Improved Protocol for Classification and Analysis of Stormwater-Borne Solids

Currently accepted practices for characterizing stormwater-borne solids need to be critiqued, rethought, and revised. Stormwater-borne solids include suspended sediment, bed-load, settleable and non-settleable solids, and gross solids, as well as organic and other natural material. These solids can have adverse impacts to receiving water systems and can lead to loss of aquatic habitat. They cause channel instability, and transport harmful pollutants.

This report summarizes the current state of stormwater solids characterization and sampling techniques, and suggests improved monitoring methods. It identifies a standardized classification system based on particle size and discusses draft protocols for improved analytical and monitoring methods.

Defining Solids

One of the fundamental obstacles in storm water management is the lack of consistent definitions of stormwater solids. This report explores a classification system (see Figure 1) based on size, taking into account sampling techniques, ecologic impact, and potential treatment. This report proposes that:

- **Gross solids** are defined as solids greater than 5 mm, including litter, debris, and coarse sediment. Litter includes human derived solids such as trash, plastic, clothes/fabric, styrofoam, and glass. Debris includes organic matter such as twigs, grass, and leaves.

- **Coarse solids** are defined as solids between 75 µm and 5 mm. In general, this includes sand size sediment and larger. Coarse solids have been shown to carry a large amount of metals and other toxic compounds into the waterways. In addition, coarse solids tend to settle and infill habitat areas, smother benthic organisms and fish eggs, and change bedforms that are necessary for aquatic habitat.

- **Fine solids** are defined as solids less than 75 µm and greater than 2 µm, including silt and clay. Fine solids are attributed to transporting harmful constituents into receiving waters, increasing suspended solids and turbidity, and reducing the numbers of sensitive organisms.

- **Dissolved solids** are the solids that pass through a 2 micron filter and are usually not treated using traditional best management practices (BMPs) that rely on settling.

The solids can further be described as settleable, suspended, volatile, and non-volatile, based on analytical characteristics. Evaluating these characteristics offers more detailed

---

**Figure 1. Solids Size Classification System**

**BENEFITS**
- Provides a detailed literature review and synthesis of the existing sample collection, handling and analysis methods.
- Develops a consistent classification system that defines the major classes of stormwater solids including solids known as gross solids.
- Recommends a draft protocol addressing sample collection, handling and analysis for use in monitoring stormwater solids.

**RELATED PRODUCTS**
- Critical Assessment of Stormwater Treatment and Control Selection Issues (02SW1)
- Performance and Whole Life Costs of BMPs and SUDS (01CTS21Ta)
- Bioassessment: A Tool for Managing Aquatic Life Uses for Urban Streams (01WSM3)
- Protocol for Studying Wet Weather Impacts and Urbanization Patterns (03WSM3)
- International Stormwater BMP Database (www.bmpdatabase.org, 03SW1CO)

**RELATED ONGOING RESEARCH**
- Linking BMP Systems Performance to Receiving Water Protection to Improve BMP Selection and Design (SW1R06)

**AVAILABLE FORMAT**
- Soft cover and online PDF.

**TO ORDER**
- Contact WERF at 703-684-2470 or visit www.werf.org and click on Publications.

**WERF Subscribers:**
- Your first copy of this report is free. Additional copies are $10 each or download unlimited free PDFs at www.werf.org.

**Non-Subscribers:**
- Hardcopy: $165  PDF: $50
- Refer to: **STOCK NO. 04SW4**

For more information, log on to www.werf.org.
understanding of fate and transport. Understanding the settling characteristics can also offer information on the proper treatment and/or removal processes.

**Solids Analytical Protocol**

Total suspended solids (TSS) are commonly reported in stormwater monitoring, but may not accurately represent the true character of the solids in the water. Moreover, vagueness in the standard methods laboratory protocol means that not all TSS measurements use the exact same protocol. Error is introduced with differences in mixing speeds and methods, subsample location, and equipment.

The report recommends that the current procedure for analyzing TSS be revised. For standardization, the sample should be filtered over a No. 4 sieve in the U.S. standard size sizes to separate gross solids from the sample. The sample should then be mixed at 600 rpm's, using a magnetic stirrer for one minute, after which an aliquot is taken from the approximate middle of the sample, mid-way between the side of the sample container and the vortex using a large bore pipette. The subsample should then be filtered through a 2 micron filter (not a 1-2 micron as the current protocol permits) and the residue analyzed to determine the TSS concentration. Using this modified procedure will help standardize the TSS method by identifying mixing speeds and aliquot sample location.

But this minimum refinement still does not adequately address the issue of heavier solids in the sample because the aliquot sampling technique of individual investigators will result in different extraction amounts. Thus it is recommended that a period of settling be included in the protocol, after mixing and before aliquot subsampling. Two analytical procedures were examined to include a period of settling to separate the rapidly settling solids from the solids that settle more slowly.

Particle size distributions can offer additional information about the solids of concern in the runoff and the potential methods for treatment. If particle size distribution is measured, it is recommended that the maximum holding time be less than six hours. Analysis on chemical constituents associated with the solids, including metals, PAHs, toxic organics, and nutrients, is also recommended, based on the water quality goals.

**Sampling and Monitoring**

Monitoring plans should be developed specifically for the location and goals of the stormwater management program. There are several existing documents with guidelines on obtaining a representative sample in the field.

Obtaining a representative stormwater sample in the field is extremely difficult because stormwater is so unpredictable. Solids in storm water runoff are variable in size, concentration, time, and location. The irregular intensities of precipitation make it difficult to predict runoff rate, sediment transport, deposition and resuspension, etc. Landscape practices, spills, construction activities, traffic density, and vehicle washing can drastically influence the runoff characteristics.

It is very difficult to accurately measure gross solids and course solids. This report recommends that gross solids samples be collected (preferably) in a gross solids removal device or by using nets or screens with 5 mm openings. Coarse solids are usually ignored in storm water sampling because grab samples are usually taken at the water surface and the intake of autosamplers is generally above the bottom of the channel, and the nozzle size is too small. Therefore, the report recommends that bed load samplers be used in addition to grab sampling or autosampling, to better sample the particle size distribution transported in the stormwater. The location of sampling points should be judiciously determined to best represent the solids in the storm water runoff and to meet the goals of the monitoring program.