CHAPTER 4

Recommended Performance Standards and Design Approach

This chapter describes recommended performance standards and design approaches to protect water quality through low impact development and conventional practices. These approaches can minimize project cost and long-term maintenance liability while also reducing water supply demand and promoting resilient practices.

4.1 PERFORMANCE STANDARDS

This guidance manual recommends the management of stormwater runoff from development activity through the implementation of performance standards identified in Table 4-1. This includes structural control measures and low-impact development design. The aim of these design standards and environmental incentives is to improve methods of stormwater management by relying less on individual BMPs and more on mimicking existing hydrology through total site design techniques. This approach can eliminate constructed stormwater control measures when impervious cover is limited or produce smaller facilities that are less costly.

Table 4-1: Performance Standards

Performance Standards	Purpose	Minimum Requirements
Pre-development Planning	Clarify stormwater requirements, encourage low impact development that costs less and facilitate permitting	Meeting with the jurisdictional stormwater authority staff and/or engineer
Water Quality and Drainage Management	Improve stormwater runoff water quality and manage runoff quantity. Eighty percent TSS management and peak rate management	Structural practice design, size, and define the low impact development design approach and compliance
Buffer Zones	Protect creeks, rivers, wetlands, and tidal waters from construction activities, manage flood risk	Delineate buffer widths on creeks, rivers, wetlands, and tidal waters
Construction – Phase Erosion and Sediment Control	Minimize construction sediment runoff, protect creeks, rivers, wetlands, and tidal waters	Construction phase erosion control plan per the TCEQ Construction Stormwater General Permit
Water Quality Education	Reduce the runoff of herbicides, pesticides, fertilizers, and trash to creeks, rivers, and tidal waters	Provide to residents and building/ site managers – GLO website
Maintenance of Structural Practices	Ensure long-term water quality and peak management performance, improve appearance and function	Prepare a maintenance plan and perform annual inspections and maintenance when necessary

These performance standards would apply to all new development and redevelopment projects per the criteria below:

Alternate BMP requirements employing low impervious cover levels with vegetative conveyance of stormwater runoff have been established. Compliance with the following specifications is assumed to meet the water quality management performance standards in this guidance manual. Development eligible for these Alternative Standards must meet the following design requirements:

- The gross development site impervious cover is 20% or less and the cluster development sections (individual drainage areas) have 25% or less gross impervious cover,
- Street and drainage network are designed to include the use of open-roadway sections, ribbon curb, and maintenance of sheet flow,
- Stormwater credits as defined in this guidance manual can be used to gain compliance with the impervious cover limits stated above.

- Commercial tracts with gross impervious cover less than 15% can obtain Alternate Standards compliance by providing vegetated filter strips per the guidance manual design criteria.

A cluster development section can be considered as an individual drainage area or discharge point containing development. The impervious cover is computed within this area and divided by the drainage area to determine the cluster development impervious cover percentage.

Development projects with less than 8,000 square feet of impervious cover and less than 1 acre of disturbance are exempt from providing permanent water quality measures. The landowner provides written notification to the regulating community and provides documentation that the planned activities meet these criteria.

Impervious cover includes but is not limited to:

- Pavement including streets, sidewalks, driveways, parking lots, etc;
- Rooftops if not part of a rainwater harvesting system;
- Compacted road base, such as that used for parking areas; and
- Other surfaces that prevent the infiltration of water into the soil.

Bicycle and pedestrian paths separated from other impervious surfaces by a distance of at least 10 feet, except at intersections, are considered sustainable and do not require any special runoff management.

When the development project includes residential tracts that will be developed subsequently, and whose future impervious level is unknown, the assumptions presented in Table 4-2 should be used. The values in this table do not include the area of streets in the development.

Table 4-2: Impervious Cover Assumptions for Residential Tracts

Lot Size	Assumed Impervious Cover (ft^2)
> 3 acres	10,000
Between 1 and 3 acres	7,000
Between 15,000 ft^2 and 1 acre	5,000
Between 10,000 and 15,000 ft^2	4,000
< 10 acres	3,500

4.2 PRE-DEVELOPMENT PLANNING

Pre-development planning is an important first step in all projects.

A pre-development/concept plan meeting should occur for all single-family development projects greater than 20 acres in area and all commercial development greater than three (3) acres in area. The meeting should focus on land plan, slopes, floodplains, buffer zones, water quality management practices, and may include a site reconnaissance.

Sound land use planning is perhaps the most important step in managing construction and post development runoff problems. All new development plans (e.g., subdivisions, shopping centers, industrial parks, office centers, etc.) and redevelopment plans should be based upon accurate topographic data, up-to-date aerial photographs, field reconnaissance of the site, soils information, and knowledge of unique resources that serve amenities and add value to the project. Site planning may then proceed to minimize drainage impacts, avoid the concentration of flow to the maximum extent practical, and use natural topography and vegetation to manage stormwater runoff. Comprehensive site planning can reduce impervious cover and stormwater runoff volume, gain compliance with alternate standards, and avoid costly structural water quality basins.

Once a pre-development plan is prepared for the proposed development, the designer will need to coordinate with the local government to convene a pre-development planning meeting.

4.3 SUSTAINABLE DRAINAGE DESIGN

Sustainable drainage design is necessary for the protection of creek, river, and tidal waters in order to manage stormwater runoff rates and reduce channel erosion and flooding. This section presents the methodology to calculate the drainage design volume and low impact development options to satisfy performance standards. If a planned development cannot achieve compliance with the given low impact development standards, then the project shall provide the design volume in approved structural measures found in Chapter 5.

4.3.1 LOW IMPACT DEVELOPMENT

SINGLE-FAMILY DEVELOPMENT

Low impact development (LID) standards employing low impervious cover levels with vegetative conveyance of stormwater runoff allow developments to protect water quality while minimizing cost and long-term maintenance needs. Compliance with the following specifications is assumed to meet the 80% total suspended solids and peak flow rate management standards using a design storm rainfall depth of 1.5 inches. Development eligible for these low impact development standards must meet the following design requirements:

- The gross development site impervious cover is 20% or less and the cluster development sections (individual drainage areas) have 25% or less gross impervious cover;
- Street and drainage networks are designed to include the use of open-roadway sections, ribbon curb, and maintenance of sheet flow;
- Stormwater credits as defined in this guidance manual can be used to gain compliance with the impervious cover limits stated above; and
- Commercial tracts with gross impervious cover less than 20% can obtain compliance by providing vegetated filter strips per below and satisfying the above conditions.

A cluster development section can be considered as an individual drainage area or discharge point containing development. The impervious cover is computed within this area and divided by the drainage area to determine the cluster development impervious cover percentage.

COMMERCIAL DEVELOPMENT

For commercial projects less than three (3) acres in area, low impact development measures employing vegetated filter strips and grassy swales can be used to comply with performance standards. Commercial development eligible for these low impact development option must meet the following design requirements:

- Projects less than three (3) acres in area can achieve compliance with this section through the use of vegetated filter strips, vegetated swales, and flow spreading methodologies.
- The vegetated filter strip area is computed per the criteria found in this Chapter and designed and constructed per the guidance in Chapter 5.
- Vegetative filter strips must be located down-gradient of the developed areas.
- Runoff must discharge in a sheet flow manner from the impervious areas to the vegetated filter strips.

Projects gaining compliance with low impact development standards still must perform pre-development planning (if required), delineate buffers, prepare an erosion and sediment control plan, and incorporate water quality education materials.

4.3.2. STORMWATER CREDITS FOR LOW IMPACT DEVELOPMENT COMPLIANCE

The stormwater basin sizing criteria provides a strong incentive to reduce impervious cover at development sites, since significant reductions in impervious cover will result in smaller and less costly sustainable drainage measures.

The techniques presented below are considered options for use by designers to gain compliance with the low impact development approach or reduce the size of structural control measures. Due to local codes, soil conditions, and topography, some of these site design features may be restricted. In single-family subdivisions, stormwater credits will most likely be accrued on single-family lots. Since these activities will be constructed by homebuilders and not the developer, the stormwater credit will require easements, deed restrictions, or other articles approved by a regulating entity in the permitting process to ensure the proper installation, maintenance, and survivability. Additional details for each credit can be found in Chapter 5.

Table 4-3: Stormwater Credits for Low Impact Development

Stormwater Credits	Alternate Standard Application	Stormwater Volume Application	Comments
Porous Pavement or Pavers	Reduce paved area IC by 90%	Reduce paved area IC by %90	Product information shall support infiltration in excess of 10 inches per hour
Rainwater Harvesting (cisterns)	Reduce roof top IC up to 75%	Reduce roof top IC based on tank volume ratio to catchment area	Tank volume requirements related to catchment area
Soil Amendment	Reduce IC by 2%	Reduce drainage area IC by 2%	6-8" blended soil depth and appropriate turf
Conservation Landscaping	Reduce IC by 5%	Reduce drainage area IC by 5%	Limitations on turf area, use native plants/shrubs
Disconnection of Roof-Top Runoff	Deduction of rooftop IC based on flow length and rainwater storage	Deduction of rooftop IC based on flow length and rainwater storage	75' flow length for full deduction with 90% grass
Natural Area Preservation	Include natural area in development cluster IC calculation	Natural area is subtracted from drainage basin area	Supports conservation development initiatives, yet connects to hydrology
Vegetated Filter Strips	Reduce IC by 50%	Reduce contributing drainage area IC by 50%	Natural filter strip minimum width of 25 feet or engineered filter strip minimum width of 15 feet and other criteria (slope, vegetation) are met
Vegetated Swale	Reduce IC by 20%	Reduce contributing drainage area IC by 20%	Vegetated channel with a slope of less than 0.5%, a minimum length of 50 feet and a maximum drainage area of 2 acres

IC = Impervious Cover
VFS = Vegetated Filter Strip

See next page for calculation procedures for each stormwater credit.

Porous pavement/pavers. Refers to porous asphalt, concrete, and paver surfaces through which stormwater runoff can infiltrate to the soil profile. Reduced impervious cover credit is computed per Equation 4.1.

Equation 4.1	**Ar = Ap * 0.90**
Where:	Ar = Allowable reduction in impervious cover
	Ap = Area of porous pavement or pavers

See Chapter 5 for details and specifications.

Rainwater Harvesting. Refers to the collection of stormwater runoff from roof-tops and its use for domestic or landscape purposes. Reduced impervious cover credit is computed per Equation 4.2. See Figure 4-1 below.

Equation 4.2	**Ar = ART * %IC REDUCTION FACTOR (Per Figure 4-1 below)**
Where:	Ar = Allowable reduction in impervious cover
	ART = Area of roof-top directed to rain barrel(s) (catchment area) (sq ft)
	% IC REDUCTION FACTOR = % Impervious area reduction
	RBV = Rain barrel volume (cubic feet)

See Chapter 5 for details and specifications.

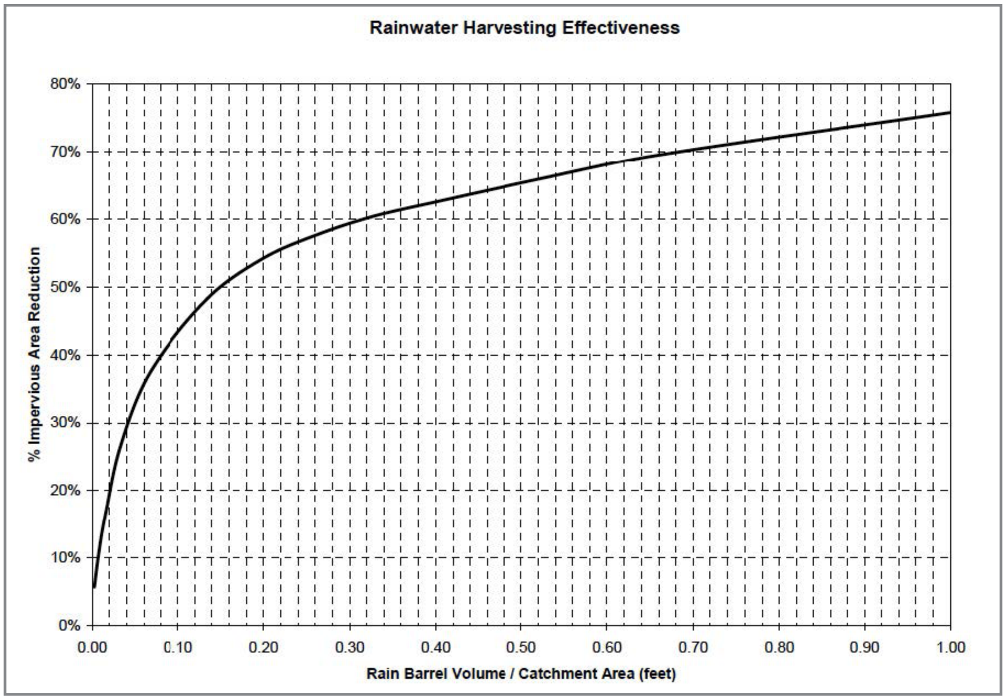

Figure 4-1: Rainwater Collection Credit (Photo courtesy of LCRA Highland Lakes Water Quality Technical Manual, 2007)

Soil Amendment. Refers to the placement of native or blended soils to a depth of six (6) to eight (8) inches to support appropriate turf grasses and landscaping. The soil amendment is applied to all lots within the development. Reduced impervious cover credit is computed by Equation 4.3.

Equation 4.3	**Ar = A * 0.02**
Where:	Ar = Allowable reduction in impervious cover
	AA = Amended area

Conservation Landscaping. Refers to the use of limited turf area, preservation of natural vegetation, and the planting of native trees, shrubs, and perennials to infiltrate stormwater runoff and minimize chemical use. Conservation landscaping should be applied to all lots within the development. Reduced impervious cover credit is computed by Equation 4.4.

Equation 4.4	**Ar = AA * 0.05**
Where:	Ar = Allowable reduction in impervious cover
	AA = Amended area

See Chapter 5 for details and specifications.

Roof-top Disconnection Credit. Using Table 4-4, the designer can deduct the disconnected impervious cover from the total impervious cover. The credit is based on distance of disconnection of roof top from conveyance system and/or use of localized water storage areas (rain gardens, bioretention, dry well, or cistern) in combination with the roof-top disconnection length. This credit applies only to single-family development with an average lawn slope of 5% or less.

Table 4-4: Rooftop Disconnection Impervious Cover Credit

Disconnection Length Provided	0 to 14 ft.	15 to 29 ft.	30 to 44 ft.	45 to 59 ft.	61 to 74 ft.	> 75 ft.
% Impervious Cover Credit	10%	20%	40%	60%	80%	100%
Dry Well, Rainwater Harvesting, Rain Garden, Storage Volume Required to achieve 100% Credit (in combination with flow length)	104 cu-ft.	83 cu-ft.	62 cu-ft.	42 cu-ft.	21 cu-ft.	0 cu-ft.

Source: LCRA Highland Lakes Water Quality Technical Manual, 2007.

Equation 4.5	**Ar = ART * %ICD**
Where:	Ar = Allowable reduction in impervious cover
	ART = Area of roof-top
	%ICD = Impervious cover credit factor per Table 4-3

The reduction in impervious cover per the above techniques is summed and then subtracted from the total impervious cover to determine the effective impervious cover.

Equation 4.6	**ICeff = ICTOT - (Sum of individual Ar)**
Where:	ICeff = Effective impervious cover
	ICTOT = Total impervious cover

The effective impervious cover is used to determine Low impact development compliance or compute the structural measure volume.

Natural Area Preservation Credit. The credit for stormwater basin volume is computed by subtracting the preserved area from the area draining to individual stormwater control measures. This credit is granted for all preservation areas permanently protected under conservation easements or other locally acceptable means. The credit is computed by Equation 4.7.

Equation 4.7	**DAeff = DATOT - ANA**
Where:	DAeff = Effective drainage area
	ANA = Natural area preserved
	DATOT = Total drainage area

When computing stormwater volume for a measure using the natural area preservation credit, the designer will not need to adjust the effective impervious cover based on the reduced drainage area.

Vegetated Filter Strip Credit. The credit is applied when parking lots and roads drain via sheet flow to a natural or engineered filter strip per the criteria and specifications in Chapter 5.

Equation 4.8	**Ar = Ap * 0.50**
Where:	Ar = Allowable reduction in impervious cover
	Ap = Area of parking lot or street with a maximum flow length of 72 ft

Vegetated Swale. The credit is applied when parking lots, roads, and rooftops drain to a vegetated swale designed per the criteria and specifications in Chapter 5.

Equation 4.9	**Ar = Ap * 0.20**
Where:	Ar = Allowable reduction in impervious cover
	Ap = Area of parking lot or street within a 2-acre drainage area

Percent impervious cover. Use Equation 4.10 to find the percentage of impervious cover.

Equation 4.10	**IC = ICeff / DATOT**
Where:	IC = Percent impervious cover

4.3.3. STRUCTURAL PRACTICES SIZING CRITERIA

Structural practices are sized to accomplish water quality protection, creek erosion management, and runoff rate management.

Designers are encouraged to use the design spreadsheet model to compute stormwater volume requirements and determine the benefits of developing under the Low Impact Development approach. The model can be obtained from the GLO website at https://cleancoast.texas.gov/.

STRUCTURAL CONTROLS

Stormwater runoff generated on the site must be managed through the use of one or more of these structural practices if low impact development compliance is not achieved:

- Vegetated Swale
- Vegetated Filter Strip
- Porous Pavement/pavers
- Enhanced Detention
- Bioretention/Rain gardens
- Infiltration Basins

For the structural practices that are sized based on runoff volume (bioretention, enhanced detention, infiltration basins, porous pavement/pavers), the capture volume must be sized to accommodate the runoff from a 1.5" rainfall event at a minimum. The runoff coefficient is a function of the impervious cover and is calculated as:

Equation 4.9 $Rv = 0.05 + 0.90IC$

Where:
Rv = Runoff Coefficient
IC = Fraction of impervious cover in the catchment of the structural practice

The minimum capture volume is then calculated as:

Equation 4.10 $V = P \times A \times Rv/12$

Where:
V = Minimum required capture volume
P = Rainfall depth (1.5 inches)
A = Watershed area of the practice (ft^2)
Rv = Runoff Coefficient

Table 4-5: Runoff Volume 1.5 Inch Storm

Impervious Cover Percentage	Runoff Volume (in)
15%	0.28
20%	0.35
30%	0.48
40%	0.62
50%	0.75
60%	0.89
70%	1.02
80%	1.16
90%	1.29
100%	1.43

The 1.5-inch rainfall event runoff volume will be detained a minimum of 24-hours but not longer than 72 hours.

To provide sediment storage between structural practice maintenance, the structural practice capture volume is increased by 5%.

4.4 BUFFER ZONES AND HYDROMODIFICATION MANAGEMENT

Buffer zones protect waterways, tidal waters, and aquatic resources from the short- and long-term impacts of development activities. The buffer width needed to perform properly will depend on the size of the stream and the surrounding conditions, but a minimum 25-foot undisturbed vegetative buffer is recommended for all waterbodies, even the smallest perennial streams. Where feasible, riparian buffers should be sized to include the 100-year floodplain.

Buffer zones shall remain free of construction, development, or other alterations. By preventing hydromodification (channelization, stream straightening, filling of headwater, stream enclosure pipes/culverts, dams), natural drainage and aquatic systems are preserved, thus, enhancing water quality treatment and preserving natural floodplain characteristics that slow and store floodwaters when compared with channelized systems. This promotes natural management of storm events and helps to greatly reduce long-term maintenance costs. The number of roadways crossing through the buffer zones should be minimized and constructed only when necessary, such as when a significant portion of the site can only be reached by crossing a buffer zone. Other alterations within buffer zones beyond the 25-foot minimum could include utility crossings, when absolutely necessary, low impact parks, and open space. Roadways and utilities crossings should be approximately perpendicular to the buffer zone. Low impact park development within the buffer zone should be limited to trails, picnic facilities, and similar projects that do not significantly alter the existing vegetation and are more resistant to flood damage. Parking lots and roads significantly alter existing vegetation and are not considered low impact.

No stormwater treatment facilities, golf courses, septic tanks, drain fields, or wastewater irrigation shall be located in the buffer zone. Manicured lawns and the application of herbicides shall not be allowed in the buffer. Stormwater discharge from development and water quality measures should be dispersed into overland sheet flow before reaching the buffer zone.

CREEK BUFFER ZONES

Creeks or swales draining less than 320 acres but more than 40 acres shall have a minimum buffer width of 25 feet from the top of bank on each side of the creek or swale or the buffer setback shall be the 100-year floodplain, whichever is greater.

Creeks or rivers draining 320 or more acres shall have a minimum buffer width of 50 feet from the top of bank on each side of the creek or river or the buffer setback shall be the 100-year floodplain, whichever is greater.

WETLAND/BAY/TIDAL WATERS/DEPRESSION STORAGE BUFFER ZONES

A buffer of 25 feet shall be maintained along all tidal waters/coastal marshlands, measured horizontally from the estuarine area.

A buffer of 25 feet shall be maintained along all wetlands as measured from the inland edge of the wetland.

A buffer of 25 feet shall be maintained along all depression storage basins as measured from the edge of the high-water mark. Additionally, the volume within the natural depressions deeper than 2’ and with a surface area larger than 1 acre shall be calculated and maintained so as to not adversely affect upstream/downstream properties. If there are no practical alternatives to maintain the depression storage volume at its existing location, the loss of volume shall be mitigated for on-site and within the same drainage basin. These depressions can be used toward the required detention storage.

4.5 WATER QUALITY EDUCATION

There are opportunities for everyone living along the Gulf Coast to help protect the quality of water resources. Even very simple changes in how landscaping is maintained, pet waste and ordinary household hazardous waste are disposed of, and how septic systems are maintained, make a difference downstream from a homeowner's property. Ideas presented in this section implemented at the neighborhood scale can have beneficial effects on managing stormwater volumes and improving runoff quality.

The performance standards require that a recipient of a development permit participate in a water quality education program using Texas General Land Office, Texas Commission on Environmental Quality, and other recommended water quality education materials that focus on water quality protection and drainage management. The development project manager shall contact the approving entity as the permitted project nears construction completion to initiate the education process. The materials and/or website will be shared with the builders and real estate agents to promote the transfer of materials to the resident, homeowner, or building manager.

Water quality education will promote limited chemical use, proper storage of chemicals, disposal of animal waste, low water demand landscapes, septic system maintenance, and good housekeeping practices to minimize watershed residents' impact to the receiving waterbody. Education activities include:

- The jurisdictional stormwater authority will provide education materials to new residents at the time of occupying their home or establishment.
- Sharing the GLO NPS website with the developer and real estate sales staff to provide to homeowners, residents, and building operators.
- Education events sponsored by the GLO, TCEQ, and other agencies that promote creek and beach cleanups, roadside trash collection days, and adoption of creeks, beaches and highways.
- Household hazardous waste collection events.

The NPS website link can be found at https://cleancoast.texas.gov/.

4.6 STRUCTURAL PRACTICE MAINTENANCE

A maintenance plan developed by the design engineer and acceptable to the jurisdictional stormwater authority should be prepared prior to permit issuance.

Typical operation and maintenance activities for the stormwater structural practices include:

- Post construction inspection by the jurisdictional stormwater authority to verify that BMPs are installed as designed;
- Removal of trash and debris that accumulates in BMPs;
- Inspection of stormwater conveyance network serving the BMP and removal of debris and sediment;
- Evaluation of continuing ability for runoff to infiltrate into infiltration BMPs;
- Vegetation management;
- Inspection of vegetation and deposition of debris after significant storm events;
- Regular inspection of deposition of sediment for removal; and
- Replanting of vegetation, soil stabilization, and debris removal, as necessary.

4.6.1 MAINTENANCE PLAN

1. Specification of routine and non-routine maintenance activities to be performed;
2. A schedule for maintenance activities;
3. Provision for access to the tract by jurisdictional stormwater authority or other designated inspectors;
4. Name, qualifications and contact information for the party(ies) responsible for maintaining the BMP(s); and
5. The plan should be signed and dated by the party responsible for maintenance.

4.6.2. GENERAL GUIDELINES

Both the ability and the commitment to maintain stormwater management facilities are necessary for the proper operation of these facilities. The designer must consider the maintenance needs and the type of maintenance that will take place, in order to provide for adequate access to and within the facility site. Key design factors include:

- Maintainability;
- Accessibility;
- Durability;
- Basin de-watering; and
- Sediment disposal.

Specific maintenance guidance for each sustainable stormwater practice is included in Chapter 5.

4.7 SUBMITTAL REQUIREMENTS

The following information must be submitted to the municipality for any new development or redevelopment where more than 10,000 square feet of impervious cover is added and the project disturbs one acre or more of land or is part of a larger common plan of development or sale that will result in disturbance of one acre or more. This material must be accompanied with a letter signed and sealed by a licensed engineer indicating that all drainage requirements in this guidance document have been met.

4.7.1. SITE ANALYSIS AND NARRATIVE

The site analysis and narrative should include:

- Location map, size, and existing land use of the site;
- Description of existing land use of all adjacent properties;
- General description of existing site topography, natural and manmade features, county's watershed name, drainage patterns, flow paths, receiving waters, soil types and ground cover;
- Identification if the following exist on-site:
    - Any body of water, including natural and manmade drainage paths, identifying each as natural or not.
    - Any natural depressions or areas identified as probable areas of inundation for 100-year storm events.
- A general description of the proposed uses and improvements, lot subdivision, roadways, and other pertinent improvements;
- Phasing and timing of project;
- A general description of proposed drainage, water quality, and erosion and sediment control facilities expected to be used on site and the methodology for choosing the facilities;
- Total Site Area and impervious cover planned for the development;
- Provide a description of the potential pollutant activities to be conducted at the site, if applicable. Such activities of interest include chemical storage and/or use, vehicle, equipment or boat repair and maintenance, on-site wastewater treatment, product fabrication or washing/cleaning activities;
- Confirmation that all applicable regulations and public health and safety requirements will be met by the developer/contractor/builder; and
- A simple drawing to depict the proposed layout, impervious cover areas, general hydrologic information, on-site and adjacent drainage conditions and improvements, and other pertinent information required for site stormwater assessment (a conceptual plan).

4.7.2. SITE LAYOUT AND DRAINAGE DESIGN

The site layout and drainage design should include:

- Legend, north arrow, and scale;
- Existing property lines, ROWs, structures, impervious surfaces and improvements;
- Existing topography - contours;
    - Location of FEMA 100-year Floodplain, Floodway, and Velocity Zone Boundaries that encroach on the site;

- Existing drainage patterns, flow paths, stormwater discharge locations, drainage easements;
- Buffer zones;
- Limits of existing disturbed area;
- Proposed lots and/or building locations, ROWs, roadway locations and cross sections impervious surface areas and pavement types;
- Proposed grading (contours or elevations), drainage patterns and basins, discharge locations, and proposed easements; and
- Size and location and basis of design for all permanent drainage and stormwater quality improvements including: culverts, pipes, detention basins, swales, etc.

4.7.3. DESIGN STEPS

1. Compute the impervious cover for the development. The applicant can use stormwater credits to reduce effective impervious cover and determine compliance with Low Impact Development.
2. Delineate drainage areas within development to define impervious cover percentage at each discharge point or structural control. When a site contains multiple drainage areas, the impervious cover shall be calculated for each area to determine the necessary water quality volume or compliance with the low impact development option in each drainage area.
3. Select the appropriate structural control(s) to meet the site constraints and manage stormwater runoff.
4. Compute the stormwater volume based on the runoff from the design storm in 4.3.3.
5. Design the stormwater controls per the guidance in Chapter 5 including discharge to the buffer zone in a sheet flow manner.

Table 4-6: Permanent BMP Summary

Permanent BMPs	Construction Cost	Recommended Drainage Area Size (acres)	Maintenance Requirement	Liability/ Safety Issues	Other Benefits
Vegetated Filter Strip	Low	< 3 acres or downstream of other measures	Low	None	Resilient
Vegetated Swale	Low	< 2 acres	Low	Low	Resilient
Extended Detention Pond	Moderate	Less than 128 acres	Low to Medium	Low, short term standing water	Promote baseflow enhancement
Bioretention/rain gardens	Moderate	< 10 acres	Medium to High	Low, shallow standing water depth	Promote baseflow enhancement
Infiltration	Moderate	Downstream of BMP	Medium to High	Moderate, standing water	Water supply
Wet Basins	Moderate to High	> 20 acres and less than 128	Medium to High	High, long term standing water	Habitat
Constructed Wetlands	Moderate to High	> 20 acres and less than 128	Medium to High	Moderate, long-term Standing water	Habitat
Stormwater Credits					

Table 4-6: Permanent BMP Summary Continued

Permanent BMPs	Construction Cost	Recommended Drainage Area Size (acres)	Maintenance Requirement	Liability/ Safety Issues	Other Benefits
Porous Pavement	Moderate	No off-site area drains to pavement	Moderate	Low, potential pavement issues	Water supply
Rainwater Harvesting	Moderate	House roof-top	Moderate	Low, rainwater stored in property owner tanks	Water supply
Soil amendment & conservation landscaping	Moderate	Lot size	Low	None	Water supply and resilient
Roof-top disconnection	Low	House roof-top	Low	None	Water supply and resilient
Natural Area Preservation	Low	NA	Low	None	Water supply and resilient
Buffers	Low	Creek, river, and tidal water boundaries	Very Low to none	None	Water supply and resilient

4.8 INCORPORATING PRACTICES INTO TYPICAL DEVELOPMENT PROJECTS

- √ Single Family Residential
- √ Multi Family Developments
- √ Commercial/Retail/Office
- √ Downtown Redevelopment

The purpose of this section is to help visualize ways in which various structural practices can be employed, alone or in combination, to achieve more sustainable drainage site design. Some of the development now occurring in the Coastal Zone already includes a sustainable drainage system, although conveyance and flood control may have been the primary design considerations. This is especially apparent in residential developments that incorporate open channel drainage for stormwater conveyance.

In addition, many developments along the coast are required by drainage districts, counties, and other regulatory entities to provide stormwater detention for flood control. This guidance manual describes in Chapter 6 how these detention facilities, with potentially only the slightest modification, can also improve the performance of drainage systems, while providing aesthetic benefits, recreational opportunities, and wildlife habitat.

4.8.1. SINGLE FAMILY RESIDENTIAL

Structural stormwater controls that make sense in a medium or high-density subdivision include bioretention, porous pavement, and vegetated swales and filter strips. Current construction practices for low density subdivisions usually include features that function as vegetated swales and filter strips.

4.8.2. MEDIUM AND HIGH DENSITY RESIDENTIAL

When designing roadways in medium density areas, conveyance of stormwater in open channels (e.g., vegetated swales and filter strips) are a logical choice if lot widths are of sufficient length to include driveways and culverts. When lots are narrow in width, an alley to service the homes can be constructed in the backyards so that street drainage is not impeded by driveway culverts, thus, promoting sheet flow in a filter strip type method from the street to the vegetated swale. While vegetated swales and filter strips may be difficult to employ in downtown, commercial, or very high density developments because of space constraints, they are well suited to receive stormwater in some lower density areas, such as the medium density subdivision pictured in Figure 4-2. As described in Chapter 2, the use of fertilizers and pesticides should be kept to an absolute minimum in order to realize the full benefits of vegetated swales or filter strips.

Figure 4-2: Medium density neighborhood uses vegetated swales for stormwater conveyance. These swales also provide water quality benefits.

Narrow sidewalks, roads and driveways, separated from each other by vegetation, help to minimize and disconnect impervious surfaces, as in Figure 4-3.

Figure 4-3: Disconnected and minimized impervious cover in Chambers County, Texas.

Driveways which use permeable pavers can help reduce overall impervious cover on a residential site (see Figure 4-4), which reduces detention requirements. Lawns or bioretention areas on either side of the driveway can further improve the performance of a site.

Figure 4-4: Driveway constructed of permeable pavers. (Photo courtesy of Mutual Materials)

4.8.3. WATERFRONT

Waterfront development, whether single family or multi-family, could include similar strategies for stormwater management as some higher density developments. Permeable pavement, bioretention areas, infiltration basins or vegetated filter strips and swales should be employed to collect and treat stormwater. Figure 4-5 illustrates how a variety of sustainable drainage practices can be incorporated into a site.

Waterfront development, whether residential or commercial, should always include an intact riparian zone buffer between the development and the waterway it is overlooking. As discussed in the beginning of this chapter, a riparian buffer should be at least 25 feet wide and should extend the entire length of the development along the waterway.

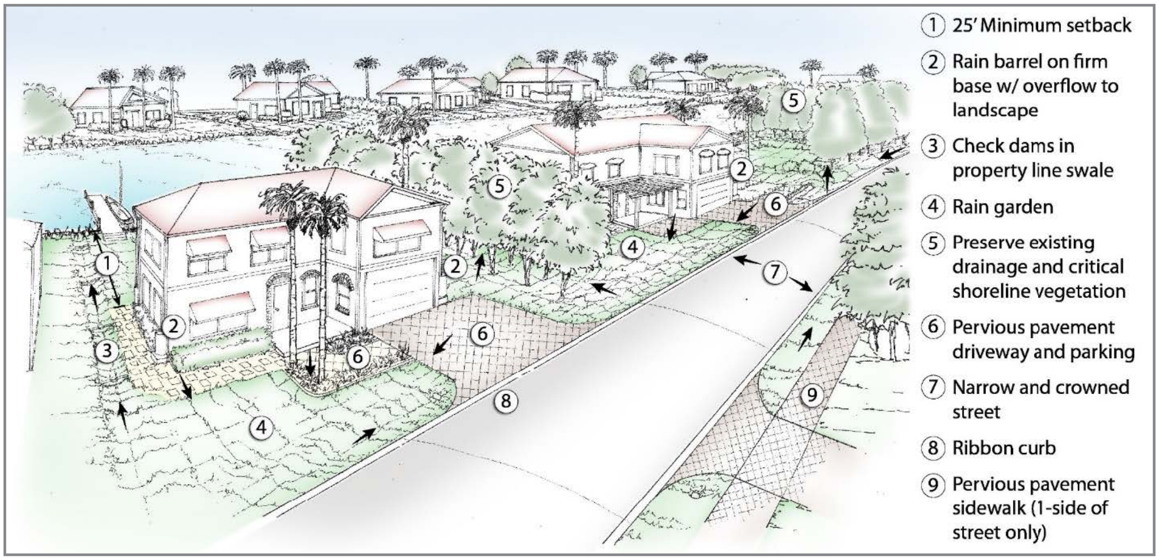

Figure 4-5: Example of waterfront development with sustainable drainage features.

4.8.4. MULTI-FAMILY DEVELOPMENTS

Options for sustainable stormwater management in high impervious cover areas such as multi-family developments include pervious pavers, bioretention areas and infiltration facilities. In Figure 4-6, bioretention areas are integrated with conventional landscaping.

Figure 4-6: Multi-family with vegetated bioretention area. (Photo courtesy of Michael Barrett)

Parking lots in multi-family developments, Figure 4-7, can be outfitted with permeable pavement parking stalls. These permeable pavers serve to reduce the quantity of stormwater as well as improve the functional and aesthetic experience of the parking lot.

Figure 4-7: Multi-family units utilize permeable pavers to beautify their parking lot

Multi-family developments on waterfront lots should include the same elements as other multi-family developments, including disconnection and minimization of impervious cover, pervious pavement, and bioretention or infiltration areas.

4.8.5. COMMERCIAL/RETAIL/OFFICE

Commercial developments are frequently built with a high percentage of impervious cover. When detention is not required, feasible stormwater solutions include permeable pavement, bioretention, infiltration, and, depending on the land use and character of the surrounding land, vegetated filter strips. Figure 4-8 demonstrates how a variety of sustainable stormwater practices can be integrated into the site design. Parking lots can be outfitted with bioretention areas in the center medians, as shown in Figure 4-8, or vegetated filter strips on the edges. Trees in these center islands can provide welcome shade during hot Texas summers.

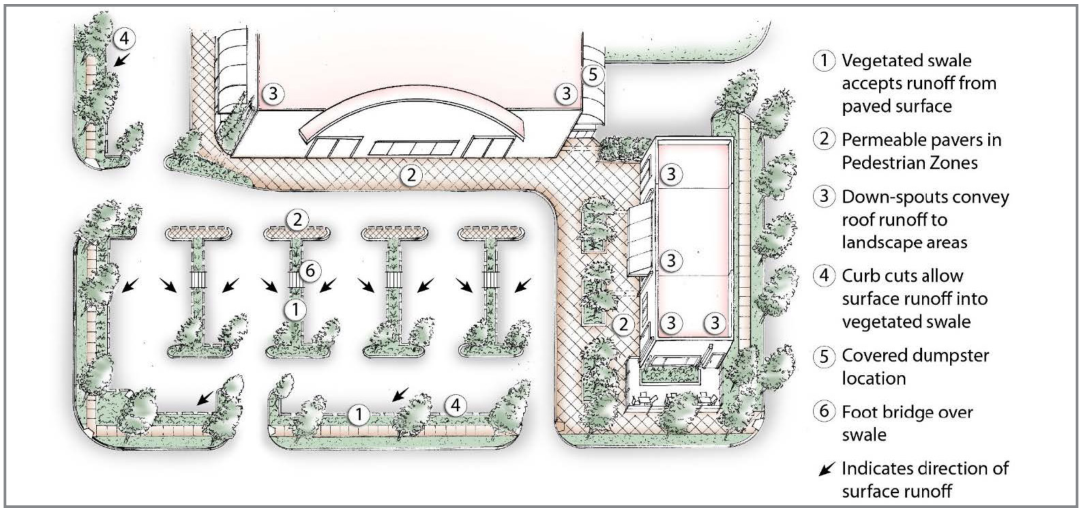

Figure 4-8: Commercial development incorporating sustainable drainage practices.

Parking lots are a key part of commercial establishments and serve as the customer's initial introduction to the business. Parking lots can reflect the quality of the business, and a puddle-free lot with landscaped or shaded areas can improve the customer experience. Figure 4-9 shows two different parking lot designs, one with stormwater controls included in the design, and the other designed and built in a conventional manner.

Figure 4-9: Parking lots can positively influence the customer experience at a commercial development.

To reduce standing water after a storm, parking lots can be fitted exclusively or in part with permeable pavement. While porous pavement is one option is for the entire parking lot, another common configuration includes standard pavement driving lanes which slope towards permeable parking stalls. This is illustrated below in Figure 4-10.

Figure 4-10: Permeable interlocking concrete pavers with regular asphalt driving lane in Cascade Park parking lot, Cameron County, Texas.

Example project designs can be found in the Appendices in the upcoming Manual edition, this will follow EPA and NOAA approval.