Don't Throw the Baby Out with the Bathwater – Sampling Collection and Processing Issues Associated with Particulate Solids in Stormwater

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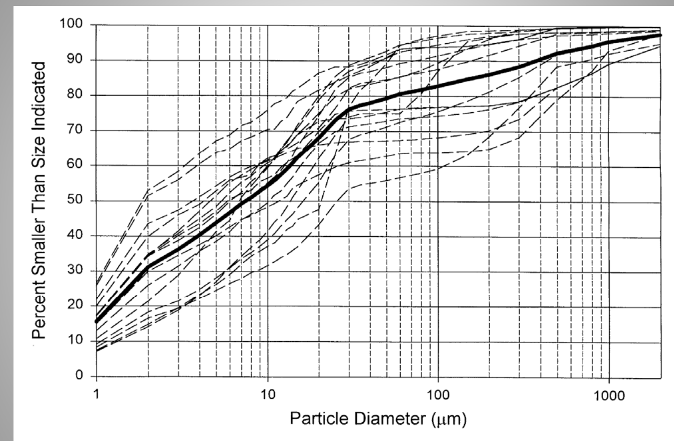
Measured Particle Sizes, Including Bed Load Component, at influent to the Monroe St. Detention Pond, Madison, WI



Very few of the large particles that enter the drainage systems are transported to the outfalls in typical urban drainage systems. Most (about 85% in this typical example) of the outfall particulates discharged are less than 100 µm in size.

2

TSS vs. SSC and PSD Relationships

Two separate issues:

- sampling to obtain representative water samples with all particulates of interest, and
- laboratory processing to represent all particulates.

Most problems result in loss of large particles. The combination of methods used affects modeling approach, especially particle size distributions and confusion between TSS and SSC.

3

Sampling Effects on Particulate Solids Characteristics

- Sampling issues associated with stratified flows and bedload.
  - Sampler intakes on bottom of pipe may collect more bedload than represented in well-mixed sample, and
  - sampler tube velocity may not be able to transport large particles to sample bottles

  These are two opposite problems that seldom cancel each other out nicely.

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Results of Verification Monitoring of a Popular Hydrodynamic Device by WI DNR and USGS (Madison, WI)

Sampled solids load in	1623 kg
Sampled solids load out	1218 kg
Trapped by difference	405 kg (25% removal)
Actual trapped total sediment	536 kg (33% actual removal)
Fraction total solids not captured by automatic samplers	8% (131 kg missed by sampler, out of 1623 kg in sampler)

Standard automatic water samplers with single intakes at bottom of pipes. Influent samplers are affected by large particles while effluent samplers should not be, assuming most any stormwater control is capable of removing the larger particles that stress the samplers.

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Bed load in storm drainage compromised about 4% of Madison area total solids discharges (WI DNR and USGS) monitoring).

6

Bedload in corrugated stormdrain and mound of settleable material at discharge into wet detention pond after many years of operation at ski resort at Snowmass, CO (drain from several acre resort parking area having sand applications for traction control).

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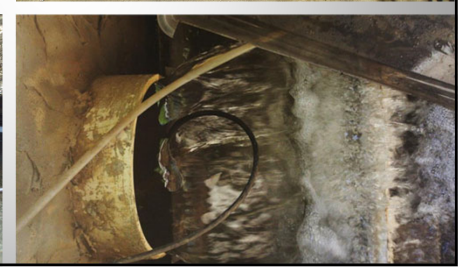
Simple methods to obtain representative sample: create cascading and well-mixed flow at sampling location (well-mixed flow with bedload and no stratification). Examples shown for gutter and pipe flow installations.



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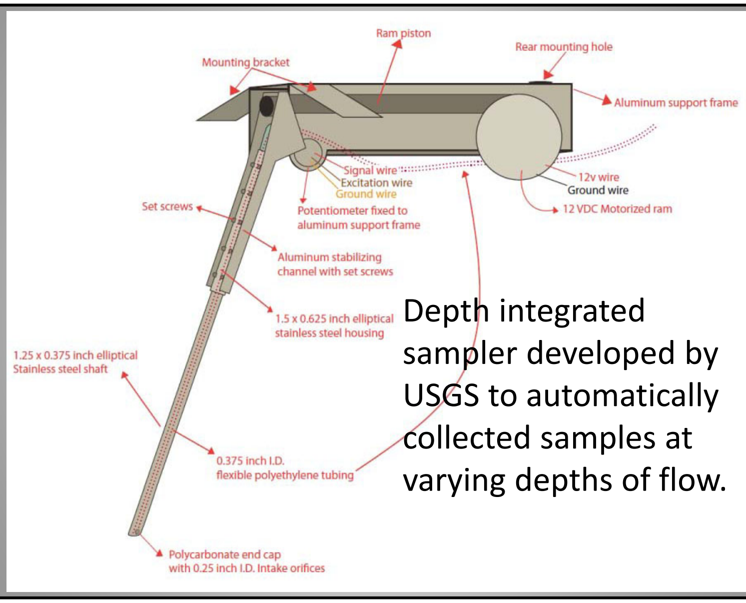

Depth integrated sampler developed by USGS to automatically collected samples at varying depths of flow.

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Comparison of Three TSS/SSC Analytical Methods

EPA TSS 160.2 Shake sample bottle vigorously then pour aliquot into graduated cylinder	Standard Methods TSS 2540D Use stir plate and pipet at mid-depth in bottle and midway between wall and vortex	USGS SSC D3977-97B Use entire sample and pour from original bottle

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USGS/Dekaport cone splitter used to separate sample into smaller volumes for different analyses.

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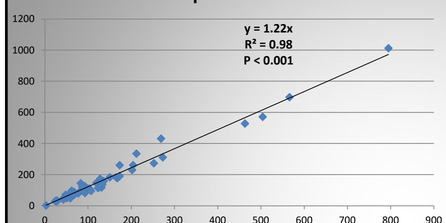
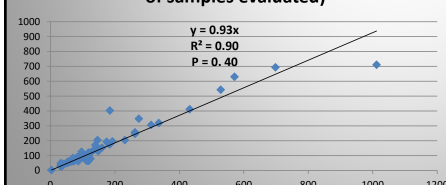
TSS (shake and pour vs. stir and pipette) Significant difference: 22% bias, shake and pour low



shake and pour vs. stir and pipette		
t-Test: Paired Two Sample for Means		
	Shake and Pour	Stir and Pipette
Mean	133	160
Variance	19818	31015
Observations	59	59
Pearson Correlation	0.99	
Hypothesized Mean Difference	0	
df	58	
t Stat	-4.99	
P(T<=t) one-tail	2.92E-06	

Results of parallel tests using 59 stormwater samples

stir and pipette TSS vs. SSC no significant difference (for the number of samples evaluated)



stir and pipette TSS vs. SSC		
t-Test: Paired Two Sample for Means		
	Stir and Pipette	SSC cone splitter
Mean	160	158
Variance	31015	26095
Observations	59	59
Pearson Correlation	0.95	
Hypothesized Mean Difference	0	
df	58	
t Stat	0.27	
P(T<=t) one-tail	0.40	

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Sample Processing before Coulter Counter Analyses

- The Coulter Counter Multi-Sizer 3 is most suitable for particles in the range of about 1 to 200 µm.
- Larger particles (especially those of about 500 µm and larger) settle to the bottom of the measurement vessel and are not kept suspended and drawn through the analytical aperture.
- Coulter recommends increasing the viscosity of the analytical solution (such as by using Karo syrup) to keep particles as large as 1,200 µm suspended. We were never pleased with this option.

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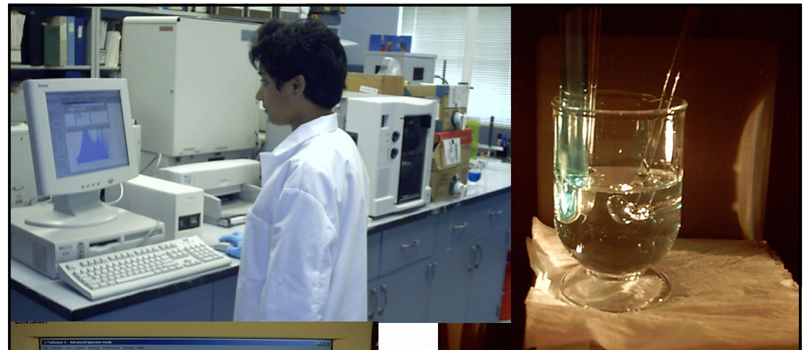

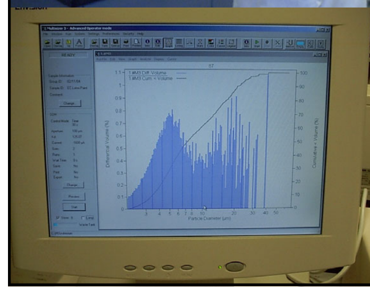

Coulter Counter Multi-Sizer 3 used to measure particle size distribution of solids up to several hundred micrometers. Larger particles (up to several mm) are quantified using sieves.

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- Normally, we have found only a few “sand” grains in the bottom of sample bottles, or in the Coulter vessel, when the instrument was not recording their presence. We were not concerned due to their few number and minimal affect on sample mass.
- During the past several years, we have started to separate the samples into at least three size fractions and measuring directly using sieves and filters: <0.45, 0.45 to 106, and >106 µm (usually 256 and 1200 also). Generally, we divide the “suspended solids” fraction at 106.
- The intermediate fraction (0.45 to 106 µm) is also used in the Coulter Counter, with no possible interference with large particles. The relatively small fraction of particles >106 µm are therefore quantified and added to the size distribution (as is the <0.45 µm “dissolved” fraction).

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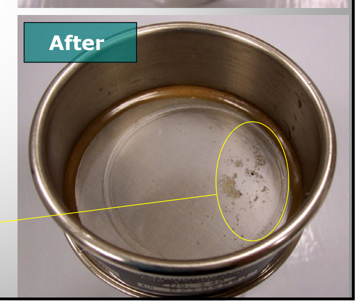
Pre-sieving a sample with 106 micrometer sieve (before use of 140 micrometer aperture tube)

Sediment sample



Large particles (sands) are captured in 106 micrometer sieve

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Pre-sieving a sample with 20 micrometer sieve (before use of 32 micrometer aperture tube)

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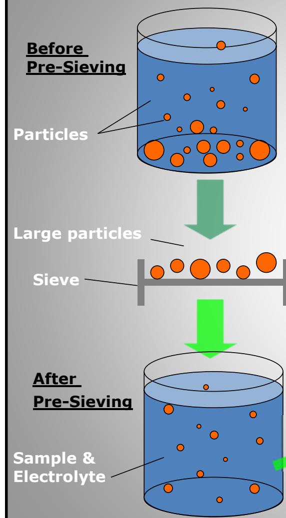
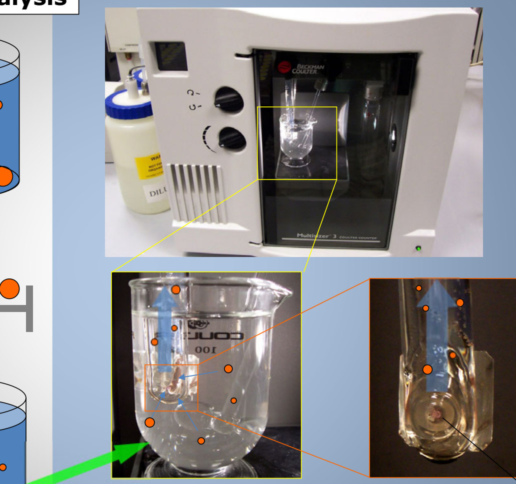
Coulter Counter analysis





Particles go through the hole in an aperture tube. Particles in a sample must be smaller than the diameter of the aperture tube.

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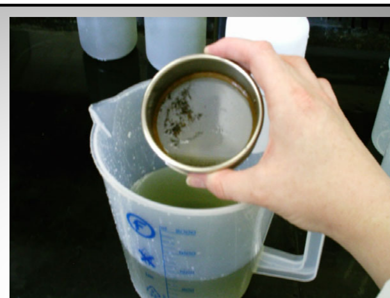
Sieving with a 106 µm sieve to remove large debris before Coulter counting. Similar sample analyzed for total solids.



Screened material showing grass debris (from 5L of sample)

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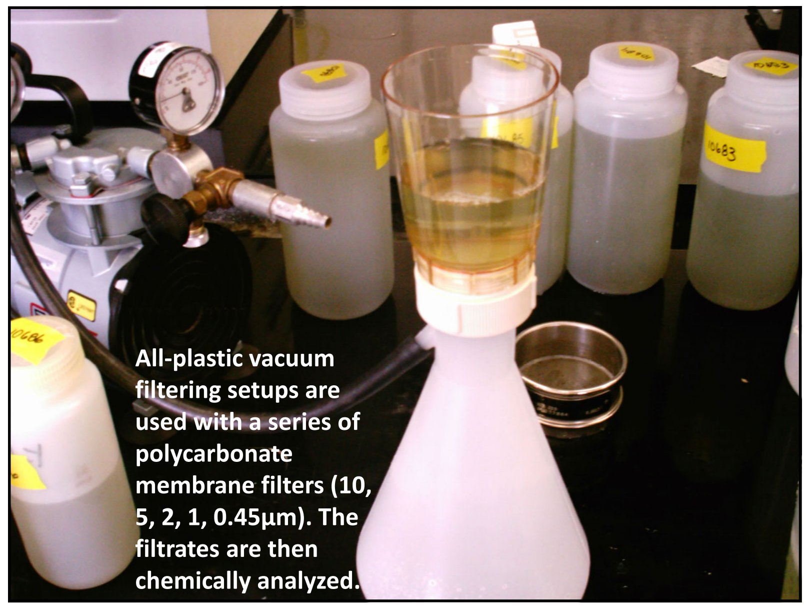

All-plastic vacuum filtering setups are used with a series of polycarbonate membrane filters (10, 5, 2, 1, 0.45µm). The filtrates are then chemically analyzed.

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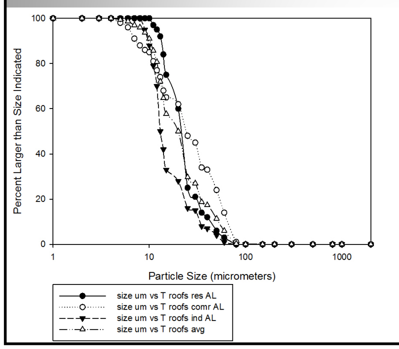
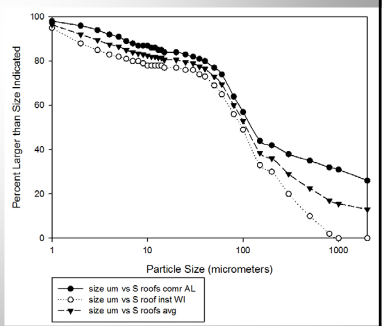
Roof runoff particle size distributions (for TSS shake and pour on left and for TSS stir and pipette and SSC on right)





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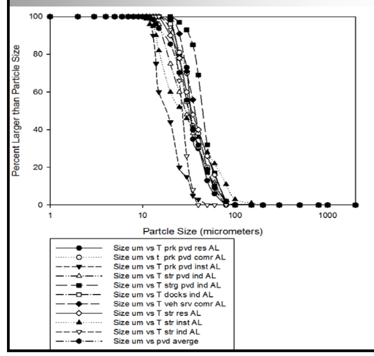
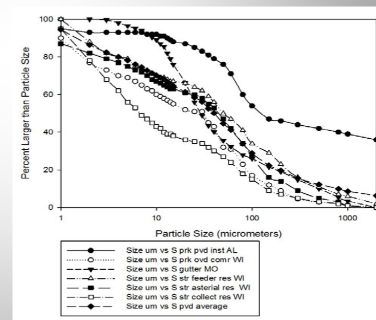
Paved parking, storage, loading dock, vehicle service area, and street runoff particle size distributions (for shake and pour TSS on left and for stir and pipette TSS and SSC on right)





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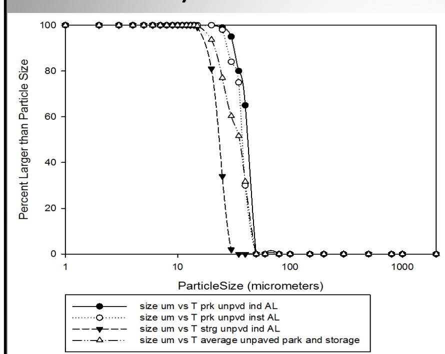
Non-paved parking and storage area runoff particle size distributions (for shake and pour TSS on left; no stir and pipette or SSC data available)



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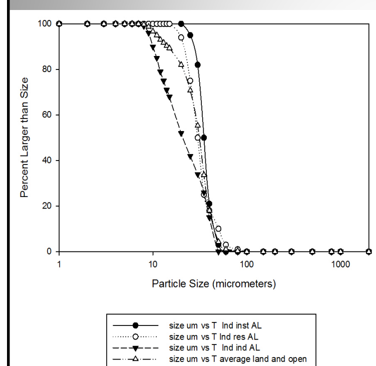
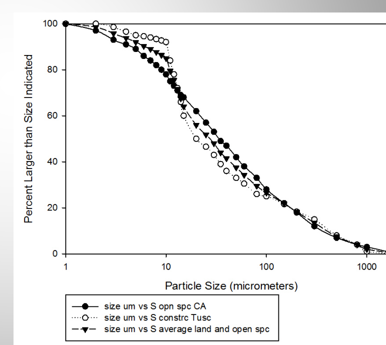
Landscaped, open space, and construction site runoff particle size distributions (for shake and pour TSS on left and for stir and pipette TSS and SSC on right)





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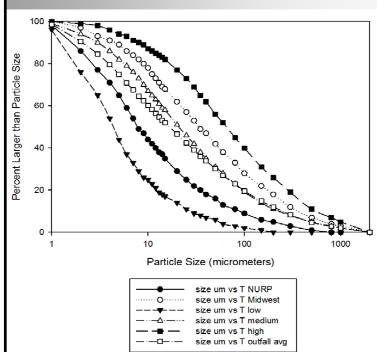
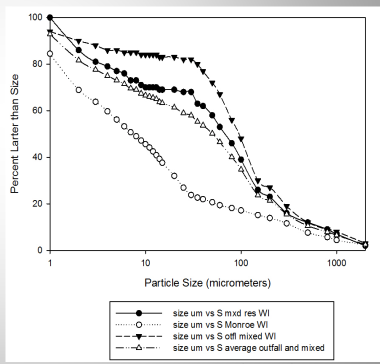
Outfall discharges particle size distributions (for shake and pour TSS on left and for stir and pipette TSS and SSC on right)





Note the relatively little differences in the PSDs at the outfalls for the two sample categories.

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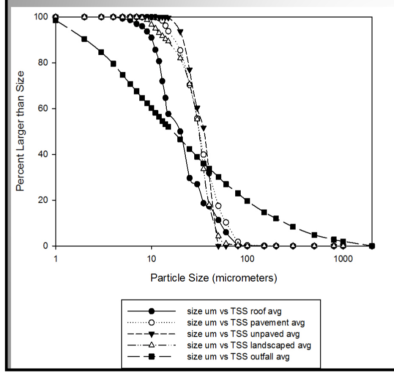
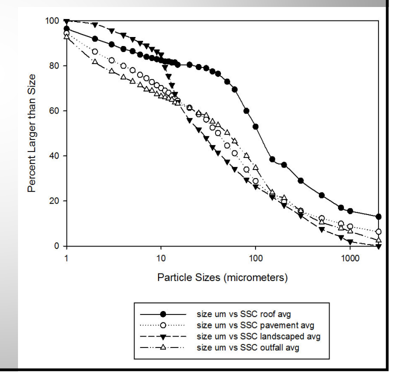
Average particle size distributions for different source area categories (for shake and pour TSS on left and for stir and pipette and SSC on right)





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A new psd source area csv file is now used to identify which psd files are associated with each source area by land use

Source Area Particle Size Distribution and Peak-To-Average Rainfall Ratio Standard Files

Select Source Area File (.csv) to Edit: C:\WinSLAMM Files\PSD source area SSC.csv

Browse to Particle Size Distribution (.cpz) File Path: C:\WinSLAMM Files\psd files\

Source Area Particle Size Distributions | Peak to Averge Flow Ratio - Light Rains | Peak to Averge Flow Ratio - Moderate Rains | Peak to Averge Flow Ratio - Heavy Rains

	Residential Land Use	Institutional Land Use	Commercial Land Use	Industrial Land Use	Other Urban Land Use	Freeway Land Use
Roofs	SSC roof average.cpz	SSC roof average.cpz	SSC roof average.cpz	SSC roof average.cpz	SSC roof average.cpz	SSC roof average.cpz
Paved Parking	SSC pavement average.cpz	SSC pavement average.cp	SSC pavement average.cp	SSC pavement average.cp	SSC pavement average.cp	SSC pavement average.cp
Unpaved Parking	SSC landscaped average.c	SSC landscaped average.c	SSC landscaped average.	SSC landscaped average.c	SSC landscaped average.	SSC landscaped average.
Driveways	SSC pavement average.cpz	SSC pavement average.cp	SSC pavement average.cp	SSC pavement average.cp	SSC pavement average.cp	SSC pavement average.cp
Sidewalks	SSC pavement average.cpz	SSC pavement average.cp	SSC pavement average.cp	SSC pavement average.cp	SSC pavement average.cp	SSC pavement average.cp
Streets	SSC pavement average.cpz	SSC pavement average.cp	SSC pavement average.cp	SSC pavement average.cp	SSC pavement average.cp	SSC pavement average.cp
Sandy Pervious Areas	SSC landscaped average.c	SSC landscaped average.c	SSC landscaped average.	SSC landscaped average.c	SSC landscaped average.	SSC landscaped average.
Silty Pervious Areas	SSC landscaped average.c	SSC landscaped average.c	SSC landscaped average.	SSC landscaped average.c	SSC landscaped average.	SSC landscaped average.
Clayey Pervious Areas	SSC landscaped average.c	SSC landscaped average.c	SSC landscaped average.	SSC landscaped average.c	SSC landscaped average.	SSC landscaped average.
Paved Playgrounds	SSC pavement average.cpz	SSC pavement average.cp	SSC pavement average.cp	SSC pavement average.cp	SSC pavement average.cp	SSC pavement average.cp
Other Pervious Areas	SSC landscaped average.c	SSC landscaped average.c	SSC landscaped average.	SSC landscaped average.c	SSC landscaped average.	SSC landscaped average.
Other Direct Con Imp	SSC pavement average.cpz	SSC pavement average.cp	SSC pavement average.cp	SSC pavement average.cp	SSC pavement average.cp	SSC pavement average.cp
Other Part Con Imp Areas	SSC pavement average.cpz	SSC pavement average.cp	SSC pavement average.cp	SSC pavement average.cp	SSC pavement average.cp	SSC pavement average.cp
Other Imp Area 1	SSC pavement average.cpz	SSC pavement average.cp	SSC pavement average.cp	SSC pavement average.cp	SSC pavement average.cp	SSC pavement average.cp
Other Imp Area 2	SSC pavement average.cpz	SSC pavement average.cp	SSC pavement average.cp	SSC pavement average.cp	SSC pavement average.cp	SSC pavement average.cp
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Cancel | Apply Default Values to All Source Areas | Save .csv File and Exit

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