Monitoring Stormwater: Do's, Don'ts, Why's and How's

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The Root of All Monitoring Evil

The OBJECTIVE

The easiest way to:

- fail to meet goals,
- overspend budgets,
- frustrate project team,
- waste time, and
- lose sleep at night…..

is to have a poorly defined or non-existent objective.

Stormwater Monitoring Objectives

- Water Quality
- Water Quantity
- Variability
- Frequency
- Treatment performance
- Regulatory/compliance
- TMDL

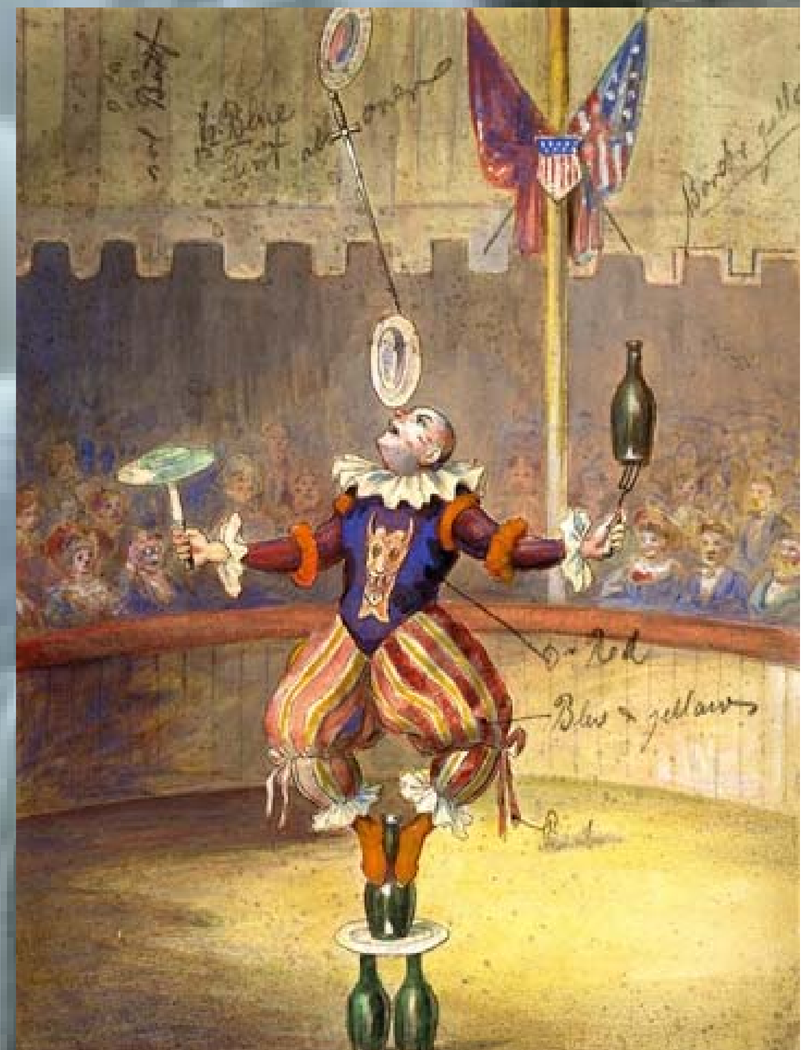
Define the Objective

- Definition should be in such a way that the monitoring data itself (or a simple transformation of the data) meets the objective.

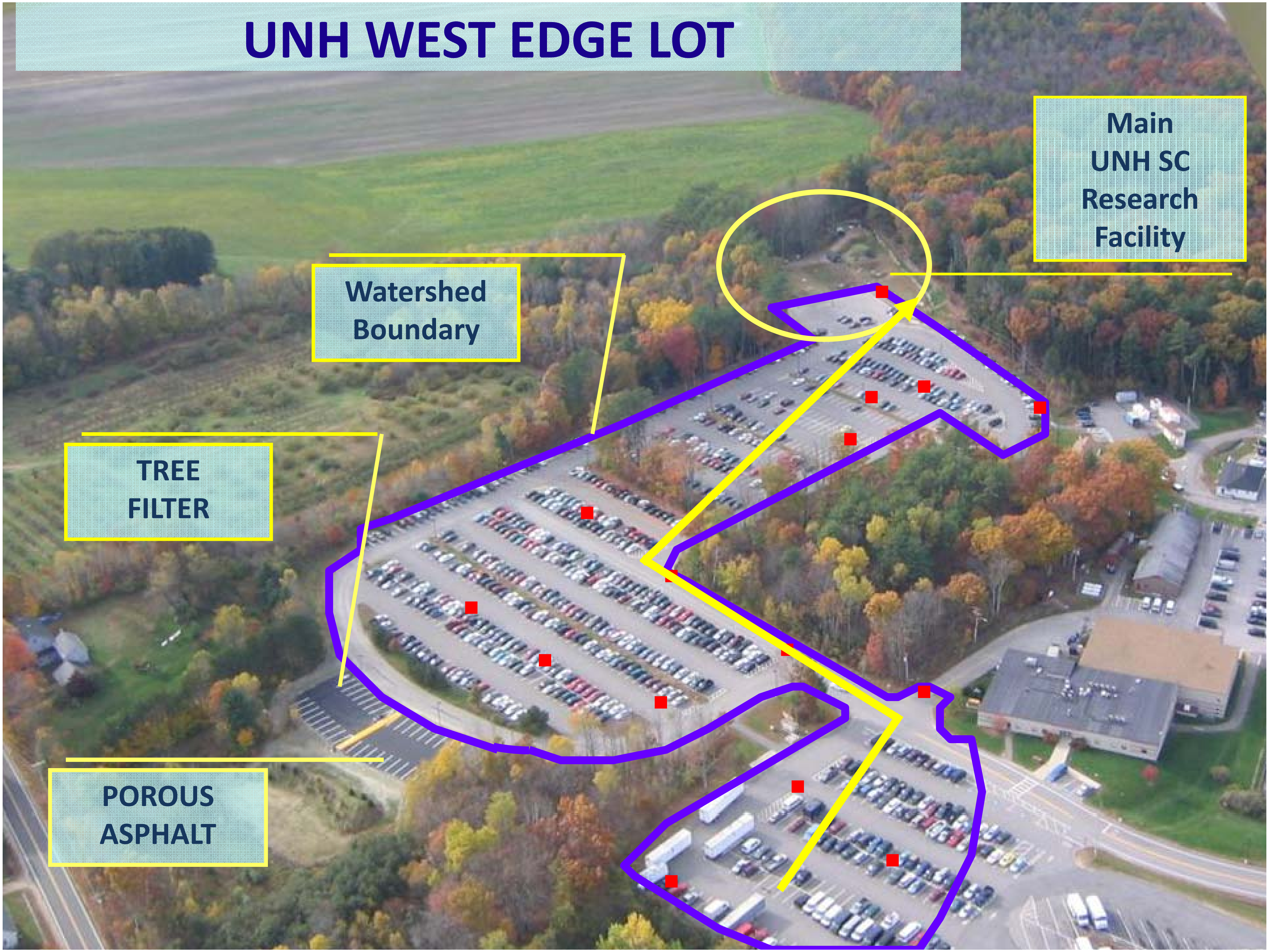
Budget

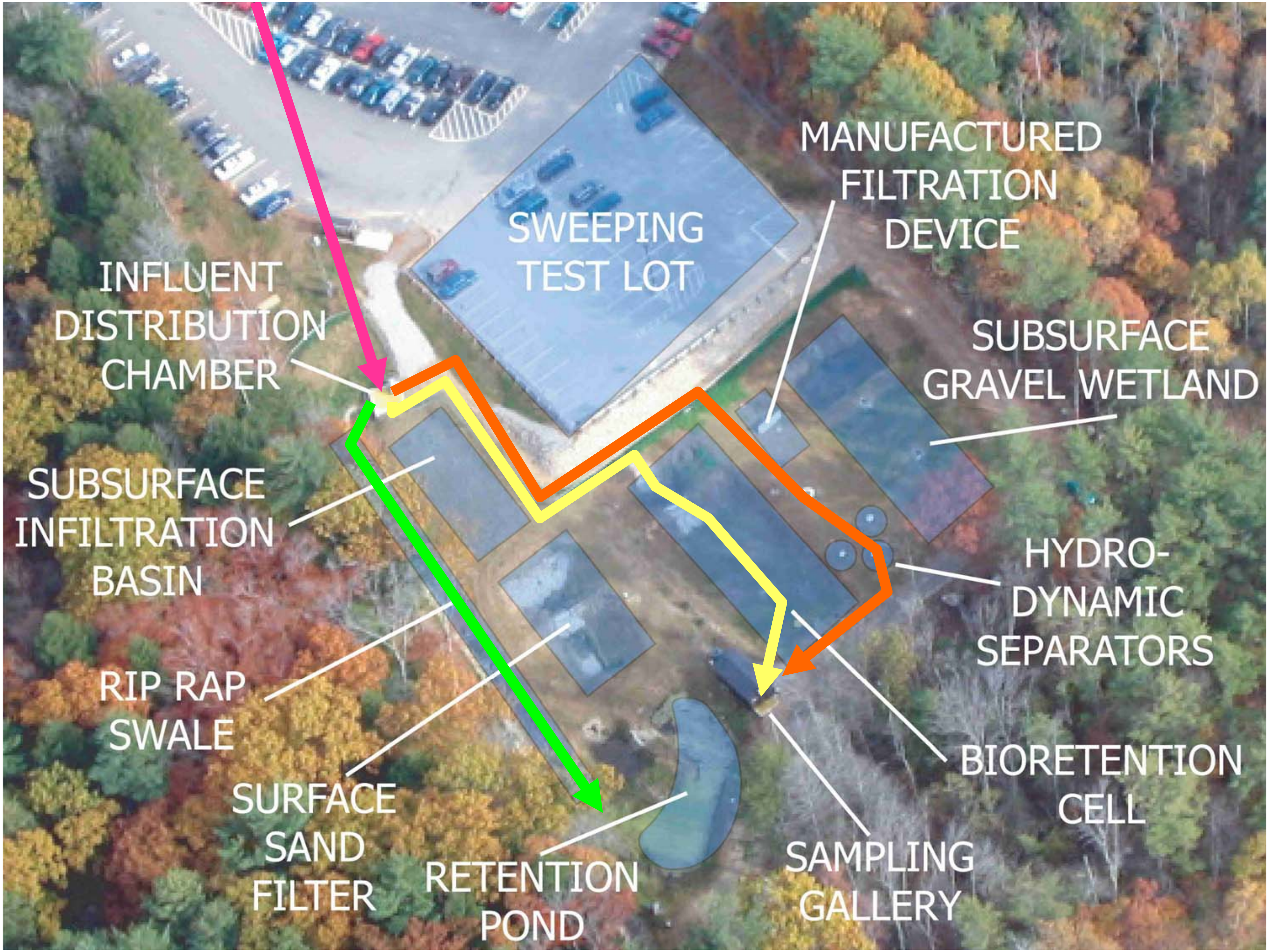
- Budget must meet objective scope: *it is better to do one thing right, than a lot of things wrong.*

"A lousy trillion? Call me when you're ready to talk some real money."



The UNH Stormwater Center


UNH WEST EDGE LOT
Main
UNH SC
Research
Facility
Watershed
Boundary
TREE
FILTER
POROUS
ASPHALT


MANUFACTURED FILTRATION DEVICE
SWEEPING TEST LOT
INFLUENT DISTRIBUTION CHAMBER
SUBSURFACE GRAVEL WETLAND
SUBSURFACE INFILTRATION BASIN
HYDRO-DYNAMIC SEPARATORS
RIP RAP SWALE
BIORETENTION CELL
SURFACE SAND FILTER
RETENTION POND
SAMPLING GALLERY


POROUS ASPHALT
TREE FILTER

TREATMENT STRATEGIES:
Conventional Devices

Retention Pond---2004 to 2006

Detention Pond---2006 to present

Rock-Lined Swale---2004 - 2005

Vegetated Swale---2005 - 2006

Veg Swale with Engineered Filter Berm---2006 - 2007

Retention Pond

Rip Rap Swale

TREATMENT STRATEGIES: Manufactured Devices

Tested 2004-2006: ADS Subsurface Detention System, Aqua Swirl and Aqua Filter; VortSentry, CDS, V2b1, ADS Isolator row

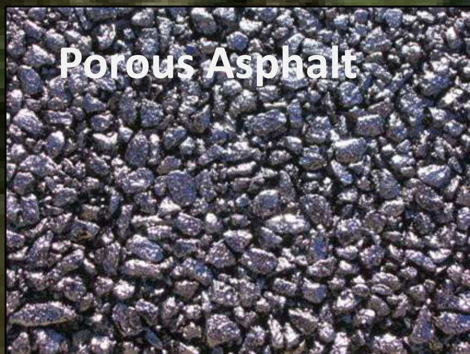
Tested 2006-present: Stormtech Isolator Row; HIL Up-Flo Filter, HIL Downstream Defender, VortSentry, Deep Sump Catch Basin

Hydrodynamic Separator

Subsurface Infiltration Unit

Filter Unit

Infiltration and Filtration Systems



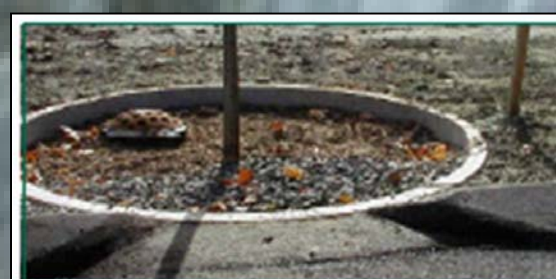
Porous Asphalt

Pervious Concrete

Gravel Wetland

Sand Filter

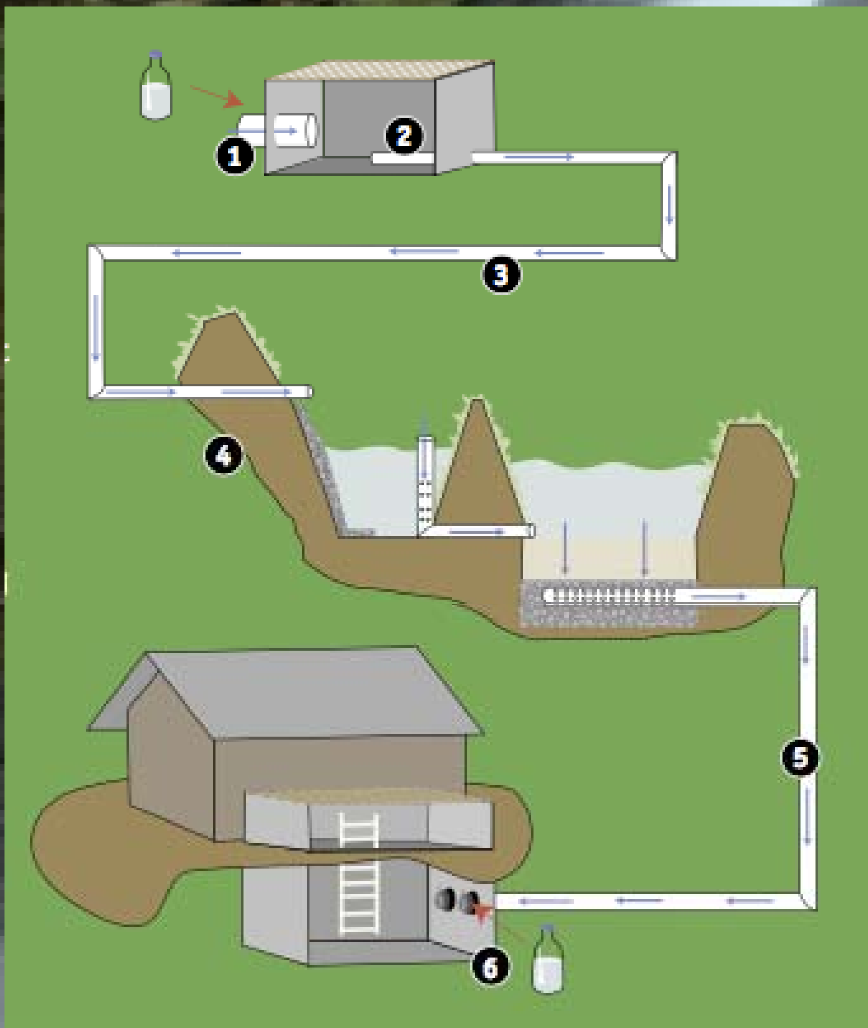
Bioretention Cell



Tree Filter

Subsurface Infiltration Unit

BMP Monitoring: How We Do It



QAPP-Governed Protocol

1. Runoff is sampled
2. Influent enters distribution chamber
3. Equal volumes flow out to systems
4. Influent flows through systems
5. Effluent leaves system
6. Effluent enters sampling gallery

Monitoring

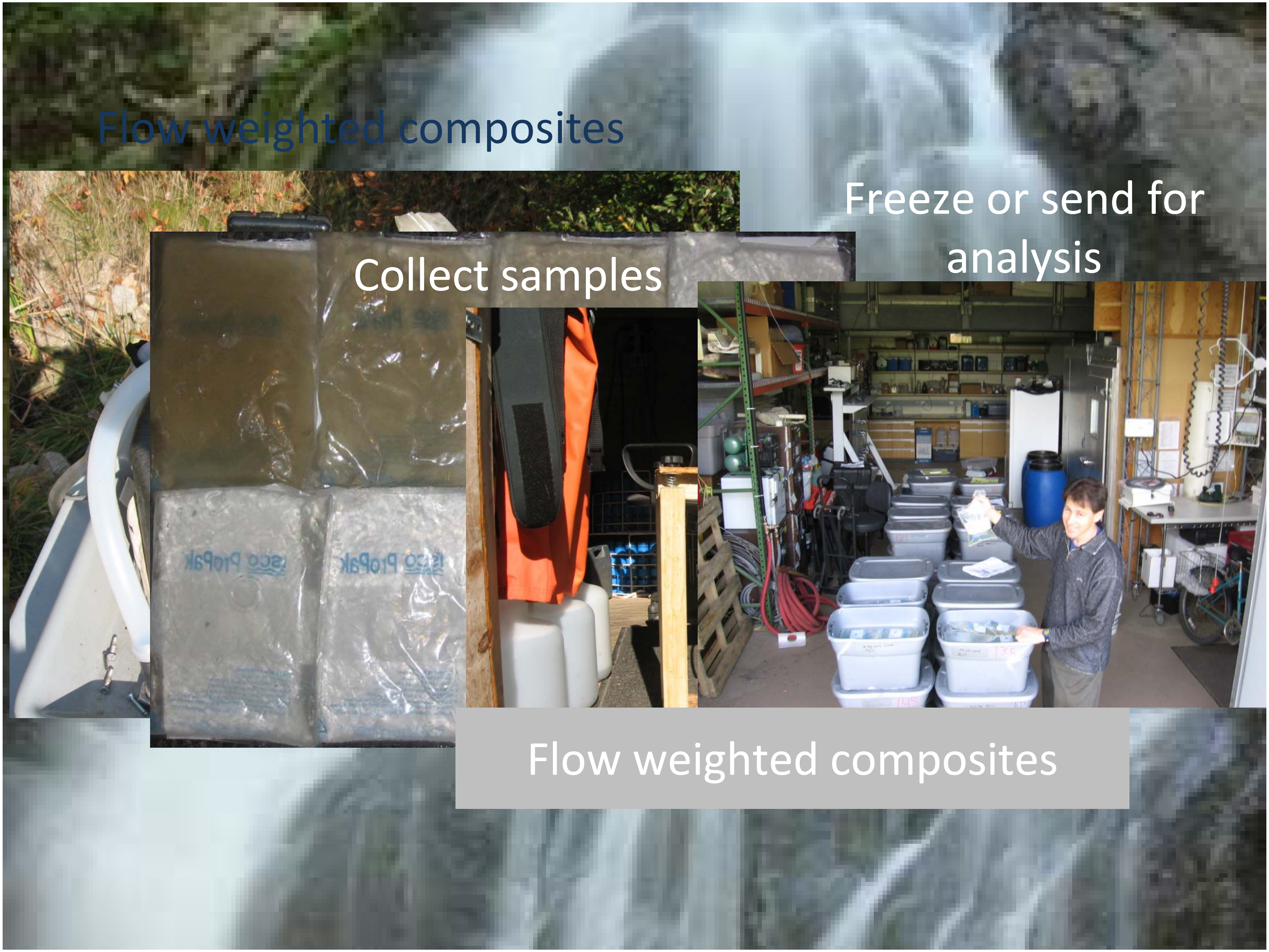
Real Time

Automated Samplers

Site Monitoring

- **Real Time**
  - Precipitation
  - Flow
  - pH
  - Temperature
  - Conductivity
  - Dissolved Oxygen
  - Turbidity

- **Discrete Samples**
  - Metals
  - Petroleum Hydrocarbons
  - Sediment
  - Anions and Cations
  - Nutrients
  - Microorganisms


Flow weighted composites
Freeze or send for analysis
Collect samples
Flow weighted composites

Know Hydrology

- Understand the runoff (rain, snowmelt, etc.) characteristics of the watershed to the location of monitoring
  - Time of concentration
  - Lag
  - CN
  - Unit hydrograph peak discharge
  - Base flow
  - Land use

Water Quality

- Estimate the water quality characteristics of what you are attempting to monitor
  - Maximum
  - Minimum
  - Median
  - Variance
  - Memory
  - Sources

Measurement

- Know the analytical capabilities of equipment/lab
  - Detection level
  - Accuracy
  - Precision
  - Reliability

Interferences

- Understand water quality interferences
  - Vegetation
  - Quenching
  - Sunlight
  - Temperature
  - Turbulence
  - Point sources

Data

- Build and maintain the data vault
  - Access
  - Entry
  - Logs
  - QA

Reality

- Just one suspicious data point in a data set can cast a doubt on the entire study and conclusions

Objectives – Bad Examples

- Will this impair the creek?
  - Too vague
  - Possibly many other causes of impairments
  - How is this answered?
- Is this a good design?
  - Is monitoring a necessity to answer?
  - Non-quantifiable statement
  - Units of measure
  - When answered?

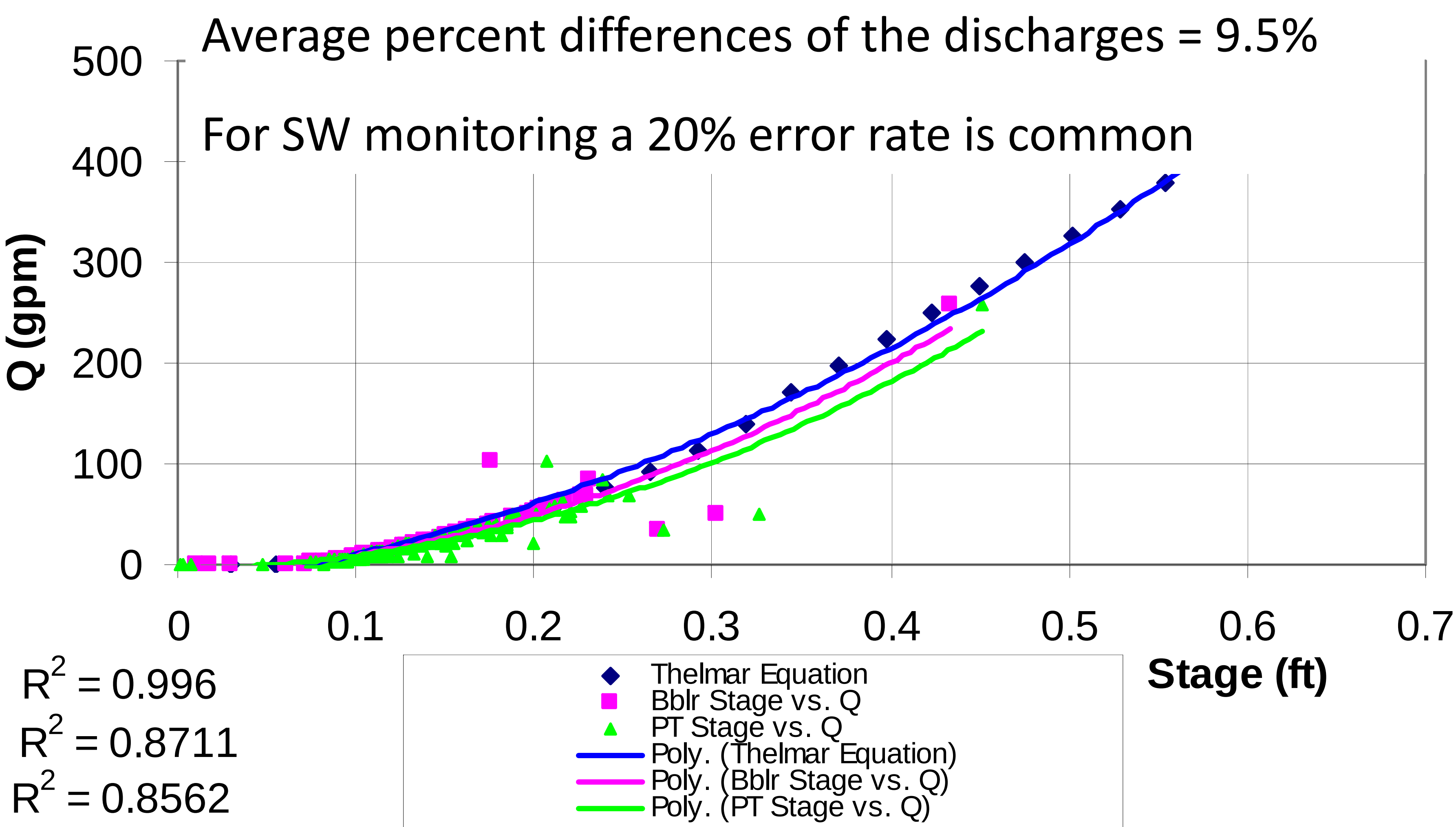
Objectives – Good Examples

- Is the design meeting the infiltration goal?
  - Infiltration goal established (say equal to pre-development)
  - *At what point in time is question answered?*
- Is stormwater meeting compliance (for some target contaminant)?
  - Simple metric
  - *At what point in time is question answered?*

DO NOT THINK LIGHTLY ABOUT FLOW MEASUREMENT

- Discharge is considered a “no brainer”
- Reality is that accuracy is problematic
- Cannot do a good mass balance without excellent flow monitoring
- Often measure water level or depth and convert

Thelmar vs Field Stage vs. Q Equations

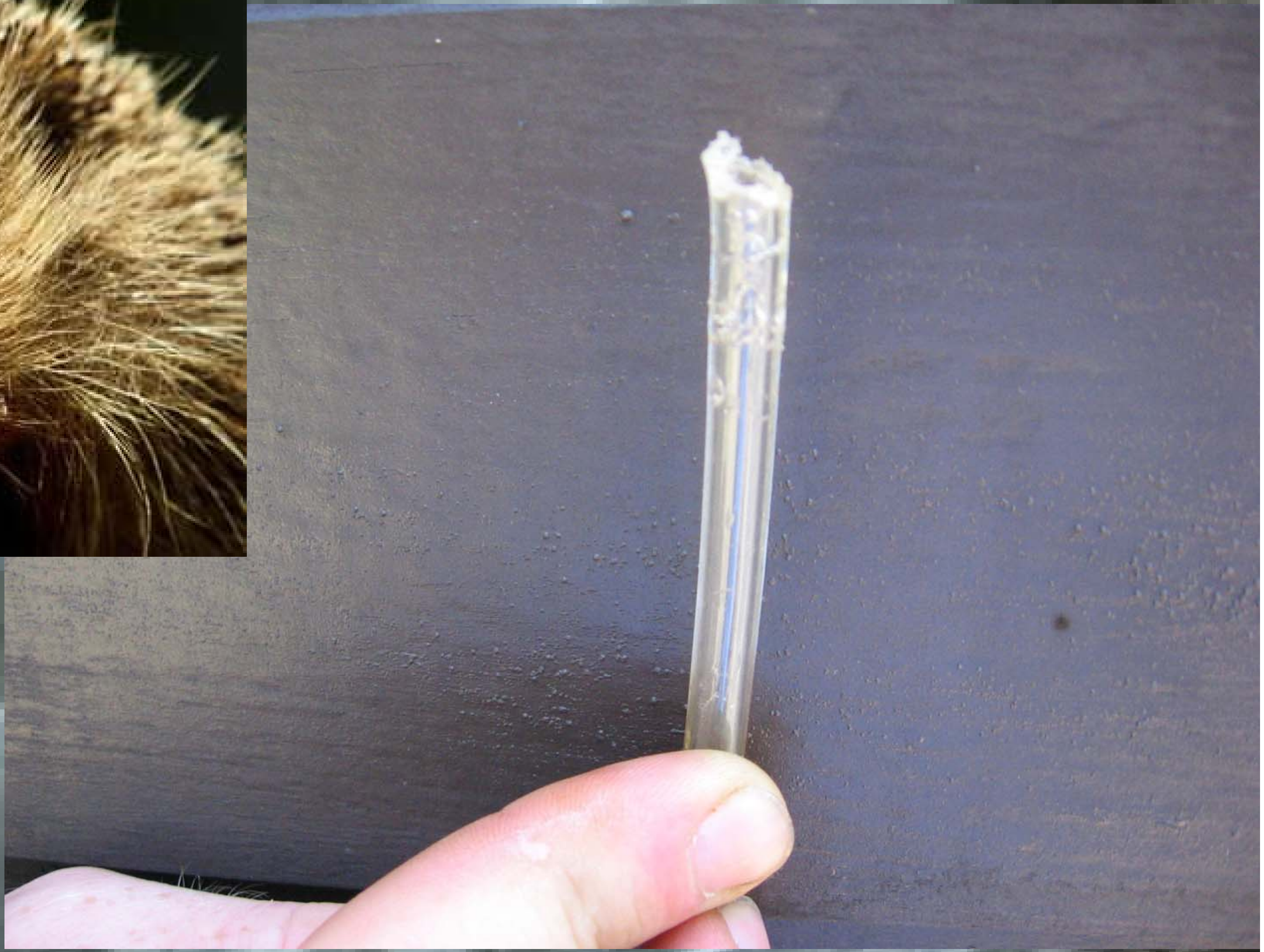


Effective Sample Collection

- BE PREPARED!!
- Clean containers
- Purging
- Representative
- Preservation
- Chain of Custody

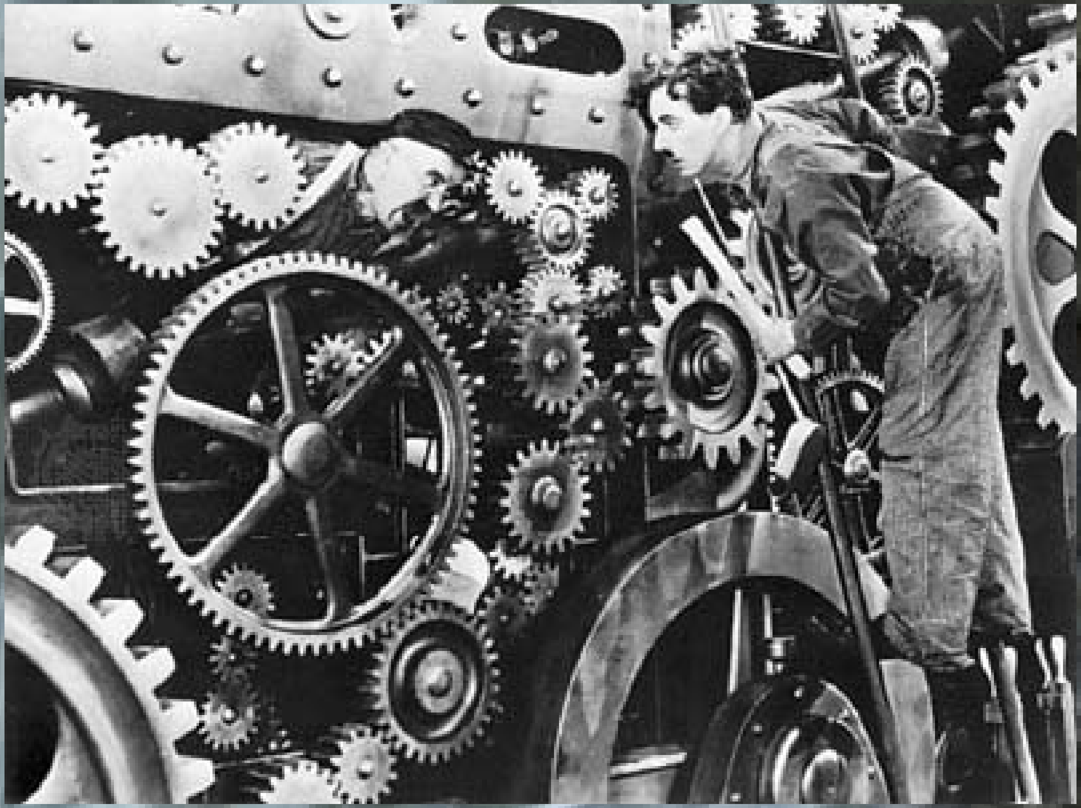
If you really want to understand the importance of each sample, ask yourself, “What is it worth to me for this sample to be lost?”

Expect the unexpected



Quality Assurance

- Duplicates
- Spikes
- Double-checks
- QA officer
- Review Data
  Frequently



Interpretation

- Graphical
- Statistical

What will make the biggest impact?

Dissemination

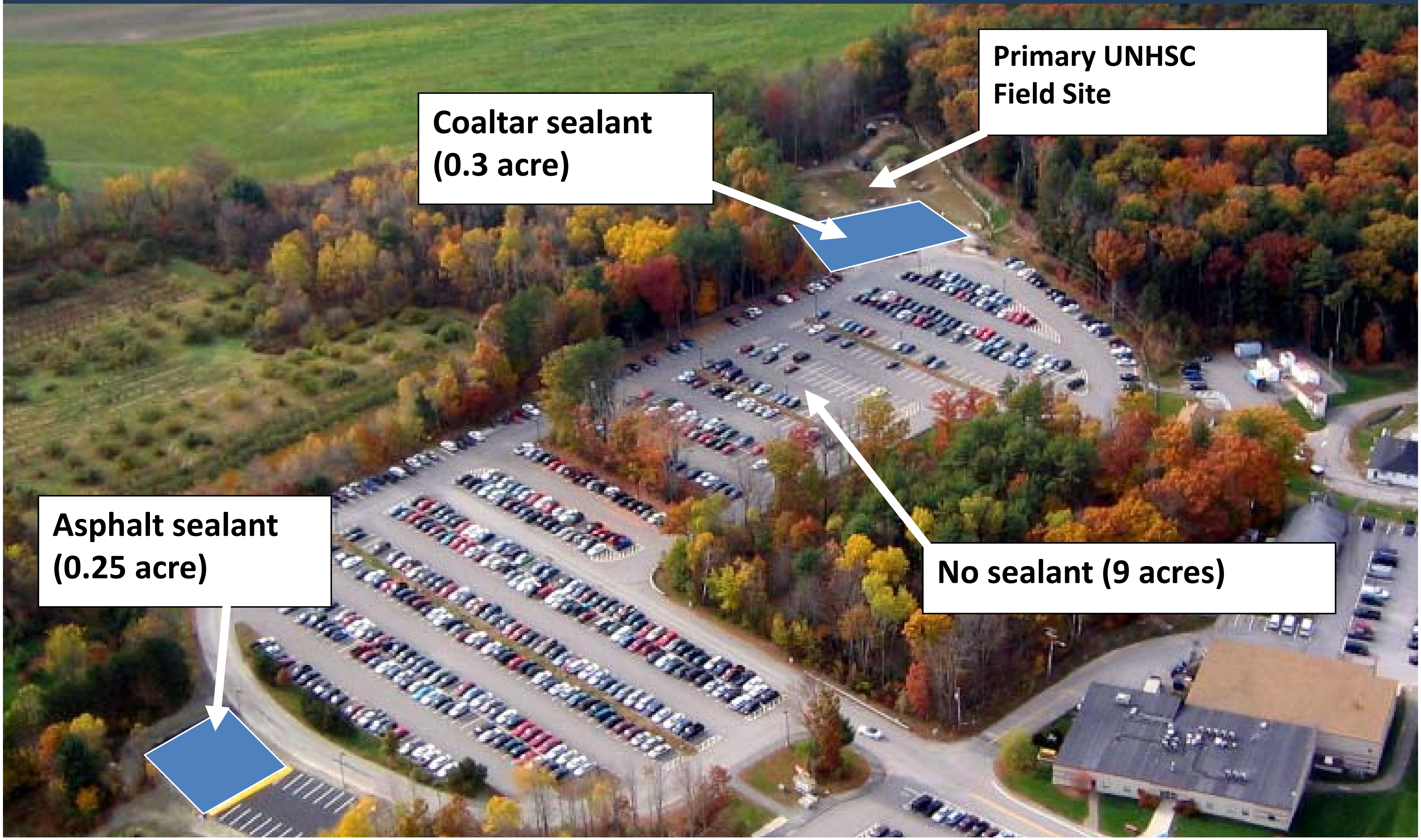
- Final report
- Project updates
- Public presentations
- Professional presentations

Example - PAH

OBJECTIVE

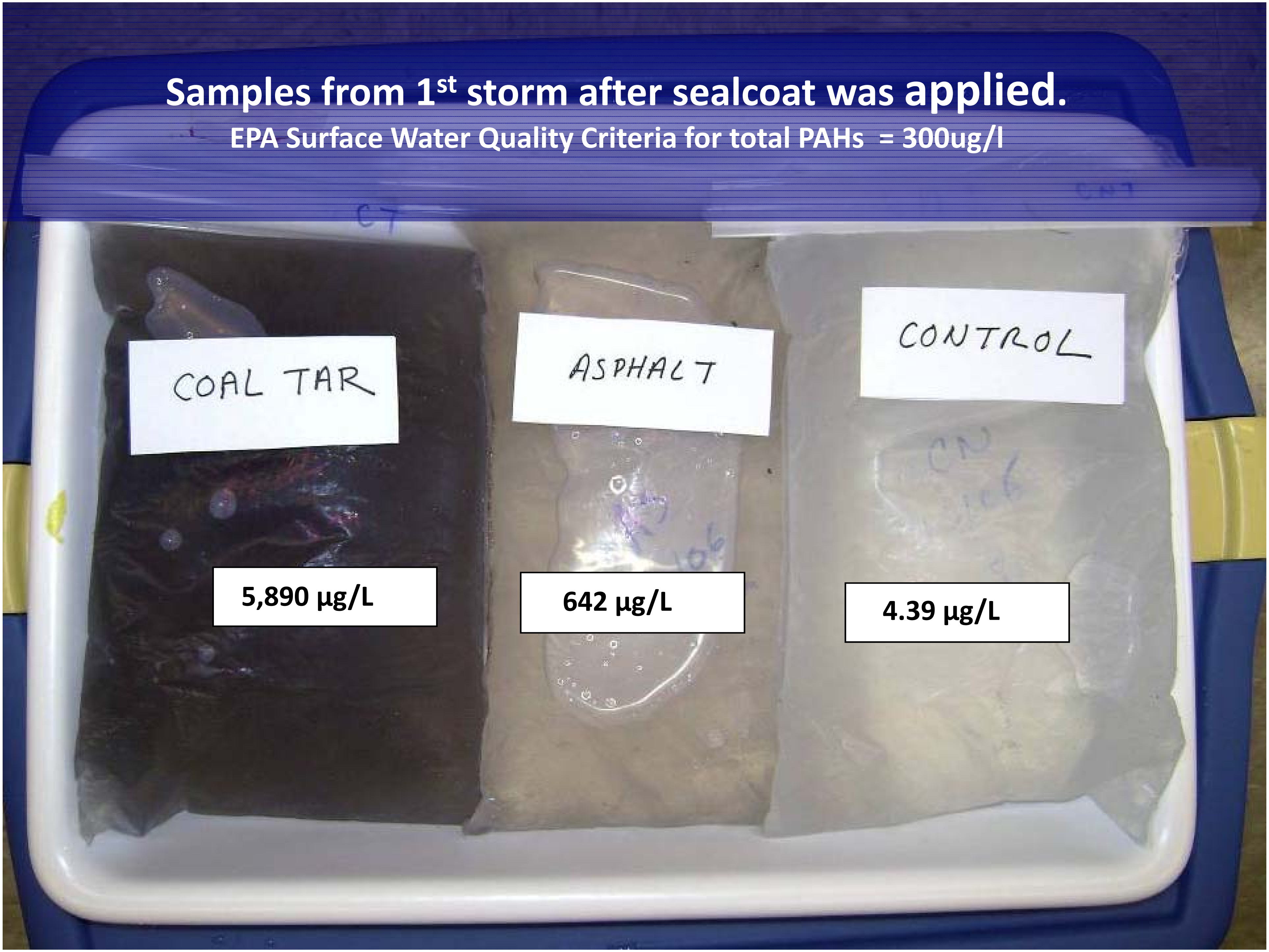
- Are sealcoats (coal tar and asphalt) sources of PAHs in runoff and in our waterways?

Polycyclic Aromatic Hydrocarbons (PAHs) in runoff from sealcoated parking lots

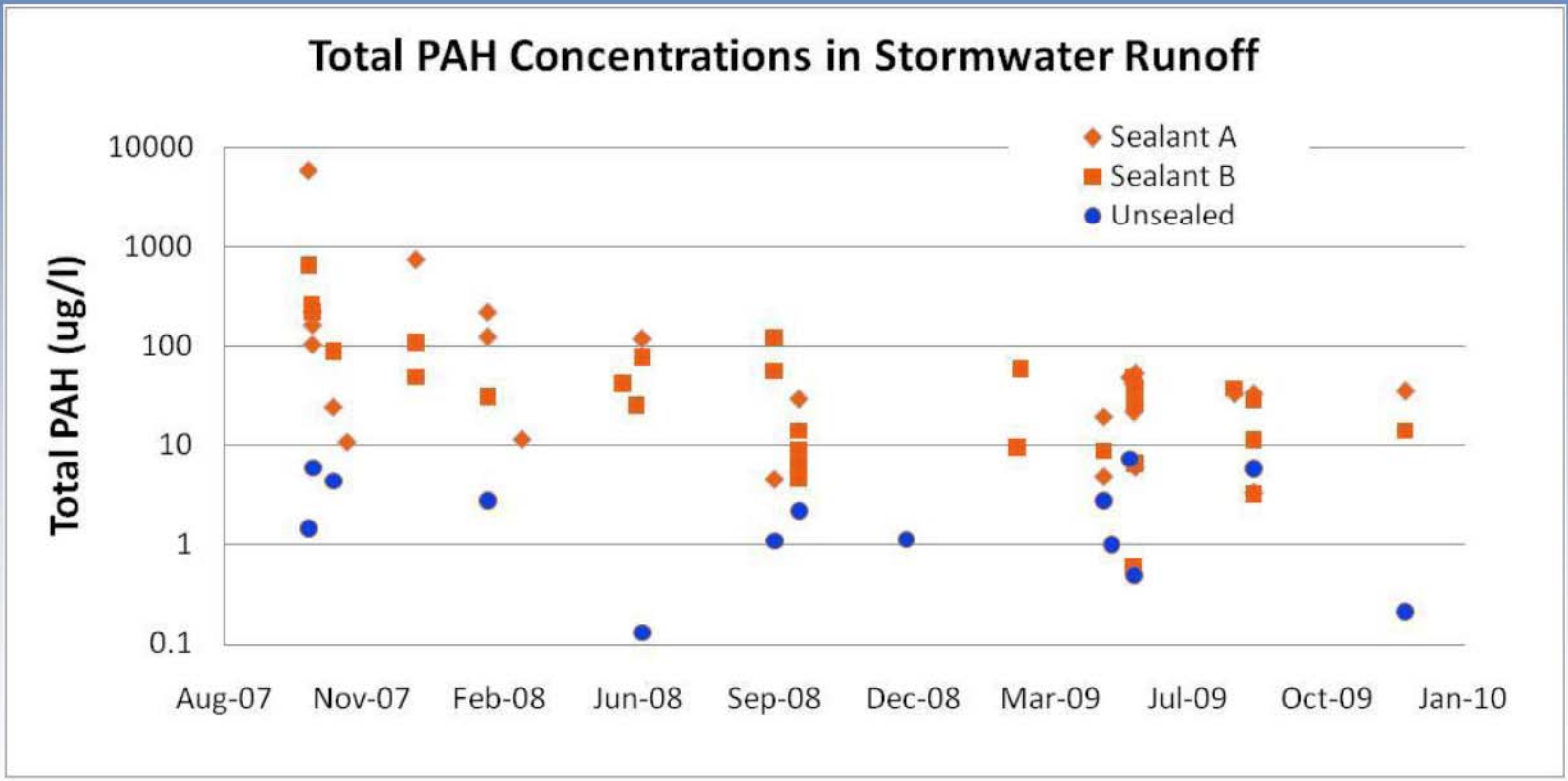


Samples from 1st storm after sealcoat was applied.

EPA Surface Water Quality Criteria for total PAHs = 300ug/l



PAH (Sum 16) Concentrations in Composite Stormwater Samples



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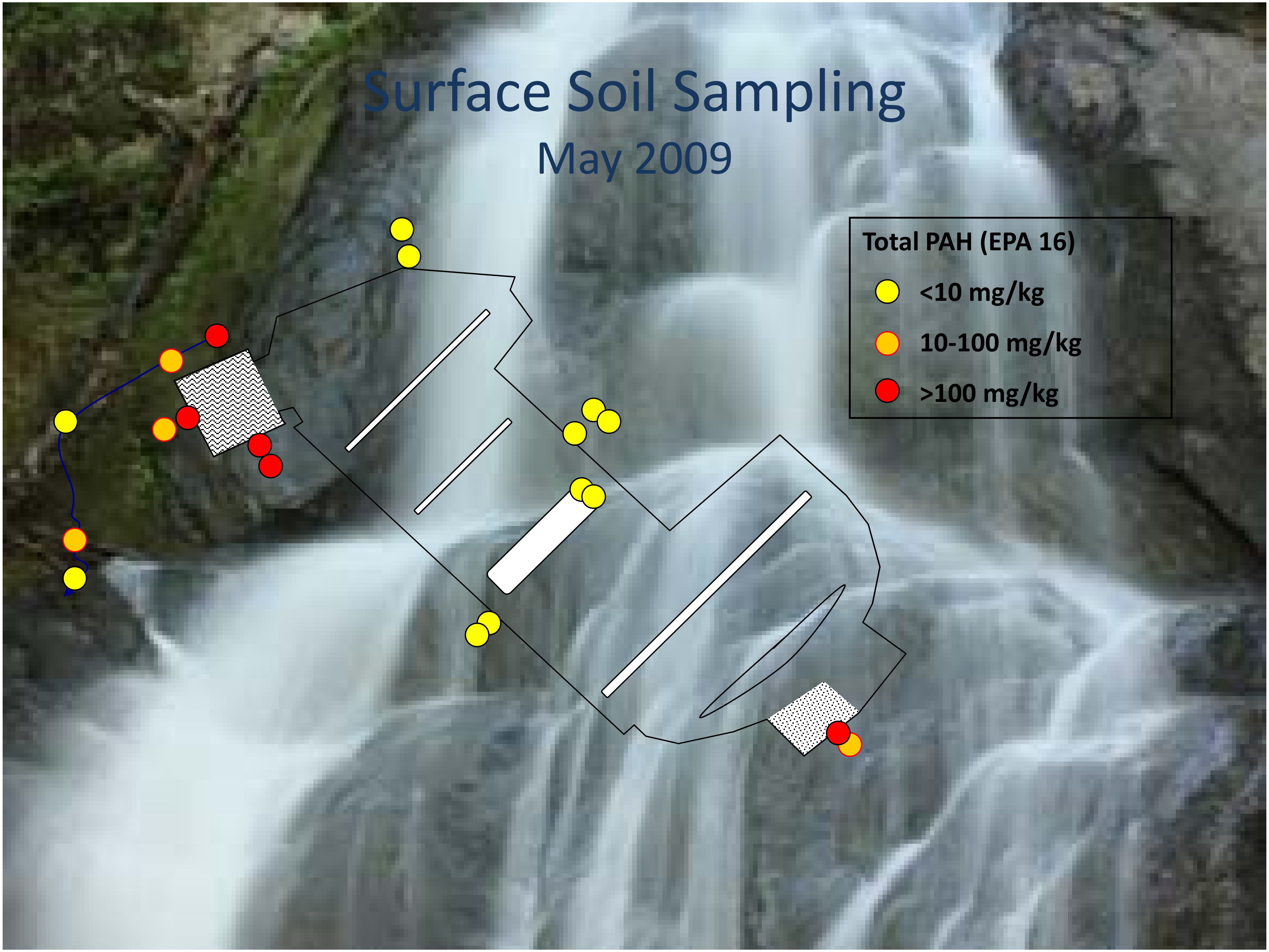
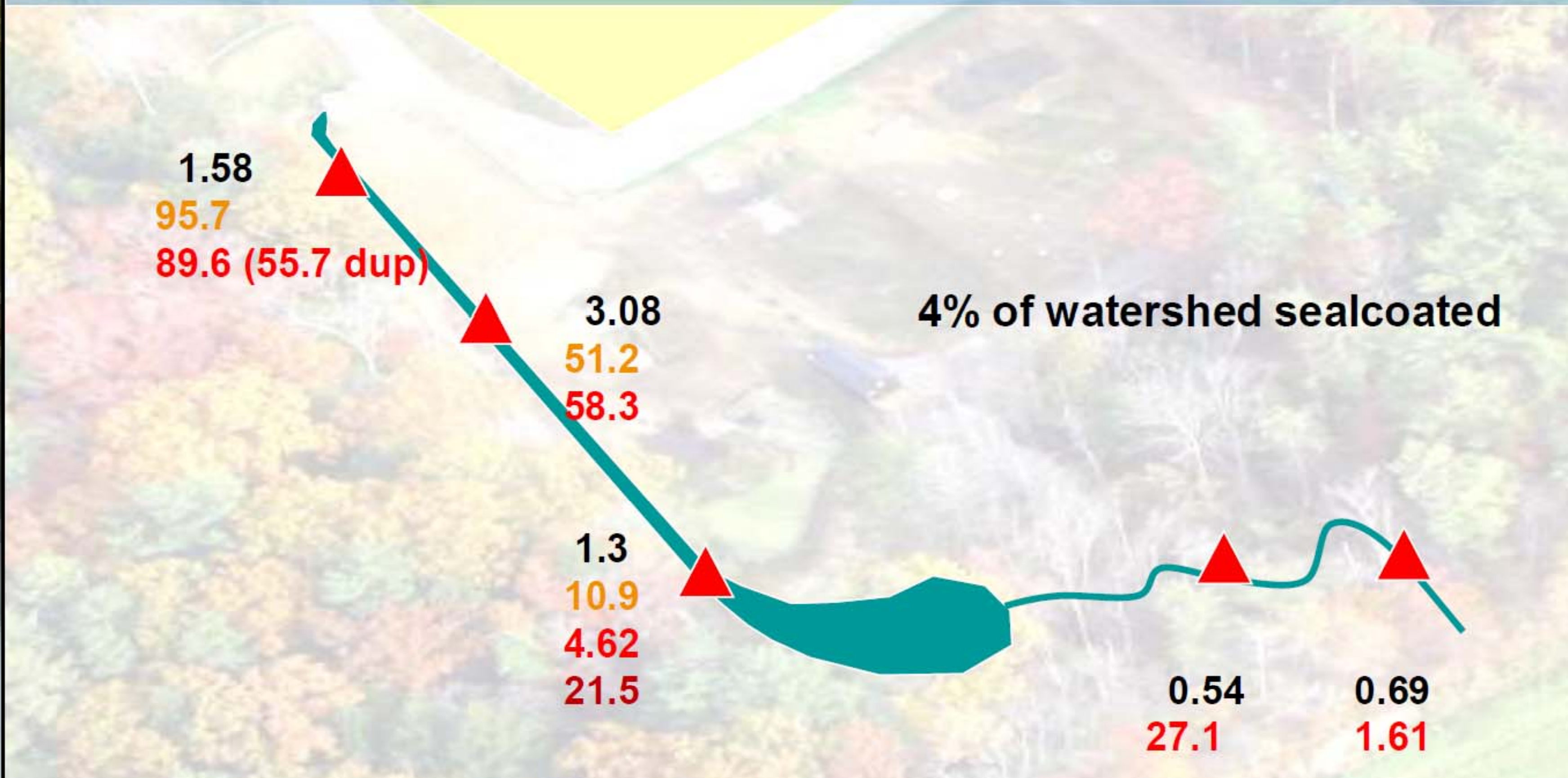
Surface Soil Sampling

May 2009



Total PAH (mg/kg) in surface sediments

Pre sealant - Oct 2007
9 months after sealant - June 2008
12 months after sealant – Oct 2008
24 months after sealant – Oct 2009



So –What have we learned?

- Increased PAHs in surface soil –possible human health risk in residences
- Stormwater runoff: 5 –1,000 ug/l total PAHs (6,000 ug/l in first rain), consistently higher than control
- Application matters: type of sealant, pavement conditions, weather may change release rate
- Increased PAH concentrations downstream of site, but may be fairly local

Example – Total Capture

OBJECTIVE

Which method of sediment sampling and reporting best reflects total sediment mass or sediment particle size distribution?

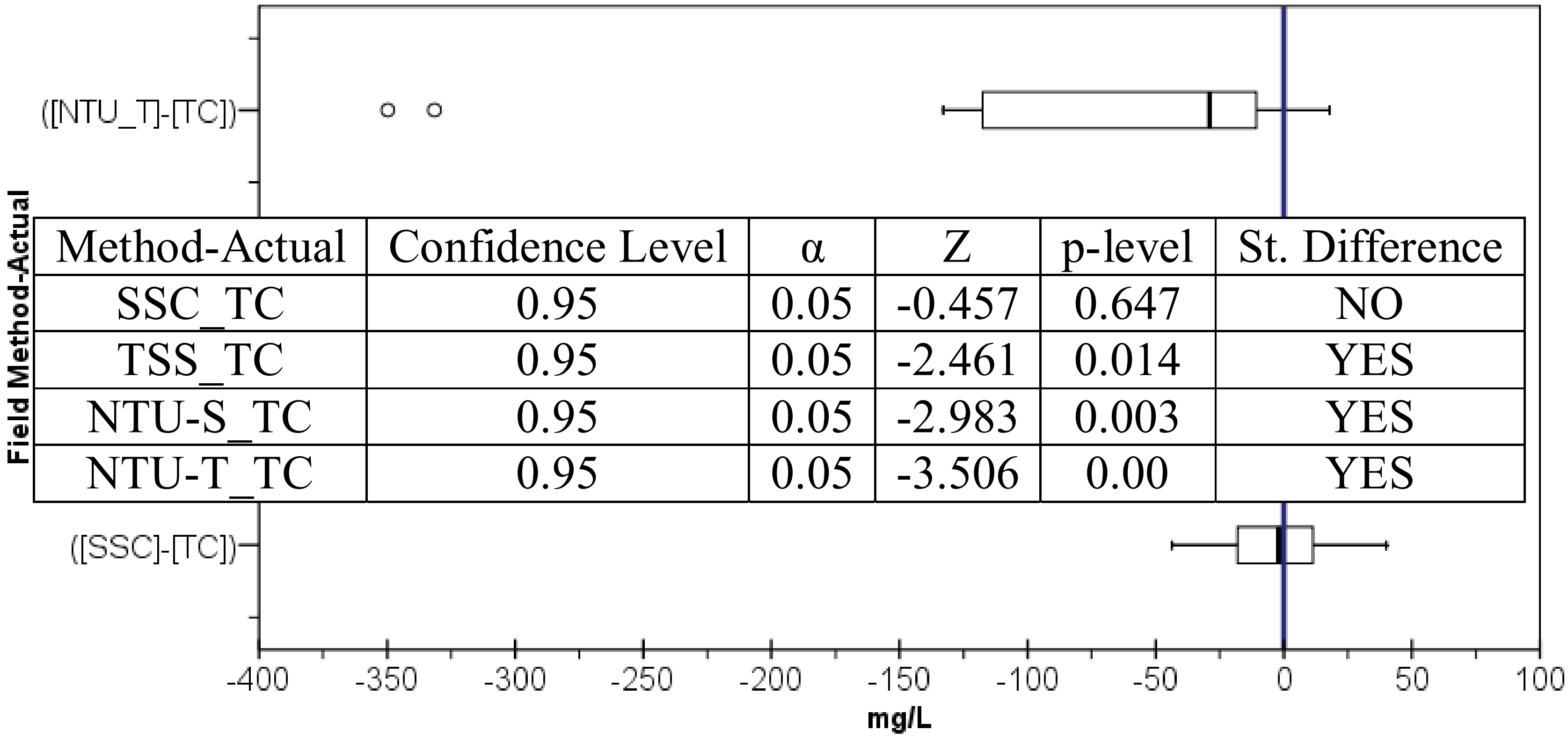
Experimental Design:

Sampling and Measuring Suspended Sediments

- One Bench Mark Method
  - Total Capture Sample
- Four Monitoring Methods
  - Automatic Samplers With Analytical Method
    - Suspended Solids Concentration
    - 2. Total Suspended Solids
  - Real Time Turbidity Measurements
    - 3. Paired with a SSC measurement
    - 4. Paired with a TSS measurement

Results

Data Synthesis: Event Mean Concentration



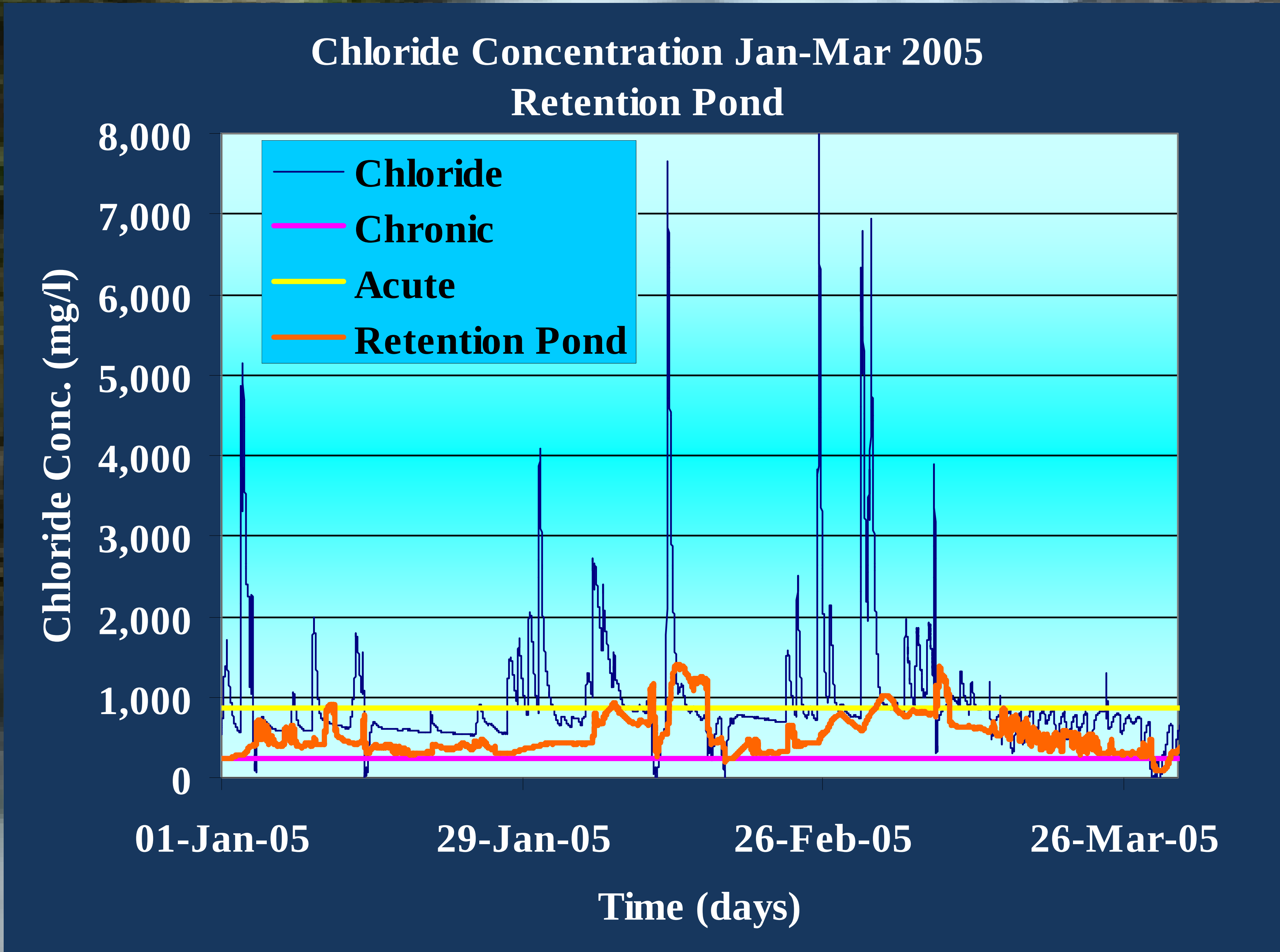
Method-Actual	Confidence Level	α	Z	p-level	St. Difference
SSC_TC	0.95	0.05	-0.457	0.647	NO
TSS_TC	0.95	0.05	-2.461	0.014	YES
NTU-S_TC	0.95	0.05	-2.983	0.003	YES
NTU-T_TC	0.95	0.05	-3.506	0.00	YES

n=18

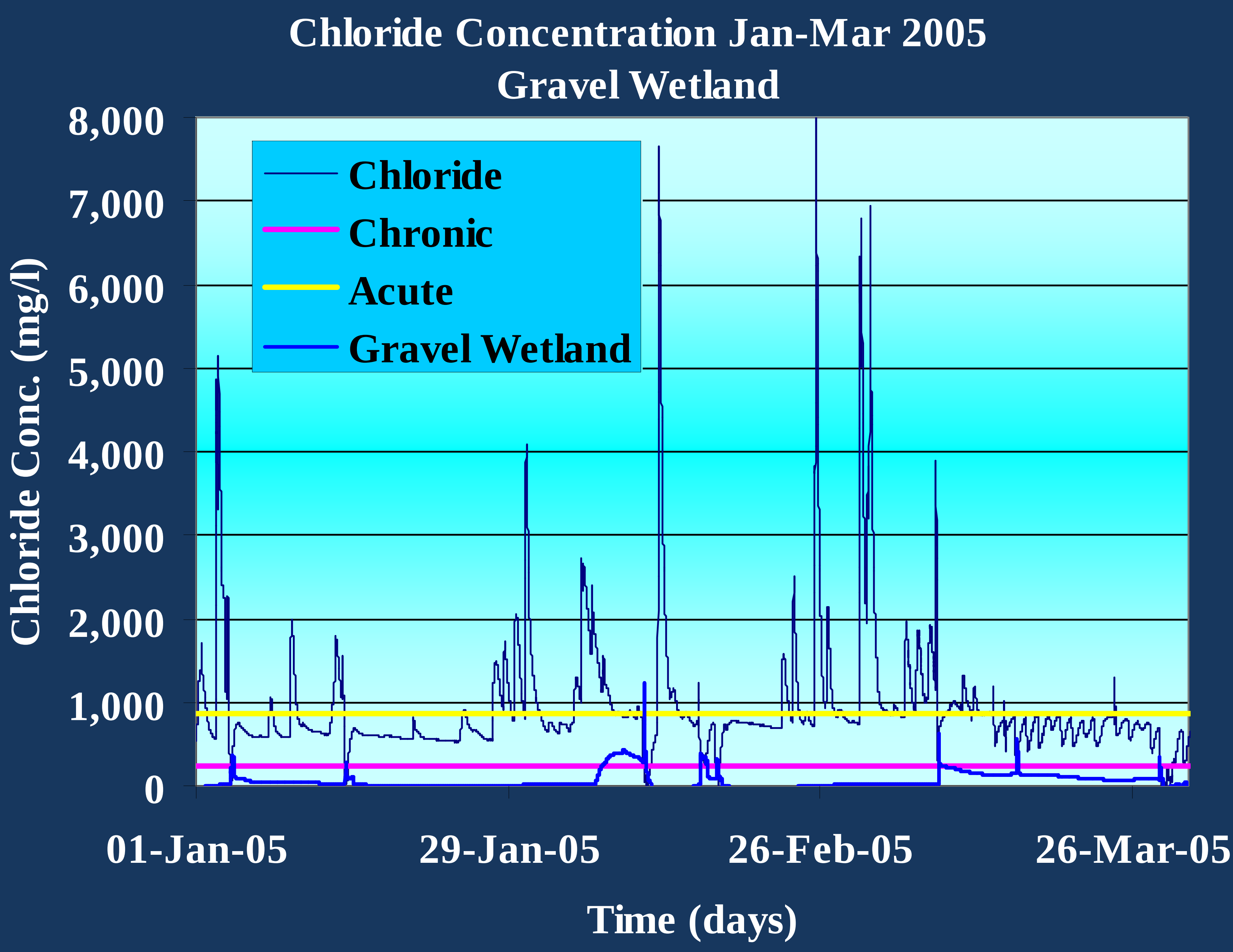
Example – Salt and Porous Pavements

OBJECTIVE

Is there a possible winter salt reduction for porous pavements?



Chloride Concentration Jan-Mar 2005
Retention Pond
Chloride
Chronic
Acute
Retention Pond
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
Chloride Conc. (mg/l)
01-Jan-05
29-Jan-05
26-Feb-05
26-Mar-05
Time (days)

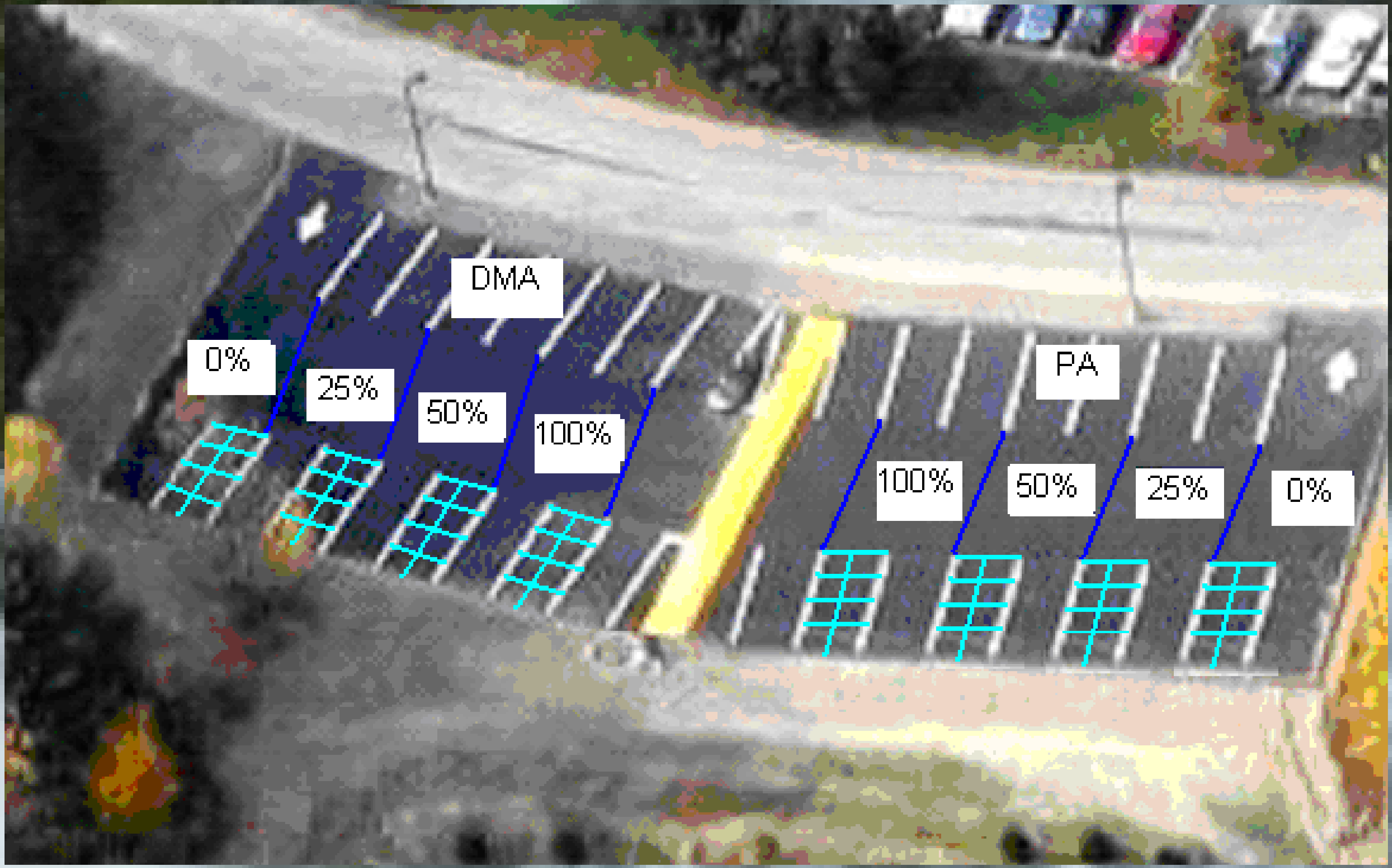

Chloride Concentration Jan-Mar 2005
Gravel Wetland
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
Chloride Conc. (mg/l)
Chloride
Chronic
Acute
Gravel Wetland
01-Jan-05
29-Jan-05
26-Feb-05
26-Mar-05
Time (days)

Chloride in Parking Lot Runoff

- 95% of the 3 month period Chloride was above the chronic level (230 mg/l)
- 33% of the 3 month period Chloride was above the acute level (860 mg/l)
- Routinely observed over 5,000 mg/l, with recorded peaks of 18,745 mg/l

  {Saltwater = 28,000-32,000 mg/l}

Porous Asphalt Study Area Orientation



Measuring Skid Resistance w/ BPT

ASTM STANDARD E303-93

Chloride (Salt) Recovery

- Vacuumed salt
- Dissolved material in warm water
- Measured specific conductivity
- Applied value to UNHSC regression
- Compared results for both lots

Observations of Surface Cover

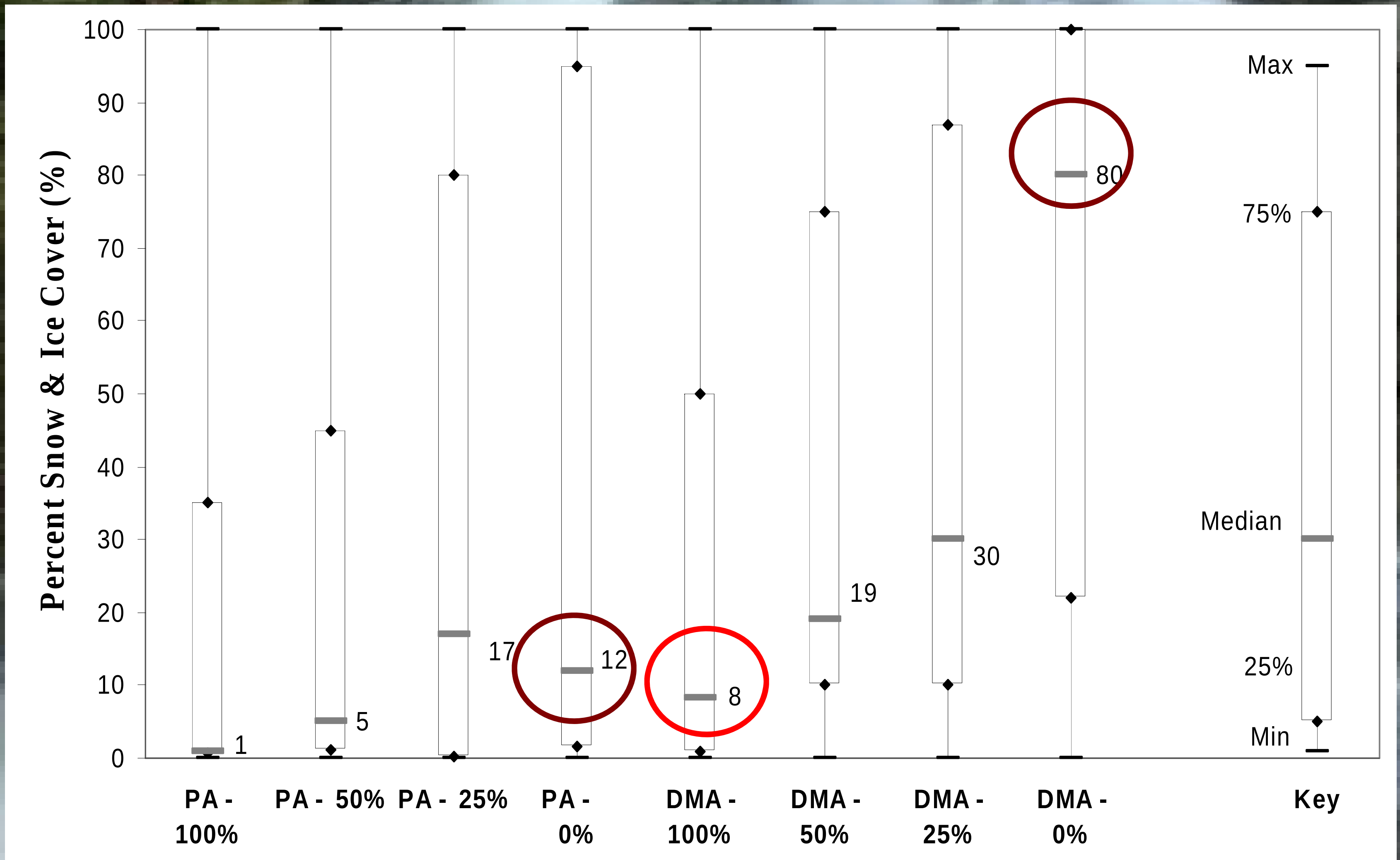
DMA 1-HR AFTER PLOWING, 11AM
-4°C

PA 1-HR AFTER PLOWING, 11 AM
-4°C

Conditions after thawing and refreezing of melt-water (3/18/07)(a) PA at 9AM (left); (b) DMA at 9AM (rt)

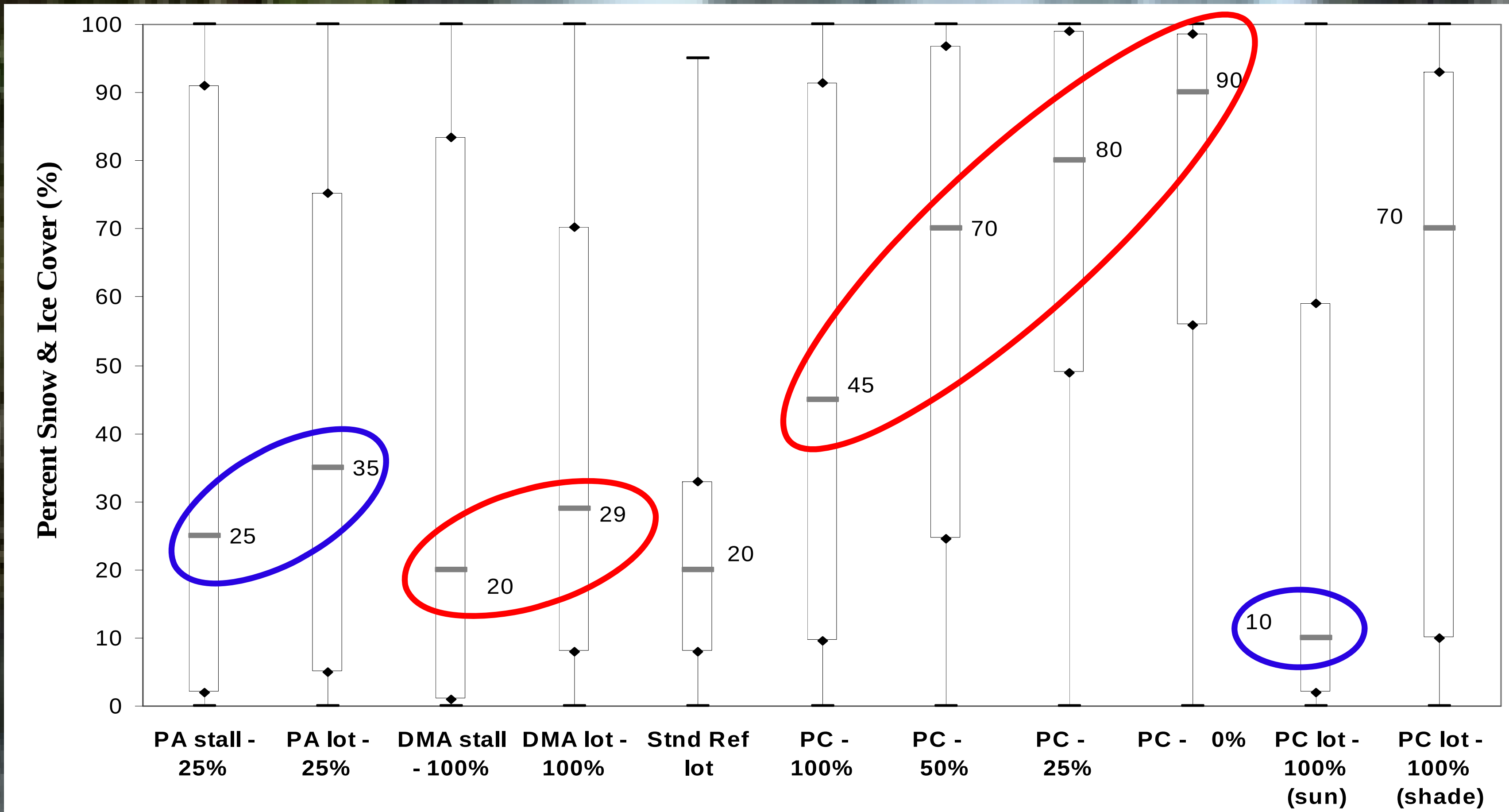
Conditions after thawing and refreezing of melt-water (2/16/08) (a) PC at 1PM (left); (b) DMA at 1PM (rt)

Comparison of snow/ice percent cover for study areas on all lots (winter '06-'07)



- More snow & ice present on DMA

Comparison of snow/ice percent cover for study areas on all lots (winter '07-'08)



- Snow and Ice Cover is comparable for PA 25%, PC 100% (full sun) and DMA 100% application
- PC does poorly in shaded areas

Conclusion About Friction

- Higher frictional properties on PA and PC
- Salt reductions possible during freeze-thaw conditions
  - No standing water
- Little to no salt needed if plowing occurs
- Up to 75% salt reduction from SOP possible
- Deicing may still be necessary after freezing-rain
- PA and PC are currently the only stormwater strategies that can minimize chloride threat to groundwater w/o lining
  - Less chloride applied = Lower risk

Questions?

http://www.unh.edu/erg/cstev/