SECTION 1: General Information

This document presents the Drainage Criteria, Procedures, and Design Guidelines for typical site developments that share frontage with Texas Department of Transportation (TxDOT) and have proposed discharge to TxDOT right-of-way (ROW).

Please note that hydrology, hydraulics, and watershed impacts are very complex topics, and no two sites are exactly the same; therefore, TxDOT Houston District (HOU) Hydraulics Section (HYD) must apply engineering judgement to prevent impacts to the TxDOT drainage system, traveling public, and adjacent properties. *The TxDOT parallel drainage systems are not intended to provide drainage infrastructure for new development; the primary purpose of TxDOT's drainage infrastructure is to limit the severity and duration of flood events to facilitate safe driving and minimize the duration of any traffic disruption caused by flooding. Ultimately, TxDOT's priority is to uphold the safety of the traveling public, and preventing roadway flooding impacts goes to serve that priority.*

⚠ Before beginning an analysis:

1. Examine the existing conditions topographic survey, as well as the best available LiDAR topographic data for the surrounding area. If the existing topography within the project site boundary does not drain entirely to TxDOT in existing conditions, and the development is proposing to drain this area to TxDOT, this constitutes diverted area; refer to Figure 1 for an illustration of diverted area. **TxDOT does not accept diverted area** unless one of the conditions as described in the *Diverted Drainage Area Guidelines* document applies. Any variances to the *Diverted Drainage Area Guidelines* must be approved by the TxDOT HOU HYD Director on a case-by-case basis. Please note the TxDOT HOU HYD Director reserves the right to deny any variance requests.

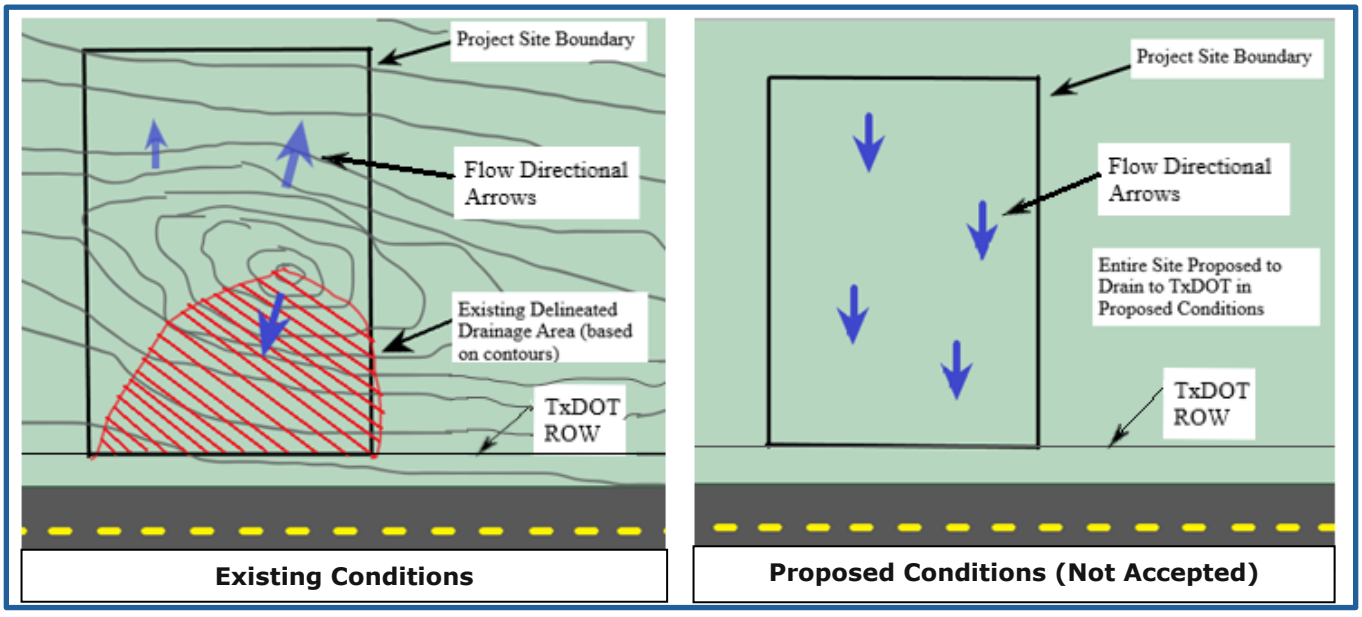

Figure 1: Example of Diverted Area

2. Please schedule a meeting with TxDOT HOU HYD (email: HOU_HYD_Permits@txdot.gov) prior to beginning a drainage impact analysis, which is required under the following circumstances:

    a. If the development site is greater than 10 acres.
    b. If the offsite contributing area is larger than five acres.
    c. If other design complexities exist (such as those that necessitate the use of modeling software).
    d. If any routing software is used for the project site detention/impact analysis. The following are the only routing software accepted by TxDOT HOU HYD:

        i. HEC-HMS
        ii. XP-SWMM
        iii. EPA-SWMM
        iv. HEC-RAS (when applicable)

3. Refer to Figure 2 flow chart to determine if the proposed site will require a meeting with TxDOT HOU HYD prior to submitting a permit application. Meeting requests should be sent to HOU_HYD_Permits@txdot.gov.
4. In addition to subsequent sections of this document, please also refer to the *Pump Discharge Criteria* document for applicable requirements, when a pump is utilized in the drainage design.
5. Other jurisdictional entities may have more stringent criteria than the information outlined in this document. It is the responsibility of the Development's Engineer to coordinate with all applicable jurisdictional entities to ensure adherence to applicable policies.
6. The Development's Engineer must be a licensed professional engineer in the State of Texas. As such, TxDOT HOU HYD recognizes the Development's Engineer takes full responsibility for the proposed design of the site. It is the responsibility of the Development's Engineer to ensure the proposed development will not create adverse impacts to the TxDOT ROW or to the adjacent property owners.
7. The Development's Engineer may choose to design the site based on a more conservative solution than what is presented in this document, if for example, another jurisdictional entity's criteria is more stringent. In such cases, it must be demonstrated to TxDOT HOU HYD that a more conservative solution is being proposed.
8. Civil Drawing Set (plans) submitted to TxDOT HOU Driveway Access Permit (DAP) system will not be reviewed if a drainage impact analysis is required and not completed.

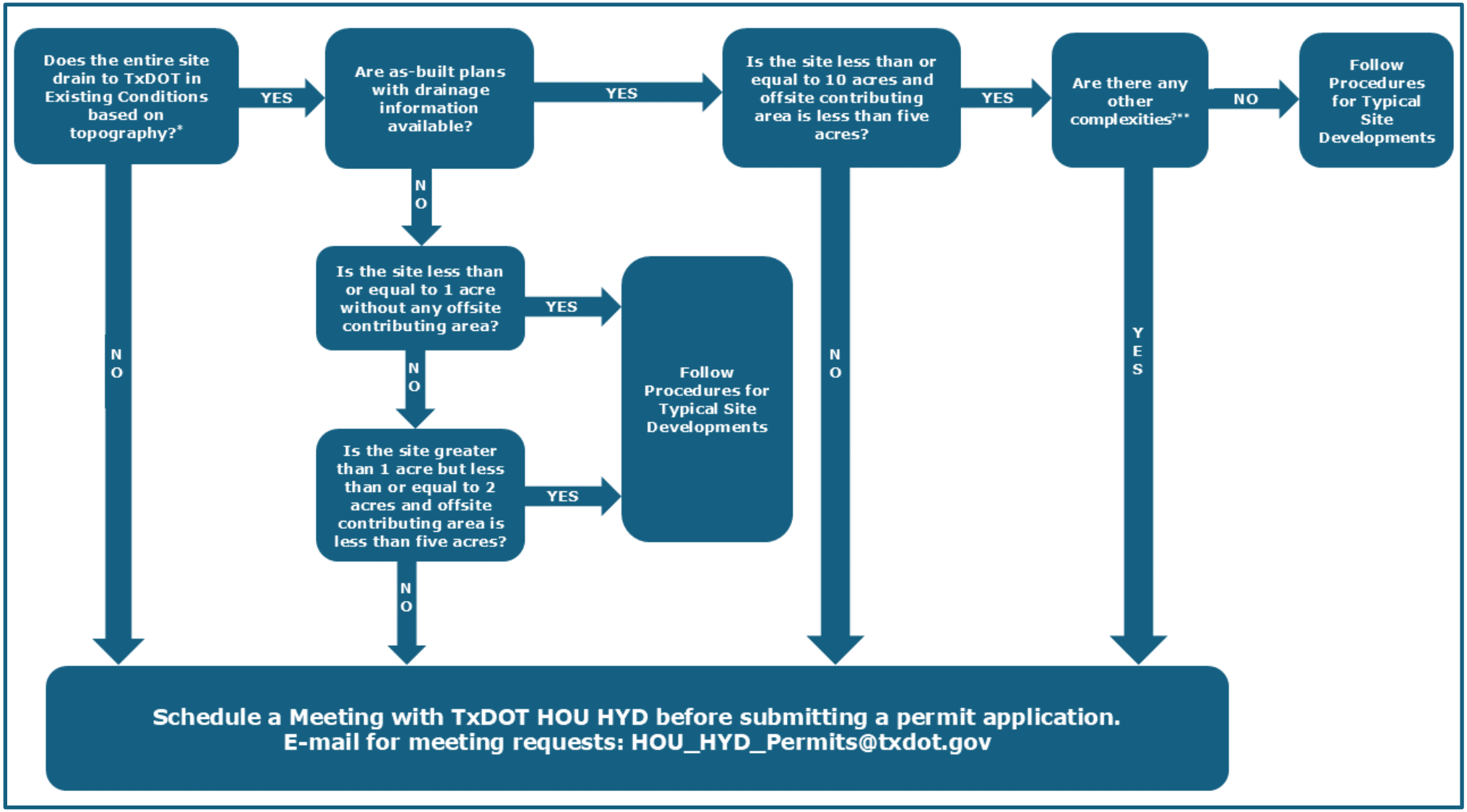

Figure 2: Procedure Flow Chart

*See Diverted Drainage Area Guidelines for exceptions. If the site falls under one of the listed exceptions, follow the yes arrow.

**Other complexities may include, but are not limited to: hydrologic and hydraulics models used in calculations; drainage report/memo; agreements; and situations where the site receives flow from TxDOT ROW.

SECTION 2: Definitions, Equations, and Methods

For the purposes of TxDOT HOU HYD review of typical developments and information presented in this document, the following definitions, equations, and methods are applicable.

1. Disturbed area is any area where the existing state of the land will be altered or modified by any activity that will affect the volume or rate of stormwater runoff from a property. Examples include: grading; changing the pervious properties of the land surface; changing the type of vegetive cover; changing the land use; installing drainage systems (storm sewers and ditches); or increasing the conveyance capacity of existing drainage systems.
2. Required detention volume is the approximated volume needed to mitigate for the proposed development's increase in impervious cover and any changes to the time of concentration.
3. The 100-year (yr) water surface elevation (WSEL) is the necessary WSEL to obtain the required detention volume for a 100-yr 24-hour (hr) storm event.
4. Allowable discharge is defined as the acceptable release rate from the proposed development to TxDOT ROW for storm events up to and including events which achieve a 100-yr WSEL. The total discharge from the proposed site (including the summation of flow through the proposed outfall and any bypass flow from the site (if applicable)) must be equal to or below the allowable discharge.
5. The allowable discharge is used to size the primary restrictor for the proposed development. The restrictor must be sized to not exceed the allowable discharge for storm events up to and including the 100-yr.

   A. If any area from the proposed site bypasses the detention system/restrictor undetained, the 100-yr peak flow from this bypass area must be computed using TxDOT HOU HYD methodology as outlined in this document and subtracted from the total allowable discharge in order to determine the allowable flow through the restrictor. **Please note discharge from a proposed development site is not allowed to sheet flow to TxDOT ROW.**

   B. Generally, the orifice equation as defined in HEC-22 Manual dated February 2024 (Equation 10.23) is applicable for use with typical developments. If the Development's Engineer determines this approach is not applicable, it must first be discussed with TxDOT HOU HYD prior to using alternative methods. The orifice equation, shown below, should be used to determine the restrictor size.

$$Q = C_d A\sqrt{2gH} \qquad \textit{(Equation 1)}$$

Q = discharge in cubic feet per second (cfs)
C_d = coefficient of discharge
A = cross sectional area of opening in square (sq) feet (ft)
g = gravitational acceleration in ft per second^2
H= head in ft

   a. The differential head value, H, in the orifice equation should be the 100-yr WSEL minus the centroid of outfall pipe (restrictor).
   b. Values for the C_d as defined in Equation 6.7.6 of the Harris County Flood Control District (HCFCD) Policy Criteria and Procedure Manual (PCPM) Revised July 2019 should be used:

      i. Sharp-edged (e.g., restrictor plate): C_d=0.60
      ii. Short tube (e.g., PVC restrictor grouted into a pipe): C_d=0.80

6. The Rational Method (Equation 4-20) as defined in the TxDOT Hydraulic Design Manual (HDM) dated September 2019 must be used to calculate peak flows as it is applicable for typical site developments covered under this document. TxDOT does not utilize frequency factor (C_f) for computing peak flow with the Rational Method. Do not use C_f factors for calculations to be reviewed by TxDOT HOU HYD.

   A. Calculate the time of concentration (t_c) using the Natural Resources Conservation Service (NRCS) Method (Equation 4-16) as outlined in the TxDOT HDM. Utilize sheet flow travel time (TxDOT HDM Equation 4-17), shallow concentrated flow (TxDOT HDM Equation 4-18), and channel (pipe) flow (TxDOT HDM Equation 4-19) as applicable.

   B. Utilize the rainfall intensity equation (Equation 4-21) as defined in the TxDOT HDM.

      a. Intensity should be based on the t_c and the TxDOT National Oceanic and Atmospheric Administration (NOAA) Atlas 14 e, b, d coefficients available at the following link: https://ftp.txdot.gov/pub/txdot/hou/resources/ebdlkup-2019-vc6.2.10.xlsm
      b. Use the spreadsheet referenced above and ensure the correct county and zone are selected. The partial duration series (PDS) values must be used within TxDOT HOU; do not use the annual maximum series (AMS) values for calculations within TxDOT HOU.

   C. Accepted Runoff Coefficients (C-values) for use within TxDOT HOU are provided in Table 1. Any deviation from the C-values in Table 1 must be presented to the TxDOT HOU HYD Director for concurrence.

Table 1: Runoff Coefficients for Use in TxDOT Houston District

Description	**Percent Impervious (%)**	**Runoff Coefficient (C-value)**
Impervious Cover	100	0.90
Wooded to Heavy Vegetated Areas (e.g. brushy areas)	0	0.15 – 0.20
Maintained Grassy Areas	0	0.30 – 0.35
Gravel (or equivalent)	83	0.80
Detention Ponds (side slope flatter than or equal to 3:1) Earthen	75	0.75
Detention Ponds (side slope steeper than 3:1) ~or~ Clay-lined ~or~ Concrete-lined	100	0.90
Wet Bottom Detention Ponds	100	0.90
Commercial or Industrial (inclusive of pervious cover)	>65	0.85
Residential (inclusive of pervious cover):		
Multifamily Complexes (Apartments)	65	0.60 – 0.70
¼ ac lots (subdivision)	38	0.55
½ ac lots (subdivision)	25	0.45
Farmstead (1 ac or greater)	12 – 20	0.40

7. Discharge produced from a development strip is computed using the Rational Method and the parameters below:
   A. 2-yr storm event using the TxDOT NOAA Atlas 14 e, b, d coefficient spreadsheet (PDS), t_c = 10 minutes
   B. C-value = 0.65
   C. Area determined by the frontage length with a depth not to exceed 150 ft. If the site has a depth less than 150 ft from the TxDOT ROW, use the actual depth in the calculation.
8. For the purposes of TxDOT HOU HYD review, the required detention volume is based on the determined excess runoff volume produced by the development's increase in impervious cover and changes to time of concentration as accounted for by the Small Watershed Method for the 100-yr 24-hr storm event. If the allowable release rate results in a more conservative detention requirement, then the Development's Engineer may decide to use this approach.
9. While overflow weirs are not required by TxDOT HOU HYD to be included in the detention design, they are recommended. The required detention volume as outlined in this document is computed using a simplistic approach. As such, the design of an overflow weir helps provide an additional safeguard to compensate for these assumptions. If the Development's Engineer decides to incorporate an overflow weir in the detention design, the weir should be sized such that the total discharge from the site (inclusive of both the weir flow and any other sources of flow from the site) will not exceed the existing 100-yr peak flow.
10. Malcom's Small Watershed Hydrograph Method is used to approximate the required detention volume per Section 5 of this document. Hydrograph Computation Equations 3.6.4 of the HCFCD PCPM Revised July 2019 are presented here as Equations 2, 3, and 4.

$$T_P = \frac{V}{1.39 Q_P} \qquad \textit{(Equation 2)}$$

$$q_i = \left(\frac{Q_P}{2}\right)\left[1 - cos\left(\frac{\pi t_i}{T_P}\right)\right] \qquad t_i \leq 1.25 T_P \qquad \textit{(Equation 3)}$$

$$q_i = 4.34 Q_P e^{\left(-1.3 t_i / T_P\right)} \qquad t_i > 1.25 T_P \qquad \textit{(Equation 4)}$$

$Q_P = peak\ discharge\ in\ cubic\ feet\ per\ second$
$T_P = time\ to\ Q_P\ in\ seconds$
$V = total\ volume\ of\ runoff\ for\ the\ design\ storm\ in\ cubic\ feet$
$t_i\ and\ q_i = the\ respective\ time\ and\ discharges\ which\ determine\ the\ shape\ of\ the\ hydrograph$

SECTION 3: Mini Development Site

A mini site for the purposes of TxDOT HOU HYD review is defined as a proposed development site which is equal to or less than 1 acre (ac) in size without any offsite contributing area. If the proposed development site is equal to or less than 1 ac without any offsite contributing area, the following calculation procedures apply. If the site receives any offsite contributing area (no greater than five ac) refer to information presented under Section 4.

1. Determine the detention volume requirement by using a rate of 0.85 ac-ft per ac of disturbed area.
2. In lieu of allowable discharge calculations, a restrictor size no greater than 6 inches may be used with the following constraints; refer to the orifice equation as outlined in Section 2 Item 5.
    a. If using an **orifice plate**: **Maximum Allowable Head** between the calculated 100-yr WSEL based on the required detention volume and centroid of the restrictor cannot exceed **7 ft.**
    b. If using a **short segment of pipe restrictor**: **Maximum Allowable Head** between the calculated 100-yr WSEL based on the required detention volume and centroid of the restrictor cannot exceed **4 ft.**
3. Utilize the TxDOT Houston District Drainage Summary Table for Sites Less Than 1 ac and include this table on a signed and sealed sheet of the provided civil drawing set.
4. Refer to Section 6 Detention Pond Design, Section 7 Outfall to TxDOT ROW Design, and Section 8 Civil Drawing Set for additional applicable requirements.

SECTION 4: Small Development Site

A small site for the purposes of TxDOT HOU HYD review is defined as a proposed development site which is greater than 1 ac but less than or equal to 2 ac. If the proposed development site is greater than 1 ac but less than or equal to 2 ac, the following calculation procedures apply.

I. Determine the detention volume requirement by using a rate of 0.85 ac-ft per ac of disturbed area.

II. Determine Allowable Discharge:
1. Obtain the TxDOT As-Built plans for the relevant roadway segment in front of the proposed site (indicate the proposed site location), including all drainage-related sheets (drainage area maps, hydraulic data sheets, runoff calculations, drainage plan and profile sheets, drainage lateral sheets, etc.). As-Builts can be requested from the following email: HOU_PlanRequest@txdot.gov
2. If the TxDOT As-Built plans cannot be located or do not show allowable discharge for the site, please see below for guidance based on the proposed drainage outfall connection:
    a. If the outfall connects to a TxDOT Storm Sewer System, determine the discharge produced from the development strip adhering to the method described in Section 2 Item 7.
    b. If the outfall discharges to a roadside ditch:
        i. Delineate the existing drainage area from the site (inclusive of any offsite contributing area) to TxDOT ROW based on the existing site topographic survey and best available topographic data such as LiDAR.
        ii. The delineated area in acres should be multiplied by a rate of 2 cfs per ac. For example: if 1.75 ac drains to TxDOT ROW in existing conditions, the allowable discharge rate = 1.75 ac x 2 cfs/ac = 3.5 cfs.
3. The Allowable Discharge value should be used to size the restrictor using the orifice equation as outlined in Section 2 Item 5.

a. Determine the restrictor size by rearranging the orifice equation to calculate the maximum cross-sectional area of the opening. In most cases a circular opening is used; as such, the maximum diameter in inches should be determined and included in the civil drawing set.
b. Select the restrictor size to be used and compute the actual discharge for the selected restrictor size for the 100-yr storm event. As an example, the preceding step may have resulted in a maximum diameter of 6.2 inches; however, the Development's Engineer may decide to use a 6-inch restrictor. Show selected restrictor size and actual discharge in the civil drawing set, as applicable.

III. Refer to Section 6 Detention Pond Design, Section 7 Outfall to TxDOT ROW Design, and Section 8 Civil Drawing Set for additional applicable requirements.

SECTION 5: Medium Development Site

A medium site for the purposes of TxDOT HOU HYD review is defined as a proposed development site which is greater than 2 ac but less than or equal to 10 ac. If the proposed development site is greater than 2 ac but less than or equal to 10 ac, the following calculation procedures apply.

****Please note each step in the below procedures must be clearly detailed on the civil drawing plan set****

I. Determine the Required Detention Volume:

1. Existing Conditions Peak Flow:
    a. Create an existing conditions drainage area map based on existing topographic survey.
        i. Include flow directional arrows.
        ii. Delineate the actual contributing area. In many cases, this does not perfectly align with the development site boundary. This delineation should be based completely on topography. Any offsite contributing area must be accounted for.
    b. Calculate the existing t_c using NRCS Method as outlined in the TxDOT HDM.
        i. Information which designates the various flow types (sheet, shallow, channel) must be depicted and clearly labeled.
        ii. All variables and calculations used in computing the t_c must be presented for review (length, elevations to calculate slopes, appropriate roughness/overland coefficients, etc.).
    c. Calculate the existing conditions C-value; refer to Table 1 for acceptable values.
        i. If only one land use is present in existing conditions, please clearly indicate the land use type and the selected C-value which adheres to Table 1.
        ii. If multiple land uses are present in existing conditions, please include a land use map with areas delineated and labeled by land use type and corresponding acreage. Include the selected C-value used to determine the weighted C-value. Refer to the TxDOT HDM Equation 4-23 for weighted C-value.
        iii. Existing impervious cover can only be accounted for in existing conditions if the impervious area was in place prior to 2001. **Any existing impervious cover that was created after 2001 cannot be counted for the existing conditions weighted C-value**. It is the Development's Engineer's responsibility to consult with any other entities' criteria regarding existing impervious cover.
    d. Calculate the existing 100-yr peak flows using the Rational Method:
        i. Intensity should be based on the existing t_c from Section 5 Item I.1.b and the TxDOT NOAA Atlas 14 e, b, d coefficients: https://ftp.txdot.gov/pub/txdot/hou/resources/ebdlkup-2019-vc6.2.10.xlsm
        ii. Use the spreadsheet referenced above and ensure the correct county and zone are selected. The PDS values must be used within TxDOT HOU; do not use the AMS values for calculations within TxDOT HOU.
        iii. TxDOT does not utilize frequency factor (Cf) for computing peak flow with the Rational Method. Do not use Cf factors for calculations to be reviewed by TxDOT.

2. Proposed Conditions Peak Flow:
    a. Create a proposed conditions drainage area map based on the proposed design.
        i. Include flow directional arrows.
        ii. Ensure entire proposed site (including landscape area, building/site perimeter tie-in grading, etc.) is accounted for.
    b. Determine proposed t_c:
        i. Option A (preferred method): Use the minimum t_c of 10 minutes for proposed conditions calculations.
        ii. Option B: Calculate the proposed t_c using the NRCS Method. Follow steps under Section 5 Item I.1.b to demonstrate determined proposed t_c. The proposed t_c should be calculated starting at the hydraulically most distant point on the site (upstream end) and ending when the flow reaches the detention pond. **The proposed tc flow path cannot include routing through the detention pond**.
    c. Determine the proposed conditions weighted C-value:
        i. Option A (preferred method): Use default C-value of 0.85 for the entire proposed site.
        ii. Option B: Calculate the proposed weighted C-value. Please refer to Table 1 for C-values. Please consult TxDOT HOU HYD for any land use and corresponding C-value not included in Table 1 prior to use. Provide a land use map with associated area in acres within the civil drawings set.
    d. Calculate the proposed 100-yr peak flows using the Rational Method:
        i. Intensity should be based on the proposed t_c from Section 5 Item I.2.b and the TxDOT NOAA Atlas 14 e, b, d coefficients: https://ftp.txdot.gov/pub/txdot/hou/resources/ebdlkup-2019-vc6.2.10.xlsm
        ii. Use the spreadsheet referenced above and ensure the correct county and zone are selected. The PDS values must be used within TxDOT HOU; do not use the AMS values for calculations within TxDOT HOU.
        iii. TxDOT does not utilize frequency factor (Cf) for computing peak flow with the Rational Method. Do not use Cf factors for calculations to be reviewed by TxDOT.

3. Calculate the 100-yr Required Detention Volume:
    a. Determine the Excess Runoff Depth, P_e as defined in the TxDOT HDM Equation 4-39, for existing and proposed conditions using the NRCS Curve Number (CN) loss model as outlined in Chapter 4 Section 13 of the TxDOT HDM dated September 2019 or other method as approved by the TxDOT HOU HYD. Document the following parameters:
        i. 100-yr 24-hr rainfall depth.
        ii. Hydrologic Soil Group.
        iii. Potential Maximum Retention, S, based on the TxDOT HDM Equation 4-36.
        iv. Initial Abstraction, I_a, based on the TxDOT HDM Equation 4-37.
        v. Existing CN.
        vi. Proposed CN.
    b. Determine the existing volume of runoff, V as described in Section 2 Item 10, for both existing and proposed conditions. This is calculated by multiplying the drainage area by the Excess Runoff Depth.
    c. Use Malcom's Small Watershed Hydrograph Method, refer to Section 2 Item 10 for equations, to develop an existing and proposed conditions hydrograph using a time increment of five minutes.
        i. Use the existing peak flow value from Section 5 Item I.1.
        ii. Use the proposed peak flow value from Section 5 Item I.2.
    d. The required detention volume is computed as the maximum cumulative difference (from time increment zero up to the point of hydrograph intersection) between the existing conditions and proposed conditions hydrographs developed using the Small Watershed Method hydrograph equations presented in Section 2 Item 10.

II. Determine Allowable Discharge:

1. Obtain the TxDOT As-Built plans for the relevant roadway segment in front of the proposed site, including all drainage-related sheets (drainage area maps, hydraulic data sheets, runoff calculations, drainage

plan and profile sheets, etc.). As-Built plans can be requested from the following email: HOU_PlanRequest@txdot.gov

2. If the TxDOT As-Built plans cannot be located or do not show allowable discharge for the proposed site, please see below for guidance based on the proposed drainage outfall connection:
    a. If the outfall connects to a TxDOT Storm Sewer System, determine the discharge produced from the development strip adhering to the method described in Section 2 Item 7.
    b. If the outfall discharges to a roadside ditch: **Please set a meeting with TxDOT HOU HYD to determine the allowable discharge.**

3. The Allowable Discharge value should be used to size the restrictor using the orifice equation as outlined in Section 2 Item 5.
    a. Determine the restrictor size by rearranging the orifice equation to calculate the maximum cross-sectional area of the opening. In most cases a circular opening is used; as such, the maximum diameter in inches should be determined and included in the civil drawing set.
    b. Select the restrictor size to be used and compute the actual discharge for the selected restrictor size for the 100-yr storm event. As an example, the preceding step may have resulted in a maximum diameter of 6.2 inches; however, the Development's Engineer may decide to use a 6-inch restrictor. Show selected restrictor size and actual discharge in the civil drawing set, as applicable.

III. Refer to Section 6 Detention Pond Design, Section 7 Outfall to TxDOT ROW Design, and Section 8 Civil Drawing Set for additional applicable requirements.

SECTION 6: Detention Pond Design

The following section provides information to be used for the detention pond design and items to be included to demonstrate the required detention volume is achieved.

1. Include the provided detention calculations on the plans.
2. Include a stage-storage table on the plans (elevation in ft, depth in ft, surface area in ac, cumulative volume in ac-ft). Include information for the associated 100-yr WSEL and elevation at which gravity flow begins (if applicable). An example of the requested stage-storage table is presented below.

Table 2: Example of Stage-Storage Table (values are arbitrary)

Elevation (ft)	Depth (ft)	Surface Area (ac)	Cumulative Volume (ac-ft)	Notes
200.00	0.0	0	0	
201.00	1.0	2	10	
201.50	1.5	3	25	
202.00	2.0	4	50	
203.00	3.0	6	75	Gravity Flow Begins
203.50	3.5	7	100	100-YR WSEL
204.00	4.0	8	110	
205.00	5.0	10	120	

3. If the proposed site includes an overflow weir, the following items apply:
    a. Concrete slope paving must be provided within the TxDOT ROW downstream of the weir if the weir is located adjacent to TxDOT ROW; see Section 7 Outfall to TxDOT ROW Design for concrete erosion protection design parameters.
    b. The weir must not be designed to have a total discharge from the site which exceeds the existing 100-yr peak flow.
4. Detention pond cross section with the following values labeled:
    a. 100-yr WSEL.
    b. Groundwater table elevation (if a pump is used).
        i. Groundwater table elevation should be established based on a geotechnical investigation; see Subject 7 of the Pump Discharge Criteria document.
        ii. If the geotechnical investigation did not encounter groundwater at or above the proposed detention pond flowline, include a note stating no groundwater encountered.
        iii. Include a note to reference the geotechnical report by title, author/prepared by, and signed and sealed date.
5. TxDOT HOU HYD does not accept TrueGRID or comparable detention systems (e.g., permeable pavers).
6. Backflow detention systems (in which the site's internal storm sewer system is sloped away from the detention pond and the site flow is intended to "back up" into the detention system) are not recommended by TxDOT HOU HYD. In situations in which this design cannot be avoided, a dynamic routing analysis will be required per TxDOT HOU HYD standards to demonstrate proposed detention pond will operate as intended without exceeding the allowable discharge and prove that the 100-yr Atlas 14 hydraulic grade line (HGL) is contained within the site. Discuss with TxDOT HOU HYD prior to using this method.
7. If the proposed detention pond is located adjacent to TxDOT ROW, a 12 ft minimum buffer between the maintenance berm and TxDOT ROW must be provided. See Figure 3 for an illustrative example.

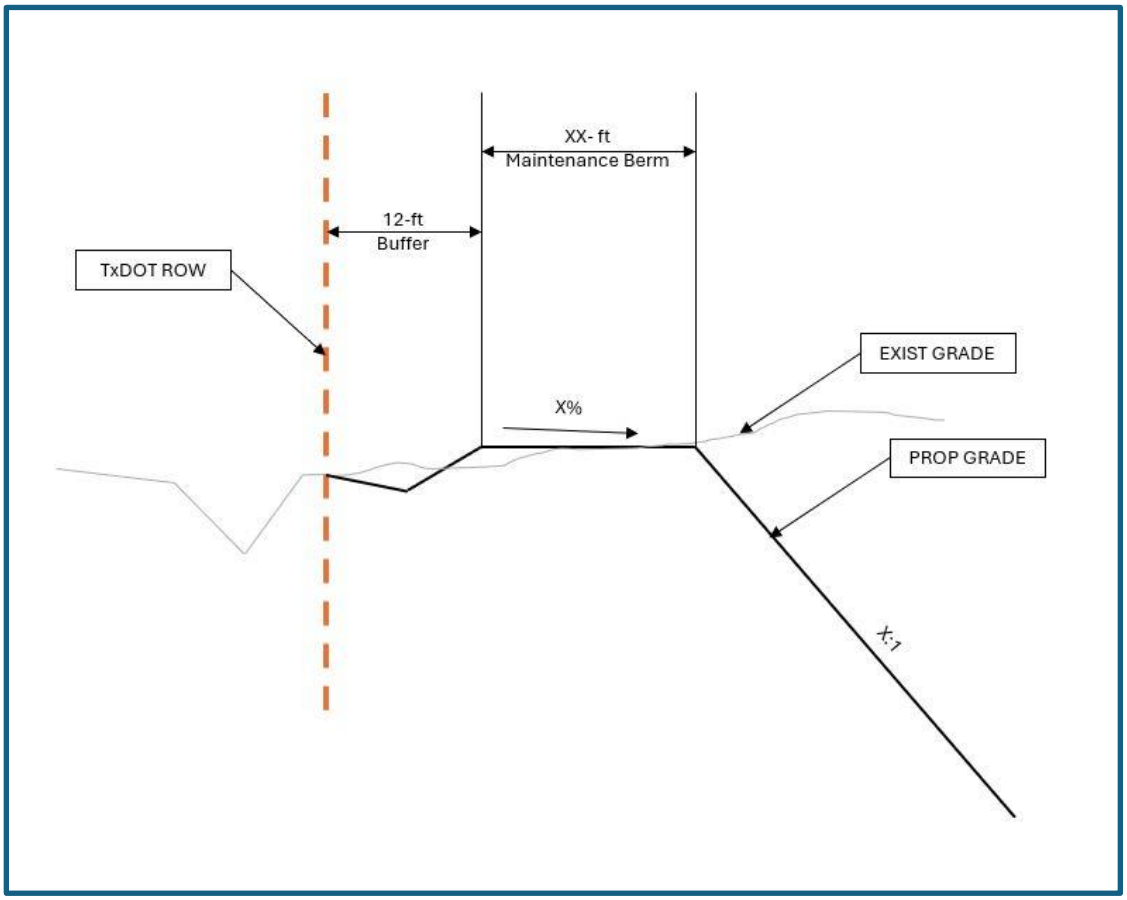

Figure 3: Example of Buffer Along TxDOT ROW

8. The proposed drainage system (upstream of the restrictor) and the pavement (e.g., parking lot) within the proposed site may be used as provided detention volume if determined appropriate by the Development's Engineer. The following applies if the pavement is used for detention:
    a. Maximum depth of ponding in the site's pavement is recommended based on the City of Houston Infrastructure Design Manual (IDM) dated November 2023, Chapter 9 Section 2.
        i. Maximum depth of ponding cannot exceed 9 inches.
        ii. If the pavement is to serve as parking for transport trucks only, the maximum depth of ponding cannot exceed 15 inches.
    b. Provide within the civil drawing set a sheet which includes proposed pavement contours, top of curb elevation, delineation of area used for detention, inlet top of grate elevation, and the area clearly labeled. Provide the detention volume calculated for each drainage area and the depth used to calculate the provided volume.
    c. Use the Frustum Equation to determine the provided volume. Any other method must be approved by TxDOT HOU HYD.
9. The detention volume used to mitigate the increase in impervious cover and changes to the t_c cannot be used as floodplain fill mitigation. Required floodplain fill mitigation must be provided in addition to the required detention volume used for increased impervious cover and changes to the tc. Any floodplain fill volume mitigated in the detention pond must be provided above the detention volume required to mitigate for the increased impervious cover and changes to the time of concentration.

SECTION 7: Outfall to TxDOT ROW Design

The following items present the requirements for proposed site development outfalls which tie-in to TxDOT ROW.

1. Only one outfall tie-in to TxDOT ROW per development is accepted. TxDOT HOU HYD may allow for conditional exceptions. An example which would warrant an exception is if the existing site discharged to two curb inlets in existing conditions which do not connect to the same trunkline.
2. A profile drawn to scale for the proposed outfall is required to be shown on the plans. The profile must also include:
    a. Outfall pipe size, material, length, flowlines, etc.
    b. Restrictor location, size, length, material, etc. The restrictor must be entirely contained within the project site and shall not encroach upon TxDOT ROW.
    c. Critical elevations (existing grade, proposed grade, flowline elevations, etc.).
    d. TxDOT ROW line must be labeled.
    e. All existing utilities must be verified and shown with clearance distances labeled. If no utilities were encountered during verification, please add a note stating no utilities encountered.
3. Proposed outfalls to TxDOT roadside ditches require the following concrete erosion protection:
    a. Minimum 5-inch reinforced concrete slope paving
    b. Minimum toe wall depth of 18 inches on both the front and back slope of the TxDOT ditch
    c. The pad should match the geometry of the roadside ditch
    d. Extend across the bottom and up the slopes of the ditch to an elevation of 1 ft above the top of pipe on each side. If the depth is constrained, concrete slope pave to the top of banks.
    e. The width should be at least the width of the outfall pipe(s) plus 4 ft on each side.
    f. The outfall pipe shall be mitered to the ditch slope per TxDOT Standard (SETP-CD) for pipe(s). See link provided in Section 8 Item 12 of this document.
    g. Show this concrete on the plan view and create a cross section of the pipe outfall showing this information.
4. Sheet flow to TxDOT ROW is not permissible. If small areas cannot drain to the primary drainage system, discuss with the TxDOT HOU HYD.

SECTION 8: Civil Drawing Set

The civil drawing set (plan set) to be submitted must include, but is not limited to, the listed information within this Section. Refer to the Drainage Check List for a comprehensive list of items to be included in the submittal of the civil drawing set. Include the completed drainage check list with submission of the permit application.

1. Cover sheet
2. General construction notes
3. Site Boundary Survey Map (signed and sealed by a Registered Professional Land Surveyor (RPLS) in Texas).
4. Existing site topographic survey map (signed and sealed)
5. Existing conditions drainage area map
6. Proposed drainage area map. Show the extreme event sheet flow direction with arrows
7. Internal drainage system calculations for the 100-yr storm event.
    a. Internal drainage system design may use the City/MUD or County criteria
    b. Inlet capacities
    c. HGL
    d. Demonstrate the 100-yr storm event is able to be conveyed to the detention pond
8. Flow paths used to determine the t_c.
9. Proposed grading plan with inlet flow arrows
    a. Provide elevations at site boundary and at driveway (if applicable) to TxDOT ROW.
    b. Grading plan must demonstrate the 100-yr WSEL and the proposed 100-yr HGL is contained in the site.
10. Proposed drainage plan including all pertaining peak flow, restrictor, and detention calculations. Cross sections and details of the detention area (underground, above ground, parking area, etc.) with elevations are required.
11. Restrictor details at the outfall location to TxDOT are required. The restrictor pipe shall be located inside the private property and not in the TxDOT ROW.
12. All proposed work within TxDOT ROW must adhere to TxDOT Standards and Specifications. Typical construction standards to be included are listed below:

    a. TxDOT safety end treatment (SET) Standards are available on the TxDOT Bridge Standards Website, see list under Culvert and Drainage: https://www.dot.state.tx.us/insdtdot/orgchart/cmd/cserve/standard/bridge-e.htm
        i. Use parallel drainage SETs for proposed driveway culverts.
        ii. Use cross drainage SETs for outfalls into TxDOT ROW.
    b. TxDOT Houston District Standards Website: https://www.dot.state.tx.us/hou/specinfo/specs.htm
        i. TxDOT Houston District Excavation and Backfill Diagrams (E&BD-24 (HOU))
        ii. TxDOT Houston District Driveway Standards for proposed driveways (DD-25 (HOU))
    c. Stormwater Pollution Prevention Plan (SWPPP) plan and standard details (see Temporary Erosion Details on TxDOT Roadway Standards website: https://www.dot.state.tx.us/insdtdot/orgchart/cmd/cserve/standard/rdwylse.htm)
13. Off-site sheet flow path arrows and design consideration, if applicable
14. TxDOT Houston District Drainage Summary Table with all applicable information. The table is obtainable from the Houston District Permit Information Page.