PARTICLE SIZE DISTRIBUTION (PSD) IN STORMWATER RUNOFF

Atmospheric deposition and traffic activities deposit solids on roads and parking lots which are available for transport into the storm drain system during rain events. These solids vary in size from fine gravel to clays. The variation in particle size is due to site conditions, vehicular activity, wind patterns, rainfall/runoff characteristics and the application of winter de-icing materials.

The performance of the Stormceptor for suspended solids is dependent on the assumed particle size distribution used for the design and the actual particle size distribution of suspended solids emanating from the site. As a generic particle size distribution, Stormceptor uses a distribution referenced in the Ministry of Environment (MOE) Stormwater Practices Manual (1994) that was derived from a review of the National Urban Runoff Program (NURP) data (USEPA, 1983). The settling velocities for this particle size distribution are based on Stokes' law. The settling velocities derived using Stokes' law depend on the specific gravity of the particles. Stormceptor varies the specific gravity depending on the size of the particle. Lower specific gravities are assigned to the smaller particles (= 150 µm) to account for organic material in stormwater. Using lower specific gravities with a certain particle size distribution would equate to a finer particle size distribution with a uniform specific gravity of 2.65. Furthermore, flocculation is assumed for particles = 20 µm. The use of the flocculated settling velocity equation provides a consistent settling velocity for particles < 50 um that is equal to a 20 µm particle with a settling velocity based on Stokes' law with a specific gravity of 2.65. The upper limit (largest particle size) of the Stormceptor default particle size distribution was further modified to be consistent with the Municipal Research Service Center's typical stormwater particle size distribution (MRSC, 1999).

Pitt et. al has documented a particle size distribution associated with the EPA NURP program that differs from both the MOE Manual and the EPA Detention Analysis study (EPA, 1986). Although it is expected that there will be variations in particle size distribution, all of the distributions (Stormceptor, MRSC, NURP, EPA 1986) are predominantly fine (60% to 100% of the particles are finer than 100 µm). This is supported by other studies (Wisconsin DNR, 1997; Molash, 2001; Ball et al., 1995) that suggest that the majority of particles in stormwater are fine.

Randall et al. 1982 reported that over 80% of the total particles found in storm water runoff were less than 25 µms. In a study conducted by the Federal Highway Authority (Kobriger, 1984) (Table 1), the PSD of storm water runoff samples from highways indicated that the majority of the particles were less than 88 µms.

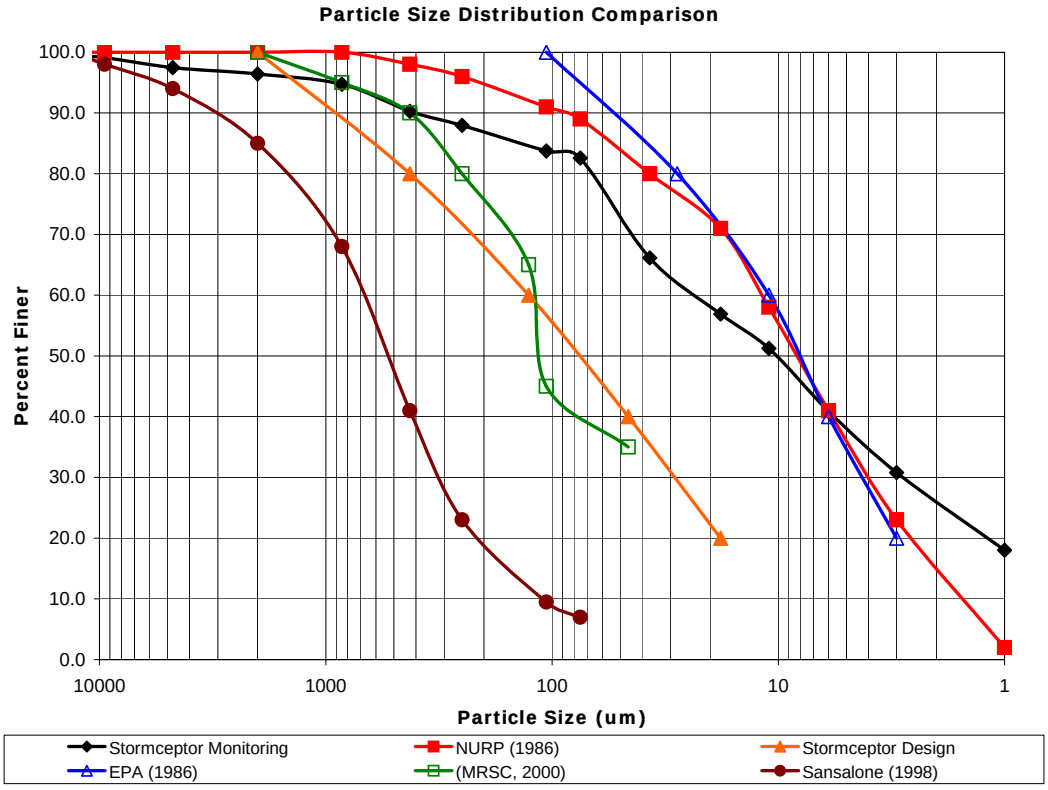
Table 1

Wet Sieving Analysis of Highway Runoff Composite Samples

Particle Size	Sacramento	Harrisburg	Milwaukee	Effland	Mean Value
< 44 µm	79 %	76 %	73 %	87 %	78 %
≤ 88 µm	90 %	88 %	80 %	95 %	87 %

There are also studies that indicate that the particle size distribution is coarse. Sartor and Boyd (1972) analyzed sediment from street surfaces and found about 6% of the total solids were less than 43 µm, 37% ranged from 43 to 246 µm and 57% were greater than 246 µm. In a similar study of sediment on highway surfaces, Shaheen (1975a) found that about 10% of the particles were less than 75 µm, 32% between 75 and 250 µm, 24% between 250 and 420 µm, 19% between 420 and 850 µm and 15% between 850 and 3350 µm. Sansalone (1998) investigated runoff from a freeway and found that approximately 10% of the mass was less than 100 µm, 25% to 60% of the solids were between 100 and 400 µm, and 40% to 70% of the solids were larger than 400 µm.

Figure 1



NURP - National Urban Runoff Program (EPA, 1983)
EPA - Detention Basin Analysis (EPA, 1986)
MRSC - Municipal Research & Services Center (of Washington)

Figure 1 illustrates the variation in particle size distribution data from the literature. The data clearly suggest that the particle size distribution will vary with each site and that the Stormceptor design distribution represents an intermediate or average distribution.

It is important to recognize that the NURP and Stormceptor monitoring particle size distributions represent numerous sites (over 25 sites alone for the Stormceptor monitoring) whereas the Sansalone study only considers one site. It is also important to note that heavy toxic metals and other pollutants (oils, grease, bacteria, nutrients) are typically associated with the smaller particles (< 100 µm) (Walker, 1997). Considering that 50% to 100% of the material for most distributions is less than 100 µm in size, stormwater quality design criteria need to be created that mandate the design of control structures that capture fines (< 100 µm).

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