Urban Stormwater Management Part 2

Take a moment to recall the effects that development has on hydrology.

Development leads to changes in peak flow characteristics (both the height and duration), changes in total runoff volume (usually increases), changes in water quality, changes in the aesthetic character of the hydrological system, changes in drainage areas because of grading, and changes in base flow (usually decreases).[1]

What do we do to manage these effects? We try to engineer solutions that return local hydrological systems to a semblance of natural ones. When engineering solutions are being designed, they need to take into account "the worst case scenario", although it requires the judgment of a human to decide just how "worst case" to consider. As I write this now, images of Hurricane Katrina's effects on New Orleans still dominate my mind – a clear example of human judgment about what sort of storm conditions to build for.

An important idea in storm water management is the notion of a "storm return interval". The "two year storm" is a storm that has about a 50% probability of occurring in any given year. A "100 Year Storm" is a storm that has a bout a 1% probability of occurring in any given year.

Return Interval (yr)	24 Hour Storm (in)	24 Hour Storm (cm)
1	2.5	6.4
2	3	7.6
5	3.9	9.9
10	4.6	11.7
25	5.4	13.7
100	6.5	16.5
500	7.8	19.8

Most engineering practice is for small streams in small watersheds -- generally under a couple hundred acres. Would the same return intervals apply at larger scales?

River geomorphologists believe that stream channels are shaped primarily by moderate high flow events. Low flow events do not carry enough energy to move much sediment and extremely high flow events are erosive no matter wyat, and happen so seldom that they are not the dominant geomorpholic event. A

[1] Maine DEP 1995. Stormwater Management For Maine: Best Management Practices. Page 18.

“bankfull” flood is a flood that floods to the edge of the river’s bank. They generally have return intervals of about 1.5 to 2 years. They are often considered the “channel shaping flow” and most stormwater management plans are designed to avoid just these sorts of flows. Following urbanization, bankfull floods are more frequent.

The primary tool used to offset the effects of urbanization is detention basis. These basins restrict peak flow. In Maine, they are required to restrict peak flow following the two-year, 10 year, and 25 year storm post-development so that they are no greater than the peak pre-development flows. In practice, this means that a developer needs to store the volume of the two year 24 hour rainfall post development, and release it through a small pipe or weir that limits downstream flow volumes to no more than pre-development flows. The same thing needs to be done with 10 year and 25 year storms. In practice, complex hydrological models are often built to decide exactly how much water needs to be stored. For the “order of magnitude” purpose of this site, we can simplify by assuming that a developer will need to store almost the entire volume of these storms.

Here is a problem for you to work through. Imagine your favorite retailer wants to build a new store in your area. How big does the detention basin need to be to store the post development 2, 10, and 25 year storms.

We’ve worked the problem below for a hypothetical store being built on a 90 acre (~36 hectare) site.

2 Year Storm

> *in Androscoggin County, the "2 year storm" contains about 3.0 inches of rainfall, or about 7.5 cm of rain*
>
> *Total volume of rain = 36 ha x (10000 m^2/ha) x 0.075 m = 27000 cubic meters*
>
> *Of that, about (I think this is an underestimate) 55% comes as runoff. Runoff is 14850, or about 15000m^3*
>
> *Assume no more than 1 meter deep for storage of 2 year storm (deeper part of basin would, in practice, be used to store water from larger (10 or 25 year) storm events*
>
> *We end up with about 1.5 Ha for storage*

10 Year Storm

> *"10 year storm" contains about 4.6 inches of rainfall, or about 11.7 cm of rain*
>
> *Total volume of rain = 36 ha x (10000 m^2/ha) x 0.117 m = 42120 cubic meters*

Of that, 55% comes as runoff. Runoff 23166, or about 23,200m³

Assume 2 meter deep

We need about 1.16 ha for storage -- smaller than that required for the 2 year storm because we have constructed a deeper basin.

25 Year Storm

The "25 year storm" contains about 5.4 inches of rainfall, or about 13.7 cm of rain

Total volume of rain = 36 ha x (10000 m^2/ha) x 0.137 m = 49320 cubic meters

Of that, nominally 55% comes as runoff. Runoff 27126, or about 27,000m^3 (probably a severe underestimate)

Assume 2.5 meter deep for storage of 25 year storm events,

we need about 1.08 ha for storage -- smaller than that required for the 10 year storm. (because of the greater depth...)

I would plan for much larger runoff -- 50,000, leading to a recommended stormwater detention area of about 2.0 ha

Summary

		Return Interval	
	2 Year	10 Year	25 Year
Rainfall, Inches	3	4.6	5.4
Rainfall, cm	7.5	11.7	13.7
Total Water Arriving in Precipitation (m^3)	27000	42120	49320
Runoff (m^3, 55% of precipitation assumed)	15000	23166	27126
Depth of water in basin (m)	1	2	2.5
Area required (ha)	1.5	1.16	1.08

Urbanization requires us to create systems that mimic the natural processes used to maintain landscapes. Engineered systems require maintenance. Increasingly clever urban planners are finding ways to use natural systems in urban landscapes. If you are interested in this area, there are a growing number of graduate programs that specialize in urban landscape architecture and urban planning that have the potential to train new generations of planners.

Back of the envelope questions

How much would the water level of a nearby lake rise during a "10 year storm"? 1 inch, 5 inches, 10 inches, or more?

How much water runs off the rooftop of the building you are in now during 24 hour storm with a 10 year return interval?