A Demonstration of SIMPTM's Ability to Predict Fine Sediment Discharges from Existing Urbanized Landscapes Tributary to Lake Tahoe

Presented at:

2012 Tahoe Science Conference
May 23, 2012
Sierra Nevada College
Incline Village, NV

Presented by:

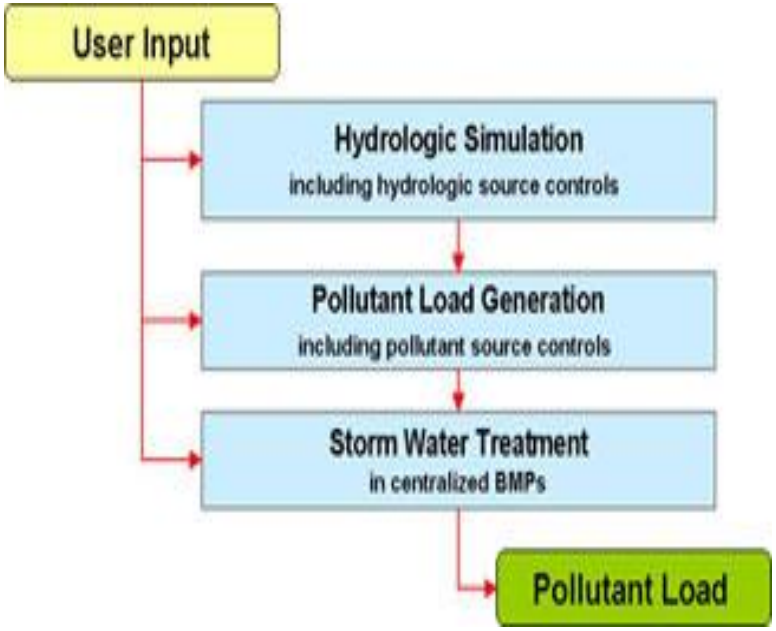
Roger C. Sutherland, PE
AMEC Environmental and Infrastructure, Inc
7376 SW Durham Road
Portland, OR 97224
503-639-3400
roger.sutherland@amec.com

Pollutant Load Reduction Model (PLRM)

The primary purpose of the PLRM is **to assist project designers to select and justify a recommended storm water project alternative based on a quantitative comparison of pollutant loads and runoff volumes for project alternatives.** Pollutant loads in stormwater are highly variable, and notoriously difficult to predict with absolute accuracy at particular locations and times. The focus of the PLRM is to make use of best available Lake Tahoe storm water quality information to compare relative performance of alternatives over the long term.

Clearly, the PLRM should be as accurate as possible in the simulation of the various processes that result in the contamination of stormwater and the BMP related interactions that can result in the reduction of that contamination.

Pollutant Load Reduction Model (PLRM)



The three elements used for simulating pollutant loads in the PLRM are:

1) hydrology and hydrologic source controls (HSC),

2) pollutant load generation and pollutant source controls (PSC), and

3) storm water treatment (SWT).

User input is required for each element, and the results derived from each element are used in subsequent elements. Computed pollutant loads represent the combined effectiveness of the three major elements.

This presentation will focus on the pollutant load generation and pollutant source control component since that is the component that many users believe needs the most improvement

Pollutant Load Reduction Model (PLRM)

Pollutant generation in the PLRM is based on the product of average annual runoff and land use based characteristic runoff concentration (CRC).

Two separate methods are used to represent the implementation of Pollutant Generation and Pollutant Source Control (PSCs) that can reduce the CRC's:

- Road Methodology –a standardized approach for public right of ways that integrates physiographic characteristics, pollutant source control efforts, and pollutant recovery to predict the likely road condition and associated CRCs

- Parcel Methodology - a simple method to estimate improvements in CRCs from private property BMP implementation consistent with current regulations

PLRM Uses a Simple Method for Load Estimates

Many models like the PLRM simplistically generate estimates of TSS or other pollutant loadings by multiplying an computed runoff volume by an assumed TSS or pollutant concentration (i.e. CRC in the PLRM). This is referred to as the Simple Method (SM). The representative concentration is either an average or a medium concentration observed for a given land use and remains invariable from storm to storm which is the case in the PLRM. More advanced SM approaches assume a distribution of concentrations in an attempt to add the appearance of variability and uncertainty.

Problems with the Simple Method approach are:

- Cannot estimate actual storm-by-storm pollutant loadings, concentrations and sediment particle size distributions (PSD's) transported by the runoff.
- Cannot accurately estimate pollutant reduction benefits of various BMPs especially non structural practices such as street and catchbasin cleaning.
- Loads will always mimic any errors or bias in the stormwater data itself which have been shown to be quite extensive on many occasions.

PLRM Cannot Accurately Compute Fine Sediment Concentrations or Particle Counts

The PLRM can not directly compute the particle size distribution (PSD) of the sediments being transported by runoff nor the number of particles within certain specified size groups like the fine sediment fraction of less than 16 micron fraction.

Accurate estimates of the TSS mass loadings and the number of fine sediment particles in stormwater entering the Lake is important information needed for TMDL implementation planning and the Lake Clarity Model (LCM).

Accurate estimates of the reduction in the TSS mass loadings and the number of fine particles entering the Lake as a result of implementing specific stormwater management practices is essential to achieving compliance with the TMDLs

AMEC's Simplified Particulate Model (SIMPTM) offers the solution

Simplified Particulate Transport Model (SIMPTM)

SIMPTM explicitly simulates over a extended time frame:

- The physical processes that relate to the accumulation of contaminated sediments on impervious urban surfaces and their association to other pollutants like nutrients, metals and toxics.
- The physical processes that relate to the washoff of accumulated contaminated sediments by shallow upland overland and/or gutter flow (i.e. based on proven sediment transport equations).
- The physical processes that relate to the ability of a specified street cleaning operation to periodically pick up and remove variable amounts of accumulated contaminated sediments within pre determined particle size ranges.

Simplified Particulate Transport Model (SIMPTM)

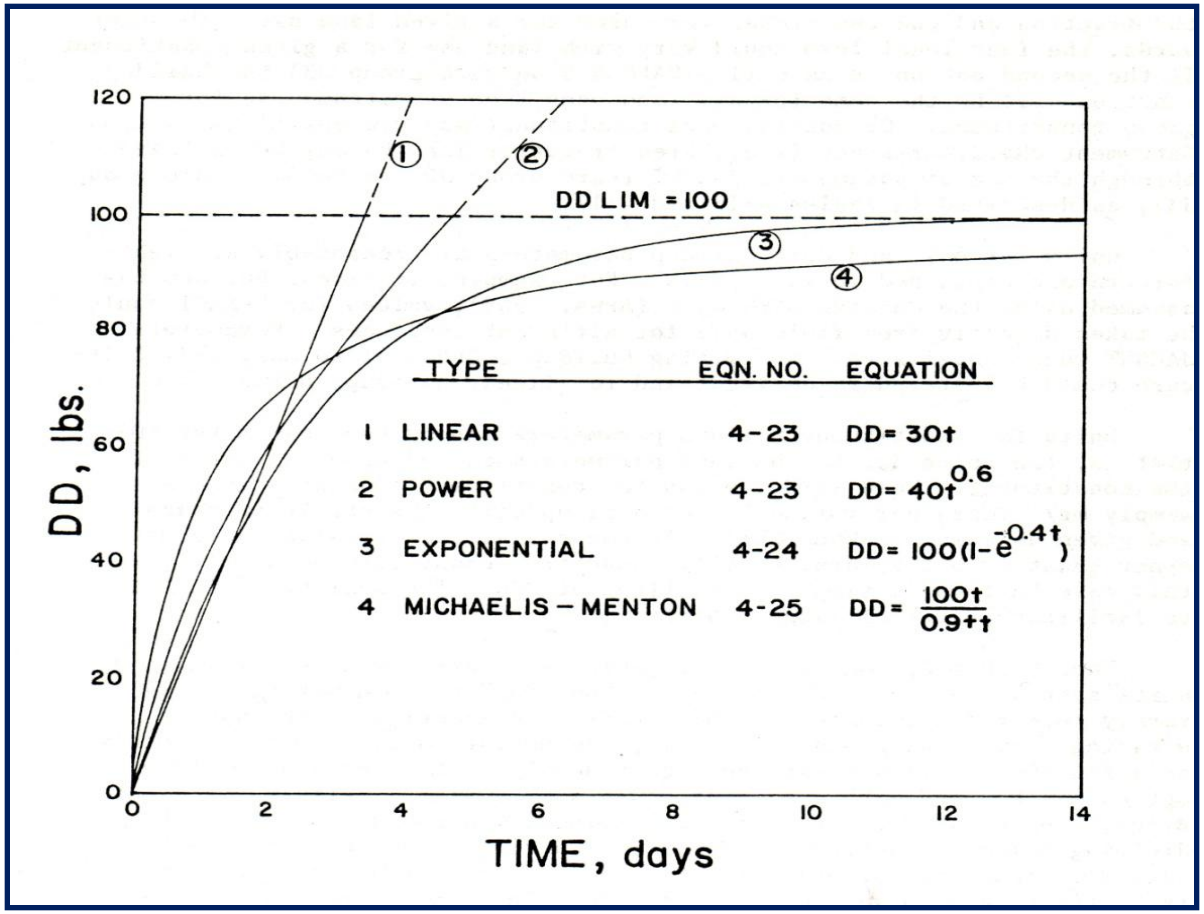
This results in accurate estimates of:

- Event by event sediment loadings, concentrations and particle size distributions (including particles counts) from urban watersheds with user specified physical characteristics such as slope, and effective imperviousness over a historic rainfall record of unlimited length

- Accumulated contaminated sediment loadings (i.e. street dirt) including particle size distribution and associated pollutants using user specified potencies or dry weight concentrations by particle size range.

- Contaminated sediment and associated pollutant pick up or removal from simulated user specified street cleaning or catchbasin cleaning operations.

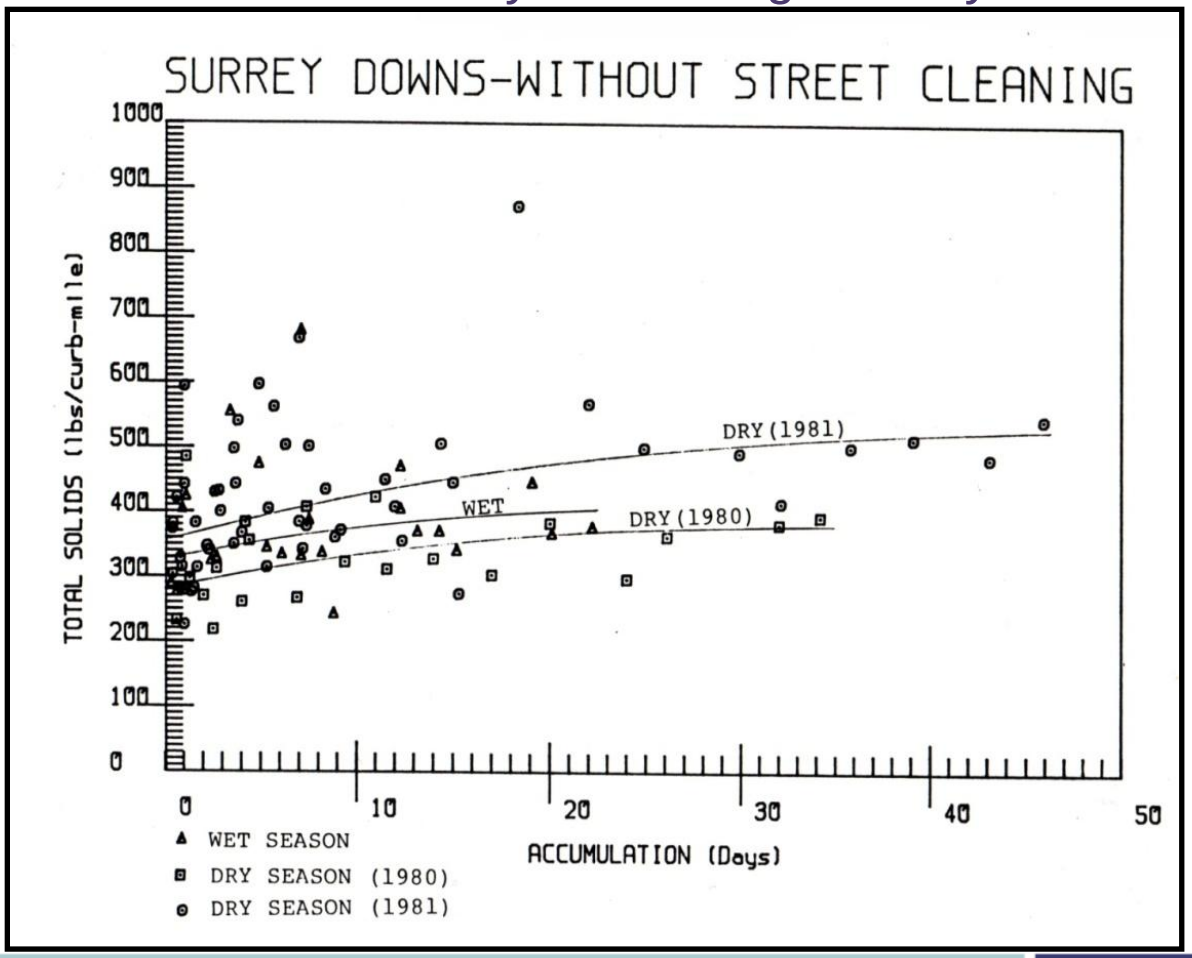
Accumulation Functions Available in EPA's StormWater Management Model (SWMM)



The exponential accumulation equation (i.e. equation 3) predominately used in the water quality component of SWMM is assumed to approach a maximum allowable value thought by many to vary by land use

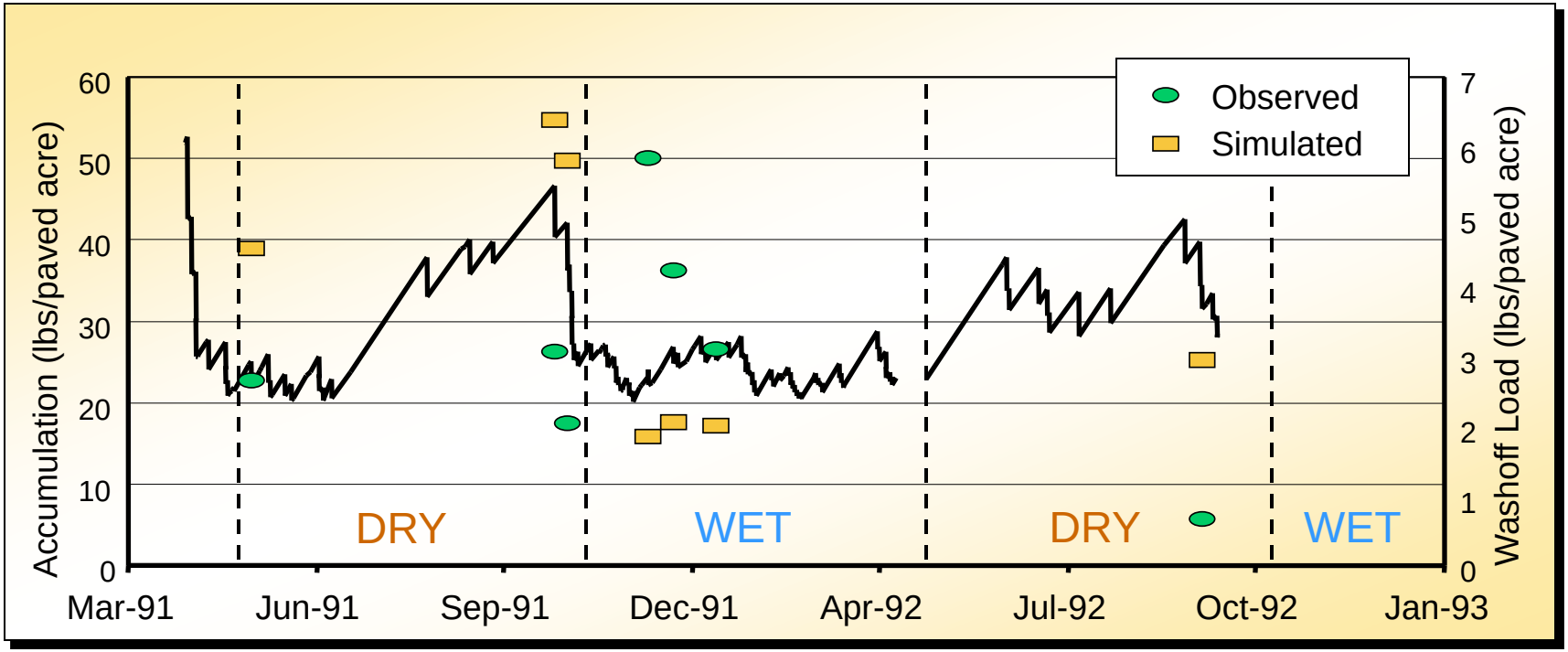
SWMM's Exponential Accumulation Equation Cannot Explain Observed Behaviors

SWMM's exponential accumulation equation cannot explain high accumulations found at relatively short accumulation time periods like those observed in the 1981 Bellevue NURP data for Surrey Down single family residential site



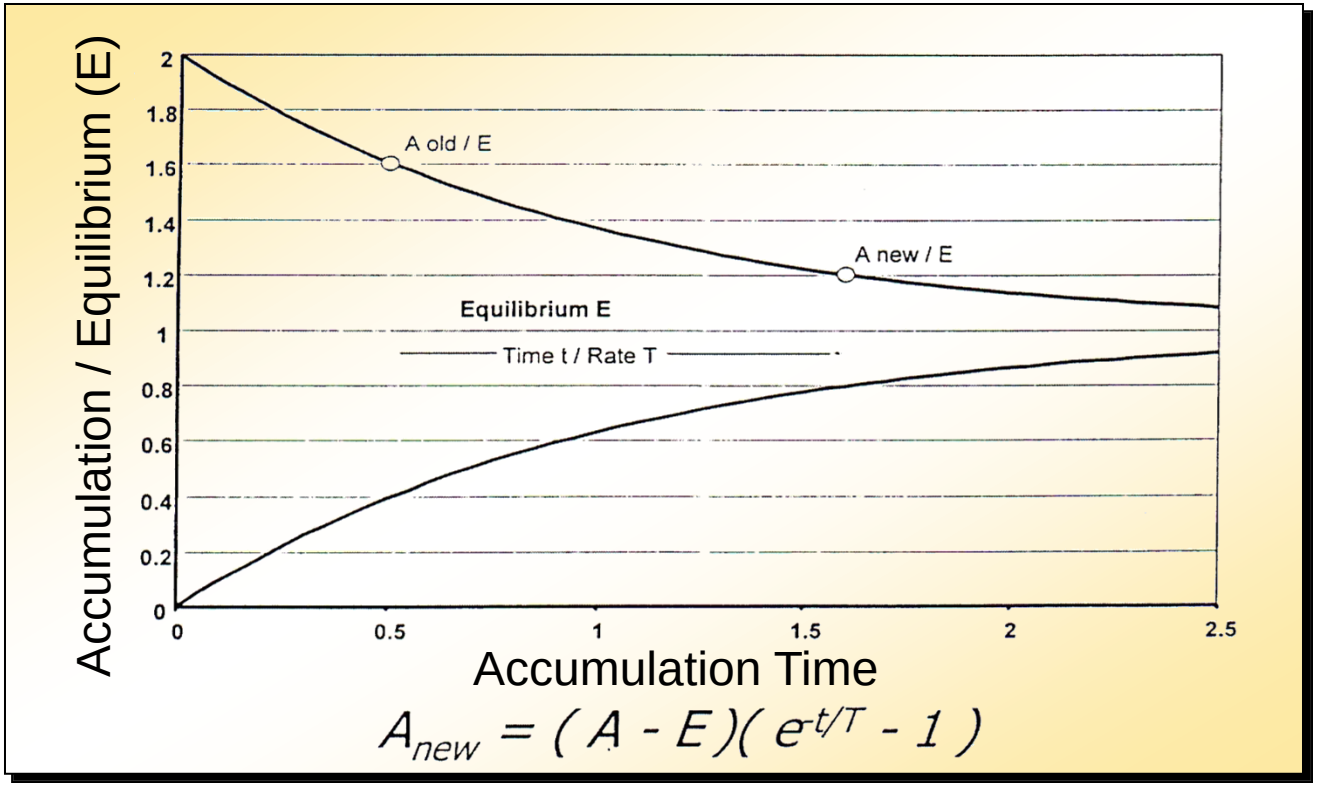
Exponential Accumulation Provides Poor Results

Simulated washoff values using SWMM's exponential accumulation equation are higher during dry seasons and lower during the wet season than observed as shown using the City of Portland Phase I NPDES data for site C1



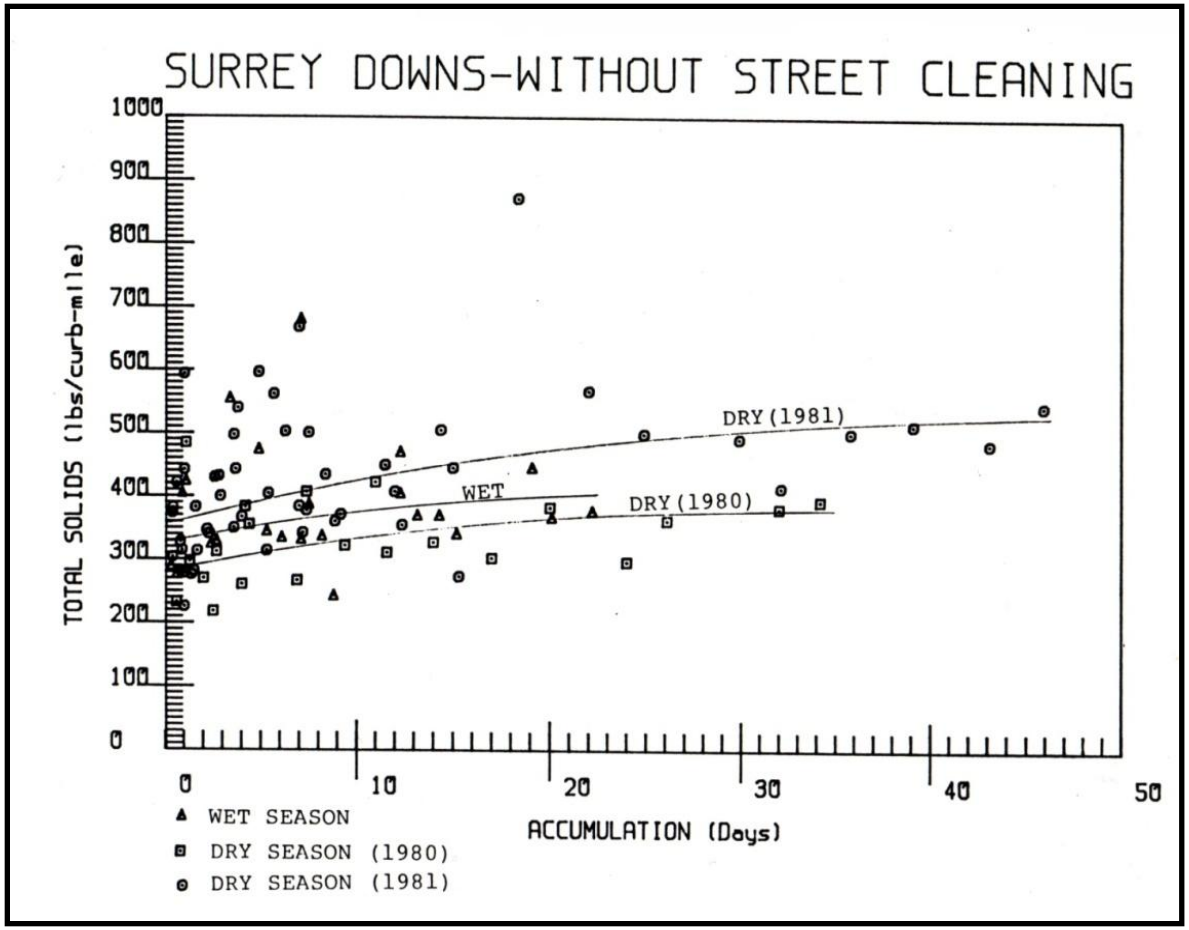
Accumulation Algorithm used by SIMPTM

The previously defined maximum value is actually an equilibrium value. In a process referred to as **wet weather washon** sediments from adjacent impervious areas are deposited by overland flow onto streets and parking lots. This occurs somewhat infrequently and is driven by storm intensity with an intensity of 0.5 inches per hour or more that appears to trigger it.



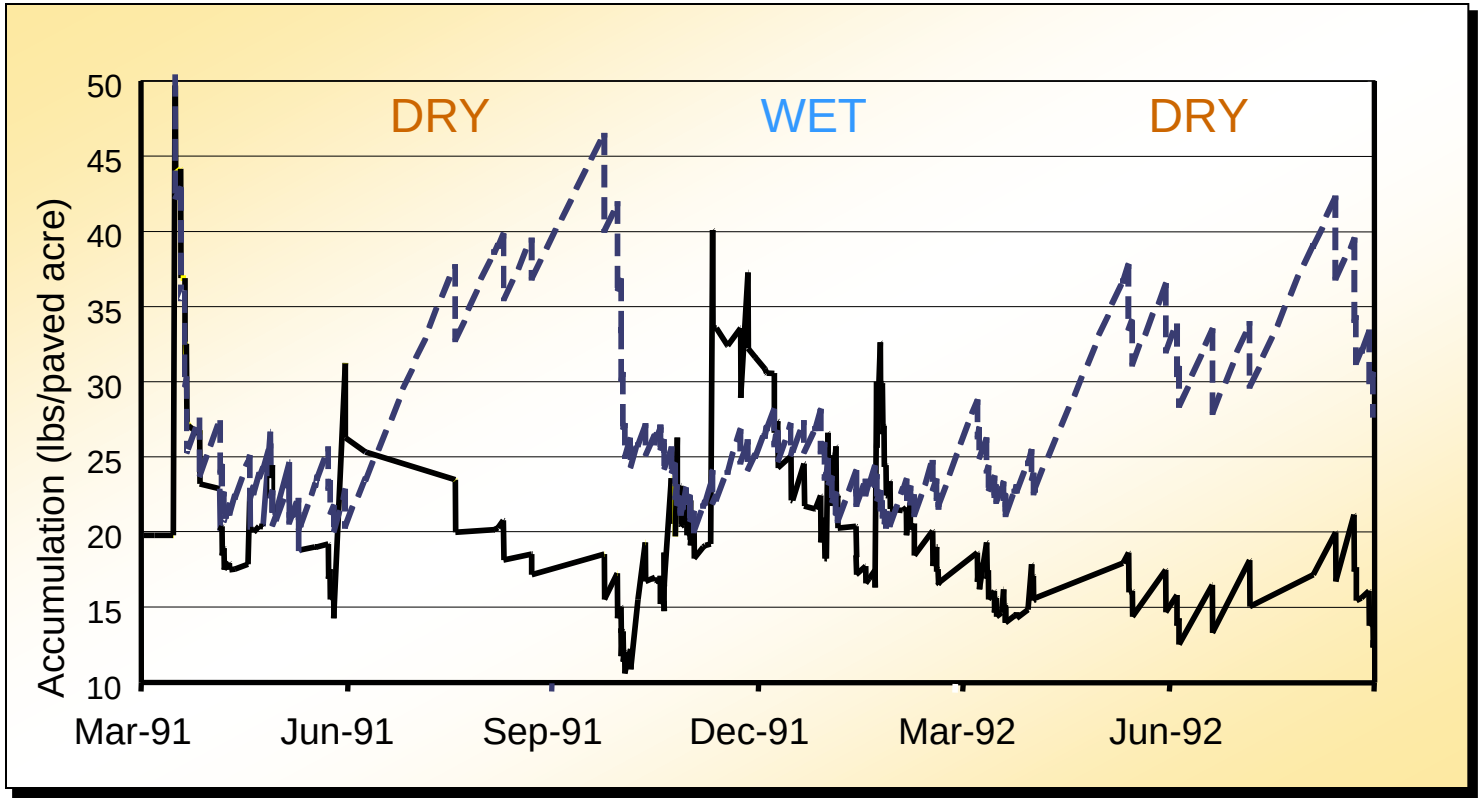
SIMPTM's Unique Accumulation Algorithm

SIMPTM's unique accumulation algorithm can explain high accumulations at relatively short accumulation periods like those observed in 1980-81 Bellevue NURP data for Surrey Downs single-family residential site



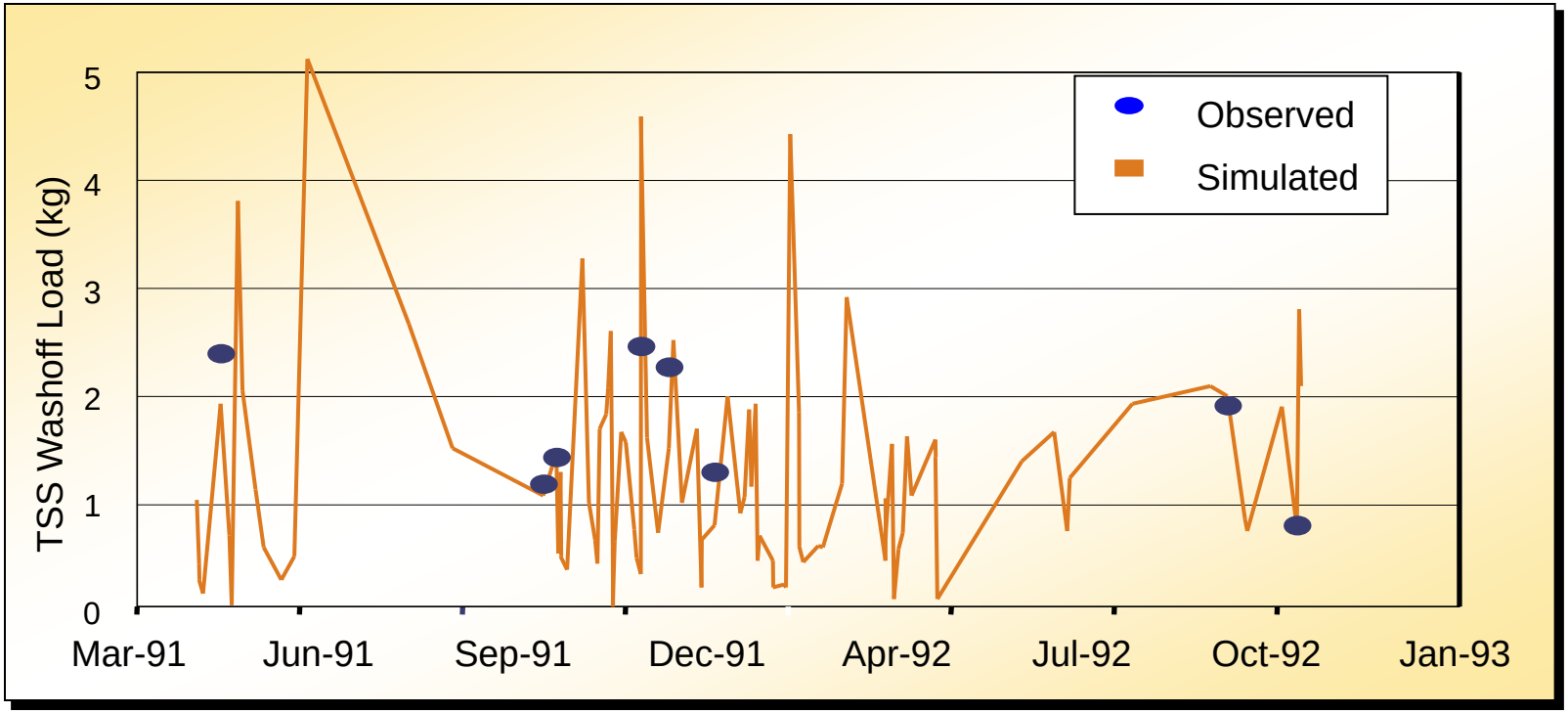
SIMPTMs Algorithms Have Proven They Work

Dashed line is the accumulation results from the exponential accumulation equation shown previously and the solid line is SIMPTMs results with its unique accumulation function. Notice that SIMPTM accumulations are reduced during the dry seasons and increased during the wet season



SIMPTMs Algorithms Have Proven They Work

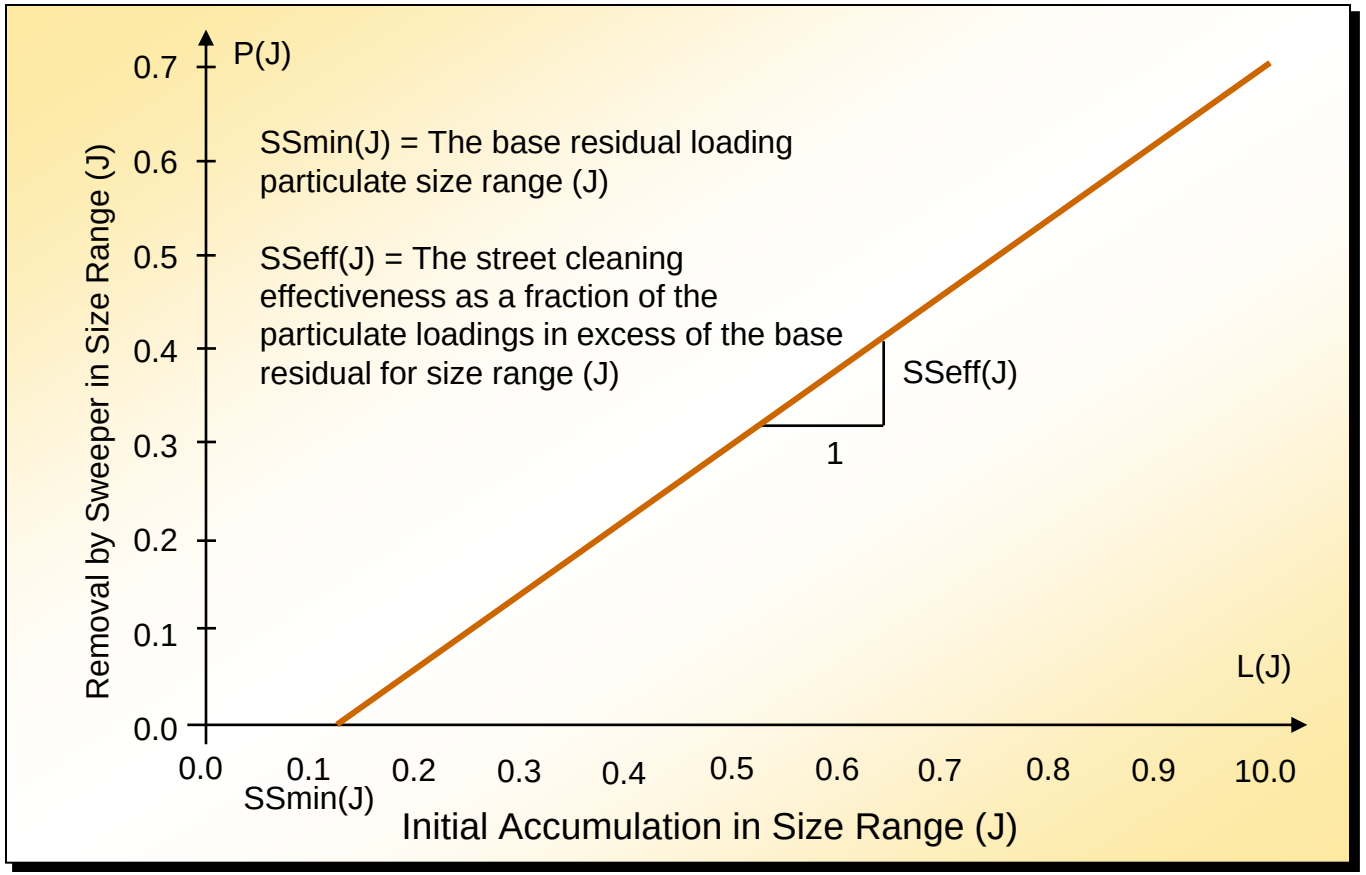
There is a direct relationship between accumulation and washoff and as a result of SIMPTM's unique accumulation and sediment transport based washoff algorithms the model has been proven to work



Site C-1 City of Portland NPDES Phase I data

Street Cleaning Algorithm Used by SIMPTM

Street Cleaner Sediment Pick Up by Particle Size Group (J)



User specified SSeffs and SSmins for each particle size group describes the pick up characteristics of specific street cleaning model. Obtained from sweeper pick up performance testing.

Street Sweeping Function Used by SIMPTM

SIMPTM's Algorithms Have Proven They Work

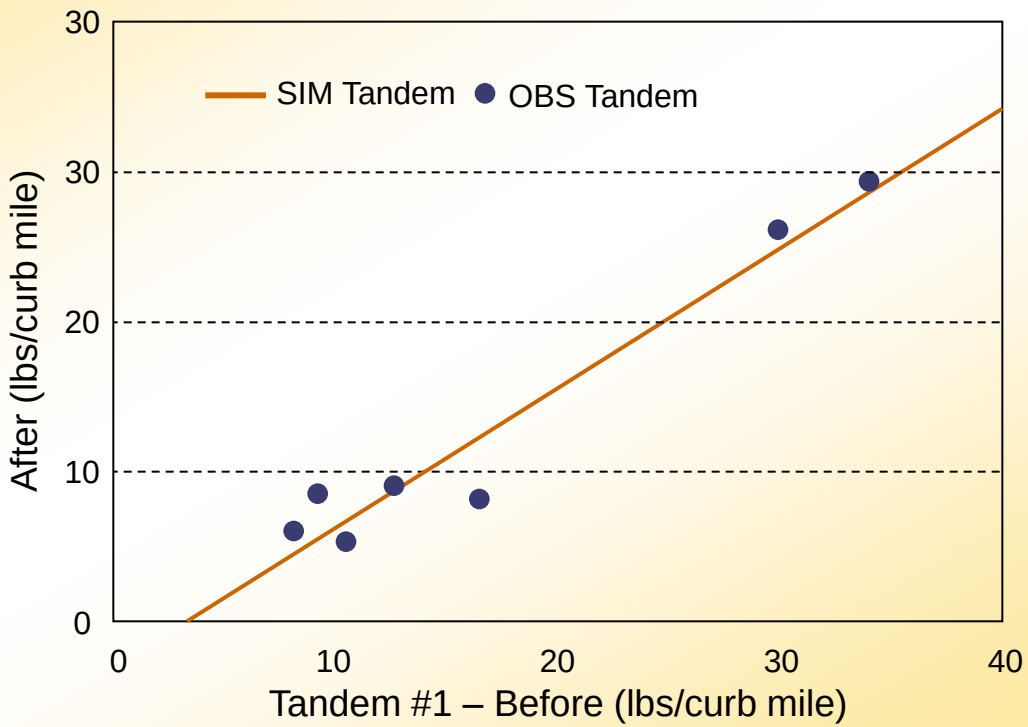
Size Group #1

<63 microns

SSeff = 93%

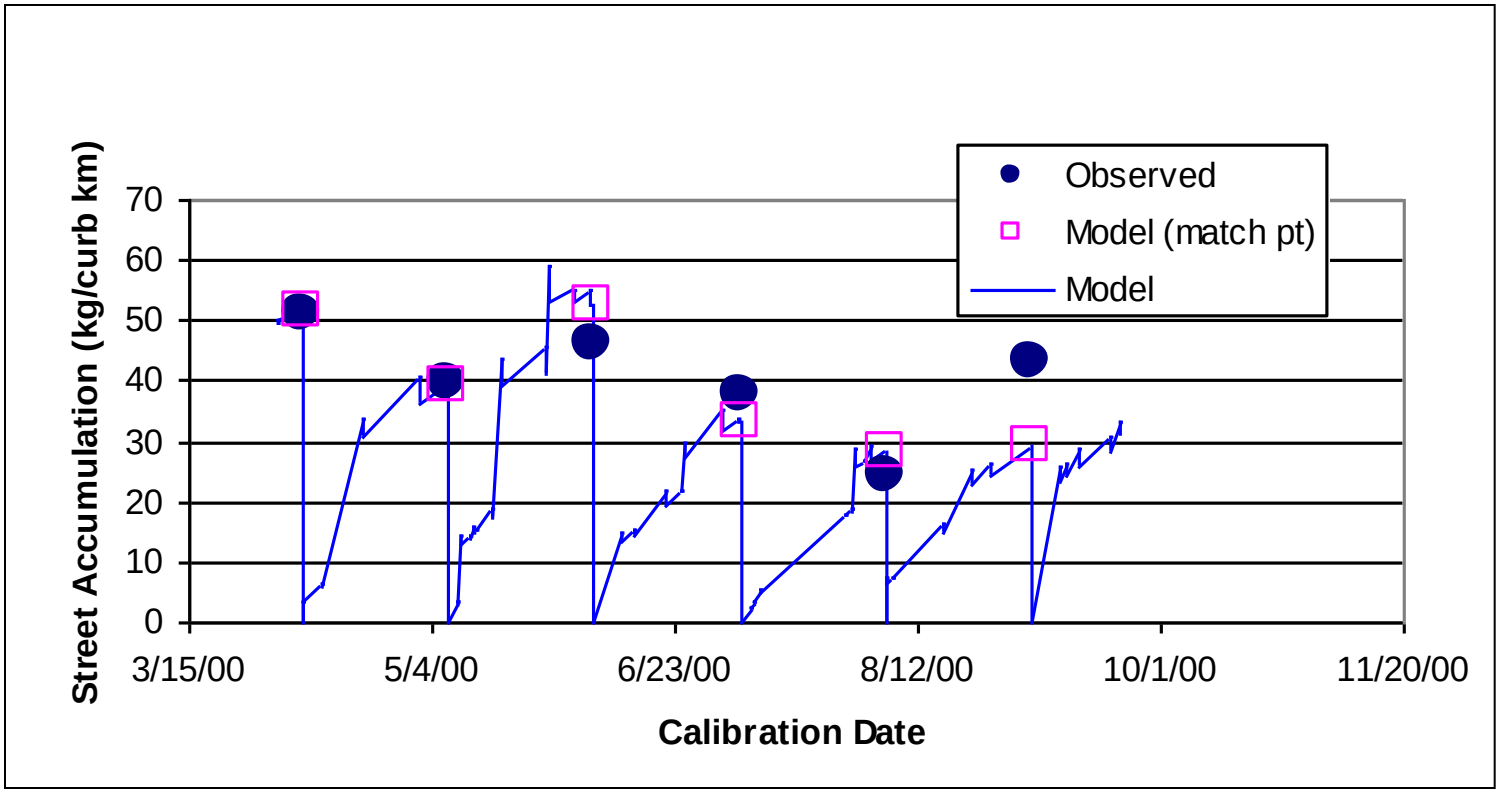
SSmin = 2.0

Lbs/Paved acre



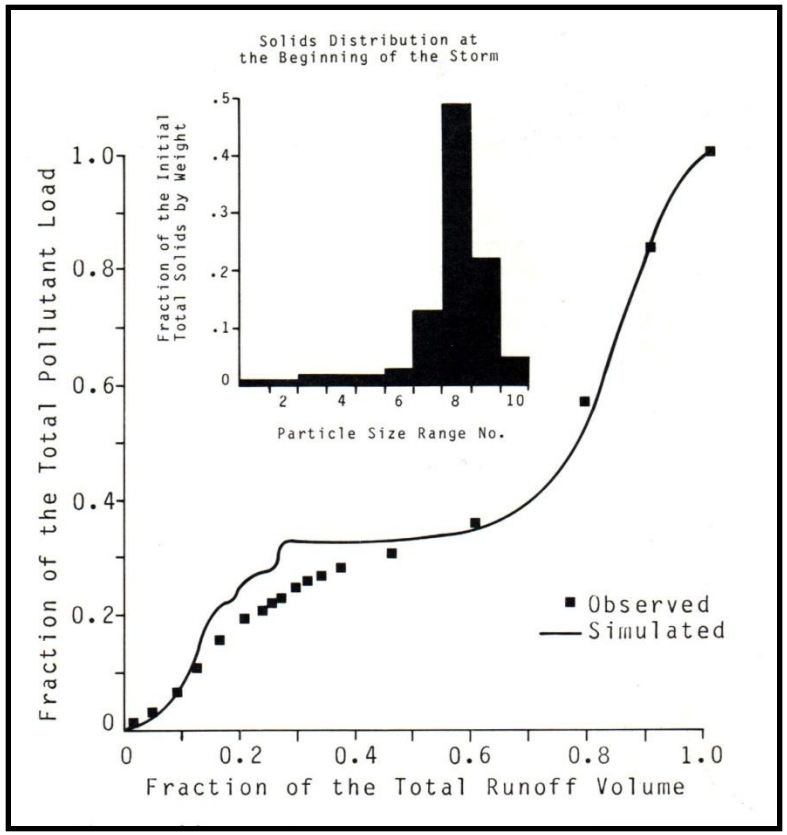
SIMPTM's Algorithms Have Proven They Work

SIMPTM Calibration

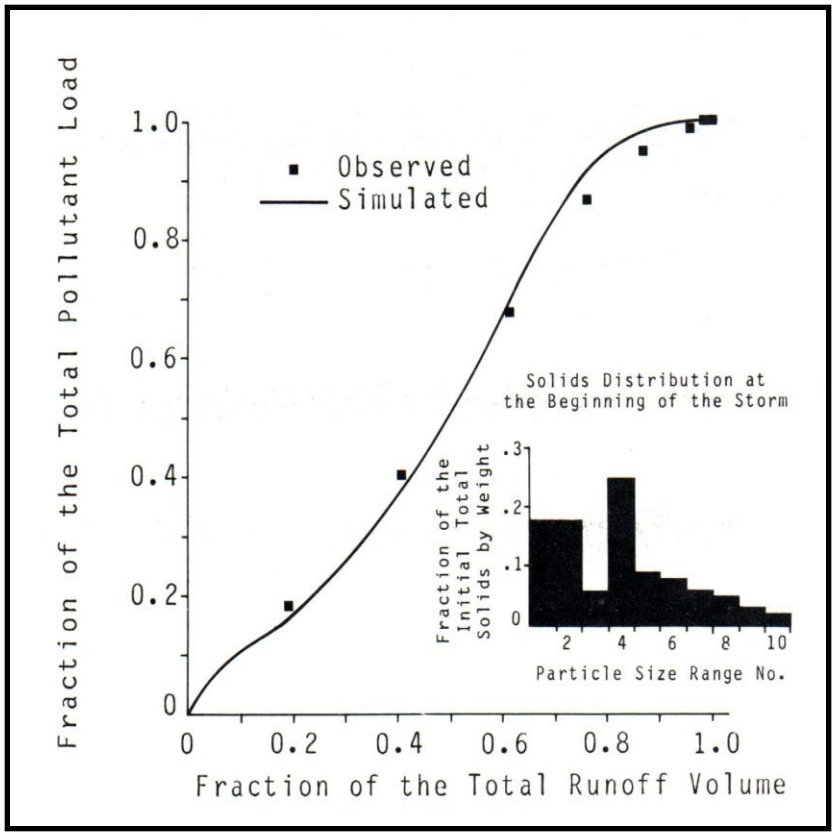


Durand Single Family Residential Site
City of Jackson Michigan Street Sweeping Study

SIMPTM's Algorithms Have Proven They Work



Calibration Results for Ross Ade Storm of Nov 1, 1972



Calibration Results for Livonia Drain Storm of 29 June 1977

from Ellis & Sutherland, 1979

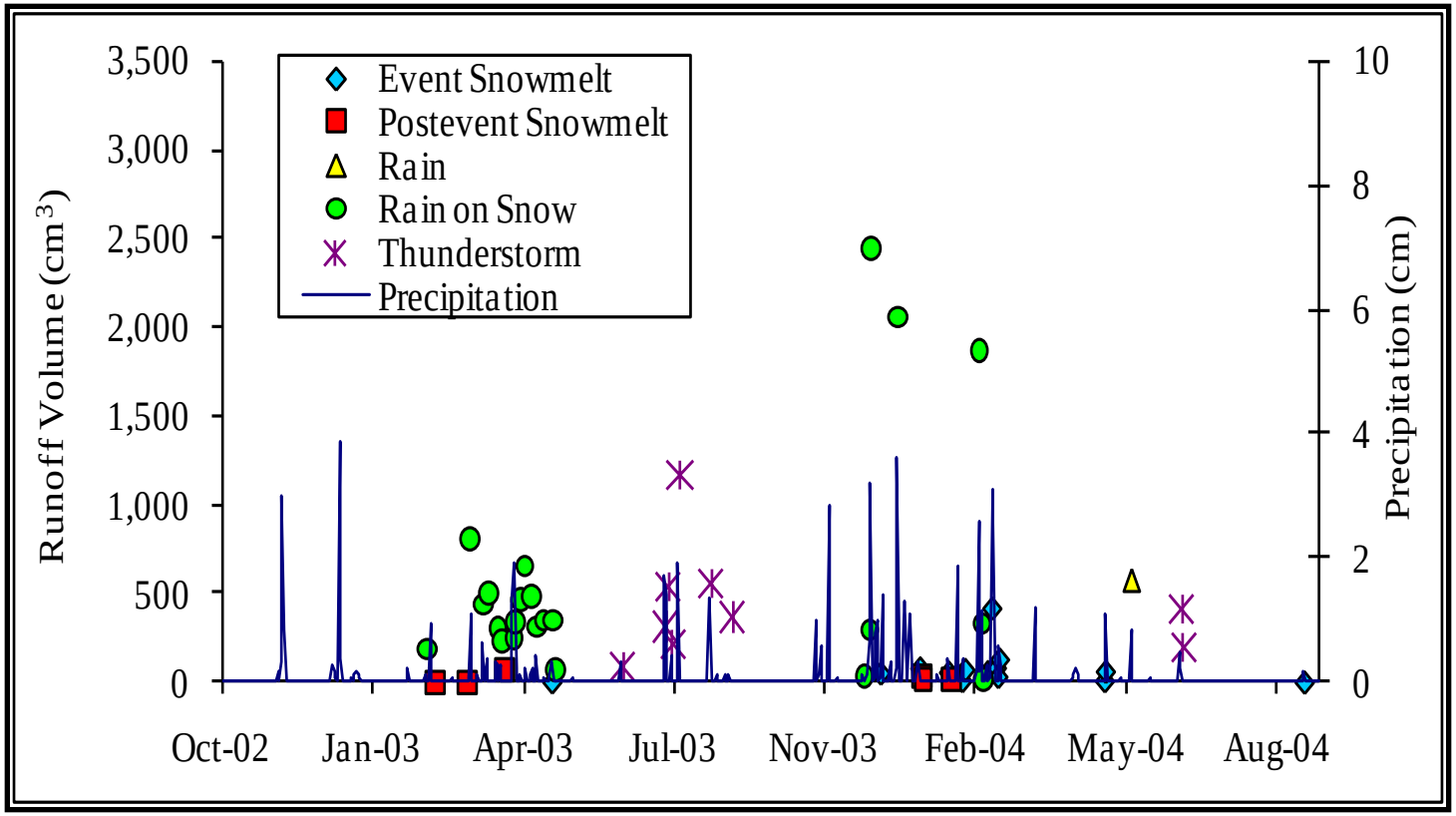
Why Do the Algorithms in SIMPTM Matter Now?

The Tahoe Basin needs a reliable methodology that can provide user's with an accurate estimate of TSS concentrations, particle counts for fine sediment and the concentration of other associated pollutants that are expected to be realized once a specific set of actions or BMP's are implemented including an exciting new technology called Captive Hydrology.

More knowledge can be gained from an analysis of the extensive 2003-2004 TMDL data base that contains a total of 254 sampled storm events that occurred on eight different relatively small urban watersheds that encircle the Lake (i.e. ~32 events per watershed). The sampled storms only represent ~50% of the events that actually occurred during the study period and an explicit modeling approach allows us to predict the quality of those unsampled storms.

Site Name	ID
Speedboat	SB
SLT-Y	SY
TCWTS	S1
Osgood Ave.	O3
Coon St.	CI
Mountain Dr.	MD
Sequoia	SQ
B and Bonanza	BB

Example of TMDL 2003-2004 Storm Data Base



Time series of sampled runoff events at SY and precipitation measured at South Lake Tahoe Airport, CA (Arneson 2009)

Figure taken from Matthew Zelin's 2011 UC Davis Master of Science Thesis on the "Characterization Of Fine Sediment In Urban Runoff In Lake Tahoe, California-Nevada"

Captive Hydrology Cleaner Tel Aviv Israel Jan 2002

Captive Hydrology – Will It Work in the Tahoe Basin?

- Has existed for many years in Great Britain, Netherlands, Germany and Israel
- Used to retexture or clean both traditional and porous pavements
- Can extend pavement life by 3 to 5 years which will save highway departments money
- Removes pollutants accumulated on the surface and embedded in the pavement matrix which should provide huge stormwater quality benefits especially as it relates to fine sediment discharges.
- Can attack the primary source of stormwater pollution which is “street dirt”
- Can operate in winter conditions
- Should provide the most cost effective pollutant reduction that can be achieved
- Will pick up 100% of the fine sediment it can access – the perfect street cleaner!

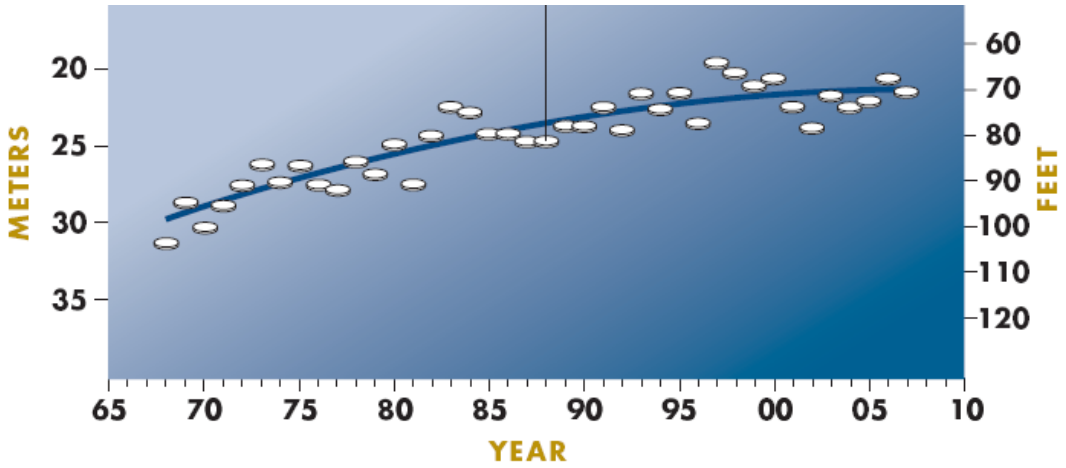
Captive Hydrology needs to be carefully evaluated before a decision is made to acquire one of these machines since the acquisition cost will be close to $1 million

So AMEC's Proposal is to Add the Tested and Proven SIMPTM Algorithms to the PLRM

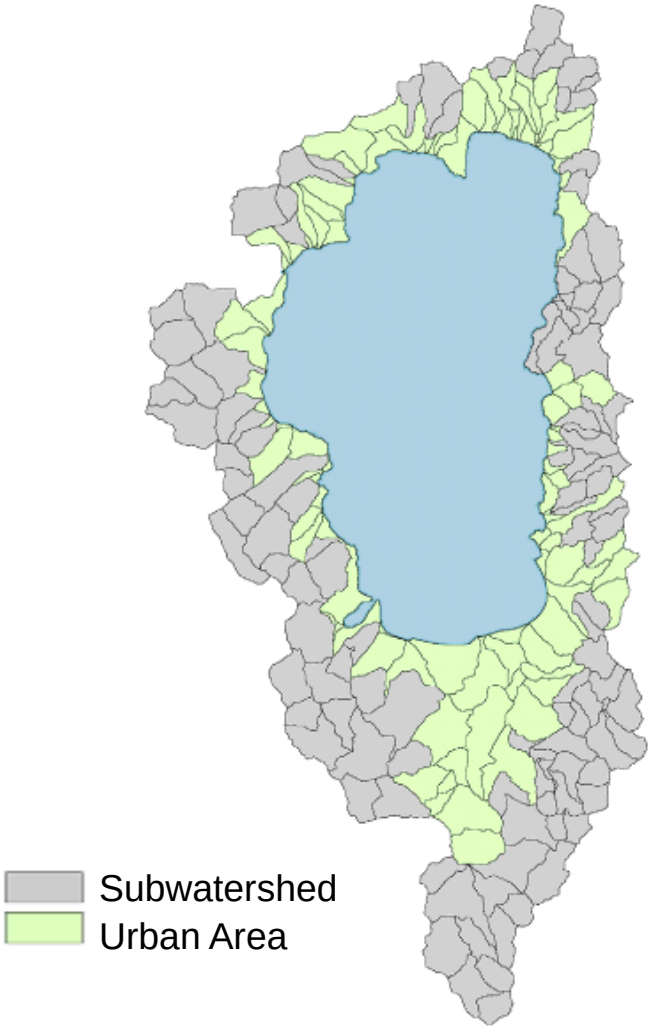
SIMPTM cannot currently handle the complicated rain on snow and snowmelt hydrology that occurs throughout the Tahoe Basin. As a result a direct demonstration of its unique simulation cababilities could not be provided as originally intended.

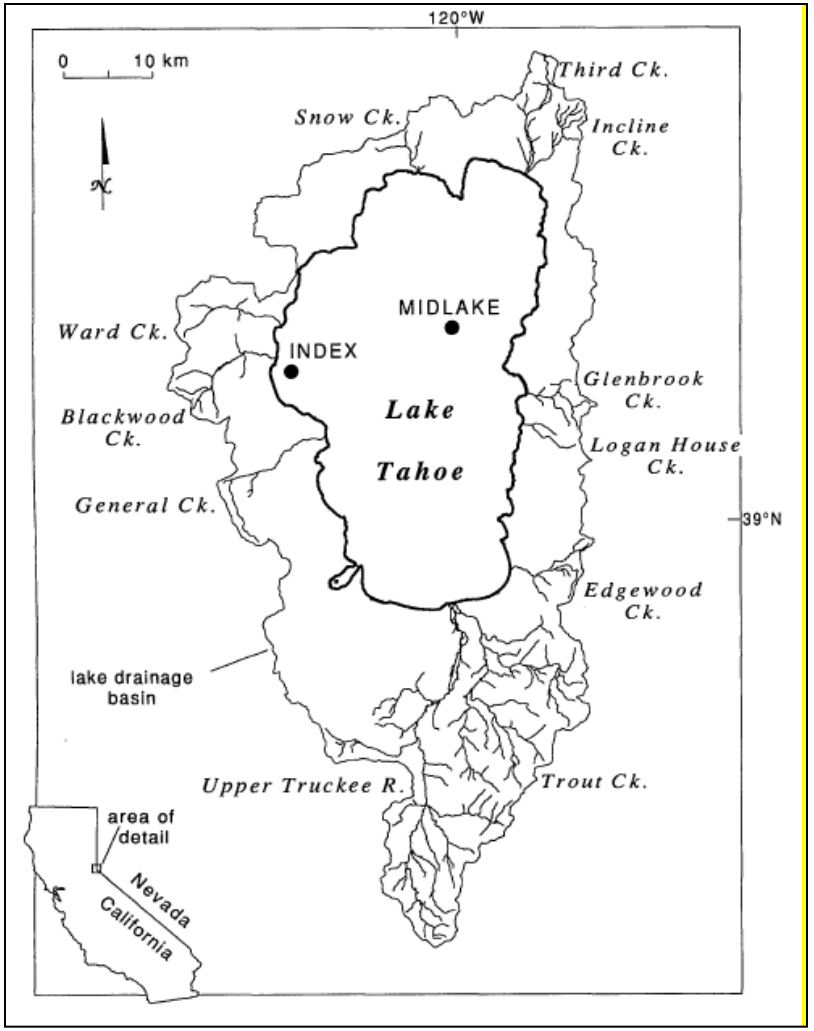
So assuming that the continuous event by event hydrologic response of these urban Lake Tahoe watersheds has already been sufficiently dealt with in the Hydrologic Simulation Element of the PLRM then SIMPTM's algorithms for accumulation, washoff, removal by cleaning practices and other pollutant associations should be added to the PLRM.

The Clarity Of Lake Tahoe Depends On It



QUESTIONS????


Subwatershed
Urban Area


120°W
0
10 km
Third Ck.
Snow Ck.
Incline Ck.
N
MIDLAKE
Ward Ck.
INDEX
Glenbrook Ck.
Lake Tahoe
Blackwood Ck.
Logan House Ck.
General Ck.
39°N
Edgewood Ck.
lake drainage basin
Upper Truckee R.
Trout Ck.
area of detail
Nevada
California