MINIMUM DRAINAGE CRITERIA

Sec. 1. - General requirements.

a) These guidelines contain the minimum storm drainage design criteria to be followed in the design of storm drainage facilities and demonstrates the design procedures to be used on drainage projects on TAC property.

b) The design factors, formulas, graphs and procedures described are intended to serve as guidelines. Responsibility for the actual design remains with the Engineer of record for each project.

c) It is the responsibility of the Engineer to provide all necessary calculations and designs described herein. The Engineer shall provide TAC the data, calculations, and plans necessary to demonstrate the design does not adversely impact the surrounding or downstream property and meet local, state, and federal rules, regulations, and requirements.

d) The runoff coefficient ("C" factor) for use in drainage calculations for improvements should be based on 'non-residential' development of the subject property. If the land use in the drainage area is toward development which would produce a lower "C" factor, this "C" factor may be used for design calculations only upon approval of the Operations Department.

e) Compliance with the minimum requirements of this chapter in no way shall be construed as relieving the property owner or developer of any liability which the owner may incur as a result of damage to downstream or upstream properties resulting from the development of the site.

Sec. 2. – Curb and gutter street drainage.

The following are criteria for curb and gutter street drainage:

Street Classification	Design Storm	Runoff Depth and Ponding Width
Residential	Q_2	Depth should not exceed curb or roadway centerline elevation. Six-inch standard and four-inch and six-inch mountable curbs acceptable.
		Minimum cross slope equals 0.02 feet/feet (2%)
		Maximum cross slope equals six-inch (6") crown
Residential collector	Q_2	One 12-foot (12') lane shall remain clear during design storm

Note: For closed storm sewer systems and inlets at street low point, sag or sump and the downstream storm sewer, the design frequency shall be Q_{10} for all street classifications.

Sec. 3. – Rural street sections; Cross drainage; bridges and culverts.

a) The following are criteria for rural street sections, cross drainage of bridges and culverts:

Street Classification	Design Storm	Runoff Depth and Other Requirements
Residential and residential collector	Q_5	Q_{10} storm shall not produce inundation greater than two inches at the street centerline
Collector	Q_{10}	Design storm runoff must be contained within the ditch section
Arterial	Q_{25}	Design storm runoff must be contained within the ditch section

b) Cross drainage structures shall be Class III reinforced concrete pipe or Class "A" concrete box culvert, or approved equal. Alternate pipe materials with appropriate backfill may be allowed only upon approval of the Operations Department.

Sec. 4. - Channels.

a) The following are criteria for drainage channels:

(1) $Q_{10} < 10$ cfs:

Type of Channel	Design Storm	Maximum Side Slope	Other Requirements
Concrete or storm sewer	Q_{10}	N/A	Extended from back of curb to the building line. Storm sewer may be a substitute.

(2) $Q_{10} > 10$ cfs:

Type of Channel	Design Storm	Maximum Side Slope	Other Requirements
Grass Lined Earthen Channel	Q_{10}	4:1	Minimum four feet (4') wide by six-inch (6") thick concrete pilot channel or six feet wide if curbed for V > six fps
Concrete Lined	Q_{10}	1.5:1	As approved
Box Culvert	Q_{25}	N/A	—
Storm Sewer	Q_{25}	N/A	Class III RCP or other approved material
Other Approved	Q_{10}		As approved

b) Due to owner desire and/or technical reasons, a natural drainageway may be preserved, provided the following criteria are met:

1) A request for the preservation of a natural channel shall be made to the Operations Department prior to approval of plats or site development plans.

2) Limits of the 100-year (Q_{100}) flood boundary are determined and indicated on the plat or site plan and no improvements shall be constructed within that established flood boundary unless plans for such improvements have been approved by the Operations Department.

3) In general, no easement will be required and maintenance shall rest with the property owner or developer.

Sec. 5. - Designation of the 100-year (Q_{100}) flood boundary.

a) For all cross drainage and other significant drainageways, whether publicly or privately maintained:

1) The limits of the Q_{100} flood boundary shall be determined.

2) Minimum finished floor elevations, which are at least two (2) feet above the Q_{100} flood boundary elevation shall be calculated for each platted lot or each structure for an individual site plan.

b) This information shall be indicated on the following:

1) Subdivision plats, before they are filed for record.

2) Individual site plans, grading plans or full site development plans as applicable.

Sec. 6. - Easement requirements.

a) For drainageways serving an area of less than 100 acres, the minimum requirements shall be:

1) Private drainageways shall be utilized to control drainage and indicated on a plat or site plan.

2) Q_{100} flood boundary indicated on a plat or site plan per Section 5.

3) Drainageway maintenance shall be the responsibility of the property owners.

4) No drainage easement required.

b) For drainageways serving an area of 100 or more acres, the minimum requirements shall be:

1) Adequate drainage easements through the development site shall be reserved for TAC and maintenance shall rest on the property owner or developer. In instances where there are existing easements, such easements shall be modified as necessary to accommodate the required channel section and conform to all requirements in this subsection.

2) Drainage easements shall be initially cleared of any obstructions which would prevent routine maintenance of the drainageway by motorized equipment. No obstructions, including trees, are to be placed in the drainage easement which would prevent routine maintenance of the drainageway by motorized equipment. No fence or similar barrier is to be placed within the drainage easement.

3) Drainage easements shall be of sufficient width to provide for the designed channel section, including adjacent areas for the maintenance of the channel.

c) Earth channels shall be constructed to provide for:

1) A maximum side slope of 4:1.

2) A minimum 12-foot maintenance way along one side of the channel that can be maintained utilizing equipment with a 20-foot maximum reach. Where such equipment cannot maintain a channel, a minimum 12-foot maintenance way shall be provided along both sides of the channel.

3) Grass shall be established on the flowline and side slopes and shall have sufficient growth to maintain the design shape and grade. Sodding, soil retention blanket, hydro mulching or some effective combination thereof will allow for immediate acceptance as established grass.

d) Concrete channels shall be constructed to provide for:

1) A maximum side slope of 1.5:1.

2) Adequate easement widths (same as for earth channels) and/or access facilities designed and constructed, free of obstructions, so that routine maintenance can be accomplished with motorized equipment.

3) Other type channel improvements: as approved by the Operations Department.

Sec. 7. - Required submittal data.

a) A drainage area map with on-site drainage and, where applicable, off-site drainage areas shown.

b) The areas, time of concentration, runoff coefficients and rainfall intensities used to calculate runoff indicated on the drainage area map or drainage plans. In lieu of this, the designer may submit a copy of drainage calculations performed.

c) Minimum finished floor elevations and limits of Q_{100} flood boundary indicated on plats which are to be filed for record or on site development plans, whichever is applicable.

d) If adequate drainage easements do not exist, easements shall be established and reserved for TAC and maintenance shall rest on the property owner or developer. In instances where there are existing easements, such easements shall be modified as necessary to accommodate the required channel section and conform to all requirements in this subsection.

e) the owner or developer of the property shall submit acceptable instruments of dedication for required easements.

f) Size and location provided for all drainage facilities.

g) Plan/profile of all channels, ditches and storm sewers, including hydraulic calculations, will be required.

h) Cross-sections of all channels on 50-foot intervals will be required.

i) Certification by a registered professional engineer that all requirements of the criteria have been met.

Sec. 8. - Appeals.

Any person contesting any disapproval and/or interpretation and/or application of any rule, standard, regulation, determination, requirement of necessity set forth in this chapter by the Operations Department, shall have the right to appeal such decision to the Executive Director. Any person who is in disagreement with the decision of the Executive Director, shall within ten days of that decision, file an appeal with the Board of Directors. The appeal should state what areas, in the opinion of the person adversely affected, the decision of the Executive Director disagrees with provisions or the intent of this chapter. It shall be the duty of the Board to hear any such appeal within a reasonable amount of time.

Sec. 9. - Waiver of drainage regulations.

The Executive Director, after consultation with the Operations Department, is authorized to waive compliance with any part of this policy in those instances wherein it is neither technically reasonable nor feasible or where it is technically impossible to comply with such part. This waiver authority shall be strictly construed.

Sec. 10. – Withholding of Permits

The Executive Director shall withhold the issuance of certificate of compliance, electrical, plumbing and/or building permits or issuance of certificate of occupancy as deemed necessary to enforce the provisions of this chapter based on policy as follows:

a) For developments requiring the construction or extension of streets or storm sewer collection systems, a drainage plan shall be included with the plans submitted for approval. Construction of required drainage improvements shall be accomplished in conjunction with the street construction and both street and drainage facilities must be constructed to a level of completion adequate to function effectively at their design capacity prior to issuance of any certificate of occupancy connected with such development. If stage development is proposed, each stage must be designed and constructed to the extent necessary to ensure effective functioning independent of future planned stages, prior to permit issuance.

b) For singular site type developments, a drainage plan shall be submitted along with the site and construction plans for total development. Construction of required drainage improvements shall be accomplished in conjunction with the site development and shall be constructed to a level of completion adequate to function effectively at the design capacity prior to the issuance of any certificate of occupancy connected with such site development.

Sec. 12. - Definitions.

For the purposes of this chapter, the words and phrases below shall have the following meanings, except where the context clearly indicates a different meaning:

Channel means a natural or manmade (i.e., improved channel, storm sewer, box culvert) feature that provides for the conveyance of rainfall runoff or stream flow in a concentrated form exclusive of street drainage and cross drainage.

Cross drainage means any structure, such as pipe, box culvert or bridge, utilized for transporting water in a subsurface manner across a public or private street or driveway.

Private drainageway means any eligible channel (less than 100-acre drainage area) or cross drainage for a private street, that the owner or developer, by choice, elects to designate as private as opposed to dedicating an easement. All maintenance responsibility shall rest with the individual property owner.

Q means the volume of stormwater discharge calculated on various storm frequencies. (i.e., Q_2, Q_5, Q_{10}, Q_{25}, etc.)

Storm sewer means a pipe system utilized for the conveyance of water, generally below the ground surface, comprised of Class III concrete pipe or other approved material. A storm sewer may be utilized for street drainage, cross drainage or channel purposes. As an alternative, HDPE pipe meeting the H-20 loading requirement and special backfill requirements (see HDPE detail) may be used with approval by the Operations Department.

Street drainage means that rainfall runoff that travels to the street and then parallel with the street to a release point. This drainage is carried at the curb on urban section streets and in parallel ditches on rural section streets.

Street low point, sag or sump means the lowest point in the profile of a street which normally coincides with the natural low at which point street drainage is discharged.

Sec. 13 - Determining Design Discharge

The Rational Method may be used to determine the runoff generated from a property when a contributing drainage area is less than 100 acres. A unit hydrograph method shall be used to determine the runoff generated from a property with a contributing drainage area greater than 100 acres. The Director of Operations may require developments with contributing drainage areas less than 100 acres to use a unit hydrograph method if the hydrologic results of the contributing drainage area or components within the drainage area more accurately reflect a unit hydrograph.

a) Rational Formula (Drainage Areas < 100 acres)

   a. The Rational Formula for computing peak runoff rates is as follows:

$$Q = C * I * A$$

Q = runoff rate (cfs)

C = runoff coefficient (dimensionless)

I = rainfall intensity (in/hr)

A = drainage area (ac)

b) Runoff Coefficient (C)

   1) The following runoff coefficients are provided for typical land uses within the TAC property:

RUNOFF COEFFICIENTS

LAND USE	RUNOFF COEFFICIENT	INLET TIME
	C	(min)
Single Family Residential	0.55	15
Two Family Residential	0.70	10
Multi-Family Residential	0.90	10
Non-Residential Uses	0.90	10
Undeveloped areas	0.30	20
Streets	0.90	10

   2) Runoff coefficients reflecting other conditions may be used with the approval of the Operations Department.

   3) The table above provides guidelines for runoff coefficients for typical land use within the TAC property; however, a weighted runoff coefficient may be used for the design if it is more representative of the site conditions.

c) Rainfall Intensity (I)

1) The equation used to determine the rainfall intensity values for various storm events and durations is provided below.

$$I = b/\ (Tc + d)^e$$

Tc = Time of concentration (min)

Refer to the following table for b, d, and e values.

Intensity for 5 min <= Td <= 60 min (I = b/(Tc+d)^e)

Return Period	b	d	e
2	51.45	11.44	0.7890
5	59.34	10.18	0.7738
10	68.56	10.24	0.7681
25	74.94	9.45	0.7577
50	84.79	9.34	0.7547
100	95.73	9.29	0.7528

RAINFALL INTENSITY (IN/HR)
STORM DURATION (MIN)

STORM FREQUENCY	5	10	15	30	60	120	180	360
2-YEAR	5.65	4.58	3.88	2.72	1.77	1.10	0.81	0.48
5-YEAR	7.23	5.80	4.89	3.41	2.21	1.37	1.02	0.61
10-YEAR	8.46	6.80	5.74	4.01	2.62	1.63	1.22	0.73
25-YEAR	9.91	7.91	6.65	4.63	3.01	1.88	1.41	0.85
50-YEAR	11.36	9.07	7.62	5.31	3.46	2.16	1.62	0.98
100-YEAR	12.93	10.31	8.67	6.04	3.94	2.46	1.85	1.12

Sec. 14 - Design of Enclosed Storm Sewer System

a) Design Flow

All enclosed systems shall be hydraulically designed and all required calculations shall be provided on the construction plans. The hydraulic gradient and full-flow velocity shall be calculated using the design flow, appropriate pipe size, and Manning's equation:

$$Q = (1.486/n)*A*(R^{2/3})*(S^{1/2})$$

Q = Runoff rate (cfs)

A = Cross sectional area of the conduit (ft^2)

n = Manning's roughness coefficient (0.013 for concrete)

R = Hydraulic radius (ft) (Area of conduit divided by wetted perimeter (R=A/P)

S = Slope of the hydraulic gradient (ft/ft)

b) Hydraulic Gradient

1) TAC requires that all hydraulic gradient calculations begin at the outfall of the system.

2) The starting hydraulic grade line (HGL) shall be based upon an assessment of the conditions downstream of the site to be developed. The stormwater runoff from the site shall not cause adverse impacts to adjacent or downstream properties or facilities. In order to determine the impacts to downstream properties or facilities, the Operations Department may request an assessment of downstream conditions to ensure that no new or increased flooding will occur, that the Q_{100} water surface elevation will not be increased, that post development velocities will increase to erosive levels of existing drainage facilities, that the discharge will not increase to a level beyond the capacity of downstream conveyance systems or that other hazards are created as a result of the development. The results of the downstream assessment will provide the Engineer with the capacity and resulting design storm of the downstream facilities.

3) The starting HGL at an outfall into a creek or channel shall be the Q_{100} fully developed water surface unless an approved flood hydrograph is available to provide a coincident flow elevation for the system's peak.

4) When a proposed storm sewer is to connect to an undersized existing storm sewer system, calculation of the hydraulic gradient for the proposed storm sewer shall start at the outfall of the existing storm sewer system.

c) Hydraulic Design

1) The hydraulic grade line (HGL) must be calculated for all storm drain mains and laterals using appropriate head loss equations. In all cases, the storm drain HGL must remain below lime treated subgrade and must be at least 1' below top of curb at each inlet.

2) In partial flow conditions, the HGL represents the actual water surface within the pipe. The velocity of the flow should be calculated based on actual area of flow, not the full flow area of the pipe or box.

3) Unless partial flow conditions exist, the beginning hydraulic gradient shall begin at either the top of pipe or at the hydraulic gradient of the receiving stream at the coincident frequency, whichever is higher.

d) Lateral Design

1) The HGL shall be calculated for all proposed laterals and inlets, and for the existing laterals being connected into a proposed drainage system.

2) Laterals shall intersect the storm drain at standard angles.

e) Velocity Head Losses (HL)

1) Adjustments are made in the HGL whenever the velocity in the main changes due to conduit size changes or discharge changes. Laterals in partial flow must be designed appropriately and the partial flow velocity shall be used in the calculations.

2) In determining the HGL for the lateral, begin with the hydraulic grade of the main line at the junction plus the HL due to the velocity change. Where the lateral is in full flow, the hydraulic grade is projected along the friction slope calculated using Manning's Equation.

3) HL losses or gains for wyes, pipe size changes, and other velocity changes will be calculated by the following formulas:

$$HL = [(V_2)^2/2g] - [(V_1)^2/2g]$$

HL = Head loss or gain (ft)

V_1 = Upstream velocity (fps)

V_2 = Downstream velocity (fps)

g = Gravity constant (32.2 ft/s^2)

2) HL for pipe in full flow at manholes, bends, and inlets, where the flow quantity remains the same, shall be calculated as follows:

$$HL = Kj\ [\ V^2/2g\ ]$$

HL = Head loss or gain (ft)

V = Velocity in the lateral (fps)

g = Gravity constant (32.2 ft/s^2)

Kj = Coefficient of loss.

3) Head losses or gains at manholes and junction boxes where there is an increase in flow quantity shall be calculated as follows:

$$HL = [\ (V_2)^2/2g\ ] - Kj\ [\ (V_1)^2/2g\ ]$$

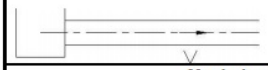
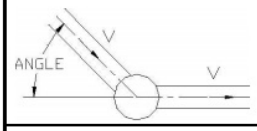
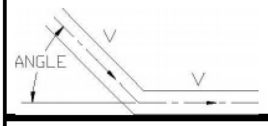
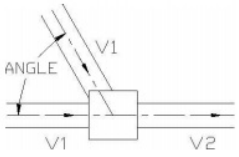
HL = Head loss or gain (ft)

V_1 = Upstream velocity (fps)

V_2 = Downstream velocity (fps)

g = Gravity constant (32.2 ft/s^2)

Kj = Coefficient of loss per

Inlet		
Schematic		**Kj**
		1.25
Manhole at Change in Pipe Direction		
Schematic	**Angle**	**Kj**
	90°	0.55
	60°	0.48
	45°	0.42
	30°	0.30
	0°	0.05
Bend in Pipe		
Schematic	**Angle**	**Kj**
	45°	0.35
	30°	0.20
Manhole		
Schematic	**Angle**	**Kj**
	0°	1.00
	22 1/2°	0.75
	45°	0.50
	60°	0.35
	90°	0.25

Sec. 15 - Detention/Retention Facility Design

a) Detention facilities shall be designed based upon the following minimum criteria:

    4) Detention shall be provided for the 2, 5, 10, 25, and Q_{100} design storms based on the results of a downstream assessment. Sites without a downstream assessment will be required to provide detention to undeveloped runoff rates.

    5) Pilot channels may be required for detention facilities for maintenance purposes if the bottom slope is less than 2%.

    6) The Engineer shall provide a maintenance plan for the detention facility as part of the design. The maintenance plan shall indicate the ingress and egress locations to enter and maintain the pond, maintenance roles and responsibilities, contact information for the party responsible for the maintenance, and a maintenance schedule.

b) Should the results of a downstream assessment show that the downstream facilities are adequate and on-site detention is not required, fully developed off-site conditions must be taken into account for the on-site design facilities.

c) Detention Storage Calculation

    1) Detention facilities without upstream detention areas and with drainage areas of 20 acres or less can be designed using the Modified Rational Method otherwise the Unit Hydrograph Method shall be used.

    2) No required parking space or fire lane may be located within a surface drainage pond. A maximum depth of 6” of ponded water is allowed in the parking lot.