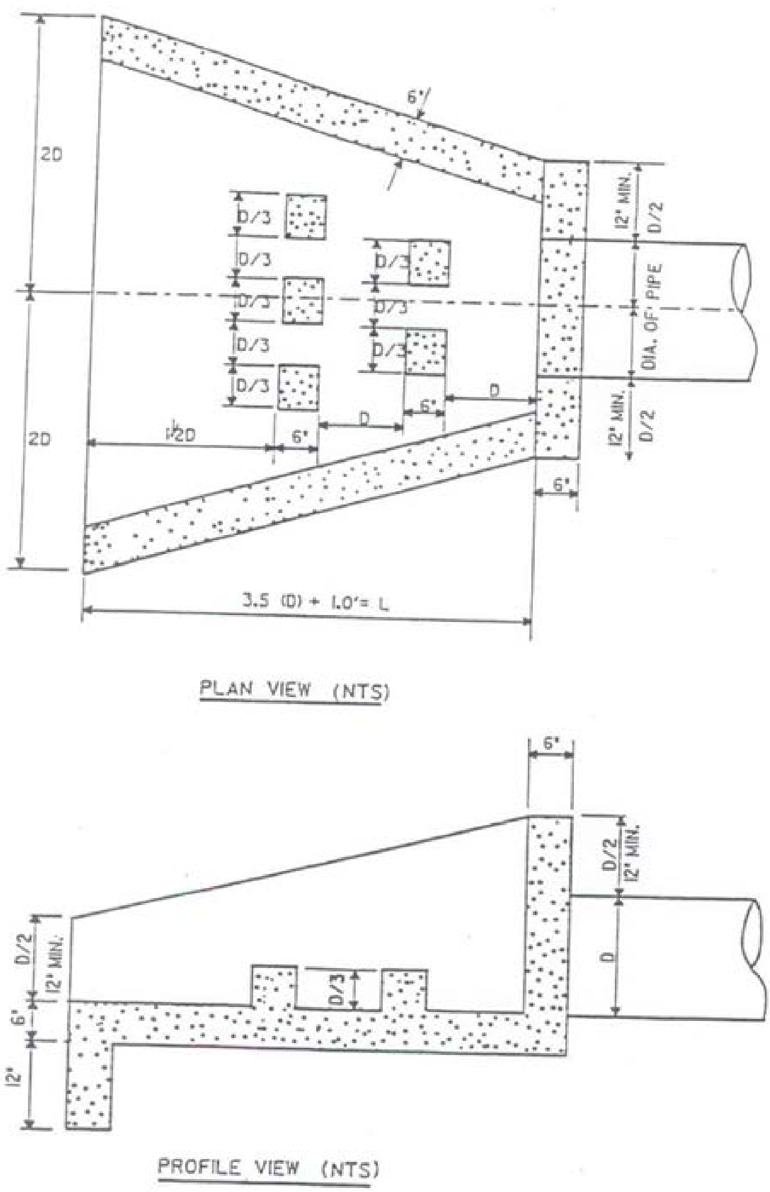


E.10 Conceptual Design of Debris Pins



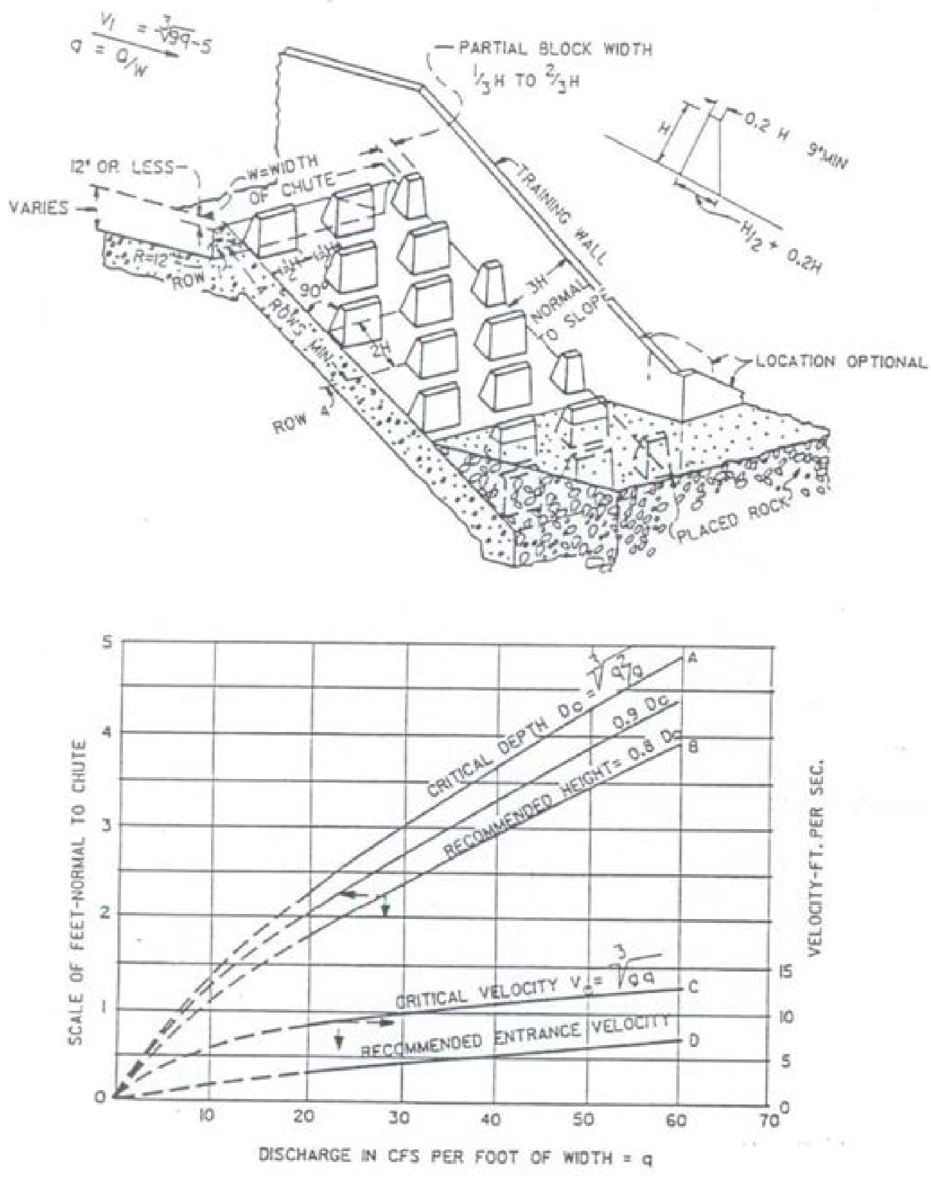
CONCEPTUAL DESIGN OF DEBRIS FINS

E.11 Baffled Outlet



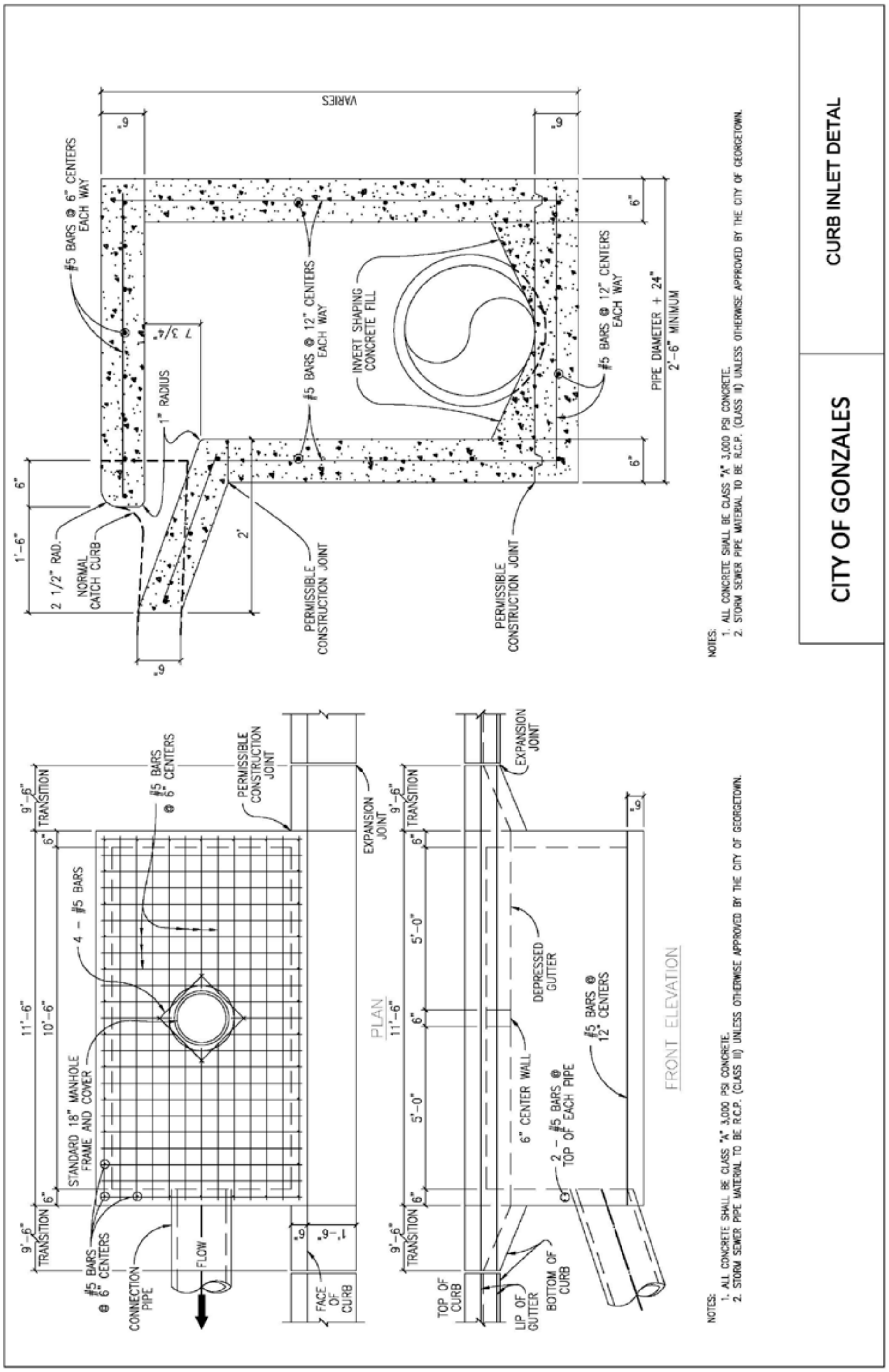
BAFFLED OUTLET

E.12 Baffled Apron and Its Design Curve

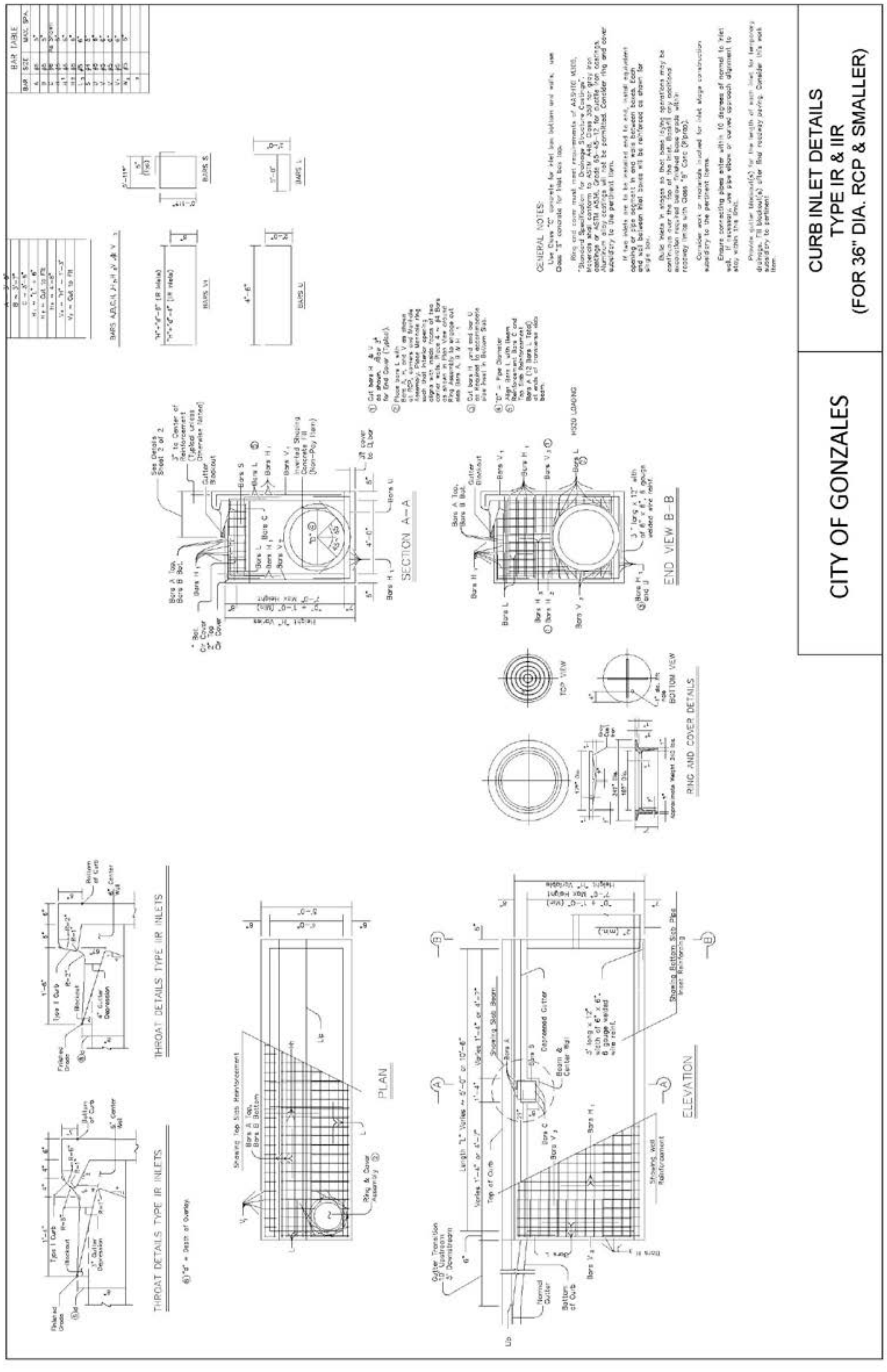


BAFFLED APRON AND ITS DESIGN CURVE

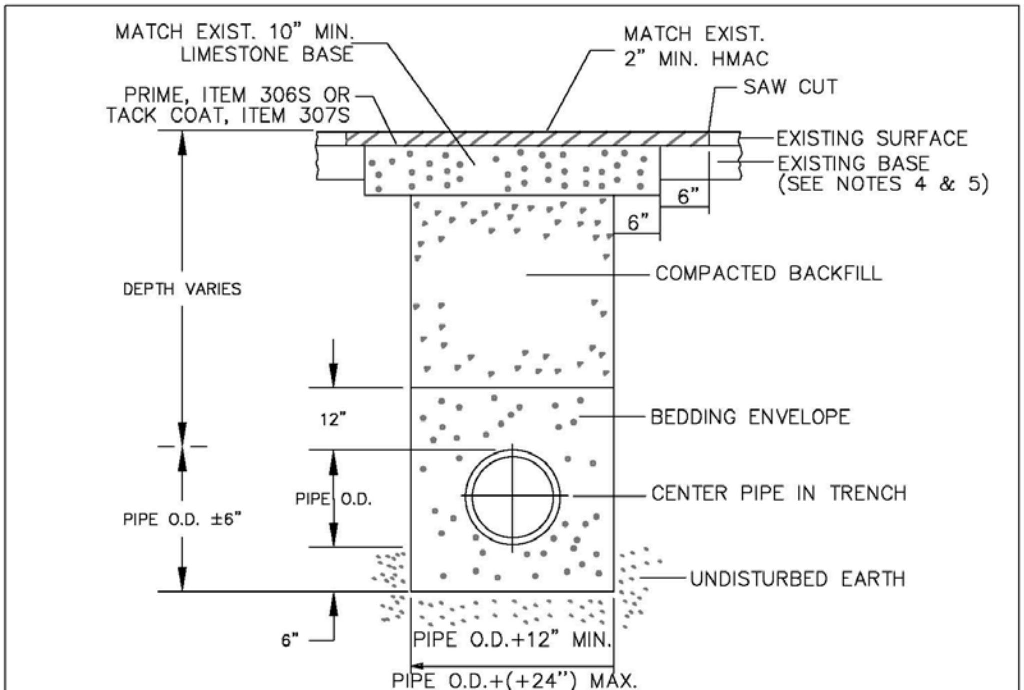
E.13 Curb Inlet-1



E.14 Curb Inlet-2



E.15 Typical Trench with Paved Surface

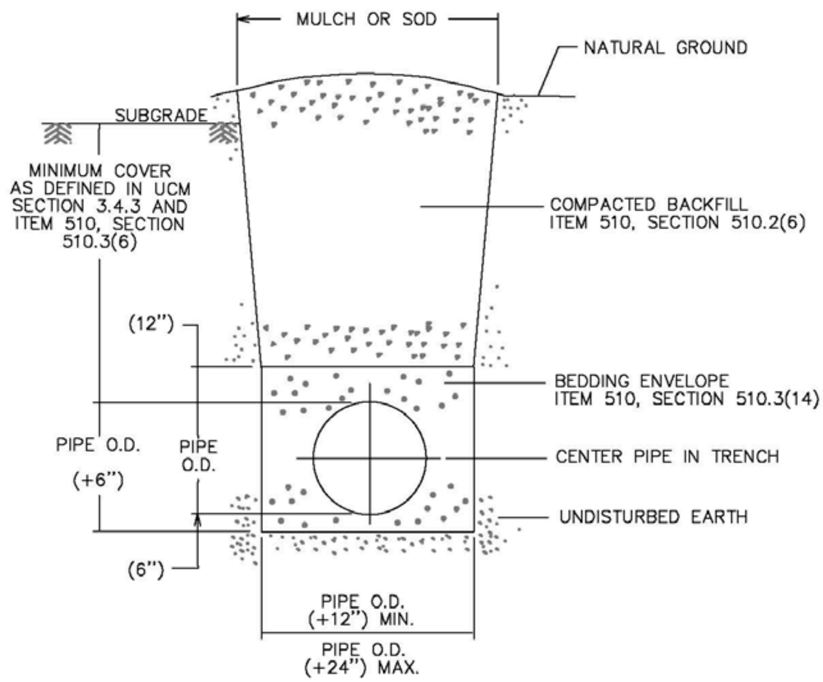


NOTES:

1. THE EXISTING PAVING SURFACE SHALL BE SAW CUT IN A STRAIGHT LINE A MINIMUM OF (12") WIDER THAN THE UNDISTURBED SIDES OF THE TRENCH, SYMETRICAL ABOUT THE CENTER LINE OF THE EXCAVATION.
2. ANY CONCRETE PAVING SHALL BE SAW CUT (6")WIDER THAN UNDISTURBED SIDES OF EXCAVATION.
3. IF EXCAVATION AREA IS OPEN FOR TEMPORARY PUBLIC USE, THE SURFACE SHALL BE MAINTAINED LEVEL WITH ADJACENT RIDING SURFACE WITH COLD MIX OR TEMPORARY HOT MIX ASPHALTIC CONCRETE.
4. ROAD BASE AND SURFACE MATERIALS IN THE TRENCH CUT SHALL BE REPLACED IN KIND OF EQUAL THICKNESS, OR MINIMUM BASE THICKNESS OF (10"), WHICHEVER IS GREATER.
5. ALL DAMAGED AREAS OF PAVEMENT OUTSIDE THE TRENCH CUT SHALL BE REMOVED AND REPLACED WITH MINIMUM OF (8") OF BASE OR MATCH EXISTING THICKNESS, WHICHEVER IS GREATER.
6. SURFACE PAVEMENT SHALL BE OF THE KIND AND THICKNESS AS EXISTING, OR MINIMUM (2"), WHICHEVER IS GREATER.
7. COMPACTED BACKFILL TO BE SANDY MATERIAL APPROVED BY CITY, OR EXISTING MATERIAL COMPACTED TO 95% BASED ON ASTM D698, AT MOISTURE CONTENT OF +/− 2% OF OPTIMUM.
8. BEDDING ENVELOPE SHALL CONSIST OF A SANDY MATERIAL APPROVED FOR USE BY THE CITY OF GONZALES.

CITY OF GONZALES	TYPICAL TRENCH WITH PAVED SURFACE

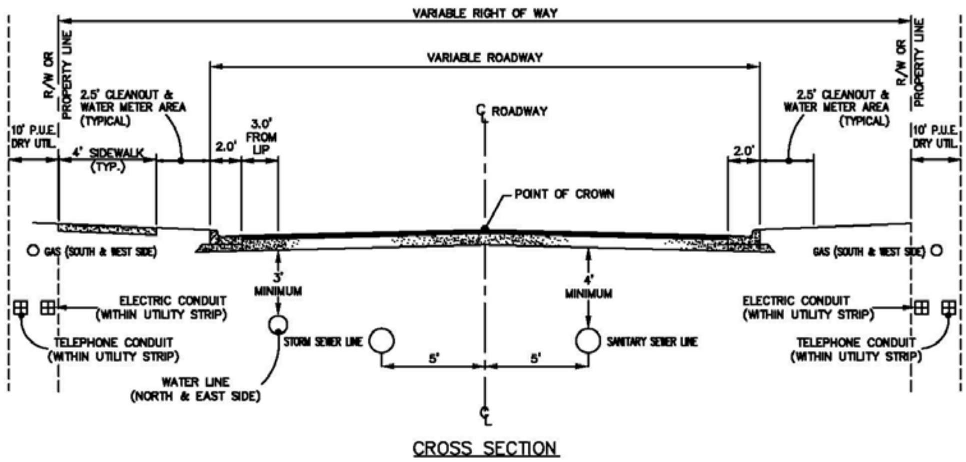
E.16 Typical Trench Unpaved Surface



1. **COMPACTED BACKFILL TO BE SANDY MATERIAL APPROVED BY CITY, OR EXISTING MATERIAL COMPACTED TO 95% BASED ON ASTM D698, AT MOISTURE CONTENT OF +/- 2% OF OPTIMUM.**
2. BEDDING ENVELOPE SHALL CONSIST OF A SANDY MATERIAL APPROVED FOR USE BY THE CITY OF GONZALES.

CITY OF GONZALES	TYPICAL TRENCH WITH UNPAVED SURFACE

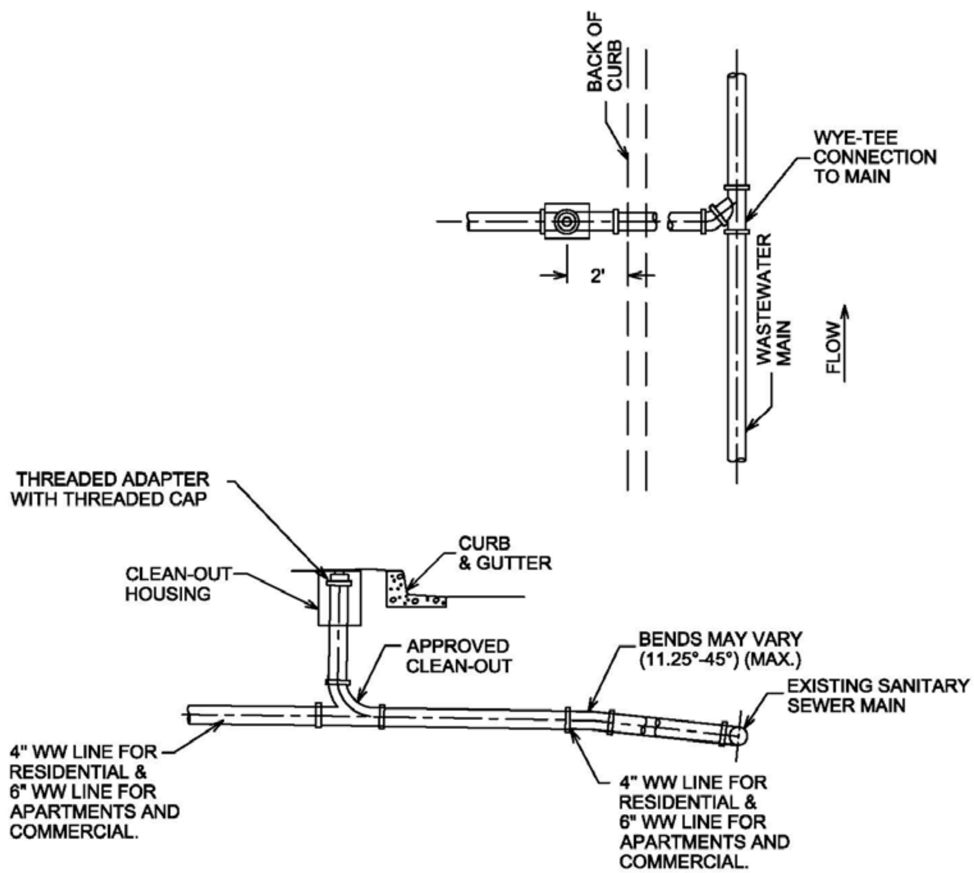
E.17 Utility Locations



CITY OF GONZALES

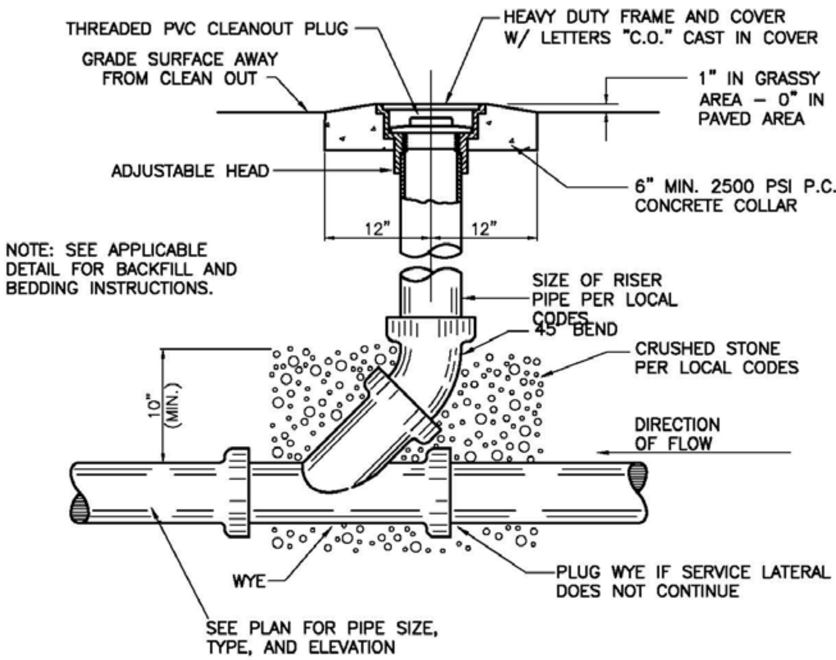
UTILITY LOCATIONS IN STREET

E.18 WW Service Connector



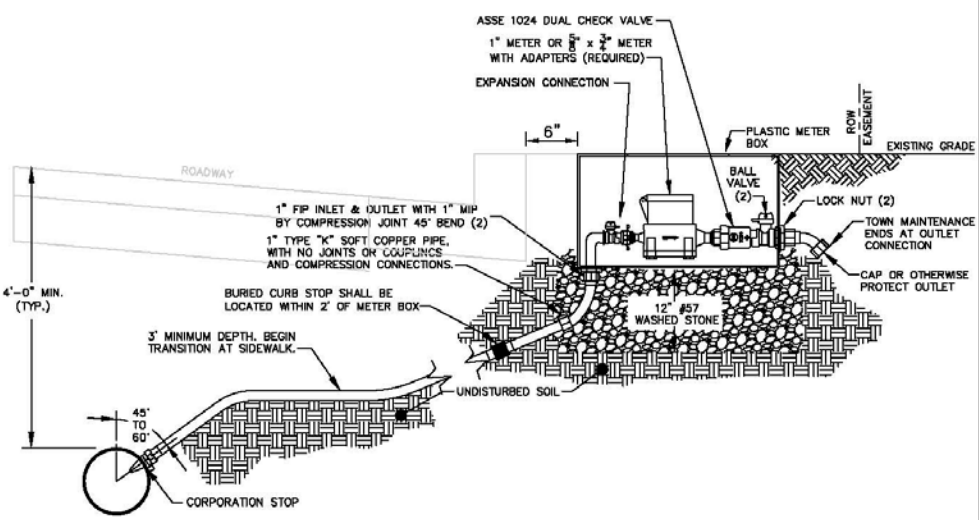
CITY OF GONZALES	WASTEWATER SERVICE CONNECTION

E.19 Single Cleanout



CITY OF GONZALES	SINGLE CLEANOUT

E.20 Water Meter

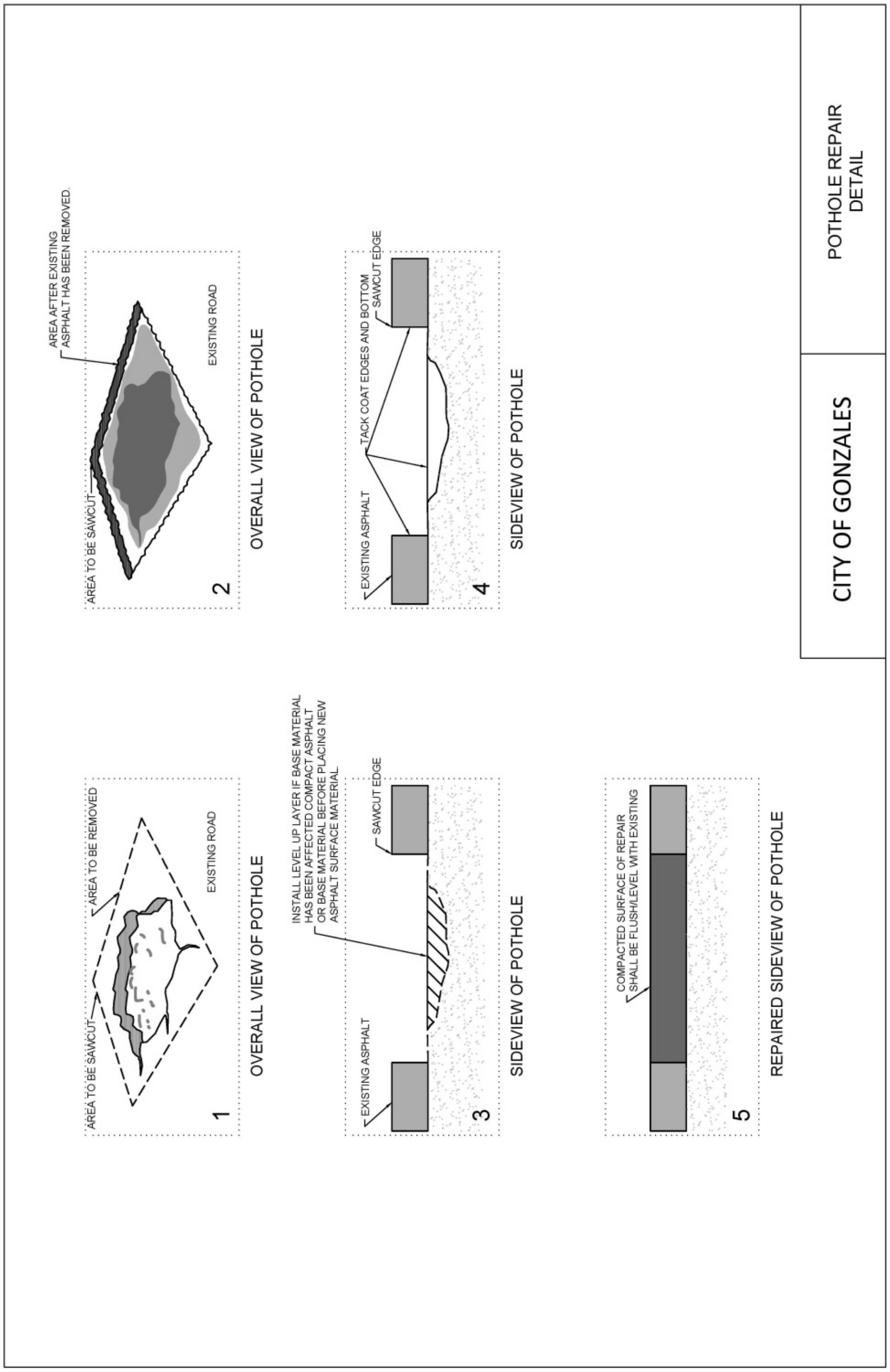


NOTES:

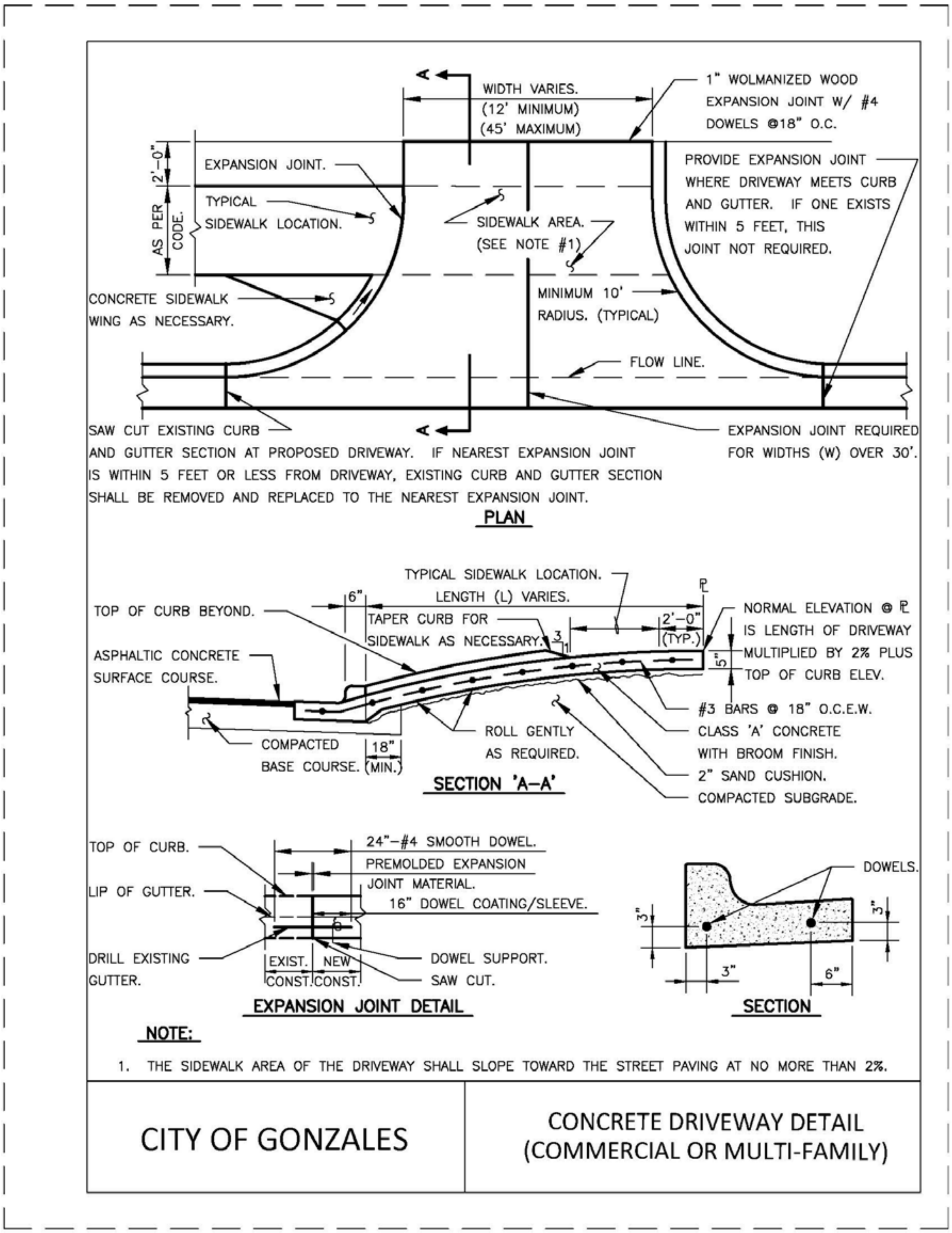
1) WATER METER SHALL NOT BE LOCATED IN AREAS SUBJECT TO VEHICULAR TRAFFIC.
2) ALL METER BOXES AND LIDS SHALL BE APPROVED BY THE CITY.
3) ALL SERVICE LINES, VALVES AND FITTINGS SHALL COMPLY WITH AWWA C800.
4) FOR NON-RESIDENTIAL APPLICATIONS THAT REQUIRE AN ABOVE-GROUND BACKFLOW PREVENTER, THE DUAL CHECK ASSEMBLY MAY BE OMITTED.
5) BOX AND LID SHALL BE NDS D1000 PLASTIC METER BOX AND LID OR EQUIVALENT.
6) ALL BRASS OF 85-5-5-5 RED BRASS, AWWA C800, ASTM B62.
7) ONE 2" OR 6" GRADE ADJUSTER MAY BE UTILIZED WHEN NEEDED TO MEET FINAL GRADE (NO GRADE ADJUSTERS MAY BE USED ON NEW CONSTRUCTION PROJECTS). GRADE ADJUSTER AND BOX SHALL BE BY THE SAME MANUFACTURER.

CITY OF GONZALES	WATER SERVICE & METER BOX INSTALLATION

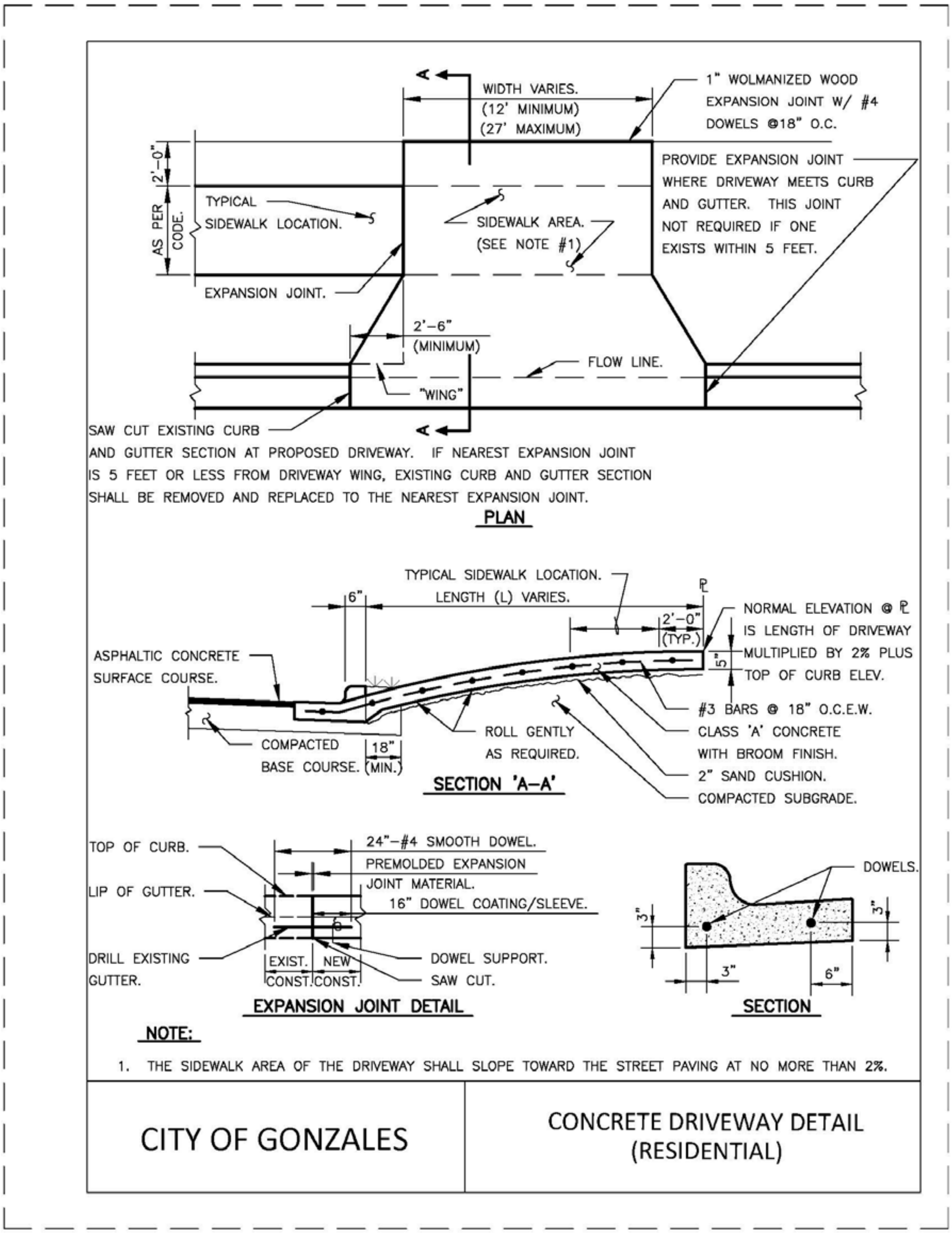
E.21 Pothole Detail



E.22 Concrete Driveway - Commercial



E.23 Concrete Driveway - Residential



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