Designing Monitoring Programs to Evaluate BMP Effectiveness

Nancy Mesner, Dept of Watershed Sciences
Utah State University
nancy.mesner@usu.edu; 435 797 7541

Ginger Paige, University of Wyoming
Andree' Walker, USEE

University of Wyoming
New Thinking

Applying knowledge to improve water quality
Northern Plains & Mountains Regional Water Program
A Partnership of USDA CSREES & Land Grant Colleges and Universities

UtahStateUniversity

Overview

- Lessons learned
  - USDA/CSREES Conservation Effects Assessment Project

- The Guidance Document

  Water Quality Monitoring Training Resources
  - Components and key links…
  - Next steps

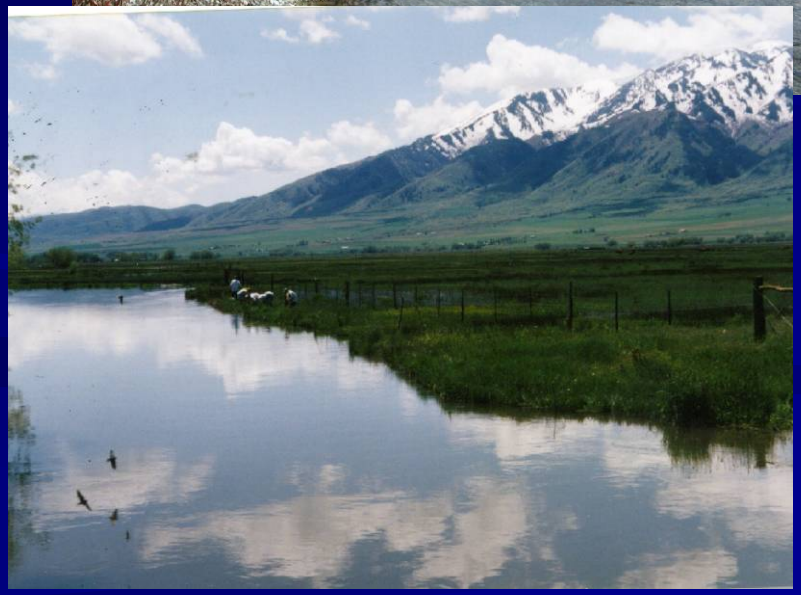
CSREES Conservation Effectiveness Assessment for the Little Bear River

Objective 1. Determine if programs to promote adoption of best management practices have reduced P loads at **a** watershed scale.

Objective 2. Critically examine strengths and weaknesses of different water quality monitoring techniques.

Objective 3. Develop recommendations on the most effective and socioeconomically viable agricultural bmps.

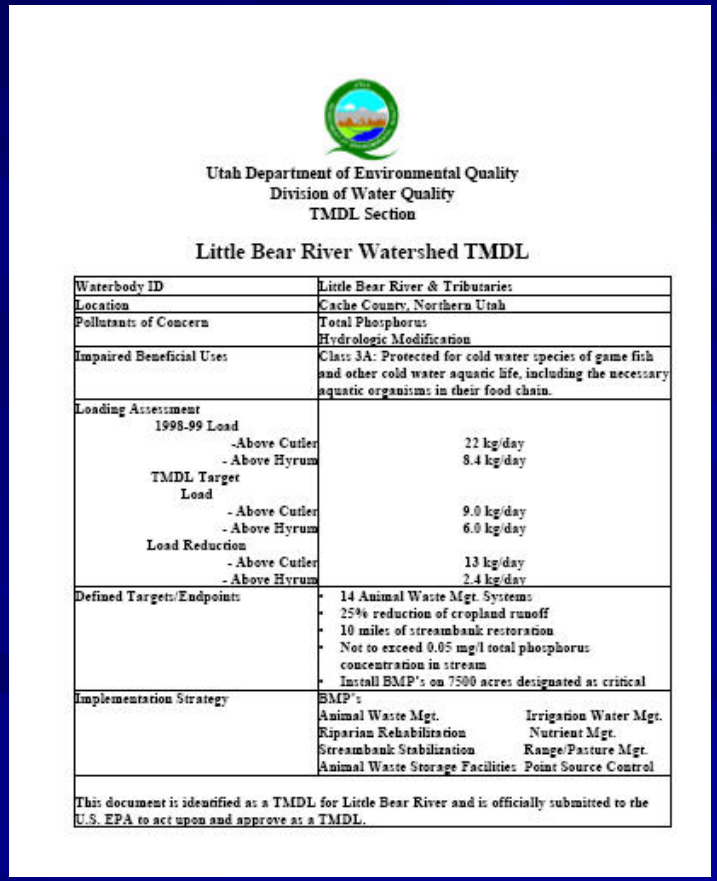
Little Bear River Hydrologic Unit Project



Pre-treatment problems:
Bank erosion, manure management, flood irrigation problems

WQ efforts in Little Bear

- Hydrologic Unit Area Project
- TMDL Project, 319 funds
- Additional cost share programs
- Other planning (eg Phase II, Source Water Protection)



Utah Department of Environmental Quality
Division of Water Quality
TMDL Section

Little Bear River Watershed TMDL

Waterbody ID	Little Bear River & Tributaries
Location	Cache County, Northern Utah
Pollutants of Concern	Total Phosphorus Hydrologic Modification
Impaired Beneficial Uses	Class 3A: Protected for cold water species of game fish and other cold water aquatic life, including the necessary aquatic organisms in their food chain.
Loading Assessment 1998-99 Load -Above Cutler - Above Hyrum TMDL Target Load - Above Cutler - Above Hyrum Load Reduction - Above Cutler - Above Hyrum	 22 kg/day 8.4 kg/day 9.0 kg/day 6.0 kg/day 13 kg/day 2.4 kg/day
Defined Targets/Endpoints	• 14 Animal Waste Mgt. Systems • 25% reduction of cropland runoff • 10 miles of streambank restoration • Not to exceed 0.05 mg/l total phosphorus concentration in stream • Install BMP's on 7500 acres designated as critical
Implementation Strategy	BMP's Animal Waste Mgt. — Irrigation Water Mgt. Riparian Rehabilitation — Nutrient Mgt. Streambank Stabilization — Range/Pasture Mgt. Animal Waste Storage Facilities — Point Source Control
This document is identified as a TMDL for Little Bear River and is officially submitted to the U.S. EPA to act upon and approve as a TMDL.	

Little Bear River
Hydrologic Unit Area

Jon Hardman
1800 North 100 East
North Logan, UT 84321
(435) 753-5616

Michael D. Allred
179 North Main Room205
Logan, UT 84321
(435) 753-5279

Overview

Introduction

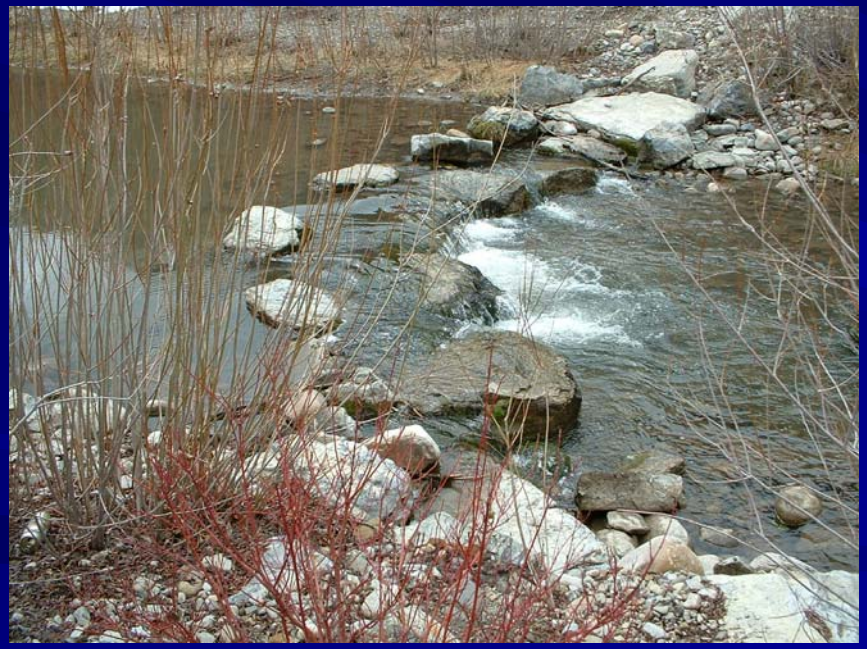
Located in the southern end of beautiful Cache Valley, the Little Bear River rises under from its headwaters in the Southeast East Fork to its confluence with Cutler Reservoir. The 122 miles of perennial streams and 228 miles of intermittent streams drain water from a 194,432 acre watershed supporting a variety of land uses including forest and rangeland, irrigated and dry cropland, pasture and urban areas.

In 1990, the Little Bear River became part of a five year on going water quality project with the goal of raising water quality awareness and voluntarily implementing specific conservation practices to help improve and protect the quality of water in the river.

As Utah's first USDA-assisted Hydrologic Unit Area Water Quality Project the Little Bear River Project (LBRP) continues to showcase resource management systems that have been implemented and duplicated throughout the state.

Identified as a high priority watershed by the Utah Non Point Source Task Force, LBRP staff collected monitoring data during 1990 - 92 on potential sources of water quality problems in the watershed. Scoping meetings with area residents, conservation groups, local, state, and federal agencies indicated a number of resource concerns in the watershed. With limited staff and financial resources the project steering committee targeted streambank restoration activities, manure management and erosion reduction on grassland as their top priorities and developed a plan to guide implementation of the project's goals.

Project staff have worked with landowners and area decision makers to address water quality concerns throughout the project area. Through coordinated resource management planning efforts a broad array of partners provided guidance and input into project priorities and activities.



Treatments:

- bank stabilization,
- river reach restoration,
- off-stream watering,
- improved manure and water management

Lessons Learned: Common problems in BMP monitoring programs

- Failure to design monitoring plan around BMP objectives

- Failure to identify and quantify sources of variability in these dynamic systems.

- Failure to understand pollutant pathways and transformations → choosing inappropriate monitoring approaches

- Failure to design monitoring plan around BMP objectives

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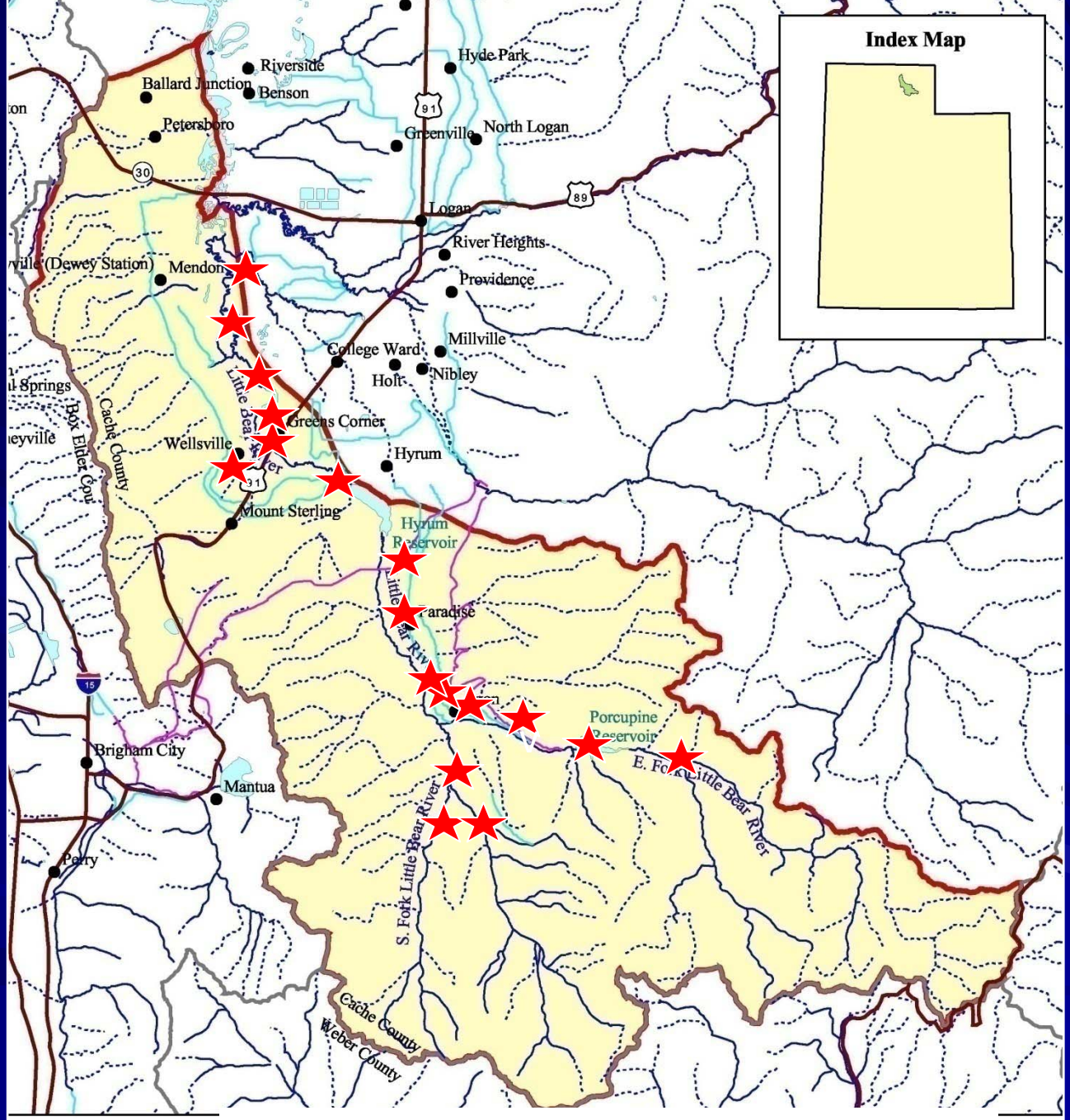


Little Bear River Watershed, Utah

Total Observations at Watershed Outlet site

	Discharge	Total phosphorus
1976 - 2004:	162	241
1994 - 2004:	72	99
1994	11	13
1995	10	13
1996	10	13
1997	11	4
1998	6	10
1999	7	10
2000	6	5
2001	4	7
2002	2	8
2003	4	8
2004	1	8

Number of observations each year

Was the original UDWQ monitoring program a failure?

No….Program was intended to detect exceedences of water quality criteria.

The failure was ours…. In attempting to use these monitoring data for detecting change in loads

- Failure to design monitoring plan around BMP objectives

- Failure to identify and quantify sources of variability in these dynamic system.

- A failure to understand pollutant pathways and transformations → choosing inappropriate monitoring approaches

Since 2005, measure flow and turbidity at 30 minute intervals

Stage recording devices to estimate discharge

http://www.campbellsci.com

Turbidity sensors

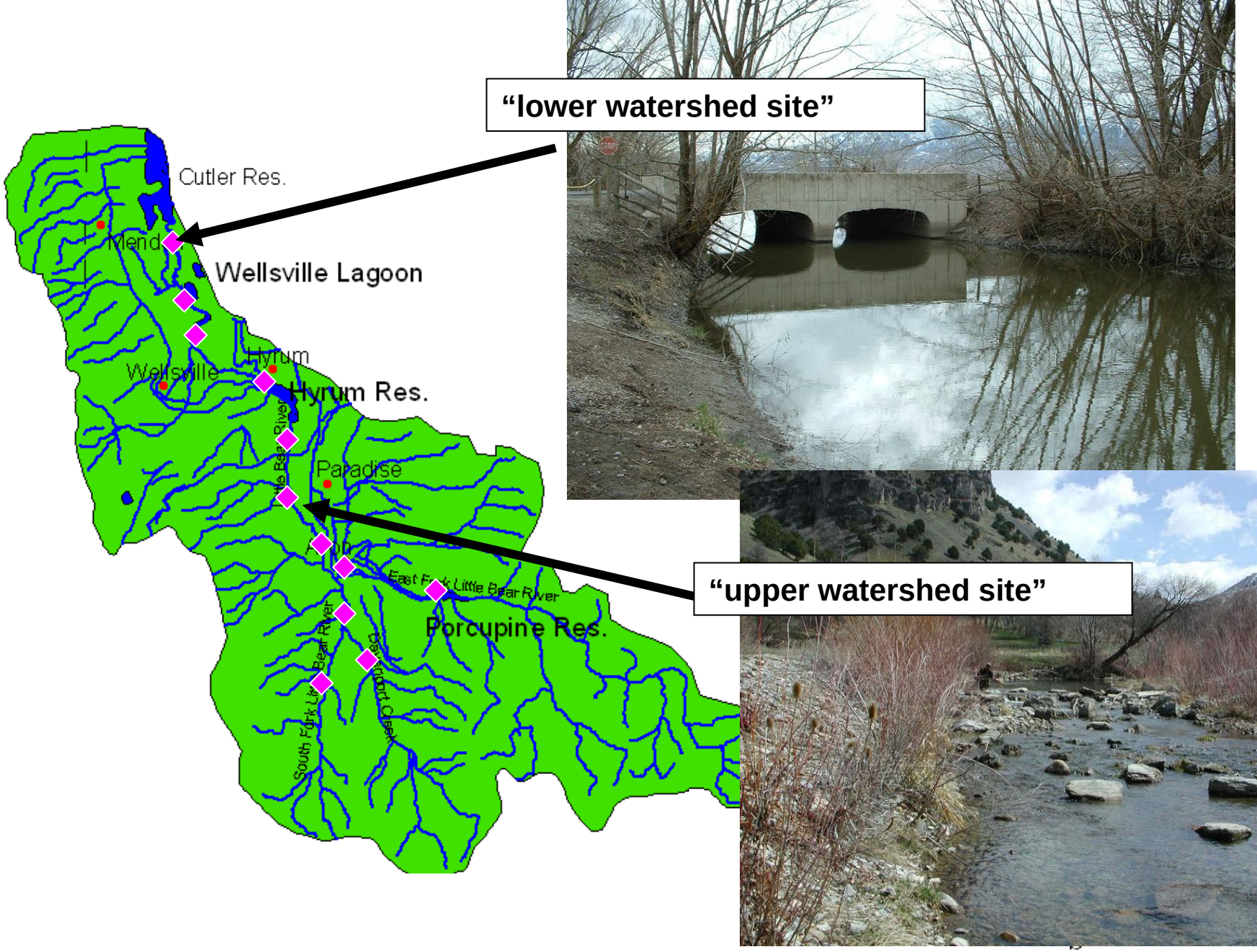
http://www.ftsinc.com/

Dataloggers and telemetry equipment

http://www.campbellsci.com

Additional monitoring:

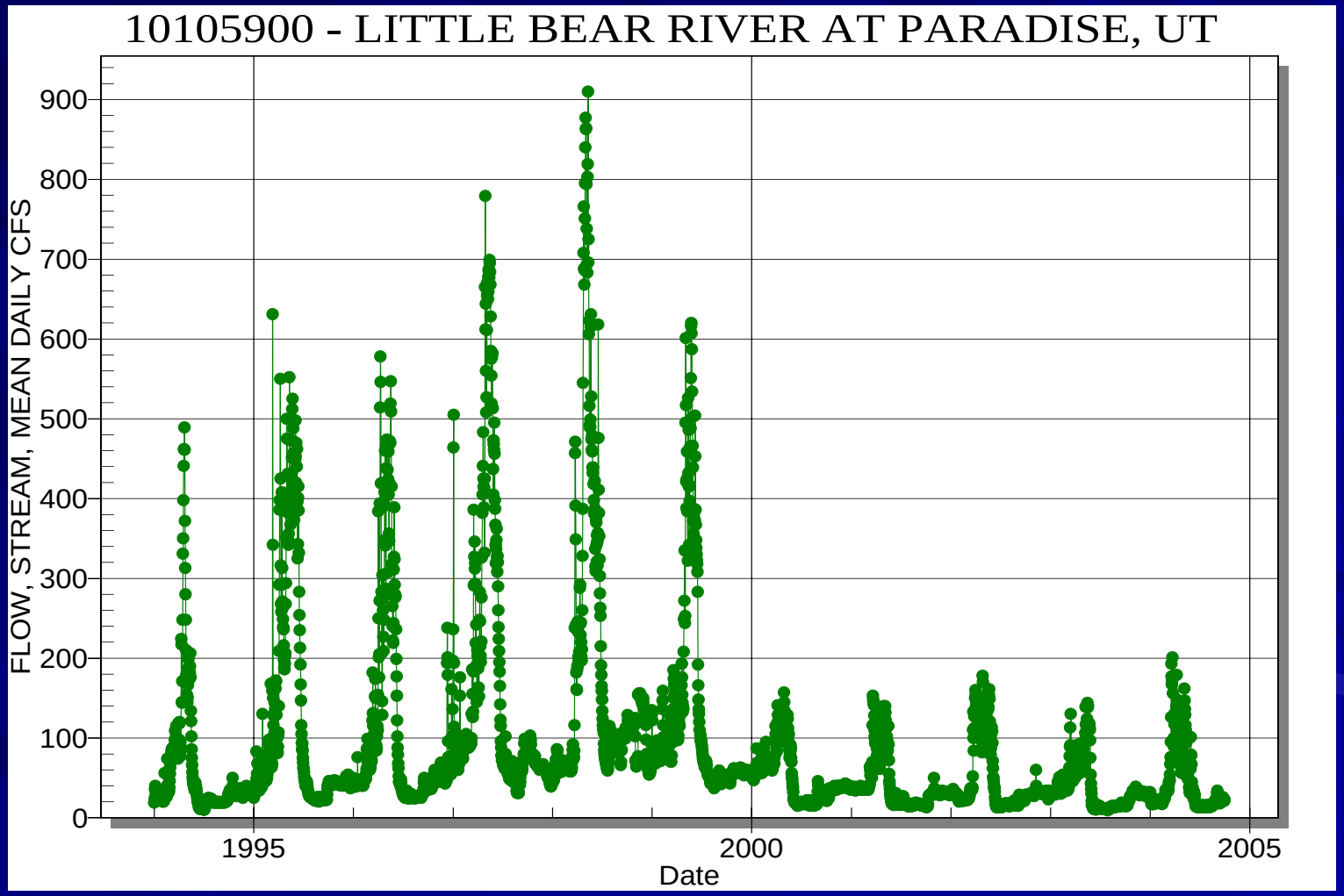
- Automated sampling of storm events at two sites
- Ongoing monitoring program by Utah Division of Water Quality
- Periodic grab samples to establish Flow / TSS and TSS/TP relationship

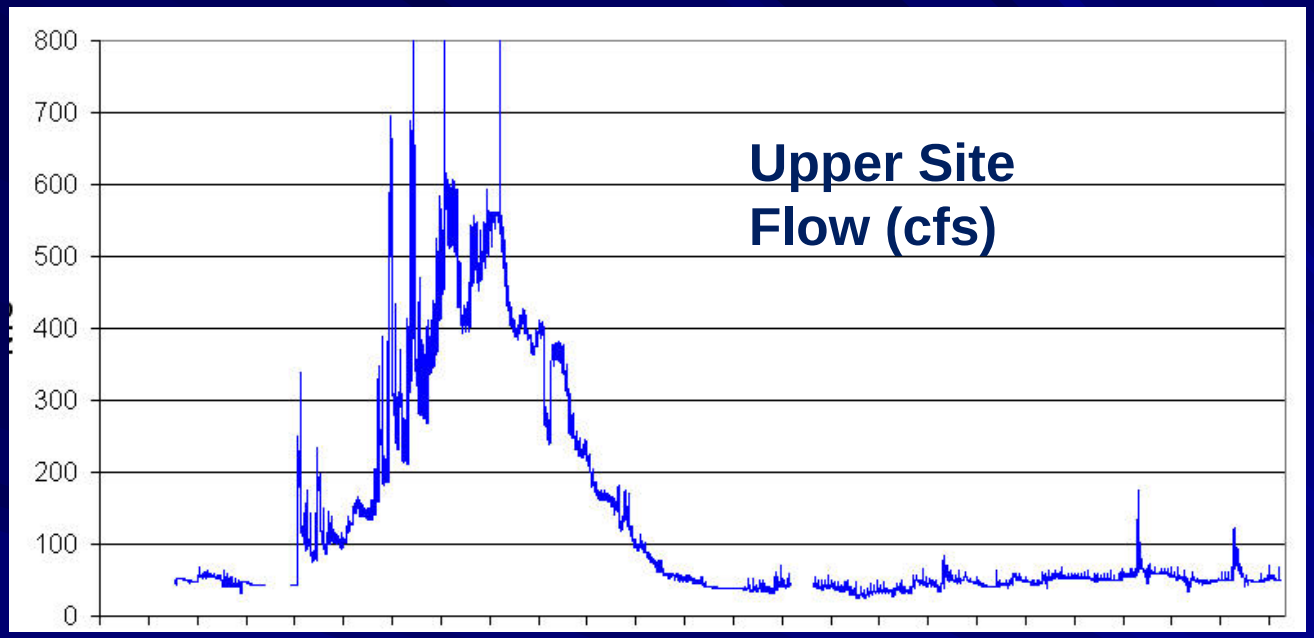

“lower watershed site”
“upper watershed site”
Cutler Res.
Mend
Wellsville Lagoon
Hyrum
Wellsville
Hyrum Res.
Paradise
Porcupine Res.
East Fork Little Bear River
South Fork Little Bear River

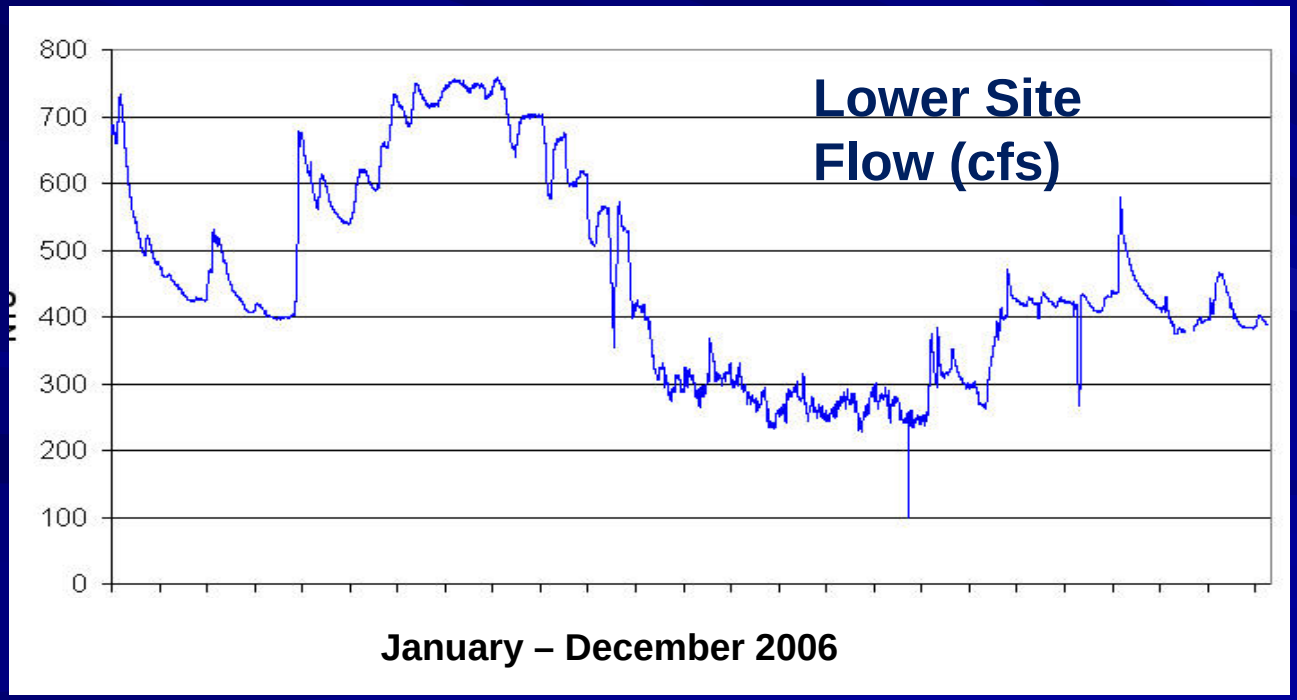
Understanding natural variability: Sources of error in sampling

- Relationship of surrogate to target pollutant
- Sampling frequency
- Timing of sampling
- Rare events

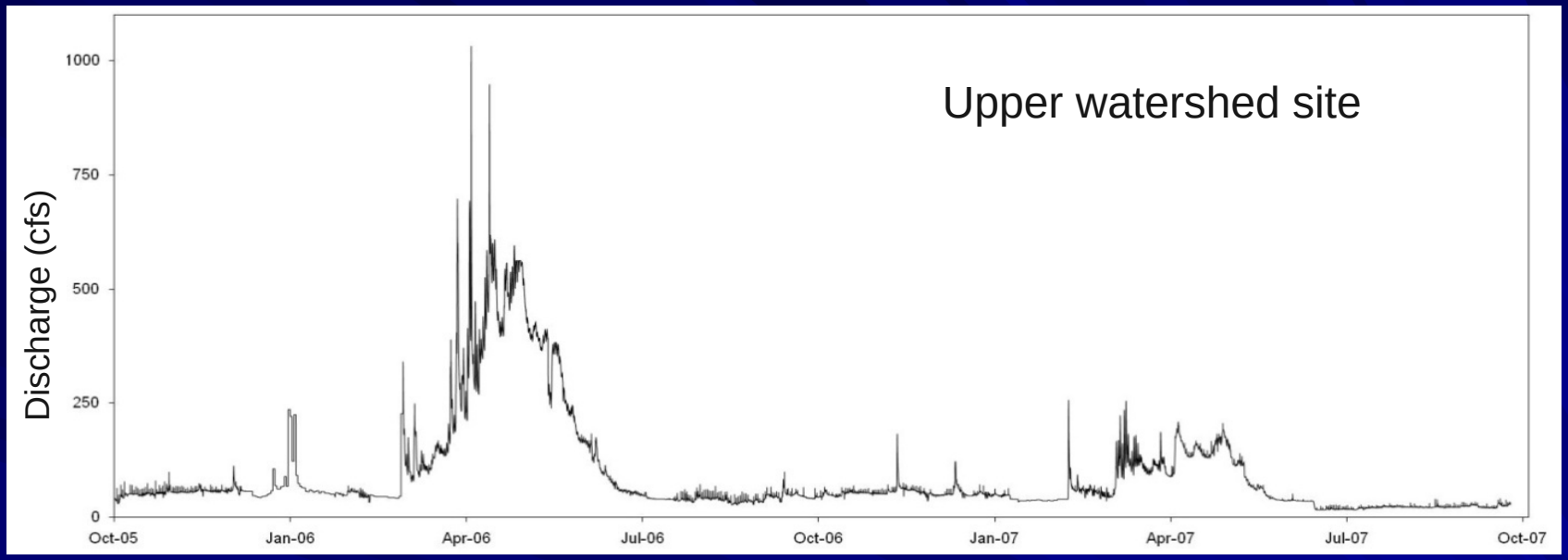
- Seasonal and annual variation

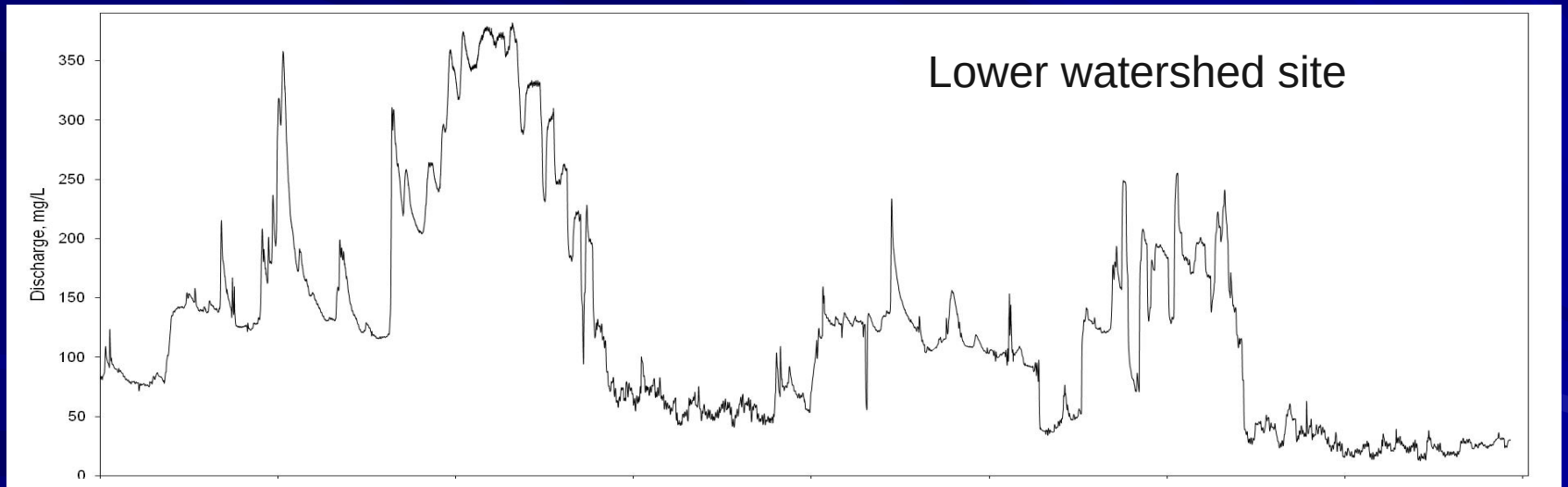




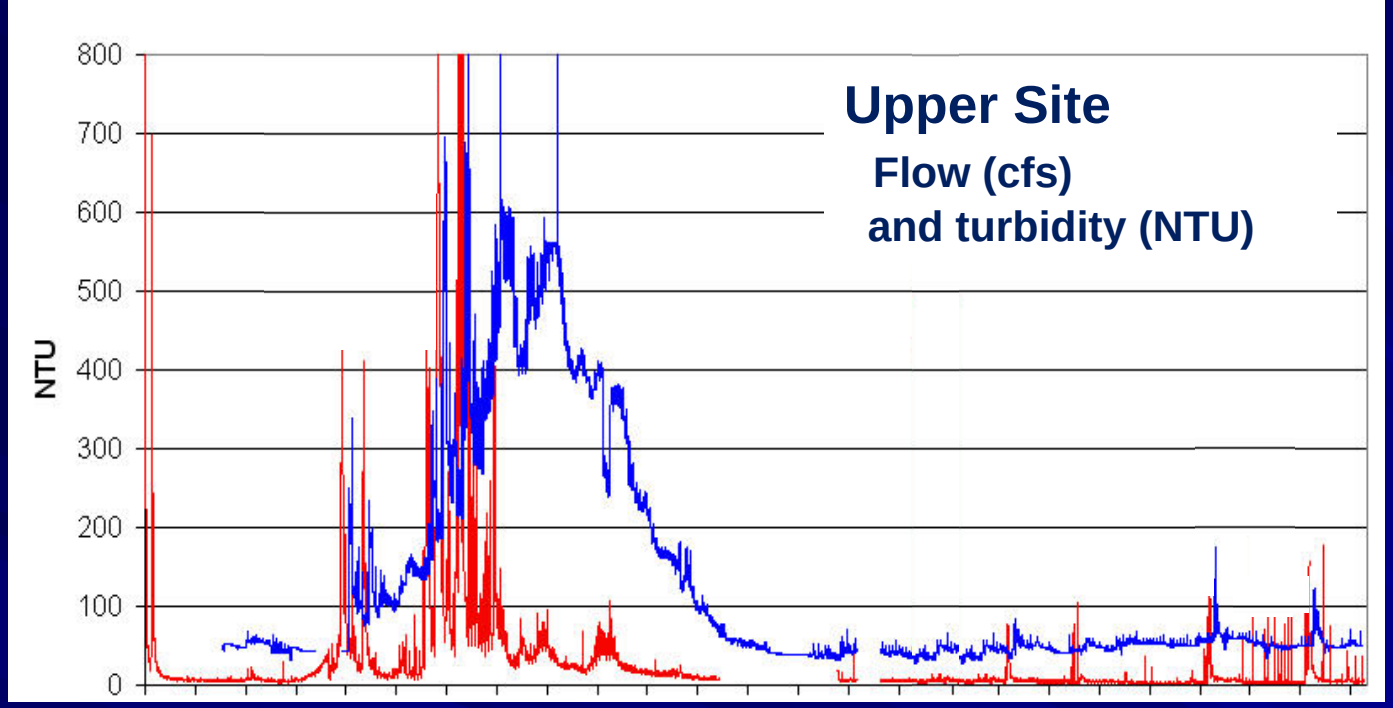


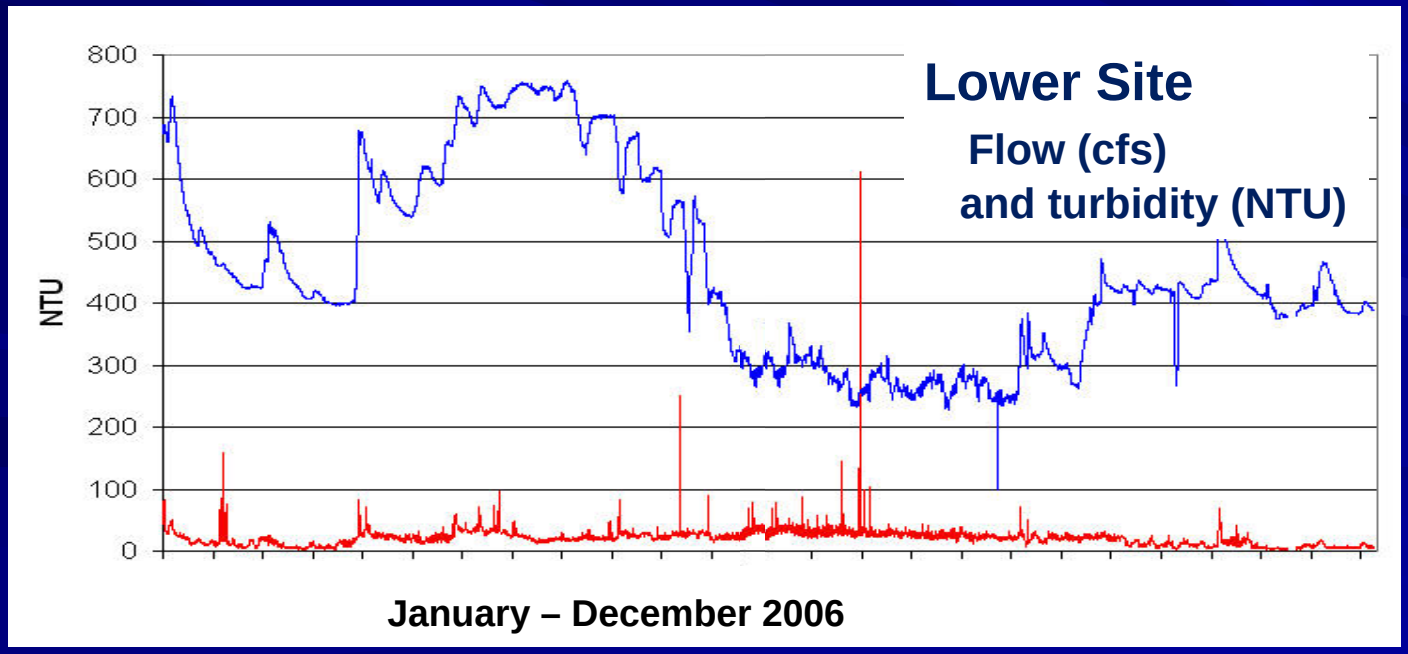
- Seasonal and annual variation
- Variation between sites



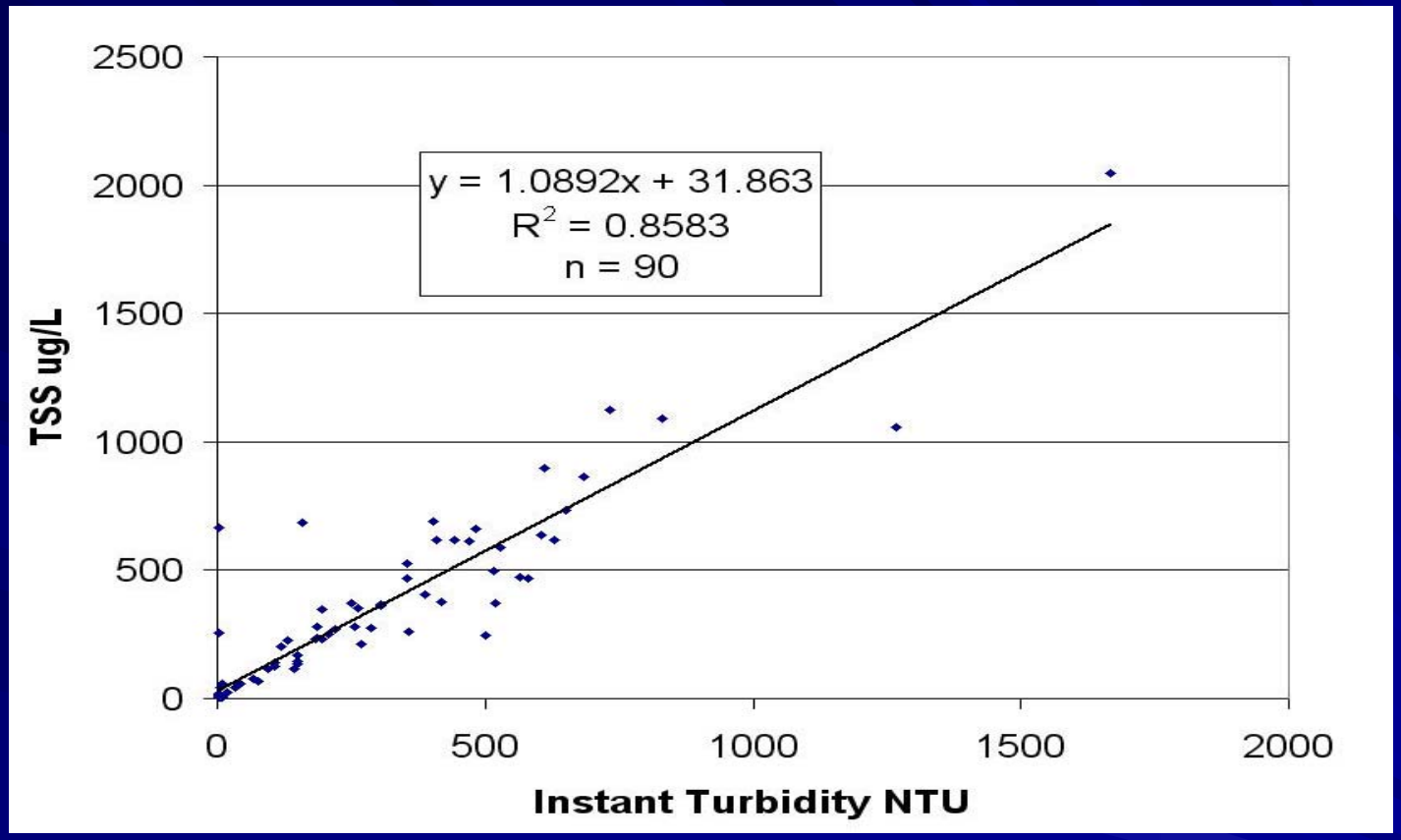


October 2005 – October 2007



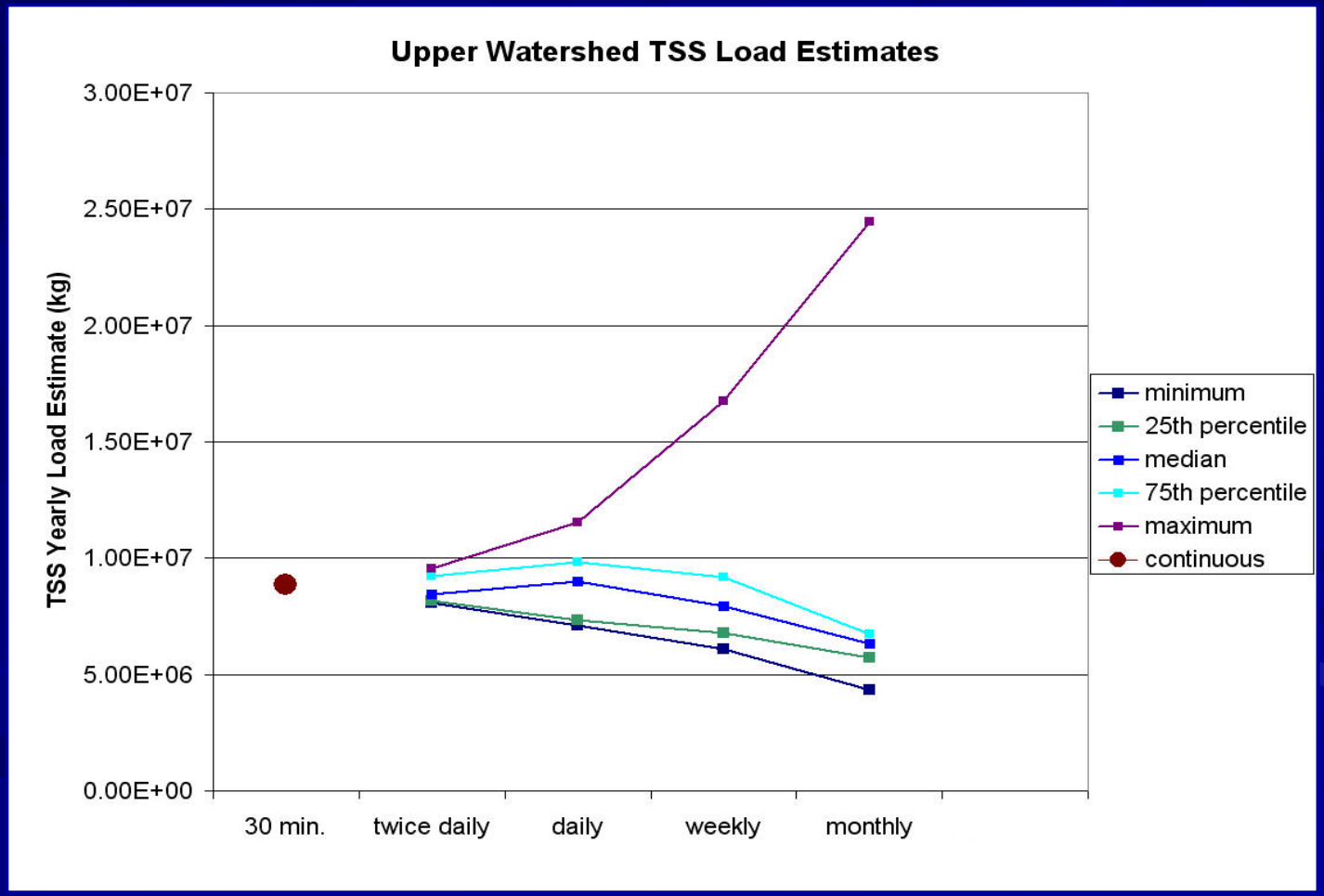


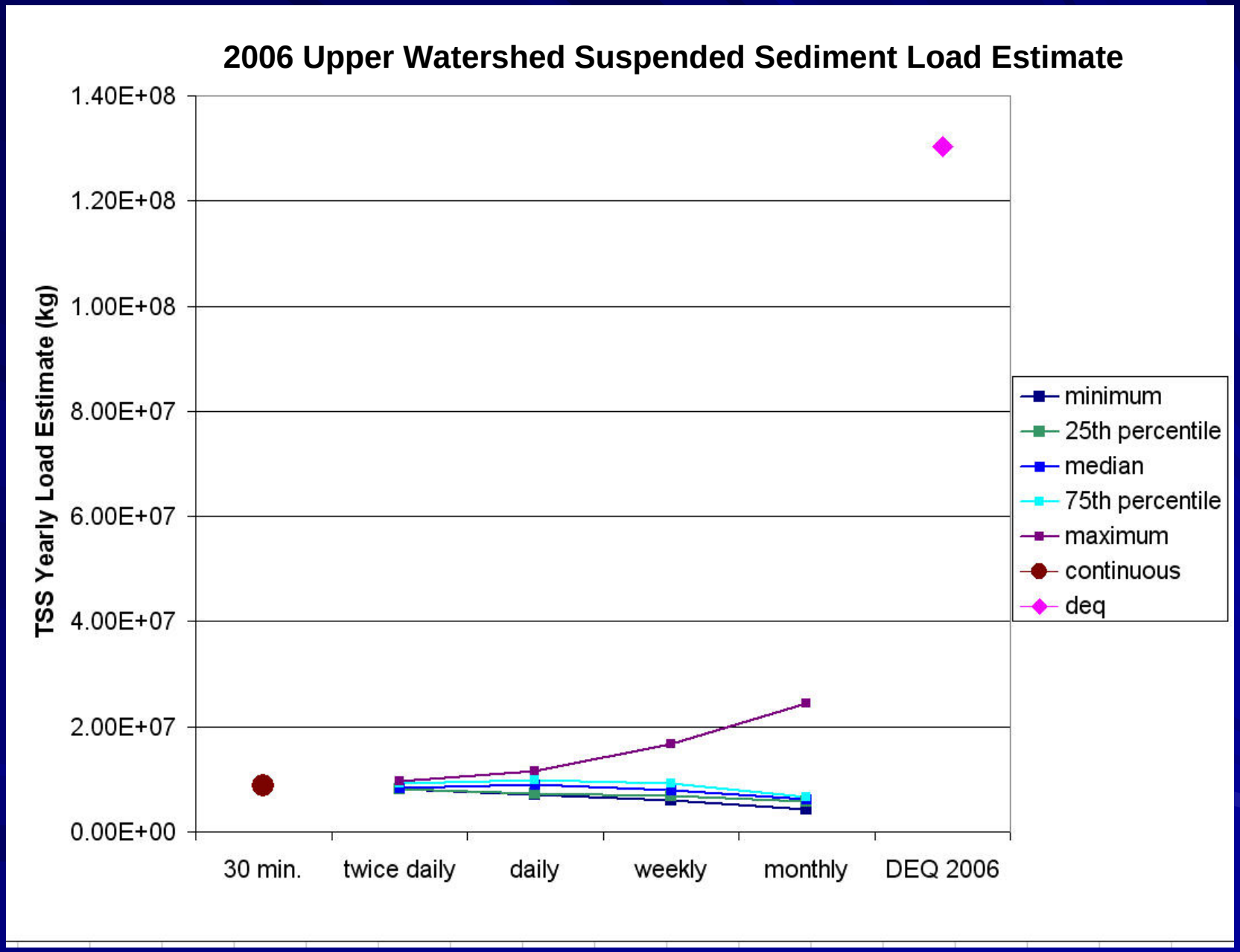
- Seasonal and annual variation
- Variation between sites
- Different pathways of pollutants



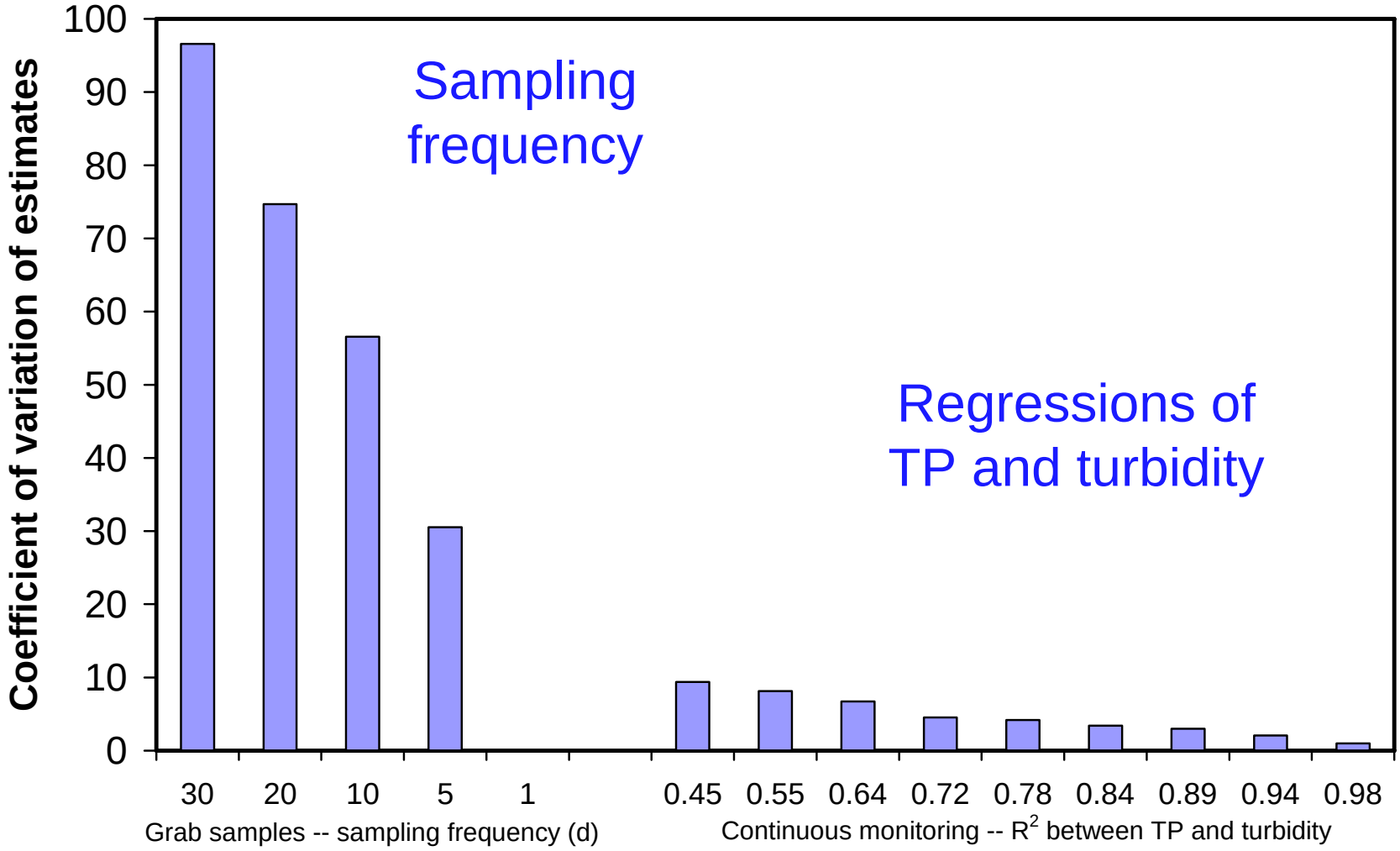
- Variability in correlations between turbidity and water quality parameters (TSS and TP)

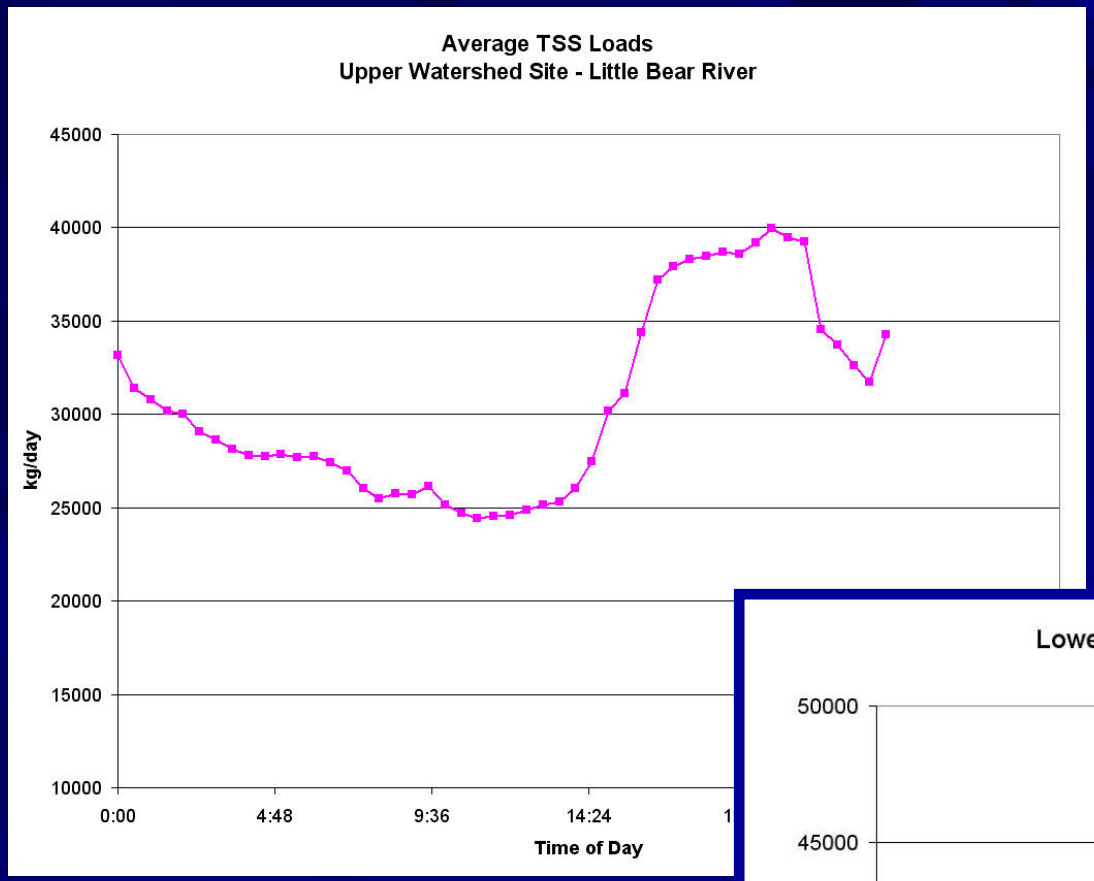
- Variability associated with frequency of sampling



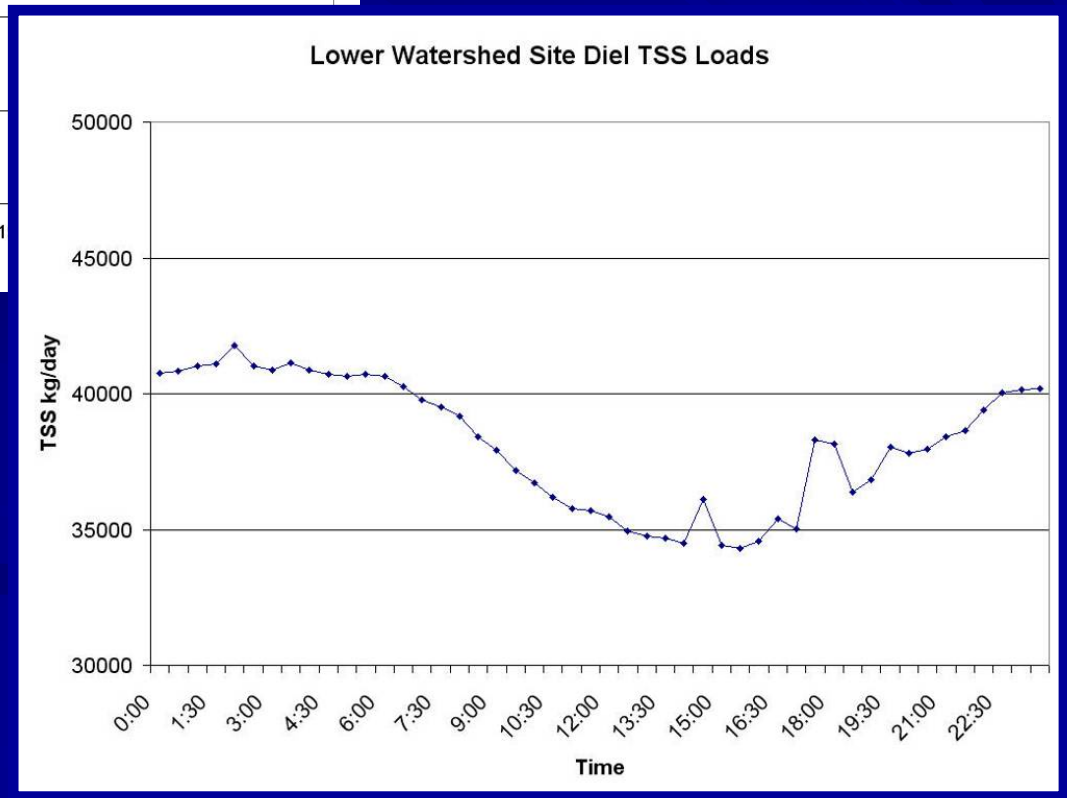

2006 Upper Watershed Suspended Sediment Load Estimate
TSS Yearly Load Estimate (kg)
1.40E+08
1.20E+08
1.00E+08
8.00E+07
6.00E+07
4.00E+07
2.00E+07
0.00E+00
30 min.
twice daily
daily
weekly
monthly
DEQ 2006
minimum
25th percentile
median
75th percentile
maximum
continuous
deq

The relative importance of two sources of variability in estimates of annual phosphorus load

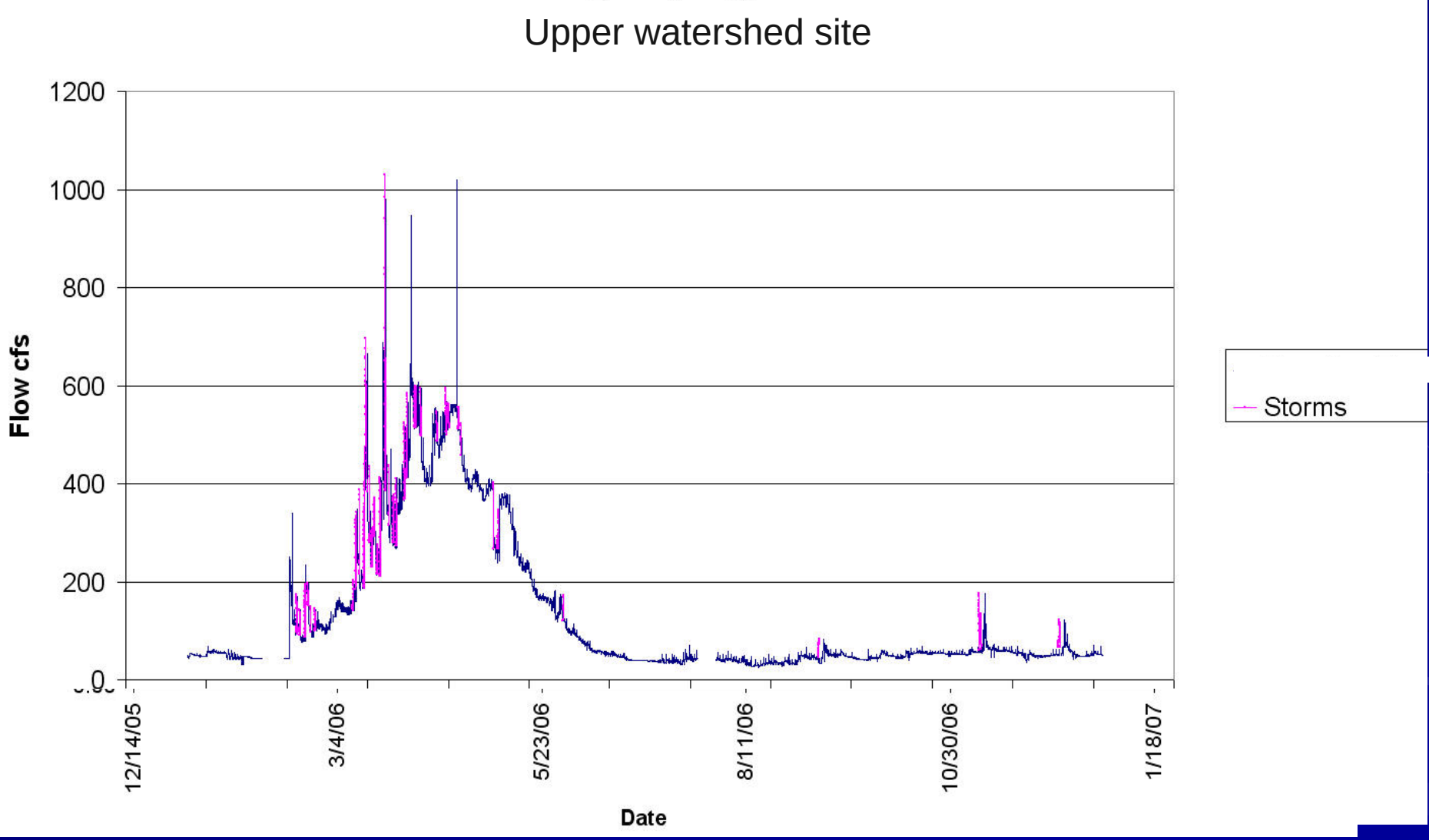


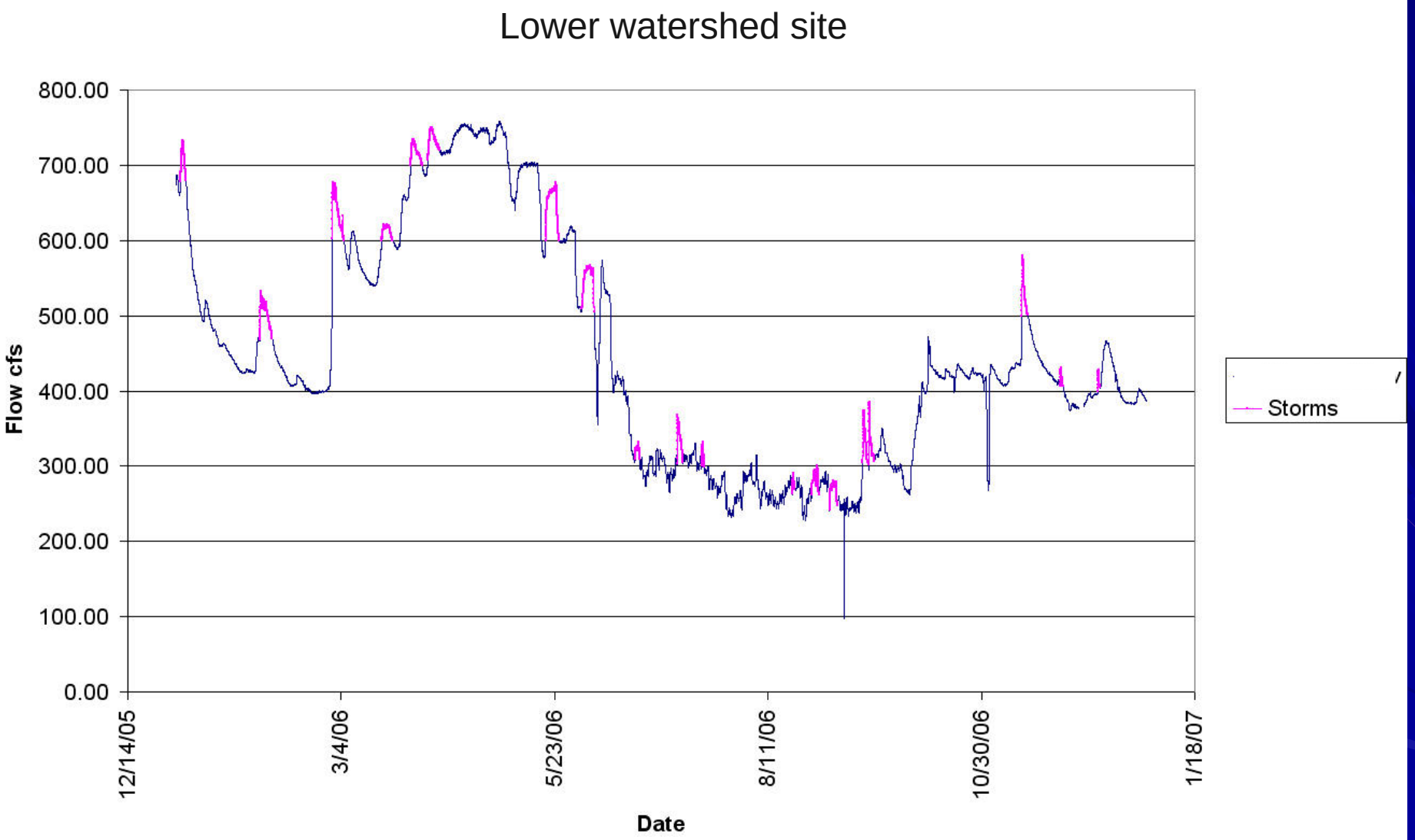


Effect of sample timing



Importance of monitoring rare events




Lower watershed site
800.00
700.00
600.00
500.00
400.00
300.00
200.00
100.00
0.00
Flow cfs
12/14/05
3/4/06
5/23/06
8/11/06
10/30/06
1/18/07
Date
Storms

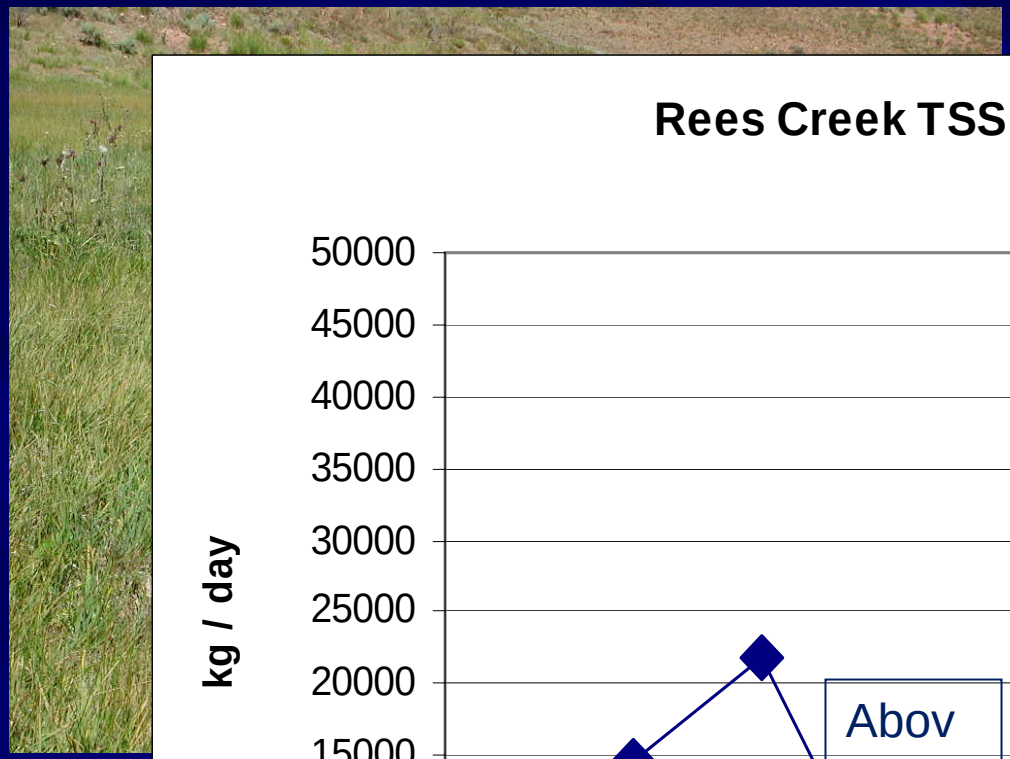
TSS Load	Upper Site	Lower Site
Annual (kg)	8.9×10^6	1.4×10^7
Runoff (% of total)	89%	54%
Baseflow (% of total)	11%	46%
Storms (% of baseflow)	<1%	16%

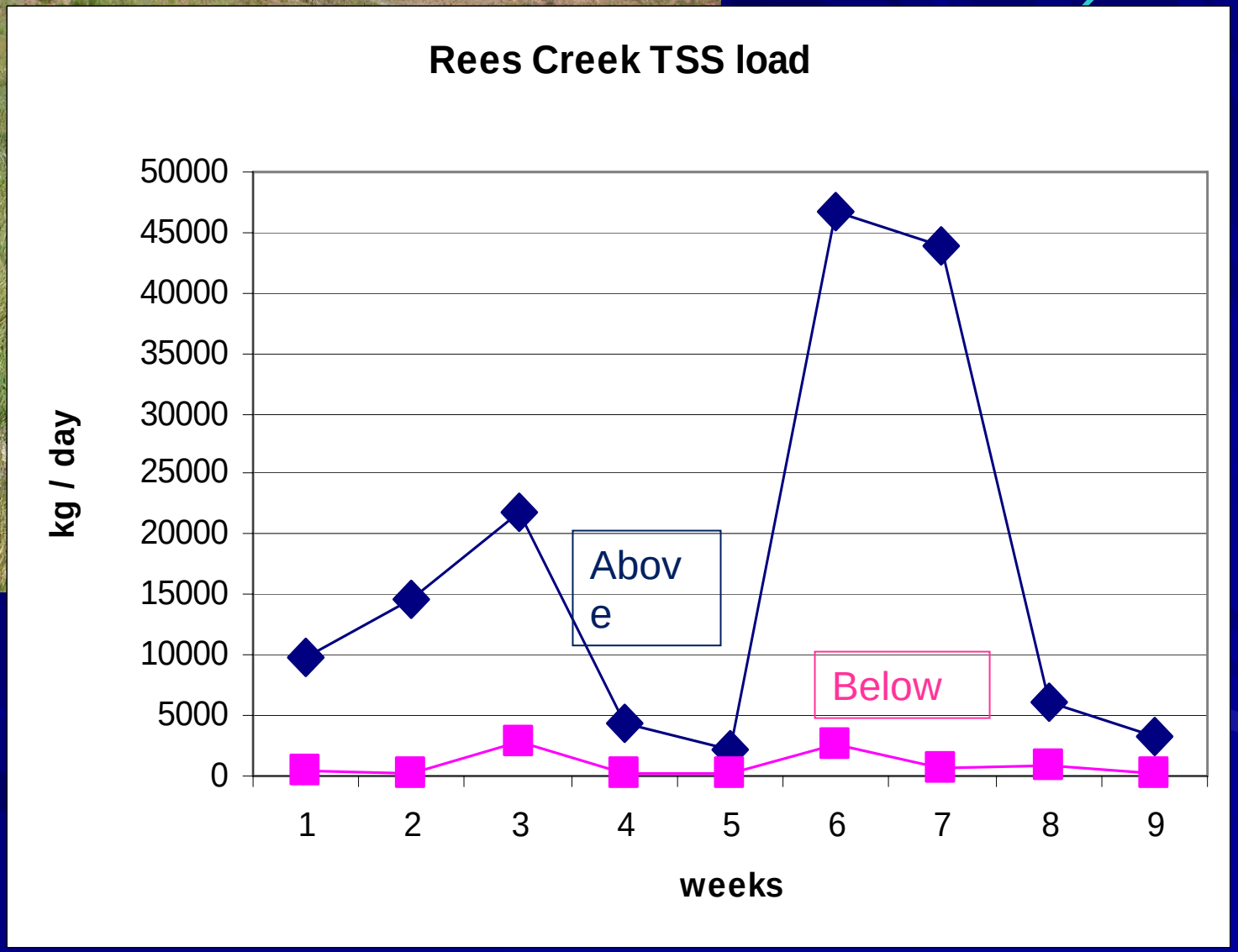
- Failure to design monitoring plan around BMP objectives

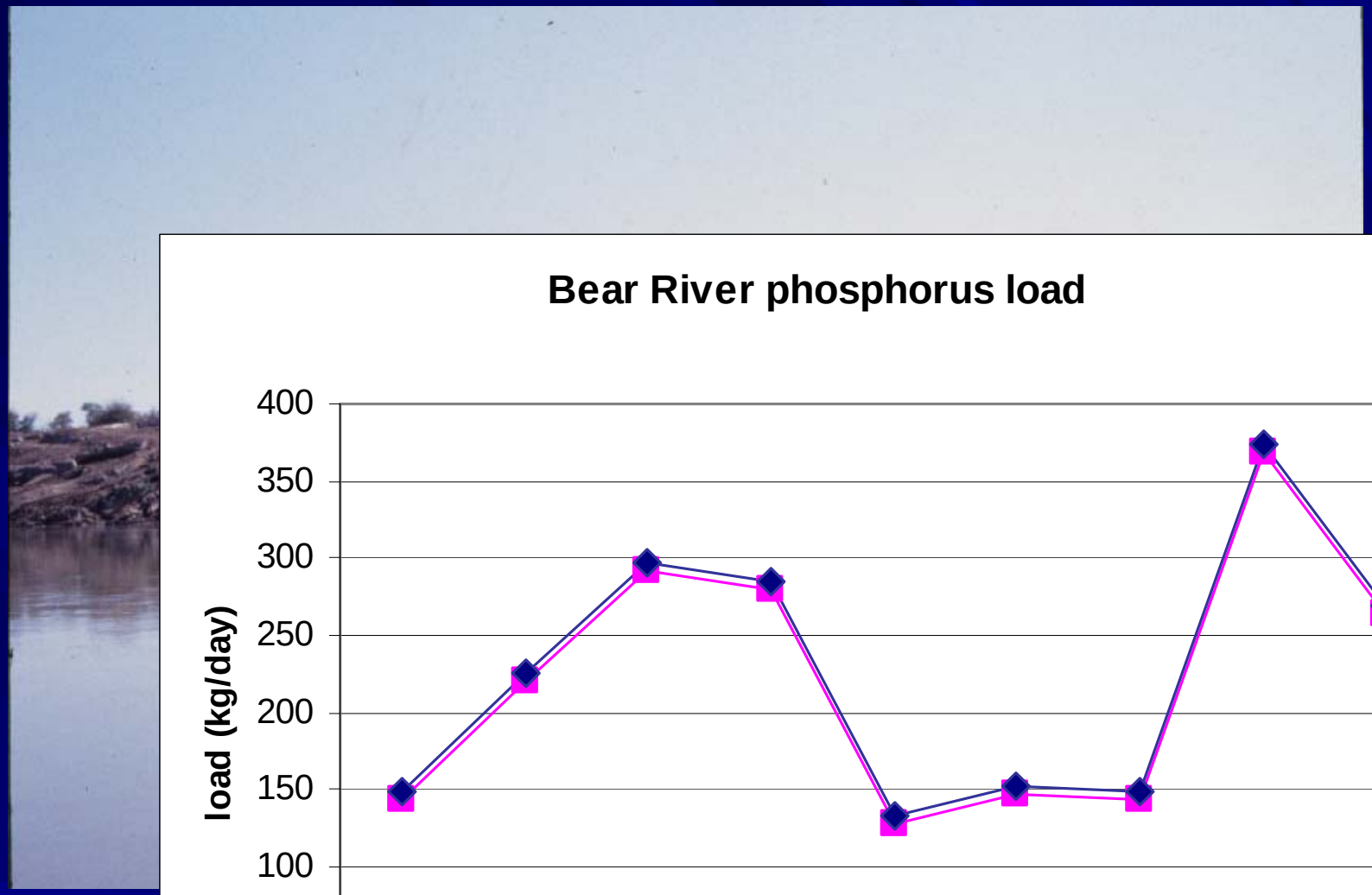
- Failure to identify and quantify sources of variability in these dynamic system.

- A failure to understand pollutant pathways and transformations → choosing inappropriate monitoring approaches

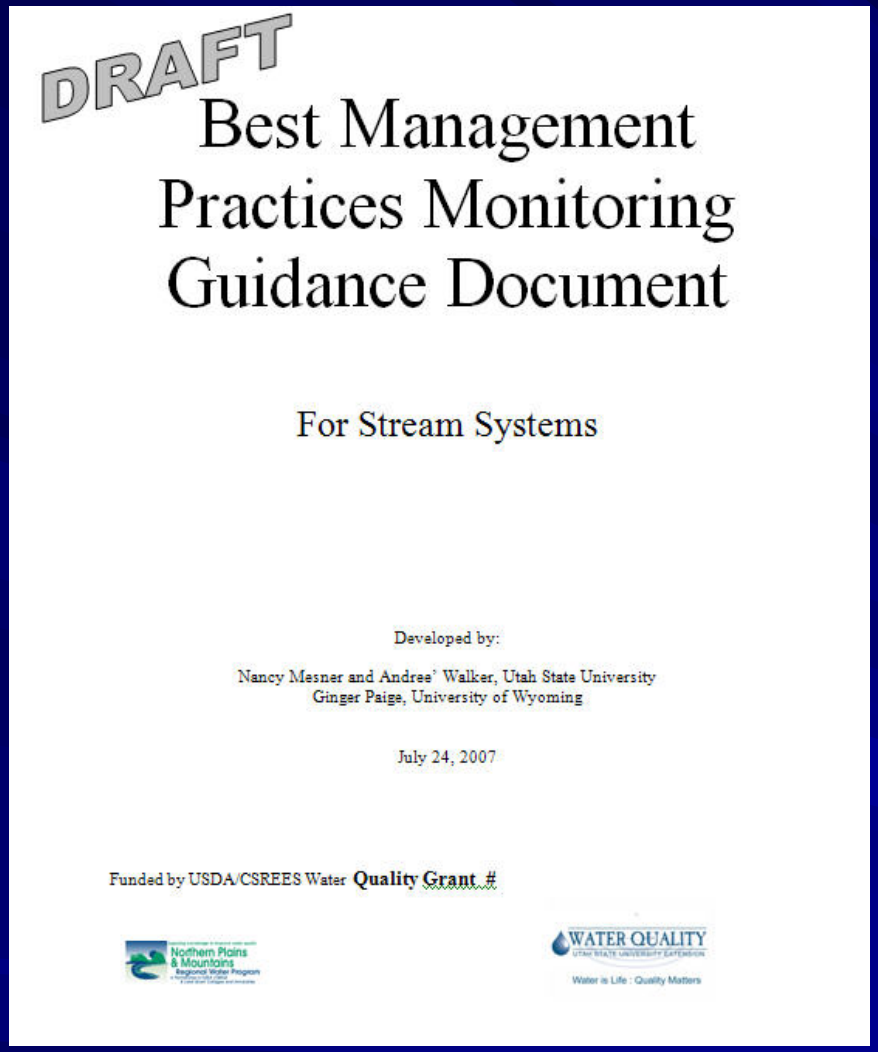
Problems with “one-size-fits-all” monitoring design







Bear River phosphorus load
load (kg/day)
400
350
300
250
200
150
100
50
0
1
2
3
4
5
6
7
8
9
weeks



DRAFT

Best Management Practices Monitoring Guidance Document

For Stream Systems

Developed by:

Nancy Mesner and Andree' Walker, Utah State University
Ginger Paige, University of Wyoming

July 24, 2007

Funded by USDA/CSREES Water Quality Grant #

Northern Plains & Mountains Regional Water Program

WATER QUALITY
UTAH STATE UNIVERSITY EXTENSION
Water is Life : Quality Matters

Focuses on the considerations and decisions necessary as a project is first being considered.

NOT a “how-to” manual of protocols

Document in review
Training workshops underway

Target Audience

- State Environmental Agencies
- Conservation Groups
- Land Management Agencies
- Citizen Monitoring Groups

Table of Contents

- DEFINITIONS
- INTRODUCTION
- SECTION 1 What is Your Monitoring Objective?
- SECTION 2 Understanding Your Pollutant and Your Natural System
- SECTION 3 Consider the Scale
- SECTION 4 Monitoring versus Modeling: Different Approaches to Detecting Impacts
- SECTION 5 Choosing the Best Monitoring Design
- SECTION 6 Site Specific Considerations
- SECTION 7 Protocols
- SECTION 8 Quality Assurance and Quality Control
- SECTION 9 Data Management
- SECTION 10 Analysis of Data
- SECTION 11 Interpreting and Using the Data
- REFERENCES
- RESOURCES
- APPENDIX A Specific Models to Consider

What is your objective?

- ✓ Long term trends?
- ✓ UPDES compliance?
- ✓ Educational?
- ✓ Assessment for impairment?
- ✓ Track response from an implementation?

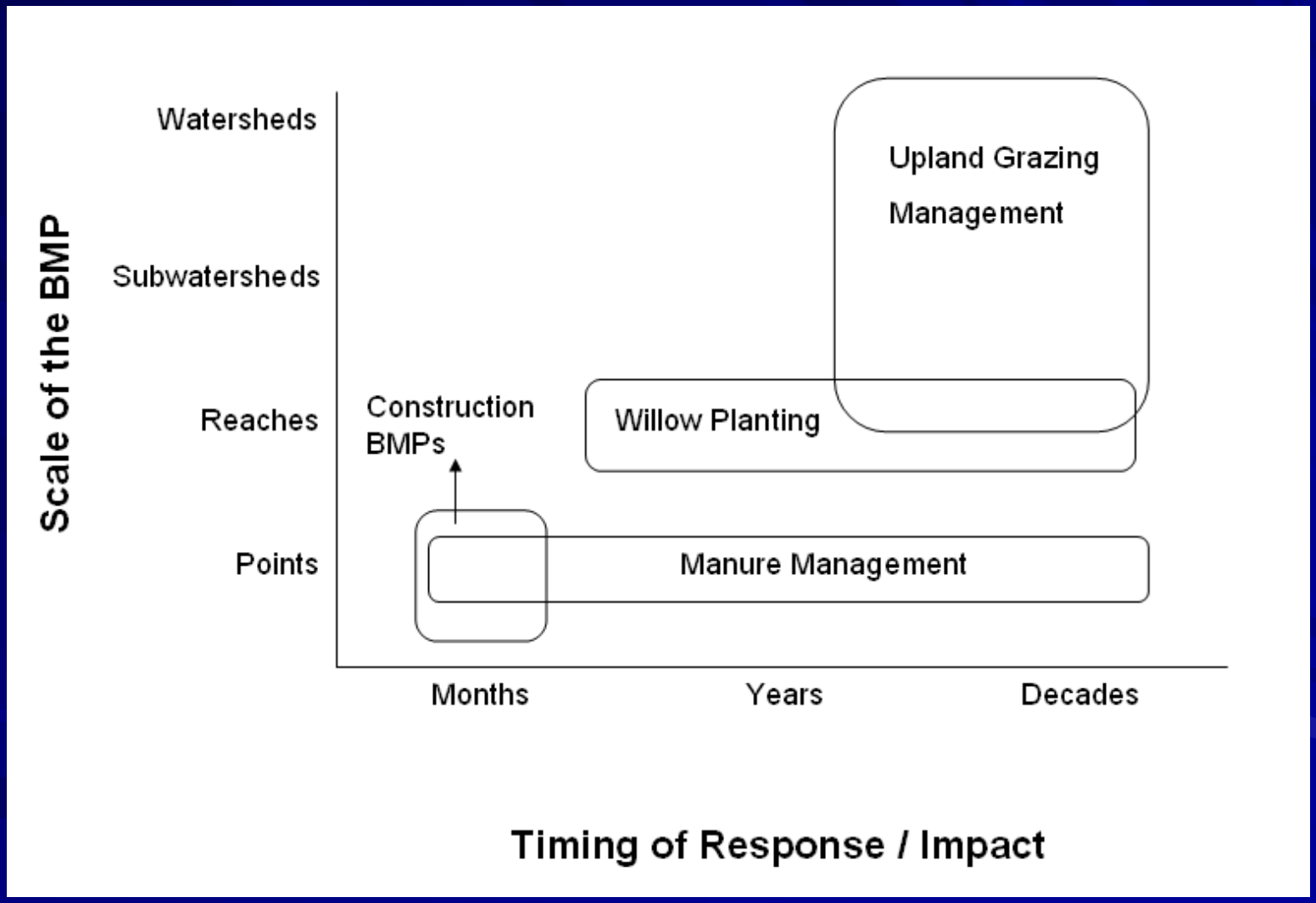
How do pollutants “behave” within your watershed?

- ✓ How does the pollutant move from the source to the waterbody?
- ✓ How is the pollutant processed or transformed within a waterbody?
- ✓ What is the natural variability of the pollutant? Will concentrations change throughout a season? Throughout a day?
- ✓ What long term changes within your watershed may also affect this pollutant?
- ✓ What else must be monitored to help interpret your data?

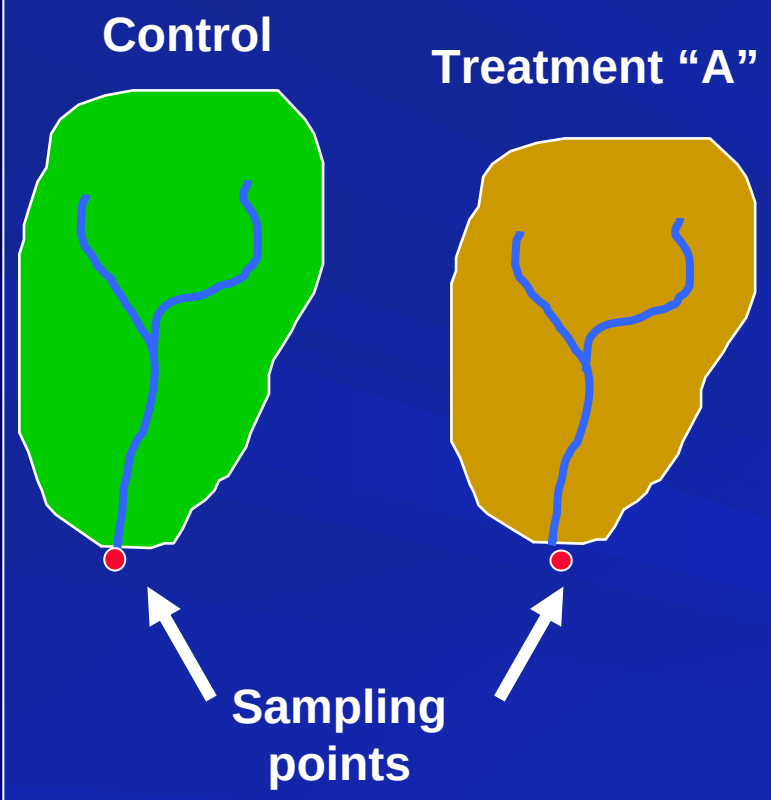
What to monitor?

- Monitor the pollutant(s) of concern?
- Monitor a “surrogate” variable?
- Monitor a response variables?
- Monitor the impacted beneficial use?
- Monitor the BMP itself?
- Monitor human behavior?
- Model the response to a BMP implementation.
- Collect other data necessary to interpret monitoring results OR calibrate and validate the model?

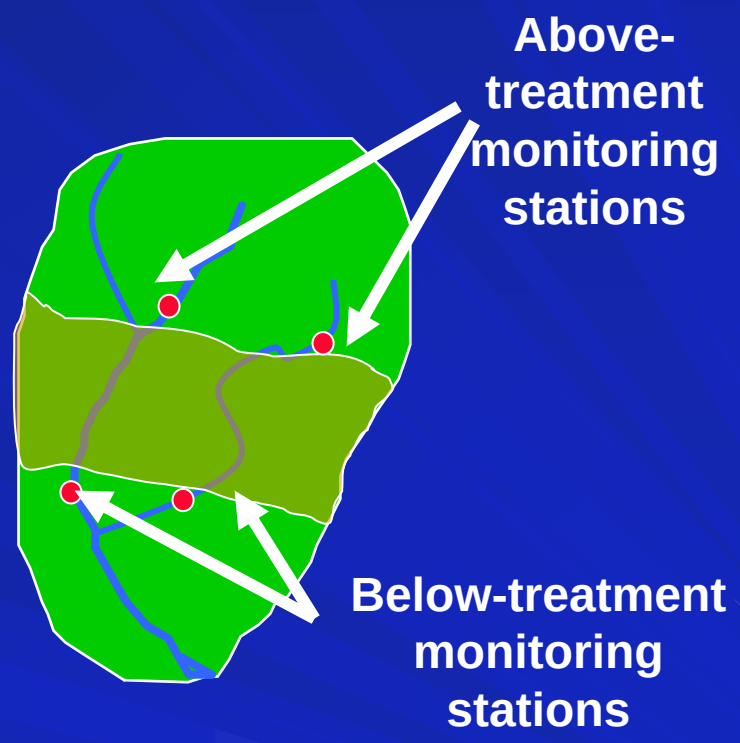
Where and when to monitor?



Choose appropriate monitoring or modeling



BACI Design



Above and below treatment design

Guide to multiple approaches, including model resources

Pollutant	Direct Monitoring	Surrogate Monitoring	Other important variables *	Response variables	Models
Temperature	Probes, launched monitors (e.g. hobo), and direct measurements	Light / shading, ground water signal (stable isotope variables)	Air temperature	Algae, macros, and fish	CEQual WASP(7) SNTEMP (USGS)
Dissolved Oxygen (DO)	Probes and direct measurements	Temperature, redox, and Flow/temperature/algal biomass	Temperature will affect percent saturation	Macros and fish	Streeter Phelps
Nutrients (phosphorus and nitrogen)	Grab samples and integrated samples In some cases use probes, or streamside auto-analyzers to collect surrogate samples	Turbidity or sediment	pH, temperature, and DO might affect the solubility of phosphorus	Algae, macros, and fish	UAFRI SWAT QUAL2K
Sediment	Grab samples and integrated samples	Turbidity		Physical characteristics, embeddedness, macros, and algae	PSIAC AgNPS SWAT KINEROS2
Salts / TDS	Probes and grab samples	Riparian vegetation		Macros and fish	QUAL2K
Pathogens	Grab samples and integrated samples	Fecal Coliform Bacteria, *E.coli*	Turbidity, nutrients		
Metals	Grabs samples	Bioaccumulation in living organisms	DO might affect total hardness	Bacteria in the sediments	
Organics	Grabs samples	Bioaccumulation in living organisms		Bacteria in the sediments	

How to monitor?

- ✓ points in time versus continuous
- ✓ integrated versus grab samples
- ✓ consider:
  - cost
  - skill and training required
  - accessibility of sites

The road to more effective monitoring….

- Monitoring plans require careful thought before anything is implemented.
- Consider how the data will be used to demonstrate change.
- Use your understanding of your watershed and how the pollutants of concern behave to target monitoring most effectively
- Use different approaches for different BMPs

In Conclusion:

Keep project goals and objectives in mind when monitoring BMPs

Monitor at an appropriate scale

Keep time lags in mind

Be selective, consider individual situations

Monitor surrogates when appropriate

Control or measure human behaviors / other watershed changes.

Next Steps

- Finalizing document & review process
- Available as a document & online as pdf
- Northern Plains and Mountains Website

  http://region8water.colostate.edu/

- Links to “key” information
  - models
  - websites
  - water quality standards

Thank You

Questions?

Before any monitoring program is initiated… think carefully about goals and objectives.

- Why?
- What?
- Where?
- When?
- How?

“One size fits all” approach rarely fits anything very well