

**ASCE GUIDELINE FOR MONITORING  
STORMWATER GROSS SOLIDS**

Written by the

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## 1.0 INTRODUCTION

Gross solids are the litter, trash, leaves and coarse sediments that travel either as floating debris or as bedload in urban runoff conveyance systems. In the past, most monitoring programs designed to determine the effectiveness of Best Management Practices (BMPs) for stormwater pollution have narrowly defined the size, concentration, and mass of *solids* in the runoff. This is attributed to the sample collection method commonly used. These methods generally exclude *solid material* greater than 75 microns that is not effectively collected using automatic water quality samplers, or the coarse sediments that are transported as bedload. Though often unaccounted for in monitoring programs, these large size pollutants degrade aquatic habitat, cause visual blight, smother productive sediments, leach harmful pollutants, and can cause unpleasant odors.

Historically, evaluations of stormwater Best Management Practices, (BMPs), have focused on dissolved and suspended pollutants in the water column because the sampling methods were adapted from people's experience with wastewater treatment plants. Therefore, pollutants were sampled in the influent and effluent water using grab samples from the water column or autosamplers, and flow measurements were made using velocity or weir measurements. Stormwater pollutants differ from wastewater, however, by being intermittent in nature and often having high volumes of gross solids in the storm runoff that are not measured using autosamplers or other standard techniques. This report recommends guidelines for measuring the gross pollutant fractions found in stormwater. Other reports are recommended for measuring the pollutants in the water column.

Gross solids are divided into 3 categories:

1. **Litter** includes human derived trash, such as paper, plastic, Styrofoam, metal and glass greater than 4.75 mm in size.
2. **Organic Debris** consists of material including leaves, branches, seeds, twigs and grass clippings greater than 4.75 mm in size.
3. **Coarse sediments** are inorganic breakdown products from soils, pavement, or building materials greater than 75 microns. It also includes fragments of litter and organic debris not included in the other two categories.

The selection of 75 microns as the lower size limit used in the definition of gross solids was chosen because this is usually the largest size that can be seen by the naked eye or representatively collected and analyzed using auto-samplers. It is also about the smallest size collected by proprietary units designed to collect gross solids. A lower limit of 75 microns was also selected since this is the boundary between sand and silt used by soil scientists (AASHTO and USCS (Liu, T.K. 1970, Das 1997) and it is easily separated in the laboratory using a #200 U.S. sieve size (ASTM Standard D 2487-92). In addition, it is close to the 63 micron divide used by the U.S. Geological Survey to distinguish between silt/clay and sand-sized suspended sediment in rivers (Horowitz 1995).

Litter has been reported in the literature using a wide range of sizes as the lower limit (5 to 10 mm). These have usually been selected to match the size of the mesh in the type of device used to collect the litter. In this guideline, the boundary of 4.75 mm (close to 5 mm) was selected as the lower limit for litter and organic debris since it would be impossible to separate small fragmented particles from the coarse sediment size fraction. In addition, this size can be conveniently separated in the laboratory using a #4 U.S. sieve size and includes the 5 to 10 mm size reported by other studies (Caltran 2000, Allison et al. 1996, Allison et al. 1998, Hydroqual 1995, Armitage and Rooseboom 2000, Lloyd et al. 2001, Butler et al. 2002). In addition, the #4 sieve corresponds to the separation between coarse sand and gravel (ASTM standard D 2487-92). A laboratory test can be used to quantify the organic fraction of the less than 4.75 mm solids and distinguish the organic fraction from the coarse sediment, if this is one of the goals of the monitoring project. Also visual separation can be performed on solids larger than 5 mm if the monitoring program requires it.

Other researchers have also designated these general size ranges for classifying solids as shown in Figure 1 adapted from a recent publication describing monitoring methods for solids (Roesner *et al.* 2007).

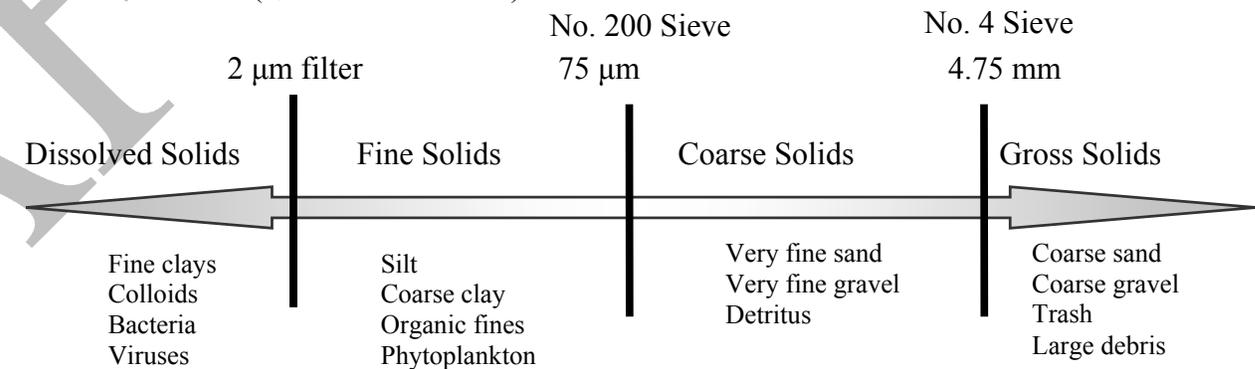


Figure 1. Solids Size Classification Diagram (Roesner et al. 2007).

These particle size boundaries are meant to be general guidelines and not hard and fast rules. For example, the AASHTO classification considers the material to be silt-clay if more than 35% passes the #200 sieve size. For ASTM D2487 the criteria for fine-grained soils (silts and clays) occur when 50% or more pass the #200 sieve. On the other end of the scale for coarse solids, automatic water quality samplers are able to collect particles larger than 75 μm (Owens 1996), but even when these particles make it into the 4 to 5 gallon collection bottle it is difficult to keep them in suspension long enough to become a part of the laboratory sample (Rushton personal experience). In addition, proprietary devices often collect particles smaller than 75 μm. For example, in a study of a CDS unit, 1 to 8 percent of samples passed the #200 sieve in 10 samples analyzed for three cleanout periods (Rushton 2006). In an evaluation of drop box inserts between 2 to 11 percent of six samples collected for three sampling events passed the #200 sieve (Rushton et al. 2004).

A gross solid monitoring guideline is needed for several reasons:

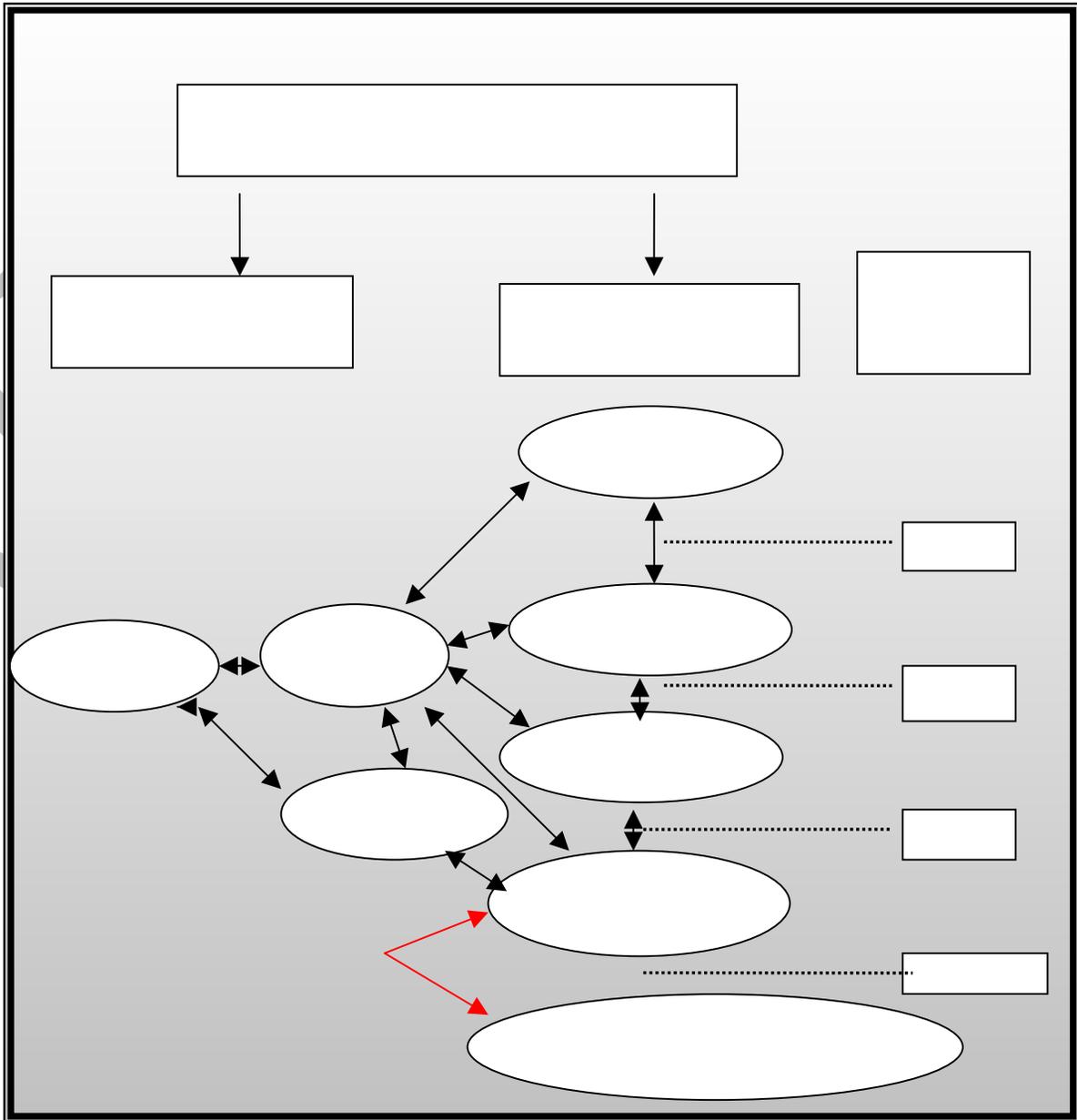
- The U.S. Environmental Protection Agency has identified sediment as a widespread impairment of the Nation's rivers and streams, affecting aquatic habitat, drinking water treatment processes, and recreational uses of rivers, lakes and estuaries as well as providing attachment sites for harmful pollutants such as mercury, pathogens and metals (US EPA 2000, US EPA 2007).
- Physical, chemical and biological damages attributable to fluvial sediment in North America alone are now estimated to be between \$20 billion and \$50 billion annually (Pimental and others, 1995, Osterkamp and others 1998, 2004).
- The growing interest in mitigating the aesthetic and environmental impacts of trash and debris in the nation's waters and regulation of these pollutants through TMDLs has resulted in the development of a number of proprietary products designed to trap and separate large particles from the runoff flow path before discharge. The performance of treatment devices and the material collected by these devices have not been fully tested with standardized methods and cannot be evaluated using historical or even wastewater techniques.
- An accurate quantification and characterization of gross pollutants is needed for selecting the proper BMP design to capture gross solids and to rmine maintenance requirements and schedules.
- Most gross solids cannot be sampled by traditional automatic samplers and have been ignored in studies evaluating the impact of storm water runoff on receiving waters.
- Some research of source area runoff in the eastern United States has reported that a significant portion of the mass of heavy metals, PAHs, and nutrients such as total phosphorous are associated with particles >150  $\mu\text{m}$  that have not been effectively sampled in the past (Sansalone et al. 1998, Rushton 2006).
- In an intensive sampling program of fluvial sediment in rivers, the U.S. Geological Survey reported that the > 63  $\mu\text{m}$  fraction can make a substantial contribution to suspended sediment associated trace element concentrations and should not be ignored (Horowitz 1995).

The purpose of this guideline is to standardize data collection procedures used in evaluating the removal of Gross Solids by BMPs and also to allow for direct comparison of field data from separate studies by using the same collection methodologies. Since the protocol for collecting and analyzing pollutants in the water column is well represented elsewhere, (i.e. TARP 2003, ASCE/EPA 2002, EPA 2002, USGS variable dates), these practices will only be mentioned in passing; while the guidelines presented in this report will emphasize methods for evaluating Gross Solids. This document is only a guideline and should be revised and refined once it has been tested in the field.

## 2.0 BACKGROUND

The total pollutant load entering a BMP is a combination of pollutants suspended and dissolved in the water column, as well as pollutants associated with the Gross Solids, which may be floating litter and debris, large organic and inorganic materials suspended

in the water column, or material moving as bedload by sliding, rolling, or bouncing along on or near the bottom of the conveyance system. A conceptual framework of the various phases of constituents in stormwater is shown in Figure 2. Solids in stormwater consist of dissolved molecules, colloids, and suspended particles, as well as larger-sized floating or suspended matter.



**Figure 2. Conceptual Framework of Particle Size Distribution and Partitioning in Stormwater Runoff.** The division between suspended and settleable particle sizes uses the 1-hr Imhoff settling test. The division between settleable and sediment is the fraction that passes through a #200 U.S. size sieve. Figure 2 is based on work done by Dr. John Sansalone. [Citation](#)

The smallest particles, colloids, are present in large concentrations in natural water and their relatively large surface area per mass provide numerous adsorption sites for pollutants (Minton 2005), but larger often heterogeneous particles also provide numerous adsorption sites. Large particles are rarely smooth or spherical in shape and scanning electron microscopy readily reveals that these highly irregular shapes greatly increase their surface area. In a detailed study of highway runoff, particles in the 420 to 850 micron range had the highest total surface area per mass for all storm events measured (Sansalone *et al.* 1998). These folds, pores, notches, pits and roughness result in additional surface area which increases the opportunity for attachment sites and chemical reactions.

In addition, it is important for the stormwater manager to understand the granulometric characteristics of particles in stormwater in order to apply appropriate treatment techniques to control pollution. Different BMP systems are more efficient for removing certain particle sizes. Also understanding the relative location in the watershed of the treatment system can make the best use of limited resources. For example, coarse and gross solids are discharged and deposited near source areas while smaller particles are more readily transported in the flow stream. An understanding of particles also takes into consideration that larger ( $>75 \mu\text{m}$ ) particles and organic debris tend to cause progressive clogging of the filter systems that are more efficient for removing small suspended solids, colloidal and dissolved constituents.

It should be remembered that chemical reactions are constantly taking place between constituents in all particle size classes. These are controlled by conditions in the water column, such as temperature, pH, dissolved oxygen, and alkalinity. In addition, physical conditions including parameters such as position in the watershed, flow characteristics, storm intensity, turbulence, hydraulic efficiency, first-flush phenomenon, and friction also affect the size of particles and constituent fractionations shown in Figure 2. Colloids, dissolved and suspended solids have been well studied in stormwater research projects since they are routinely collected by using automated water quality samplers. Even much of the settleable fraction, which is defined as material that falls to the bottom of an Imhoff Cone in one hour, is usually included in the water sample. But measuring only the water column solids has led, at times, to the misleading conclusion that most pollutants in stormwater are primarily suspended. In many cases the settleable suspended solids have fallen out in the upstream collection system of pipes and swales and are underrepresented or not collected at all in water column samples. Floating litter and debris are not collected by water column samplers with intake pipes located below the surface, or are removed by strainers. In contrast, studies that capture the entire cross-section of flow or take samples close to the location of solids entrainment have shown that the majority of the original particle mass in urban rainfall-runoff are actually in the settleable-sediment range ( $>250 \mu\text{m}$ ) (Sansalone *et al.* 1998, Sansalone *et al.* 2005). Proprietary devices such as hydrodynamic separators and baffle boxes primarily capture only this large size fraction. However including these coarse sediments, organic debris and trash in this larger size fraction increases the complexity in calculating a removal efficiency of solids and other pollutants.

There are at least three ways to look at performance of BMPs. One is to compare the influent and effluent Event Mean Concentrations (EMCs) for judging their effectiveness. The second is to convert the EMCs to loads and calculate the mass of constituent removed by the BMP. These first two methods can give a direct estimate of the loads of various constituents reaching the receiving waters. The third is to calculate BMP removal efficiencies in term of percent removals, whether based on average annual EMCs or annual loads removed. Doing this for Gross Solids is not straight forward because sampling of the inflow and outflow mass of gross solids is challenging. At best we can measure the volume or mass of the material actually removed by the BMP device. These data do not lend themselves to clear estimates of “efficiencies” or percent removals. The nature of Gross Solids is such that at this point in time there are no proven methods for comparing upstream and downstream loadings since Gross Solids are measured as a total mass rather than a concentration and there is no appropriate “conversion factor” for combining TSS or other stormwater constituents in the water column along with the gross sediment mass in order to calculate overall removal efficiencies.

Another challenge in measuring Gross Solids is that some gross pollutant traps are designed to retain the collected material in a wet sump until the unit is cleaned out (wet systems) while others are designed to collect the material above any standing water in the trap (dry systems). Quantification of the amount of gross pollutants collected in wet units is not a simple task since (1) it is difficult to obtain an accurate dry weight of collected material, (2) the decanted water may dissolve or mask gross pollutants, and (3) some of the pollutants (i.e. N, metals, organics, inorganics and P) leach from the gross solids into the standing water in relatively short time periods (Strynchuk *et al.* 2000, Dodge 2005). In addition, even when pollutants, such as heavy metals associated with gross solids are not immediately bio-available they can accumulate in the sediments and under anoxic conditions can, in part, mobilize into the water column and introduce toxicity to benthic organisms (Burton and Pitt 2002).

In contrast, dry systems, such as inlet traps, make characterization and testing of gross pollutants a somewhat simpler task than wet traps. In dry systems, it may be possible to collect nearly 100% of the pollutants in the screens or filters. Where appropriate in this guideline, a distinction is made for methods that are necessary for wet verses dry systems. For your information, Appendix A provides a list, brief summary, and some web addresses for various types of gross solid collection devices.

### **3.0 MONITORING PLAN DEVELOPMENT**

There are large variations in pollutants accumulated in structural BMP devices among rainfall runoff events. These are due to many variables, such as size of contributing watershed, rainfall intensity and duration, antecedent dry period, land use, soil type, seasonality, deicing practices, landscaping practices, etc. These variations are even more significant for Gross Solids. In order to normalize these variations whenever studying Gross Solid removal effectiveness of various BMP facilities, yearly data

accumulation measurements of such solids can provide more useful results than shorter time frequency comparisons. It therefore becomes important to keep accurate records of cleanout intervals, cleanout volume, and cleanout mass. In addition, tributary catchment and weather characteristics should be collected, such as rainfall amount, intensity and duration, number of rainfall events, area of the catchment, land use, types of curbing, other BMPs in the catchment, street sweeping activities, unusual weather events, urban landscaping practices and proximity to major pollution sources such as picnic and outdoor dining areas, beaches and industries. The basic information collected should be as a minimum consistent with the International Stormwater BMP Database Requirements (See Appendix B) and future efforts. Weather and flow requirement are discussed in a later section.

Each site and structural BMP type is unique and the guidelines should be customized to meet individual circumstances. For example, excess dry weather flows or submerged pipes can result in disposal and testing problems in wet systems. When cleaning a “wet” device, the inflow to the unit should be closed off to eliminate dry weather flows. If the outflow is submerged it should also be plugged. This becomes important because the volume of water in the conveyance system will flow into the BMP as it is cleaned and can be many times greater than the capacity of the cleanout truck. Although undesirable, field conditions may cause the decanted or diverted water to be returned untreated downstream of the BMP.

In order for a monitoring program to deliver a reasonable level of accuracy, the program must be well planned. Unless a study is designed to compare characteristics of a specific rainfall event to gross pollutant accumulation, the Gross Solids analysis should be performed at the time of clean out. Since BMPs have a designed storage capacity, units should be cleaned out before this capacity is reached to prevent resuspension or bypass in future storm events. A running record of cleanouts should become a standard procedure for all BMPs that remove gross solids, which will assist in estimating required maintenance cleanout frequency. The capacity should be noted in the cleanout report, along with the volume and characterization of material cleaned as discussed below.

### **3.1 PROGRAM LEVEL DETERMINATION**

The first step in any monitoring plan for determining the effectiveness of Gross Solids removals is to determine the purpose and budget available for such testing and monitoring. A monitoring program can range from basic and relatively inexpensive, to extremely complex and expensive. Recognizing that not all BMP monitoring programs have the same goals or available funds, three levels of monitoring are defined to balance goals, funding constraints, and levels of accuracy. The levels are first defined based upon broad goals in this section, followed by specific level sampling requirements in Section 5.0 tailored to the program level. Each succeeding higher program level should include all of the elements of the preceding lower level.

*Level 1* - A Level 1 monitoring program is intended to demonstrate basic effectiveness of a facility to remove Gross Solids. It requires only a simple data

gathering effort to provide minimal performance data to quantify the mass or volume of the Gross Solids removed and to analyze a limited number of pollutants in the solids. It is not necessary to include water column monitoring, although this would provide other useful information. Examples of Level 1 programs are the requirements associated with State or Federal grants to communities for stormwater retrofitting projects. Grant conditions often require that a small number of parameters be tested, which will provide performance data to estimate the effectiveness of a structural BMP installed with grant funding. The objective is to demonstrate pollution removal for the BMP based upon the pollutants collected. In order to control costs, minimal laboratory analysis is performed and statistical validity of results using a large number of storms is not typically required. At least two gross solid samples should suffice for analysis of each cleanout period.

*Level 2* - Level 2 programs are of a higher level of complexity and cost than Level 1 programs. In addition to Level 1 parameters, Level 2 programs include water quality sampling, collection of flow data, and a more detailed analysis of gross solids. More extensive laboratory tests are used to quantify individual pollutants of concern. These programs could be used by BMP developers or agencies for screening performances of BMPs, or for studies to set TMDL regulations.

An example of the water column sampling and analysis component for Level 2 testing program is published in the Technology Acceptance Reciprocity Partnership Protocol for Stormwater Best Management Practice Demonstrations (TARP 2003 or later), endorsed by California, Massachusetts, Maryland, New Jersey, Pennsylvania, and Virginia. For the TARP (Tier 2) protocol, a minimum of 15 qualifying storm events greater than 0.1 inch of rainfall are tested using flow weighted composite samples from autosamplers. Accurate flow measurements are required to determine flow rates and volumes for each storm. Long term sampling of at least one year is recommended to account for seasonality of pollutant loadings and rainfalls. The TARP program and others of this type only measure water column pollutants in dissolved and suspended forms. The sampling scheme proposed in this Guideline for Monitoring Gross Solids should be added to the TARP-type program to produce a Level 2 monitoring effort. Other current sources for water quality sampling methods are the Environmental Technology Verification Protocol (US EPA 2002 or later) and the United States Geological Survey Field Manual for Water Quality Testing (USGS variable dates).

*Level 3* - Level 3 programs are highly complex, and often expensive studies of BMPs that could be used to develop data for research programs or for development of new or improved BMPs, and to perform multi-year analysis of annual mass loadings, long term impacts on ecosystems, or TMDL development. These programs are customized to study many parameters, or specific parameter(s), such as toxic organics. They are typically performed by technology testing and development firms or universities and the research scientist or engineers determine the parameters to be measured.

## 3.2 QUALITY ASSURANCE PLAN

The next step is to develop and obtain approval of the appropriate Quality Assurance Project Plan (QAPP) required by local or state authorities. A QAPP establishes the test methods, equipment, and procedures that should be used to collect stormwater BMP data. Test results will often not be recognized by authorities without an approved QAPP. An example of a QAPP checklist is provided in Appendix C.

## 4.0 GROSS SOLIDS SAMPLING TECHNIQUES

After developing a plan, implementing the plan is the next step. The techniques that are used to collect samples are critical to the success of a monitoring or research program. If proper techniques are not employed, the samples may be compromised during collection and no subsequent analyses will provide accurate data. For all levels of effort, the litter and trash should be separated from the sediment. For levels two and three, the debris and sediment also should be separated from each other and analyzed independently. The subjects discussed in Sections 4.1, 4.2, and 4.3 apply to all sampling activities.

### 4.1 Sample Collection.

Some types of units designed to collect gross solids, such as inlet traps, can be easily accessed to collect representative samples by hand or with appropriate tools. Some BMPs are not designed to collect litter and this sample collection discussion will not apply to them. For more difficult applications in large inaccessible units, specialized sediment sampling techniques may be required.

*4.1.1 Litter (trash)* – Floating trash is collected by being skimmed off the top of the water on a regular basis (monthly is suggested) and air dried under cover in mesh bags. In some BMPs, trash will be captured on screens and will be mixed with large organic debris and associated sediments. This material is stored within the trapping device until the device is cleaned out, and the entire mass, or sub-samples of the litter/debris/sediments are collected upon cleanout. Once the material is taken to the disposal site, a final sorting through the sample will be performed to separate the litter from the rest of the material. The volume of all of the litter should then be air dried and measured. For more detailed studies, the litter should be sorted into categories and each category measured and weighed. Examples of studies designed to quantify litter are described in Appendix D.

*4.1.2 Sediment/Debris* – Some types of collection devices are easy to access and can be sampled by hand using an appropriate tool such as a shovel. In others, representative samples of the sediment/debris portion can be more difficult to collect and sediment sampling techniques may have to be used. Choosing the most appropriate sediment sampler for site conditions is important. Burton (1991), US EPA (2006a) and Edwards and Glysson (1999) provide some insight into the pros and cons of various samplers. The

two types of samplers recommended for our purposes are grab samplers and core samplers.

Grab Samplers – Grab samplers are effective for surface samples. They consist of a set of jaws that shut or a bucket that rotates into the sediments. They are relatively easy to operate, but are prone to washout, especially when leaves, litter or rocks are present that keep the jaws from completely closing. Also they tend to fall to one side due to inadequate or incomplete penetration of the material.

Core Samplers – Core samplers give better results if the researcher is interested in stratification, or if a single core can be taken from the top to the bottom of the material. Core samplers usually collect less material than a grab sampler and several cores may be necessary to collect adequate volumes of sample material for lab testing. A core sampler may not be able to penetrate a mass that contains mostly leaves

Other Methods –

- Use of a pre-washed vacuum truck and segregation and dewatering of materials at the dump site.
- Collection by hand via confined-space entry
- Freezing core samplers

#### 4.2 Contamination Prevention

*Type of material* - Care must be taken to keep from contaminating the sample while it is being collected. For collecting and storing samples, for example, stainless steel or glass is recommended for metals. Some plastics can not be used for PAHs, while Teflon is necessary for other samples. Consideration for contamination prevention should also be given for the sampling devices, such as scoop, spatula, mixing containers, or any other utensils that come in contact with the sample. Depending on the type of analysis, only equipment and containers made of certain materials can be used.

*Equipment Decontamination* – For most sampling applications, site water rinse of equipment in between sampling sites is sufficient, but if cross contamination is thought to be a problem, an approach recommended by ASTM (2000) ([reference](#)) includes: 1) soap and water wash, 2) distilled water rinse, 3) acetone or ethanol rinse, and 4) site water rinse. It is also recommended that equipment be washed in the lab by the ASTM procedure before sampling is initiated to make certain that the equipment has not been contaminated by a previous application.

*Constituents of Special Concern* – If metals or other inorganic compounds are specifically targeted, sampling and handling equipment should be suspended over a tub and rinsed from the top down with 10 percent nitric acid using a pump or squirt bottle (ASTM 2000). If organic compounds are targeted, sampling equipment can be decontaminated using acetone, followed by a site water rinse (US EPA 2006a). Also organic compounds can be contaminated from rubber or plastic materials. According to ASTM (2000) and APHA (1995) contact of the sample with the following substances should be avoided: PVC, natural or neoprene rubber, nylon, talcum powder, polystyrene,

galvanized metal, brass, copper, lead and other metal materials, soda glass, paper tissues, and painted surfaces.

*Sample Containers* – Most containers for samples are sent directly from the laboratory where the samples are to be analyzed. The sample containers are often specifically prepared for the targeted constituents and are suitable for most applications. Commercially pre-cleaned containers are also available from many vendors. For samples stored at the laboratory, the US EPA (2006a) recommends the following precautions: High density PTFE or Teflon containers are least likely to add chemical artifacts and are less likely to break than glass. Volatile compound containers should have a septum to minimize the escape of volatile gases. If samples contain photoreactive compounds, such as PAHs, then brown glass or shielding with an opaque material such as aluminum foil will reduce changes in concentrations and should be stored in the dark. Plastic or acid-rinsed glass containers are recommended for heavy metals.

#### 4.3 Sub-sampling and Compositing Samples

The contents of most of the units designed to collect gross solids will have to be sub-sampled. For small dry systems such as inlet traps, this can usually be accomplished directly in the unit. For large units with deep enclosures, vertical stratification can result and sub-samples should be collected from each depth. Spacing will depend on the total depth of the material, but aliquots from at least four or five depths should be collected. Gross solids are usually not homogeneous, and at least two samples collected separately should be analyzed for all testing levels to help determine variability. The following suggestions for compositing samples are recommended (US EPA 2006a):

- Overlying water should be siphoned off, not decanted, from samples prior to sub-sampling<sup>1</sup>.
- All utensils used to process samples should be made of inert materials.
- Sub-samples should be collected away from the sides of the sampler to avoid potential contamination.
- For samples of parameters with holding times, samples should be processed prior to long-term storage, within 72 hours (and preferably within 24 hours) of collection. See Appendix E for holding times recommended for various constituents.
- Sufficient sample homogenization, prior to placing in containers is critical for accurate quality measurements.
- Similar depths for each duplicate sample aliquot should be maintained.
- Samples should be kept at 4° C or frozen and sent to the laboratory for analysis. Be aware that freezing and thawing appears to increase the release

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<sup>1</sup> Siphoning water off the top of the sample uses the same principle as siphoning gas out of your automobile gas tank. Take a piece of laboratory flexible tubing, fill with water, crimp both ends and place down the side of the container, let go of the ends of the tubing and decant into a glass cylinder placed at a lower level. If some sediment is transferred to the cylinder, this water can be decanted and the sediment placed back into the sample container.

of soluble organic carbon (Burton 1991) so if organic carbon is a constituent of concern, do not freeze.

- If samples are to be refrigerated, the container should be filled to the brim to reduce oxygen exposure. This is particularly critical for volatile compounds. If a sample is to be frozen, the container should be filled to approximately 90% of its volume to allow for expansion.
- Mechanical sieve analysis shall be conducted on the entire mass of air-dried solids (40°C and low humidity). A dry mass is determined before and after sieving and a mass recovery error of < 2% is generally required.
- Results are to be reported as mg/kg or µg/kg dry weight.

## 5.0 PROCEDURES FOR PROGRAM LEVEL MONITORING

Table 1 summarizes the specific measurements and analyses that are recommended for each of the three levels of gross solids monitoring. Note that the chemical analysis for the Gross Pollutants may cover different parameters than the water quality testing regime since some parameters, such as PAHs, are often detected in sediment/debris, but not in the water column, while dry sediment cannot be tested for TSS. Certain BMPs have a combination wet and dry designs. Monitoring of gross pollutants for these devices will require customized approaches. The plan for testing BMPs should be designed using the appropriate combinations of the procedures described below.

*Level 1* – This basic level of evaluation is planned so that the amount and type of material collected by gross solid collectors can be compared to each other. It includes basic information such as: rainfall, cleanout intervals, the volume and type of material collected by the BMP, as well as watershed information and BMP cost (see Appendix B).

1. *Rainfall* should be measured at the site, if possible, or at a nearby weather station. Data recorded daily is desirable.
2. *Time interval since the last cleanout* - Document the time interval between cleanouts and the depth and volume of accumulated material, percent of maximum volume for the unit under study, and other pertinent data. One method to do this is to measure the accumulated depth of gross solids in the BMP each month and plot it on a graph with the monthly rainfall data. See Appendix E for an example.
3. *Volume of material captured in each chamber* will depend on the type of unit under study, but should estimate the volume and mass of material collected by the BMP at the time of cleanout. For Level 1, the entire volume including litter, debris and sediments can be estimated either while in the unit (if possible), in the vacuum truck, or at the disposal site. Usually the dimensions of the unit are known and the volume can be estimated by measuring the depth of the accumulated mass at one or more locations in the containment chamber. Wet and/or dry density determinations can be made to estimate wet and/or dry mass from volume. Record method used to measure volume of material.

**Table1. Program Level Summary. Each level should include the steps from each preceding level.**

<b>Level 1 Minimal Monitoring (Screening Evaluation)</b>	<b>Level 2 Detailed Monitoring (Performance Evaluation)</b>	<b>Level 3 Advanced Monitoring (Research and Design)</b>
<ol style="list-style-type: none"> <li>1. Rainfall amount</li> <li>2. Time interval since last cleaning</li> <li>3. Volume and weight of material captured in each chamber</li> <li>4. Separation of large litter from coarse sediment and organic debris</li> <li>5. At least two samples for chemical analyses of sediment/debris mixture</li> <li>6. Percent Organic Matter of sediment/debris sample</li> <li>7. Percent Solids</li> </ol>	<ol style="list-style-type: none"> <li>1. Rainfall characteristics</li> <li>2. Separation of organic debris from coarse sediment</li> <li>3. Mass and weight of debris</li> <li>4. Mass and weight of sediment</li> <li>5. Sediment particle size distribution using sieve analysis</li> <li>6. Chemical analysis for two debris sample per chamber</li> <li>7. Chemical analysis for two sediment sample per chamber</li> <li>8. Percent Organic Matter of sediment sample in each chamber</li> <li>9. Water Quality sampling using standard methods.</li> <li>10. Flow measurement for storm duration including bypassed &amp; base flow</li> <li>11. Mass Balance</li> </ol>	<ol style="list-style-type: none"> <li>1. Sediment chemical analysis for each sieve size and whole sample.</li> <li>2. Additional chemical analysis for special parameters</li> <li>3. Subdivide litter and debris into special categories</li> <li>4. Baseflow measurement and chemical analysis.</li> <li>5. Leachate analysis</li> <li>6. Other Analysis as Needed</li> </ol>

4. *Separation of litter from sediment and debris* – This can usually be done by hand. Some units such as inlet traps are not designed to capture large litter. In units such as these, only remove any stray litter in the sub-samples targeted for laboratory analyses. In units that are designed to capture litter, the litter should be removed either by hand at the time of cleanout or skimmed off the top each month. After it is separated it should be air dried ~~in mesh bags~~ under cover and a volume calculated for each cleanout period. At the time of cleaning, large, heavy litter such as bottles should be separated from the litter and debris. Air-dried weight can vary depending on humidity, temperature, and drying time. It is recommended that if weights are

recorded, keep accurate records of how the material was dried and report it with the data.

5. *Chemical analyses of sediment/debris mixture for pollutants of concern* – After the litter is separated from the sediment/debris, the remaining material should be prepared for the chemical analysis and at least two separate representative samples of the mixture taken from each chamber, composited together for each of the two samples, and analyzed for pollutants of concern using standard soil analysis techniques. At a minimum analyze for total nitrogen, total phosphorus, recoverable metals, % moisture and total solids. Since PAH are often found in measurable amounts in gross solids this would be a desirable parameter to measure. Report the results as  $\mu\text{g}/\text{kg}$  or  $\text{mg}/\text{kg}$  dry weight.
6. *Percent Organic Matter* - One example method is the Walkley-Black Method

*Level 2.* This level includes all of the Level 1 tests and adds more intensive techniques to separate litter, debris and sediment. It also includes storm flow data and adds additional laboratory analyses.

1. *Rainfall* should be measured at the site, if possible, or at a nearby weather station and rainfall characteristics should be calculated using the following parameters. See Appendix E for an example.
  - Rainfall amount (cm, in) = amount measured for each event  $> 0.127$  cm (0.05 in).
  - Inter-event dry period (hr) = time period since previous rain event ( $> 6$  hrs hours between storms).
  - Duration (hr) = period of active rainfall.
  - Intensity (cm/hr, in/hr) = total event rainfall/duration
2. *Separation of debris from sediment* – Separate the sediments from the herbaceous materials (leaves, twigs etc.) and other larger gross solids by using screens or sieves. Representative samples are composited and then spread to approximately  $\frac{1}{2}$  inch thickness on plastic sheeting, and air dried for 4 days at room temperature. The dried material is then sieved through a 4.75 mm nylon screen or stainless steel sieve (No. 4 U.S.mesh). Material is then shaken or vibrated to remove visible sediment from surfaces of herbaceous material. For contaminants that preferentially volatilize a dry analysis should be coupled with a wet analysis (with an accurate determination of moisture content.). Gross solids that contain a significant amount of attached fine solids should include a separation process so that the gross solids and attached fine solids are separated and quantified. For example, burning may have advantages over washing methods.
3. *Mass and weight of debris* - The next step in taking samples is to determine the volume and mass of each of the different categories (litter, debris, or sediment) sampled. With dry systems, 100% of the volume of Gross Solids can generally be collected and measured inside or outside of the BMP. Representative sub-samples

should be taken for analysis and the debris separated from the sediment as described above. Litter should have already been separated from the total mass and measured as described in level 1(4). Organic debris from decomposing leaves and grass sometimes breaks down to become small particles which are difficult to discern from coarse sediment. Some pollutants attach to the organic debris with concentrations that vary depending on particle size. With each increase in program level there will be an increased effort and expense to more accurately separate the organic particles from coarse sediment and determine the associated pollutants.

4. *Mass and weight of sediment* – Representative samples of mixed debris/sediment in each chamber should be taken. Wash any sediment from floating litter unless it is such a small percentage that it doesn't matter. Separate the debris from the sediments as described above. Report as dry weight.
5. *Sediment particle size using sieve analysis* – A laboratory sieve analysis should be made using standard methods with four or five different sieve sizes between and including #4 and #200. This would be used to characterize the gradation of the sediment (see discussion below). [Wet sieving is another alternative \(Selbig 2007\)](#).
6. *Chemical analysis for sediment samples* – Chemical analysis should be performed on at least two samples and should also include the whole sample before sieving. It is important to analyze samples before sieving since analytical methods recommend pulverizing particles to a fine dust then using a rigorous acid digestion to dissolve the material. This will bias the results as the concentrations of interest are on the surface area of the particle, not the entire particle itself. It would be more appropriate to run a test similar to that used for water analyses. This would include keeping the particle intact (not pulverizing) and running a whole sample digestion with a trace-metal acid. A comparison of the results with the sample that was not sieved will document any changes caused by the method.
7. *Chemical analysis for debris samples* – In addition to the analyses recommended for Level 1, these should be included for level 2: nitrate + nitrite, ammonia, PAHs, total organic carbon and bulk density. Other constituents should include any pollutants of special concern for the region. Report as mg/kg or µg/kg dry weight. A complete list of possible constituents and suggested laboratory methods can be found in Appendix G.
8. *Percent Organic Matter of sediment* - A common analysis for measuring percent organic matter of soils is the loss-on-ignition (LOI) method carried out at high temperatures. It gives quantitative oxidation of organic matter, but inorganic constituents of the soil, chiefly the hydrated aluminosilicates, lose structural water and carbonate minerals and some hydrated salts are decomposed upon heating (Nelson and Sommers 1996). The Walkley-Black Method is preferred since the weight loss caused by heating in the LOI method is considerably in excess of the actual organic matter content. If this error is acceptable then use ASTM D 2974-87 Method C, which is an ash burning at 440 degrees Celsius. We think that the

Walkley-Black Method is a more accurate method to quantify organic matter. Walkley-Black provides a more precise characterization of organic matter with acid-dichromate and heat oxidation (modified Walkley-Black) and a conversion factor (a factor of 2 appears acceptable) (Nelson and Sommers 1996).

9. *Water Quality sampling using standard methods.* Use the methods suggested by the Technology Acceptance Reciprocity Partnership (TARP 2003 or later update), the ETV Verification Protocol (US EPA 2002 or later update), or other methods such as those promulgated by the United States Geological Survey (variable dates).

10. *Flow measurement for storm duration* is accomplished by installing weirs, flumes, velocity meters or other types of flow measuring devices that do not have an affinity for clogging or blinding. Descriptions of flow measurements can be found in texts such as: Burton and Pitt (2002 pp373-377), EPA (2002 p 83), Brater and King (many editions). Useful advice about setting up automatic water quality sampling stations is available from the USGS (Bent et al. 2003). The amount of bypassed flow and base flow should also be measured.

11. *Accounting for gross solids*

*Level 3.* This level of testing consists of customized studies and data collection: (1) to facilitate in-depth data interpretation for development of new BMP processes to enhance BMPs, (2) to better understand BMP functioning, or (3) to answer specific questions posed by the study. The program design and procedures are to be developed by research scientists and engineers. Some characterization methods are listed in Table 1, but these are not mandatory. For example, chemical analysis on each sediment particle size might be one of the goals for this level.



## 6.0 SUMMARY

Gross solids have not usually been considered in monitoring studies that have quantified pollutant removal efficiency for stormwater Best Management Practices (BMPs). Gross pollutants generally consist of litter, debris, and coarse sediments. While these pollutants are not normally monitored in testing programs, many pollutants of concern are bound to the gross solids. In response to growing concerns about gross solids in urban areas, manufacturers have developed a number of proprietary products designed to trap and separate this trash from the runoff flow path before discharge. In order to address this issue, ASCE's Urban Water Resources Research Council (UWRRC) has written a standardized guideline for measuring gross solids. This guideline establishes a standard for testing end of pipe BMPs, inlet traps, and other devices that collect gross solids.

There are many variables to consider in monitoring gross pollutants. Principal factors to investigate in developing a monitoring program for Gross Solids are the purpose of the monitoring program, fiscal constraints, desired accuracy, parameters to be

monitored, whether the BMPs traps Gross Solids in a wet, dry, or combined condition, and time constraints for completion of the program. These factors should be used to determine a program level for monitoring. Three program levels have been defined. Level 1 is basic collection of samples with a minimal amount of laboratory analysis. Level 2 starts with Level 1 and adds intensive techniques to separate litter, debris, and sediment, and uses laboratory analysis to quantify basic individual parameters of concern. Level 3 programs are research programs customized for specific goals. Suggestions are made for Level 3 analysis, but these programs can be customized for any type of research needs. The program levels increase in cost and intensity of effort required as greater levels of accuracy are pursued. Note that the collection and analysis in each Level are minimum criteria, and additional techniques or parameters may be added as needed.

To determine the total pollutant load removed in a BMP, the dissolved and suspended solid mass should be calculated using traditional auto-sampling techniques, flow composite sampling and analyses. It is straightforward to calculate removal efficiencies for dissolved and suspended solids, but methods for calculating removal efficiencies under field conditions for Gross Solids are currently not possible. It is suggested that for Level 2 and Level 3 programs that the entire spectrum of pollutants be analyzed using additional guidelines or protocols. These include, but are not limited to the following:

For Water Quality:

- The Technology Acceptance Reciprocity Partnership (TARP 2003 or later).
- The ETV Verification Protocol: Stormwater Source Area Treatment Technologies (US EPA 2002 or later).
- U.S. Geological Survey Techniques of Water-Resources Investigations, book 9 USGS (2006 or later)

For Solids:

- Guidance for Improving Monitoring Methods and Analysis for Stormwater-Borne Solids (Roessner et al. 2006).

Monitoring methods for gross solids are still in the developmental stage. These guidelines should not be considered a protocol until they are tested, refined and improved.

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## APPENDIX A

### REPRESENTATIVE TECHNOLOGIES CURRENTLY AVAILABLE

Hydrodynamic Separators, inlet devices and oil-water separators are a group of pre-constructed devices that are engineered for stormwater pollutant removal designed for ultra-urban areas (i.e. areas where parking lots, roads, and sidewalks can cover nearly 100 percent of the Land). A variety of companies make these units. The list below, with brief descriptions, is provided as a sample of the types of technology available to remove gross solids. A virtual trade show of available products is available on the internet (US EPA 2006b).

**Sedimentation Basins** are sumps which allow surface water runoff to retain coarse material before it has a chance to enter a stormwater system. Their purpose is to prevent solids from clogging the storm sewer or being washed downstream. These must be cleaned on a regular schedule to maintain their function of trapping sediments.

<http://www.epa.gov/OW-OWM.html/mtb/catchbas.pdf/>  
<http://www.stormwatercenter.net/>

More sophisticated devices have been developed to improve on performance.

**Baffle Boxes** are concrete or fiberglass structures which contain a series of sediment settling chambers separated by baffles. Stormwater flows into the first section of the box causing pollutants to settle out of the water. As water overflows the baffles separating each section, further reduction of pollutants takes place.

[http://www.epa.gov/OW-OWM.html/mtb/baffle\\_boxes.pdf/](http://www.epa.gov/OW-OWM.html/mtb/baffle_boxes.pdf/)  
<http://www.stormwater.ucf.edu/toolkit/vol2/Contents/pdfs/>

**Hydrodynamic Separators** are flow-through structures with a settling or separation unit to remove sediments and other pollutants. Depending on the type of unit, this separation may be accomplished by means of swirl action or other methods.

<http://www.epa.gov/OW-OWM.html/mtb/hydro.pdf/>  
[http://www.stormwaterauthority.org/assets/Hydrodynamic\\_separators.pdf/](http://www.stormwaterauthority.org/assets/Hydrodynamic_separators.pdf/)

**Oil Grit/Separators** are similar to baffle boxes but have the added advantage of also collecting the free oil from storm water. They also may contain screens to help retain larger or floating debris and a coalescing unit to help promote oil/water separation.

<http://www.epa.gov/OW-OWM.html/mtb/wtrqlty.pdf/>

**Modular Treatment Systems** consists of a series of sedimentation chambers and constructed wetlands within a modular tank.

<http://www.epa.gov/OW-OWM.html/mtb/modtreat.pdf/>

**Inlet Traps** are designed to either hang from a drain-inlet frame or hang well below the drain inlet in the sump area. Some of the models are also designed with an inner component that contains an oil-absorbent material.

<http://www.fhwa.dot.gov/environment/ultraurb/3fs13.htm/>

[http://www.stormwaterauthority.org/assets/Catch\\_basins.pdf/](http://www.stormwaterauthority.org/assets/Catch_basins.pdf/)

<http://www.mackblackwell.org/OLD/research/finals/arc2018/>

[http://www.lowimpactdevelopment.org/ffxcty/2-1\\_catchbasin\\_draft.pdf](http://www.lowimpactdevelopment.org/ffxcty/2-1_catchbasin_draft.pdf)

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## APPENDIX B Standard Format Examples

The information in this section has been adapted from the National Stormwater BMP Database Requirements and I strongly urge researchers to go to the source for more detailed instructions. The entire manual is available at <http://www.bmpdatabase.org/doc>. Read especially manual pages 156-160 for watershed and site information requirements and pages 192 and 193 for specific information about hydrodynamic separators. These pages will provide specific instructions that will help you fill out the information in this Appendix.

### GENERAL TEST SITE INFORMATION

Test Site Name including: City, County, State, Zip Code, Country, Time Zone

Geo-referencing including: Township, Range, Principal Meridian  
USGS Quadrangle Map with Altitude, Section, and Quarter Sections  
Latitude: Degrees, Minute, Seconds  
Longitude: Degrees, Minute, Seconds

Sponsoring Agency including: Name, Agency Description and Address.  
The address should include: street, City, State, County, and Zip Code.  
Also include Phone, Fax and E-Mail

Monitoring Agency includes: Agency Name, Description, Address and Phone as above.

Provide any other comments that apply

### WATERSHED INFORMATION

Watershed Name, Hydrologic Unit Code (8-digit), EPA Reach Code (RF1 or RF3)  
Unit System (S.I. or U.S. Standard)

Physical Characteristics such as Total Watershed Area, Total Length of Watershed, Total Length of Grass-Lined Channels, total Disturbed Area, % Irrigated Lawn and/or Agriculture, % Total Impervious Area, % of Total Impervious Area that is Hydraulically Connected, % of Watershed served by Storm Sewers, Storm Sewer Design Return Period, Average Watershed Slope, Average Runoff Coefficient, Hydrologic Soil Group, Soil Type and Type of Vegetation, Visual Observations of Gross Solids.

Description of Roads which included: Total Paved Roadway Area, Total Unpaved, Total Length of Curb and Gutter on Paved, Total on Unpaved, % Paved Roads Draining to Grass Swales/Ditches, % Unpaved Roads Draining, Type of Pavement on Roadways, Traffic Counts (such as AADT or VDS).

Parking Lots: Total Paved Parking Lot Area, Unpaved. Total Length of Curb and Gutter on Paved, on Unpaved. % Paved Parking Lot Draining to Grass Swales/Ditches, Unpaved, Type of Pavement in Parking Lots with % porous.

Land Uses: Land Use Type, % of Land Use in Watershed.

#### GROSS SOLID COLLECTOR DESIGN DATA

The information required for the data base did not seem to describe our systems and most of this section has been adapted to more nearly reflect our specific needs.

- Test Site Name, Watershed Name and BMP Type and Name.Design Information:
- Should include a drawing with dimensions of each element.
- Other BMPs in Watershed such as Ponds, Forebays, Ditches, Swales, Street Sweeping.
- Gross Solids Storage Capacity, Site Visit, Maintenance, and Clean-out Schedule
- Maximum Flow Capacity and By-Pass Information
- Maintenance in the Watershed such as Street Sweeping
- Proximity to pollution sources such as beaches, picnic and outdoor dining areas, drive through restaurants, incinerators, industries, etc.
- Description of the tributary catchment and activities that affect delivery of Gross Solids
- Installation Cost Estimates - Cost of Unit, Construction Costs, Land Costs and Value, Engineering and Overhead.
- Clean-Out: Type and Cost of Clean-out and Disposal of Gross solids
- Date of Cleanout
- Volume of Mass in Vault – by individual compartments
- Characterization of Material in Screens
- Volume of Material in Screens

Provide any Other Comments that Apply

APPENDIX C  
Example of Elements Often Required in a Quality Assurance Project Plan (QAPP)  
Baffle Box Example  
Reference from Daniel Smith

**QUALITY ASSURANCE ELEMENTS**

**Section 3 Distribution List**

**Section 4 Project Organization**

**Section 5 Problem Definition and Background**

- A. Study Site Names and Addresses

**Section 6 Project Description**

- A. Project Purpose
- B. Project Objectives
- C. Project Tasks
- D. Site Locations

**Section 7 Quality Objectives and Criteria**

- A. Precision and Accuracy
- B. Representativeness
- C. Comparability
- D. Completeness

**Section 8 Special Training/Certifications**

**Section 9 Documentation and Records**

- A. Field Logs
- B. Sample Collection, Preservation and Transport
- C. Equipment Decontamination, Calibration and Maintenance Logs
- D. Laboratory Documentation and Reporting
- E. Archival of Electronically Stored Data
- F. QAPP Document Control

**Section 10 Sampling Process Design**

- A. Site Location
- B. Sampling Frequency and Duration
- C. Number of Samples and Matrices

**Section 11 Sampling Methodology**

- A. Aqueous Sample Collection
  - 1. Equipment Specifications

- a) Rain Gauge
- b) Flow Meters
- c) Autosamplers
- d) Flowlink Software
- 2. Procedure for Collection and Preservation of Flow Weighted Composite Samples
- 3. Procedure for Collection and Preservation of Oil and Grease and Fecal Coliform Samples

**B. Sediment and Debris Collection**

- 1. Sediment and Debris In Baffle Box Chambers
- 2. Sediment and Debris Gathered from NSBB Screens

**C. Equipment Decontamination**

**Section 12 Sample Handling and Chain of Custody**

**A. Sample Identification**

**B. Chain of Custody Procedures**

**C. Shipping Procedures**

**D. Sample Containers, Preservation and Holding Times**

**Section 13 Analytical Methodology**

**A. Sediment/Debris/Solids Matrix**

**B. Aqueous Matrix**

**Section 14 Quality Control**

**A. Field Quality Control Samples**

**B. Laboratory Quality Control Samples**

- 1. Quality Control Requirements for Chemical Analyses
  - a) Matrix-Related Quality Control Samples
  - b) Laboratory Control Sample
  - c) Spiking/Fortification Requirements
  - d) Evaluation of Matrix Spikes
  - e) Evaluation of Laboratory Duplicate/Replicate Samples
  - f) Instrument Calibration
  - g) Quality Control Blanks
  - h) Quality Control Failure
  - i) MDL/PQL Adjustment
- 2. Quality Control Requirements for Microbiological Testing
  - a) Quality Control Blanks
  - b) Laboratory Quality Control Duplicates
  - c) Colony Counts

**Section 15 Instrument/Equipment Decontamination,**

**Testing, Inspection and Maintenance**

**A. Equipment Requiring Maintenance, Testing or Inspection**

**B. Equipment Decontamination**

**C. Equipment Maintenance**

**Section 16 Field Instrument/Equipment Calibration and Frequency**

**A. Autosampler Calibration**

**Section 17 Inspection/Acceptance of Supplies and Consumables**

- A. Sample Containers**
- B. Sample Coolers**
- C. Field Filtration Apparatus**
- D. Sample Preservation Kits**
- E. Analyte Free Water**
- F. Equipment Decontamination Reagents**
  - 1. Liqui-Nox Detergent
  - 2. Pesticide Grade Solvents
  - 3. Reagent Grade Hydrochloric Acid

**Section 18 Non-Direct Measurements**

**Section 19 Data Management**

- A. Record Retention**
- B. Field Logs**
- C. Chain of Custody Records**
- D. Laboratory Data**
- E. Data Archival**

**Section 20 Assessments and Response Actions**

- A. Planning Review Audits**
- B. Field Audits**
- C. Corrective Action**

**Section 21 Reports to Management**

- A. Reports to Management**

**Section 22 Data Review, Verification and Validation**

- A. Data Verification**
- B. Data Validation**

**Section 23 Verification and Validation Methods**

Section 24 Reconciliation with User Requirements

**APPENDIX D  
LITTER COLLECTION HANDLING, CATEGORIZATION AND  
QUANTIFICATION**

**NEW YORK EXAMPLE:**

One of the largest and most comprehensive litter investigations has been conducted by New York City in response to what has been described as "one of the major issues of wet-weather pollution, the control of floatable pollution". Information from this monitoring program determined that an average of 2.3 floatable litter items were discharged through the catch basin inlets per day per 100 ft of curb and that the total litter load discharged was about twice this floatable amount. The characteristics of the litter found in the study shows plastics contributed over 50 percent.

**Floatable Litter Characteristics Found on New York City Streets**

Category	No. of Items (%)	Wt. of Items (%)	Density (lb/ft <sup>3</sup> )
Plastics	57.2	44.3	2.8
Metals	18.9	12.0	3.8
Paper	5.9	4.0	2.0
Wood	5.9	5.3	7.7
Polystyrene	5.4	1.3	0.7
Cloth/fabric	2.5	12.5	8.3
Sensitive Items	1.7	0.4	na
Misc.	1.0	3.6	9.8
Glass	0.4	15.6	13.8

From HydroQual, Inc. Floatables Pilot Program Final report: Evaluation of Non-Structural Methods to Control Combined and Storm Sewer Floatable Materials. Department of Environmental Protection, Division of Water Quality Improvement, NYPD2000. Dec 1995.

The New York study further described the litter material categories characterizing litter as follows:

- Sensitives                      Syringes, crack vials, baby diapers
- Paper-coated                 Milk cartons, drink cups, candy wrappers
- Paper-cigarette               Cigarette butts, cigarettes
- Paper – other                 Newspaper, cardboard, napkins
- Plastic                         Spoons, straws, sandwich bags
- Polystyrene                  Cups, packing material, some labels
- Metal/foil                     Soft drink cans, gum wrappers
- Rubber                         Pieces from autos, toys
- Glass                          Bottles, light bulbs
- Wood                          Popsicle sticks, coffee stirrers
- Cloth/fabric                  Clothing, seat covers, flags
- Misc. floatables              Citrus peels, pieces of foam
- Non-floatables                Opened food cans, bottles, bolts

## LITTER

### CALTRAN EXAMPLE:

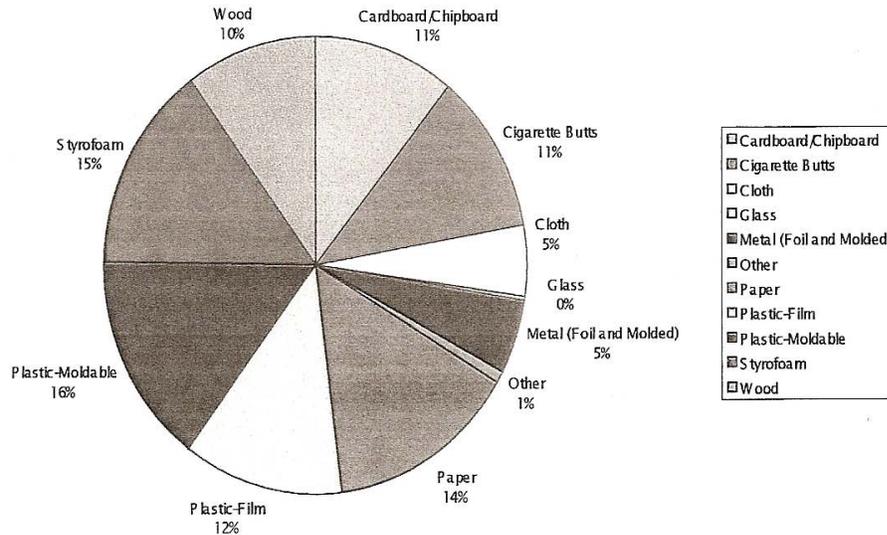
Litter characterization was conducted in a specially designed litter lab. All litter samples/bags collected from the outfall locations were returned to the litter lab for analysis. The litter bags contain all material retained by the 1/4<sup>th</sup> inch mesh openings. This material was termed gross pollutants and consists of both vegetation and litter. The weight and volume were measured at the start of the characterization process. The contents of the litter bag were emptied into a sorting tub and the vegetation was sorted from the litter. The weight and volume of vegetative material was recorded on the data sheet and then disposed.

The litter material was then sifted through to recover any spike materials. The spike material was weighed as a composite and weight was recorded on the data sheet. The spike materials were then sorted into different material categories (i.e. cigarette butts, Styrofoam, fabric, etc.). Both the color and category of the recovered spike material were recorded on the data sheet.

The remaining litter material was placed on a drying screen and allowed to dry for a minimum of 24 hours and the time of air drying was recorded on the data sheet. Other data included antecedent dry period and a photographic record for each site with outfall number, storm number and event number. Litter data were compiled at the end of the storm season and processed into charts and graphs. An example is shown below.

In a later report, Caltrans recommends a specific procedure to analyze Gross Solids (Caltrans, 2003). The total wet weight and volume of Gross Solids should be measured in the field. Gross solids can be weighed using an electronic scale while volume measurements can be done by displacing a known volume of water. Once the Gross Solids arrive in the lab, they should be separated into debris (vegetative matter) and litter. Separation may require visual examination and separation of natural and manmade material. The weight and volumes of each component should be recorded. The litter is allowed to air dry for 24 hours and again the weight and volume are measured.

**Figure 6-3**  
**LITTER CATEGORY DISTRIBUTION BY VOLUME FOR ALL**  
**EVENTS COMBINED**



From Caltrans 2003

**ALBUQUERQUE STUDY:**

A leachate analysis was conducted on the Gross Solids collected in the AMAFCA/Albuquerque study (Dodge, 2005). Leachate from the solids was used to determine the amount of water quality constituents of concern that would leach or wash off of the gross pollutants. Based on this study, it appears that a significant amount of water quality pollutants easily wash off of debris. The following procedure was used.

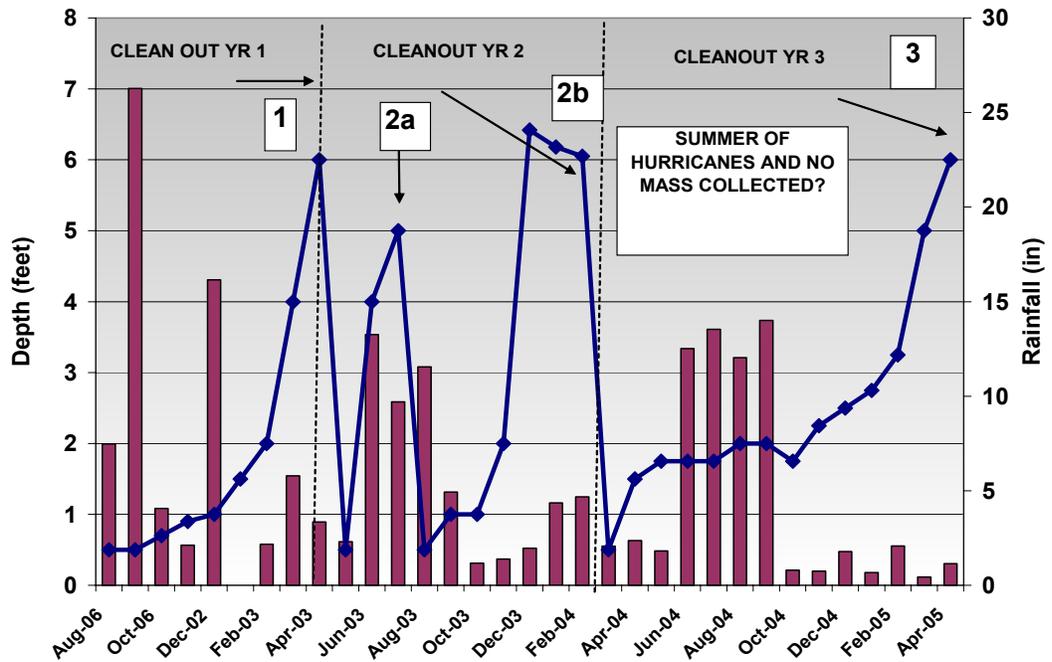
- One cubic yard of Gross Solids was collected from separate locations
- Each cubic yard was immersed in distilled water for 15 minutes
- The leachate was sampled and delivered to a laboratory for water quality analysis using standard procedures.

Their results supported the conclusion that Gross Solids can markedly degrade the water quality by increasing metal concentrations. Specifically total copper, total lead, and total zinc of the leachate solutions showed increased concentrations when compared to the stormwater average. The leachate also showed presence of Petroleum Hydrocarbons and Solvents, (ethylbenzene, toluene, total xylenes, 1,2,4-trimethylbenzene, 1,3,5-trimethylbenzene, chrysene, fluoranthene, and pyrene).

## APPENDIX E

### EXAMPLE OF A RAINFALL, SOLIDS ACCUMULATION AND CLEANOUT RECORD EXAMPLE

*Rainfall* should be measured at the site, if possible, or at a nearby weather station. The most common method is a tipping bucket rain gauge. Excellent descriptions of the proper placement, calibration and other useful advice are available in many texts (Burton and Pitt 2002, p. 378, 387; EPA 2002, p. 61).



**Figure E-1.** The graph is an example of how the monthly rainfall, accumulated volume, and cleanout record might be presented. The bars represent the monthly rainfall amount and the line represents the height of the mass collected in the chamber of the device. The cleanout intervals are represented by the numbered boxes and the yearly records are separated by the dotted lines. Six feet was the depth of the containment chamber. Street sweeping likely affected the results.

APPENDIX F  
Information for Debris/Sediment Sample Handling Procedures  
Daniel Smith [Reference](#)

Parameter	Container	Preservation	Holding Time
Sieve analysis	1 gal. Ziploc bag	N/A	N/A
Percent Organic Matter	1 gal. Ziploc bag	N/A	N/A
Density	1 gal. Ziploc bag	N/A	N/A
Total Nitrogen	8 oz Glass Wide Mouth	4°C	7 days
Chemical Oxygen Demand	8 oz Glass Wide Mouth	4°C	7 days
Total Phosphorus	8 oz Glass Wide Mouth	4°C	7 days
Mercury	8 oz Glass Wide Mouth	4°C	28 days
Aluminum	8 oz Glass Wide Mouth	4°C	6 months
Barium	8 oz Glass Wide Mouth	4°C	6 months
Chromium	8 oz Glass Wide Mouth	4°C	6 months
Cadmium	8 oz Glass Wide Mouth	4°C	6 months
Iron	8 oz Glass Wide Mouth	4°C	6 months
Nickel	8 oz Glass Wide Mouth	4°C	6 months
Zinc	8 oz Glass Wide Mouth	4°C	6 months
Copper	8 oz Glass Wide Mouth	4°C	6 months
Acenaphthylene	Glass, 8 oz. wide mouth with Teflon lined lid	4°C	7 days until extraction, 40 days after
Benzo(a)pyrene	Glass, 8 oz. wide mouth with Teflon lined lid	4°C	7 days until extraction, 40 days after
Benzo(g,h,i)perylene	Glass, 8 oz. wide mouth with Teflon lined lid	4°C	7 days until extraction, 40 days after
Fluoranthene	Glass, 8 oz. wide mouth with Teflon lined lid	4°C	7 days until extraction, 40 days after
Fluorene	Glass, 8 oz. wide mouth with Teflon lined lid	4°C	7 days until extraction, 40 days after
2-Methylnaphthalene	Glass, 8 oz. wide mouth with Teflon lined lid	4°C	7 days until extraction, 40 days after
Naphthalene	Glass, 8 oz. wide mouth with Teflon lined lid	4°C	7 days until extraction, 40 days after
Pyrene	Glass, 8 oz. wide mouth with Teflon lined lid	4°C	7 days until extraction, 40 days after

APPENDIX G  
ANALYTICAL METHODOLOGY FOR ORGANIC DEBRIS AND COARSE SOLIDS  
[Daniel Smith \(Reference?\)](#)

Parameters	Matrix	Units	Method	Precision (% RSD)	Accuracy (% Recovery)	MDL	PQL
Sample Preparation	Sediment/Debris/ Solid	N/A	USBR 514.2.6	N/A	N/A	N/A	N/A
Sieve Analysis (5 screens: #4 #20, #40, #80, #100, <#200)	Sediment/Debris/ Solid	N/A	ASTM D422	N/A	N/A	N/A	N/A
Percent Organic Matter	Sediment/Debris/ Solid	%	ASTM D2974	N/A	N/A	N/A	N/A
Density	Sediment/Debris/ Solid	g/cc	ASTM D2937	N/A	N/A	N/A	N/A
Total Nitrogen	Sediment/Debris/ Solid	mg/kg	EPA/CE81	12	64 - 136	2	8
Chemical Oxygen Demand	Sediment/Debris/ Solid	mg/kg	EPA 410.4	12	71 - 136	500	2000
Total Phosphorus	Sediment/Debris/ Solid	mg/kg	EPA 365.4 (HBEL)/ EPA 365.1 (USBIO)	14	70 - 132	0.0094	0.0376
Mercury	Sediment/Debris/ Solid	mg/kg	EPA 7470	12	67-141	0.0035	0.014
Aluminum	Sediment/Debris/ Solid	mg/kg	EPA 6010	15	80 - 116	1.5	6
Barium	Sediment/Debris/ Solid	mg/kg	EPA 6010	9	88 - 111	0.09	0.36
Chromium	Sediment/Debris/ Solid	mg/kg	EPA 6010	7	88 - 112	0.09	0.36

<b>Parameters</b>	<b>Matrix</b>	<b>Units</b>	<b>Method</b>	<b>Precision (% RSD)</b>	<b>Accuracy (% Recovery)</b>	<b>MDL</b>	<b>PQL</b>
Cadmium	Sediment/Debris/ Solid	mg/kg	EPA 6010	8	89 - 113	0.035	0.14
Iron	Sediment/Debris/ Solid	mg/kg	EPA 6010	18	79 - 138	1.25	5
Nickel	Sediment/Debris/ Solid	mg/kg	EPA 6010	7	85 - 111	0.1	0.4
Zinc	Sediment/Debris/ Solid	mg/kg	EPA 6010	18	80 - 125	5	20
Copper	Sediment/Debris/ Solid	mg/kg	EPA 6010	17	84 - 120	0.07	0.28
Acenaphthylene	Sediment/Debris/ Solid	µg/kg	EPA 8270	22	36 - 122	69	276
Benzo(a)pyrene	Sediment/Debris/ Solid	µg/kg	EPA 8270	9	55 - 117	67	268
Benzo(g,h,i)perylene	Sediment/Debris/ Solid	µg/kg	EPA 8270	13	56 - 123	130	520
Fluoranthene	Sediment/Debris/ Solid	µg/kg	EPA 8270	20	50 - 126	72	288
Fluorene	Sediment/Debris/ Solid	µg/kg	EPA 8270	14	40 - 131	74	296
2-Methylnaphthalene	Sediment/Debris/ Solid	µg/kg	EPA 8270	18	25 - 113	79	316
Naphthalene	Sediment/Debris/ Solid	µg/kg	EPA 8270	21	27 - 112	82	328
Pyrene	Sediment/Debris/ Solid	µg/kg	EPA 8270	13	51 - 121	160	640