



Storm Water Management Alternatives for Small Commercial Sites

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Overview

- Basics of hydrology for commercial sites
- Rainfall data
- Storage Options

Commercial Site Hydrology

- Issues to be addressed include:
 - Directing runoff away from buildings and parking areas, including storm sewer design
 - Reducing peak flows to pre-development levels
 - Encouraging infiltration to reduce runoff volumes

Commercial Site Hydrology

- For small sites, Rational Equation is typically adequate
- $Q = CIA$
 - Q = peak flow, in cfs
 - C = runoff coefficient
 - I = intensity, inches per hour (for a time equal to time of concentration)
 - A = area, in acres

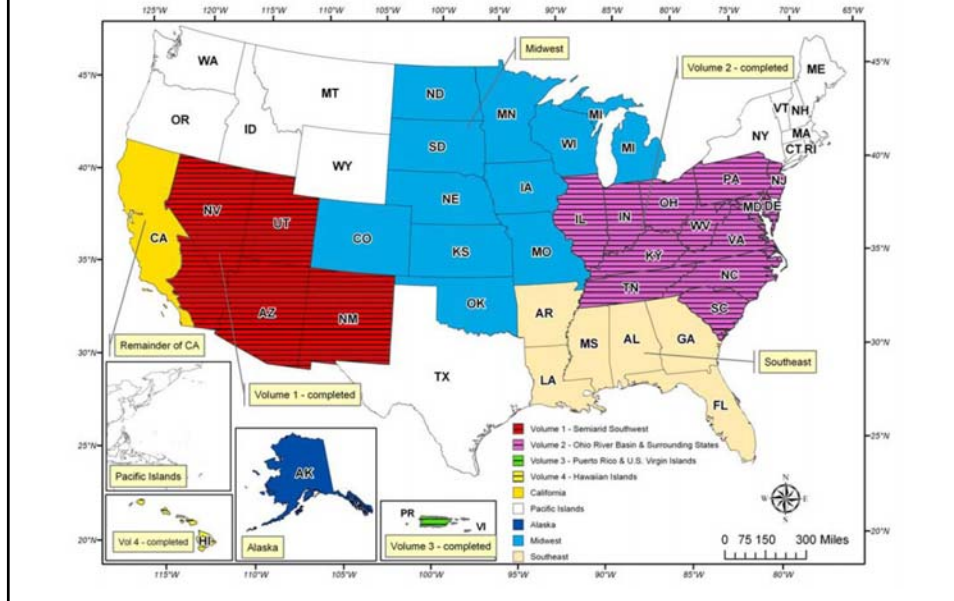
Commercial Site Hydrology

- Typical Runoff Coefficients:
 - Pavements ~ 0.9
 - Grassed Areas ~ 0.2 to 0.3, depending on soils and slope

Rainfall Data

- Local Regulatory Agency
- National Weather Service - NOAA Atlas 14, Vol. 1 (2003), UT, NV, AZ, NM & southern CA - Precipitation Frequency Data Server - <http://hdsc.nws.noaa.gov/hdsc/pfds/>
- Vol. 2 (2004), DE, IL, IN, KE, MD, NJ, NC, OH, PA, SC, TN, VA, WV, DC
- Vol. 3 (2006), PR & VI; Vol. 4 (2009), HI; Vol. 6 (12/2009), Pacific Islands
- Vol. 5 (9/2010?), northern CA; Vol. 7 (9/2011?), AK; Vol. 8 (5/2012?), ND, SD, NE, KS, MI, MN, IA, MO, OK, CO, WI; Vol. 9 (5/2012?), FL, GA, AL, MS, AR, LA.

Rainfall Data – NOAA Atlas 14



Rainfall Data NOAA Atlas 14 Philadelphia

Precipitation Frequency Estimates (inches)

ARI* (years)	5 min	10 min	15 min	30 min	60 min	120 min	3 hr	6 hr	12 hr	24 hr	48 hr	4 day	7 day	10 day	20 day	30 day	45 day	60 day
1	0.35	0.56	0.69	0.95	1.19	1.43	1.56	1.93	2.34	2.68	3.07	3.44	3.98	4.46	6.01	7.49	9.49	11.32
2	0.41	0.66	0.83	1.15	1.44	1.73	1.89	2.33	2.82	3.23	3.71	4.15	4.78	5.34	7.13	8.83	11.15	13.27
5	0.49	0.78	0.98	1.40	1.79	2.17	2.37	2.91	3.54	4.08	4.70	5.22	5.94	6.54	8.53	10.34	12.86	15.18
10	0.54	0.86	1.08	1.57	2.05	2.49	2.73	3.38	4.13	4.80	5.51	6.10	6.89	7.50	9.63	11.51	14.15	16.59
25	0.60	0.95	1.21	1.79	2.38	2.93	3.22	4.03	5.01	5.85	6.68	7.36	8.27	8.87	11.14	13.07	15.79	18.37
50	0.64	1.02	1.29	1.94	2.63	3.26	3.61	4.56	5.75	6.74	7.66	8.40	9.42	9.97	12.32	14.26	17.02	19.67
100	0.68	1.08	1.37	2.09	2.88	3.60	4.01	5.11	6.55	7.70	8.71	9.52	10.64	11.12	13.52	15.44	18.18	20.88
200	0.72	1.14	1.43	2.23	3.13	3.93	4.40	5.69	7.42	8.76	9.85	10.72	11.95	12.32	14.74	16.61	19.29	22.01
500	0.76	1.20	1.51	2.40	3.44	4.38	4.94	6.51	8.68	10.30	11.48	12.45	13.82	14.05	16.38	18.13	20.67	23.39
1000	0.79	1.24	1.56	2.52	3.68	4.72	5.36	7.16	9.73	11.60	12.84	13.87	15.36	15.48	17.64	19.26	21.66	24.36

10-yr, 5-minute = 0.54 inches = 6.48 in/hr

10-yr, 10-minute = 0.86 inches = 5.16 in/hr

Hydrology Example

- For a 1.5 acre site, 85% pavement and buildings, 15% grass/landscape with granular soils and flat slopes, in Philadelphia, 10-yr design
- Time of concentration will be short
 - 5 to 10 minutes minimum
- $C = 0.9$ for pavement, 0.2 for grass
- Weighted $C = (0.9 * 0.85) + (0.2 * 0.15)$
- $C = 0.8$

Hydrology Example

- For a 1.5 acre site, 85% pavement, 15% grass/landscape with granular subsoils and flat slopes, in Philadelphia, 10-yr design
- Use intensity for a 10-minute event
- so $I = 5.16$ in/hr
- $Q = CIA$
- $Q = 0.8 * 5.16$ in/hr * 1.5 acres = 6.19 cfs
- Used for storm drain sizing

Runoff Volume

- Rational Equation can also be used to estimate runoff volume
- $V = Qt = CIA_t$, where t is duration of the rainfall event (in seconds)
- Design duration for volume purposes is often 24 hours

Runoff Volume

- For a 1.5 acre site, 85% pavement, 15% grass/landscape with granular subsoils and flat slopes, in Philadelphia, 10-yr design
- Use intensity for a 24-hour event
- $P = 4.80$ inches in 24 hours
- so $I = 0.20$ in/hr
- $V = CIA_t$
- $V = 0.8 * 0.20 \text{ in/hr} * 1.5 \text{ acres} * (24 \text{ hours} * 60 \text{ min/hr} * 60 \text{ sec/min}) = 20,736 \text{ ft}^3$

Runoff Volume

- For a 1.5 acre site, $V = 20,736 \text{ ft}^3$
- If pond takes up 10% of the 1.5 acre site, pond area = 6534 square feet
- so average depth = $20,736 / 6534$
average depth = 3.2 ft

Storm Water Management Options

- Immediate discharge to storm sewer system (design for peak flow)
- Temporary storage, with discharge to storm sewer system (design for peak flow and total volume)
- Permanent Storage of small events, peak flow reduction for large events
- Permanent Storage of all events

Storage Options

- Detention Pond – on pavement or in landscaped area
- Retention Pond
- Rain Garden
- Permeable Pavements
- Underground Storage

Detention Ponds

- Designed to hold water temporarily
- Must have an outlet – either to a storm sewer system or an overflow to the street
- Outlet sized to reduce peak flow from development to pre-development levels
- For small commercial sites, outlet size gets small and can require maintenance

Detention Ponds

- Complete hydraulic analysis requires development of inflow hydrograph along with depth-storage relationship and depth-discharge relationship
- Typically dry ponds on a small site – wet ponds more aesthetically pleasing but requires water source
- Functionally, a rain garden is either a detention pond (with a high level overflow) or a retention pond

Pond Outlet Capacity

- Pipe outlet – compute capacity based on culvert hydraulics – FHWA HY-8 software
- Grate outlet – compute capacity based on inlet grate capacity from FHWA HEC-22
- Orifice outlet – compute capacity based on orifice equation: $Q = CA(2gh)^{1/2}$, $C \sim 0.60$ to 0.67
- Weir overflow outlet – compute capacity based on weir equation: $Q = CLH^{3/2}$, $C \sim 3.0$

Underground Storage

- Detention storage, using pipes instead of above ground pond. Discharge can be by gravity or may need to be pumped
- French Drains – Standard storm drain catch basin, except concrete structure is perforated to allow water into adjacent soils
 - Need native soils that are permeable
 - Usually put large washed gravel around catch basin. Need to include a filter fabric to keep gravel from clogging.

Underground Storage



Detention Pond Examples

Pipe Outlet



Elongated Pond, Grate Outlet



Landscaped Pond, Elevated Grate Outlet



Sandy Bottom in Arid Climate, Elevated Grate



Wet Detention Pond



Retention Ponds

- Designed to hold water temporarily, but typically much longer than a detention pond
- Doesn't have an outlet – water either infiltrates or evaporates
- For small commercial sites, pond size can become large
- Rain garden could be a combination of a retention pond (for frequent rain events) and a detention pond (during infrequent events)

Retention Pond



Retention Pond after rainfall



Retention Pond two weeks later



Rain Gardens



LEED Credit 6.1

Leadership in Energy and Environmental Design,
U.S. Green Building Council

Credit 6.1 – Stormwater Design – Quantity Control

- Intent – Limit disruption of natural hydrology by reducing impervious cover, increasing on-site infiltration, reducing or eliminating pollution from stormwater runoff and eliminating contaminants.
- Technologies and Strategies:
 - Maintain natural stormwater flows by promoting infiltration
 - Vegetated roofs and pervious paving
 - Reuse stormwater for non-potable uses such as irrigation

LEED Credit 6.1

Credit 6.1 – Stormwater Design – Quantity Control

- Case 1 – Existing imperviousness is less than or equal to 50% and a stormwater management plan will be implemented to prevent the post-development peak discharge rate and quantity from exceeding the predevelopment peak discharge rate and quantity for the one- and two-year 24-hour design storms.
- Case 2 – Existing imperviousness is greater than 50% and a stormwater management plan will be implemented that results in a 25% decrease in the volume of stormwater runoff from the two-year, 24-hour design storm

LEED Credit 6.2

Credit 6.2 – Stormwater Design – Quality Control

- Intent – Limit disruption and pollution of natural water flows by managing stormwater runoff.
- Implement a stormwater management plan that reduces impervious cover, promotes infiltration, captures and treats 90% of average annual rainfall.
- BMPs used to treat runoff must be capable of removing 80% of average annual TSS.

LEED Credit 6.2

Credit 6.2 – Stormwater Design – Quality Control

- Technologies and Strategies:
 - Use alternative surfaces (vegetated roofs, pervious pavement, grid pavers)
 - Non structural techniques (rain gardens, vegetated swales, disconnection of imperviousness, rainwater recycling) to promote infiltration reducing pollutant loadings
 - Design integrated natural and mechanical treatment systems such as constructed wetlands, vegetated filters and open channels to treat stormwater runoff.