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TECHNICAL BULLETIN

DATE: June 24, 2008

TO: City Council, Stormwater Advisory Committee, Planning Commission, Murfreesboro Water & Sewer Department, Stakeholder Community

FROM: Murfreesboro Water & Sewer Department Staff

RE: Small Site Development Option – Utilizing Low Impact Development (LID) Techniques to Eliminate Extended Detention Ponds

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OBJECTIVE:

Determine the criteria associated with small sites employing low impact development (LID) techniques in lieu of requiring extended detention of the streambank protection volume.

BACKGROUND:

In developing the City of Murfreesboro's post-construction standards to the City's existing stormwater management ordinance (Chapter 27 ½ of the City Code), as required by the City's National Pollutant Discharge Elimination System (NPDES) Phase II stormwater permit, staff put forth the suggestion of allowing small sites the option of utilizing LID techniques to mitigate the streambank protection volume of stormwater runoff from these sites. The benefit of employing LID techniques provides for improved emulation of the post-developed site to the pre-developed condition (i.e., reduces post-developed peak runoff rates to imitate pre-developed runoff rates), and LID techniques allow for eliminating the proliferation of small detention ponds throughout the City of Murfreesboro.

The initial proposal developed by staff was to look at sites with less than one (1) acre of imperviousness; however, upon more in depth modeling and runoff calculations, staff is recommending that low impact development techniques be allowed on sites of up to two (2) acres of imperviousness.

The technical calculations associated with this recommendation follow; however the premise is based on other State and municipal guidelines publishing the lack of requiring streambank protection for post-developed sites having a peak flow (q_i) of stormwater runoff less than two (2) cubic feet per second (cfs). The specific technical reference is contained in the Maryland Department of the Environment's stormwater design manual.

REQUIRED DESIGN CRITERIA FOR SMALL SITE DESIGN OPTION APPROVAL:

1. ***Objective #1 – Runoff Volume Reduction***
   LID Requirement #1 – Construct pervious paving on all parking stall areas of site.
   Rationale – Reduces the % imperviousness of the small site.
   a. A typical 2 Ac. site in Murfreesboro is assumed as having 85% impervious surface with a Soil Conservation Service Class "C" soil. This translates into a Soil Conservation Service Curve Number (CN) of 94. This CN is used in the hydrologic modeling, and calculation of the peak runoff rate for the site. The streambank protection volume is the calculated runoff from a 3.11 inch rainfall event in a 24-hour period.
   b. By constructing all parking stalls on a typical 2 Ac. site with pervious pavement or pervious concrete, the % imperviousness of a 2 Ac. site is reduced to 65%.

2. ***Objective #2 – Peak Discharge Rate Reduction***
   LID Requirement #2 – Disconnect all roof drains from impervious surface (i.e, route the discharge of roof drains to pervious areas), and route 1/3 impervious parking to pervious areas. (Note: results in an effective 64% disconnect of site's impervious area).
   Rational: Increase the time of concentration (t_c) for stormwater to discharge into the conveyance system.

   Table 1 – *Time of Concentration for 1.0 and 2.0 Ac. Imperviousness Site*

	1.0 Ac. Imperviousness	2.0 Ac. Imperviousness
Connected Imperviousness	t_c = 4.2 min.	t_c = 5.3 min.
Disconnected Rooftop and 1/3 Imp. Parking	t_c = 7.8 min.	t_c = 9.9 min.

3. *Objective #3 – Water Quality Treatment (80% TSS Removal)*
   LID Requirement #3 - Construct landscaping areas as recessed bio-retention areas.
   Required design criteria for bio-retention areas:
   a. Construct each bio-retention area with an overflow outlet with a 9"x9" square grate, 0.70 discharge coefficient above the bio-retention invert at height (h_f)
   b. Depth of filter media (d_f) = four (4) feet of topsoil below the invert of the bio-retention area. Assumed permeability coefficient of topsoil & clay, k = 0.23 (ft per day)
   c. Allow for a two (2) day time of infiltration, (t_f)
   d. Area of bio-retention (A_{bio}) = WQv * d_f / [(k)*(h_f + d_f) * (t_f)]
   e. See attached detail and spreadsheets for required bio-retention area based on total depth (t_d) and overflow height (h_f) for 1.0 Ac. and 2.0 Ac. impervious sites.

4. *Objective #4 – Streambank Protection Volume Mitigation*
   LID Requirement #3 – Construct landscaping areas as recessed bio-retention areas.
   a. When modeling the bio-retention BMP's as storage areas with a 9"x9" square grate (w/ 0.70 discharge coefficient) placed at the storage depth (h_f) above the invert, the rate of discharge for the 1-yr, 24 hour rain event (3.11 in) on a one (1) and two (2) acre impervious site is not released at a rate greater than 2.0 cfs.

5. *Resulting Site Characteristics* – CN = 90; 65% imperviousness; Class "C" soil.

Table 2 – *Calculated Post-Construction Parameters for 1.0 and 2.0 Ac. Imperviousness Site*

	1.0 Ac. Imperviousness	2.0 Ac. Imperviousness
t_c (minutes) =	7.8	9.9
WQv (cf) =	1,901	3,799
SPv (cf) =	4,922	9,845
Landscaping (sf) =	7,684	15,355
Peak Discharge (cfs) =	< 2.0 cfs	< 2.0 cfs

INFILTRATION CREDIT IN LIEU OF BIO-RETENTION FOR EMBANKMENT FILL SITES:

Staff recognizes that certain sites will be primarily constructed using fill material in order to bring them up to grade for roadway access. In these instances, staff acknowledges that recessing landscaping areas for the purpose of bio-retention may be unachievable. Therefore, staff intends to recognize those sites utilizing shot-rock fill for sub-grade construction, and by allowing infiltration to occur into that shot-rock fill as performing the same function as an infiltration trench best management practice (BMP). Clay soil used as fill embankment material shall not be deemed an acceptable replacement to bio-retention BMP's.

The infiltration volume shall be considered a substitute to bio-retention area and shall be deemed as meeting the same water quality treatment and streambank protection mitigation, insofar as the following criteria are met:

- Acceptable amounts of pervious pavement is over the shot-rock base, allowing acceptable infiltration rates, and
- The infiltration volume (Inf_v) shall be calculated as follows:
  - Inf_v = ~~A / (n*d + k*T/12)~~ A*(n*d+K*T/12) **Revised 10/2009**
  - Where A = Area of shot-rock placement (s.f.); n = 0.3 porosity for shot rock; k = 1.0 in/hr infiltration rate; d = depth of shot-rock fill and T = 2.0 hrs for fill time.
  - The two (2) site specific variables for input into the equation are Area and depth of shot-rock fill.
  - For every 2.6 cubic feet of water stored in infiltration into the shot-rock subgrade, 1.0 cubic feet of volume may be deducted from the water quality volume requiring treatment in the bio-retention areas.

Small Site Design Analysis for 1.0 Ac. Imperviousness

Low Impact Development (LID) BMP's

Murfreesboro, TN Post-construction Standards

	Acreage	Square Footage	
Site Acreage	1.18	51227	
Imperviousness	1.00	43560	
15% Landscaping	0.176	7684.0	
20% Pervious Parking	0.235	10245.3	
30% Impervious Rooftop	0.353	15368.0	Disconnected
35% Impervious Parking	0.412	17929.3	1/3 Disonnected

CN = 90, tc = 7.8 min, % Imp = 65%		
Rv = .05 + (Imp.)*.009	0.635	
Area = Imp. Area minus Diconnected	0.69	Ac.

	Ac-ft	cubic feet	Ratio - Spv to WQv
WQv = 1.2"/12 * Rv * (A)	0.0436	1901	2.6
SPv = Runoff Volume * Vs/Vr (.65)	0.1130	4922	

Bioretention Area Depth, t_d (ft)	A_{bio} (sf)	A_{eff} (sf)	WQv	d_f (ft)	k (ft/day)	h_f (ft)	t_f (days)	Post Disch. (cfs)	Grate Coef.
1	3674	6502	1901	4	0.23	0.50	2	1.83	0.70
1.25	3481	5737	1901	4	0.23	0.75	2	1.79	0.70
1.5	3307	5167	1901	4	0.23	1.00	2	1.68	0.70
1.75	3149	4704	1901	4	0.23	1.25	2	1.55	0.70
2	3006	4329	1901	4	0.23	1.50	2	1.41	0.70

Infiltration Volume, Inf_v (ft3)	A (sf)	d (ft)	n	k (in/hr)	T (hrs)	Volume Calc
4922	15750	0.5	0.3	1	2	4987.50
4922	10750	1	0.3	1	2	5016.67
4922	8250	1.5	0.3	1	2	5087.50
4922	6500	2	0.3	1	2	4983.33

NOTE: For every 2.6 cubic feet of infiltration into the shot-rock sub-grade for a site,
1.0 cubic feet of water quality volume may be deducted from required treatment in a bio-retention area.

Small Site Design Analysis for 2.0 Ac. Imperviousness

Low Impact Development (LID) BMP's

Murfreesboro, TN Post-construction Standards

	Acreage	Square Footage	
Site Acreage	2.35	102366	
Imperviousness	2.00	87120	
15% Landscaping	0.353	15354.9	
20% Pervious Parking	0.470	20473.2	
30% Impervious Rooftop	0.705	30709.8	Disconnected
35% Impervious Parking	0.823	35828.1	1/3 Disonnected

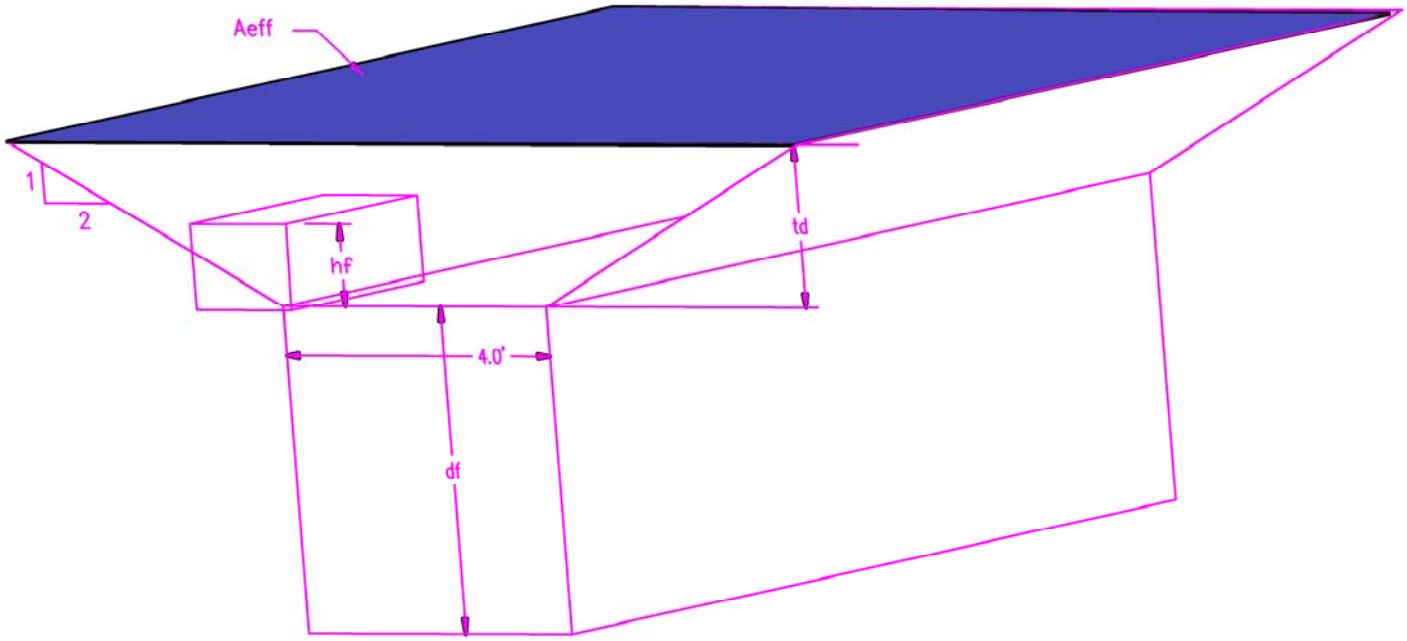
CN = 90, tc = 9.9 min, % Imp = 65%		
Rv = .05 + (Imp.)*.009	0.635	
Area = Imp. Area minus Diconnected	1.37	Ac.

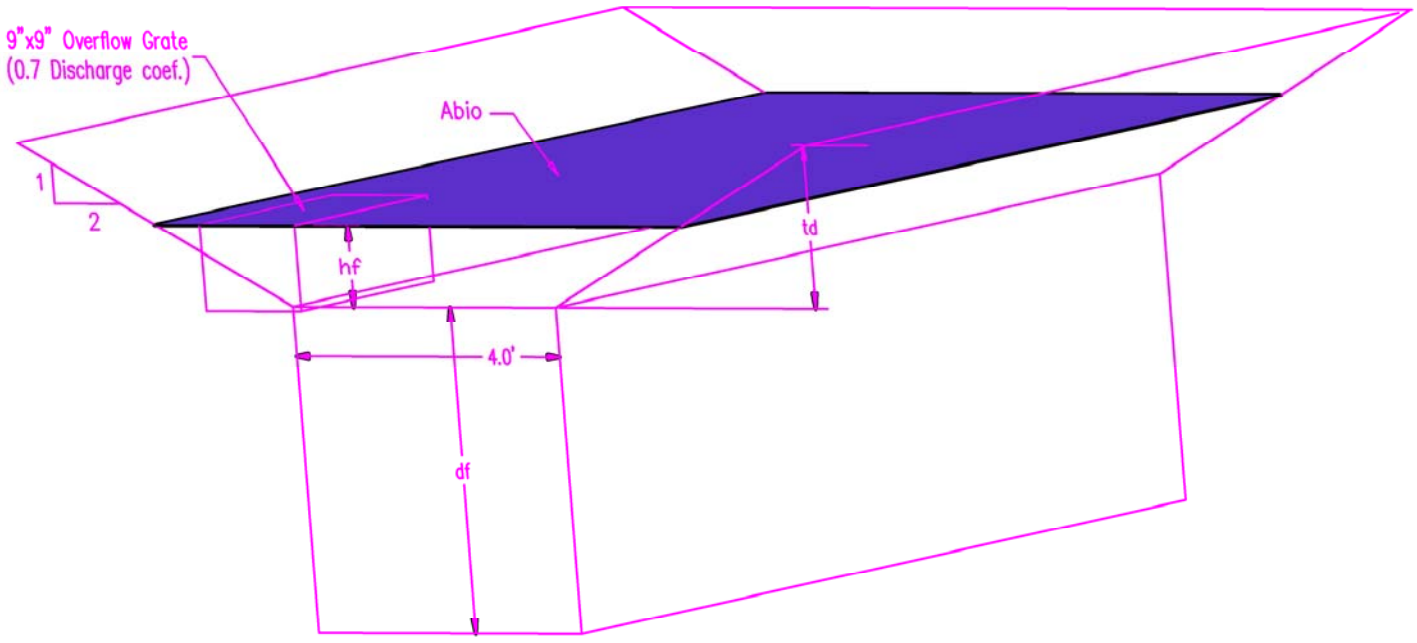
	Ac-ft	cubic feet	Ratio - Spv to WQv
WQv = 1.2"/12 * Rv * (A)	0.0872	3799	2.6
SPv = Runoff Volume * Vs/Vr (.65)	0.2260	9845	

Bioretention Area Depth, t_d (ft)	A_{bio} (sf)	A_{eff} (sf)	WQv	d_f (ft)	k (ft/day)	h_f (ft)	t_f (days)	Post Disch. (cfs)	Grate Coef.
1	7342	13052	3799	4	0.23	0.50	2	1.93	0.70
1.25	6955	11497	3799	4	0.23	0.75	2	1.98	0.70
1.5	6608	10325	3799	4	0.23	1.00	2	1.93	0.70
1.75	6293	9401	3799	4	0.23	1.25	2	1.87	0.70
2	6007	8650	3799	4	0.23	1.50	2	1.79	0.70

Infiltration Volume, Inf_v (ft3)	A (sf)	d (ft)	n	k (in/hr)	T (hrs)	Volume Calc
9845	31200	0.5	0.3	1	2	9880.00
9845	21100	1	0.3	1	2	9846.67
9845	16000	1.5	0.3	1	2	9866.67
9845	13000	2	0.3	1	2	9966.67

NOTE: For every 2.6 cubic feet of infiltration into the shot-rock sub-grade for a site, 1.0 cubic feet of water quality volume may be deducted from required treatment in a bio-retention





Bio-retention Design Parameters for Small Site Design (LID) Option Murfreesboro, TN