R. Pitt
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Incorporation of Gross Solids Analyses in WinSLAMM

Contents

Definitions/Categories of Gross Solids for WinSLAMM

The following definitions are from the ASCE gross solids committee report (ASCE 2010):

Table 1
Gross Solids Categories

Category	Description
Litter	Human derived trash, such as paper, plastic, Styrofoam, metal, and glass greater than 4.75 mm in size (#4 sieve)
Organic Debris	Leaves, branches, seeds, twigs, and grass clippings greater than 4.75 mm in size (#4 sieve)
Coarse Sediments	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. (#200 sieve).

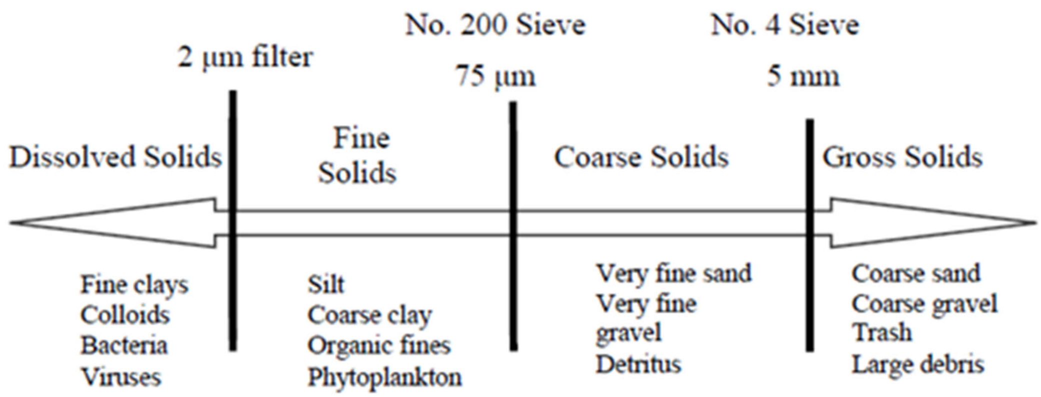


Figure 1. Solids Size Classification Diagram
Source: Roesner *et al*. 2007

Armitage (2004 and 2006) further separate gross solids materials into the following categories that relate to the sources of the materials (focusing on anthropogenic litter components, with some organic debris):

- Plastics: e.g. shopping bags, wrapping, containers, bottles, crates, straws, polystyrene blocks, straps, ropes, nets, music cassettes, syringes, and eating utensils.
- Paper: e.g. wrappers, newspapers, advertising flyers, ATM dockets, bus tickets, food and drink containers, and cardboard.
- Metals: e.g. foil, cans, bottle tops, and vehicle number-plates.
- Glass: e.g. bottles and various broken pieces.
- Vegetation: e.g. branches, leaves, rotten fruit, and vegetables.
- Animals: e.g. dead dogs, cats, and sundry skeletons.
- Construction material: e.g. shutters, planks, timber props, broken bricks, and lumps of concrete.
- Miscellaneous: e.g. old clothing, shoes, rags, sponges, balls, pens and pencils, balloons, oil filters, cigarette butts and old tires.

A New York study (noted by Armitage 2006) further described the litter characterization categories as Follows during their wet weather flows floatable research:

- 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

Historically, floatables (especially in the CSO context) have also been used to describe material with a specific gravity <1, and therefore are found near the surface of flowing water. Many CSO control technologies focus on this category of gross solids. Swirl concentrators were developed to separate the floatables and the grit from overflows, for example. In sanitary wastewater treatment, grit chambers and bar screens are also used to remove these large materials. It is likely that in the stormwater context, most litter and organic debris would be floatable, while coarse sediments would be grit. However, water-logged organic debris approach a specific gravity of 1 and can easily bypass controls relying on floatation mechanisms.

Therefore, it is suggested that WinSLAMM be expanded to include these three categories of gross solids as defined by the ASCE:

- Litter (greater than 4.75 mm or 4,700 µm); local accumulation information would be needed for litter as it is site specific and variable. Also need specific gravity for modeling performance of some controls.
- Organic debris (leaves, twigs, branches, grass clippings (greater than 4.75 mm or 4,700 µm); local seasonal accumulation/loading/washoff data is needed for these materials. Leaf contributions are usually highly seasonal. Also need specific gravity for modeling performance of some controls, and nutrient content of the organic material to calculate these contributions associated with the organic material.
- Coarse sediments (inorganic material, along with organic breakdown products >75 µm and <2,000 µm are already incorporated in the WinSLAMM size distributions, and data exist for these materials. Data is also generally available up to 6,400 µm, with >6,400 µm generally available also). Specific gravity information is also needed to model sedimentation control performance. These coarse sediments rarely are effectively moved through storm drainage systems and are easily captured in many stormwater controls, if present.

Litter does not have any specific pollutant contributions besides inherent aesthetic and interferences with aquatic life issues. Vegetation, however, can leach nutrients and can contribute to traditional stormwater pollutants. The flowing summaries describe some of the available literature on source, loadings, and control of these materials.

Locations of Gross Solids Contributing to Stormwater Contamination

Marais, *et al*. (2001) state that US researchers have identified seven typical sources of litter:

- household litter collection and placement for curbside collection.
- commercial waste dumpsters.
- loading docks.

- building construction and demolition activities.
- vehicles travelling with uncovered loads.
- pedestrians.
- people in motor vehicles.

Examples of litter or illegal dump generating events or enterprises they have identified include community events (parades, street fairs, concerts, sports events), roadway shoulder loads, the unloading of bags of garbage at remote locations, lack of litter bins, convenience stores and fast-food establishments (National Center for Environmental Decision-making Research, 1999).

Marias, *et al.* (2001) also note that research carried out in Australia and New Zealand has shown that the rate at which litter is deposited on a catchment and the composition of that litter is highly variable and depends on a large number of independent factors including:

- the type of development, i.e. commercial, industrial, residential – generally commercial and industrial areas produce higher litter loading rates than residential areas;
- the density of development;
- the type of industry – some industries tend to produce more pollutants than others;
- the rainfall patterns, i.e. does the rain come in one season only or year-round? Litter will build up in the catchment until it is either picked up by refuse removal, or is swept into the drains by a downpour. Long dry spells give greater opportunity to the local authority to pick up the litter, but also tend to result in heavy concentrations of accumulated rubbish being brought down the channels with the first rains of the season – the so-called "first flush;"
- the type of vegetation in the catchment – in Australia for example, leaves form the major proportion of "litter" collected in traps with the highest proportions recorded in residential areas.
- the efficiency and effectiveness of refuse removal by the local authority – it is important that the local authority not only clean the streets and bins regularly, but also that cleansing staff do not sweep or flush the street litter into the stormwater drains;
- the level of environmental concern in the community – leading to, for example, the reduction in the use of certain products, and the recycling of others.

Modeling litter sources should be restricted to streets, sidewalks/walks, and paved parking areas. Organic debris should also be restricted to these areas, as little of these materials are likely to be removed by rain from landscaped and other areas where they occur. Coarse sediments are currently modeled as from all areas and no WinSLAMM changes are needed (unless the upper particle size limit is to be increased above 2,000 µm).

Characteristics and Accumulations of Gross Solids

The ASCE (2010) gross solids committee report noted that "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." The following table indicates the characteristics of these floatable litter materials found during this research, including their densities. Being "floatables," these densities are all well below the density of water (at 62.4 lb/ft^3).

Floatable Litter Characteristics Found on New York City Streets

Category	No. of Items (%)	Wt. of Items (%)	Density (lb/ft^3)
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

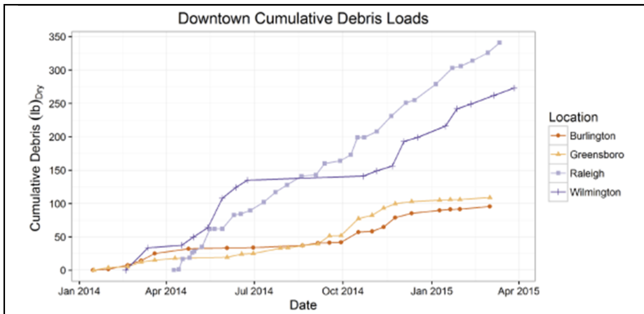
Source: HydroQual, Inc. Floatables Pilot Program Final report: Evaluation of Non-Structural Methods to Control Combined and Storm Sewer Floatable Materials. Department of Environmental Protection, Division of Water Quality Improvement, NYPD2000. Dec 1995.

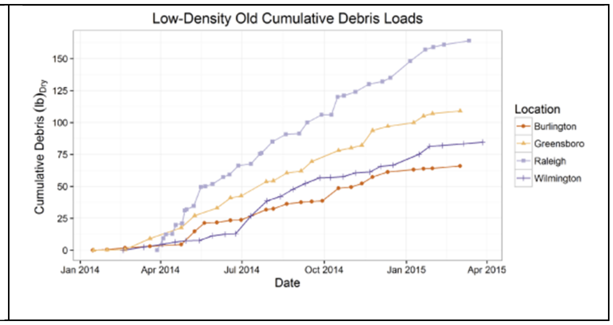
Alam, *et al.* (2017) monitored material captured in catchbasin inserts near Perth, Australia. The following table summarizes their findings, converted to lbs/ac. This also assumes 0.1 curb-miles per acre for downtown commercial areas. The wet season had about two or three times as much vegetation and litter as the dry season in the runoff, most likely due to the greater amount of rainfall. The gross solids material was mostly comprised of vegetation material (93%).

	season	lb/ac/season	lb/yr/curb-mi	% by season in runoff
vegetation	dry	19.0		35.9
	wet	33.9		64.1
	total	52.9	529	
litter	dry	1.0		27.1
	wet	2.8		72.9
	total	3.8	38	
total vegetation plus litter		56.7	567	

	% vegetation	93.3		
	% litter	6.7		

Accumulation of debris (defined as organic material consisting of: branches, leaves, twigs, flowers, and grass) was measured by North Carolina State researchers (Waickowski, *et al*. undated) in four North Carolina cities over a 13 month period. The urban/downtown areas averaged 1.5 acres with 0.12 miles of curbs, and 7 to 21 trees. The low-density residential areas averaged 1.4 acres with 0.14 miles of curbs, and 4 to 37 trees. The following plots show the accumulation of the debris over time.





It's interesting to note that the Raleigh downtown plots indicate a relatively consistent accumulation rate over the year, while the Burlington and Greensboro plots are flat over the summer months and then increase in the fall, as expected. The Wilmington plot, however, shows a large increase in the early summer. In contrast, the debris accumulation plots for the low-density residential areas are all relatively consistent with an even accumulation rate over the year.

The following tables show the approximate accumulation rates for these two land uses. The low density residential area debris loads are about half of the downtown loading, on a unit area, or unit length basis.

Downtown	approx. total load after 13 months (dry lbs)	approx. total load (dry lbs/ac/yr)	approx. total load (dry lbs/curb-mi/yr)
Burlington	95	58	731
Greensboro	110	68	846
Raleigh	340	209	2,615
Wilmington	263	162	2,023
average	202	124	1,554
minimum	95	58	731
maximum	340	209	2,615
COV	0.59		

low density resid	approx. total load after 13 months (dry lbs)	approx. total load (dry lbs/ac/yr)	approx. total load (dry lbs/curb-mi/yr)
Burlington	65	43	429
Greensboro	110	73	725
Raleigh	160	105	1,055
Wilmington	83	55	547
average	105	69	689
minimum	65	43	429
maximum	160	105	1,055
COV	0.40		

UCLA researchers (Kim, *et al*. 2004) studied gross pollutants (wet vegetation, wet litter, dry litter, biodegradable dry litter, and non-biodegradable dry litter) at six highway locations in Southern California over two years. The following table summarizes the calculated annual unit area accumulation values for these constituents, averaged for all sites. The gross pollutants (wet) are comprised of the wet litter plus the wet vegetation. Unfortunately, no dry vegetation values are available, but the litter dry weights are about 60% of the litter wet weights. The litter weights are about 10% of the total gross solids for these freeway locations, with vegetation comprising about 90%. The overall average wet specific gravities for the bulk gross solids is 0.49, and was 0.20 for the wet litter, and 0.64 for the wet vegetation.

Freeway gross solids (litter and vegetation) accumulation rates (Kayhanian, *et al.* 2004)

lbs/ac/yr	gross pollutants wet	wet litter	dry litter	biodegradable dry	non-biodegradable dry	vegetation wet
avg	4.89	0.55	0.34	0.17	0.15	4.26
min	2.38	0.22	0.11	0.06	0.04	2.18
max	8.31	1.03	0.72	0.30	0.38	7.40
avg COV	1.20	1.08	1.17	1.27	1.34	1.22

The following table shows the estimated freeway litter and vegetation lbs/curb-mile/yr accumulation rates, assuming 0.035 curb-miles/acre for 8-lane freeways.

lbs/curb-mi/yr	gross pollutants wet	wet litter	vegetation wet
avg	128	13	113
min	37	4	33
max	237	29	211

The litter and vegetation accumulation rates are of most interest for including into WinSLAMM, although there was no information provided for seasonal changes for these rates. They did present a set of regression equations that indicated that there was a increasing trend in litter stormwater concentrations observed with increasing total rainfall or total runoff volume, along with an increasing trend observed with increasing antecedent dry days.

Conley, *et al.* (2019) compared visual estimates of urban litter loadings on city streets and sidewalks with measured values during a two-year study in Salinas, CA. The following plot shows this relationship, along with error bars. High and very high estimates had larger potential errors, while low and moderate estimates had relatively smaller absolute errors.

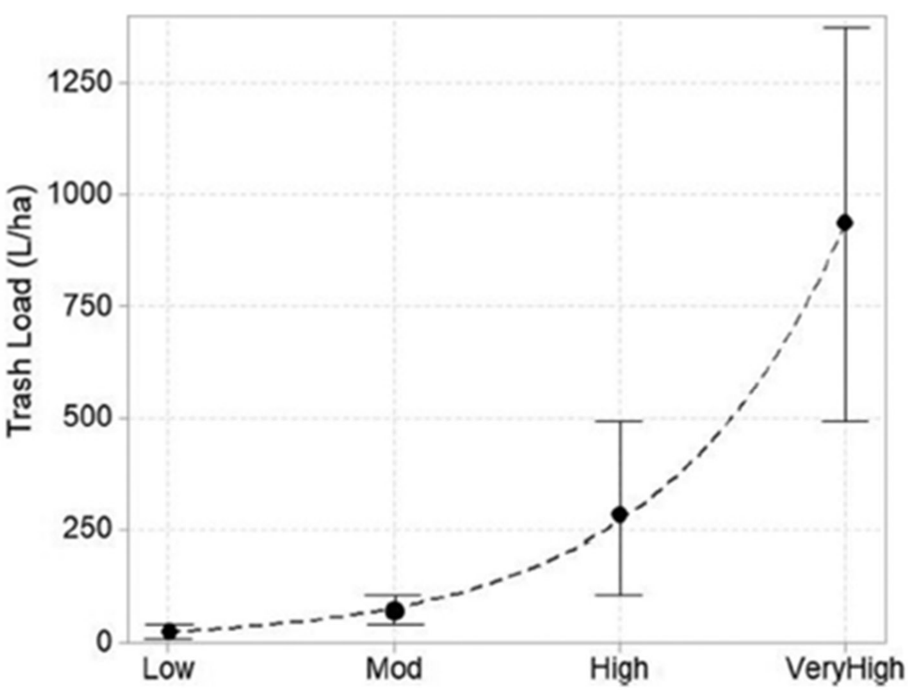
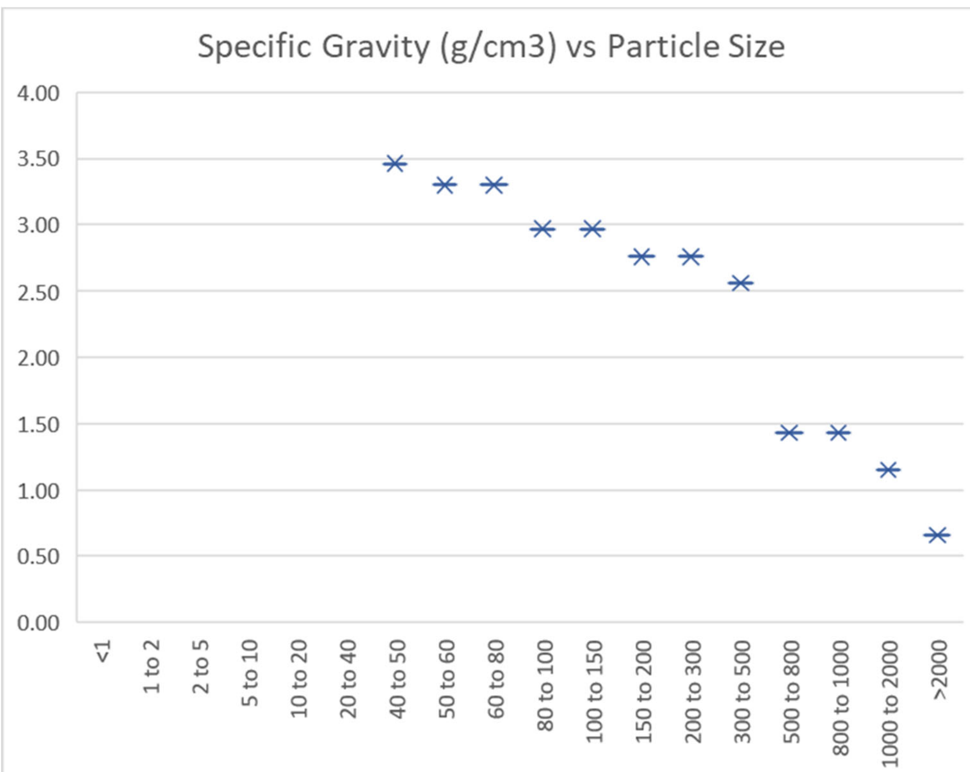


Fig. 2. Trash condition score category relationship to measured mean trash loads (volume/area) adapted from BASMAA (2014).

Cai (2013) separated material captured in the UpFlow filter sump by particle size (too few particles <40 µm available for analyses) and measured specific gravity for each size range, as noted below:

WinSLAMM particle range (um)	specific gravity (g/cm3) (Cai 2013)
40 to 50	3.46
50 to 60	3.30
60 to 80	3.30
80 to 100	2.97
100 to 150	2.97
150 to 200	2.76
200 to 300	2.76
300 to 500	2.56
500 to 800	1.43
800 to 1000	1.43
1000 to 2000	1.15
>2000 mixed material (including leaves)	0.66
>2000 Sticks	0.84
>2000 Decomposing (water-logged) leaves	2.28



The mixed material large particle sizes are heavily influenced by the presence of organic materials, while the separated decomposing leaves (water-logged) have relatively large specific gravities (and also very high volatile solids content).

Ray (1997) studied street dirt as a stormwater phosphorus source. She summarized past measurements of total phosphorus in street dirt. The largest particle sizes (>1/4 inch) had total phosphorus concentrations of about 500 to 1,000 mg/kg. The leaf samples in the street dirt from Madison, WI, that Ray studied had total phosphorus concentrations of 400 to 2,600 mg/kg. Ray also developed a procedure to estimate the components of street dirt through mass loss associated with increasing temperatures in a laboratory muffle furnace. The WI leaf samples lost about 60% of their mass when the temperatures were between 200 and 300°C. The leaf content of the large street particles (>250 µm, no visual leaf components) ranged from 0.8 to 93%, based on the combustion analyses.

Table 6. Mass Loss Percentages for Various Street Dirt Sources and Temperatures

Street Dirt Source	Temperature Interval (°C) (where most of the mass loss occurred)	Avg. Mass Loss (%)
Paper	300-350	49.2
Asphalt	350-450	4.3
Rubber	350-450	55.2
Cigarettes	150-250	76.3
UAB grass	250-350	18.0
UAB leaf	250-350	60.0
Seneca leaf	250-350	51.0
Glenway leaf (8/94)	200-300	63.2
Glenway leaf (9/94)	200-300	56.8

Hobbie, *et al.* (2014) monitored the decomposition of tree leaf on pavements in St. Paul, MN. They found that "litter decomposed more rapidly in the gutter than in nearby natural areas. And decomposition rates were as rapid as those measured in other urban settings (forests and streams), with most species losing 80 % of their initial mass after 1 year. Across all species, a small fraction (from 0–22 %) of the initial mass decomposed extremely rapidly." The following chart shows the decomposition of several leaf types.

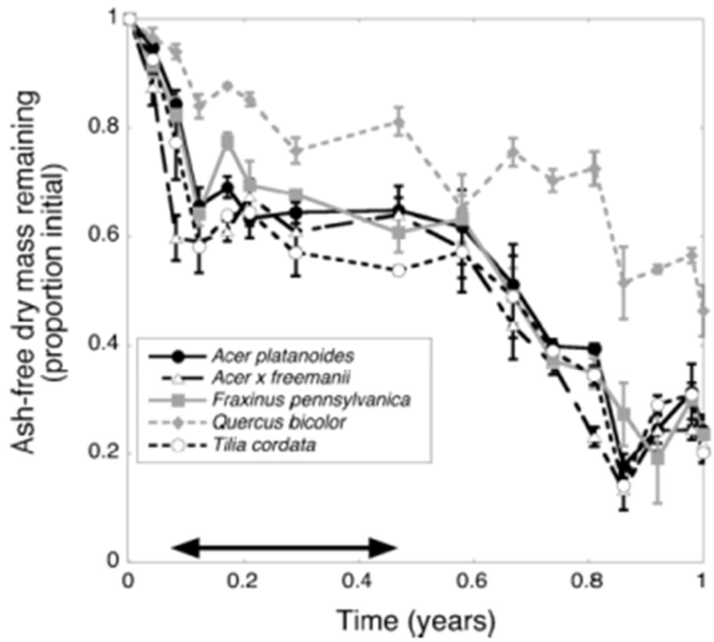


Fig. 2 Proportion ash-free dry mass remaining for litter of five tree species decomposing in a gutter. The arrow indicates the time during the year when precipitation fell as snow

Bratt, *et al*. (2017) examined the role of leaf material to the export of nutrients during snowmelt in Minnesota. They found that the snowmelt events contributed about 50% of the annual nitrogen and phosphorus discharges.

Pitt and Field (2004) presented the results of gross solids trapping using a conventional catchbasin with a sump, and two inlet screening devices. They found that the screening devices that forced stormwater through the trapped leaves resulted in increased concentrations of many stormwater pollutants compared to the influent, likely caused by decomposition of the organic material, including suspended solids, turbidity, color, conductivity, COD, and many major ions (nutrients were not measured, but would also be expected to increase after the screening).

Control of Gross Solids by Stormwater Management Practices

Leisenring, *et al.* (2011) in their summary of solids data contained in the International BMP Database note that "gross solids are the litter, trash, leaves, and coarse sediment that travel either as floating debris or as bedload in urban runoff conveyance systems. A variety of BMPs are designed to remove gross solids, including sediment basins, baffle boxes, hydrodynamic separators, oil/grit separators, modular treatment systems, and inlet traps, among others." They also note that "researchers have not typically submitted gross solids data to the BMP Database; however, a number of researchers have collected such data and expressed interest in providing it in the future to the BMP Database."

Litter removal by street cleaners was measured by Pitt and Shawley (1981) in Castro Valley, CA. Mechanical broom street cleaners removed about 70% of the street litter, while regenerative air street cleaners removed about 55 to 60% of the street litter. During street cleaning tests in San Jose, CA, Pitt (1979) found that mechanical street cleaners removed 39 to 54% of the gross solids >6350 µm (1/4 inch), depending on the street texture and condition. From 70 to 90% of the gross solids were removed by mechanical street cleaners during research conducted by Pitt (1985) in Bellevue, WA.

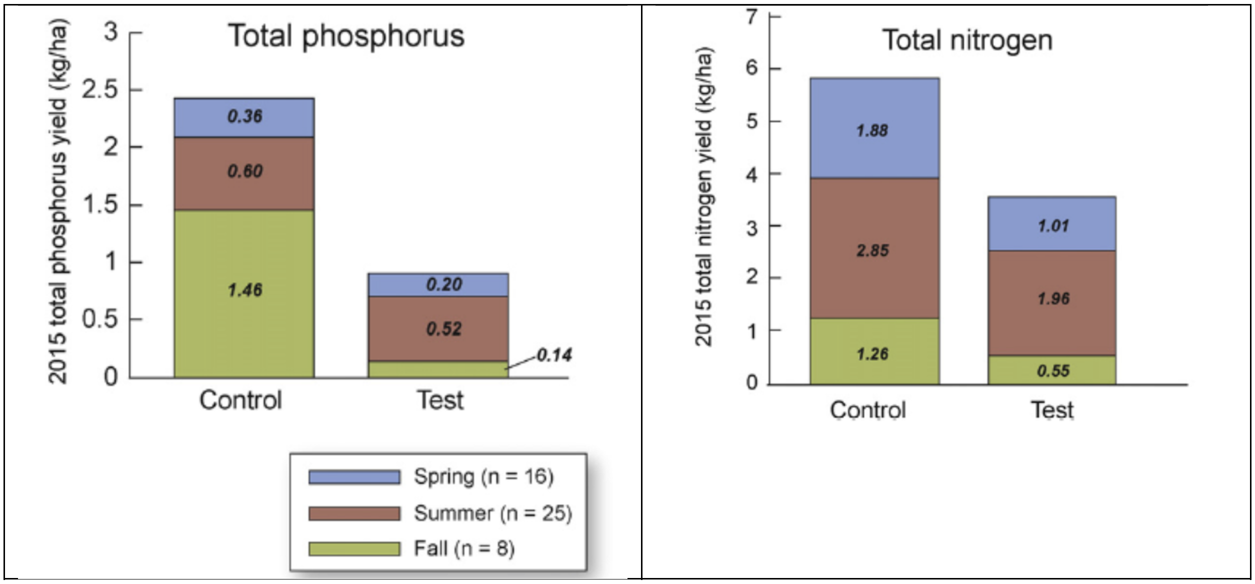
Catchbasins with different types of hoods on the outlets were studied by Smith (2010) in Boston to determine their floatable capture effectiveness. The hoods studied included the Snout, the Eliminator, and cast-iron hoods. The effectiveness for the deep-sump hooded catchbasins, excluding the mass of high-density materials identified in the solids collected from the outlet pipe and the sump of the catch basins, ranged from 13 to 38 percent. The effectiveness for each catchbasin, based solely on the material that remained floating at the end of the monitoring period, was less than 11 percent. The effectiveness of the catchbasins equipped with hoods in reducing gross solids was not greatly different among the three types of hoods tested in this study. The following summarizes the floatable capture effectiveness for different types of floatable materials:

Gross solids (excluding mineral and metallic materials): 27 to 52%
Low density gross solids: 19 to 38%
Floatable solids: 4 to 10%
Anthropogenic low-density solids: 54 to 80%

Nichols and Lucke (2016) studied the nutrient removal performance of a gross pollutant trap in Victoria, Australia. The overall solids and nutrient removal performance for 15 rains was as follows:

TSS: 49%
Total phosphorus: 41%
Total nitrogen: 26%

Selbig (2016) examined the role of leaf removal in Madison, WI, to reduce stormwater nutrient concentrations and loads. In the fall (late September to early October) the city uses leaf collection vehicles to collect and remove leaf litter and other organic material, mostly from residential areas. Residents are asked to pile their leaves adjacent to the street to limit excess debris in the street gutter. A vehicle equipped with a modified plow moves the piles of leaves near the curb into the street, which are then pushed into a garbage collection vehicle. A high-efficiency vacuum-assisted street cleaner is used in the area within a few days following leaf collection to remove any remaining organic debris from the street and gutter. The leaf collection and street cleaning operations were repeated about weekly during this fall period. For this study, leaves that would accumulate were manually cleaned before predicted rains to eliminate as much organic material from the streets as possible. Stormwater quality data from the cleaned areas were compared to control areas that did not receive any leaf removal. The following graphs illustrate the large benefits that leaf removal had on reducing the stormwater phosphorus and nitrogen loads. The percentage reduction in stormwater loads during the fall were 84% for total phosphorus and 74% for total nitrogen. Spring reductions were 45% for total phosphorus and 52% for total nitrogen, while during the summer months, only total phosphorus had a significant reduction (36%).



Seasonal contribution to annual yields of total phosphorus and total nitrogen (winter excluded) in the control and test catchments during the treatment phase (Selbig 2016).

Suggested Incorporation of Gross Solids in WinSLAMM Analyses

There are three categories of gross solids that should be incorporated in WinSLAMM, based on the ASCE (2010) committee report. These include:

- Coarse sediments (>75 µm). These are already included in WinSLAMM up to 2,000 µm, and are not further discussed)
- Litter (human derived trash) (>4,750 µm)
- Organic debris (leaves, branches, seeds, twigs, and grass clippings) (>4,750 µm)

Litter

There are substantial data for stormwater litter in the literature, but it focusses on descriptions of the litter components, discussions of how to monitor litter in receiving waters, the volume of litter (L/m^3 for example) in stormwater and receiving waters, and capture efficiency in screening devices, but few studies measured accumulation rates of litter in source areas. The following lists some of the example litter accumulation rates for stormwater litter by land use. These values are from stormwater monitoring and not source area monitoring so do not differentiate accumulation and washoff processes. These could be used to calculate stormwater litter concentrations for rains having different dry antecedent periods (little to no data available for rain depth or intensity affecting the stormwater litter concentrations). These are example values and are expected to vary widely for different locations. Therefore, the user will need to enter these values, as appropriate.

Armitage (2006) reviewed a few studies that had measured litter loadings. Melbourne, Australia, reported inner-city suburban litter loadings of 5 lbs/ac/yr, and New York City reported litter loadings of 45 lbs/ac/yr. Johannesburg central business district, South Africa reported the same litter accumulation rate as New York City.

Cape Town, South Africa litter monitored loadings (washoff)

Land Use	lbs/ac/yr
Medium density residential area	5.2
Low density residential area (high income)	0.2
Light industrial area	44
Central business district	44

General Litter Loadings for South Africa (washoff)

Land Use	lbs/ac/yr
Low density residential	1
Medium density residential	15
High density residential	150
Manufacturing industrial areas	75
Offices	50
Schools	100

Freeway litter accumulation rates (from UCLA) (washoff)

freeways	litter (wet) (lbs/ac/yr)	litter (wet) (lbs/curb-mi/yr)
average	0.55	13
COV	1.08	1.08

Litter entering stormwater likely originates mostly from streets (use the lbs/curb-mi values) and paved parking/storage areas (use the lbs/ac/yr).

Most of the litter by volume is likely in the “floatable” category (plastics), with specific gravities close to 1.0 for some items. Unlike organic debris, these would not become water-logged and sink, but items such as plastic bags, bottles, and cans can hold air, which may be displaced with water and sink (especially cans, high-density plastics, and glass bottles).

Stormwater controls for litter in stormwater include the following estimates:

- Hooded catchbasins can remove 54 to 80% of the low-density litter materials, but could be much less.
- Screens would capture 100% of the gross solids in the stormwater that pass through the screens, but much less for any bypass flows (such as like the hooded catchbasins).
- Street cleaning removal of gross solids has been reported to be 70 to 90% for high loads and streets in good condition, and as low as 40% for low loads and streets in rougher condition.

Organic Debris (Leaves)

Few accumulation rates for organic debris are available. One example near Perth, Australia, reported catchbasin insert captures of vegetation material of 529 lb/curb-mile/yr, or 53 lb/ac/yr in a downtown commercial area. North Carolina State and UCLA research identified the following organic debris rates in different land uses:

Downtown commercial area vegetation debris accumulations in stormwater (from NC State) (washoff)

Downtown	approx. total load (dry lbs/ac/yr)	approx. total load (dry lbs/curb-mi/yr)
average	124	1,554
COV	0.59	0.59

Low density residential area vegetation debris accumulations in stormwater (from NC State) (washoff)

low density resid	approx. total load (dry lbs/ac/yr)	approx. total load (dry lbs/curb-mi/yr)
average	69	689
COV	0.40	0.40

Freeway vegetation (wet) debris accumulation rate (from UCLA) (washoff)

lbs/curb-mi/yr	vegetation wet
avg	113
min	33
max	211

Armitage (2006) also reviewed vegetation debris loadings at various international locations. Melbourne, Australia, inner city suburban area, reported dry leaf matter annual washoff of 30 lb/ac/yr. The following table summarizes some measured Cape Town, South Africa annual washoff quantities of dry leaf material.

medium density residential area	1.7 lb/ac/yr
Low density residential, high income area	25
Light industrial area	4.5
Central business district	25

General Leaf Accumulations for South Africa (washoff)

Land Use	lb/ac/yr
Low density residential	25
Medium density residential	25
High density residential	25

Manufacturing industrial areas	4.5
Offices	25
Schools	25

Vegetation debris entering stormwater likely originates mostly from streets (use the lbs/curb-mi values, if available) and paved parking/storage areas (use the lbs/ac/yr values). Oddly, the references reporting leaf debris loadings and washoff did not show significant seasonal variations. This is likely due to the arid character of the Australia, South Africa, and LA areas reporting data. The time series plots for the North Carolina leaf accumulations (washoff) indicated some seasonal variations. It is recommended that local data be used whenever possible and be presented by season. The rates summarized here are also for loads in the stormwater, and not on the surfaces. Therefore, they should be used as influent concentrations for the stormwater controls, or as base levels before percentage reductions associated with street cleaning controls.

Leaf material can account for substantial amounts of the total nutrient discharges in stormwater. The reported nutrient content of this material is about 400 to 2,500 mg/kg for total phosphorus. Total nitrogen is also an important component for leaf material, but particulate strength values were not noted in the literature examined (only concentrations).

The performance of stormwater controls in reducing leaf material is similar to the performance previously reported for litter. Stormwater controls for leaf material in stormwater include the following estimates:

- Hooded catchbasins can remove 54 to 80% of the leaf materials, but could be much less as the leaves become waterlogged.
- Screens would capture 100% of the leaf material in the stormwater that pass through the screens, but much less for any bypass flows (such as like the hooded catchbasins). However, if the captured leaves are trapped on screens and stormwater is forced through them, increased phosphorus and many other pollutants will increase compared to the influent water quality (due to degradation of the organic material).
- Street cleaning, especially conducted in conjunction with special leaf removal front end loaders, can be very effective in the removal of leaf material. Street cleaning by itself has been reported to be 70 to 90% effective for high material loads (but not excessive piles of leaves in the street) and for streets in good condition.

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