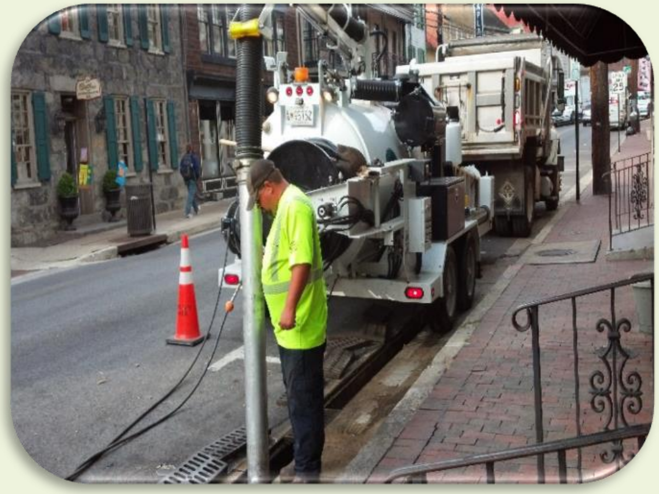
Chesapeake Bay
Stormwater Training Partnership

Street Sweeping & Storm Drain Cleaning Recommendations 'Debut Webinar'



CHESAPEAKE STORMWATER NETWORK

A County employee cleans out the catch basins in historic Ellicott City, MD

Welcome to the Webcast

- To Ask a Question
  - Submit your question in the chat box located to the left of the slides. We will answer as many as possible during Q&A.
- To Answer a Poll Question
  - Simply select the preferred option. For those viewing this session alongside several colleagues, respond in a manner that represents your organization as a whole.
- We ARE Recording this Session
  - All comments and questions will be recorded and included in the archives. We will notify you as soon as the recording and related resources are loaded on the web.
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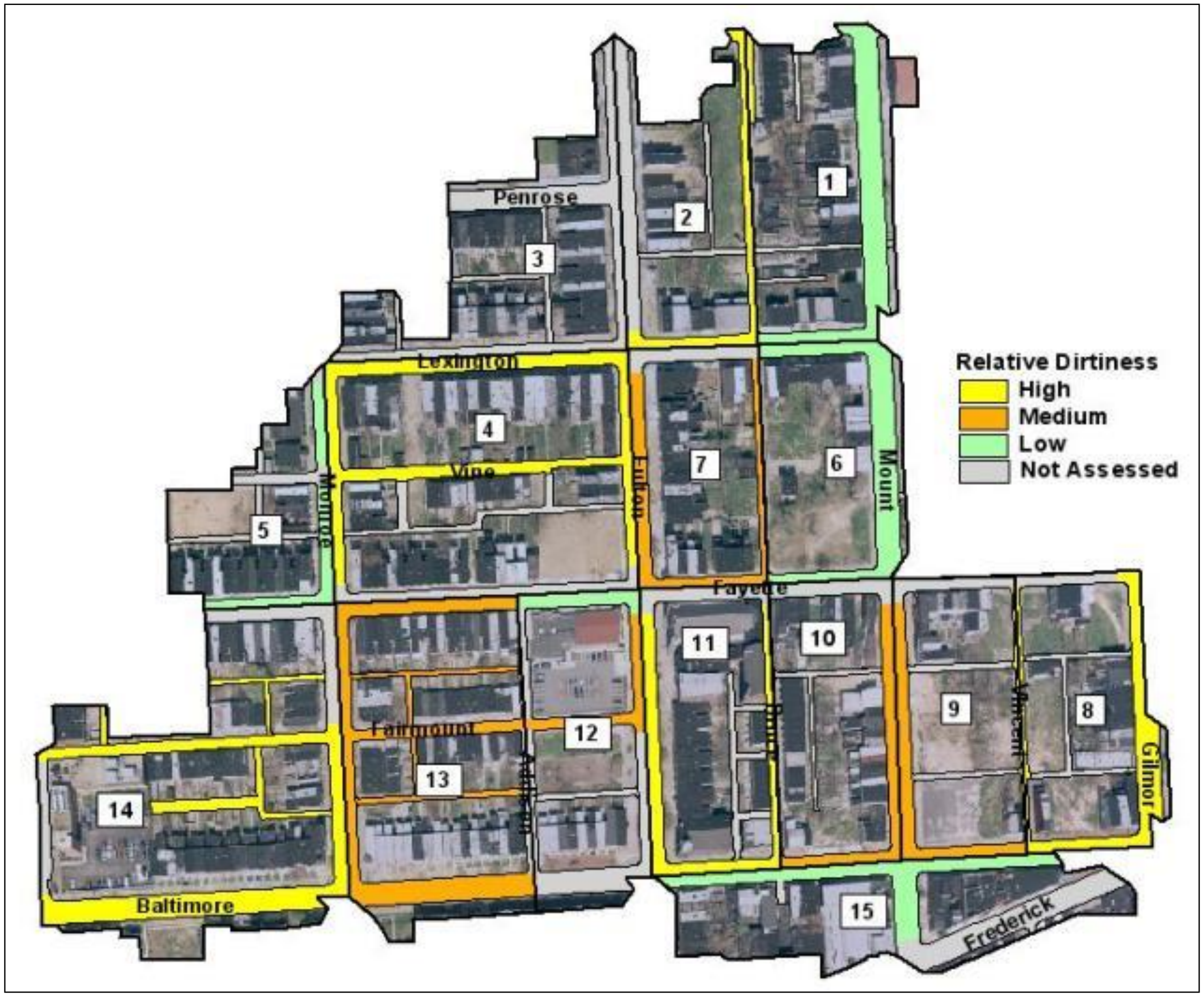
- TBD: Building Local Technical Capacity Networks for Small Scale Stormwater BMPs

http://chesapeakestormwater.net/events/categories/webcasts/2015-webcast-series/

What is the Water Quality Benefit of Street Cleaning ?

30 years of controversy about the impact of street sweeping on the quality of stormwater runoff

Street and Storm Drain Cleaning Expert Panel Report



Today's Agenda

A. Background on Street Cleaning
B. Research on Street Solids
C. Recent Street Cleaning Research
D. WinSLAMM Modeling
E. The Street and Storm Drain Credits
F. Reporting, Tracking and Verification
G. Other Panel Recommendations

EXPERT BMP REVIEW PANEL		
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Non-panelists that contributed to the panel's discussions: Ken Belt, US Forest Service; Roger Bannerman, Wisconsin Department of Natural Resources; Matt Johnston, UMD/CBPO; Jeff Sweeney, EPA/CBPO. Special thanks to David Wood and Emma Giese for their panel support		

A. Background on Street Cleaning in the Chesapeake Bay Watershed

Prior Street Sweeping Panel Recommendation (2010)

Method 1: Mass loading approach, calculates sediment and nutrient removal based on the mass picked up by the sweeper fleet, with an adjustment for particle size

Method 2 : Qualifying street lanes method.

Percent Removal			
Technology	TSS	TP	TN
Mechanical	10	4	4
Regenerative/Vacuum	25	6	5

Both methods only apply to streets that are swept biweekly (26 times per year) or more frequently.

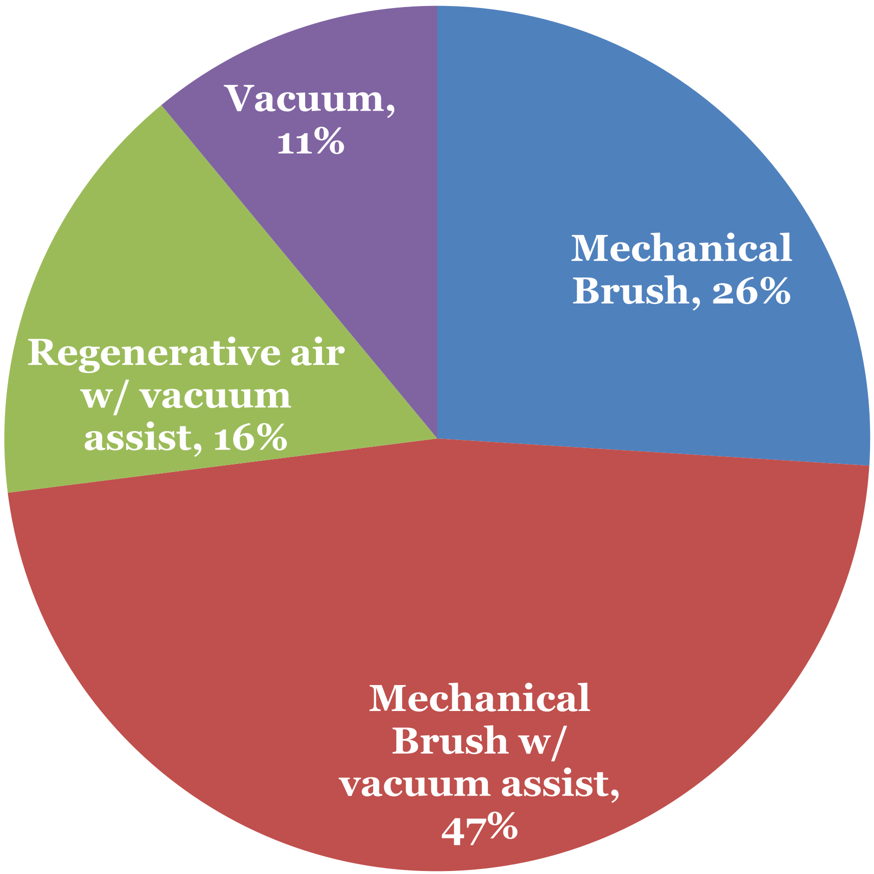
Why a New Panel was Launched

- Current Street Sweeping Credits and Definition Were Approved by CBP in 2010
- Urban Work Group Quickly Realized the Credits Needed to be Re-visited
  - No reporting, tracking and verification protocols
  - Need to assess new monitoring studies in the last 5 years
  - Two methods were recommended that gave different answers, leading MS4s to shop for which one gives the most credit
  - Locals: Sweeping too frequent to get credit for most streets

Current Sweeping Practice in Watershed

- Most Bay communities do not sweep streets or clean storm drains for water quality purposes
- The technology used in most sweeper fleets is old, and most streets are not swept frequently enough to provide a meaningful water quality benefit
- Streets are a significant fraction of total impervious cover

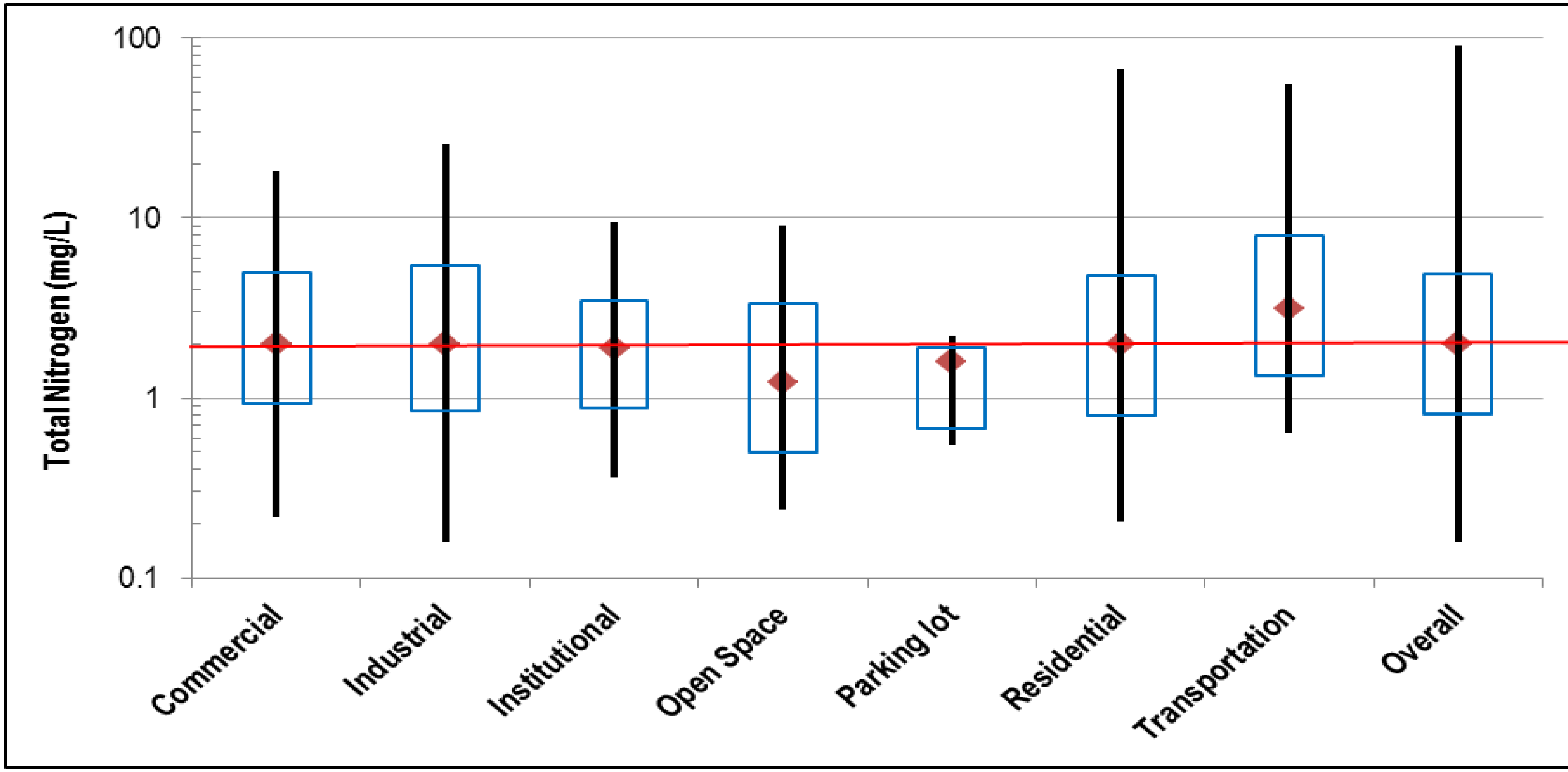
The Sweeper Fleet in the Chesapeake Bay Watershed (circa 2006)



B. Some Things We Learned About Street Solids

1. Are Nutrients and Sediments in Street Runoff Different From Impervious Cover?

- **Yes**, higher TN concentrations in street runoff, compared to other types of urban impervious cover monitored.
- Weak relationship between higher TN and TSS concentrations with street traffic volume
- Street TP concentrations are not different from other IC



Land Use	Count	Concentration (mg/L)					
		Min.	Average	Maximum	10th percentile	Median	90th percentile
Roads	230	0.64	4.28	55.38	1.32	3.11	7.93
Overall	4,778	0.16	2.73	90.10	0.81	1.98	4.84

Streets Do Have Higher TN Event Mean Concentration than other Urban Land Uses

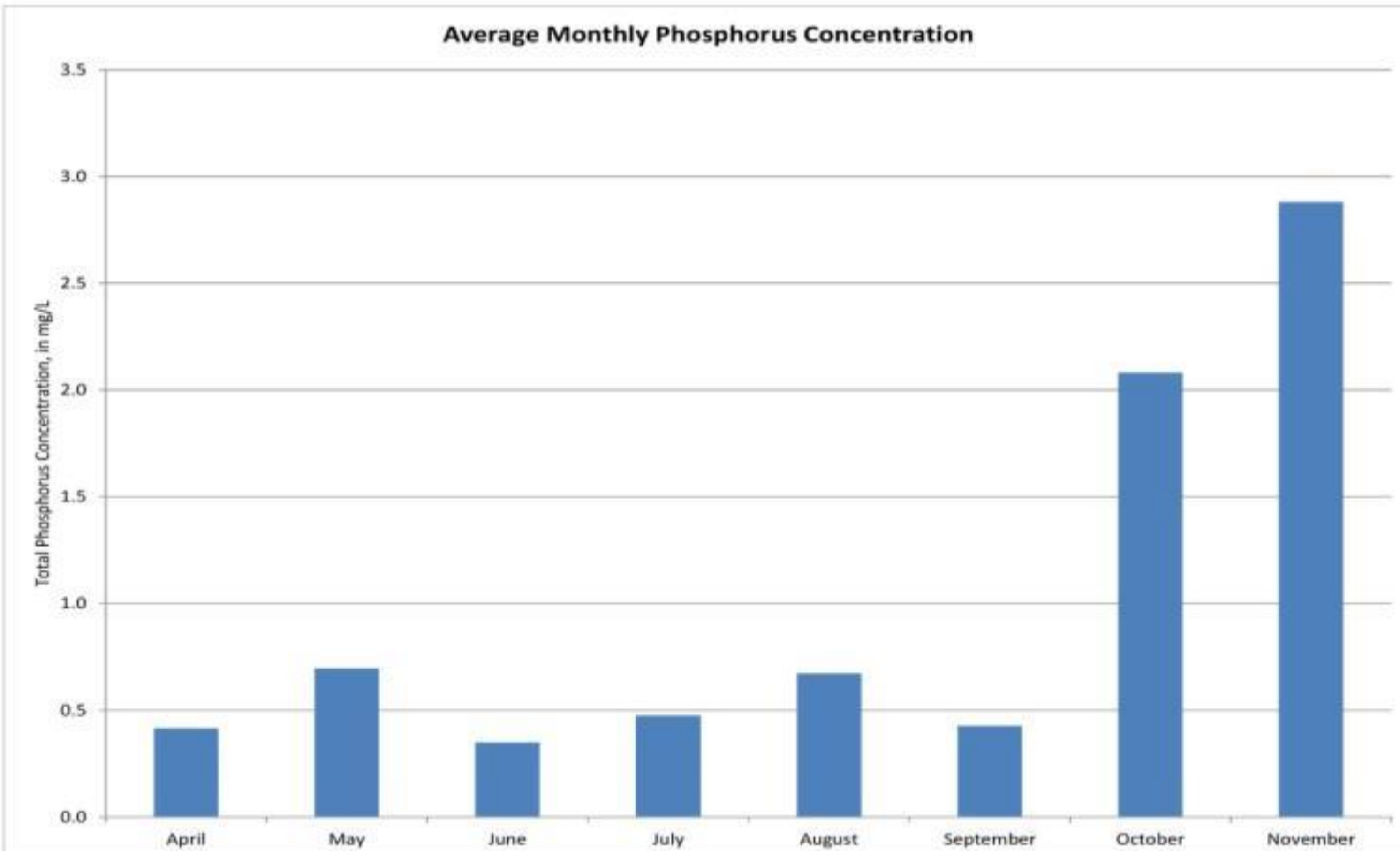
(Source: Tetra Tech, Inc, 2014).

2. Strong seasonal trends in how much "dirt" accumulates on street surfaces

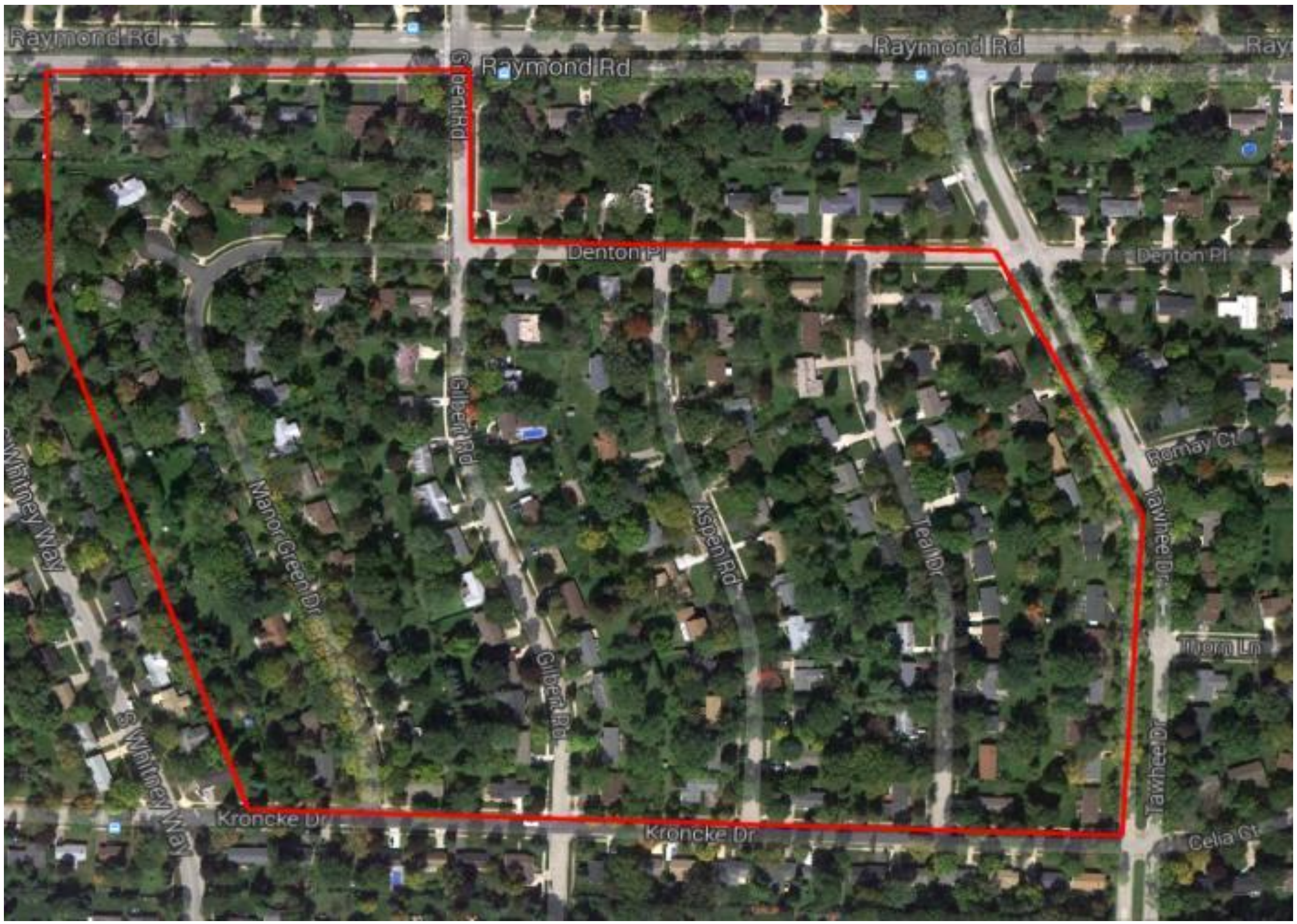
Highest sediment, carbon and nutrient concentrations in the fall, end of winter and late spring

Sweeping season is shorter in the top part of the Bay watershed (i.e., winter shutdown)

Highest Concentration in Fall and Winter



3. How Important Are Fall Leaf Litter Inputs to Streets?



Still an Un-answered Question

Nowak's Baltimore Tree Analysis:

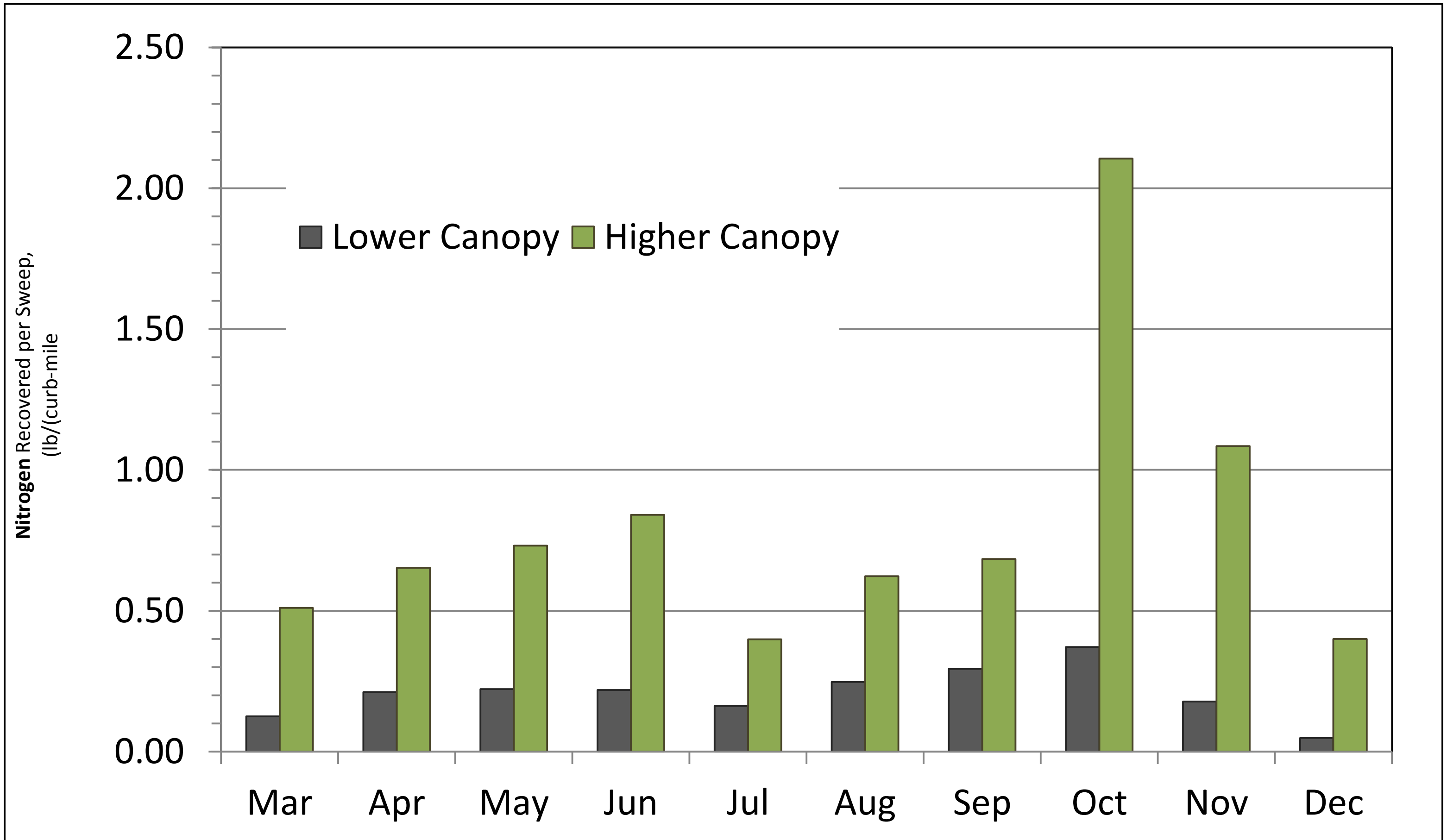
- 1194 lbs/acre/yr of TOC leaf drop
- 28.8 lbs/acre/yr of TN leaf drop
- 2.95 lbs/acre/yr of TP leaf drop

Photo Credit: Ken Belt

The panel was split about the potential importance of leaf litter in the urban nutrient budget.

It strongly agreed the top research priority should be monitoring to settle the issue.

Effect of Street Tree Canopy on N Levels in Sweeper Waste (Kalinosky, 2014)



4. Street solid characteristics are pretty universal across the country

General Particle Size Distribution of Street Solids			
GRAND MEAN of 9 Studies [1]	**Coarse Grained**	**Medium Grained**	**Fine Grained**
	19.9 %	**65.3 %**	**9.2 %**
•numbers do not add up to 100% due to rounding			

Source: Expert Panel Report

Surprising consistency in nutrient enrichment of street dirt across the country

Nutrient Enrichment of Street Solids				
Solid Type	Value	% P	% N	Reference/Notes
Street Solids	Mean	0.10	0.25	CBP EP Report (2011)
Street Solids	Mean	0.05	0.20	Mean 4 Studies (Table B-2)
Street Solids	Mean	0.07	0.14	Baker et al (2014)
Street Solids, Fine	Mean	0.08	---	Sorenson (2013)
Sweeper Waste	Mean	0.04	0.15	Mean of 4 Studies (Table B-3)
Mid-Point of Data	**--**	**0.07**	**0.20**	Estimated

Nutrient Enrichment of Coarse Organic Matter				
Type	Value	% P	% N	Reference/Notes
Coarse Organic Matter	Mean	0.17	1.6	Baker et al 2014
Municipal Leaf Litter	Mean	0.10	0.94	Heckman and Kluchunski, 1996
Leaves	Mean	0.06	0.80	Rushton, 2006
Leaves	Mean	0.19	1.25	Ostrofsky, 1997
Leaves	Mean	0.08	0.96	Stack et al 2013
Mid-Point of Data	**--**	**0.12**	**1.11**	Calculated

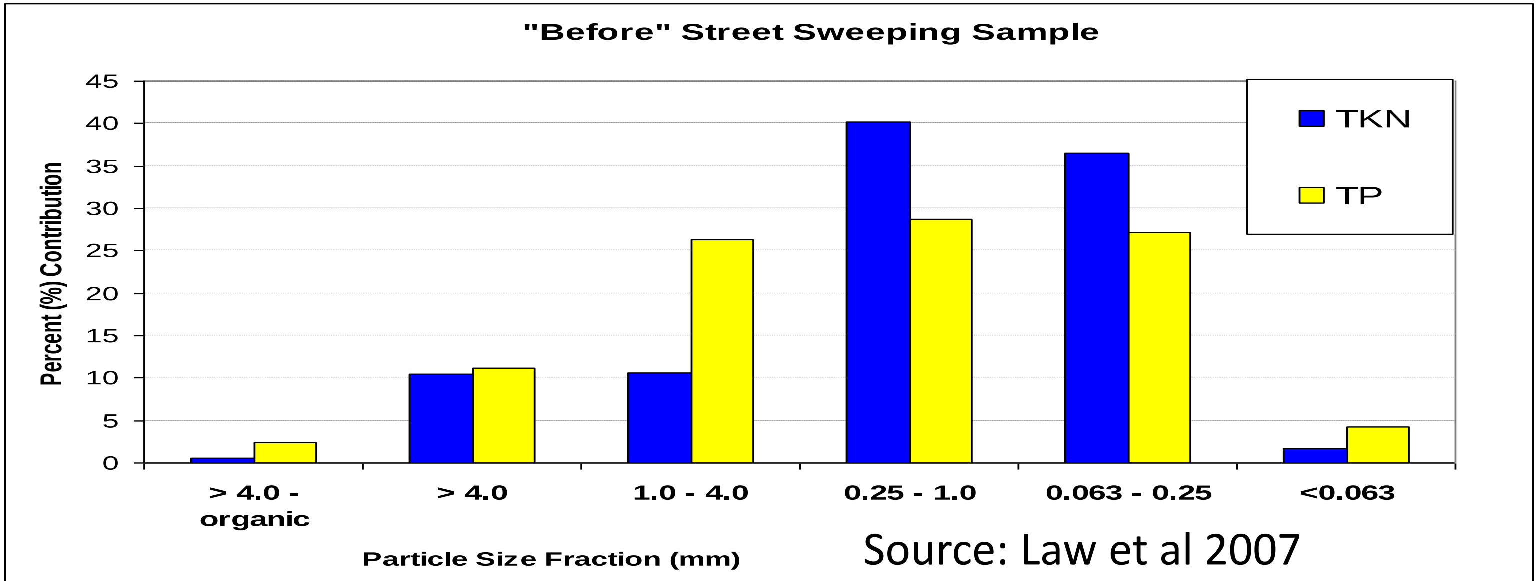
5. Particle size matters, but maybe not

- "Street Solids" are a complex mix of organic and mineral particles
- Particle size ranges over <u>four</u> orders of magnitude
- Bi-modal particle size distribution for nutrients and carbon

Several Studies Indicate Much of the Nutrient Load is Associated w/ Larger Particle Sizes !

Percent of pollutants (by mass) in street dirt found in Madison, WI (Waschbusch et al. 1999).

	< 63 µm	63-250 µm	>250 µm	Leaves
Sediment	2.5	15.5	74	8
TP	5	15	50	30



Source: Law et al 2007

6. Street Dirt is Highly Contaminated

Trace Metal Content of Street Sweeper Waste (mg/kg)				
Study	STATE	Copper	Lead	Zinc
Sorenson, 2012	MA	72	62	146
Sorenson, 2012	MA	47	111	169
SPU, 2009	WA	49	103	189
CSD, 2011 (1)	CA	92	23	136
CSD, 2011 (2)	CA	157	204	210
Walch, 2006	DE	64	81	208
MEAN		**80**	**97**	**176**
Urban Soils (Pouyat et al, 2007)		35	89	91

Source: Expert Panel Report

Other Street Dirt Toxins

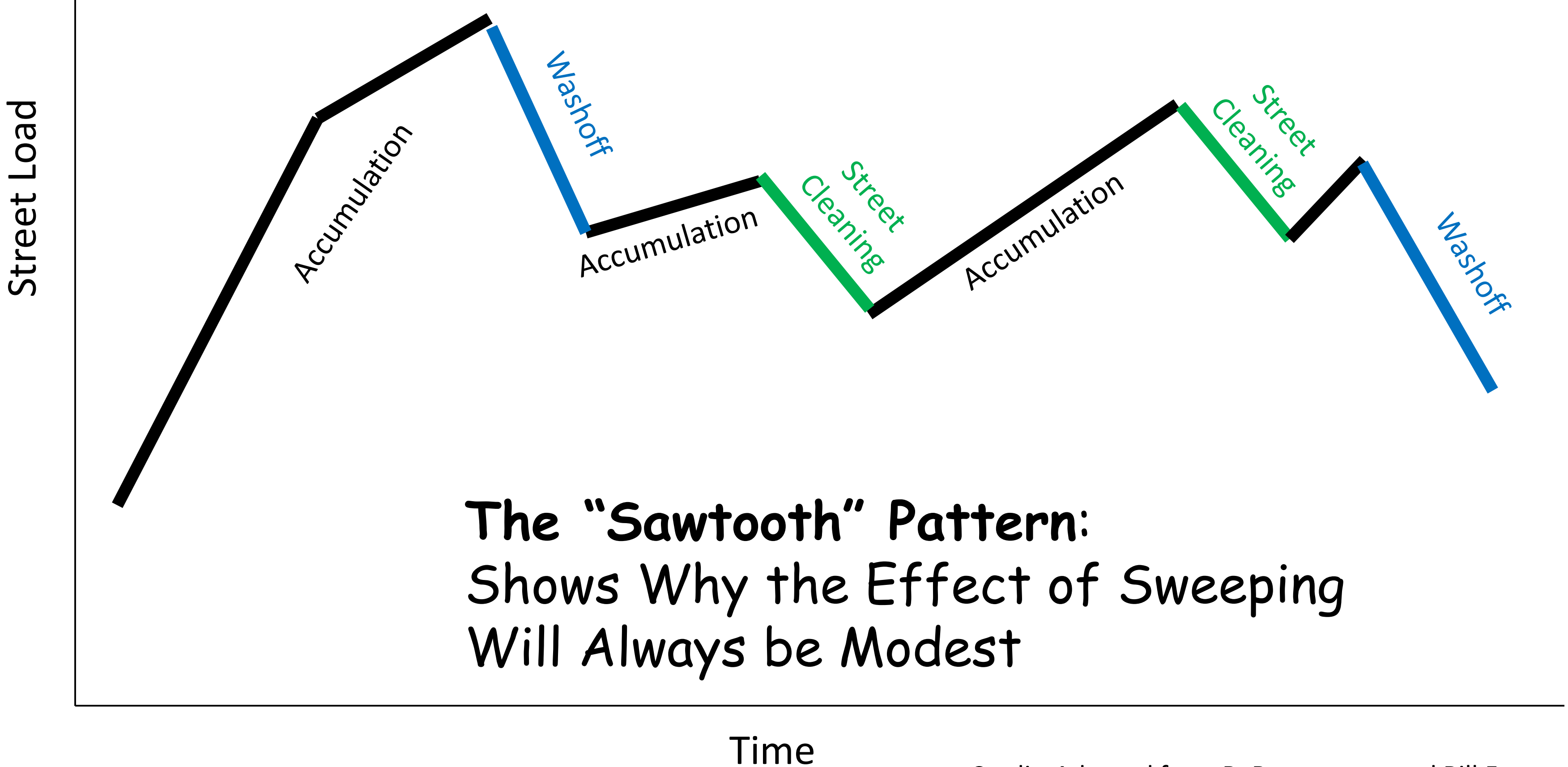
Toxic Contaminant	Sediment Concentration
Petroleum Hydrocarbons	Diesel range: 200 to 400 mg/kg Motor Oil/Oil Grease: 2,200 to 5,500 mg/kg
PCB's	0.2 to 0.4 mg/kg
PAH	Total: 2,798 ug/kg Carcinogenic 314 ug/kg
Pthalates	1,000 to 5,000 ug/kg
Pesticides	Pyrethroids present
Chloride	980 mg/kg
Mercury	0.13 mg/kg
Based on 3 West Coast Studies of street dirt and/or sweeper waste contamination. Source: Expert Panel Report	

C. Review of recent street cleaning research

- About a dozen new sweeper studies
- Lot of new data on the sediments and nutrients that are picked up by sweepers
- Less data on whether material picked up would ever reach the storm drain

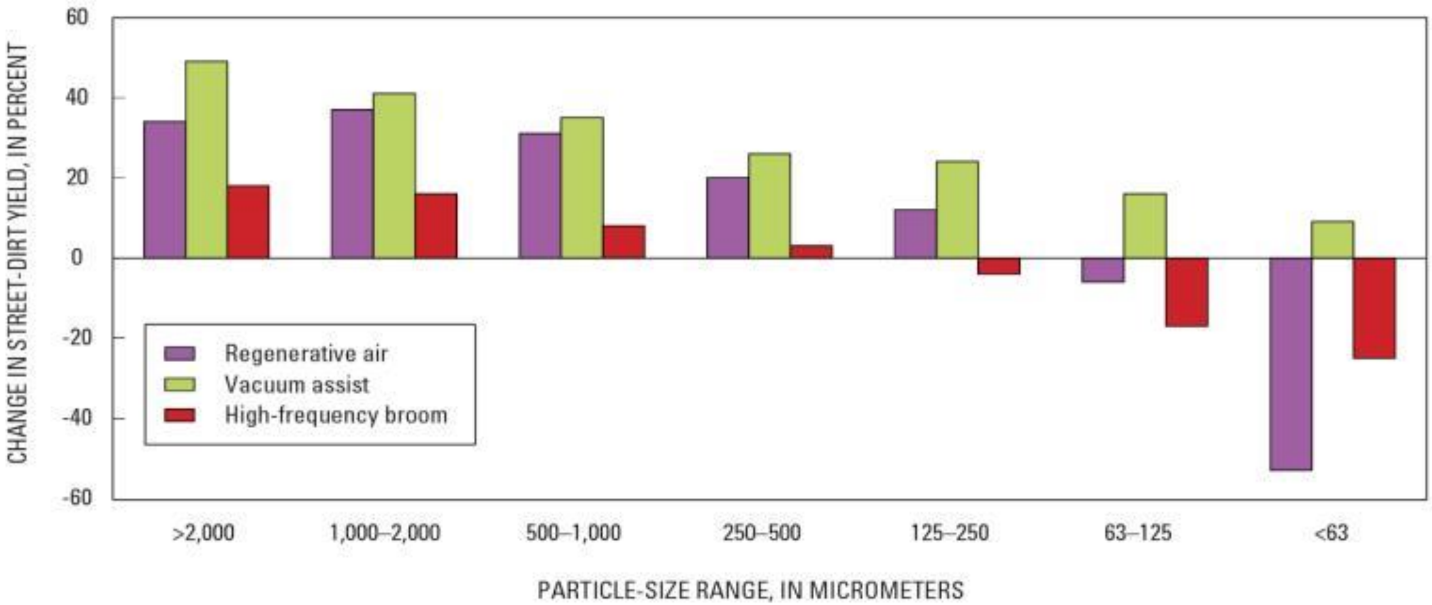
Photo Credit: Roger Bannerman/Bill Selbig

1. Rain storms are also pretty efficient at cleaning the street, moving smaller particles, and they come every 4 to 5 days



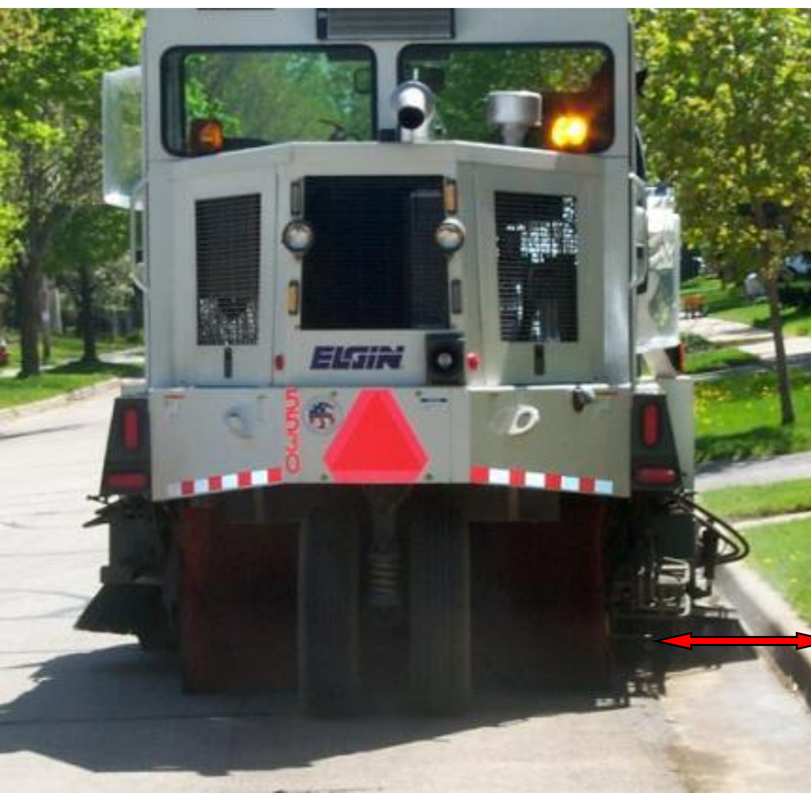
Credit: Adapted from R. Bannerman and Bill Frost

2. High sweeper street dirt pick-up efficiency does not equate to downstream sediment removal



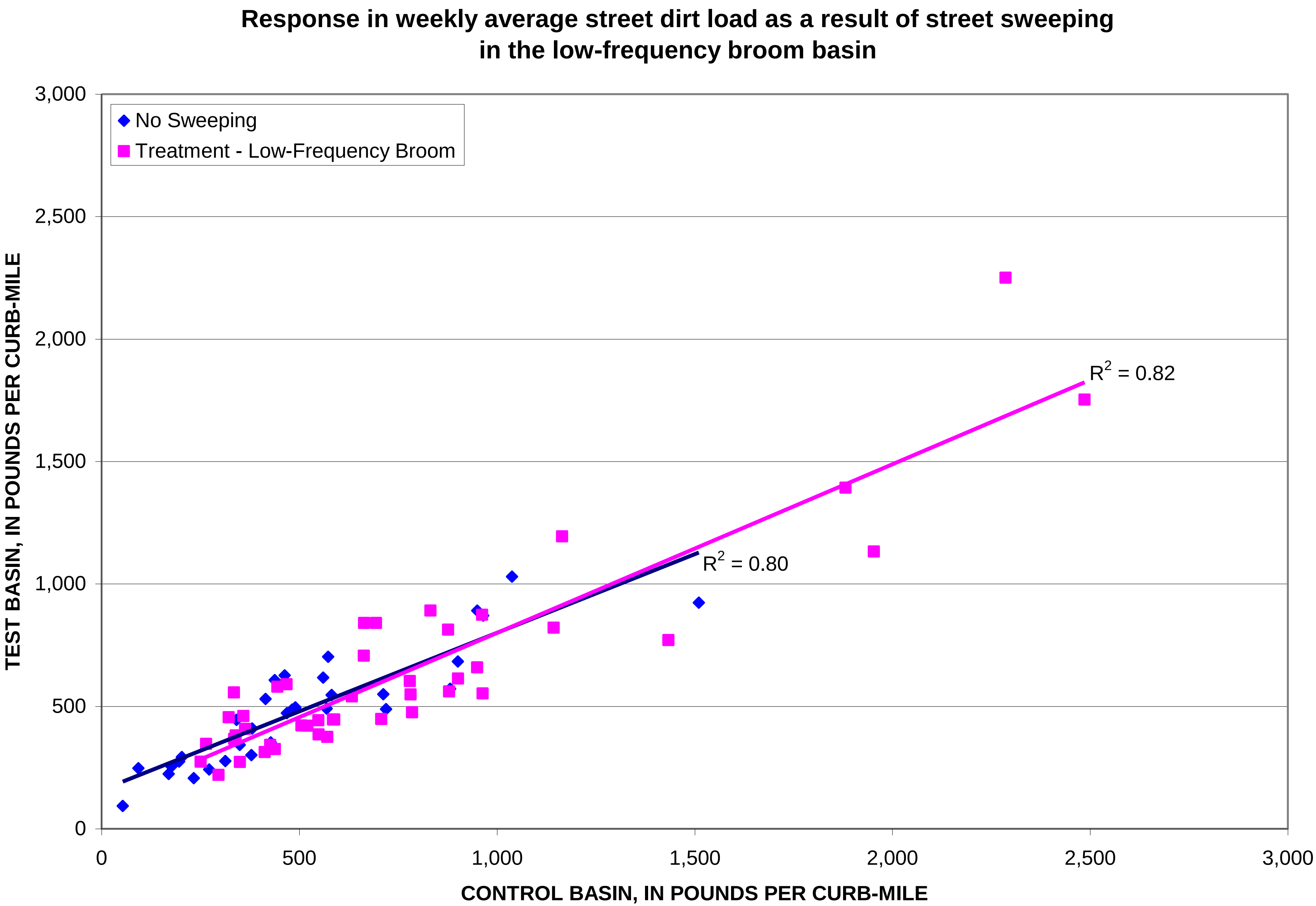
Comparative pick up efficiency of three types of sweepers (Selbig and Bannerman, 2007).

Mechanical Broom Cleaning Effectiveness is Reduced Because Gutter Broom Makes More Fine Particles Available for Wash off



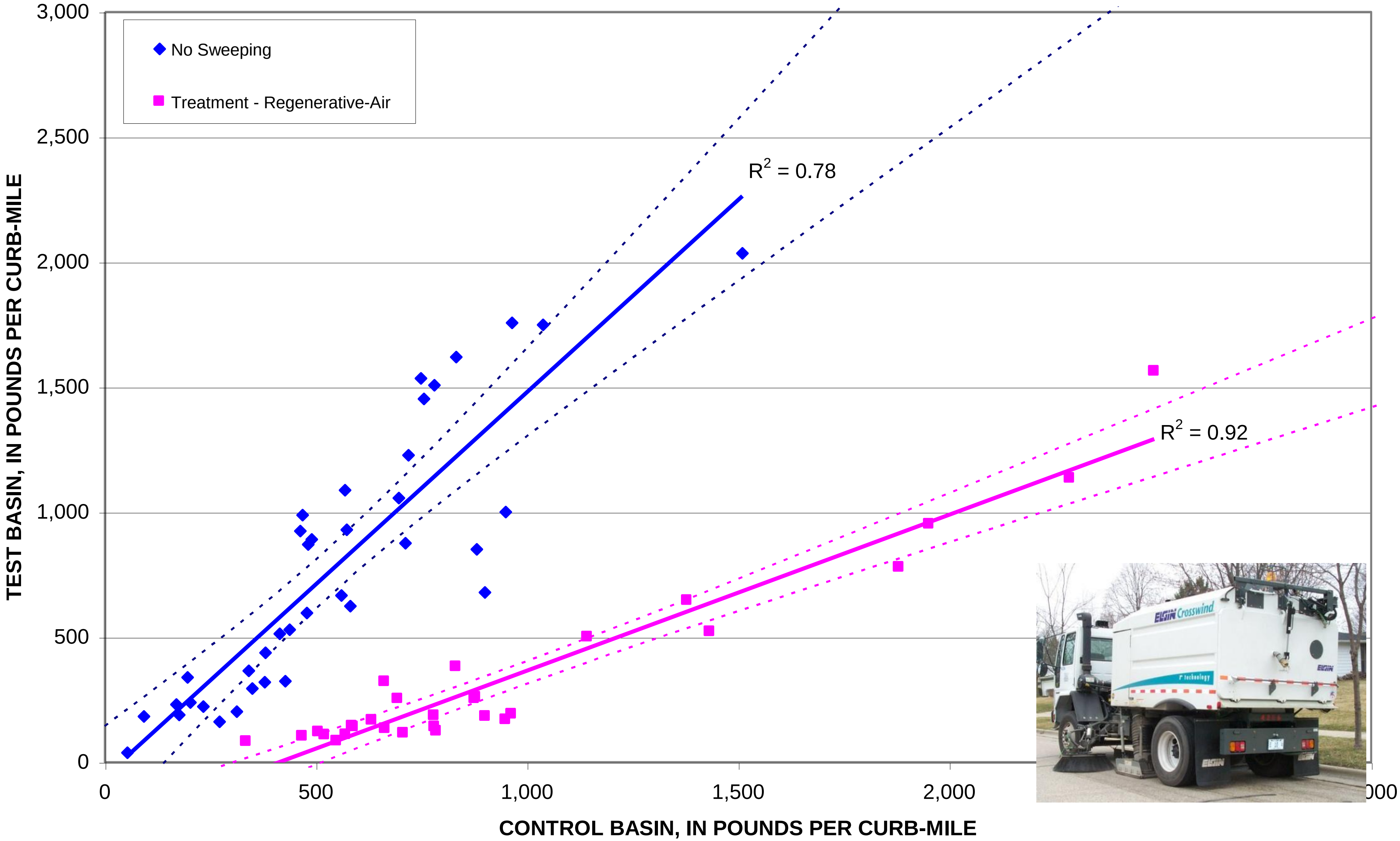
3. Sweeping Technology Matters a Lot

- Mechanical broom sweepers used by many Bay communities pick up a lot of large particles, but not a lot of the sediments that are ultimately transported to the Chesapeake Bay.
- These sweepers have very low sediment reductions.



Source: Bill Selbig

Response in weekly average street dirt load as a result of street sweeping in the air sweeper basin



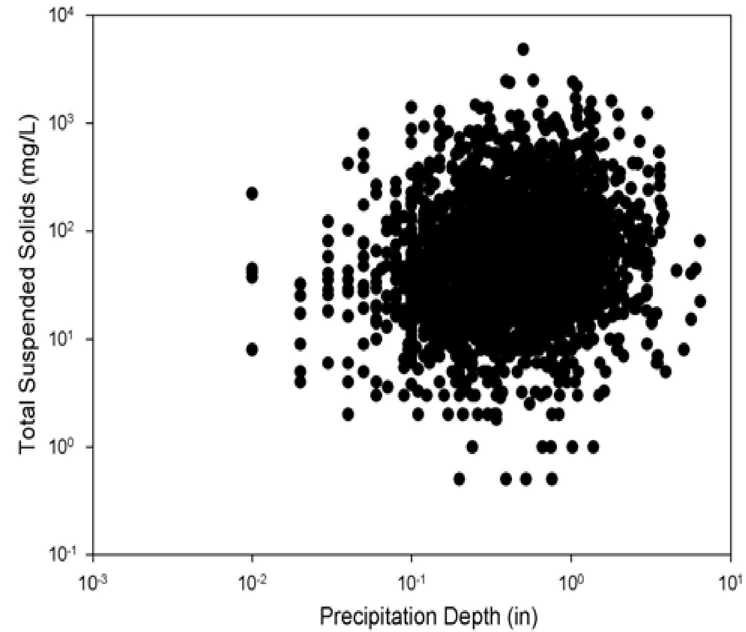
Source: Bill Selbig

4. Frequent street sweeping is needed to get real sediment reductions

- Need to beat those rain storms that are also great at cleaning streets 30 to 50 times a year
- Panel provided a lot more options than the "once a week" sweeping frequency allowed by the last panel
- Seasonal options provide more flexibility in how MS4s deploy their sweeper fleets

5. Variability in Street Runoff Makes it Hard to Monitor the Impact of Street Cleaning

- Despite a dozen studies in recent years, none has shown a detectable water quality improvement based on monitoring in downstream storm drains
- Pollutant concentrations are so variable that hundreds of paired sampled are needed to show a detectable difference (if it exists)



Source. Pitt, NSQD, 2004

The statistics on powers of detection

Samples Required to Detect Change Given Variability in Event Mean Concentration		
Pollutant	Coefficient of Variation [1]	Approx. No. of Samples Required [2]
TSS	1.8	250
TN	1.0	75
TP	1.3	150

[1] Per most recent edition of National Stormwater Quality Database (Pitt, 2014)

[2] 95% confidence interval and assuming a sampling error rate of 25%, as shown in Figure 2 of Sample et al (2012).

Source: Expert Panel Report

6. Need to resort to simulation models to derive street cleaning estimates, given monitoring limitations

- Modeling also allows managers to determine removal rates for hundreds of different street cleaning scenarios
- Models are intended to guide better environmental decisions, but managers who use them should be aware of their inherent limitations, false precision, and uncertainty of model predictions.

D. WinSLAMM Model

- The Panel selected the WinSLAMM Model as the tool to estimate sediment removal rates for streets in urban watersheds.

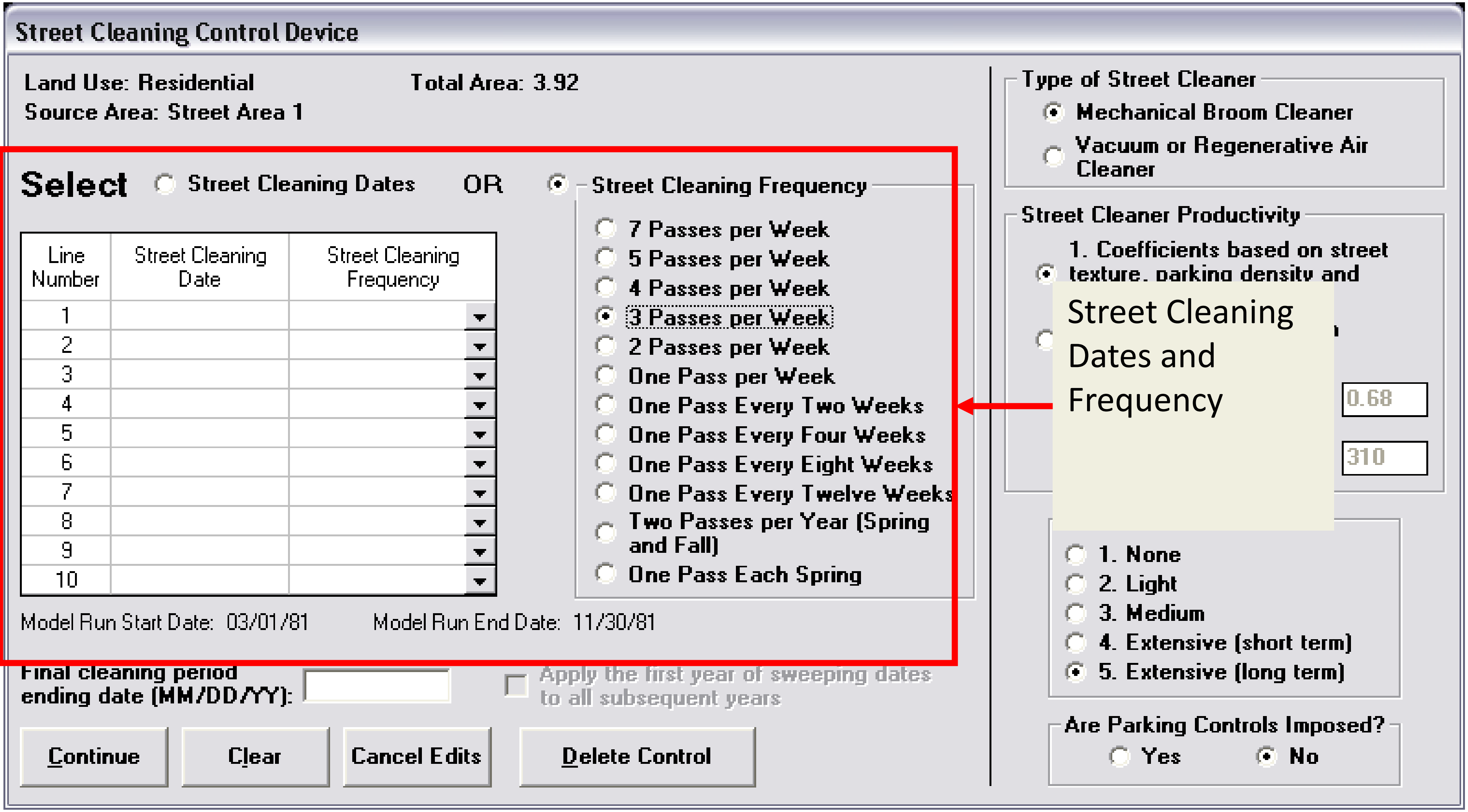
  WinSLAMM is widely accepted and documented model that simulates urban hydrology, pollutants and the effect of stormwater practices

- The basic street cleaning module in WinSLAMM is a conservative simulation of the potential sediment reductions associated with different street cleaning scenarios, and relies on sediment production and wash-off functions derived from empirical monitoring data

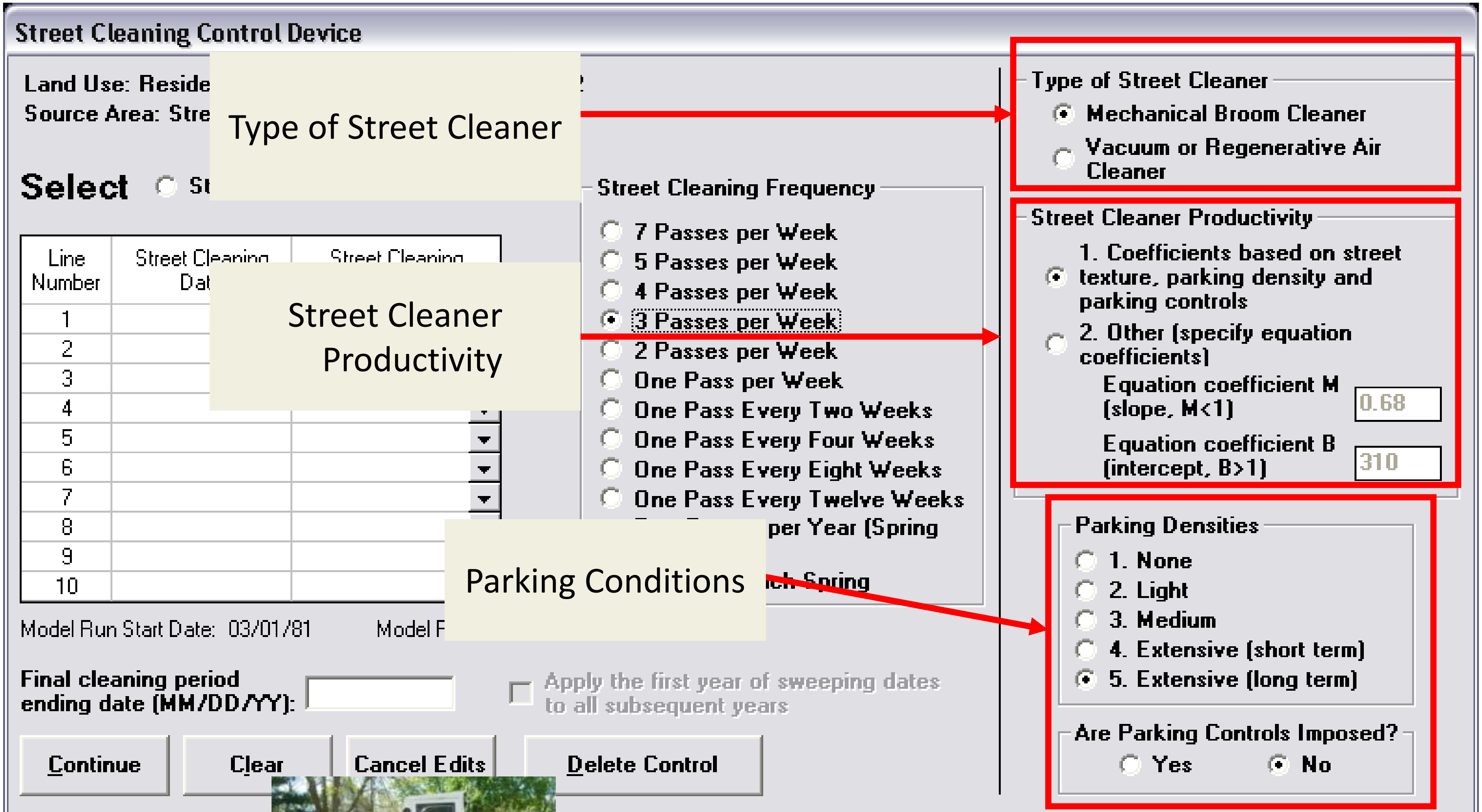
- Model was customized to incorporate East coast sediment buildup and washoff data, Chesapeake Bay rainfall, and expected variations in street types, technologies and urban land uses.

- Used in MN and MA to determine TP credits in lake TMDLs

WinSLAMM Street Cleaning Module



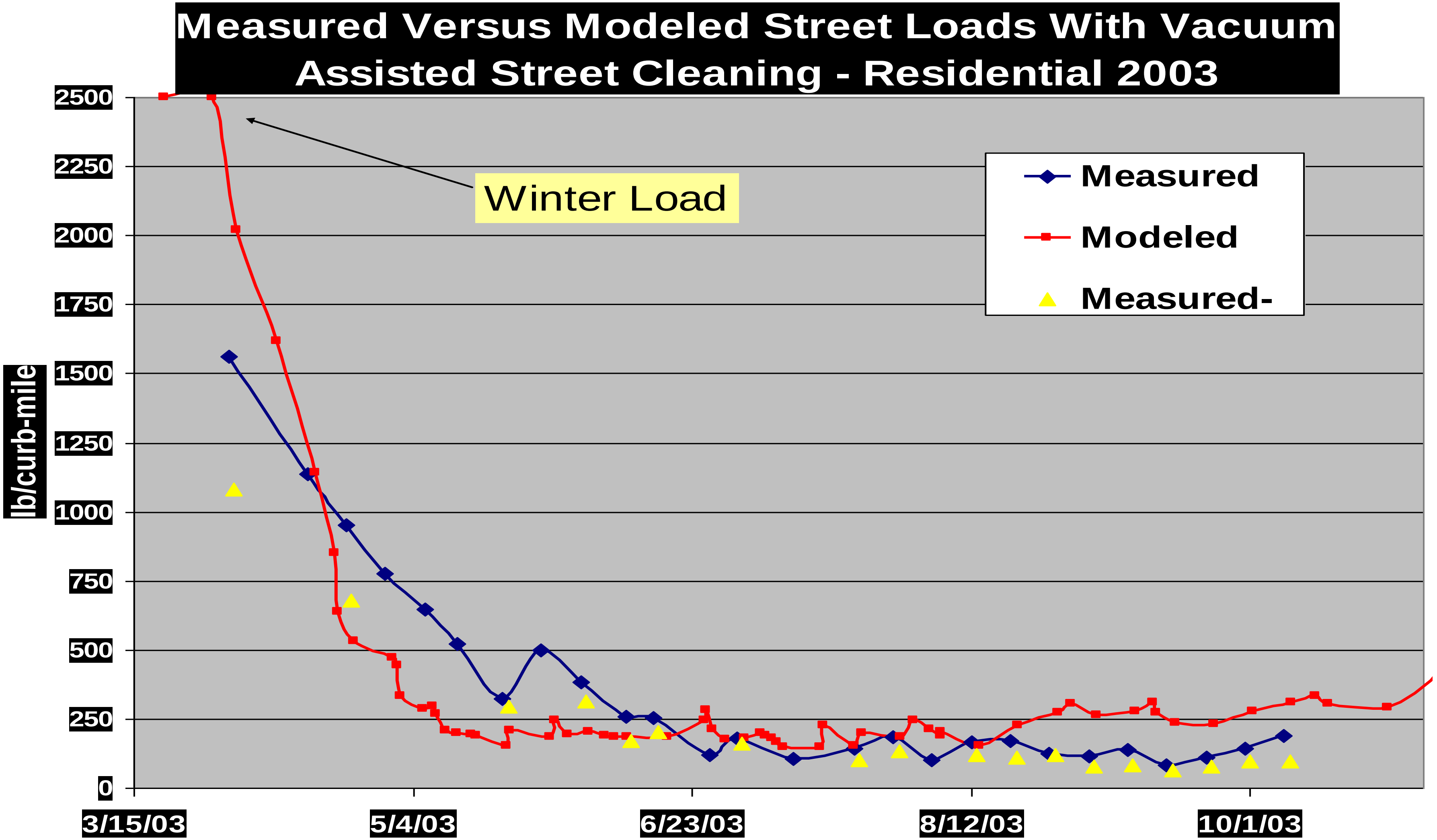
Evaluates many street cleaning scenarios



Model helped the Panel to evaluate nearly a thousand street cleaning scenarios

- 3 Sweeping Seasons
- 4 Street Types
- 2 Levels of Sweeper Technology
- 10 Different Sweeping frequencies (some seasonal)
- 4 combinations of street parking levels/controls

The Street Cleaning Module has been calibrated and verified to real street dirt datasets



Source: Bannerman

WinSLAMM Findings

- Mechanical broom efficiency is very low (e.g., 0 to 5%) for nearly all street cleaning scenarios evaluated.
- The effect of winter sweeping shutdown was very modest, compared to areas of the watershed where sweeping can be done year round
- High levels of street parking decrease street-sweeping efficiency.
- The best seasonal cleaning scenario involved S3 (one pass every week in spring, March to April and fall, October to November, and monthly otherwise)

Source Tetra Tech, 2014

Questions?

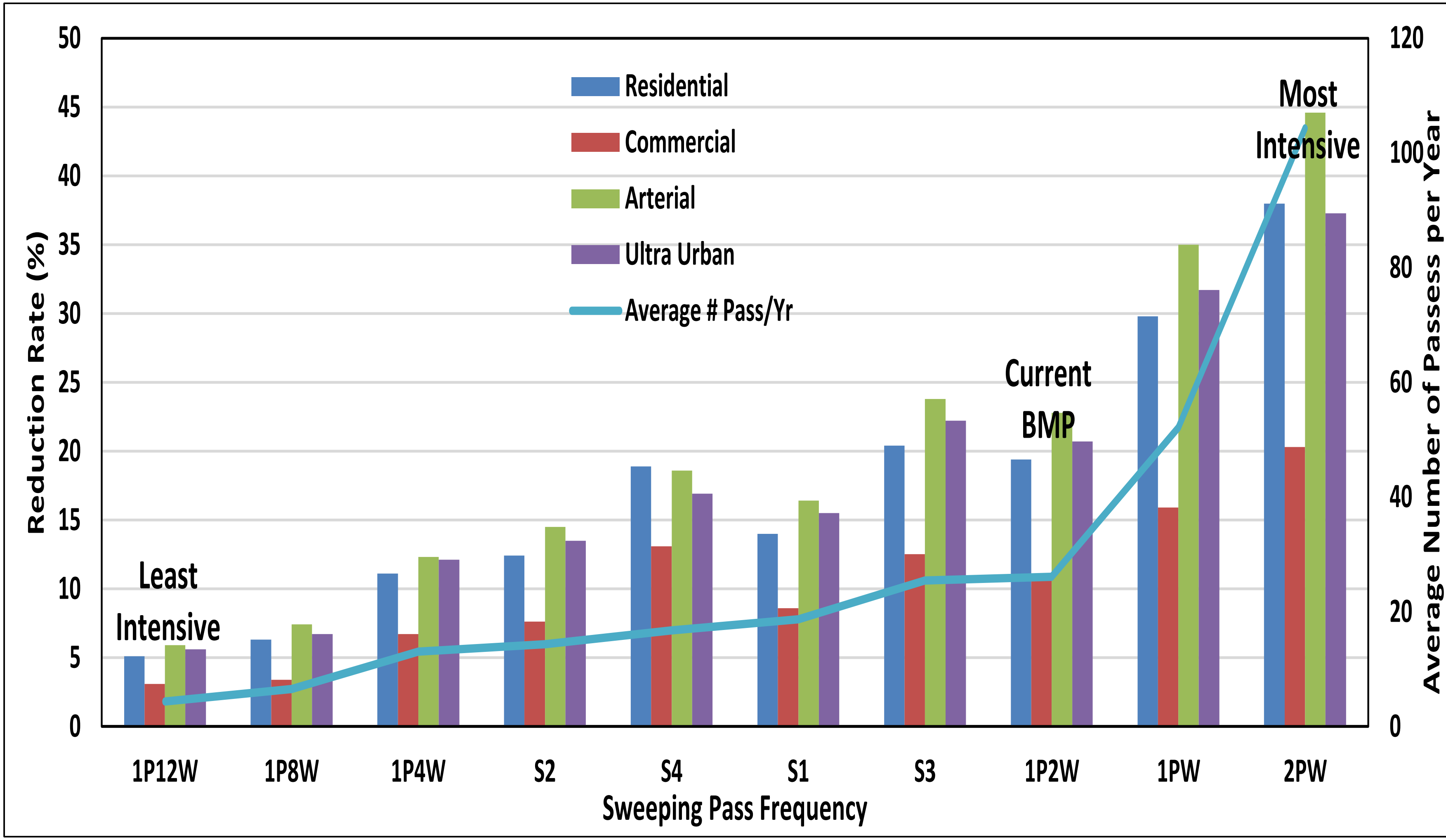
E. The Three Credit Changes

1. Street Cleaning Credit, for lane miles swept
2. No Street Cleaning Credit for Hopper Mass
3. Storm Drain Cleaning Credit, mass collected

1. The Street Cleaning Credit

- The standard unit is curb miles swept
- One impervious acre is equal to one curb-lane mile swept, for streets with curb and gutters, assuming they are swept on one-side only
- A spreadsheet calculated the annual sediment and nutrient reduction for 960 street cleaning scenarios…which were then consolidated into 11 street cleaning practices (SCPs)
- Credit must be calculated every year

Sediment Reduction Based on Street Type and Cleaning Frequency



Source: Tetra Tech, 2014

An empirical nutrient enrichment factor is applied to compute the mass of N and P reduced

Nutrient Enrichment of Street Dirt				
Solid Type	Value	% P	% N	Reference/Notes
Street Solids	Mean	0.10	0.25	CBP EP Report (2011)
Street Solids	Mean	0.05	0.20	Mean 5 Studies
Street Solids	Mean	0.07	0.14	Baker et al (2014)
Street Solids, Fine	Mean	0.08	---	Sorenson (2012)
Sweeper Waste	Mean	0.04	0.15	Mean of 5 Studies
Mid-Point of Data	--	**0.07**	**0.20**	Estimated

Pollutant Reductions Associated with Different Street Cleaning Practices

Practice #	Description [1]	Approx Passes/Yr [2]	TSS Removal (%)	TN Removal (%)	TP Removal (%)
SCP-1	AST- 2 PW	~100	21	4	10
SCP-2	AST- 1 PW	~50	16	3	8
SCP-3	AST- 1 P2W	~25	11	2	5
SCP-4	AST- 1 P4W	~10	6	1	3
SCP-5	AST- 1 P8W	~6	4	0.7	2
SCP-6	AST- 1 P12W	~4	2	0	1
SCP-7	AST- S1 or S2	~15	7	1	4
SCP-8	AST- S3 or S4	~20	10	2	5
SCP-9	MBT- 2PW	~100	0.7	0	0
SCP-10	MBT- 1 PW	~50	0.5	0	0
SCP-11	MBT- 1 P4W	~10	0.1	0	0

AST: Advanced Sweeping Technology MBT: Mechanical Broom Technol0gy

[1] See Table 15 for the codes used to define street cleaning frequency

[2] Depending on the length of the winter shutdown, the number of passes/yr may be 10 to 15% lower than shown

An Example of How it Works

Estimating Pollutant Reduction by Local Street Cleaning Program							
Lane Miles/ Acres	SCP	Removal Rate (%) [1]			Mass Removed (lbs) [2]		
		TSS	TN	TP	TSS	TN	TP
150	SCP-2	16	3	8	31,200	69.8	14.5
50	SCP-7	7	1	4	4,550	7.8	3.8
25	SCP-4	6	1	4	1,950	3.8	1.9
75	SCP-9	1	0	0	9.75	0	0
Total for Community					37,710	81.4	20.2

[1] From Table 17, and assume one curb mile equals an acre
[2] Assume annual load from impervious cover of 1,300 lbs/ac/year (sediment), 15.5 lbs/ac/yr (nitrogen) and 1.93 lbs/ac/yr (phosphorus) -- Table 4

2. The Hopper Method for Street Cleaning Credit is Being Phased Out

- The last expert panel recommended an alternate street cleaning credit that relies on the dry mass of street solids picked up by the sweeper fleet

- Never a good idea to provide two methods that may give different answers to the same question.

Photo Credit: Kalinsoky

2. End of the hopper credit

- The WINSLAMM modeling provides better support for the curb lane miles swept approach
- Eliminates the possibility that users will "shop" for the method that gives them the most credit.
- The Old Hopper Method Credit is OK in Phase 5.3.2, but expires with Phase 6 of CBWM
- Hopper data is still used to calculate and verify the storm drain cleaning credit

3. The Storm Drain Cleaning Credit

- Sediment and nutrient credit for solids that are directly removed from catch basins, storm drain pipes or are collected at the outfall, based on the dry weight of the mass of solids collected, using a default nutrient enrichment factor (or a locally derived one).

- Must also meet 3 qualifying conditions to ensure cleaning has a water quality focus


VAC-CON

The Credit Promotes Innovative Practices Within the Storm Drain or its Outfall

- Use of bag filters and end of pipe treatment can be credited, in addition to catch basin cleanouts

Photo Credits: Law et al 2013

Photo Credits: MWCOG 2009

Three Step Calculation

- **Step 1:** Measure the mass of solids/organic matter that is effectively captured and properly disposed by the storm drain cleaning practice on an annual basis.

- **Step 2:** Convert the initial wet mass captured into dry weight. Default factors can be used to convert wet mass to dry weight in the absence of local data:
  - 0.7 for wet sediments
  - 0.2 for wet organic matter

- **Step 3:** Multiply the dry weight mass by a default nutrient enrichment factor depending on whether the material captured is sediment or organic in nature).

Different Nutrient Enrichment Factors Are Applied to Solid Mass Removed

Default Nutrient Enrichment Factors to Apply to the Dry Weight Mass of Solids Removed From Storm Drains		
Nutrient Enrichment Factor	% P	% N
BMP and Catch Basin Sediments	**0.06**	**0.27**
Organic Matter/Leaf Litter	**0.12**	**1.11**
Note: locals may substitute their own enrichment factor if they sample the nutrient and carbon content of the materials they physically remove from the storm drain.		

3. Storm Drain Cleaning Credit Additional Qualifying Criteria

1. To maximize reduction, efforts should be targeted to focus on catch basins trapping the greatest organic matter loads, streets with the greatest overhead tree canopy and/or outfalls with highest sediment or debris loads.

2. The loads must be tracked and verified using a field protocol to measure the mass or volume of solids collected within the storm drain system. The locality must demonstrate that they have instituted a standard operating procedure (SOP) to keep track of the sediments and/or organic matter that are effectively removed.

3. Material must be properly disposed so that it cannot migrate back into the watershed

Appendix F provides an example of an SOP used to track storm drain inlet cleaning in Baltimore County, MD that may serve as a useful template

Interaction of Street Cleaning with Other BMPs

- Roads inevitably intersect drainage areas that may be served by upstream and/or downstream BMPs.
- Potential double counting situation.
- Could not find a a practical method to isolate the BMP interaction effect over the entire road network of a MS4
- Given the panels conservative protocol, the effect is too small to quantify

F. Reporting, Tracking and Verification

For Street Cleaning & Storm Drain Cleaning

Street Cleaning Reporting

Annual Reporting of:

Total qualifying lane miles swept in the community each year that correspond to the appropriate SCP category, as follows:

Lane Miles/ Acres	SCP	Removal Rate (%) [1]		
		TSS	TN	TP
150	SCP-2	16	3	8
50	SCP-7	7	1	4
25	SCP-4	6	1	4
75	SCP-9	1	0	0

Provide general lat/long coordinates for
(a) centroid of jurisdiction, or
(b) midpoint of sweeping route, or
(c) 12 digit HUC watershed address

so reductions can be properly assigned

Street Cleaning Tracking

Keep accurate records to substantiate their actual street cleaning operations that are being claimed for credit.

Typical records will include:

1. Actual sweeper routes (and type of road)
2. Total curb miles swept on each route
3. Average parking conditions and controls along the route (optional)
4. Sweeper technology used (AST or MBT)
5. Number of sweeping passes per year on each qualifying route

Street Cleaning Verification

Collect one high quality street sweeper waste sample on one route for each unique SCP they report for credit every year.

The single sample is used to characterize the mass and quality of sweeper waste picked up along a single route by a single sweeper that is disposed at a landfill or a solid waste transfer station

The data is used to compute more accurate:

- Average dry weight solids load collected over the route (lbs/curb mile)
- Wet mass to dry weight conversion factor
- Sweeper waste nutrient enrichment ratios

RTV for Storm Drain Cleaning Credit

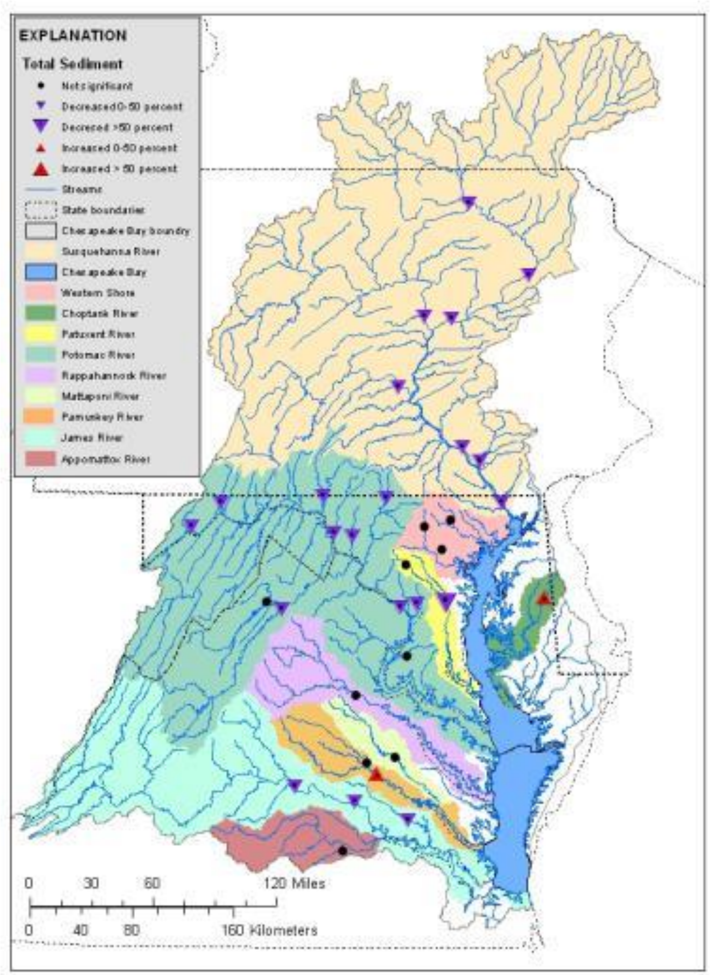
Reporting: Annual TSS, TP and TN load removed by the practice(s) each year (in pounds), and the coordinates of the centroid of either (a) the jurisdiction or (b) the 12 digit HUC watershed in which the cleaning occurs.

Tracking:

- Develop a standard operating procedure to collect reliable data in the field and the office
- Institute a tracking system to document annual storm drain cleaning efforts
- Substantiate how annual sediment and nutrient reductions were calculated.

Verification: sampling of storm drain solids

G. Other Panel Recommendations



- Research
- Modeling
- Local Implementation

Research Recommendations

1. Share and analyze street and storm drain cleaning data collected during verification
2. Fate and significance of leaf litter in streets
3. Delivery of different particle sizes of street solids
4. Pick-up efficiency of next generation of sweeping technology
5. Enhanced catch basin design
6. Toxics and trash reduction achieved by street cleaning

Modeling

- The panel endorses the creation of a new land use in the next generation of the Chesapeake Bay Watershed Model that represents the impervious cover associated with transport land uses (i.e., streets, roads and highways).

Local Implementation Considerations

- Develop more detailed sampling guidance and standard operating procedures to support the proposed verification protocols for street and storm drain cleaning.
- Training and Outreach
- Support Website for MS4s on the Practices
- Annual forum for MS4 fleet managers

Review Process

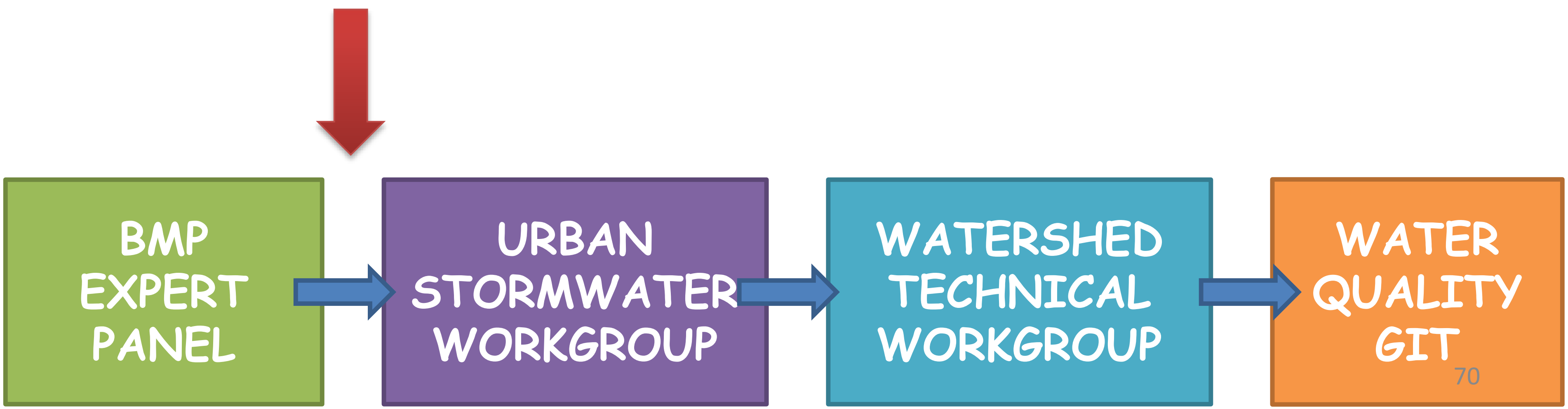
“Debut Webinar” in late September

30 Day Comment Period

Response to Comments Prepared

Seek USWG/WTWG approval in November

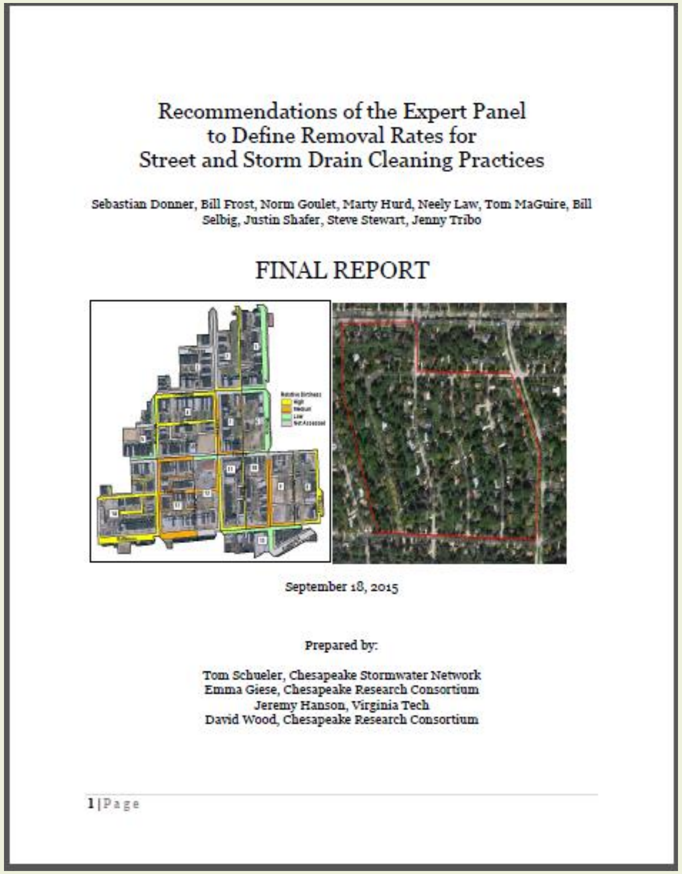
Final Approval by WQGIT in December



Questions?

Webcast Resources

- Recommendations of the Expert Panel to Define Removal Rates for Street and Storm Drain Cleaning Practices. Final Report. 2015



Recommendations of the Expert Panel
to Define Removal Rates for
Street and Storm Drain Cleaning Practices

Sebastian Donner, Bill Frost, Norm Goulet, Marty Hurd, Neely Law, Tom MaGuire, Bill Selbig, Justin Shafer, Steve Stewart, Jenny Tribo

FINAL REPORT

September 18, 2015

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