9.2.01.F continued

4. Invert Protection.

    a. Ditch invert protection shall be used when velocities exceed 3 feet per second.

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

5. Depth and Size Limitations.

    a. Maximum depth shall not exceed 4 feet from adjacent edge of pavement.

    b. Roadside ditch bottoms shall be at least 2 feet wide, unless design analysis will support a narrower width.

    c. Ditches in adjoining and parallel easements shall have top of bank not less than 2 feet from the outside easement line.

9.2.01.G. Design of Outfalls: Outfalls from storm sewers or detention facilities that discharge directly into a channel or other HCFCD facility shall be designed and constructed in accordance with HCFCD criteria. If the criteria conflicts with City of Houston, the more restrictive criteria shall govern.

9.2.01.H. Stormwater Detention.

1. The intention of Stormwater detention is to mitigate the effect of New Development, Redevelopment, or Site Modifications on an existing drainage system. Stormwater detention volume requirements are based on the acreage of the Disturbed Area that results in Impervious Surface or alters stormwater runoff. Stormwater detention volumes are calculated at the minimum rates set forth in Paragraph 9.2.01.H.3.

2. Application of Detention.

    a. The use of on-site detention is required for all Developments within the City and for new or expanding utility districts within the City's ETJ. Detention may not be required if the City has developed detention capacity for a drainage watershed, and/or infrastructure improvements, to serve the drainage watershed in compliance with the requirements of this Chapter. Under these conditions, the City will consider a funding contribution in lieu of on-site detention volume constructed by the owner.

    b. Stormwater detention requirements are invoked for redevelopments that include disturbed area resulting in Impervious Surface.

    c. If the drainage system outfalls directly into a channel maintained by HCFCD, and the requirements of HCFCD include payment of an impact fee, then no further impact fee will be required by the City.

9.2.01.H.2
continued

d. Project site that discharges directly into the Harris County, HCFCD, Fort Bend County, Montgomery County or other jurisdictions requires their review and approval.

e. If the detention criteria conflicts with Harris County, HCFCD, Fort Bend County, Montgomery County or other jurisdictions, the more restrictive criteria shall govern.

f. City no longer allows timing analysis to avoid detention requirements.

g. A master drainage plan for the purpose of grandfathering projects regarding drainage and detention plan is as follows:

A master drainage plan establishes the current and future drainage plan for a developmental site. A master drainage plan generally consists of drainage, grading, detention, and other applicable site plans. These site plans contain detailed calculations for impervious area, detention, restrictors, flow rate, etc. For any master drainage plan with provided detention that is based on the Atlas 14 rainfall data, the City shall allow Development to proceed under the approved master drainage plan for up to five years. If the master drainage plan for provided detention is not based on the Atlas 14 rainfall data, then the delta of the detention requirement must be provided by the property owner.

h. Plat, replat, change the use of, or subdividing any tract to reduce stormwater detention requirements will not be permitted. Original tract size on plat or replat, change the use of, subdividing, HCAD and survey will be used to determine stormwater detention requirements.

3. Calculation of Detention Volume.

a. Detention volume for redevelopment and new Development areas is calculated on the basis of Disturbed Area that results in Impervious Surface (defined in 9.1.04.O) or alters stormwater runoff, associated with the project development.

b. Detention Volume for Criteria 1: For a tract containing only one Single family residential (SFR) home, follow Table 9.3.

9.2.01.H.3.b
continued

Table 9.3 - Detention Volume For Criteria 1

SFR Tract Size	Percentage/Total Impervious Area[i]	Detention Required (Y/N)	Detention Volume	Notes
One SFR tract ≤ 15000 SF	% Total impervious area ≤ 65% of tract	N	N/A	1-2
One SFR tract ≤ 15000 SF	% Total impervious area > 65% of tract	Y	0.75 ac-ft/ac rate × impervious area in excess of 65% of tract	1-2
One SFR tract >15000 SF	Total impervious area ≤ 9750 SF	N	N/A	1-2
One SFR tract >15000 SF	Total impervious area > 9750 SF	Y	0.75 ac-ft/ac rate × impervious area in excess of 9750 SF	1-2

[i]Total impervious area = (existing + proposed) impervious area.

Notes for Table 9.3:

(1) For a tract with multiple lots, the detention exemption shown in Table 9.3 is not applicable. Refer to Table 9.4 for detention volume requirements.

(2) No Sheet Flow shall be permitted to an alleyway, neighboring properties, nor to a ditch. Without sharing storm outfall with others, a point of connection shall be through a curb via a 4-inch schedule 40 pipe or to the roadside ditch with a 12-inch schedule 40 pipe within the ROW.

c. Detention Volume for Criteria 2: For tracts with SFR Developments with direct driveway access, joint access, shared access, courtyard access drive or multi-unit residential (MUR) Development, follow Table 9.4.

9.2.01.H.3.c
continued

Table 9.4 - Detention Volume For Criteria 2

Tract Size	Percentage/Total Impervious Area[i]	Detention required (Y/N)	Detention Volume	Notes
Tract ≤ 15000 SF	Total % impervious area within tract ≤ 65% of tract	N	N/A	1-5
Tract ≤ 15000 SF	Total % impervious area within tract > 65% of tract	Y	0.75 ac-ft/ac rate × impervious area in excess of 65% of the tract	1-5
15000 SF < Tract < 1 acre	Total impervious area within tract ≤ 9750 SF	N	N/A	1-5
15000 SF < Tract < 1 acre	Total impervious area within tract > 9750 SF	Y	0.75 ac-ft/ac rate × impervious area in excess of 9750 SF	1-5
Tract ≥ 1 acre	All proposed impervious area	Y	Refer to requirements in Table 9.5	1-5

[i]Total impervious area = (existing + proposed) impervious area also including direct driveway access, joint access, shared access, courtyard access drive or MUR Developments.

Notes for Table 9.4:

(1) When a tract of one acre or more is divided into multiple lots; detention is required for all proposed impervious area within the lot. No residential exemption will be granted for the individual lot within this subdivision tract.

(2) No Sheet Flow shall be permitted to an alleyway, neighboring properties, or a ditch. For projects using Table 9.4, a subsurface drainage system with one shared outfall is required. A point of connection shall be through a minimum 24-inch RCP inside diameter or equivalent cross-section described in 9.2.01.C.4.a. A separate project, plan and profile shall be submitted to OCE for storm outfall approval.

An alternative outfall option to SFR Developments that are 15,000 SF or less with direct driveway access, joint access, shared access, courtyard access drive, and MUR Developments: Storm outfall analysis to be provided by a state of Texas Licensed Professional Engineer to justify using a 4-inch schedule 40 pipe curb cut or 12-inch schedule 40 pipe connection to the roadside ditch. This option is only available if curb or ditch is directly fronting these Developments. The Professional Engineer shall confirm through storm outfall analysis that there is no negative drainage impact on the City system.

9.2.01.H.3.c
continued

(3) The detention exemption for impervious area should be proportionate among all the lots within the tract; this also includes any direct driveway access, shared access, joint access, and courtyard access drive. A state of Texas Licensed Professional Engineer shall breakdown impervious area calculation for each lot to take the detention exemption.

(4) A public alley created with recorded plat prior to January 1st, 2023, is exempt from detention requirements.

(5) Proposed permanent access easement (28' PAE), private alley, public alley, or similar accessway by any other name requires detention; no detention exemption will be allowed.

d. Detention Volume for Criteria 3: For other projects not subject to 9.2.01.H.3.b or 9.2.01.H.3.c, follow Table 9.5.

Table 9.5 - Detention Volume For Criteria 3

Tract Size	Proposed Percent Impervious[i]	Detention Required (Y/N)	Detention Volume	Notes
Tract < 1 acre	All proposed impervious area	Y	0.75 ac-ft/ac rate × proposed impervious area of the tract	1-2
1 acre ≤ Tract ≤ 20 acre	All proposed impervious area	Y	Follow Figure 9.2/Table 9.6 Minimum Detention Rate chart/table	1-4
Tract > 20 acre	All proposed impervious area	Y	Follow the most current version of the HCFCD PCPM; Minimum rate is 0.75ac-ft/ac	1-4

[i]Proposed percent impervious = proposed impervious area/Disturbed Area.

Notes for Table 9.5:

(1) No Sheet Flow shall be permitted to an alleyway, neighboring properties, or a ditch. For projects using Table 9.5, subsurface drainage system is required. A point of connection shall be through a minimum 24-inch RCP inside diameter or equivalent cross-section described in 9.2.01.C.4.a. A separate project, plan and profile shall be submitted to OCE for storm outfall approval.

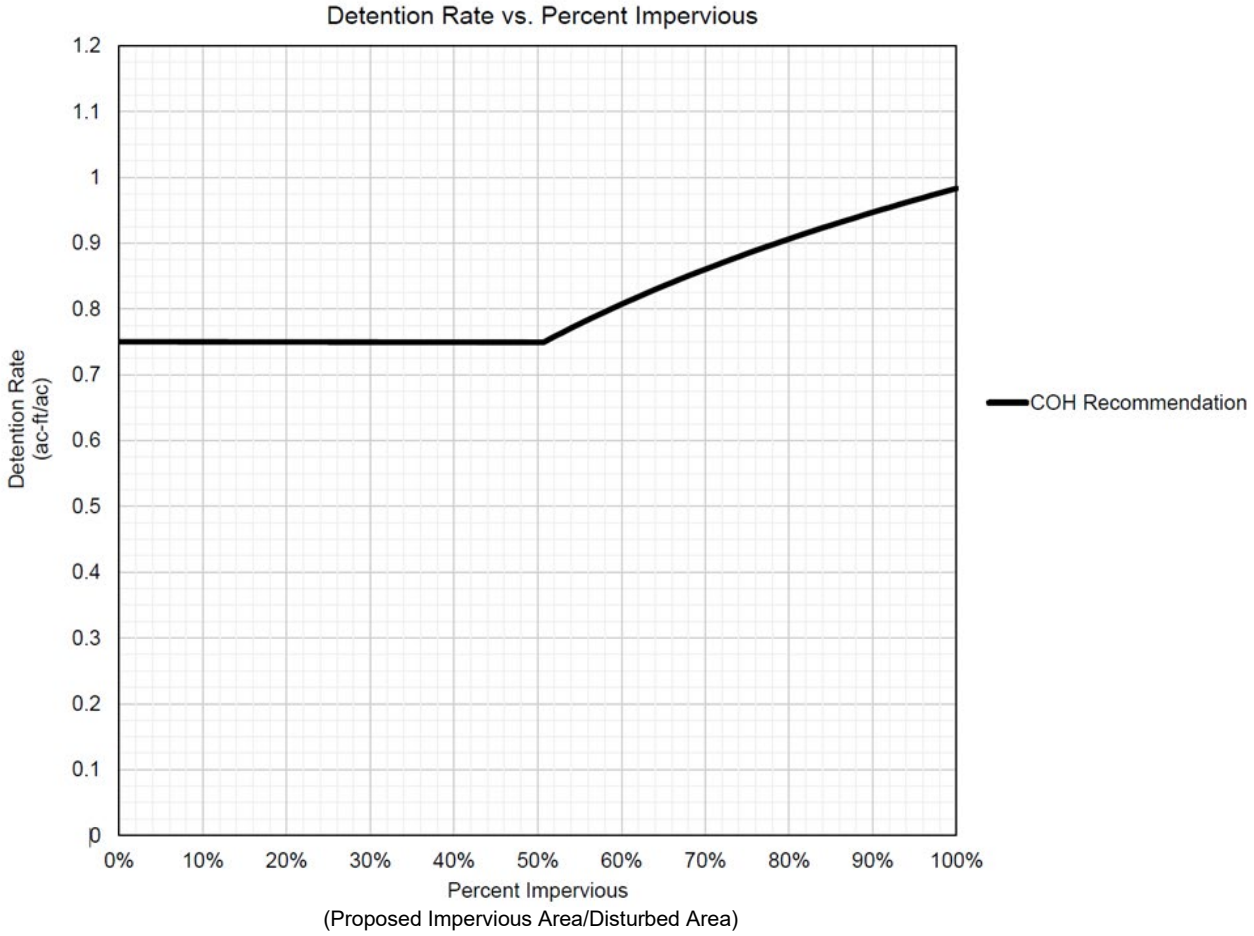
9.2.01.H.3.d continued

(2) For projects within City limits, the minimum detention rate is 0.75 acre feet per acre.

(3) Tract size greater than 20 acres: Detention calculation will be per the most current version of the HCFCD PCPM. Refer to https://www.hcfcd.org/About/Technical-Manuals/2019-Atlas-14-Policy-Criteria-and-Procedures-Manual-PCPM

(4) For those properties equal to 20 acres or more, if property is added to become larger than 20 acres, then the curve/values shown in Figure 9.2 and Table 9.6 must be utilized on the additional property. The percent Impervious Surface will be used to define the detention rate.

Figure 9.2 - Minimum Detention Rate Chart



9.2.01.H.3.d continued

Table 9.6- Minimum Detention Rate

Proposed Percent Impervious (Proposed Impervious Area/ Disturbed Area)	**Minimum Detention Rate** acre-foot/acre
0% - 51%	0.75
55%	0.78
60%	0.81
65%	0.83
70%	0.86
75%	0.88
80%	0.91
85%	0.93
90%	0.95
95%	0.97
100%	0.98

e. In private parking areas, and private streets, provide detention or portion of detention utilizing underground system or detention pond, whenever possible. If the existing conditions do not allow for underground detention or detention pond, detention through ponding in private parking areas, private transport truck only parking areas will be considered. Engineer shall provide calculations and analysis to the Office of the City Engineer for approval of design method prior to plan submittal.

f. If approved for detention through ponding in private parking areas, the maximum depth of ponding cannot exceed 9 inches directly over the inlet and paved parking areas must provide signage stating that the area is subject to flooding during rainfall events.

   If approved for detention through ponding in private transport truck only parking, the maximum depth of flooding cannot exceed 15 inches directly above the inlet and signage must be provided stating that the area is subject to flooding during rainfall events.

g. All mitigation facilities shall be located within or adjacent to the project area except for roadway projects or projects where impacts are mitigated in a regional stormwater detention facility. Engineer shall provide calculations indicating receiving stormwater system was designed to have conveyance capacity to non-adjacent detention facilities.

h. Low Impact Development (LID) techniques that are considered acceptable for achieving detention are Bioretention, Infiltration Trenches, Porous Pavement, Vegetative Swales, Green Roof, Hard Roof, and Rain Barrels. See section 9.10.01 for LID design guidelines.

9.2.01.H.3.h continued

Review and approval of engineering calculations demonstrating the volume of detention achieved for each LID feature will be required.

If LID techniques are considered for achieving detention, review and approval of a maintenance and Life Cycle plan are required per this section and section 9.2.01(H) of this chapter. Review and approval of engineering calculations demonstrating the volume of detention achieved for each LID feature will be required. This plan shall be signed and sealed by a professional registered engineer and included as part of the review and approval process.

i. For any new development or any part of an existing development that is still undeveloped, the most recent detention requirements would apply.

4. Calculation of Outlet Size.

a. Detention pond discharge pipe into an existing storm sewer line or existing City of Houston ditch:

(1) If the maximum pool elevation is at or below the design hydraulic grade at the drainage system outfall, the discharge line shall be sized for the Design Rainfall with the discharge pipe flowing full. The pond will float on the drainage system to provide maximum benefit.

(2) If the maximum pool elevation is at or above the hydraulic grade at the drainage system outfall, provide a reducer or restrictor pipe to be constructed inside the discharge line. The discharge line shall be sized for the Design Rainfall with the discharge pipe flowing full.

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

(1) Allowable Discharge Rate - Use the lowest of the discharge rates described below:

9.2.01.H.4.b.(1)
continued

(a) Restrictor pipes will provide a combination of low level and high level controlled release from the detention basin. The low level restrictor pipe (primary orifice) shall be sized to provide a release rate of 0.5 CFS/acre when the detention basin water depth is 25% of capacity. The low level restrictor pipe (primary orifice) shall be located at the bottom of the basin to provide complete drainage of the pond. The high level restrictor pipe (secondary orifice) shall be sized to provide a combined release rate (from the primary orifice and secondary orifice) of 2.0 CFS/acre at full basin depth. The high level restrictor secondary orifice) shall begin releasing flow when detention basin water depth reaches 75% of capacity. The combined rate of 2.0 CFS/acre is the approximate discharge from an undeveloped tract for the 100-year storm. The basin is considered 100% full when it reaches its maximum volume during the 100-year storm.

(b) Flow discharged to the storm drain shall not exceed the proportional amount of pipe capacity allocated to the Development. The proportional amount of pipe capacity allocated to the Development shall be determined by the ratio of the area (acres) of the Development (in storm drain watershed) divided by the total drainage area (acres) of the storm drain multiplied by the capacity of the storm drain.

(2) Use the following equations to calculate the required outflow orifice:

$$Q = CA\sqrt{2g}\sqrt{h}$$

$$D = Q^{1/2} / (2.25h^{1/4})$$

Where:

Q	=	outflow discharge (cfs)
C	=	coefficient of discharge
	=	0.8 for short segment of pipe
	=	0.6 for opening in plates, standpipes, or concrete walls
A	=	orifice area (square feet)
g	=	gravitational factor (32.2)
h	=	head, water surface differential (feet)
D	=	orifice diameter (feet)

(3) For rectangular weir flow calculation:

$$Q = CLH^{3/2}$$

Where:

Q	=	weir discharge (cfs)
C	=	weir coefficient
L	=	horizontal length (ft)
H	=	head on weir (ft)

The value of the weir coefficient, C, depends on the weir shape (i.e., broad crested or sharp crested) and if the weir is submerged or not. See Brater and

9.2.01.H.4.b.(3) continued

King's Handbook of Hydraulics or other applicable references.

(4) 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.

c. 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.

5. Ownership and Easements.

a. Private Facilities:

(1) Pump discharges into a roadside ditch or storm sewer system must comply with the following:
(a) Submittal of pump specifications, including capacity (GPM) of the pump, on the design drawings.
(b) Provide a backup pump in the event of a pump failure.
(c) Provide emergency power from a second source or install a quick connect for a mobile generator.
(d) Provide a stilling basin to dissipate the energy from the pump outlet prior to gravity flow into the ditch or storm sewer.

(2) The City reserves the right to prohibit the use of pump discharges where their use may aggravate flooding in the public R.O.W.

(3) Responsibility for maintenance of the detention facility must be confirmed by letter submitted to the City as part of the design review and shall also be stated on the drawings.

(4) All private properties being served have drainage access to the pond. Dedicated easements may be required.

(5) No public properties may drain into the detention area.

(6) A private maintenance agreement must be provided when multiple tracts are being served.

(7) All detention facilities must completely drain out of property within 48 hours.

(8) A grading set-back of one fifth the vertical height of the cut or 2 feet minimum is required between the top of the cut of pond or swale and the property line or boundary.

9.2.01.H.5.a continued

(9) A grading set-back of one half the height of the slope (H/2) or 2 feet minimum is required between the toe of the slope of pond or swale and the property line or boundary.

b. Public Facilities:

(1) Facilities will only be accepted for maintenance by the City within the City limits in cases if public drainage is being provided.

(2) The City requires a maintenance work area of 20-foot width surrounding the extent of the detention area. Public R.O.W. or permanent access easements may be included as a portion of this 20- foot width. See Table 9.7 below from the HCFCD PCPM for minimum berm widths around a detention basin.

Table 9.7 - Minimum Berm Width around a Detention Basin

Detention Basins That Are	The Minimum Berm Width Is
Grass-lined with a depth > 7 feet	30 feet
Grass-lined with a depth ≤ 7 feet	20 feet[1]
Grass-lined where side slopes are 8(horizontal):1(vertical) or flatter	10 feet[2]
Grass-lined with the 20-foot maintenance access on a bench	10 feet
Lined with riprap or articulated concrete blocks or partially concrete-lined	Same as grass-lined channel
Fully concrete-lined	20 feet[1]

[1]Backslope swale system not needed.
[2]Maintenance access is on the side slope.

(3) A dedication of easement shall be provided by plat or by separate instrument.

(4) 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.

(5) Backslope drainage systems are required where the natural ground slopes towards the drainage basin. A basin that is within 30 feet of a parking lot or roadway with berms that drain away from the basin does not require a backslope swale. Comply with criteria provided in HCFCD Criteria Manual.

SECTION 2B - STORM STRUCTURAL DESIGN REQUIREMENTS

9.2.02 STRUCTURAL DESIGN REQUIREMENTS

The engineer of record is responsible for the design of all structural components within the proposed storm water design. This includes but is not limited to pipe, box sewers, manholes and junction boxes.

Cast in place and precast structural elements are both allowed given that each design is signed and sealed by a professional engineer.

SECTION 3 - EASEMENT AND RIGHTS-OF-WAY

9.3.01 EASEMENT AND RIGHTS-OF-WAY

Storm sewer easement and R.O.W. requirements are described in Chapter 5 Easement Requirements.

SECTION 4 - SUBMITTALS

9.4.01 SUBMITTALS

9.4.01.A. Submittal for review and comments:

1. Approximate definition of lots and street patterns.

2. Stormwater Information Form.

3. Any proposed drainage easements.

4. Floodplain information, including floodplain boundary, if any; FEMA map number, effective map date and zone.

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

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

7. Design calculations for the Hydraulic Grade Line of each line or ditch, and for detention facilities, if any.

8. Drainage Area Map with the following information:

    a. Existing contour map.

    b. Existing and Proposed drainage area and sub-drainage area boundaries.

    c. Existing and Proposed drainage area (acres) and flow quantity (cfs) draining to each inlet and each pipe segment from storm structure (i.e. manhole, inlet, catch basin, etc.) to storm structure.

    d. Extreme event (100-year) Sheet Flow direction.

    e. Existing condition and proposed condition Sheet Flow direction for the surrounding properties.

9. Plan and profile sheets showing Stormwater design (public facilities only).

    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 Drainage Area Map.

9.4.01.A.9 continued

b. Comply with all applicable submittal requirements of Chapter 19, Code of Ordinances.

c. Review and approval of this project by the City of Houston Floodplain Management Office (FMO) is required.

10. 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 R.O.W., and hydraulic gradient lines for the 2-year and 100-year extreme event; or an alternative equivalent drawing accepted by the City.

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

12. If the detention has been provided by other projects, a Memorandum should be provided to explain how the existing detention facility serves this proposed project.

9.4.01.B. Signature Stage - Submit the following for approval:

1. Review prints with all comments.

2. Original drawings

   a. Provide Stormwater Information Form log number on the cover sheet.

   b. Provide all information requested in section 9.4.01A.

3. Stormwater detention maintenance agreement letters.

4. All required permits from other agencies or departments (i.e., HCFCD approval, Floodplain Management Office (FMO) approval, etc.)

9.4.01.C Geospatial Data Deliverables: Provide GIS datasets in accordance with Chapter 13 – Geospatial Data Deliverables for projects that are proposing or modifying assets identified in Chapter 13 that are or will be operated and/or maintained by the City.

SECTION 5 - QUALITY ASSURANCE

9.5.01 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 responsible for the development of the drawings.

SECTION 6 - SURVEY

9.6.01 SURVEY

Projects shall be tied to 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.

SECTION 7 - LOW IMPACT DEVELOPMENT

9.7.01 LOW IMPACT DEVELOPMENT

Design requirements for Low Impact Development techniques are included in section 9.10.01. Only three techniques may be considered to have impact on impervious surface: Hard Roof, Green Roof, and Porous Pavement.

STORMWATER QUALITY DESIGN REQUIREMENTS

SECTION 8 - STORMWATER QUALITY OVERVIEW

9.8.01 SECTION INCLUDES

9.8.01.A. Criteria for the design of Stormwater pollution prevention procedures and controls for construction activities.

9.8.01.B. Criteria for the design of permanent Stormwater pollution prevention facilities and controls to minimize impacts for new development and decrease impacts for redevelopment on tracts of land of one acre or more.

9.8.02 REFERENCES

9.8.02.A. Stormwater Management Handbook for Construction Activities, City of Houston, Harris County, Harris County Flood Control District, 2006 or Current Edition.

9.8.02.B. Stormwater Quality Management Guidance Manual, City of Houston, Harris County, Harris County Flood Control District, 2001 or current edition.

9.8.02.C. Minimum Design Criteria (MDC) for Implementation of Certain Best Management Practices for Stormwater Runoff Treatment Options, 2001 edition, City of Houston.

9.8.02.D. Article XII of Chapter 47 Water and Sewers of the City of Houston Code of Ordinances.

9.8.02.E. National Pollutant Discharge Elimination System Permit Number TXS001201.

9.8.02.F. Texas Pollutant Discharge Elimination System (TPDES) Permit No. WQ0004685000 (known as the Municipal Separate Storm Sewer System - MS4 permit)

9.8.02.G. Texas Pollutant Discharge Elimination System (TPDES) General Permit No. TXR150000 (known as the Construction Stormwater General Permit)

9.8.02.H. Texas Pollutant Discharge Elimination System (TPDES) General Permit No. TXR050000 (known as the Industrial Stormwater Multi-Sector General Permit)

9.8.02.I. Texas Pollutant Discharge Elimination System Permit Number WQ0004685000

9.8.02.J. International Stormwater Best Management Practices (BMP) Database, www.bmpdatabase.org

9.8.03 DEFINITIONS

9.8.03.A. Applicant - The owner of the land on which the new development or significant redevelopment will occur, or authorized agent.

9.8.03.B. Best Management Practice (BMP) - Schedules of activities, prohibitions of practices, maintenance procedures, and other management practices to prevent or reduce the pollution of waters of the United States. Stormwater management BMP to control or abate the discharge of pollutants when authorized under section 402(p) of the Clear Water Act (CWA) for the control of Stormwater discharges.

9.8.03.C. Best Management Practices (BMP) - A number of Stormwater structural and non-structural control strategies that have become the national focus for the mitigation of Stormwater pollution. BMP types include ponds, bio retention facilities, infiltration trenches, grass swales, and filter strips (Ref EPA.gov- TMDL 2007).

9.8.03.D. Detention - A feature meant to collect a site's stormwater and slowly release it at a control rate to not significantly impact downstream areas.

9.8.03.E. Development - (i) Any activity that requires a subdivision plat or development plat pursuant to Chapter 42 of this Code; (ii) the further subdivision of any reserve tract that is part of a subdivision plat approved by the city planning commission or pursuant to article II of Chapter 42 of this Code; or (iii) any activity that requires a construction permit.

9.8.03.F. Dwelling Unit - A structure, or a portion of a structure, that has independent living including provisions for non-transient sleeping, cooking and sanitation.

9.8.03.G. Engineered Soil - Cement-Based Engineered Soil technology used to stabilize the soil on a work site where it is not solid enough to safely support a building or roadway. Portland cement is blended with soil (sometimes including aggregate) and water and then compacted. The resulting mix, known as soil cement, provides a secure and stable base for construction. It is also used for flood control structures.

9.8.03.H. Engineered Soil Media - Low Impact Design (LID) practice used to reduce storm runoff volume and loading of pollutants in the discharge from its contributing drainage area. Engineered soil incorporate a growing media with the native soil to create a functional soil designed for high infiltration, filtration, and plant sustainability. The layer should be compacted as minimally as possible to allow for surface percolation through the engineered soil layer and into the surrounding native soil or underdrain.

9.8.03.I. Impervious Surface - See article 9.1.04.O.

9.8.03.J. Low Impact Development (LID) - A land planning and engineering design approach to managing Stormwater runoff. LID emphasizes conservation and use of on-site natural features to protect water quality. This approach implements engineered small-scale hydrologic controls to replicate the pre-development hydrologic regime of watersheds through infiltrating, filtering, storing, evaporating, and detaining runoff close to its source. LID based practices are used to reduce Stormwater runoff volume and pollutant loading from developed sites.

9.8.03.K. Notice of Intent (NOI) - A written submission to the executive director from an applicant requesting coverage under general permit, reference definition 9.8.03.G.

9.8.03.L. NPDES - National Pollutant Discharge Elimination System

9.8.03.M. Regulated Construction Activity - Construction activities, including clearing, grading, and excavation that disturb either one acre or more, or less than one acre if the activities are part of a larger plan of development or sale.

9.8.03.N. Residence Time - The length of time that runoff remains in a pond, which is known as the pond's Hydraulic Residence Time (HRT). Removal efficiency is primarily dependent on the HRT.

9.8.03.O. Significant New Development - Development on a currently undeveloped parcel of land one acre or larger without regard to the amount of land that will actually be disturbed, except for development on an existing undeveloped and undivided parcel of one acre or more of one single-family dwelling unit and/or the types of non-commercial building(s) typically associated with a single-family dwelling unit, including, but not limited to, a garage, carport or barn. If the occupancy for any structure excluded under the foregoing exception at any time changes to a commercial use, the owner of the property will at that time have to comply with all requirements of this program. The term also does not include a Stormwater detention basin that includes a water quality feature. The required Stormwater quality permit must include Detention.

9.8.03.P. Significant Redevelopment - Increase of 0.2 acre or more to the impervious surface on one acre or larger developed parcel, but does not include a Stormwater detention basin that includes a water quality feature. The required Stormwater quality permit must include Detention.

9.8.03.Q. SWQMP - Stormwater Quality Management Plan.

9.8.03.R. Stormwater Pollution Prevention Plan (SWPPP) - A site-specific, written document that: Identifies potential sources of Stormwater pollution at the construction site; describes practices to reduce pollutants in Stormwater discharges from the construction site. Reduction of pollutants is often achieved by controlling the volume of Stormwater runoff (e.g., taking steps to allow Stormwater to infiltrate into the soil). Identifies procedures the operator will implement to comply with the terms and conditions of a construction general permit.

9.8.03.S. Stormwater Quality permit or SWQ permit - shall mean a current, valid permit issued pursuant to Article XII, Chapter 47, Division 2 of the City Code of Ordinances. A SWQ permit shall be obtained for all new development and significant redevelopment sites that will construct or modify their detention features. This requirement applies only to the detention feature if the facility has or will have permit coverage for stormwater discharges from industrial activity issued by the state.

9.8.03.T. TPDES - Texas Pollutant Discharge Elimination System

9.8.03.U. Undeveloped Parcel - A parcel on which there are no structures at the time that a construction permit, subdivision plat or other city approval is applied for or required.

SECTION 9 - DESIGN REQUIREMENTS

9.9.01 DESIGN REQUIREMENTS

9.9.01.A. Obtain approval from the Office of the City Engineer (OCE) for exceptions or deviations from these requirements. Exceptions or deviations may be granted on a project-by-project basis.

9.9.01.B. Construction Activity:

1. SWPPPs and BMPs will be developed in accordance with the Stormwater Management Handbook for Construction Activities (9.8.02 Reference A), for sites that are less than one acre the SWPPP can be as simple as the Stormwater Pollution Prevention Plan Detail (DWG No. 01571-01).

2. Construction plans will include a note requiring contractor to comply with the Construction Stormwater General Permit including preparation of a SWPPP and to provide a copy of the Site Notice, NOI, and maintenance checklist to City Engineer or Building Official five (5) work days prior to commencement of any construction activity.

9.9.01.C. New Development and Significant Redevelopment:

1. All designs must be consistent with the Stormwater Quality Guidance Manual[2] (SWQGM) and the Minimum Design Criteria for Certain Stormwater Runoff Treatment Options[3] (MDC), 2001 edition.

2. Pollutants expected from the site must be identified in the SWQMP. BMPs must be designed and selected to remove the pollutants identified.

3. At a minimum, the system must be designed to treat the first 1/2 inch of runoff, except as noted in the SWQGM or the MDC.

4. BMPs listed in the SWQGM but not in the MDC may be acceptable for implementation pending review of design calculations and site applicability. BMPs not listed in the SWQGM may be considered on a case by case basis. Acceptance of these BMPs will require not only review of design calculations and site applicability, but also review of case studies or other data provided by an uninterested third party indicating the effectiveness of the BMP. All calculations and literature must be provided as part of the plan submittal.

5. In addition to meeting the Stormwater quality requirements of this section, the Stormwater system must also meet the requirements of the rest of this Chapter.

[2] The Stormwater Quality Guidance Manual developed jointly by City of Houston, Harris County, and Harris County Flood Control District can be found at http://www.cleanwaterways.org/downloads/professional/guidance_manual_full.pdf
[3] The Minimum Design Criteria Manual developed jointly by City of Houston, Harris County, and Harris County Flood Control District can be found at http://www.cleanwaterways.org/downloads/criteria_2001_edition.pdf

SECTION 10 - DESIGN STANDARDS

9.10.01 DESIGN STANDARDS

9.10.01.A. When design approaches included in this section are incorporated in designs requiring City Engineer approval, the standards of this section will apply.

9.10.01.B. Low Impact Development (LID):

1. Bioretention

a. Overview

Bioretention is a terrestrial-based (up-land as opposed to wetland), water quality and water quantity control practice using the chemical, biological and physical properties of plants, microbes and soils for removal of pollutants from Stormwater runoff. Some of the processes that may take place in a bioretention facility include: sedimentation, adsorption, filtration, volatilization, ion exchange, decomposition, phytoremediation, bioremediation, and storage capacity. Bioretention may also be designed to mimic predevelopment hydrology.

b. Design Criteria

(1) Determine volume of bioretention area below maximum design water surface. Depth of ponding limited to a maximum of 6 inches.

(2) Demonstrate that sufficient area contributes stormwater runoff to the bioretention area to fill the area to its maximum design water surface for the design storm under consideration.

(3) Using in-situ or new soils, design the bioretention area to empty within 48 hours. This may be accomplished through infiltration, evapotranspiration, and/or the design of a subsurface drainage system.

(4) Mitigating detention volume requirements can be reduced by the volume in the bioretention area below its maximum design water surface.

(5) Runoff from commercial areas and parking lots require pretreatment; grass buffer strip or vegetated swales, prior to draining into bioretention area.

(6) Infiltration rates less than 0.5 inches per hour will require a subsurface drainage system.

(7) Geotechnical testing is required to confirm infiltration rates.

9.10.01.B.1.b continued

(8) The cross section for typical Porous Bioretention Basin is shown on Figure 9.7.

c. Inspection and Maintenance Requirements

(1) Verify presence of vegetation considered in design computations (if any) quarterly.

(2) Verify the bioretention area has adequate volume quarterly by checking whether sedimentation has encroached on design volume. This can be done by comparing actual maximum depth against design maximum depth.

(3) Verify ability of bioretention area to drain within 48 hours twice yearly after rainfall event.

(4) Correct deficiencies related to items 1-3 above as needed.

2. Infiltration Trenches

a. Overview

Trenches or basins that temporarily detain a design water quality volume while allowing infiltration to occur over a prescribed period of time. Trenches are applicable for both water quality and water quantity control practices.

b. Design Criteria

(1) In-situ subsoil shall have a minimum infiltration rate of 0.5 inches per hour. Geotechnical testing including one boring per 5,000 square feet or two per project is required to confirm infiltration rate.

(2) Subsurface drainage systems are required where the in-situ subsoil rate is less than 0.5 inches per hour or where the project is constructed on fill soils.

(3) Avoid placement on slopes greater than 15% in fill areas.

(4) Design of the trench area to empty with 48 hours.

(5) Backfill using clean aggregate larger than 1.5 inches and smaller than 3 inches surrounded by engineered filter fabric.

(6) Provide overflow structure or channel to accommodate larger runoff events.

(7) Provide 4 inches PVC observation well into subgrade.

9.10.01.B.2.b continued

(8) Runoff from commercial areas and parking lots require pretreatment; grass buffer strip or vegetated swales, prior to draining into infiltration trench.

(9) Locate bottom of facility at least 4 feet above seasonal high water table elevation.

(10) Locate at least 100 feet from any water supply well.

(11) Maximum contributing drainage area is 5 acres.

(12) Mitigating detention volume can be reduced by the amount of infiltration into the subsoil and the volume of voids within the trench area.

c. Inspection and Maintenance Requirements

(1) Inspect observation well for water level and drainage times.

(2) Conduct landscaping, mowing, and desilting of facility.

3. Porous Paver Systems and Porous Pavement

a. Overview

Porous Pavement consists of a permeable surface course (typically, but not limited to, pavers, asphalt or concrete) that allows infiltration of stormwater runoff into a permeable layer of uniformly graded stone bed. The underlying permeable layer serves as a storage reservoir for runoff and/or infiltration. Porous Pavement is applicable for both water quality and water quantity control practices.

b. Design Criteria

Minimum requirements for porous paver system

(1) Design details for Porous Paver Systems are shown in Figure 9.8 and for Porous Pavement Systems are shown in Figure 9.9.

(2) Restricted to Single Family Residential Construction or Commercial Construction on private property when the system is covered by a Stormwater Quality Permit.

a. Residential Porous Pavers Systems without a subsurface drainage system may be determined as pervious for up to 10% of the lot area for a Single Family Residential (SFR) lot: (1) qualifying for exemption from detention under 9.2.01.H.3 and (2) for basis of City Drainage Utility charges

9.10.01.B.3.b.(2) continued

b. Commercial Porous Paver Systems without a subsurface drainage system that have a Stormwater Quality Permit may be determined as pervious for commercial areas designed for heavy traffic volume and/or vehicles.

(3) In-situ subsoil shall have a minimum infiltration rate of 0.5 inches per hour. Geotechnical testing including one boring per 5,000 square feet or two per project is required to confirm infiltration rate.

(4) Subsurface drainage systems are required for stormwater detention where the in-situ subsoil rate is less than 0.5 inches per hour or where the project is constructed on fill soils.

(5) Subsurface drainage systems are required to be drained in 48 hours.

(6) If the volume of storage within the voids of the subsurface drainage system's stone bed meets the detention volume rate of 0.5 acre-feet per acre of development or 0.2 acre-feet per acre for tracts less than one acre, the area of the porous pavement is considered undeveloped. Otherwise, the total voids storage volume will be credited toward the required detention volume.

(7) If the time of concentration (Tc) from a project site that includes porous pavement and subsurface drainage system, is equal to the undeveloped time of concentration, the development of the project site is considered undeveloped.

(8) Soft porous pavement area shall be considered undeveloped.

(9) The cross-section typically consists of four layers, as shown in Figure 9.9. The aggregate reservoir can sometimes be avoided or minimized if the sub-grade is sandy and there is adequate time to infiltrate the necessary runoff volume into the sandy soil without by-passing the water quality volume. Descriptions of each of the layers are presented below:

Porous Pavement Layer - The porous pavement layer consists of an open graded pavement mixture, concrete or asphalt, specifically designed to be porous with binding agents that create a cohesive wearing surface. The thickness of this layer is based on the design of the pavement section and the loading requirements associated with the intended use. It is important to note that porous asphalt is not to be confused with Open Graded Friction Course (OGFC) that is used as a driving surface on highways which should not be used in this particular application except as an overlay wearing course over the porous concrete or asphalt. Porous pavement may be considered to contain 18% voids (typical range is 16% to 22%). Technical reference for porous concrete is FHWA-HIF-13-006. Technical reference for porous asphalt is FHWA-HIF-15-009.

9.10.01.B.3.b.(9) continued

Top Filter Layer - Consists of a 0.5 inch diameter crushed stone to a depth of 1 to 2 inches. This layer serves to stabilize the porous concrete layer. Can be combined with reservoir layer using suitable stone.

Reservoir Layer - The reservoir gravel base course consists of washed, bank-run gravel, 1.5 to 2.5 inches in diameter with a void space of about 40 %. The depth of this layer depends on the desired storage volume, which is a function of the soil infiltration rate and void spaces, but typically ranges from two to four feet. The layer must have a minimum depth of nine inches. The layer shall be designed to drain completely in 48 hours. The layer shall be designed to store at a minimum the water quality volume (WQv). Aggregate contaminated with soil shall not be used. A porosity value (void space/total volume) of 0.32 shall be used in calculations unless aggregate specific data exist.

Bottom Filter Layer – The surface of the subgrade shall be a 6 inch layer of sand (ASTM C-33 concrete sand) or a 2 inch thick layer of 0.5 inch crushed stone, and be completely flat to promote infiltration across the entire surface. This layer serves to stabilize the reservoir layer, to protect the underlying soil from compaction, and act as the interface between the reservoir layer and the filter fabric covering the underlying soil.

Filter Fabric - It is very important to line the entire trench area, including the sides, with filter fabric prior to placement of the aggregate. The filter fabric serves a very important function by inhibiting soil from migrating into the reservoir layer and reducing storage capacity. Fabric shall be MIRFI # 14 N or equivalent.

Underlying Soil - The underlying soil shall have an infiltration capacity of at least 0.5 in/hr, but preferably greater than 0.50 in/hr. as initially determined from NRCS soil textural classification, and subsequently confirmed by field geotechnical tests. The minimum geotechnical testing is one test hole per 5,000 square feet, with a minimum of two borings per facility (taken within the proposed limits of the facility). Infiltration trenches cannot be used in fill soils. Soils at the lower end of this range may not be suited for a full infiltration system. Test borings are recommended to determine the soil classification, seasonal high ground water table elevation, and impervious substrata, and an initial estimate of permeability. Often a double-ring infiltrometer test is done at subgrade elevation to determine the impermeable layer, and for safety, one-half the measured value is allowed for infiltration calculations.

c. Inspection and Maintenance Requirements

(1) Initial inspection of porous pavement shall be monthly for the first three months post construction.

(2) Semi-annual inspection to ensure pavement surface is free of sediment.

9.10.01.B.3.c continued

(3) Vacuum sweep hard porous pavement followed by high pressure hosing to keep voids free of sediment quarterly.

(4) Annually inspect pavement surface and subsurface drainage system (if any) for deterioration, spalling or malfunctioning.

d. Additional provisions regarding use as a pervious cover. Approval of plans considering the SFR exemption in cases including porous pavement will include the following condition:

Approval of the proposed development is based in-part on capacity for proposed porous pavement to mitigate increased stormwater runoff.

As condition of approval, applicant is required to provide notice to the owner/buyer of the property of the stormwater quality permit and that maintenance of porous paver system or porous pavement is necessary for continued functionality, that requirements for routine maintenance have been published by Houston Public Works and may be revised in the future, and that failure to fulfill maintenance actions and reporting may result in citations or an increase of drainage utility charges for the property pursuant to City of Houston Ordinance Chapter 47 Water and Sewers, Article XV Drainage Impact Fees.

4. Vegetated Swales

a. Overview

Vegetated Swales (dry or wet) are earthen, planted stormwater conveyances designed to filter a shallow depth of runoff (<4 inches) for water quality improvement and to infiltrate stormwater. There are two types, dry or wet. Dry swales include an underdrain system. Wet swales do not. Swales are typically designed to convey runoff from larger storm events, however, treatment and infiltration is reduced during high flows. Infiltrative soils or an engineered porous subgrade is required for infiltration use. Vegetated Swales are applicable for both water quality and water quantity control practices.

b. Design Criteria for Dry Swale

(1) Soil infiltration rate of 0.27 to 0.50 inches/hour.

(2) Trapezoidal or parabolic cross section.

(3) Bottom width shall be 2 feet wide minimum or 6 feet wide max.

(4) Longitudinal slope shall range from 1% to 6%.

(5) Flow depth shall be less than 4 inches for water quality treatment.

9.10.01.B.4.b
continued

(6) Flow velocity shall be less than 1 fps for water quality, less than 5 fps for 2-yr storm (non-erosive velocities for grass and soils).

(7) Length shall yield a 10 minute residence time.

(8) Side slopes shall be flatter than 3:1.

(9) Maximum ponding time shall be 48 hours.

(10) Use proper vegetation (grass or wetland plants) consistent with climate, ecoregion, soils, and hydric conditions.

(11) Provide at least 3 inches of free-board during design storm.

(12) Provide pretreatment of runoff into the swale.

(13) Design details are shown in Figure 9.10.

c. Design Criteria for Wet Swale

(1) Soil infiltration rate of 0.27 to 0.50 inches/hour.

(2) Trapezoidal or parabolic cross section.

(3) Bottom width shall be 2 feet wide minimum or 8 feet wide max. to avoid gullying or channel braiding.

(4) Longitudinal slope shall range from 1% to 6%.

(5) Flow depth shall be less than 4 inches for water quality treatment.

(6) Flow velocity shall be less than 1 fps for water quality, less than 5 fps for 2-yr storm (non-erosive velocities for grass and soils).

(7) Length shall yield a 10 minute residence time.

(8) Slide slopes shall be flatter than 3:1.

(9) Maximum ponding time shall be < 48 hours.

(10) Use proper vegetation (grass or wetland plants) consistent with climate, ecoregion, soils, and hydric conditions.

(11) Provide at least 3 inches of free-board during design storm.

(12) Provide pretreatment of runoff into the swale.

9.10.01.B.4.c continued

(13) Design details are shown in Figure 9.11.

d. Inspection and Maintenance Requirements

(1) Mow dry swales as required during growing season to maintain grass heights in the 4 to 6 inch range. Wet swales, employing wetland vegetation or other low maintenance ground cover do not require frequent mowing. Remove sediment when 25% of the original water quality volume has been exceeded.

5. Green Roof

a. Overview

A green roof, in the simplest terms, is a vegetated roof. The vegetation varies, but must be suitable to the local climate and be drought tolerant unless a method of irrigation is also installed. Installation generally consists of a waterproof membrane installed over a suitably constructed roof deck. For in-situ installations, an under-drain drainage system is installed over the membrane. A lightweight engineered soil is installed on top of the under-drain, as fill dirt or topsoil is typically too heavy to use in rooftop applications. The engineered soil is then planted with select vegetation. If a modular system is selected, the drainage system may already be incorporated into the design, along with the soil and vegetation, depending on the manufacturer. The substrate material and depth are also factors that influence the efficiency of the green roof to store and/or treat stormwater. Roofs consisting of relatively thin soil layers, called extensive roofs, are not as heavy as the intensive roofs, which are covered with thicker soil layers.

b. Design Criteria

(1) Vegetation suitable to the climate and preferably a species that is drought tolerant, unless a method of irrigation is provided, shall be installed. The effect of wind on the vegetation shall also be considered when selecting the roof foliage, as wind velocities are typically higher at rooftop elevations.

(2) The amount of credit given for the rainfall amount stored shall be as prescribed by the manufacturer for a modular system.

(3) The amount of credit given for the rainfall amount stored for non-modular systems shall be calculated for the engineered soil media. The rate shall be derived by in-situ porosity testing. The porosity test shall be performed four times with the first time results being discarded and the three remaining results averaged. The test shall require the first sample remain wet a minimum of 1 hour. The subsequent porosity tests shall be performed the same day. In no case shall the storage volume be credited more than 33% of total volume, as that is the assumed volume of clean

9.10.01B.5.b.(3) continued

graded washed gravel.

(4) The roof membrane must be sufficiently designed and installed to pond a minimum of 1 inch of water at the most shallow point on the roof for 24 hours without leaks. This shall be tested in the same manner as shower pans are tested under the building code. Additionally, special consideration shall be given for the plant root structure and prevention of soil migration during membrane selection. A root barrier may also be required to protect the waterproof membrane integrity.

(5) The under-drain drainage system shall be designed for the selected plant's tolerance for drought and varying soil moisture contents by maintaining the proper balance of moisture and aerobic conditions within the soil media for optimum vegetation sustainability. Design provisions shall address higher volume rainfall events to keep excessive amounts of water from ponding on top of the soil, to prevent erosion, and to prevent soil media saturation for extended periods. Structural calculations shall be submitted that demonstrate the structure's ability to sustain the additional loading of the green roof appurtenances plus the maximum water weight that could be stored.

c. Inspection and Maintenance Requirements

(1) A maintenance plan for the green roof system shall be developed in accordance with the membrane manufacturer's instructions and plant species selected. At a minimum, maintenance inspections shall be performed at least four times per year. The maintenance plan shall include provisions for vegetation maintenance and replacement as needed to maintain a minimum 80% coverage/survival rate in order to sustain Stormwater quality and/or detention credits. Irrigation may be required initially in order to establish the roof vegetation and to supply water under severe drought conditions. Any requirements for initial or intermittent use of fertilizer and pesticides for disease or insect control shall be identified in the plan. Plant species shall be carefully selected to minimize intermittent fertilizer and pesticide applications.

(2) Each green roof installation shall be inspected by the agency responsible for issuing the Stormwater quality or detention credits to check compliance with the approved drawings before final acceptance is issued and the proper credits are approved. At a minimum, the following items shall be checked during the inspection:

(a) Results from porosity testing (for non-modular installations).

(b) Certification from a registered Professional Engineer or registered Architect that the green roof, including membrane, drain system and engineered soil media system, was installed per the approved (permitted) drawings and operates as designed.

9.10.01.B.5.c.(2) continued

(c) Drawings of the green roof installation.

(3) Once the green roof is installed and established, additional inspections will be required in order to properly maintain the vegetation, drainage system and roof membrane. Routine inspections shall be conducted and associated maintenance activities performed on the following:

(a) Joints at adjoining walls, roof penetrations for vents, electrical and air conditioning conduits shall be inspected regularly for leaks. The ceilings located directly below the green roof installation shall also be visually inspected for signs of water staining or leaking.

(b) Designated drainage paths and drainage system components shall be inspected to ensure proper surface drainage is maintained and that the soil layer is drained to prevent excessively saturated soils. Vegetation selected to tolerate drought conditions may rot or die if the soil is allowed to become saturated for extended periods.

(c) Vegetation shall be visually inspected to identify weeds, accumulated trash or debris, dead or dying vegetation, disease or other infestation problems requiring maintenance attention. Weeds and dead vegetation shall be removed on a regular basis, especially right after the roof is planted. If a certain plant or grass species continues to die, that plant or grass shall be removed and replaced with a more tolerant species. Certified professionals shall only be used to apply chemical applications for the control of disease or insects at trouble spot locations.

(d) Trimming and pruning shall be done in accordance with horticulture practices to keep vegetation aesthetically groomed.

6. Hard Roof

a. Overview

Horizontal roof surfaces can be used to attenuate peak runoff associated with rainfall and effectively detain flow resulting from smaller rain events.
The detention volume can be controlled in several ways, but typically a simple drain ring is placed around the roof drains. As stormwater begins to pond on the roof, flow into the roof drains is controlled by orifices or slits in the drain ring. Extreme flows can be designed to overflow the ring and drain directly to the roof drains or be directed to openings in the parapet walls to prevent structural and flood damage to the roof. The roof deck must be designed to withstand the live load and be properly waterproofed.

9.10.01.B.6 continued

b. Design Criteria

(1) The structural capability of the roof system must be considered when designing a temporary rooftop storage system. For example, a 3 inch water depth is equivalent to a load of 15.6 lbs/sq.ft., which is less than most current building code requirements for live loads.

(2) Consideration must be given to the placement of electrical devices on the roof, such as air conditioning or ventilation systems and lights, and proper measures shall be taken to protect the electrical devices from the collected water.

(3) Overflow mechanisms shall be provided so that there is no danger of overloading the roof storage system during major storms. Additionally, roof slopes shall be designed to drain positively toward the roof drains to help minimize localized roof ponding or 'bird bath' formation after the detained water volume is released.

(4) It is recommended that Chapter 16 of the International Building Code, Current Edition be used for additional structural criteria along with ASCE Standard Reference Number 7, Minimum Design Loads for Buildings and Other Structures.

(5) The amount of credit given for detention volume for rooftop storage shall take into account that many flat roofs already pond significant amounts of water, although not by design. Therefore, when measuring credit given for hard roof detention volume, it is recommended that only credit be given for the total rooftop storage volume less the rooftop storage volume associated with the first inch of rain. Typically, rooftop storage volumes are only effective during the smaller, more frequent rainfall events as the larger, less frequent storms typically exceed the rooftop storage capacity.

c. Inspection and Maintenance Requirements

(1) Each hard roof installation shall be inspected by the agency responsible for issuing the detention credits to check compliance with the approved drawings before final acceptance is issued and the proper credits are approved. At a minimum, the following items shall be checked during the inspection:

(a) Roof penetrations for ventilation, electrical or plumbing connections to verify proper sealing against leaks.

(b) The overflow system that drains excessive rainfall off of the hard roof once the maximum storage volume is captured.

9.10.01.B.6.c continued

(c) Certification from a registered Professional Engineer or registered Architect that the hard roof, drain system and appurtenances have been installed and operate as designed.

(d) Drawings of the hard roof installation.

(2) Once the hard roof is installed, additional inspections will be required in order to properly maintain the drainage system and roof membrane. Routine inspections shall be conducted and associated maintenance activities performed on the following:

(a) Designated drainage paths and drainage system components shall be inspected to ensure proper surface drainage is maintained and that the roof is draining properly after the collected stormwater volume is released from a rainfall event.

(b) Routine inspections to collect and remove any trash or debris from the roof shall be conducted to prevent clogging of the roof drains and overflow drainage system.

(c) Visible cracks in the roof surface shall be identified and repaired in accordance with the roof manufacturer's recommendations in order to maintain roof integrity.

7. Rain Barrels / Cisterns

a. Overview

A cistern ("rain barrel"), ranging from 55 gallons to several hundred gallons in capacity, is placed near the down spout of a house and is used to collect rain water runoff from the roof of the house. The captured water is then typically used as a pure water source for plants and lawns.

b. Design Criteria

(1) Gutters and downspouts carry water from the rooftops to rain barrels as shown on Figure 9.12 and/or connect directly to subsurface drainage system.

(2) Screens are required on gutters to prevent clogging.

(3) Rain barrels shall be equipped with a drain spigot.

(4) Overflow outlet must be provided to bypass rain barrel from large rainfall events.

9.10.01.B.7.b continued

(5) Rain barrel must be designed with removable, child resistant covers and mosquito screening.

(6) Minimum rain barrel capacity equal to 1 inch of runoff from roof top surface area.

c. Maintenance and Inspection

(1) As condition of approval, applicant is required to provide notice to the owner/buyer of the property that the stormwater quality permit and the maintenance of rain barrel / cistern is necessary for continued functionality. The requirements for routine maintenance have been published by Houston Public Works and may be revised in the future. Failure to fulfill maintenance actions and reporting may result in citations or an increase of drainage utility charges for the property pursuant to City of Houston Ordinance Chapter 47 Water and Sewers, Article XV Drainage Impact Fees.

(2) Owner/Buyer of Property shall maintain and inspect Rain Barrels and Cisterns according to the following:

(a) Empty rain barrel after each rainfall event.

(b) Rain barrel shall be inspected annually.

SECTION 11 - QUALITY ASSURANCE

9.11.01 QUALITY ASSURANCE

Final design drawings, BMPs, SWPPPs, and SWQMPs will be sealed, signed, and dated by the Professional Engineer registered in the State of Texas responsible for their development.

END OF CHAPTER