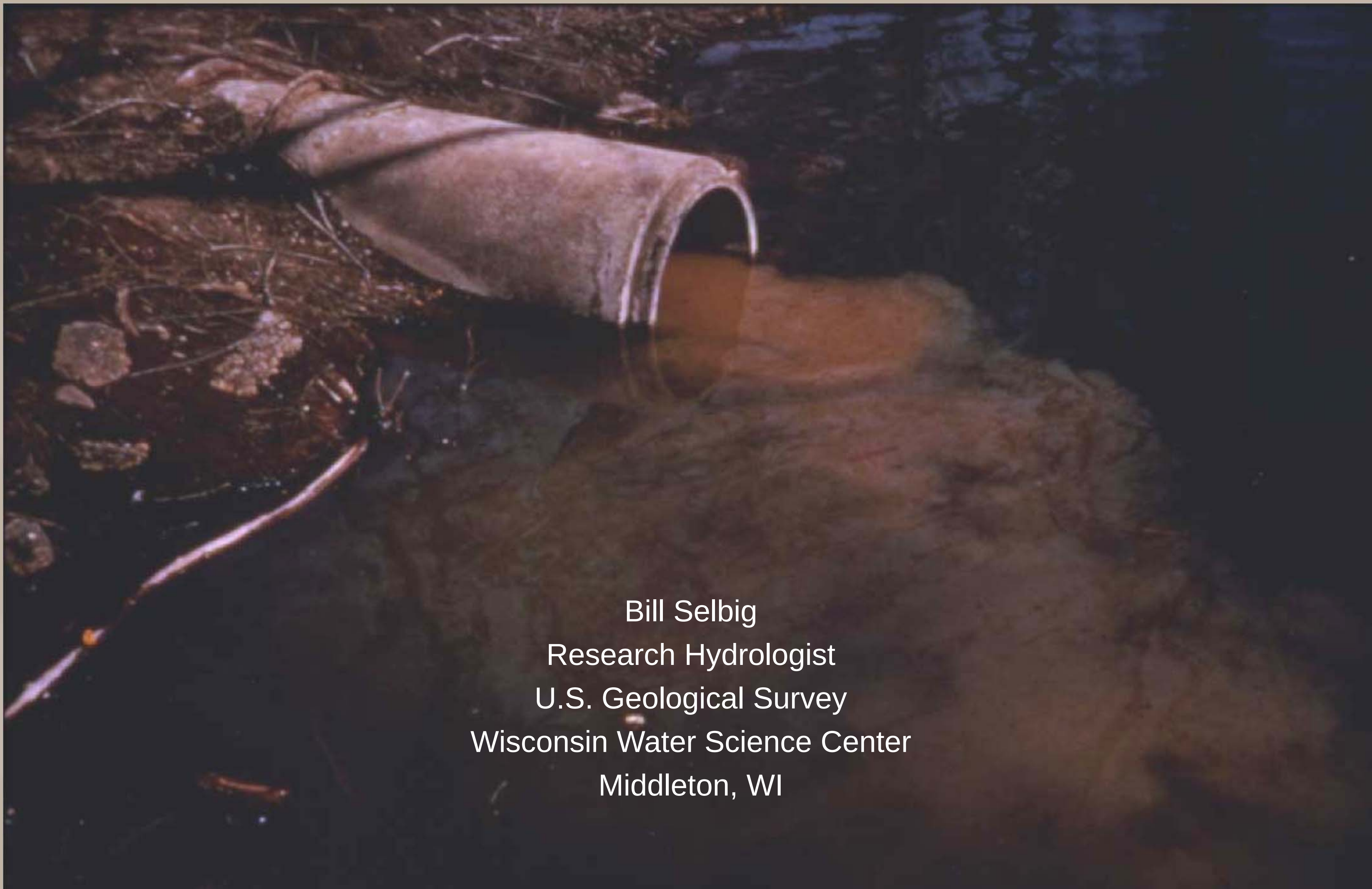
The Cost of Bias: Redefining Urban Sediment through Improved Sampling Technology



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Importance of High-Quality Urban Runoff Data

WHAT

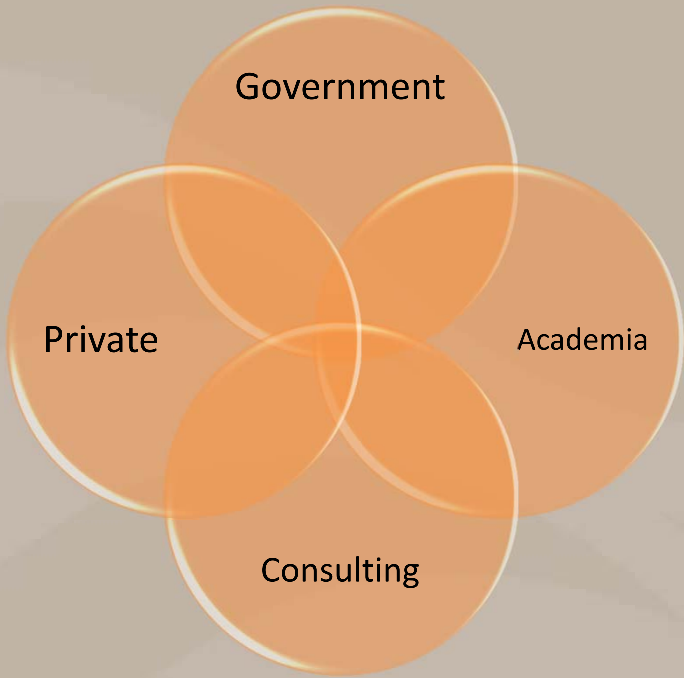
- Particle Size
- Sediment & nutrients
- Organic / Inorganic

CONCENTRATION & LOAD

WHY

- NPDES Phase I and II
- Increasing number of proprietary BMPs
- TMDLs
- Technical performance standards
- Modeling

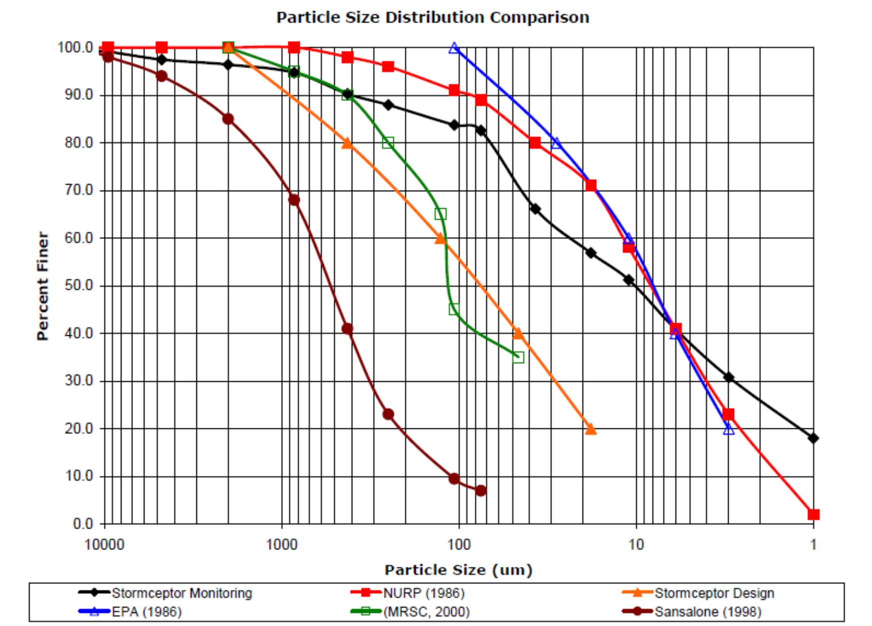
Decades of Urban Data



- High variability and uncertainty
- Difficulty with trend detection
- Inconsistent methodology
- Insufficient samples/sites
- High degree of error outside of sample collection

- Methods for processing raw sediment samples for subsequent analysis for TSS or SSC often *increase variance* and may introduce *bias*.
- Processing artifacts can be substantial if the methods used are not appropriate for the concentrations and particle-size distributions present in the samples collected.

Bent and others, 2000



NURP - National Urban Runoff Program (EPA, 1983)
EPA - Detention Basin Analysis (EPA, 1986)
MRSC - Municipal Research & Services Center (of Washington)

Rinker Materials, 2004

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What are we going to cover?

- Description of Depth-Integrated Sample Arm (DISA)
- Field and lab testing of DISA – evidence of stratification
- How does sampling method affect concentration and load
- How does sampling method impact BMP design and cost

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Fixed-point Sample Collection in Storm Sewers

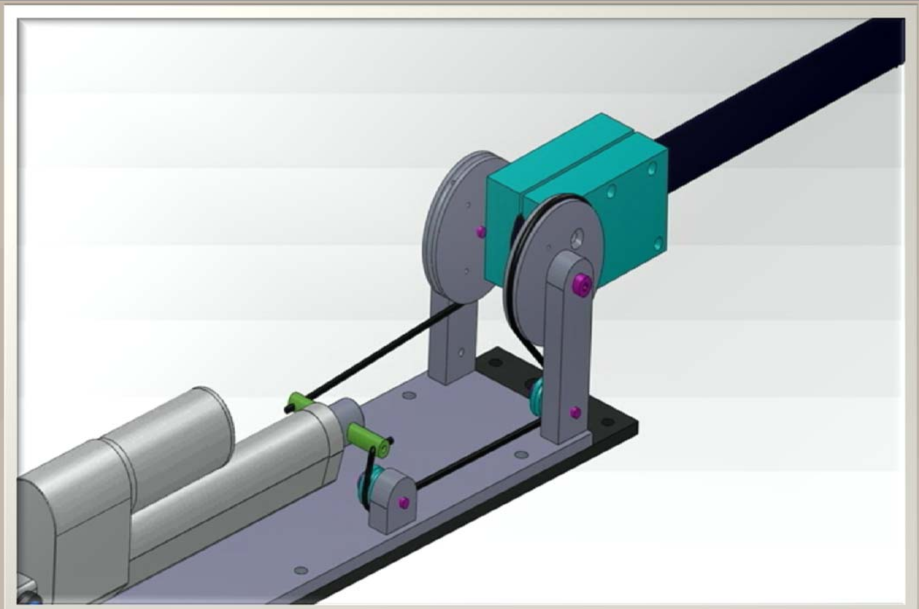
Advantages

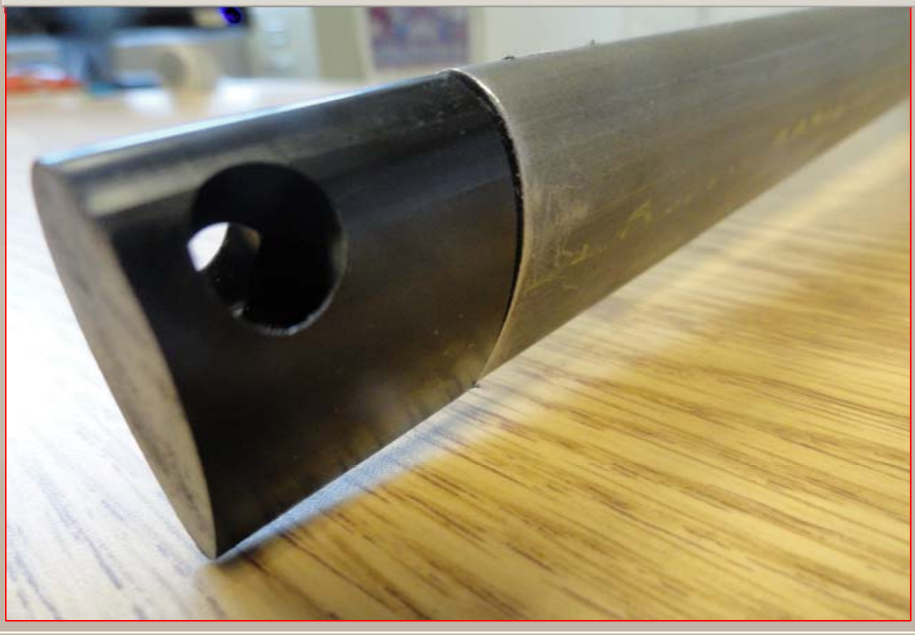
- Easy to install
- Can sample wide range flow conditions

Disadvantages

- Can have large footprint
- Hydraulic impediment
- Not isokinetic
- Samples only from the bottom

Depth-Integrated Sample Arm (DISA)





Depth-Integrated Sample Arm

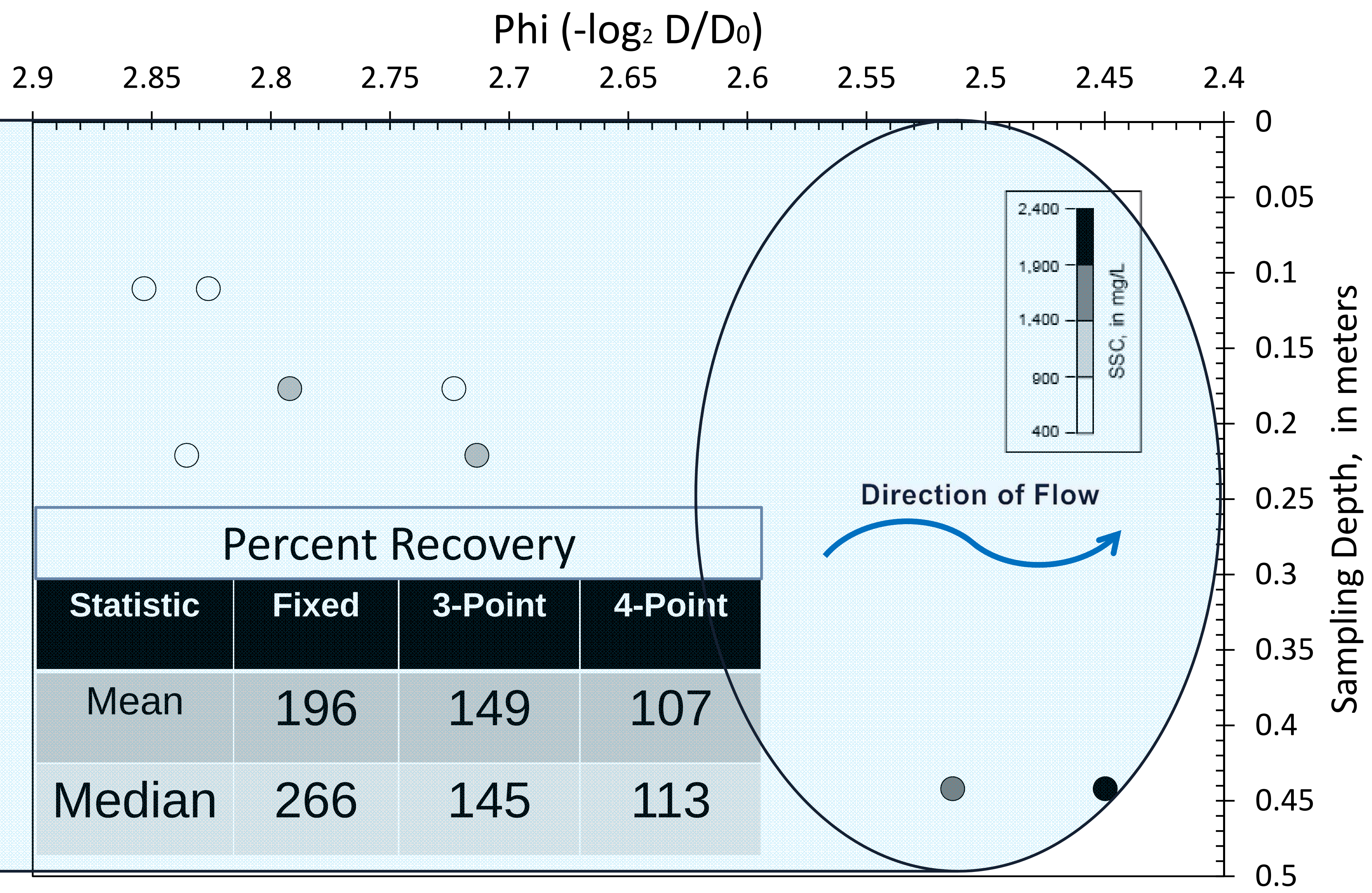
Advantages

- Easy to install
- Can sample wide range of flow
- Small footprint
- Sheds debris
- Can sample entire water column
- Programmable

Disadvantages

- Not isokinetic
- Time constraints

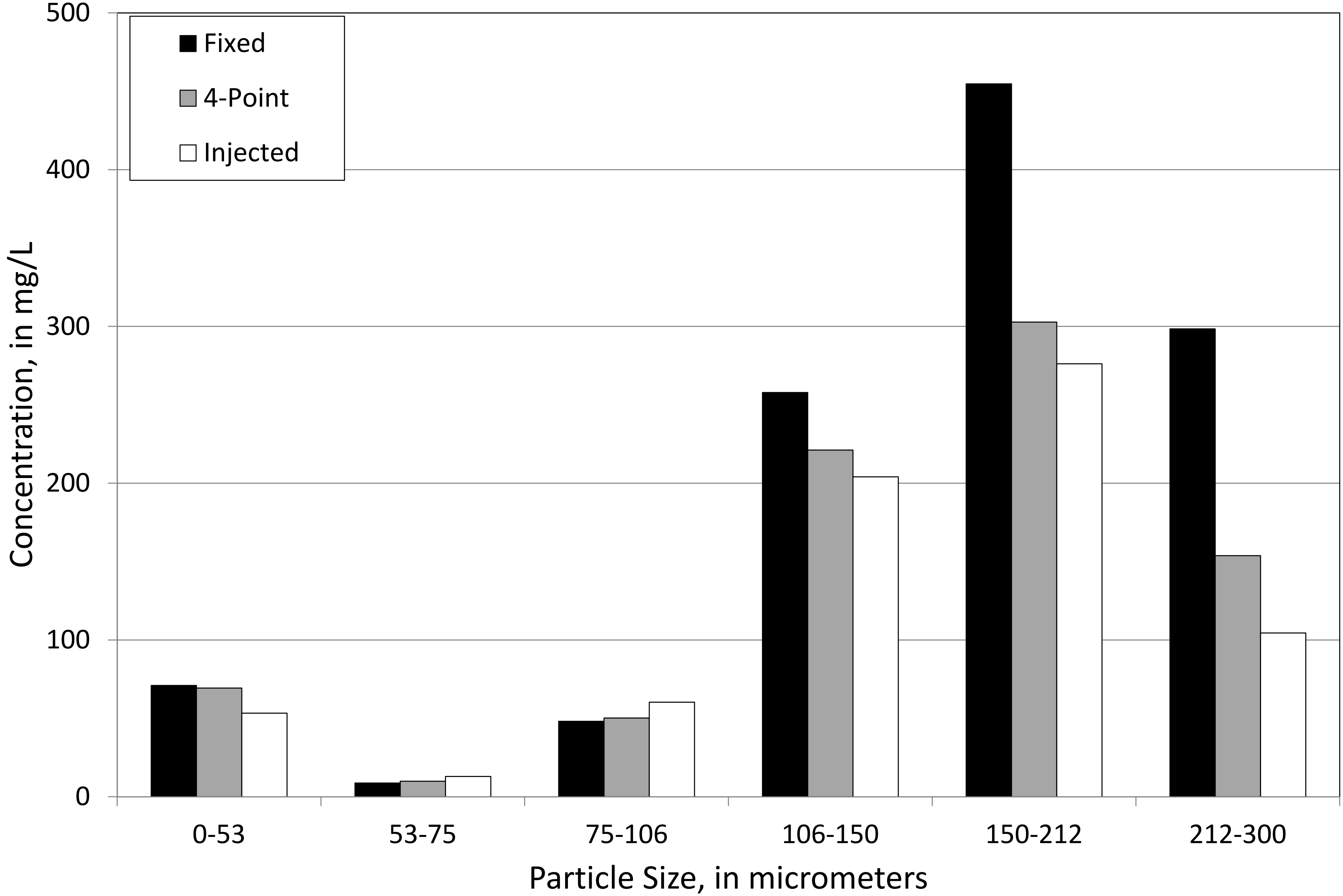
Laboratory Testing at Colorado State University



Percent Recovery

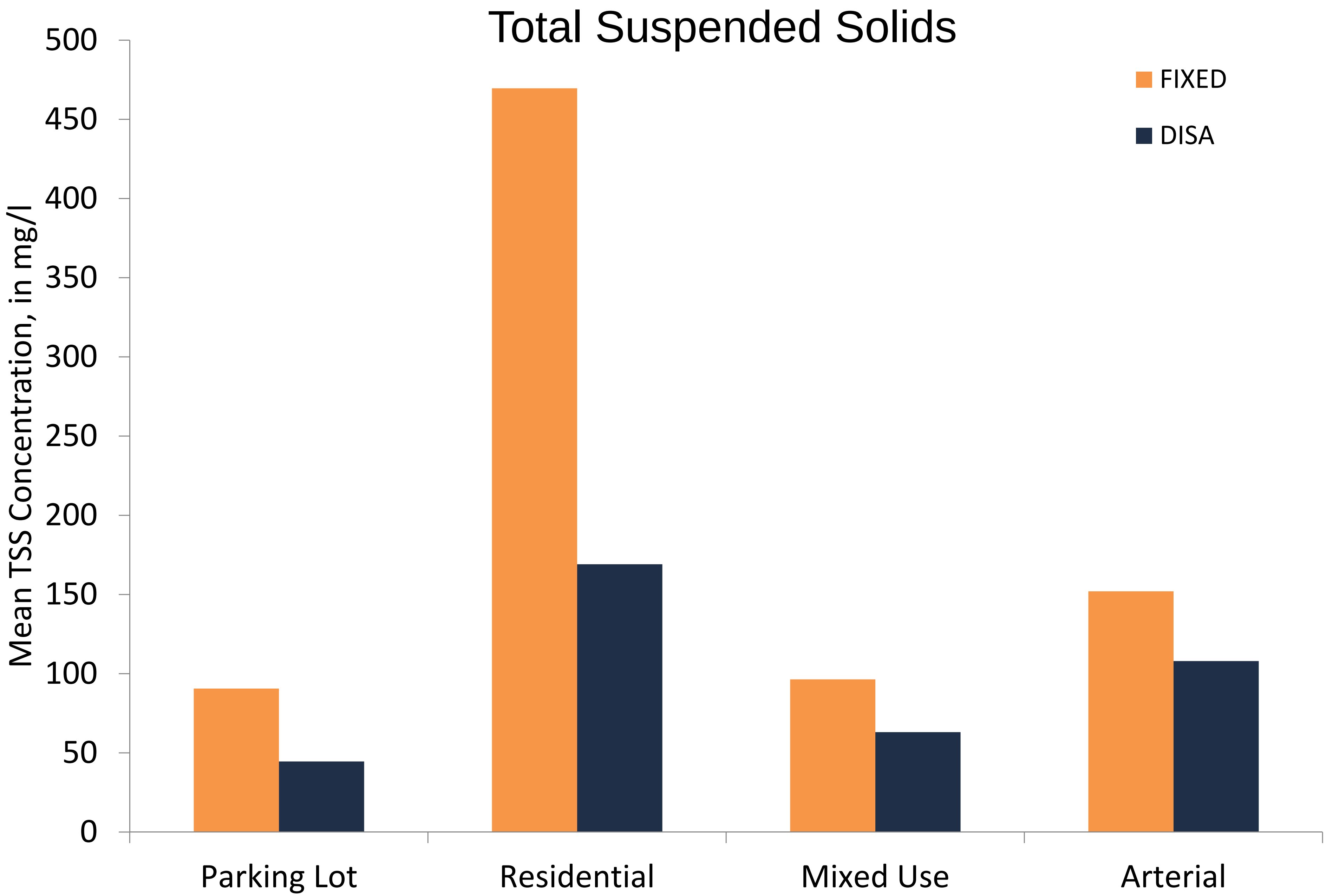
Statistic	Fixed	3-Point	4-Point
Mean	196	149	107
Median	266	145	113

Phi = $-\log_2 (D/D_0)$; where: D = particle diameter, D_0 = reference diameter (equal to 1mm)

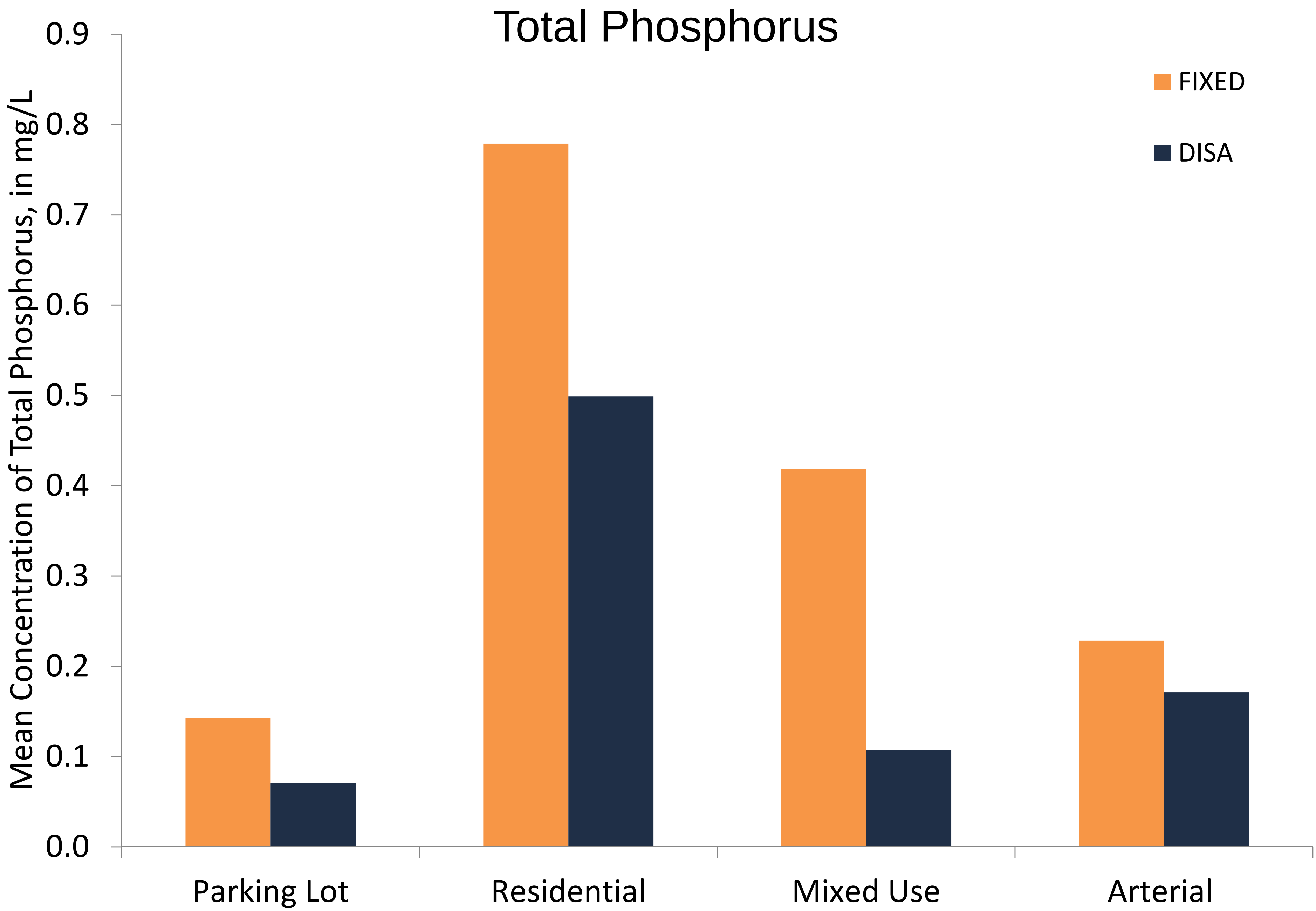


Fixed
4-Point
Injected
Concentration, in mg/L
500
400
300
200
100
0
0-53
53-75
75-106
106-150
150-212
212-300
Particle Size, in micrometers

Field Testing – Madison, Wisconsin



Total Suspended Solids
FIXED
DISA
Mean TSS Concentration, in mg/l
500
450
400
350
300
250
200
150
100
50
0
Parking Lot
Residential
Mixed Use
Arterial


Total Phosphorus
Mean Concentration of Total Phosphorus, in mg/L
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
FIXED
DISA
Parking Lot
Residential
Mixed Use
Arterial

Less Large Particle Bias = Lower Maximum Sediment Concentrations

Suspended Sediment Concentration

Location	Sampler	Mean	Max	COV
Parking Lot	Fixed	375	4,952	2.7
	DISA	38	140	0.9
Arterial Street	Fixed	365	5,110	2.3
	DISA	107	250	0.7
Residential	Fixed	1,154	5,119	1.3
	DISA	147	477	0.8
Mixed Use	Fixed	121	370	1.0
	DISA	66	150	0.6

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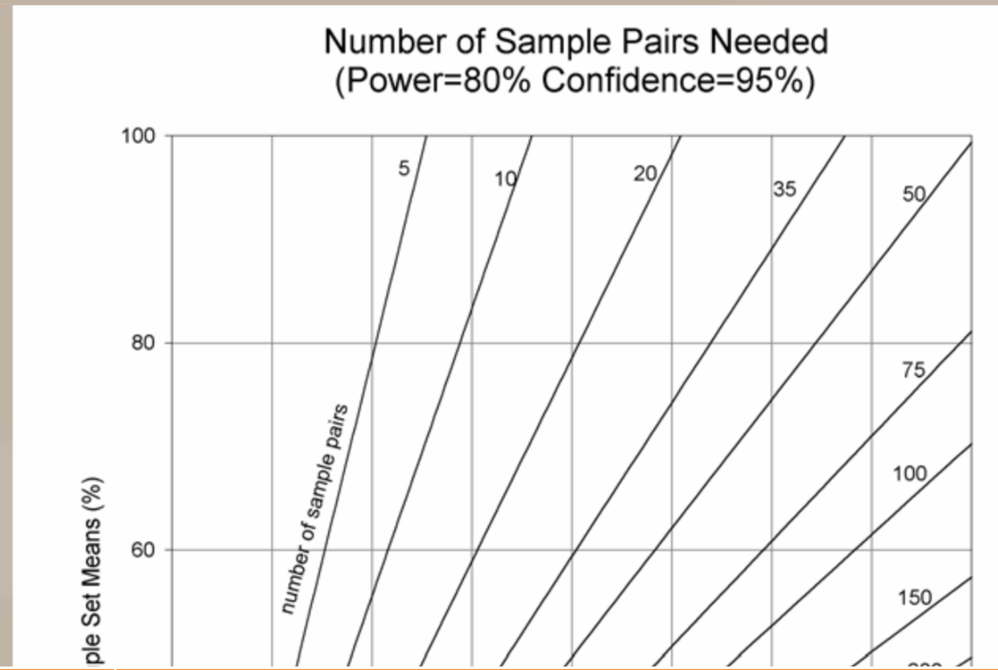
Measures of Uncertainty



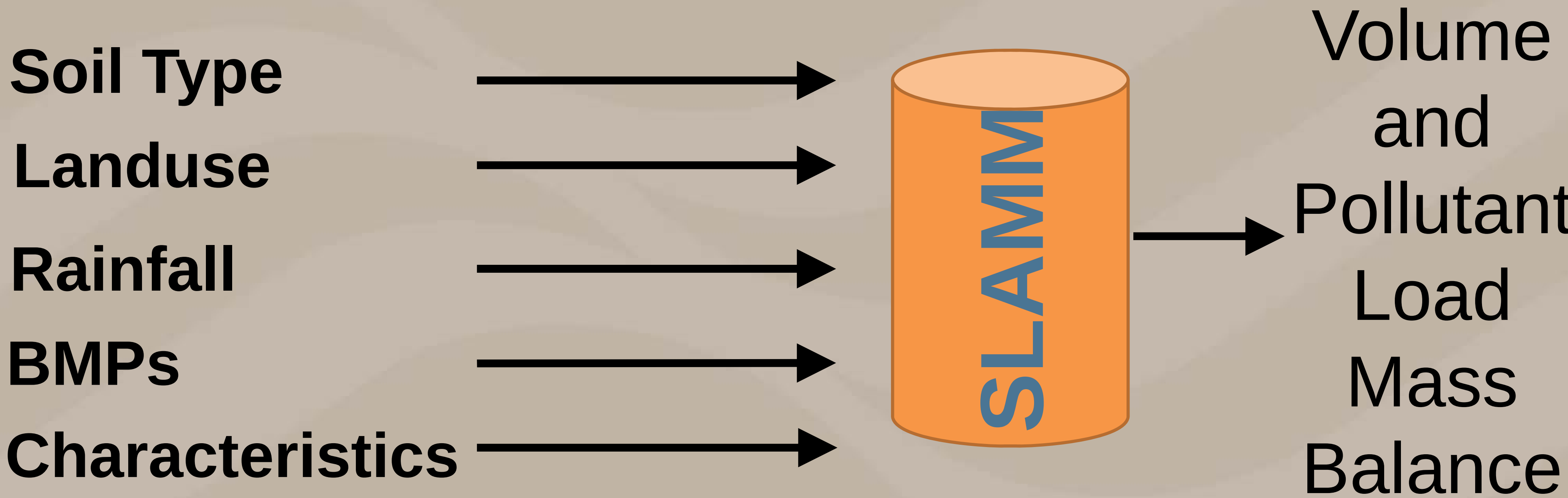
Quantifiable Differences (%)	Number of Paired Tests Needed for Selected COV		
	COV = 0.5	COV = 0.75	COV = 2.0
25	50	100	800
50	10	30	200
75	5	12	100
95	3	8	60

(Burton and Pitt, 2002)

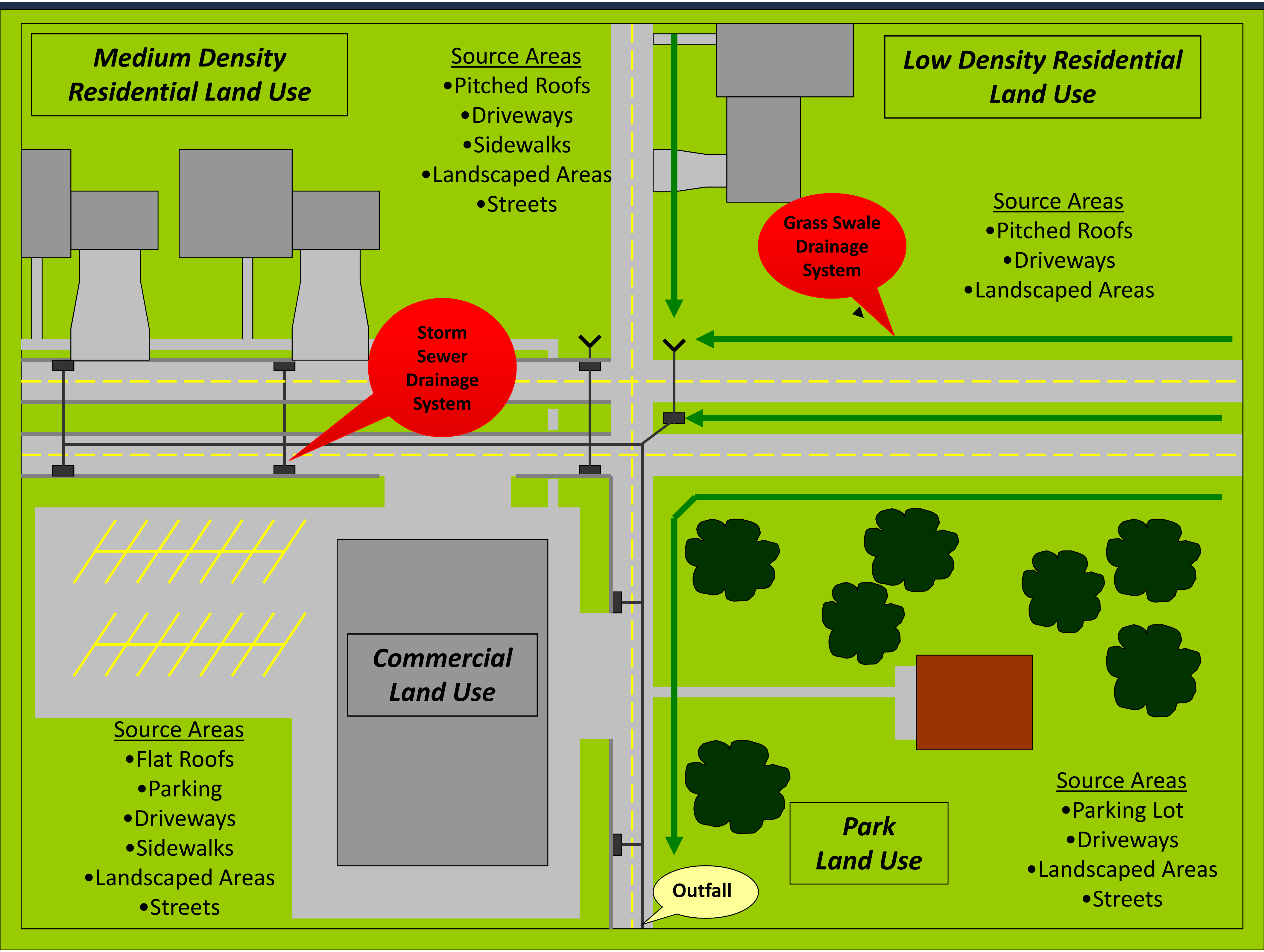
So What…?

Source Loading and Management Model (SLAMM)

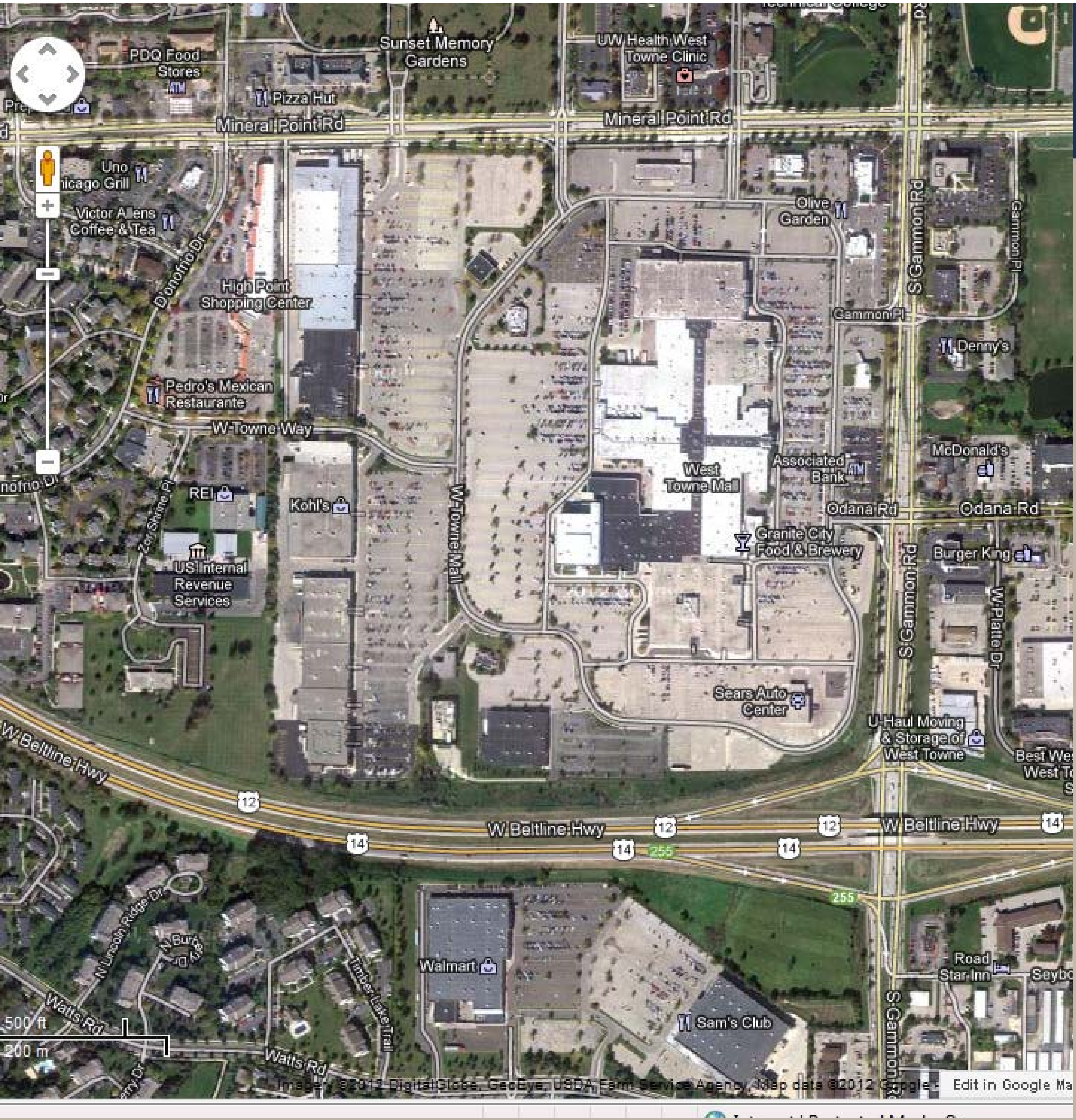
Inputs and Outputs



Robert Pitt & John Voorhees



Medium Density Residential Land Use
Source Areas
•Pitched Roofs
•Driveways
•Sidewalks
•Landscaped Areas
•Streets
Low Density Residential Land Use
Grass Swale Drainage System
Source Areas
•Pitched Roofs
•Driveways
•Landscaped Areas
Storm Sewer Drainage System
Commercial Land Use
Source Areas
•Flat Roofs
•Parking
•Driveways
•Sidewalks
•Landscaped Areas
•Streets
Park Land Use
Outfall
Source Areas
•Parking Lot
•Driveways
•Landscaped Areas
•Streets



West Towne Shopping Center Annual TSS Loads (Modifying Street and Parking Lot TSS Concentrations in WinSLAMM)

DISA – 21,000 lbs.
Fixed – 38,000 lbs.

Difference – 44%

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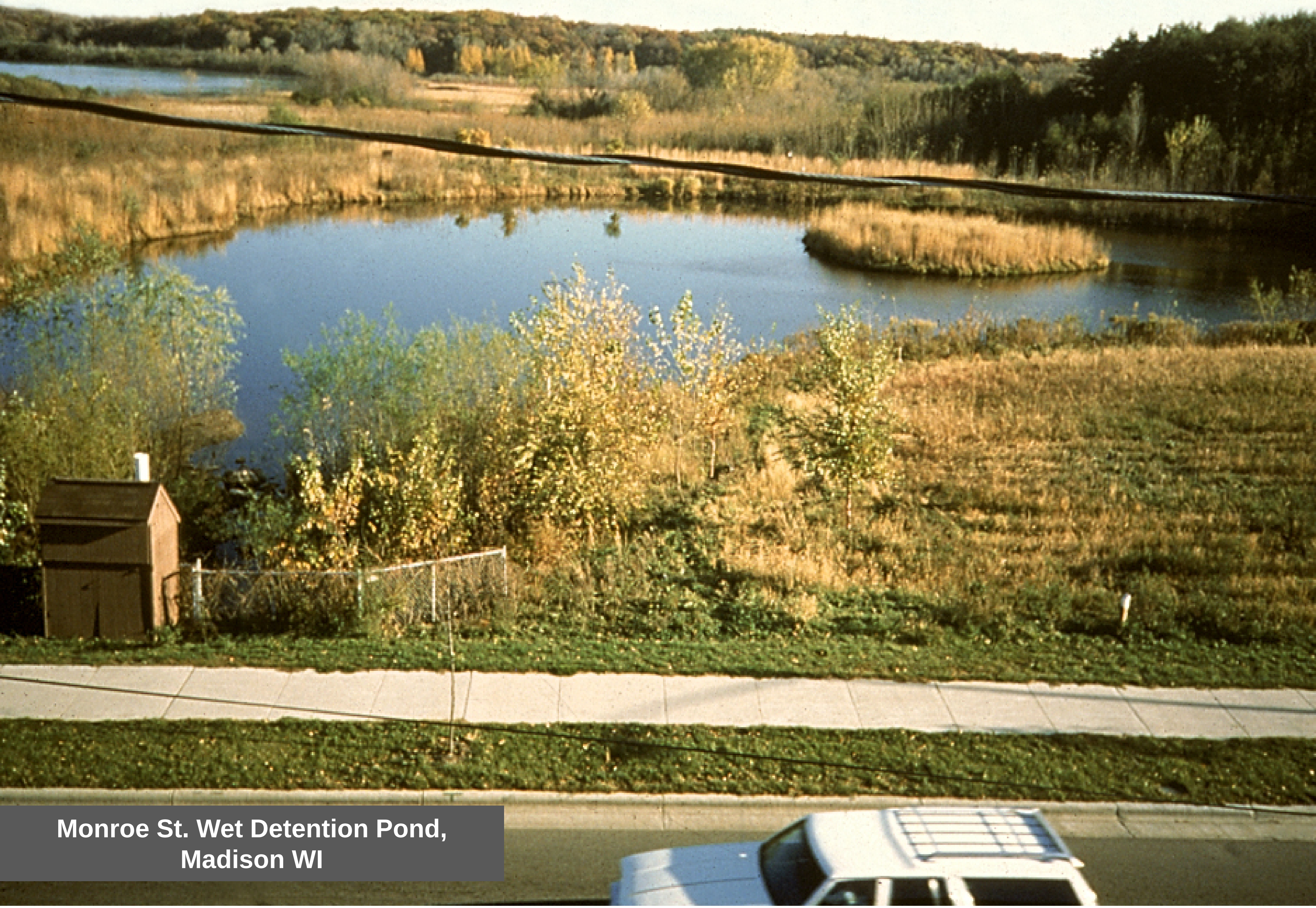
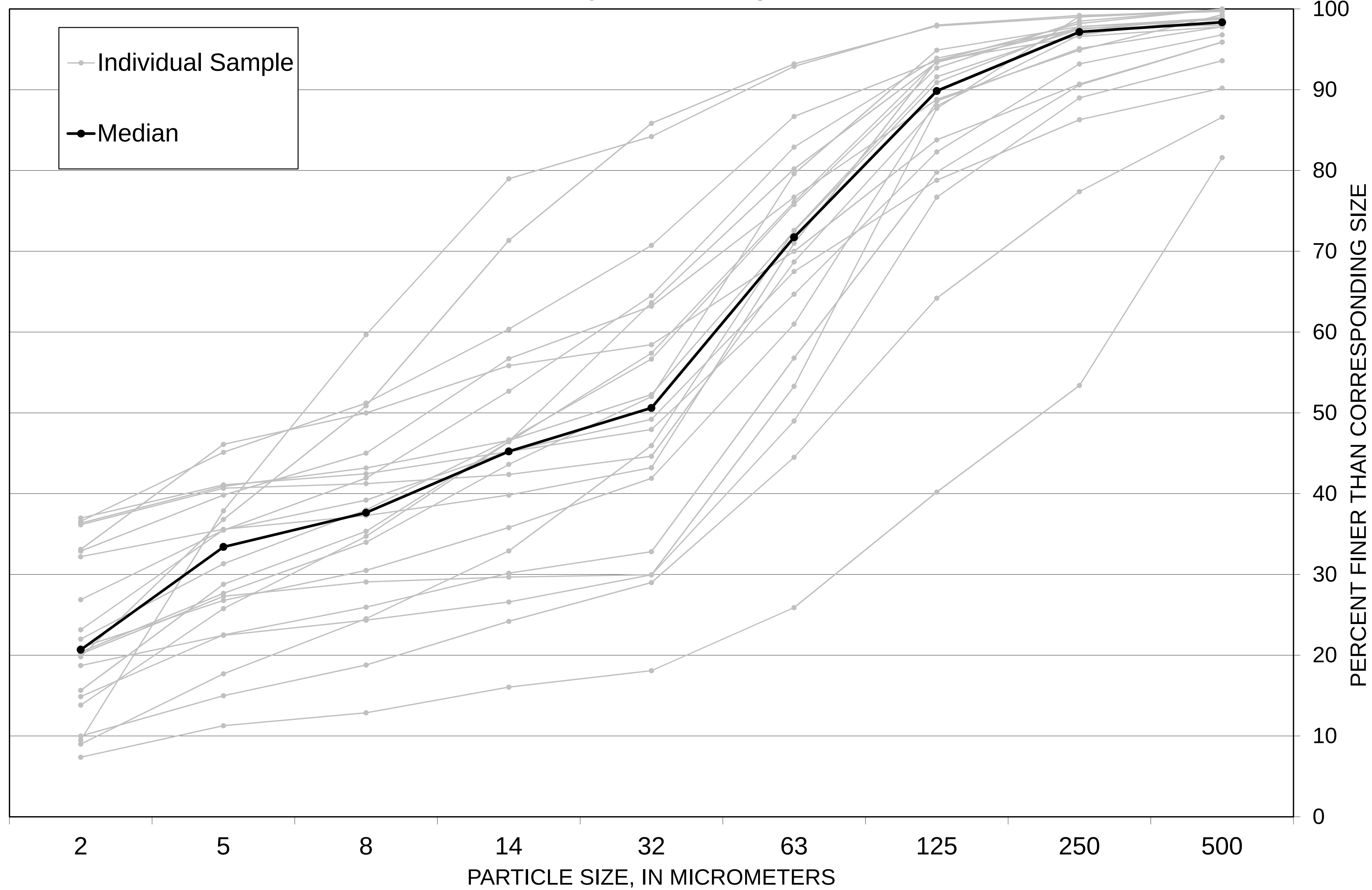
What about Particle Size?



Monroe St. Wet Detention Pond, Madison WI

Variability in Sample PSDs



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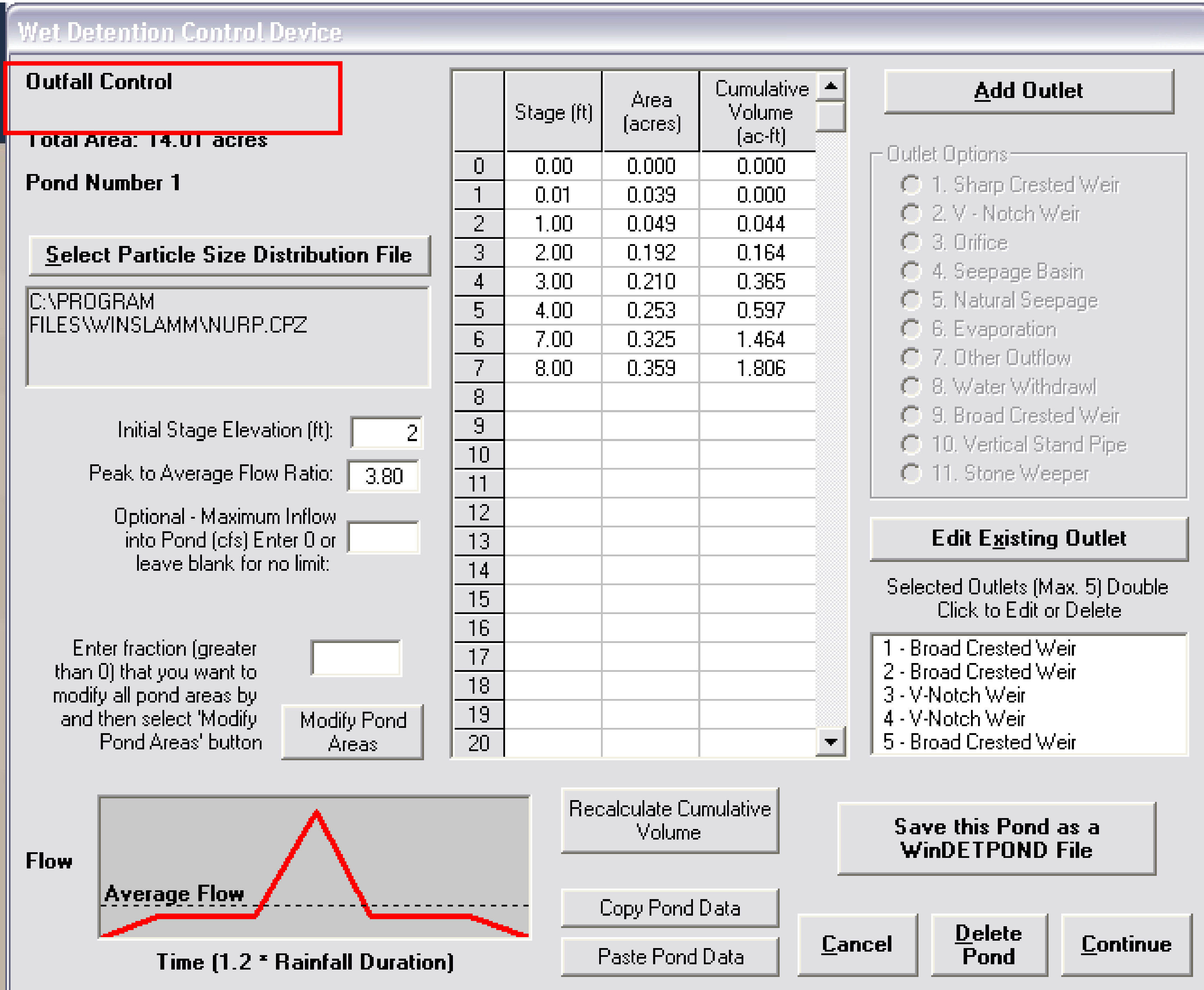
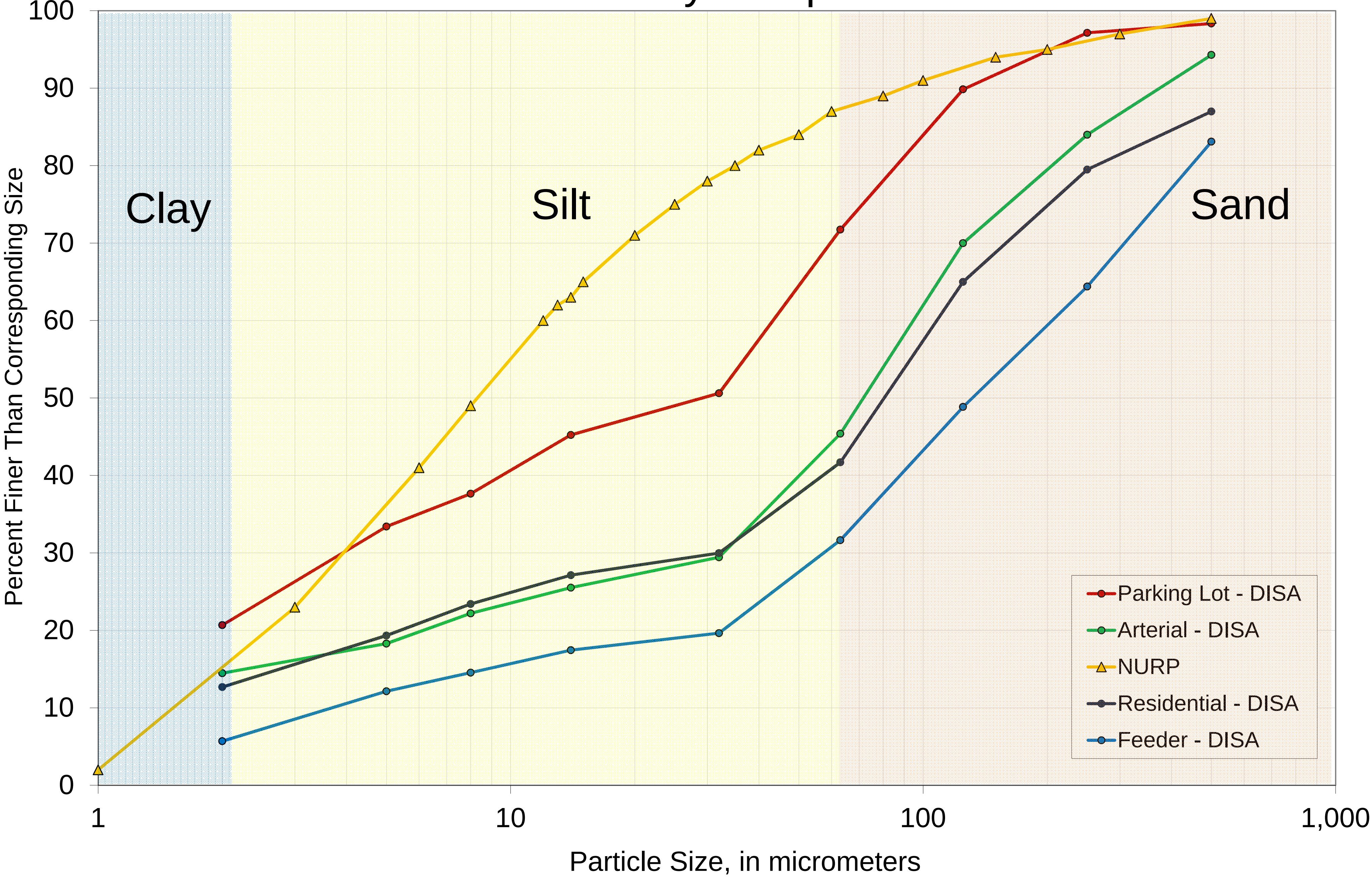
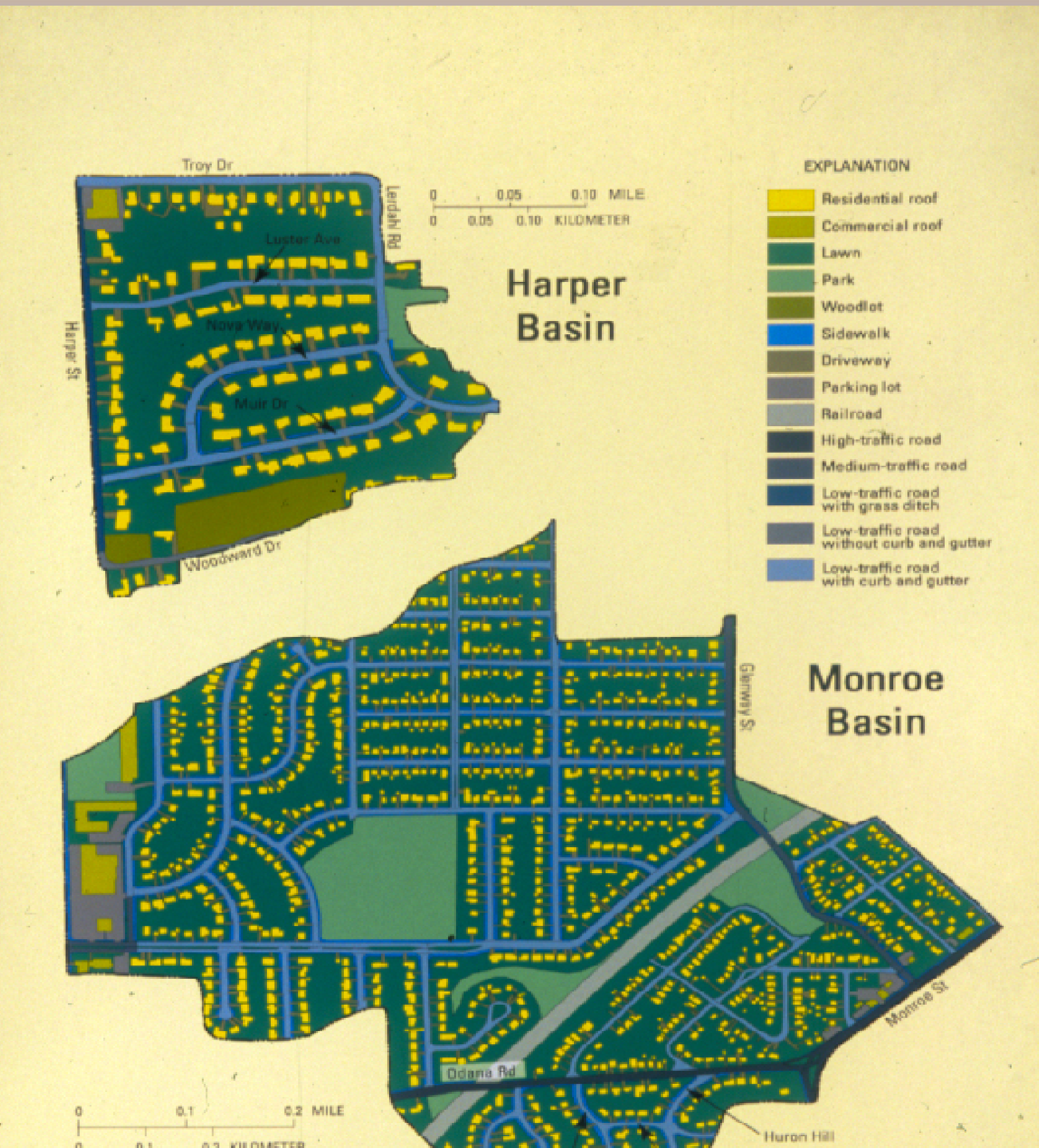
SLAMM Uses NURP PSD



Median PSDs by Sample Method



Harper Sub-watershed (44 acres): Size and Cost of Wet Ponds to Reduce Annual TSS Loads by 80%



Size:

DISA – 0.4 acres
NURP – 1.5 acres

Capital Cost:

DISA - $46,000
NURP - $125,000

Questions?