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6.0 STORM RUNOFF STORAGE

6.1 GENERAL

In an area such as Fort Bend County, which is generally characterized by flat terrain, the introduction of impervious cover and improved runoff conveyance serves in many cases to increase flood peaks quite dramatically over those for existing conditions. Increases in flows over the existing condition flows off of the site or development to receiving waterways, channels or roadside drainage systems are not allowed unless appropriate mitigation is supplied nearby and that applicable supporting analysis is supplied and agreed upon by the FBCDD Engineer. When physical, topographic, and economic conditions allow it, channel improvements downstream of the development are often used to prevent increased flooding. When this is not feasible, a widely used practice is runoff detention or retention storage, wherein the storm volume is held back in the watershed and released at an acceptable rate. This section of the manual presents information on storage techniques, including guidance for the design of appropriate storm runoff storage facilities. See also Section 8- Drainage Design Criteria for Rural Subdivisions.

6.2 MASTER PLANS

Development in a watershed can have complex and far-reaching consequences on the overall hydrologic regime. For this reason, careful plans for anticipating and meeting the long-term flood control and drainage needs of Fort Bend County have been drawn up on a watershed by watershed basis, although not all watersheds have master plans. Each watershed "master plan" has been formulated to provide the most practical and efficient basin-wide approach to the hydrologic consequences of ongoing or future development, including proper coordination of storm detention facilities and channel improvements. Accordingly, the Fort Bend County Drainage District Engineer must be consulted concerning the status of a particular master plan and the preferred watershed flood control strategies and alternatives. In addition, the models used to develop a master plan must be used in the design or analysis of new projects within the watershed. The models can be obtained from the Fort Bend County Drainage District.

If a master plan is not available for the watershed in which you are trying to develop or design a project you may be able to develop localized master planning information related to your location within the watershed. That planning should include close coordination with the Fort

Bend County Drainage District Engineer. The master plan shall provide for ultimate development upstream including full conveyance flow, to facilitate potential future channel improvements along the channel. The plan shall provide for adequate channel sizing and maintenance berms for ultimate development assuming storm sewer outfall depth requirements. This planning is needed to ensure that adequate right of way, channel sizing and channel depth is provided for each project.

6.3 STORAGE CLASSIFICATION

Storage systems may be classified as either on-line or off-line facilities. They may be designed for either detention or retention of storm water.

6.3.1 Retention Storage

In a retention storage facility, runoff is captured and released only after the storm event is over and the downstream water surface has subsided. A retention storage system is seldom used and when it is special outlet devices or pumps are usually required.

6.3.2 Detention Storage

The vast majority of flood control storage is handled by detention facilities. The purpose of detention storage is to hold storm runoff back but release it continuously at an acceptable rate through a flow-limiting outlet structure, thus controlling downstream peak flows.

6.3.3 On-line Storage

An on-line storage facility is one in which the total storm runoff volume passes through the retention or detention facility's outflow structure.

6.3.4 Off-line Storage

An off-line storage design is one in which storm runoff does not begin to flow into the storage facility until the discharge in the channel reaches some critical value above which

unacceptable downstream flooding will occur. An off-line facility serves to store only the runoff volume associated with the high flow rate portions of the flood event.

6.4 DESIGN PROCEDURES

The following design procedures are intended to insure that new development with detention will not cause any adverse impacts on existing flooding conditions downstream. (Note: The design engineers should contact the Fort Bend County Drainage District Engineer for any specific requirements for the watershed in which the proposed facility is to be located.)

Development drainage reports shall include summary charts that detail the characteristics of the storage facility and show no increase in peak flow rates and/or water surface elevations

6.4.1 For Drainage Areas <50 Acres

The maximum allowable release rate from the detention facility during the 100-year storm event is 0.125 cfs/acre.

The acre-feet of flood control storage, S, to be provided by the facility for the 100-year storm event is shown in Figure 6-1 and Table 6-1 below. The percentage of impervious area used for the storage calculation shall include all areas that are paved or where gravel or crushed stone is used, all rooftops and other covered areas, and all other impervious surfaces, including the portion of the detention pond below the 100-year design water surface elevation.

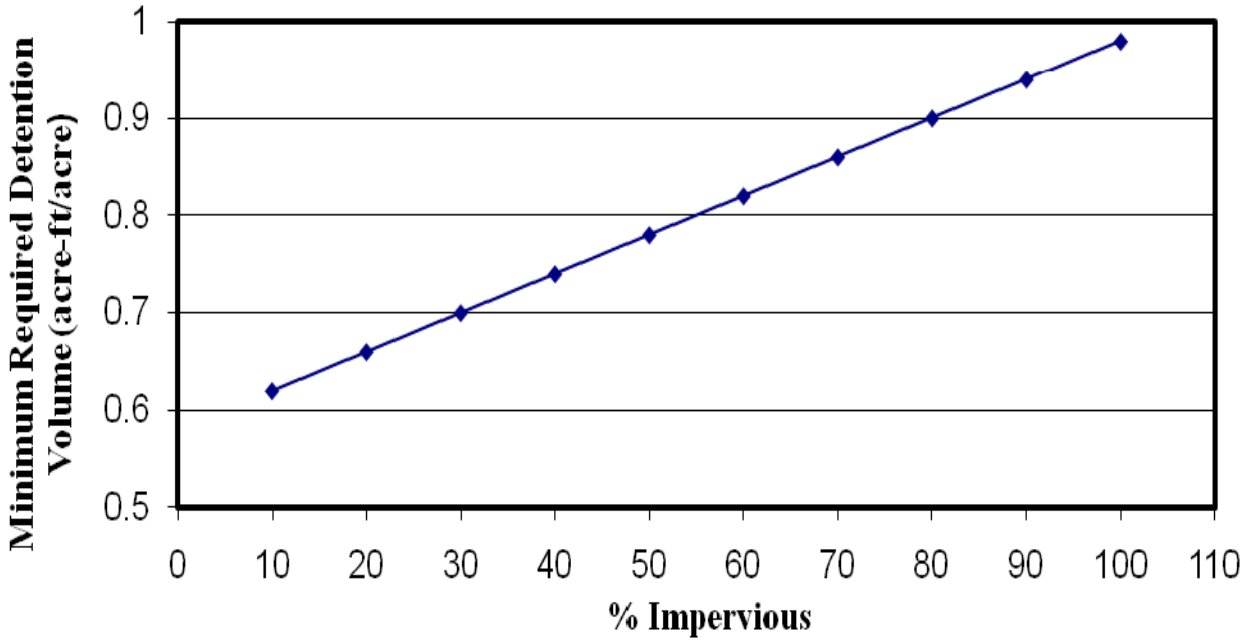

Figure 6-1 Minimum Required Detention Volume for Drainage Areas Less Than 50 Acres

TABLE 6-1

MINIMUM DETENTION RATES FOR

DRAINAGE AREAS LESS THAN 50 ACRES

% Impervious	Minimum Detention Rate (Acre-feet/Acre)
10 %	0.62
20%	0.66
30%	0.70
40%	0.74
50%	0.78
60%	0.82
70%	0.86
80%	0.90
90%	0.94
100%	0.98

The size of the outlet pipe that is required to pass the maximum allowable release rate during the 100-year storm is to be computed assuming outlet control (See Section 4.3.6), by establishing a maximum ponding level in the detention facility during the 100-year storm and assuming a tailwater at the top of the downstream end of the outlet pipe or at a depth in the outlet channel associated with the maximum release flowrate, whichever is higher.

6.4.2 For Drainage Areas ≥50 Acres and <640 Acres

The design engineer has the option to follow the simplified procedure previously described for areas smaller than 50 acres, or the more detailed analysis outlined below for areas larger than 640 acres.

6.4.3 For Drainage Areas ≥640 Acres

The HEC-HMS computer model will be used to size the facility and the outlet structure so that downstream flooding conditions will not be increased. Inflow and outflow hydrographs for detention analysis may be established using other methods approved by the Fort Bend County Drainage District. The existing conditions HEC-HMS model should be established in conjunction with the Fort Bend County Drainage District Engineer. Once existing conditions are established, the new development with the detention facility will be analyzed for the 10-, 25-, and 100-year storm events (and smaller events if the downstream channel has less than 10-year capacity).

The detention facility should be sized such that there is no increase in flow rate and water surface elevation at any point along the channel using HEC-HMS and HEC-RAS. Additional models may be considered, however they should be presented to the District for approval prior to starting.

The maximum allowable outflow rate should be determined from the procedure explained under release rates and maximum allowable discharge.

6.4.4 Design Tailwater Depth

In order to route the inflow hydrograph through the detention facility in the hydrologic model, a relationship must be established between the volume of storage in the pond and the corresponding amount of discharge through the outflow structure. In most cases in Fort Bend County this relationship is directly dependent on the elevation of the tailwater at the outlet of the outflow structure.

For the purpose of establishing an outflow rating curve, detention facilities that are evaluated using computer models shall use a variable tail-water condition based on the frequency storm being analyzed. The variable tail-water stage hydrograph can be developed using the rating curve and the flow hydrograph at the tail-water location. In certain situations where this assumption may be shown not to be reasonable, an alternative tail-water condition can be presented for approval to the Fort Bend County Drainage District.

6.4.5 Release Rates and Maximum Allowable Discharge

For drainage area less than 50 acres, the maximum release rate shall be 0.125 cfs and should be designed assuming a tailwater elevation at the top of the downstream end of the outfall pipe. When outfalling into a roadside ditch, the release rate shall be limited to the proposed developments pro rata share of the bank full capacity of the receiving ditch, considering the ditch at bank-full for the design tailwater condition. Supporting documentation should be submitted that demonstrates the calculations used to determine this share.

If using computer modeling, use variable tail-water conditions and existing conditions flows as the allowable release rate.

6.4.6 Downstream Impact Analysis Requirements

Analyze using HEC-HMS and HEC-RAS through the entire downstream channel section for the 10-, 25- and 100-year events and show no increase in flow rates and/or water surface elevations. If the outfall channel has less than 10-year storm capacity, the analysis must also include the 2-year event.

6.4.7 Final Sizing of Pond Storage and Outflow Structure

Detention or retention facilities shall be sized such that at least one foot of freeboard shall be maintained during the 100-year storm event, as measured from the minimum elevation of the top of the detention or retention facility berm to the maximum 100-year storm water surface elevation.

Detention basins and storm sewer outfalls shall be placed one foot above the flow-line of the receiving channels, creeks and detention pond. The minimum recommended outflow pipe for a detention facility is 24 inches. An 18-inch outflow pipe can be used when outfalling into a roadside ditch. The roadside ditch outfall must have the end of pipe cut to match the roadside ditch side slope and one foot of stabilized sand around the pipe. When further flow restriction is necessary, the restriction should be located at a manhole outside of the Fort Bend County channel right-of-way.

All detention facilities shall be adequately maintained in accordance with the original design so that the basin storage and outfall operate properly. The owner of the basin is responsible for maintaining the basin to the satisfaction of the Fort Bend County Drainage District Engineer.

6.4.8 Storm Sewer Hydraulic Gradients

The hydraulic gradients in storm sewers shall be determined using procedures outlined in Section 5 of this manual. The starting water surface elevation for these calculations shall be the 25-year maximum pond elevation.

If the simplified procedure was used to design the detention facility, the 25-year ponding level can be estimated as being 80% of the depth of the 100-year ponding level.

6.4.9 Allowances for Extreme Storm Events

Design consideration must be given to storm events in excess of the 100-year flood. An emergency spillway, overflow structure, or swale must be provided as necessary to effectively

handle the extreme storm event. See Section 5 of this manual for additional criteria for extreme event swale design and sizing.

In places where a control structure is to be utilized to provide detention directly in the channel, due consideration must be given to the consequences of a failure, and if a significant hazard exists, the control structure must be adequately designed to prevent such hazards.

In addition, detention facilities which measure greater than six feet in height are subject to Title 31 Texas Administrative Code (TAC) Chapter 299 (Subchapters A through E), effective May 13, 1986, and all subsequent changes. The height of a control structure, detention facility or dam is defined as the distance from the lowest point on the crest of the dam (or embankment), excluding spillways, to the lowest elevation on the centerline or downstream toe of the dam (or embankment) including the natural stream channel. Subchapters A through E of Chapter 299 classifies dam sizes and hazard potential and specify required failure analyses and spillway design flood criteria. Appendix B includes a copy of these sections of the TAC.

6.4.10 Erosion Controls

The erosional tendencies associated with a detention pond are similar to those found in an open channel. For this reason the same type of erosion protection are necessary, including the use of backslope swales and drainage systems (as outlined in Section 3), proper re-vegetation, and pond surface lining where necessary. Proper protection must especially be provided at pipe outfalls or junctions into the facility, pond outlet structures and overflow spillways where excessive turbulence and velocities will cause erosion.

The erosion protection could include concrete slope paving, adequately designed erosion control blocks or paving sections. Should erosion be observed, it will be the requirement of the owner of the facility to make appropriate repairs and or corrections to the design or construction to fix any erosion problems.

6.5 MULTIPURPOSE LAND USE

The amount of land required for a storm water detention facility is generally quite substantial. For this reason, it is logical that storage facilities could serve a secondary role as parks or recreational areas whenever possible. Such dual use areas will be allowed only after proper review of the design scenario and approval of the specific project by the Fort Bend County Drainage District Engineer.

A parking lot may be used as part of the detention system, provided that the maximum depth of water over the inlet does not exceed nine (9") inches and the maximum depth in the parking stall does not exceed six (6") inches.

When a dual use facility is proposed, a joint use agreement is required between the entity using the facility for detention, and the entity sponsoring the secondary use. This agreement must specify the maintenance responsibilities of each party.

Highly urbanized areas which do not have the option of conventional detention ponds due to available land may store storm water underground on the site, pending Fort Bend County Drainage District approval.

If wet bottom features are planned for a detention facility adequate design considerations shall be provided and included in the design and construction to make the facility:

1. Safe to the public

2. Accessible for maintenance

3. Easy to maintain

4. Provide a minimum depth of 6 feet.

6.5.1 Approval of Private, Dual-Use or Multi-Use Facilities

For privately maintained, dual-use or multi-use each storm water detention facility will be reviewed and approved only if:

1. The facility has been designed to meet or exceed the requirements contained within this manual; and

2. Provisions are made for the facility to be adequately maintained.

3. If walking paths, jogging trails or other amenity is anticipated sufficient details of the paths, jogging trails, amenity and designs for each of these shall be provided to Fort Bend County Drainage District Engineer for review and comment. The trail or path geometry and location may require special requirements, thicker base or top surface to provide access for maintenance vehicles to cross the facility. Any impact or damage to the trail or path from Fort Bend County Drainage District vehicles will not be the responsibility of the Fort Bend County Drainage District.

6.5.2 Maintenance

Each development which provides detention shall make provisions to ensure future maintenance of the detention facility. Typically, a property owners association, LID, WCID or MUD will be established and given the responsibility to maintain the drainage facility. The entity responsible for the maintenance of the facility shall be noted on the plat or plans.

A 30-foot wide access and maintenance easement shall be provided from street, road or adequate access way to and around any drainage ditch, channel or the entire detention pond. This is in addition to the dedication required for the pond itself. Figure 6-2 below shows the minimum criteria for maintenance berms in different development scenarios.

If guard rails or other impediments will block access to drainage ditches or detention facilities, adequate provisions shall be provided to allow reasonable access to the channel or drainage facility as approved by FBCDD staff.

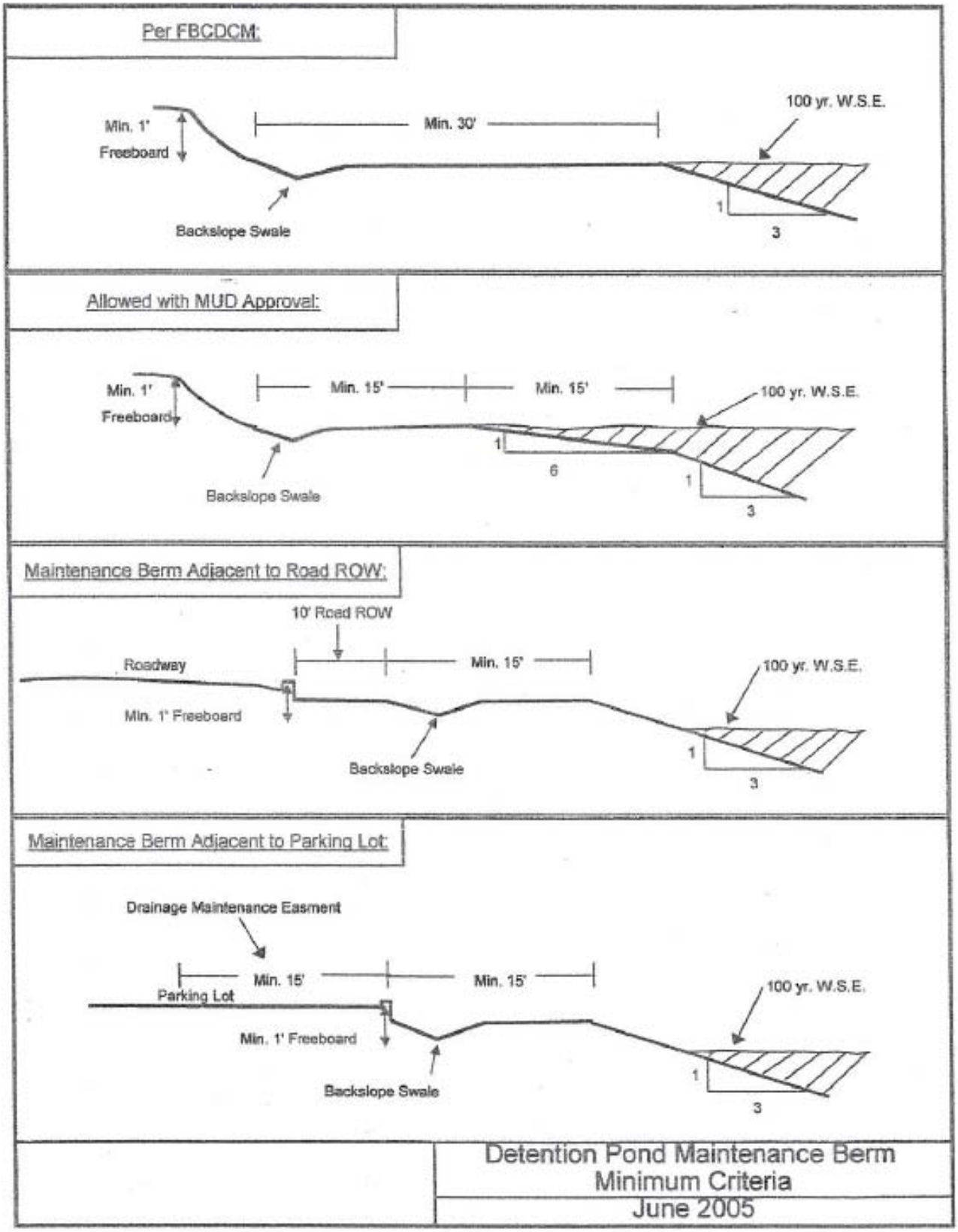

Figure 6-2 – Detention Basin Maintenance Berm Minimum Criteria

6.6 PUMP DETENTION

Pumped detention systems will not be maintained by Fort Bend County under any circumstances and will be approved for use only under the following minimum conditions:

1. A gravity system is not feasible from an engineering and economic standpoint;

2. At least two pumps are provided, each of which is sized to pump the design flow rate; if a triplex system is used, any two of the three pumps must be capable of pumping the design flow rate;

3. The selected design outflow rate must not aggravate downstream flooding. (Example: A pump system designed to discharge at the existing 100-year flow rate each time the system comes on-line could aggravate flooding for more frequent storm events.).

4. Fencing of the control panel is provided to prevent unauthorized operation and vandalism;

5. Adequate assurance is provided that the system will be operated and maintained on a continuous basis;

6. Emergency source of power is provided.

It is recommended that if a pump system is desired, review of the preliminary conceptual design by the Fort Bend County Drainage District Engineer be obtained before any detailed engineering is performed.

6.7 GEOTECHNICAL INVESTIGATION

Before initiating final design of a detention pond, a detailed soils investigation by a geotechnical engineer should be undertaken. The following minimum requirements shall be addressed:

1. The ground water conditions at the proposed site;

2. The type of material to be excavated from the pond site and its suitability for additional use;

3. If a dam is to be constructed, adequate investigation of potential seepage problems through the dam and attendant control requirements, the availability of suitable embankment material and the stability requirements for the dam itself;

4. Potential for structural movement or areas adjacent to the pond due to the induced loads from existing or proposed structures and methods of control that may be required;

5. Stability of the pond side slopes for short term and long term conditions.

6.8 GENERAL REQUIREMENTS FOR DETENTION POND CONSTRUCTION

The structural design of detention facilities is very similar to the design of open channels. For this reason, all requirements from Section 3.0 pertaining to the design of lined or unlined channels shall also apply to lined or unlined detention facilities.

In addition, the following guidelines are applicable:

1. Pond Bottom Design – A pilot channel shall be provided in detention facilities to insure that proper and complete drainage of the storage facility will occur. Concrete pilot channels shall have a minimum depth of two inches and a minimum flowline slope of .0005 ft/ft. Unlined pilot channels shall have a

minimum depth of two feet, a minimum flowline slope of .001 ft/ft, and maximum sideslopes of 3:1.

The bottom slopes of the detention basin should be graded toward the pilot channel at a minimum slope of 0.005 ft/ft, and a recommended slope of 0.0075 ft/ft.

Detention basins which make use of a channel section for detention storage may not be required to have a pilot channel, but should be built in accordance with the requirements for open channels as outlined in Section 3.0.

2. Outlet Structure – The outlet structure for a detention pond is subject to higher than normal head water conditions and erosive velocities for prolonged periods of time. For this reason the erosion protective measures are very important.

Reinforced concrete pipe used in the outlet structure should conform to ASTM C-76 Class III with compression type rubber gasket joints conforming to ASTM C-443. Pipes, culverts and conduits used in the outlet structures should be carefully constructed with sufficient compaction of the backfill material around the pipe structure as recommended in the geotechnical analysis. Generally, compaction density should be the same as the rest of the structure. The use of pressure grouting around the outlet conduit should be considered where soil types or conditions may prevent satisfactory backfill compaction. Pressure grouting should also be used where headwater depths could cause backfill to wash out around the pipe.

6.9 STORM WATER QUALITY BMPs AND PHASE II NPDES PERMIT

Fort Bend County encourages the use of storm water quality (SWQ) best management practices (BMPs) such as floatable collection screens, wet bottom features in detention basins and other practices. Water quality features must not interfere with the function, operation, maintenance, or rehabilitation of the detention basin and must comply with all applicable criteria.

6.10 LOW IMPACT DEVELOPMENT

LID is the site design strategy with a goal of maintaining or replicating the pre-development hydrologic regime through the use of design techniques to create a functionally equivalent hydrologic landscape. LIDs are based on controlling storm water at the source by the use of micro-scale controls that are distributed throughout the site. These multifunctional site designs incorporate alternative storm water management practices such as functional landscape that act as storm water facilities, depression storage and open drainage swales. Fort Bend County encourages using the LID features in the watershed. These features should be discussed with the Fort Bend County Drainage District Engineer prior to the design process to ensure that the proposed features are acceptable to the Fort Bend County Drainage District.