



# First Flush of Stormwater Pollutants Investigated in Texas

The concept of the first flush was first advanced in the early 1970s. Runoff sampling methods of this era required the collection of multiple flow and water quality samples over the duration of a storm event. As researchers examined monitoring data during storms, they discovered that pollutant concentrations tended to be much higher at the beginning of a storm compared to the middle or the end of the event.

It was reasoned that the store of pollutants that had accumulated on paved surface in dry weather quickly washed off during the beginning of the storm. Although runoff rates were greater at the middle and tail end of a storm, the store of pollutants available for washoff was depleted, and consequently the concentration of pollutants declined.

Stormwater managers quickly grasped the practical significance of the first flush phenomenon. If most of the urban pollutant load was transported in the beginning of a storm, then a much smaller volume of runoff storage would be needed to treat and remove urban pollutants. After further monitoring and modeling, the half inch rule was advanced. Essentially, the rule stated that 90% of the annual stormwater pollutant load was transported in the first half inch of runoff.

Many communities adopted this simple standard as the basis for providing water quality control in developing areas: size your stormwater practice to capture the first half inch of runoff, and you will treat 90% of the annual pollutant load. Other communities modified the treatment standard further, by requiring that stormwater practices only capture the first half inch of runoff produced from impervious areas of the site.

With the advent of sophisticated automated sampling equipment to measure stormwater runoff in the 1980s, entire storm events could be represented by a single composite sample-known as the event mean concentration (EMC). One consequence of this technological advance was that researchers were no longer analyzing multiple samples during storms, and therefore, could not examine the behavior of pollutant concentrations during individual storm events. Further research into the first flush waned, and the half-inch rule became somewhat an article of faith in the stormwater community.

Recent analysis by Chang and his colleagues (1990), however, suggests that both the first flush phenomenon

and the half-inch rule may not always hold true. Chang analyzed pollutant concentration data from over 160 storm events at seven urban runoff monitoring stations operated by the City of Austin, Texas from 1984 to 1988. The entire dataset was divided into different runoff increments (0 to 0.1 inch, 0.11 to 0.2 inch and so on). For purposes of his analysis, Chang conservatively defined the first flush as the first tenth of an inch of runoff. The pollutant concentration during the first flush was then compared to the pollutant concentration during the entire runoff event (EMC).

The results of the analysis are shown in Table 1. Shaded cells in the table indicate situations where the first flush phenomena did not occur (i.e., the storm EMC either greater than or equal to 90% of the first flush concentration). As can be seen, the first flush effect is most pronounced for sites that are highly imperviousness, but is much weaker at lower levels of imperviousness (five to 30%). For certain pollutants, such as nitrate, copper, ortho-phosphorus, bacteria and sediment, the first flush phenomena effect is weak or absent altogether.

If the first flush effect is not as strong and universal as previously thought, should it still be used as a basis for determining the volume of stormwater treatment? To answer this question, Chang performed additional modeling to determine the proportion of the annual pollutant load that would be captured under the half-inch rule (Table 2).

The analysis does suggest that the half-inch rule works effectively for sites with less than 50% impervious cover for most of the stormwater pollutants examined. However, above this threshold, the rate of pollutant load capture drops off sharply. On average, only 78% of the annual pollutant load is captured for sites with 70% impervious cover, and a mere 64% for sites with 90% impervious cover.

To put these results into perspective, consider a stormwater practice designed under the half inch rule on a 90% impervious site. Further, assume that the stormwater practice removes on average 50% of the pollutants that it captures. The net annual pollutant removal rate for the stormwater practice, however, would only amount to 32% since a large fraction of the annual pollutant load is never captured by the practice. The clear design implication is that the half-inch stormwater