Information Paper 3.6.1
Particle Size Distribution (Grain Size) Analyses

1.0 Intent and Scope

The purpose of this Information Paper (IP) and folder is to provide information on measurements of particle size distribution in water, sediment, or soil samples. It is appended, with other folders, to a Fact Sheet that provides comprehensive background about the ecological significance of erosion and sediment transport. The IP is dedicated to grain size analyses involving actual separation of the particles into various fractions and quantifying each fraction separately. It does not include any of the streambed substrate assessment methods, such as the "pebble counts" protocol (to be described in the "substrate composition" section of the CWT Compendium in a future edition). This paper supplies a "method menu" table with a list of some of the common methods, their applications (purpose of use), limitations, and the major sources of error associated with each method. The reader is then referred to the Standard Operation Procedures (SOPs) for each method, as compiled by the CWT, which include step-by-step instructions. References for existing American Society For Testing and Materials (ASTM) protocols and guidance documents are provided as well, as part of the Sources and Resources section.

It must be emphasized that this Information Paper is focused on laboratory or field procedures as applied to a sample already in a jar (or a bucket), and assumes that the reader has used sampling and compositing design and procedures provided elsewhere. Some of the guidance for sampling is provided in IP-2.1.1 (Water Sampling) of the CWT Compendium.

2.0 Method Selection

Table 3.6.1-1 provides a "method menu" that includes the commonly used methods for analyzing particle size distribution (otherwise known as Grain Size analysis) in water, sediments, or soil samples. The menu demonstrates the variety of approaches and protocols that have been suggested, but it does not provide a comprehensive list of all published methods. CWT compendium users can view it as a preliminary selection tool in response to the specific needs and the available resources of each individual project.

3.0 Principles and Endpoints of Methods

All these methods for grain size analysis are based on a common principle: the particles are physically separated into various fractions and each fraction is quantified separately. The number of fractions and the cutoff size of each fraction vary greatly, as do the techniques used to quantify each fraction. However, the separation is usually done either by size, through mechanical sieving, or by density (specific gravity) through time-limited sedimentation.

Table 3.6.1-1. Selected Methods for Analyses of Particle Size Distribution in Water, Sediments, or Soil samples

Parameter/Method Name	Type/device	Size range	Application	Level of effort /equipment type	Reference
Sand Fraction in a Water Sample	Wet sieving	As needed	Augment Suspended Sediment concentration measurement (see IP-3.1.5)	Low / lab	ASTM (1997) D 3977 Procedure C
Particle Size Distribution in water	Time-limited sedimentation and Gravimetric	2 to 63 micron	Stormwater, agricultural, or urban runoff	High / lab	Plumb, 1983
Sediment fractionation	Wet sieving and density separation	As needed	Stormwater BMP evaluation	High / lab	Katznelson, 1998
Streambed PSD analysis	Wet sieving in field	As needed	Rapid assessments of subsurface gravels	Medium / field	Booth et al, 1991
Percent fine sediment	Wet or dry sieving	63 micron	Sediment contamination status	Low / lab	
Inorganic sediment fractionation	Peroxide digestion and sieving	As needed	Focus on inorganic grain size	High / lab	(RB2 RMP method)
Silts and Clays in soil or sediment	Hydrometer	less than 75 micron	Soils, construction or fill materials	Medium / lab	ASTM (1995) Standard C 117-95
Grain size analysis	Dry Sieving	As needed	General application, sand sorting, McNeil bulk samples	High / lab	ASTM (1996) Standard C 136
Aggregate analysis	Wet sieving	As needed	Natural aggregates, soils, construction or fill materials	High / lab	Agricultural Research Service (hand written procedure)

Essentially, a sample is passed through a series of sieves of progressively smaller pore openings, and the material caught on each sieve is collected and quantified. Soils are usually sieved dry, sediments can be sieved either wet or dry. Particles smaller than the smallest pore size (usually about 63 micron) can be quantified as one fraction, or can be further separated – when suspended in water - by time-limited sedimentation.

The quantity of material in each fraction can be evaluated by drying and weighing, or by measurement of concentration through specific gravity determination with a hydrometer, or by measurement of the volume displaced when the solids in that fraction are added to water. The results can be expressed as percentage of each fraction (of the total weight) in a table or a plot; a plot of the cumulative percent of particles smaller than a given size as a function of particle size is also common. Size "Percentiles" such as the median diameter (d50) or the eighty-fifth percentile diameter (d85) are sometimes derived from the cumulative distribution plot to provide a single endpoint for comparisons or thresholds. Alternatively, the dominant size fraction (usually defined by a word, such as "sand" or "pebbles") is often used to provide a general description.

4.0 Practical Tips

So far, CWT has encountered the need to perform particle size distribution in two types of situations: (a) understanding of sedimentation patterns in stream beds and assessing siltation problems; and (b) characterizing the severity of sediment contamination (with potentially harmful materials that adhere to particles) by looking at specific concentrations in different size fractions. The Reader is referred to any of the document authors (listed in Section 5 below; contact information available with the CWT) for further information.

5.0 Sources and Resources

This Information Paper has been created by R. Katznelson of the Clean Water Team implementing the Citizen Monitoring Program of the State Water Resources Control Board, in collaboration with V. Finney, R. Dale, R. Lawton, and W. Sykes, all members of the Volunteer Monitoring Technical Advisory Committee Sediment Workgroup. Substantial comments and information have been contributed by M. O'Connor (O'Connor Environmental Inc.) and by M. Napolitano (San Francisco Bay Regional Water Quality Control Board).

For an electronic copy, to find many more CWT guidance documents, or to find the contact information for your Regional CWT Coordinator, visit our website at www.swrcb.ca.gov/nps/volunteer.html

If you wish to cite this IP in other texts you can use "CWT 2004" and reference it as follows:
"Clean Water Team (CWT) 2004. Particle Size Distribution (Grain Size) Analyses, IP-3.6.1(PSD). in: The Clean Water Team Guidance Compendium for Watershed Monitoring and Assessment, Version 2.0. Division of Water Quality, California State Water Resources Control Board (SWRCB), Sacramento, CA."

Available SOPs (2004 Compendium)

- SOP-3.6.1.1 Sorting Beach Sand

REFERENCES used in this IP

American Society For Testing and Materials (ASTM) 1996 Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates. Designation: C 136 – 96a. American Society For Testing And Materials, 100 Barr harbor Dr., West Conshohocken, PA 19428

American Society For Testing and Materials (ASTM) 1995 Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates. Designation: C 117-95. American Society For Testing And Materials, 100 Barr harbor Dr., West Conshohocken, PA 19428

American Society For Testing and Materials (ASTM) 1997. Standard Test Method for Determining Sediment Concentrations in Water Samples. Designation: D 3977 - 97. American Society For Testing And Materials, 100 Barr harbor Dr., West Conshohocken, PA 19428

Booth …. 1991

Katznelson, R. (1998) Wet Sieving for sediment fractionation by grain size and by density. Experimental procedure prepared for Woodward Clyde Consultants, Oakland, CA.

Plumb …. 1983

Original IP reference:

California Association of Resource Conservation District (CARCD). (~2001). Particle Size Distribution (Grain Size) Analyses. in: Guidelines for Citizen Monitors: Products of the 2000-2001 Technical Advisory Council on Citizen Monitoring. Prepared in collaboration with the Wild On Watershed Program and the Clean Water Team for the Citizen Monitoring Program of the State Water Resources Control Board. Sacramento, CA.