First Flush Phenomena for Highways: How it can be meaningfully defined.

Jiun-Shiu Ma¹, Sabbir Khan¹, Ying-Xia Li¹, Lee-Hyung Kim¹, Simon Ha¹, Sim-Lin Lau¹, Masoud Kayhanian² and Michael K. Stenstrom¹

¹Civil and Environmental Engineering Department, University of California, Los Angeles, 90095-1593
²Center for Environmental and Water Resources Engineering, Department of Civil and Environmental Engineering, University of California, Davis, CA 95616

Abstract

A new terminology and definition is proposed to document mass first flushes of stormwater pollutants. This newly defined terminology is applied to 52 storms over two wet seasons at nine highway sites. Most pollutants showed median mass first flushes where 30 percent of the mass is released in the first 20% of the runoff. Pollutants representing organic contaminants had the highest first flush ratios.

Introduction

Pollutants in stormwater often decline during the period of the storm, which tends to create greater emission rate at the beginning of runoff. This phenomenon is often called a “first flush,” and the existence of a first flush can influence the selection of best management practices (BMPs). The decline in concentration is sometimes offset by an increasing runoff flow rate as a storm progresses.

The existence of first flush is debated and many defining criteria exist (Bertrand-Krajewski et al., 1998). Thornton and Saul (1987) defined the first flush as the initial period of storm flow during a storm event. Geiger (1987) defined a first flush as occurring when the slope of normalized cumulative mass emission plotted against normalized cumulative volume is greater than 45%. Many recent investigators have also used this definition (Gupta and Saul, 1996; Sansalone and Buchberger, 1997; Larsen et al., 1998; Sansalone et al., 1998). Vorreiter and Hickey (1994) proposed using only the first 25% of runoff volume in defining first flush. Deletic (1998) used standard statistical methods including a multiple regression model, and restricted first flush to the first 20% of runoff. Saget et al. (1995) and Bertrand-Krajewski et al. (1998) defined a first flush as occurring when at least 80% of the pollutant load is emitted in the first 30% of the runoff volume.

First flushes have most often been observed in small watersheds, particularly if imperviousness is high, such as paved areas. Large watersheds may have longer time of travel, so that the early runoff from areas far from the sample location is mixed with later runoff from areas adjacent to the sample location.

In this paper we investigate the existence of first flush as a function of water quality parameters, site-specific variables as well as stormwater characteristics. A special attempt has been made to meaningfully define the first flush phenomenon.