

**When Concerned About Toxic Stormwater
Pollutants in the Built Environment:**

“Sweep Before You Treat”

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Many jurisdictions have been requiring new developments to treat urban stormwater with:

- ❖ *Wet ponds*
- ❖ *Grassy swales*
- ❖ *Sand filers*
- ❖ *Wet vaults*
- ❖ *Other structural devices*



**These type of treatments cost anywhere
from \$10 to \$50 lb of TSS removed**

My first question is:

**Why aren't they requiring street
sweeping which removes TSS from
runoff at \$2 to \$5 per lb?**



Introduction

Many recent studies have shown that:

Standard TSS testing techniques and the use of automatic samplers have greatly underestimated the magnitude, concentration and average particle size of sediment in urban stormwater.



Resulting in:

The inundation of treatment facilities with high unanticipated loadings of sediment and gross pollutants that have led to poor removal performance and higher maintenance costs.



Introduction

**Studies by Sutherland and Jelen
clearly establish that:**

***Street sweeping is the most
cost effective BMP from a
pollutant reduction standpoint
and should be considered first
before structural treatment
devices are used.***



Introduction

Most newer machines whether:

- ❖ *Vacuum*
- ❖ *Regenerative air*
- ❖ *Mechanical broom*

are more effective at sediment and associated pollutant pick-up.

**The practice should now be called
“Street Cleaning,” not street sweeping.**



Cleaning Streets

IS NOT

an Effective BMP



An Urban Myth

Nationwide Urban Runoff Program (NURP) 1982 conclusion:

“Street sweeping is generally ineffective as a technique for improving the quality of urban runoff.”



An Urban Myth

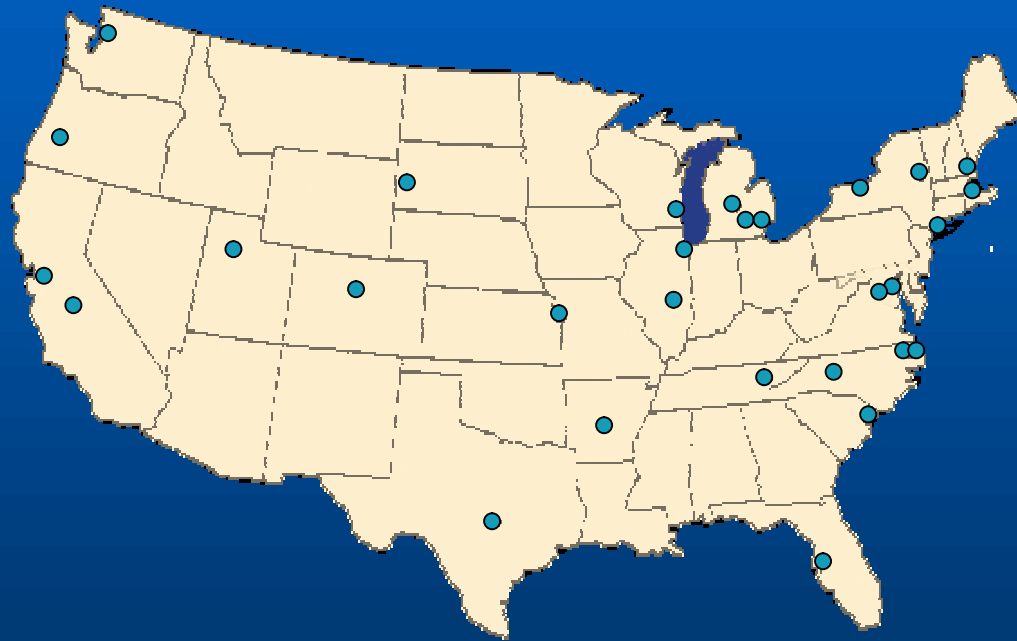
What has changed by 2006:

- ❖ *Improved sweepers*
- ❖ *NPDES permits*
- ❖ *TMDL compliance*
- ❖ *Public expectations are greater*
- ❖ *“End-of-Pipe” treatment is very expensive*



An Urban Myth

Over \$30 million was spent studying the characteristics and potential control of urban stormwater runoff quality at 28 U.S. cities between 1979 – 1982.



USEPA 1982 NURP Study

Street cleaning was investigated in the following U.S. cities:

City	Sites
Bellevue, WA	2
Champaign Urbana, IL	4
Milwaukee, WI	2
Winston-Salem, NC	2



- ❖ **The studies used either a paired basin or serial basin approach with continuous sampling of end-of-pipe urban runoff quality occurring under either *swept* or *unswept* conditions.**
- ❖ **The resulting runoff quality data was analyzed statistically, not explicitly. Computer models of that era were not considered to be reliable or accurate.**



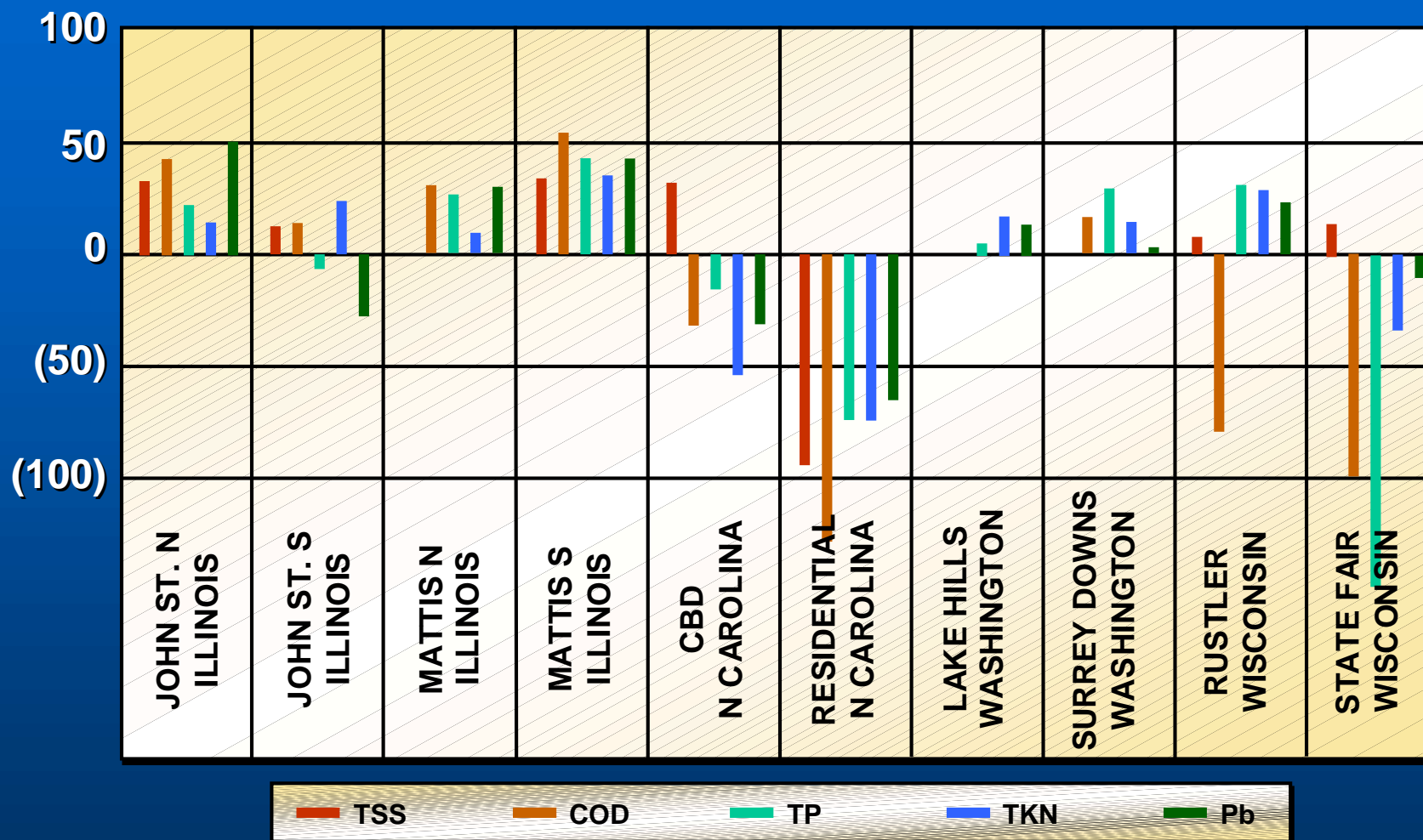
- ❖ **NURP evaluated street cleaning performance as measured by the percent change in the site median Event Mean Concentration (EMC) for each pollutant of interest.**
- ❖ **NURP concluded that street sweeping using equipment of that era was generally ineffective in reducing the concentrations of pollutants commonly found in stormwater.**



- ❖ However, the *actual* data analyses of the five major pollutants (TSS, COD, TP, TKN, and Lead) at each of the 10 sites where street sweeping was investigated showed that under swept conditions EMCs were *actually reduced* in 60% of the 50 pollutant/site investigations.
- ❖ Increases in site median EMCs were reported for 16 out of the 50 pollutant/site investigations, and 9 of those from the two North Carolina sites.



% EMC Reduction



NURP Study – Actual Data Analysis

- ❖ **We now know that these EMC increases resulted from the NURP era street sweeper's inability to pick up significant amounts of the "dirt and dust" fraction of the accumulated street dirt (i.e. less than 2000 microns).**
- ❖ **Intense rain storms (which occur more frequently in North Carolina) were then able to efficiently transport the remaining unarmored material which led to higher pollutant concentrations for the swept condition.**



Why does this matter now?

- ❖ **Technology has greatly improved the sediment pick up performance of all types of street cleaners.**
- ❖ **Because of the NURP conclusion, most stormwater people including most consultants and NPDES coordinators believe that street cleaning is ineffective at reducing pollutant loadings in stormwater.**



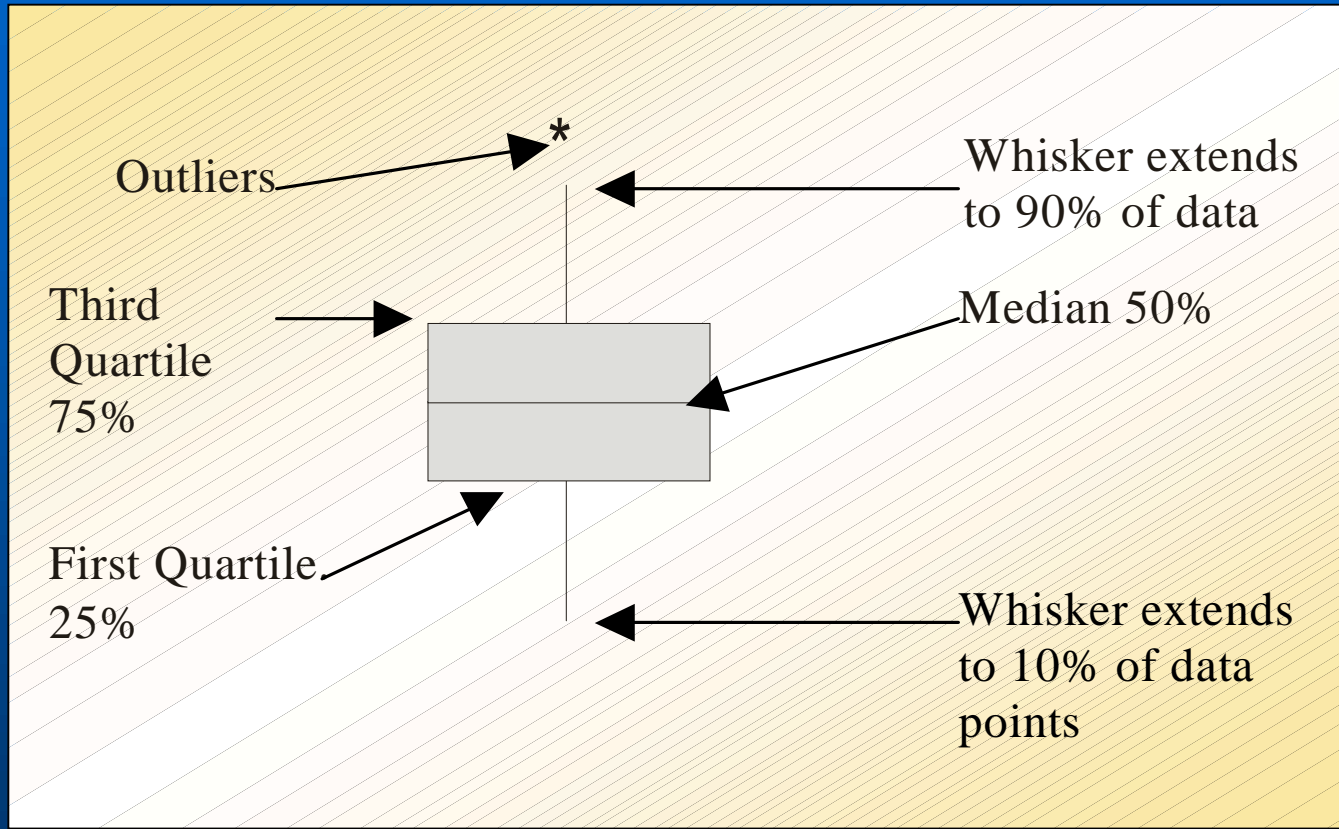
The number 1 reason to sweep is:

Sweeping Improves Water Quality



Number 1 Reason to Sweep

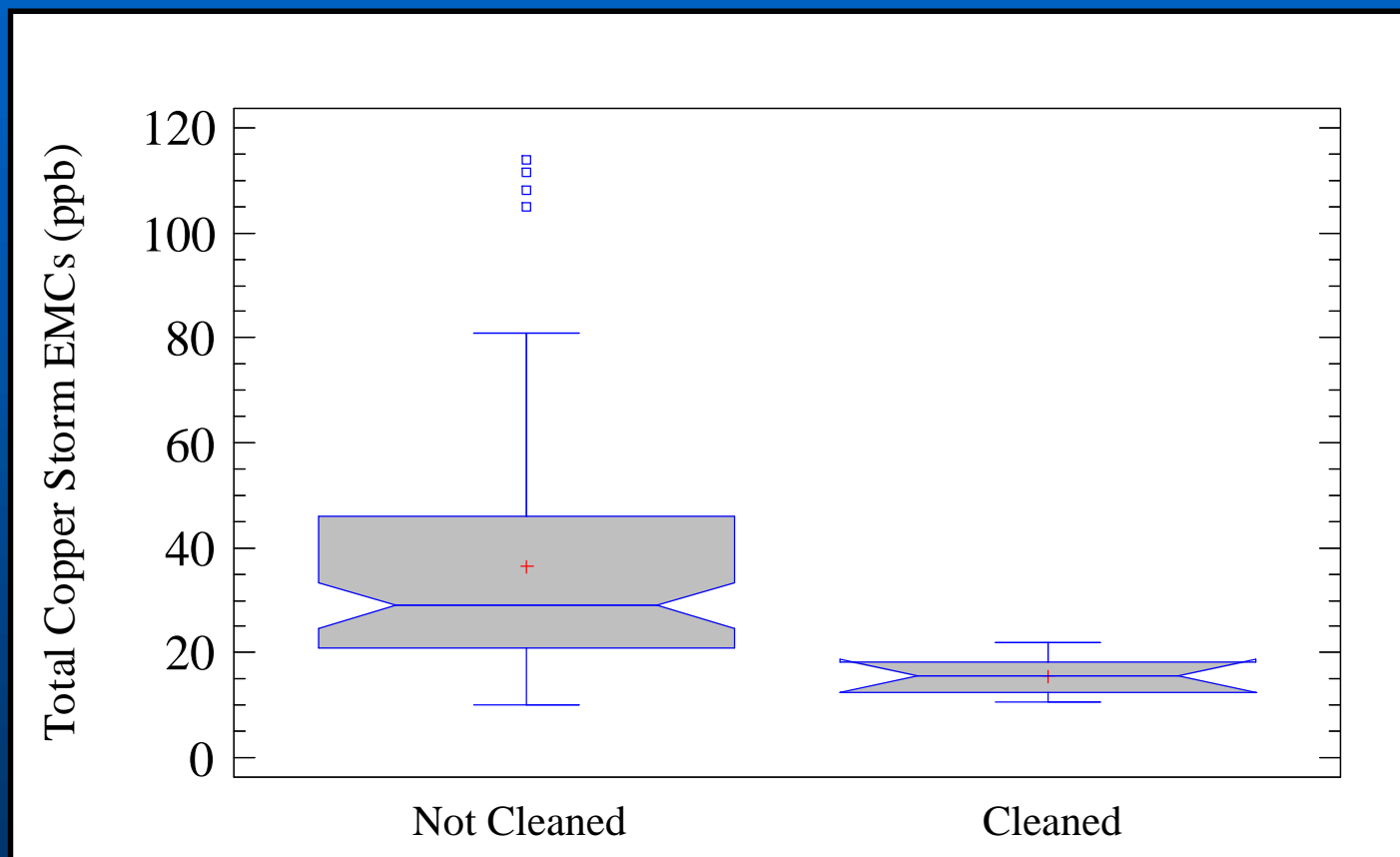
Box-Whisker Plots



Cleaning Improves Water Quality

Baltimore Street Cleaning Pilot Study

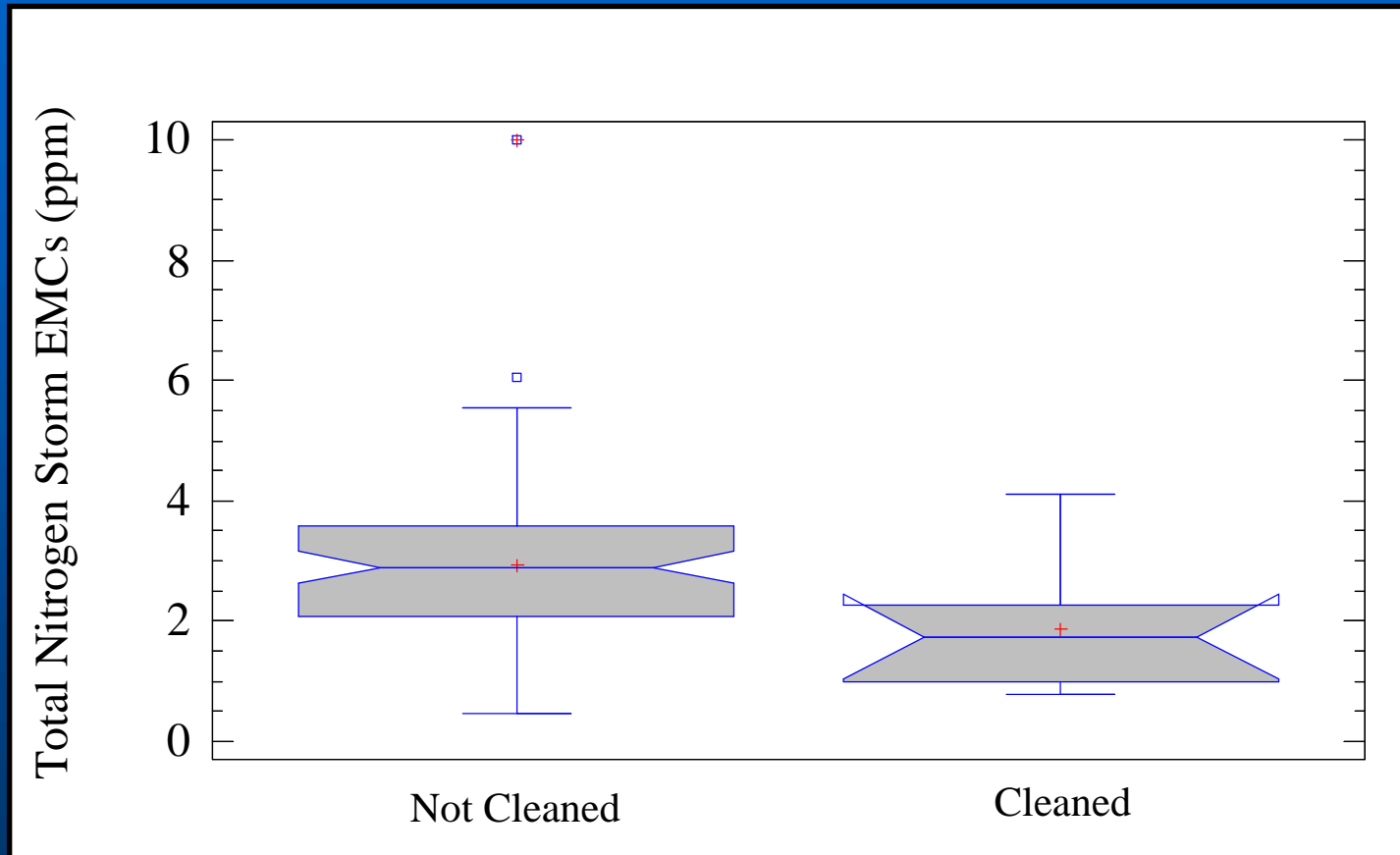
Copper concentration declined



Cleaning Improves Water Quality

Baltimore Street Cleaning Pilot Study

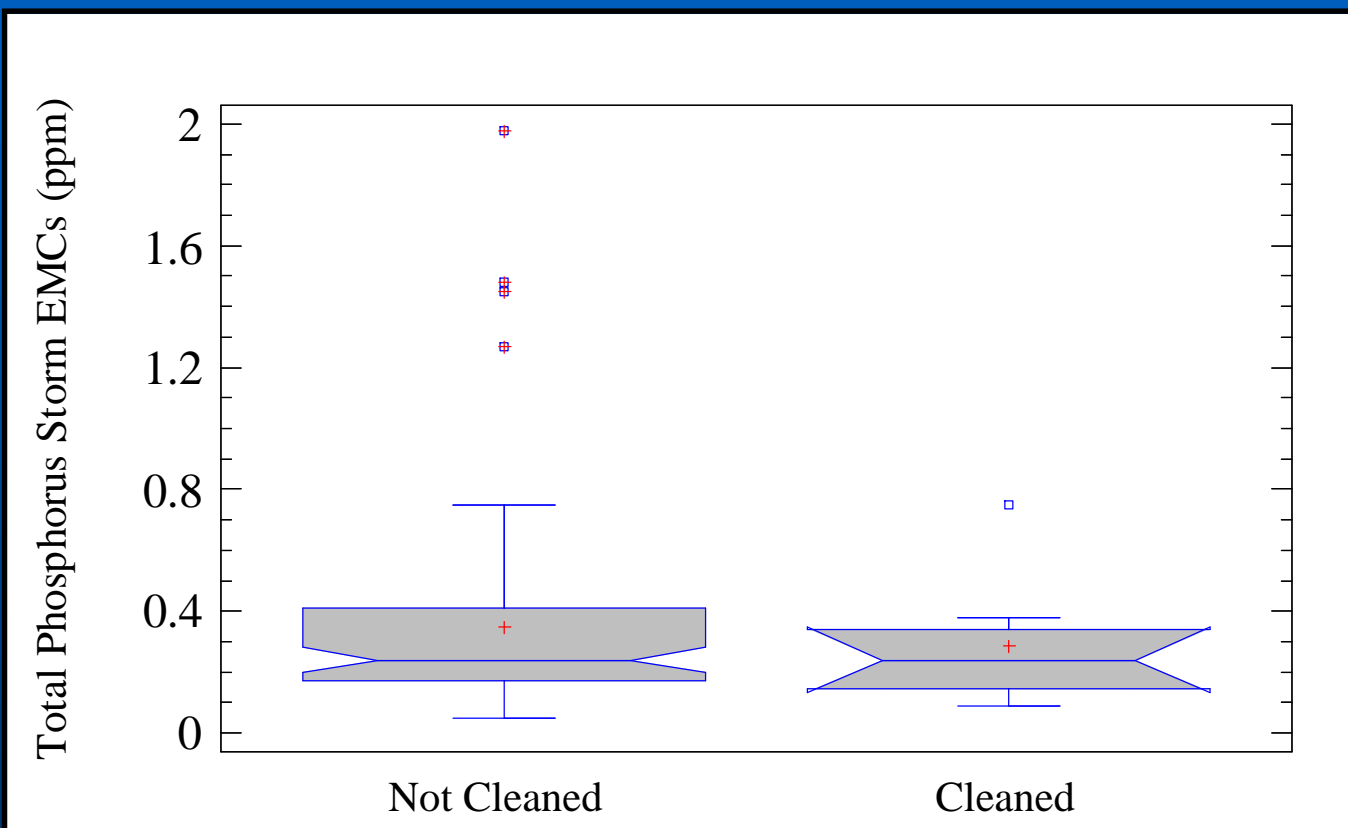
Total nitrogen concentration declined



Cleaning Improves Water Quality

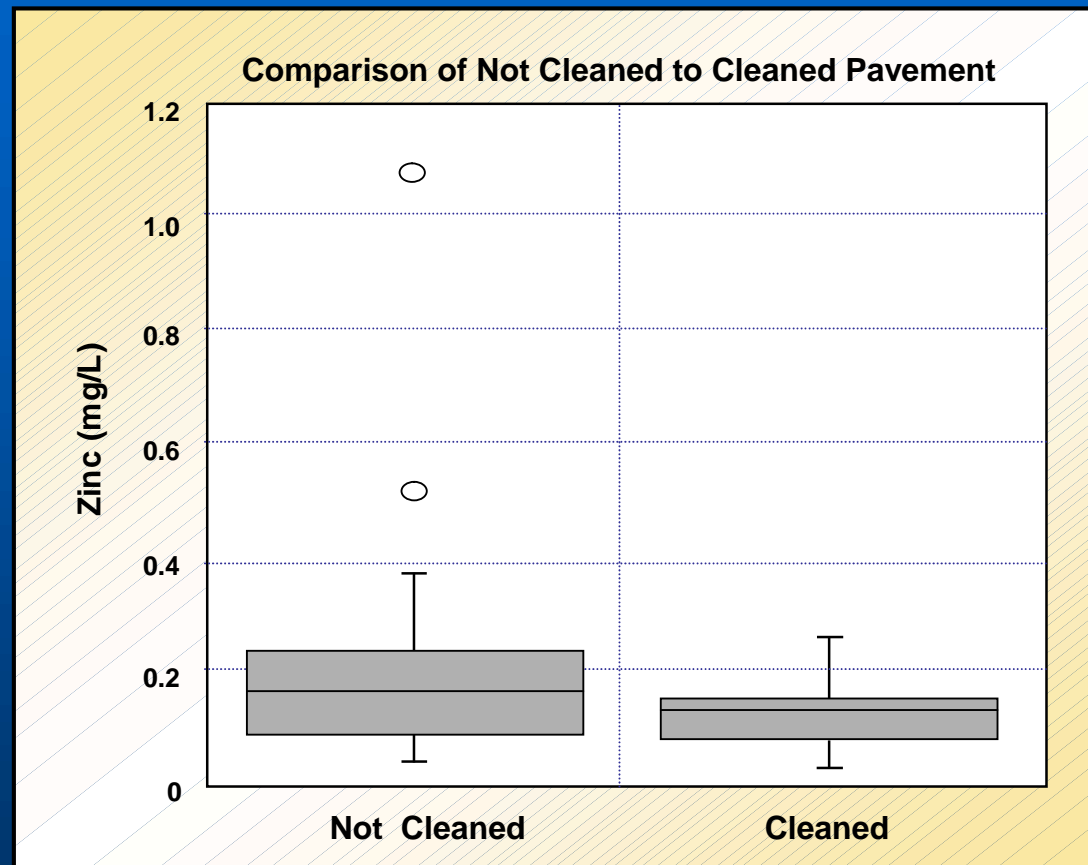
Baltimore Street Cleaning Pilot Study

Reduction of higher concentrations for total phosphorus



Cleaning Improves Water Quality

Cross Israel Highway (CIH) Stormwater Quality Study



Cleaning Improves Water Quality

In the built environment:

- ❖ *One half to two thirds of the rain that falls on impervious surfaces is falling on pavement*
- ❖ *Pavements contribute half, if not more, of the toxic pollutants found in stormwater*
- ❖ *Unlike most other BMPs, sweeping can have an immediate impact*
- ❖ *Pavement cleaning is the most cost-effective BMP based on dollars per pound of pollutant removed from the stormwater*



Working with data from 46 individual stormwater treatment devices located in Snohomish County, Washington, Minton and Ewbank (2002) reported the following costs per pound of TSS removed.



TSS Removal Costs

Treatment Device	Number of Projects	Cost Range \$/lb TSS Removed	Average Construction Cost	Median Cost
Wet pond	5	\$2.0 - \$15	\$7.0	\$4.3
Wet vault	7	\$4.3 - \$61	\$22	\$10
O/W separator	6	\$2.8 - \$24	\$10	\$5.9
Sand filter	3	\$4.0 - \$26	\$14	\$13
Swale (New)	5	\$0.5 - \$4.4	\$1.5	\$0.9
StormFilter™	1	\$7.8	\$7.8	\$7.8
Vortex separator	1	\$4.4	\$4.4	\$4.4

Excludes costs of engineering, permitting and land



TSS Removal Costs

Minton and Ewbank (2002) also estimated the cost effectiveness of retrofitting roadside ditches to function as treatment swales to be \$5.5 to \$28 per pound of TSS removed.



TSS Removal Costs

Data from a study of structural stormwater treatment devices by CALTRANS indicates that TSS removal costs ranged from \$10 to \$60 per pound, not including land costs.



TSS Removal Costs

Sutherland, Myllyoja and Jelen (2002) studied street cleaning practices in Livonia, Michigan and computed TSS removal costs for regenerative air sweeping of residential streets that ranged from \$1.80 to \$3.20 per pound of TSS removed depending on cleaning frequency, which ranged from once every two months to twice each month.

Similar TSS removal costs were computed during a study of street cleaning practices in Jackson, Michigan.



TSS Removal Costs

- ❖ **Type of sweeper used**
(pick-up performance is most important)
- ❖ **Forward speed of the sweeper**
(4-to-6 miles per hour is recommended)
- ❖ **Parked car interference**
(requires a political will, ordinances and enforcement; however, fines can be used to support the cleaning program)
- ❖ **Frequency of street cleaning**
(usually varies by land use or street categories)



Street Cleaning Programs Can Control

- ❖ **But how does a street cleaning program determine the most cost-effective or best program for reducing stormwater pollutant washoff?**
- ❖ **For accurate estimates, computer modeling must be used.**
- ❖ **Pacific Water Resources has available a model they developed called SIMPTM.**

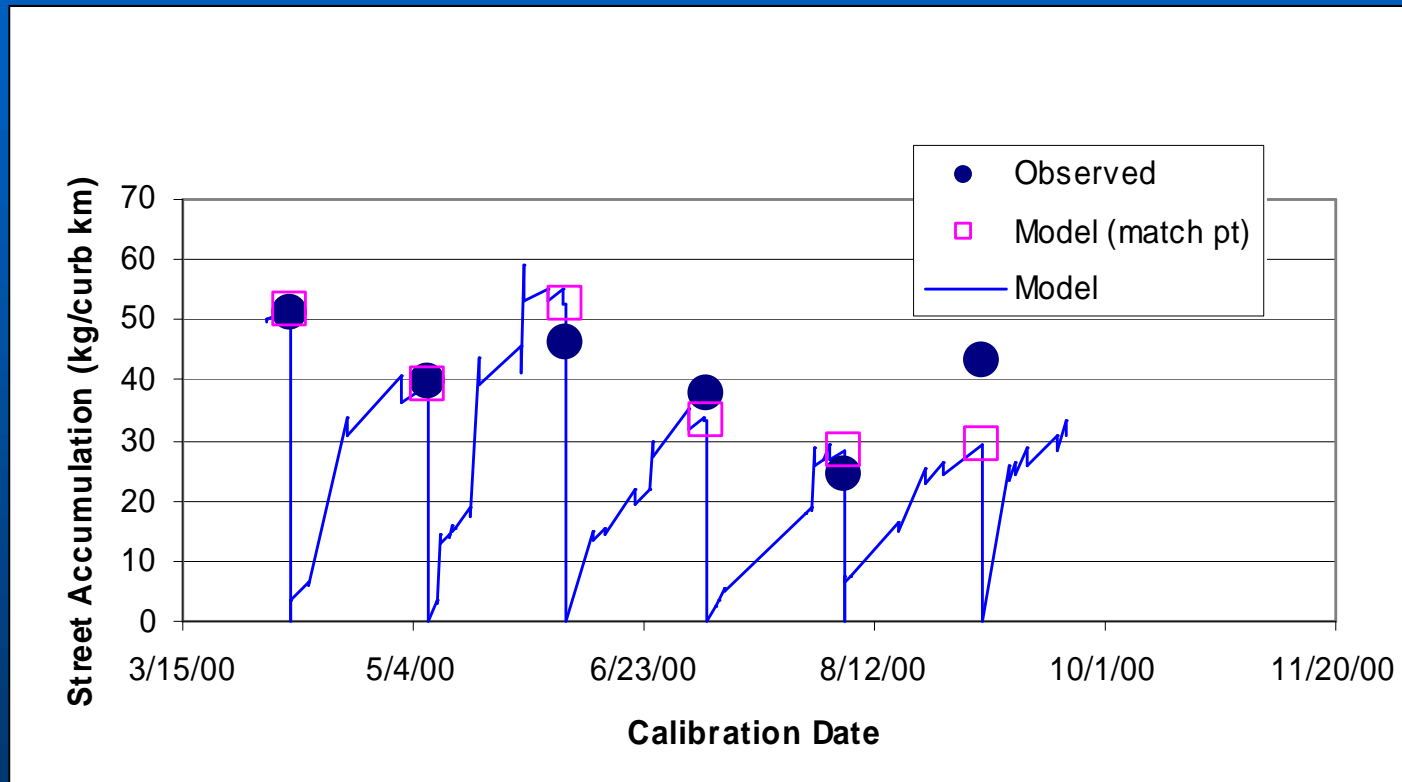


- ❖ **SIMPTM estimates stormwater pollutant loadings for both NPDES reporting and TMDL planning.**
- ❖ **Can establish the relationship between frequency of cleaning by land use or street category and the amount of pollutant that would have been removed from the urban runoff washoff over a historic rainfall record of unlimited length.**



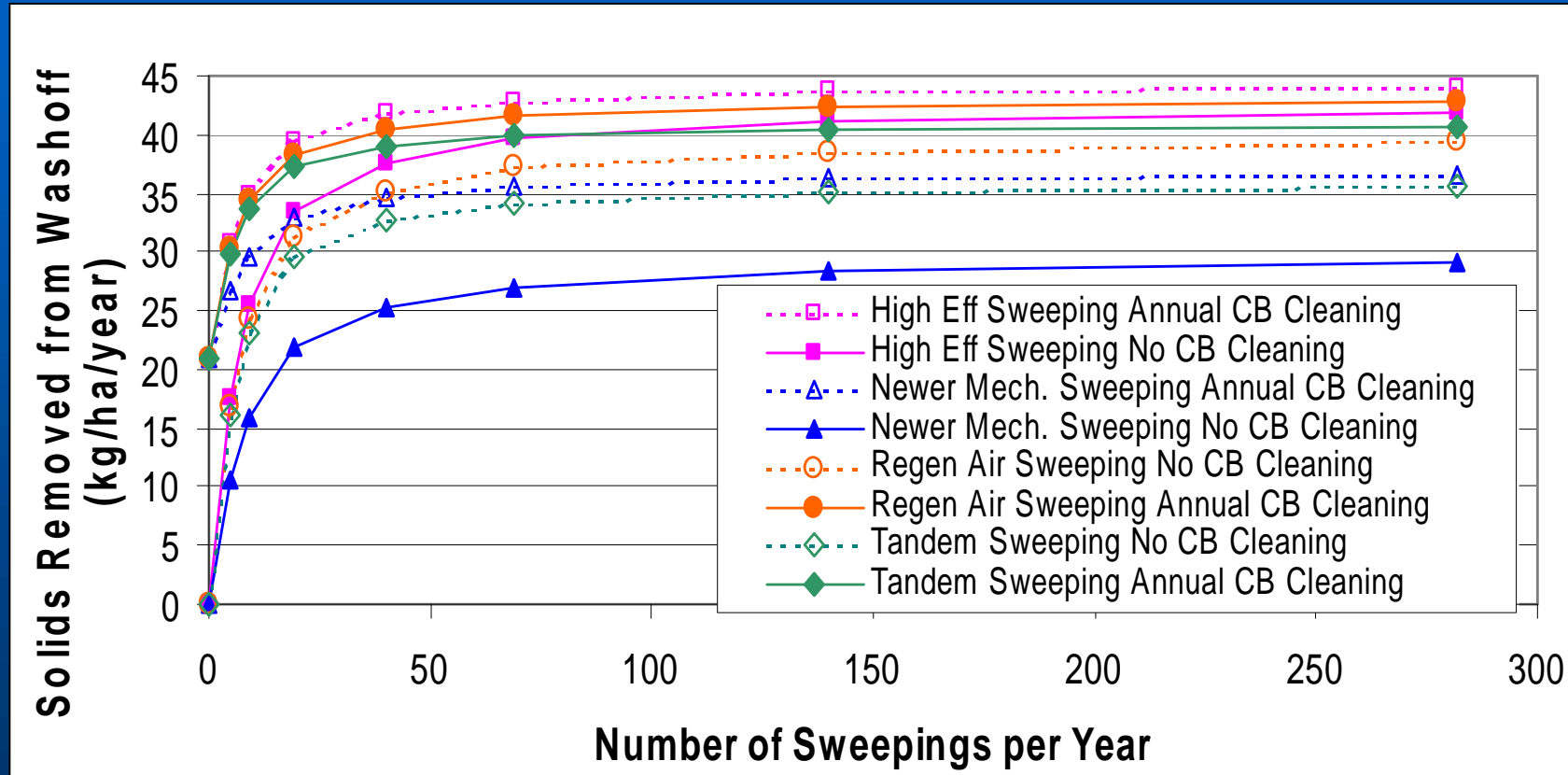
Benefits of SIMPTM Modeling

SIMPTM Calibration of Street Dirt Accumulation Durand Single-Family Residential Site



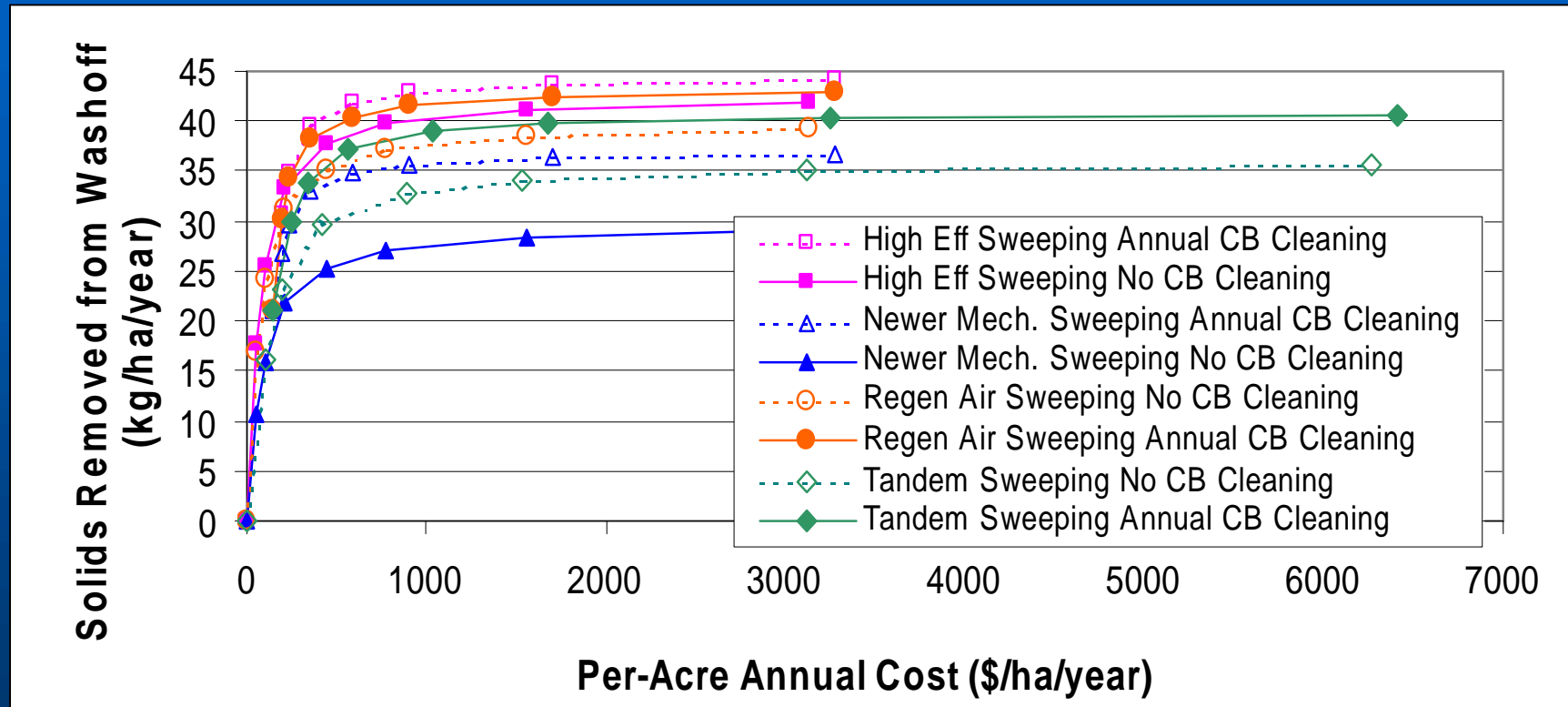
BMP Production Functions

Single-Family Residential



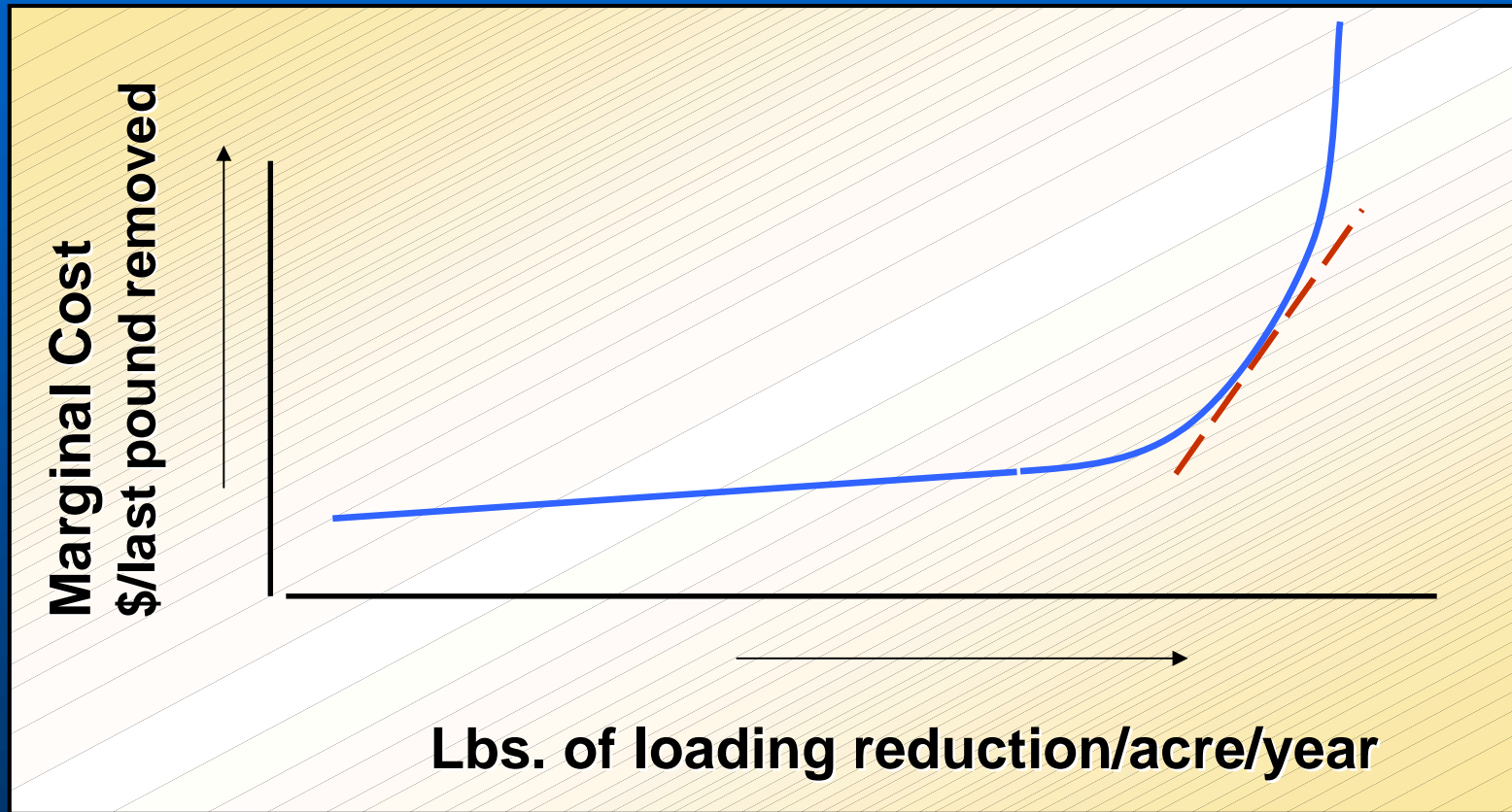
BMP Total Cost Curves

Single-Family Residential



As related to ...

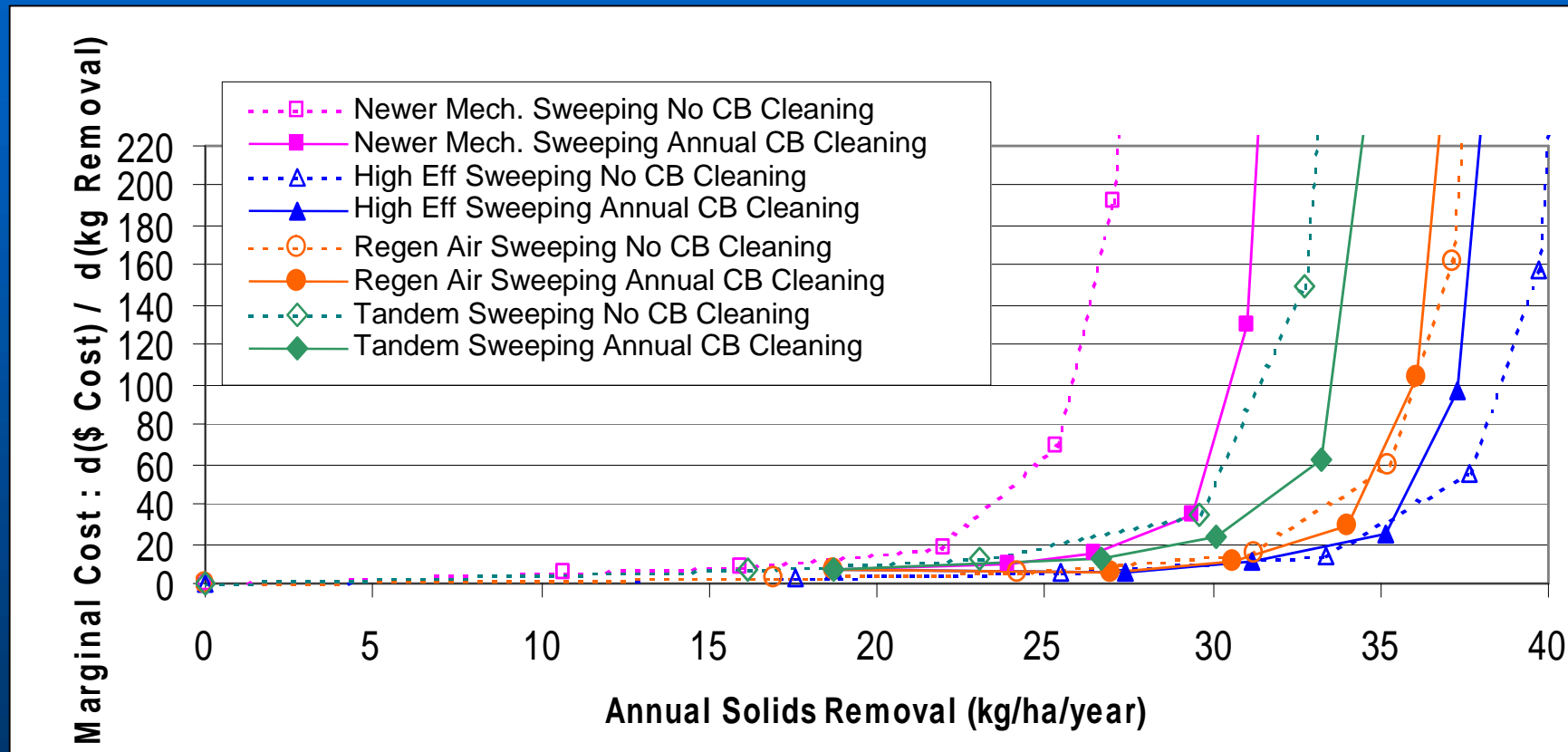
\$ and Maximum Extent Practicable



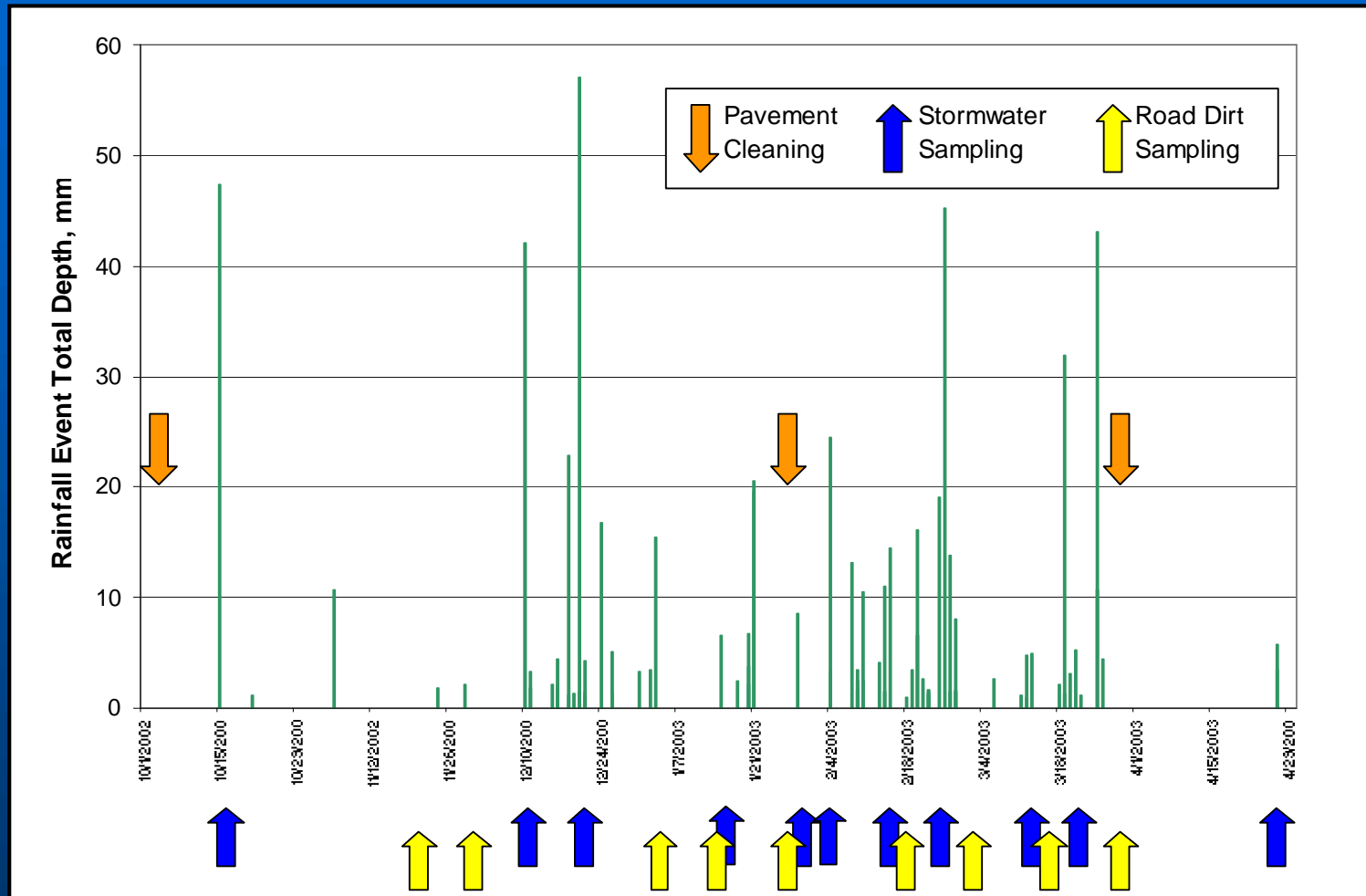
SIMPTM Modeling Results

BMP Marginal Cost Curves

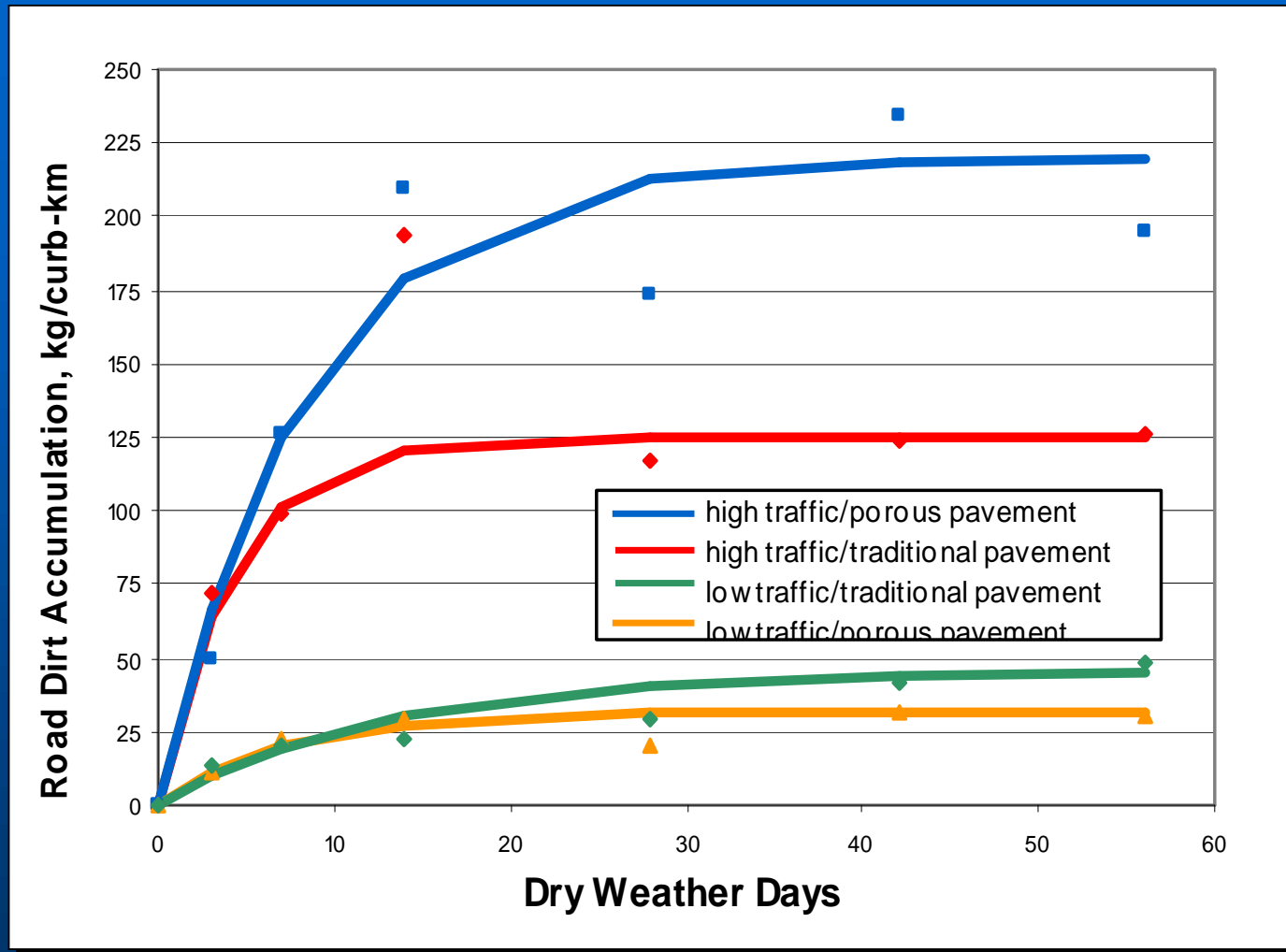
Single-Family Residential



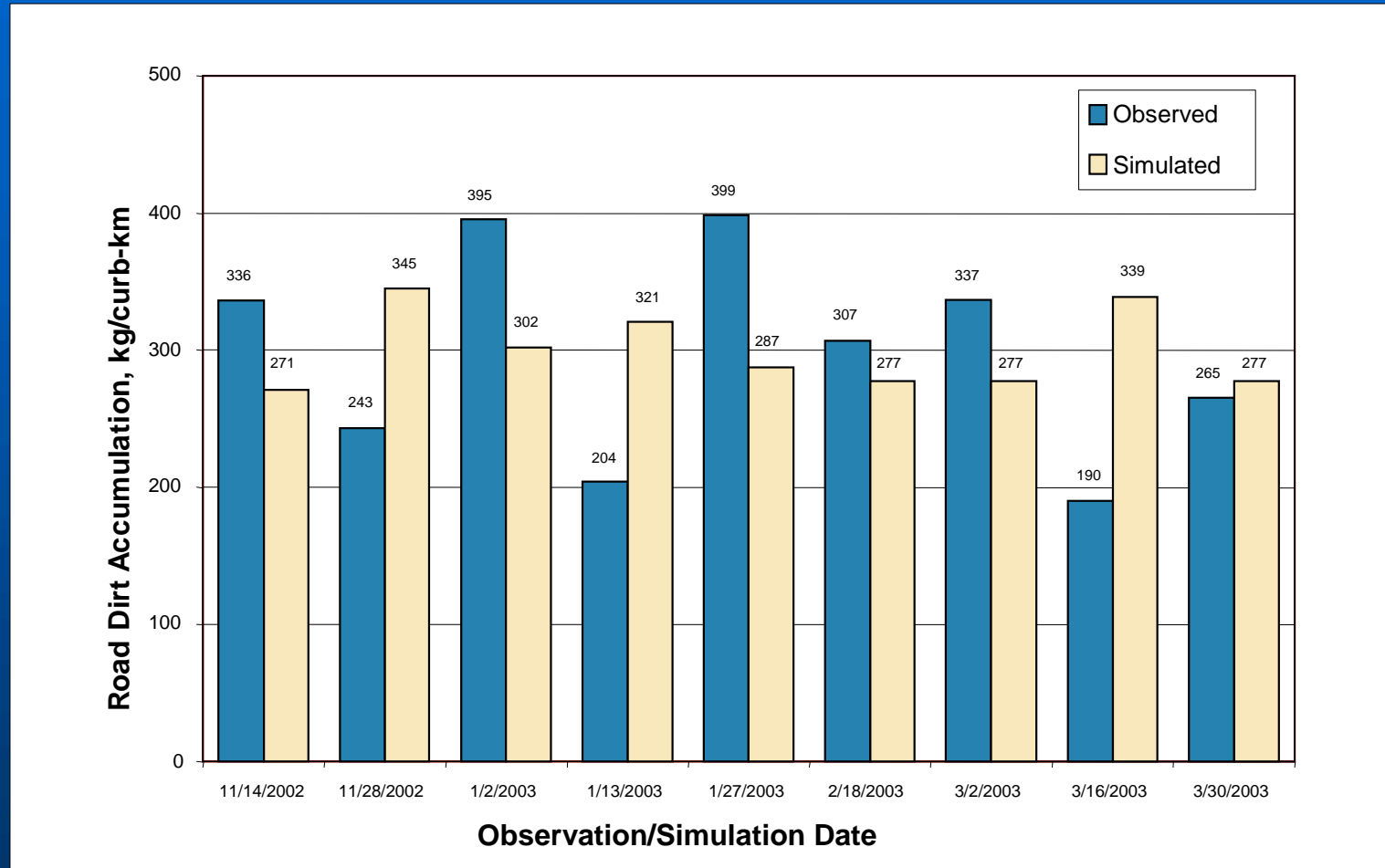
Timing of Rainfall Events, Samplings and Cleanings



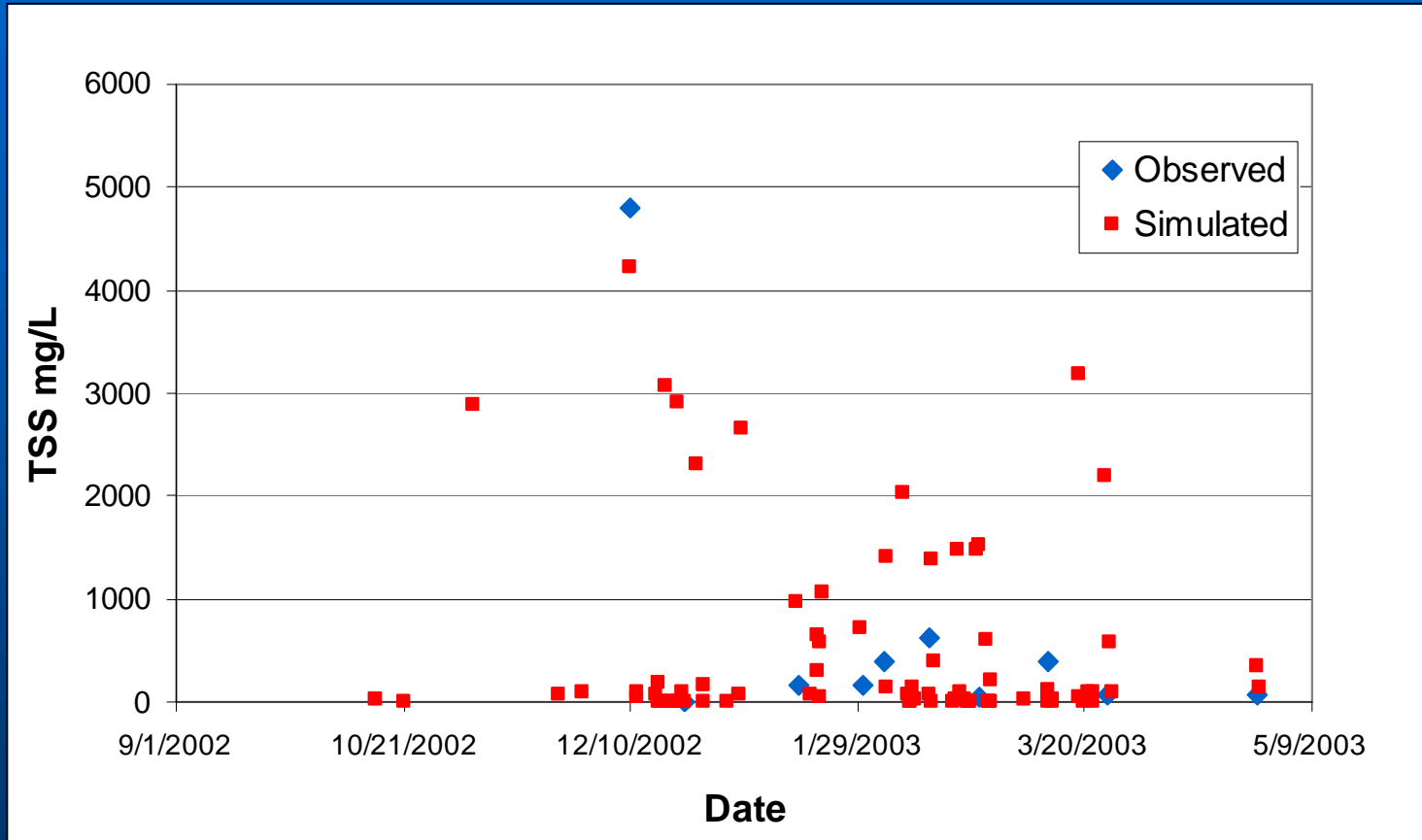
Dry Weather Road Dirt Accumulation



Simulated versus Observed Road Dirt Accumulations on Porous Pavements

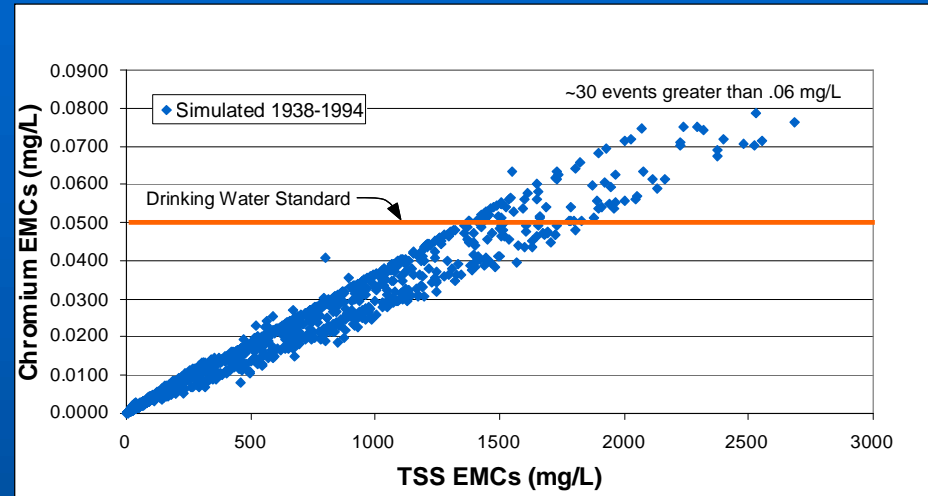


Simulated versus Observed TSS Concentrations from Traditional CIH Pavements

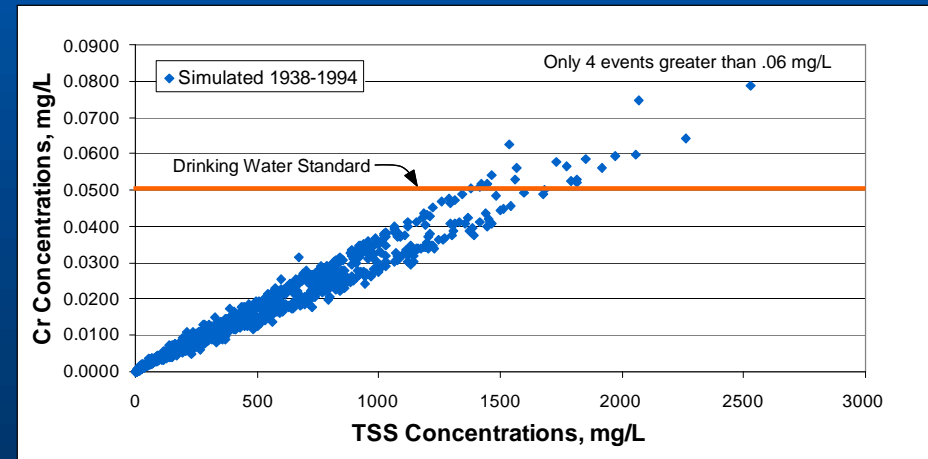


Simulated TSS and Chromium EMCs

Not Cleaned



Cleaned

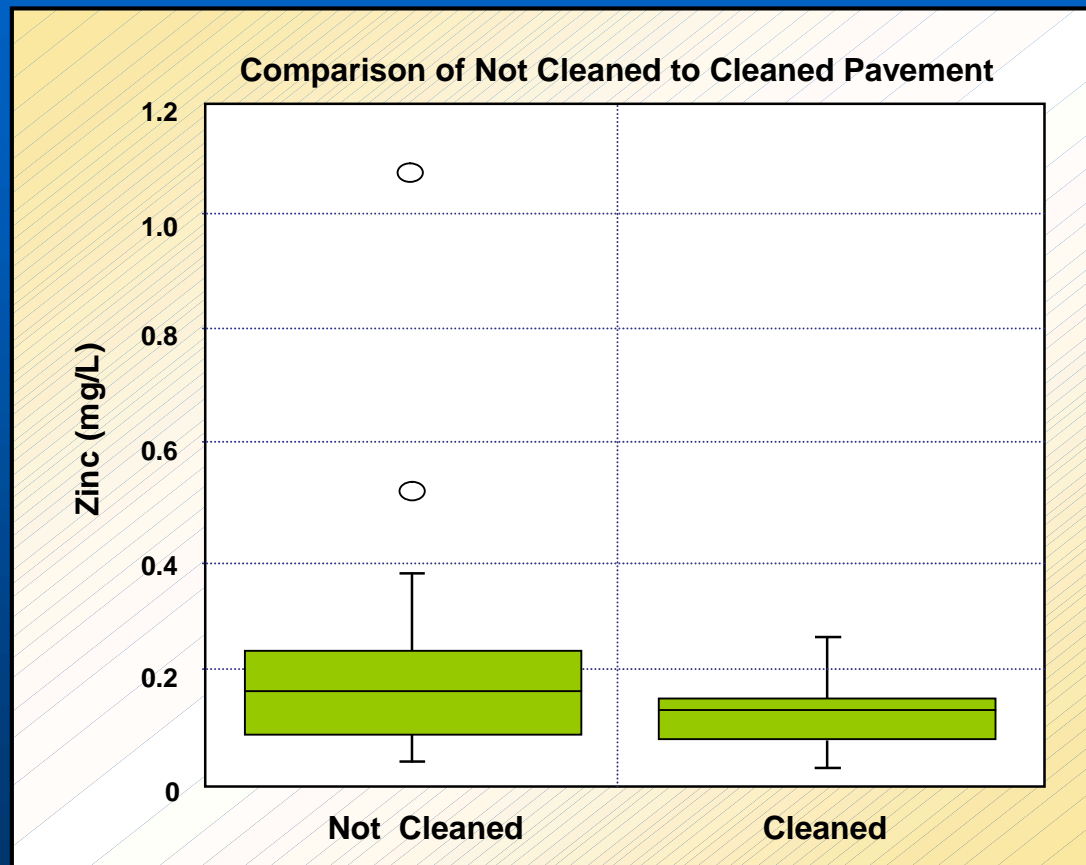


**Cleaning has greater effect on reducing
higher concentrations of pollutants
(exactly what was observed in the collected data)**

Statistic	Simulated Chromium Concentrations (mg/L) from Traditional Pavement with High Traffic Volume		
	Not Cleaned	Six Cleanings/Year with Regenerative Air	Percent Reduction
Median	.026	.023	12
Mean (\bar{x})	.031	.027	13
80 Percentile	.042	.034	19
90 Percentile	.054	.043	20
95 Percentile	.064	.050	22



Cross Israel Highway Stormwater Quality Study



Cleaning Improves Water Quality

Stormwater Treatment Devices are best suited for:

- ❖ *New development*
- ❖ *Certain retrofits where:*
 - ◆ Street sweeping is not practical
 - ◆ Toxic pollutant loadings are elevated
 - ◆ Higher level of pollutant removal is needed



Conclusion

- ❖ **No one has considered or evaluated the integration of sweeping with structural treatment, whether new or redevelopment.**
- ❖ **With effective sweeping, it is possible to use much smaller structural treatment systems or possibly eliminate the use of structural controls in some situations.**
- ❖ **The monies saved could be used (fee-in-lieu) to support the sweeper program.**



Conclusion

When dealing with the built environment:

Sweep Before You Treat

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Conclusion

For More Information

For more information on PWR and the water quality benefits of pavement cleaning practices follow the links at:

www.pacificwr.com

For more information on SIMPTM and its previous use refer to PWR's publications link at:

www.pacificwr.com/publicationsframeset.html

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