City of Tomball

Minimum Standards for Stormwater

Drainage Design

Effective

September 6, 2011

City of Tomball

Engineering and Planning Department

I. DRAINAGE POLICY

A. Design Requirements

1. Drainage criteria administered by the City of Tomball and complemented by Harris County and the Harris County Flood Control District (HCFCD) for newly designed areas provides protection from structural flooding from a 100-year storm event. This is accomplished through application of various drainage enhancements, such as storm sewers, roadside ditches, open channels, detention and overland (sheet) run-off. The combined system is intended to prevent structural flooding from extreme events up to a 100-year storm.

2. Recognizing that each site has unique characteristics that may enhance the opportunity to provide proper drainage, the intent of these criteria is to specify minimum requirements that may be modified provided that the objective for drainage standards is maintained. For projects which require a site specific approach and where unique engineering solutions will achieve drainage objectives, a request for consideration of alternative standards (pipe flow, overland sheet flow, and detention storage) shall be submitted to the City of Tomball Engineering and Planning Department, 501 James Street, for review and approval.

B. Street Drainage: Street ponding of short duration is anticipated and designed to contribute to the overall drainage capability of the system. Storm sewers and roadside ditch conduits are designed as a balance of capacity and economics. These conduits are designed to convey less intense, more frequent rainfalls with the intent of allowing for traffic movement during these events. When rainfall events exceed the capacity of the storm sewer system, the additional run-off is intended to be stored or conveyed overland in a manner that reduces the threat of flooding to structures.

C. Overland Run-off: Proposed new development, redevelopment, or in-fill development shall not alter existing overland flow patterns and shall not increase or redirect existing sheet flow to adjacent private or public property. Where the existing sheet flow pattern is blocked by construction (i.e. raising the site elevation) of the development, the sheet flow shall be re-routed within the developed property to return flow to original configuration or to the public right-of-way.

D. Flood Control: The City of Tomball is a participant in the National Flood Insurance Program (NFIP). The flood insurance program makes insurance available at low cost where the community implements measures that reduce the likelihood of structural flooding. The design criteria in this chapter are provided to support the NFIP. All development shall comply with this chapter, if located within the City limits.

E. Relationship to the Platting Process: Approval of storm drainage systems, detention facilities, and flood channel improvements is a part of the review process for planning and platting of new development. Review and approval of plats, as well as storm drainage, is conducted by the Engineering and Planning Department.

F. Development in Areas that have Deficient Drainage Systems: The City will consider joint project funding with a private entity for construction of drainage systems that improve existing drainage infrastructure or construct new infrastructure. The City's first priority will be to fund those projects included in the Capital Improvement Plan (CIP). Where feasible, City funding will be leveraged with other funding sources including private entities, civic organizations, and other public agencies (Harris County, HCFCD, Corps of Engineers) and other funding sources). For drainage systems that have been identified as deficient and are not scheduled to receive funding in the current CIP, the City will consider authorizing improvements performed by the private entity that comply with the City's objectives.

G. The criteria in this document shall apply to all projects located in the City limits and in the City's Extraterritorial Jurisdiction (ETJ). If the criteria conflicts with Harris County, HCFCD, Montgomery County or other jurisdictions the most restrictive criteria shall govern.

II. REFERENCES

A. Regulations of Harris County, Texas, for the Approval and Acceptance of Infrastructure (Harris County Infrastructure Regulations).

B. National Weather Service Documents

1. TP-40 Rainfall Frequency Atlas of the United States.

2. Hydro-35; 5-to-60-Minute Precipitation Duration for the Eastern and Central United States.

C. Hydraulic Engineering Circular No. 22, (HEC-22) Second Edition, "Urban Drainage Design Manual", Federal Highway Administration (FHWA).

D. ASCE Manual and Reports of Engineering Practice No. 77, Design and Construction of Urban Stormwater Management Systems.

E. HouStorm – The City of Houston's version of The Texas Department of Transportation's (TxDOT) WinStorm software.

F. HCFCD Policy, Criteria, and Procedure Manual (HCFCD Criteria Manual).

III. DEFINITIONS

A. Conduit – Any open or closed device for conveying flowing water.

B. Continuity Equation:

$$Q = VA$$

Where: Q = discharge (cfs or cms)

V = velocity (ft/sec or m/sec)
A = cross sectional area of Conduit (square feet or square meters)

C. Design Storm Event – Rainfall intensity upon which the drainage facility will be sized.

D. Development – The term includes New Development, Redevelopment, and In-fill Development.

1. In-fill Development – Development of open tracts of land in areas where the storm drainage infrastructure is already in place and takes advantage of the existing infrastructure as a drainage outlet.

2. New Development – Development of open tracts of land in areas where the storm drainage infrastructure has not been constructed and a drainage outlet must be extended to a channel under the jurisdiction of the HCFCD.

3. Redevelopment – A change in land use that alters the impervious cover from one type of development to either the same type or another type, and takes advantage of the existing infrastructure in place as a drainage outlet.

E. Drainage Area Map – Area map of watershed which is subdivided to show each area served by each subsystem.

F. FEMA – Federal Emergency Management Agency.

G. HCFCD – Harris County Flood Control District.

H. HouStorm – The City of Houston's version of The Texas Department of Transportation's (TxDOT) WinStorm software. The program is available at City of Houston eGovernment Center.

I. Hydraulic Grade Line - A line representing the pressure head (water surface elevation) available at any given point within the drainage system.

J. Manning's Equation:

$V = (K/n)R^{2/3} S_f^{1/2}$

Where:
V = velocity (ft/sec or m/sec)
K = 1.49 for English units, 1.00 for metric units
R = hydraulic radius (ft. or m) (area/wetted perimeter)
S_f = friction slope (headloss/length)
n = 0.012 for corrugated profile-wall polyethylene pipe, 0.013 for concrete pipes, 0.015 for concrete boxes, 0.024 for corrugated metal pipes (CMP)

K. Rainfall Frequency - Probability of a rainfall event of defined characteristics occurring in any given year at a given location. Information on Rainfall Frequency is published by the National Weather Service. For the purpose of storm drainage design, the following frequencies are applicable:

1. 2-year frequency - a rainfall intensity having a 50 percent probability of occurrence in any given year that occurs on the average every 2 years over a long period of time.

2. 3-year frequency-a rainfall intensity having a 33 percent probability of occurrence in any given year. That occurs on the average every 3 years over a long period of time.

3. 5-year frequency - a rainfall intensity having a 20 percent probability of occurrence in any given year, that occurs on the average every 5 years over a long period of time.

4. 10-year frequency- a rainfall intensity having a 10 percent probability of occurrence in any given year, that occurs on the average every 10 years over a long period of time.

5. 25-year frequency - a rainfall intensity having a 4 percent probability of occurrence in any given year, that occurs on the average every 25 years over a long period of time.

6. 100-year frequency - a rainfall intensity having a 1 percent probability of occurrence in any given year, that occurs on the average every 100 years over a long period of time.

7. 500-year frequency - a rainfall intensity having a 0.2 percent probability of occurrence in any given year, that occurs on the average every 500 years over a long period of time.

L. Rational Method Formula - A method for calculating the peak run-off for a storm drain system using the following equation for run-off:

$$Q = I(CA)$$

Where:
- Q = flow (cfs)
- C = watershed coefficient
- A = area (acres)
- I = rainfall intensity (inches per hour)

M. Sheet Flow - Overland storm run-off that is not conveyed in a defined conduit and is typically in excess of the capacity of the existing conduit system.

N. Structural Flooding – The water surface elevation from the storm event exceeds the top of slab elevation of the building (for pier and beam construction the top of first floor elevation), resulting in water entering the structure.

IV. DESIGN REQUIREMENTS

A. Design of drainage facilities shall meet requirements of the City of Tomball Standard Specifications and Minimum Construction Standards for Community Improvements (Standard Construction Details). The Regulations of Harris County, Texas, for the Approval and Acceptance of Infrastructure and the Harris County Flood Control District Policy, Criteria and Procedure Manual are used to complement the City of Tomball standards. HouStorm shall be used to perform design analysis and design of storm drainage systems as follows:

1. City of Tomball CIP Projects - Required. In conjunction with design analysis using HouStorm designs shall comply with guidelines provided in Technical paper No. 100 (TP-100), Storm Sewer Design Applications for the City of Houston, Texas, Capital Improvement Plan Projects, February 2005, or the latest published date.

2. Private Projects within City Limits which include City funding participation- Required.

3. 100% Privately-funded Project located in City Limits or its ETJ - HouStorm preferred but alternative equivalent analysis procedures with the prior approval of the City Engineer will be accepted.

B. Determination of Run-off

1. Design Storm Events

a. Rainfall Duration:

i. For design purposes, the rainfall duration for drainage areas less than 200 acres will be no less than 3 hours in duration.
ii. For design purposes, the rainfall duration for drainage areas more than 200 acres will be no less than 6 hours in duration.

b. Intensity-Duration Curves, Figure 1, IDF Curves, depicts the intensity-duration curves to be used for storm sewer and roadside ditch design in the City or its ETJ. These curves were derived from the National Weather Service publications referenced in this Chapter.

2. Application of Run-Off Calculation Models

a. The Rational Method will be used for storm sewer designs for areas up to 600 acres.

b. Rainfall Run-Off Modeling will be applied to areas greater than 600 acres in size or any areas that are drained by an open channel provided the model considers the storage and ponding in streets. Models must be acceptable to FEMA if they are to support a submittal for a map change.

3. Coefficients for the Rational Method

a. Calculation of Run-Off Coefficient:

i. The Run-Off Coefficient C values in the Rational Method Formula will vary based on the land use. Land use types and C-values which can be used are as follows:

Land Use Type	Run-off Coefficient (C)
Residential Districts	
Lots more than 3/4 acre	0.35
Lots 1/4 - 3/4 acre	0.45
Lots less than 1/4 acre	0.55
Multi-Family areas	
Less than 20 Service Units/Acre	0.65
20 Service Units/Acre or Greater	0.80
Business Districts	0.80
Industrial Districts	
Light Areas	0.65
Heavy Areas	0.75
Railroad Yard Areas	0.30
Parks/Open Areas	0.18

ii. Alternatively, the Run-Off Coefficient C in the Rational Method Formula can be calculated from the equation:

$$C = 0.6Ia + 0.2$$

Where: C = watershed coefficient

Ia = impervious area/total area

iii. If the alternate form is to be submitted, the calculation of C shall be provided as part of the drainage calculations.

b. Determination of Time of Concentration:

Time of Concentration can be calculated from the following formula:

$$TC = 10A^{0.1761} + 15$$

Where: TC = time of concentration (minutes)
A = subarea (acres)

c. Sample Calculation Forms:

i. Figure 2, Storm Sewer Calculation Form, is a sample calculation form for storm sewer systems.
ii. Figure 3, Roadside Ditch Worksheet, is a sample calculation form for roadside ditch systems.

C. Design of Storm Sewers

1. Design Frequency

a. New Development: The design storm event for sizing storm sewers in newly developed areas will be a 2-year rainfall.

b. Redevelopment or In-fill Development: The existing storm drain (sewer, ditch) will be evaluated using a 2-year design storm, assuming no development takes place. The storm drain will then be evaluated for the 2-year design event with the development in place.

i. If the proposed redevelopment has a lower or equal impervious cover, no modifications to the existing storm drain are required.

ii. If the proposed development results in the hydraulic gradient of the existing storm drain below the gutter line, no improvements to the existing storm drain are required. Detention shall comply with Paragraph IV.G. Flow discharged to the storm drain shall be in compliance with Paragraph IV.G.5.c.

iii. If the analysis of the existing conditions finds that the existing storm drain is deficient (i.e., the hydraulic grade line is above the gutter line), the applicant should check with the City to see if a CIP project is proposed that will require a impact fee. If a CIP project is not proposed for the subject system, then on-site detention will be required in accordance with Paragraph IV.G. Flow discharged to the storm drain shall be in compliance with Paragraph IV.G.5.c.

c. City Projects (CIP): Proposed City capital improvements may indicate a larger diameter storm sewer is planned in the area proposed for drainage improvements. The Engineering and Planning Department has information on proposed improvements and should be consulted for impact on new development.

d. Private Drainage Systems: Storm sewers for private drainage systems should conform to the City of Tomball International Building Code for development within the City limits.

e. The City Engineer may require a design storm event frequency less than 2-year if special conditions warrant.

2. Velocity Considerations

a. Storm sewers should be constructed to flow in subcritical hydraulic conditions if possible.

b. Minimum velocities should not be less than 3 feet (3') per second with pipe flowing full, under the design conditions.

c. Maximum velocities should not exceed 8 feet (8') per second.

3. Pipe Sizes and Placement

a. Soil boring with logs shall be made along the alignment of all storm sewers having a cross section equal to or greater than seventy-two inches (72") in diameter or equivalent cross sectional area. Each boring shall be taken at intervals not to exceed five hundred (500') linear feet and at a depth of less than three feet (3') below the flow line of the sewer. The required bedding will be determined from the soil boring.

b. Use storm sewer and inlet leads with at least 24-inch (24") inside diameter or equivalent cross section. Box culverts shall be at least 2 feet (2') by 2 feet (2'). Closed conduits; circular, elliptical, or box, shall be selected based on hydraulic principals and economy of size and shape.

c. Larger pipes upstream should not flow into smaller pipes downstream unless construction constraints prohibit the use of a larger pipe downstream, or the improvements outfall into an existing system, or the upstream system is intended for use as detention storage.

d. Match crowns of trunk storm sewer pipe at any change in pipe size unless severe depth constraints prohibit the matching of crowns. Severe depth constraints include any system in which the outfall system exists and the designed storm system cannot achieve 2 feet (2') or more of cover at the point of lowest cover without additional fill. This includes:

    i. Any system that includes a lake or detention pond, and the depth of the storm sewers is constrained by that lake or detention pond, and the designed storm sewer system cannot achieve 2 feet (2') or more cover at the point of lowest cover without additional fill.

    ii. Any time there is a conflict with the existing utility system which cannot be reasonably relocated. This includes large diameter water lines, underground electrical conduits, underground telecommunication conduits, petrochemical pipelines, or sanitary sewers.

    iii. Any time there is a conflict with a proposed sanitary sewer system which cannot be avoided due to design criteria constraints. This includes but may not be limited to sanitary sewers and their service leads.

    iv. The saving of specimen trees which would be harmed by fill on lots with a minimum lot size of 8,400 sf. A tree survey must be provided showing location, size and species of trees proposed to be saved.

e. Locate storm sewers in public street rights-of-way or in approved easements.

f. All precast, reinforced, concrete conduits must be laid in a straight line. Deflection in accordance with manufacturer's specifications will be allowed if on approved drawings.

g. In all easements restricted to storm sewers, the conduit shall be centered within the limits of the easement. The minimum width of the easement shall be two (2) times the depth plus the diameter of the pipe rounded up to the next highest five foot (5') increment but shall never be less than twenty feet (20').

h. For storm sewers located in easements adjacent to public street rights-of-way, the minimum width shall be increased for larger pipe or conduit by requiring that a minimum distance of five feet (5') shall be maintained between the easement line and the outside edge of the sewer, and a minimum distance of two feet (2') shall be maintained from the right-of-way line to the outside edge of the sewer pipe or conduit.

4. Starting Water Surface Elevation and Hydraulic Gradient

    a. The hydraulic gradient shall be calculated assuming the top of the outfall pipe as the starting water surface elevation.

    b. At any junction with a vertical drop in the invert of the downstream pipe, the upstream hydraulic grade line shall be calculated assuming that the hydraulic grade line is not lower than the soffit of the upstream pipe at that junction.

    c. For the design storm, the hydraulic gradient shall at all times be below the gutter line for all newly developed areas.

5. Manhole Locations

    a. Use manholes for precast conduits at the following locations:

        i. Size or cross section changes.

        ii. Inlet lead and conduit intersections.

        iii. Changes in pipe grade.

        iv. Street intersections.

        v. A maximum spacing of 500 feet (500') measured along the conduit run.

    b. Use manholes for monolithic-concrete storm sewers at the same locations as precast conduits, except they are not required at the intersection of inlet leads unless needed to provide maintenance access.

    c. Do not place manholes in driveways or in streets in front of or immediately adjacent to a driveway.

6. Inlets

    a. Locate inlets at all low points in gutter or at intermediate points in the profile grade to provide proper drainage.

b. Valley gutters across intersections are prohibited.

c. Inlet spacing is a function of gutter slope. The minimum gutter slope shall comply with Minimum Construction Standards for Community Improvements. For minimum gutter slopes, the maximum spacing of inlets shall result from a gutter run of 700 feet from high point in pavement or the adjacent inlet on a continuously graded street section, with a maximum of 1400 feet (1400') of pavement draining towards any one inlet location.

   i. Minor and collector streets: Maximum spacing of inlets shall result from a gutter run of 700 feet (700') from high point in pavement to the adjacent inlet on a continuously graded street section, with a maximum of 1400 feet (1400') of pavement draining towards any one inlet location.

   ii. Minor and major arterials: Maximum spacing of inlets shall result from a gutter run of 300 feet (300') from high point in pavement to the adjacent inlet on a continuously graded street section with a maximum of 600 feet (600') of pavement draining towards any one inlet location.

d. Use only City of Tomball standard inlets as listed in Table 1.

Table 1
STANDARD STORM SEWER INLETS

Minimum Construction Standards for Community Improvements
(Standard Construction Details)

INLET	APPLICATION	CAPACITY	City of Tomball Drawing NOS.
Type A	Parking Lots/Small Areas	2.5 cfs	COT STM-16
Type B-B	Residential/Commercial	5.0 cfs	COT STM-17
Type C	Residential/Commercial	5.0 cfs	COT STM-21
Type C-1	Commercial	10.0 cfs	COT STM-21
Type C-2	Commercial	15.0 cfs	COT STM-21
Type C-3	Commercial	20.0 cfs	COT STM-21
Type D	Parking Lots	2.0 cfs	COT STM-23
Type E	Roadside ditches	20.0 cfs	COT STM-24
Type H-2	Residential Commercial	5.0 cfs	COT STM-2502633-01,-02

e. Do not use beehive grate inlets or other specialty inlets.

f. Do not use grate top inlets in unlined roadside ditches.

g. Do not place inlets in the circular portion of cul-de-sac streets without providing justification based on special conditions.

h. Place inlets at the end of proposed pavement, if drainage will enter or leave pavement.

i. Do not locate inlets adjacent to esplanade openings.

j. For new residential development, locate inlets at the center of lots, such that inlets are not located within the driveway and between the radius end points as defined by the driveway radius intersection with the curb or edge of pavement.

k. Place inlets on side streets intersecting major streets, unless justification based on special conditions can be provided for alternate location.

l. For private development with internal site drainage, only one connection is permitted to any one inlet, and that connection (lead) shall be made to the back of the inlet. Connection shall not be made to the front face and to the short side of the inlet unless approved by the City. Design the connection not to exceed the pipe capacity minus either the capacity listed in Table 1, Standard Storm Sewer Inlets, or calculated inlet inflow.

m. For all new construction, convey public or private alleyway drainage to an inlet prior to entering the public street drainage system.

7. Design of Outfalls: All outfall designs shall conform to HCFCD Standards.

D. Design of Roadside Ditches

1. Roadside ditch design is permissible only for single family residential lots or commercial areas equal to or larger than 0.75 acres.

2. The City Engineer may approve deviations from residential and commercial standards based on the particular characteristics of the proposed development. The developer should submit a written request for such a deviation along with all supporting material to the Engineering and Planning Department prior to initiating detailed project design.

3 Design Frequency.

a. The design storm event for roadside ditches shall be a minimum of 2-year rainfall.

b. Design capacity for a roadside ditch shall be to a minimum of 0.5 feet below the edge of the pavement or 0.5 feet (0.5') below the natural ground at right-of-way line, whichever is lower.

c. The design must include an extreme event analysis to indicate that structures will not be flooded, and the maximum ponding elevation for the extreme event complies with Paragraph IV.E.3

d. Outfall drainage to existing roadside ditches shall be limited to tracts with frontage along the roadside ditch. If no frontage to the roadside ditch exists, but it can be shown with detail topographic surveys that the tract ultimately drains to the roadside ditch, then outfall will only be considered with full detention of the storm water during the design rainfall event.

e. The City Engineer may require a design storm event frequency less than 2-year if special conditions warrant.

4. Velocity Considerations.

a. For grass-lined sections, the maximum design velocity shall be 4.0 feet per second during the design event.

b. A grass-lined or unimproved roadside ditch shall have side slopes no steeper than three (3) horizontal to one (1) vertical (3:1). Soil conditions may dictate the use of lesser slopes. Steeper slopes will be allowed when the existing right-of-way is limited or other construction features dictate the design. The steepest slope shall not exceed two (2) horizontal to one (1) vertical (2:1).

c. Minimum grades for roadside ditches shall be 0.1-foot per 100 feet.

d. Calculation of velocity will use a Manning's roughness coefficient (n) of 0.04 for earthen sections and 0.025 for ditches with paved inverts.

e. Erosion control methods shall be used when design velocities are expected to be greater than four feet (4') per second or where erodible soil conditions are indicated in the geotechnical report.

5. Culverts.

    a. Culvert standards for driveways are provided by Drawing No. COT DW-06, Minimum Construction Standards for Community Improvements.

    b. Culverts shall be placed at all driveway and roadway crossings, and at other locations deemed necessary.

    c. Roadside culverts are to be sized based on drainage area. The minimum culvert size shall be 18 inches (18”) in residential areas and 24 inches (24") in non-residential areas unless otherwise approved by the Engineering and Planning Department. Calculations shall be provided for review upon request.

    d. All proposed culverts shall be included in the hydraulic profile. The proposed culvert shall not create a headloss of more than 0.20 feet (0.20’) greater than the normal water surface profile without the culvert.

    e. Stormwater discharging from a ditch into a storm sewer system must be received by use of an appropriate structure. (i.e., stubs with ring grates or Type E Inlets.).

6. Invert Protection.

    a. Ditch invert protection shall be used when velocities exceed 4 feet (4’) per second.

    b. Ditch invert protection will be used at the upstream and downstream ends of all culverts.

7. Depth and Size Limitations.

    a. The maximum depth for a roadside ditch shall not exceed four feet (4’) below the adjacent road centerline top of pavement. There may be instances where extreme conditions may warrant a deeper ditch. In those cases, specific written prior approval must be obtained from the Engineering and Planning Department.

    b. Roadside ditch bottoms shall be at least two feet (2’) wide, unless design analysis supports a narrower width and prior written approval is obtained from the Engineering and Planning Department.

    c. A minimum distance of two feet (2’) shall be established and maintained between the right-of-way line and the adjacent edge of the bank of a ditch.

8. Design of Outfalls: All outfall designs shall conform to HCFCD Standards.

E. Consideration of Overland Flow for the Extreme Event

1. Design Frequency: Design frequency for consideration of overland flow shall consider extreme storm events (100-year storm) which exceed the capacity of the underground storm sewer system resulting in ponding and overland flow from the development to the primary outlet.

2. Design Analysis: An overland flow analysis of the proposed drainage system shall be prepared by the design engineer. The design engineer shall submit supporting calculations, exhibits, and drawings.

    a. Three analysis methods as presented in Technical Paper No. 101, Simplified 100-year Event Analyses of Storm Sewers and Resultant Water Surface Elevations for Improvement Projects in the City of Houston, Harris County, Texas Region will be acceptable to the City.

    b. Analysis using the U.S. Environmental Protection Agency's Storm Water Management Model (SWMM) will be acceptable to the City.

3. Relationship of Structures to Street: All structures shall be higher than the highest level of ponding anticipated resulting from the extreme event analysis.

4. The following parameters are independent measures that shall be evaluated for each project. The limiting parameter will depend on project-specific conditions, and the most restrictive condition (the lowest ponded water elevation) shall govern.

    a. Streets shall be designed so that consecutive high points in the street will provide for a gravity flow of drainage to the ultimate outlet.

    b. The maximum depth of ponding at high points shall be 6 inches above top of curb.

    c. The maximum depth of ponding at low points shall be 18 inches above top of curb.

    d. Provide a minimum 20-foot (20') easement to accommodate sheet flow that is routed between lots or across reserve tracts. Fence lines and other improvements shall not be constructed on or across dedicated drainage easements.

e. A drawing(s) shall be provided to delineate extreme event flow direction through a proposed development and how this flow is discharged to the primary drainage outlet. The drawing(s) shall show a profile of the roadway (or overland flow path) from the upper reach of the drainage area to the primary drainage outlet. The drawing(s) shall be exaggerated vertical scale and shall include roadway profile at the gutter, ground profile at the right-of-way, and the hydraulic gradient for the extreme event (100-year storm), or an alternative equivalent drawing accepted by the City

f. In areas where ponding occurs and no sheet flow path exists, a calculation shall be provided showing that run-off from the 100-year event can be conveyed and remain in compliance with the other requirements of the paragraph.

g. Maximum Ponding Elevation: The design engineer shall demonstrate that the minimum slab elevation of a proposed structure shall be the highest of:

i. Eighteen inches (18”) above the 1% probability recurrence interval (100-year) flood event; or,

ii. One foot (1’) above the elevation of the center of the road or nearest sanitary or storm sewer manhole, whichever is higher; or,

iii. One foot (1’) above the calculated ponding depth.

5. Evacuation Routes and Emergency Service Routes. This standard applies to routes designated by the City for emergency evacuation and for routes where access by emergency service vehicles is a public safety need. Ponding of surface runoff is not allowed in the highest travel lane (each direction) for the 100-year event. Exceptions to this standard based on technical infeasibility or cost limitations will require approval of the Engineering and Planning Department This standard may be modified or exempted for locations in the 100-year floodplain.

6. Interim off-site sheet flow: Drainage swales may be used for interim offsite sheet flow in lieu of closed conduits in phased projects and for projects adjacent to existing development. This is required any time the proposed development will cause ponding on an adjacent owner’s property.

F. Design of Open Channels

1. Design Frequency: Design and construction standards for open channel and outfalls into channels shall conform to those in the HCFCD Criteria Manual.

2. Determination of Water Surface Elevation.

    a. Water surface elevations shall be calculated using Manning's Equation and the Continuity Equation.

    b. For the design storm event, the water surface shall be calculated to remain within banks.

3. Design of Culverts.

    a. Head losses in culverts shall conform to TxDOT Hydraulics Manual, Chapter 4, Culverts.

    b. Corrugated metal pipe will not be approved for permanent culverts in the City of Tomball right-of-way except at railroad crossings, and if used underneath the railroad crossing, the culvert shall be designed to railroad loadings.

4. Design of Outfalls: All outfall designs shall conform to HCFCD Standards.

G. Stormwater Detention

1. Stormwater detention is intended to mitigate the affects of new development on an existing drainage system. An engineer may provide calculations using acceptable design criteria to show that the impact can be mitigated using detention criteria different from the requirements of the HCFCD Criteria Manuals.

2. Application of Detention.

    The use of on-site detention is required when reported incidence of structural flooding exists; when in-fill or redevelopment will result in a potential threat to existing structures unless the current infrastructure is improved; when detention is required in accordance with the appropriate, adopted watershed master drainage plan; when post development flows result in street ponding levels which exceed City requirements; or if in the opinion of the City Engineer, post development flows will have an adverse impact on adjacent properties. If the City has developed a plan for a regional detention facility to serve a watershed, then the development is responsible for all costs of constructing the system to convey flows from their project to the regional facility. The City may elect to participate in oversizing of this conveyance if regional drainage interests are served.

    Detention is not required under the following conditions.

a. If redevelopment occurs without increasing the overall impervious character of the site, then no detention will be required by the City unless the application of detention will prevent existing structural flooding or bring the street ponding level on a major thoroughfare to within City requirements.

b. If the proposed development has less or equal impervious land cover than that used in the design of the storm sewer system as shown on the drainage area map in the roadway construction plans or other hydraulic computations.

c. If the hydraulic grade line from the current design storm of the receiving storm sewer system remains below the elevation of the gutter throughout the system with the proposed development included and considering ultimate conditions of the storm sewer watershed.

3. Detention volume for redevelopment areas is calculated on the basis of the amount of area of the redeveloped impervious cover or the detention factor for entire site determined by the basin the project is located in, typically 0.55 acre-ft per acre.

4. Private parking areas, private streets, and private storm sewers may be used for detention provided the maximum depth of flooding does not exceed six inches (6”) directly over the inlet. Underground detention facilities may be proposed for consideration by the City.

5. Calculation of Outlet Size

   Detention pond discharge pipe into an existing storm sewer line or existing City of Tomball or other public entity facility:

   a. Maximum pool elevation at or below the design hydraulic grade at the outfall - The discharge line shall be sized for the design storm with the outfall pipe flowing full. The pond will float on the drainage system to provide maximum benefit.

   b. Maximum pool elevation at or above the hydraulic grade at the outfall – Provide a reducer or restrictor pipe to be constructed inside the discharge line. The discharge line shall be sized for the design storm with the outfall pipe flowing full.

   c. Reducer or Restrictor Pipes shall be sized as follows:

i. The reducer or restrictor will be sized for undeveloped rate of discharge at no greater than 0.5 cubic feet per second per acre unless capacity for a greater flowrate is verified in the receiving system and approved by the City Engineer.

ii. Use the following equations to calculate the required outflow orifice:

$$Q = CA\,(2gh)^{1/2}$$
$$D = Q^{1/2} / (2.25\,h^{1/4})$$

Where:
Q = outflow discharge (cfs)
C = 0.8
A = orifice area (square feet)
g = gravitational factor (32.2)
h = head, water surface differential (feet)
D = orifice diameter (feet)

iii. Restrictor shall be either of the required diameter or of the equivalent cross-sectional area. The orifice diameter D shall be a minimum of 0.5 feet.

d. In addition to a pipe outlet, the detention basin shall be provided with a gravity spillway that will protect structures from flooding should the detention basin be overtopped.

e. Detention ponds shall maintain a minimum freeboard of one foot (1') between the top of bank and the 100-year water surface elevation.

6. Detention Facility Ownership and Easements.

a.. Private Facilities:

i. Pump discharges into a roadside ditch require the submittal of pump specifications on the design drawings. The maximum discharge rate of pumped facilities to a roadside ditch is 0.5 cubic feet per second unless capacity for a greater flowrate is verified in the receiving system and approved by the City Engineer. Energy dissipaters and erosion protection is required for pumped outfalls.

ii. The City reserves the right to prohibit the use of pump discharges where their use may aggravate flooding in the public right-of-way.

iii. Responsibility for maintenance of the detention facility must be indicated by letter submitted to the City as part of the design and plan review process.

iv. All private properties being served shall have drainage access to the pond. Dedicated private drainage easements may be required.

v. Public properties shall not drain into private detention ponds.

vi. A private maintenance agreement shall be provided when multiple tracts are being served.

b. Public Facilities:

i. Facilities will only be accepted for maintenance by the City in cases where public drainage is being provided.

ii. The City requires a maintenance work area of 30-foot width surrounding the extent of the detention area. Public rights-of-way or permanent access easements may be included as a portion of this 30-foot (30') width.

iii. A dedication of easement shall be provided by plat or by separate instrument.

iv. Proper dedication of public access to the detention pond must be shown on the plat or by separate instrument. This includes permanent access easements with overlapping public utility easements.

V. SUBMITTALS

A. Preliminary Submittals - Submittal, for review and comment, of one-line drawings is recommended and may be required as part of the platting process. One-line drawings should include:

1. Approximate definition of lots and street patterns.

2. The approximate drainage areas for each system.

3. A definition of the proposed drainage system by single line.

4. The proposed pipe diameters.

5. Any proposed drainage easements.

6. Floodplain information, including floodplain and floodway boundaries, if any; FEMA map number, effective map date and zone.

B. Final Design - Submit the following for approval:

1. Copies of any documents which show approval of exceptions to the City design criteria.

2. Design calculations for time of concentration, storm line sizes and grades, and for detention facilities, if any.

3. Design calculations for the hydraulic grade line of each line or ditch, and for detention facilities, if any.

4. Drainage Area Map with the following information:

    a. Existing contour map.

    b. Drainage area and sub-drainage area boundaries.

    c. Drainage area (acres) and flow quantity (cfs) draining to each inlet and each pipe segment from manhole to manhole.

    d. Extreme event (100-year) sheet flow direction.

    e. Existing condition and developed condition sheet flow direction for the surrounding properties.

5. Plan and profile sheets showing stormwater design (public facilities only).

6. Projects located within a floodplain boundary or within a floodplain management area shall:

    a. Show the floodplain boundary or floodplain area, as appropriate, on the one-line drawing or Drainage Area Map.

    b. Comply with all applicable submittal requirements of this chapter.

7. Profile drawing of roadway (or overland flow path) with exaggerated vertical scale from the upper reach of drainage area to the primary drainage outlet. Show roadway profile at gutter, ground profile at the public right-of-way, and hydraulic gradient for the 100-year extreme event; or an alternative equivalent drawing accepted by the City.

8. Calculation for proportional amount of pipe capacity allocated to the development along with the drainage area map used for these calculations.

C. Signature Stage - Submit the following for approval:

1. Review prints.

2. Original drawings.

3. Stormwater detention maintenance agreement letters.

4. Drainage Area Map with the following information:

   a. Existing contour map.

   b. Drainage area and sub-drainage area boundaries.

   c. Drainage area (acres) and flow quantity (cfs) draining to each inlet and each pipe segment from manhole to manhole.

   d. Extreme event (100-year) sheet flow direction.

   e. Existing condition and developed condition sheet flow direction for the surrounding properties.

5. Profile drawing as specified in Paragraph V.B.7.

VI. QUALITY ASSURANCE

Prepare calculations and design drawings under the supervision of a professional engineer trained and licensed under the disciplines required by the project scope. The final design drawings and all design calculations must be sealed, signed, and dated by the professional engineer, licensed by the State of Texas, responsible for the development of the drawings.

VII. DESIGN ANALYSIS

A. Projects shall be tied to the National Geodetic Survey (NGS) datum adjustment which matches the Federal Emergency Management Agency (FEMA) rate maps or the most current NGS datum which matches the FEMA rate maps. In the event GPS surveying is used to establish bench marks, at least two references to bench marks relating to the rate maps shall be identified. Equations may be used to translate other datum adjustments to the required adjustment.

B. Drawing sets shall include a drainage area map, which will contain calculations of flow by the rational method.

C. Drainage systems for curb-and-gutter pavements shall be underground closed conduits; individual residential lot drainage is exempt. Drainage systems for pavements without curb and gutter shall be roadside open-ditch sections.

VIII. LOW IMPACT DEVELOPMENT

Low impact development is a comprehensive land planning and engineering design approach with the goal of maintaining, as the minimum, the pre-development hydrologic regime in a watershed. This technique shall be allowed provided the following criteria are met:

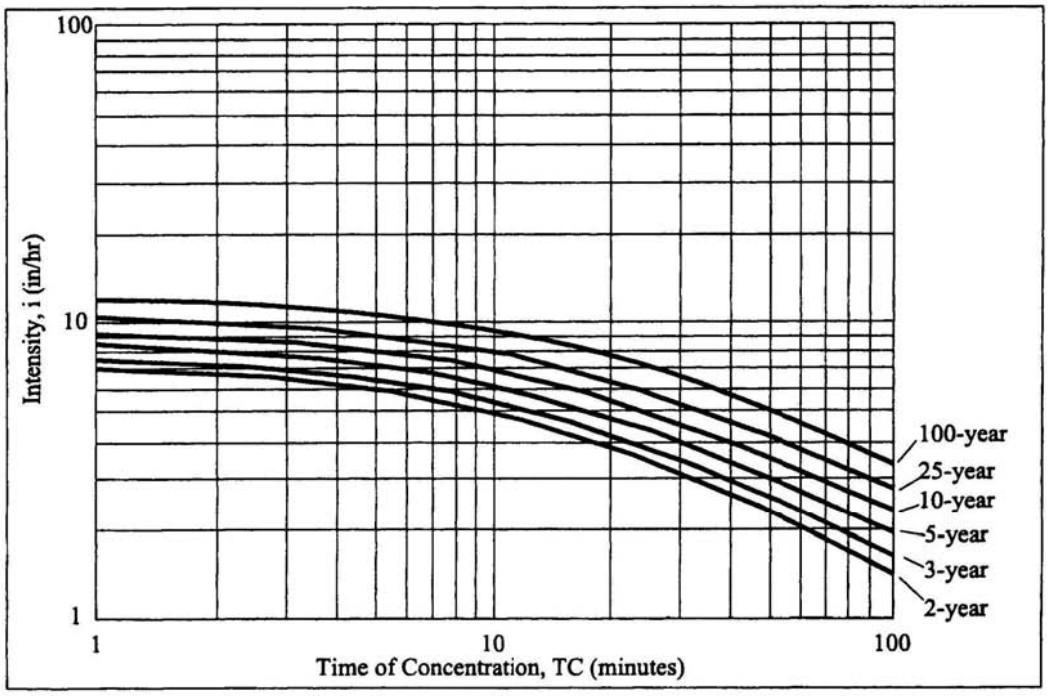
A. The post-development hydrograph for the 10 and 100 year events indicates the peak flows are at or below the pre-development hydrographs.

B. Other provisions of these regulations are met, excluding detention, or variances to those provisions are approved.

C. A conceptual design meeting is held with the City Engineer and design concepts are approved prior to proceeding to preliminary design.

FIGURE 1

City of Tomball IDF Curves
Intensity vs. Time of Concentration vs Rainfall Frequency
Source: Hydro 35/TP-40



$$i = \frac{b}{(d+TC)^{e}}$$

$$TC = 10A^{0.1761} + 15$$

A = area in acres

Rainfall Frequency	*b*	*d*	*e*
2-year	75.01	16.2	0.8315
3-year	77.27	17.1	0.8075
5-year	84.14	17.8	0.7881
10-year	93.53	18.9	0.7742
25-year	115.9	21.2	0.7808
100-year	125.4	21.8	0.7500

Figure 2

City of Tomball Storm Sewer Calculation Form

Project: _____ HGL starting elevation=_____

Job No: _____ Design Storm=_____

System: _____ b=_____

By: _____ Date:_____ d=_____

Checked by: _____ Date:_____ e=_____

M.H. From	M.H. To	Area (Acres)	Runoff Coefficient C	Sum of C*A	Intensity I (In/hr)	Sum of Flows (cfs)	Time of Conc. (Min.)	Reach Length (feet)	Diam. or Rise (in.)	Span (in.)	Slope %	Manning's "n	Design Capacity (cfs)	Design Velocit v (ft/s)	Fall (feet)	Manhole Drop (feet)	Flowline Elevation Upstream (feet)	Flowline Elevation Downstream (feet)	Actual Velocit v (ft/s)	Hydraulic Gradient %	Change in Head (feet)	Elevation of Hyd. Grad Upstream (feet)	Elevation of Hyd. Grad Downstream (feet)	Natural Ground Upstream (ft)	Natural Ground Downstream (feet)

Figure 3

City of Tomball Roadside Ditch Worksheet

Project: _____ HGL starting elevation=_____
Job No: _____ Design Storm=_____
System: _____ b=_____
By: _____ Date:_____ d=_____
Checked by: _____ Date:_____ e=_____

STATION TO STATION	SIDE	SLOPE %	DRAINAGE AREA	"C"	Tc (minutes)	I (inches/hr)	Q (CFS)	DITCH SECT			"n"	"d"	VELOCITY (fps)	DITCH LINING	SIDE DRAIN PIPE DIA	REMARKS
								FS	BW	BS						