A Storm Water Sampling Method Comparison Study: The Search for the Perfect Storm

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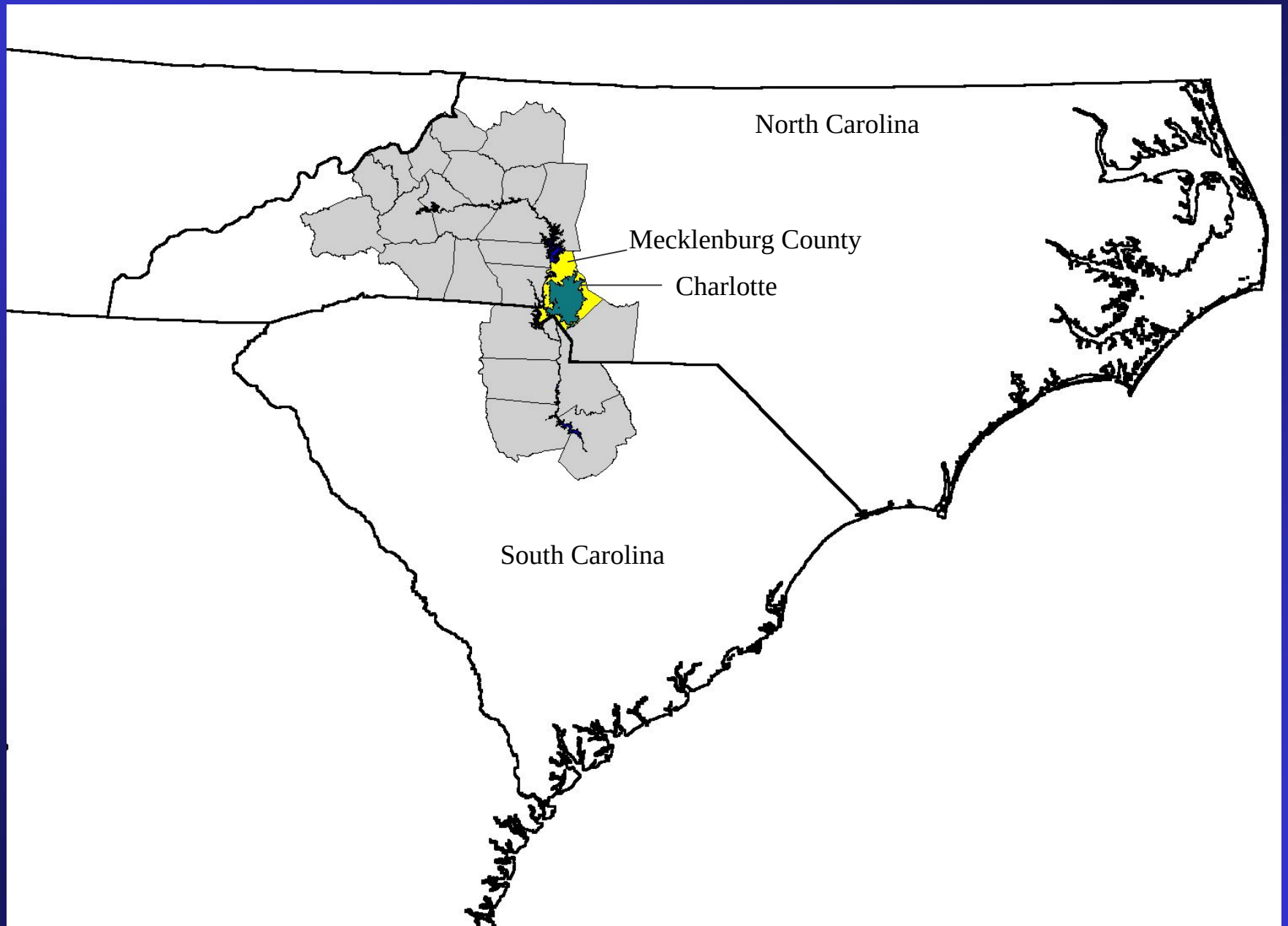
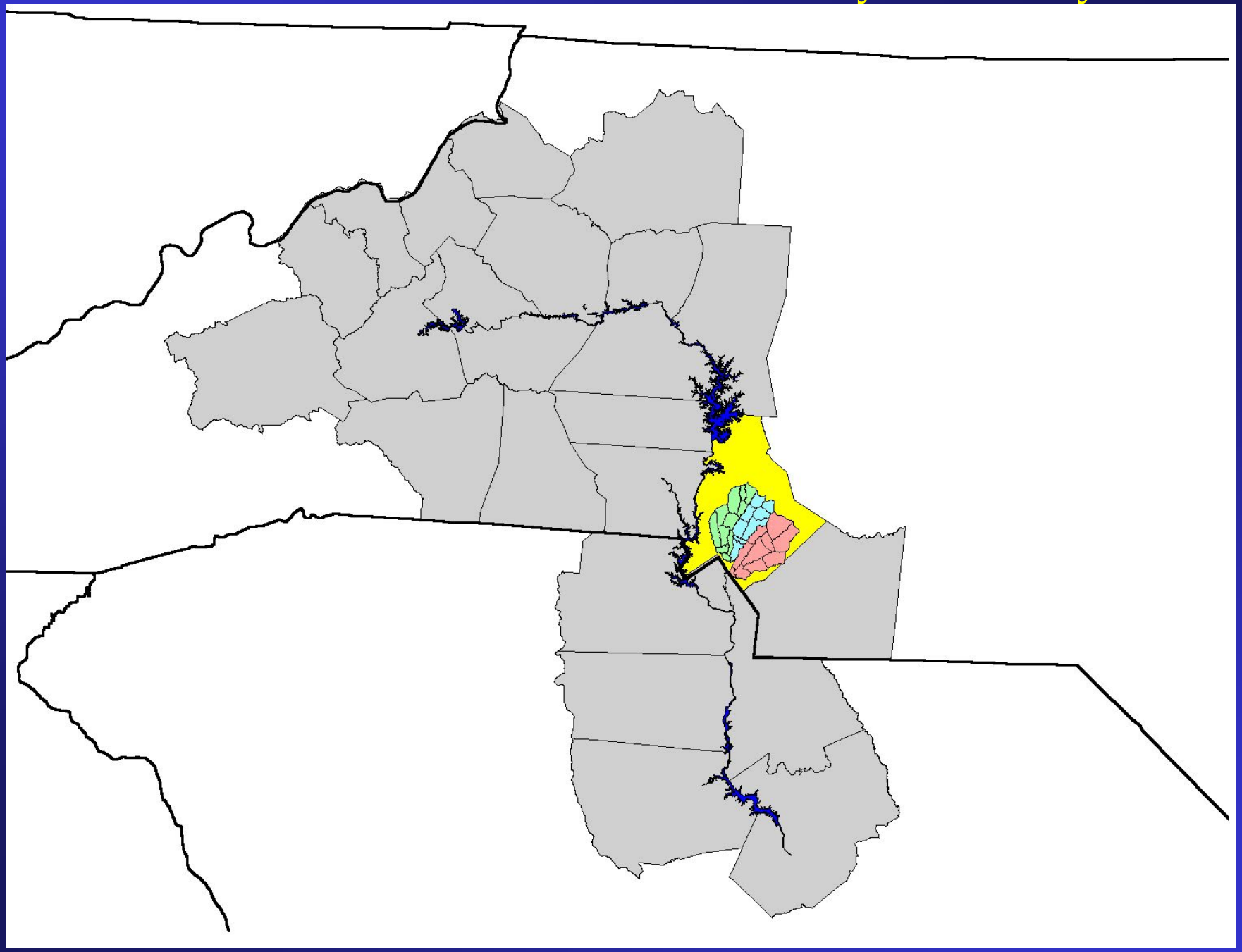
Location of Charlotte and Mecklenburg County Within the Catawba River Watershed



Location of Watersheds Within the City and County



So What are the Goals of Water Quality Monitoring:

- ID Sources of Pollution
- Characterize General Water Quality
- Support Watershed Management
  - Modeling
- Determine Program Effectiveness
- Charlotte’s Phase I NPDES Permit
- Compliance Issues
  - TMDL

A Comprehensive Evaluation

- A review of all monitoring was (is) conducted:
  - Quarterly Baseflow water chemistry at 52 Sites
  - Quarterly Storm Water Chemistry at 7 Sites
  - Annual Macroinvertebrate Sampling at 52 Sites
  - Fish samples collected every 3-5 years at 52 sites

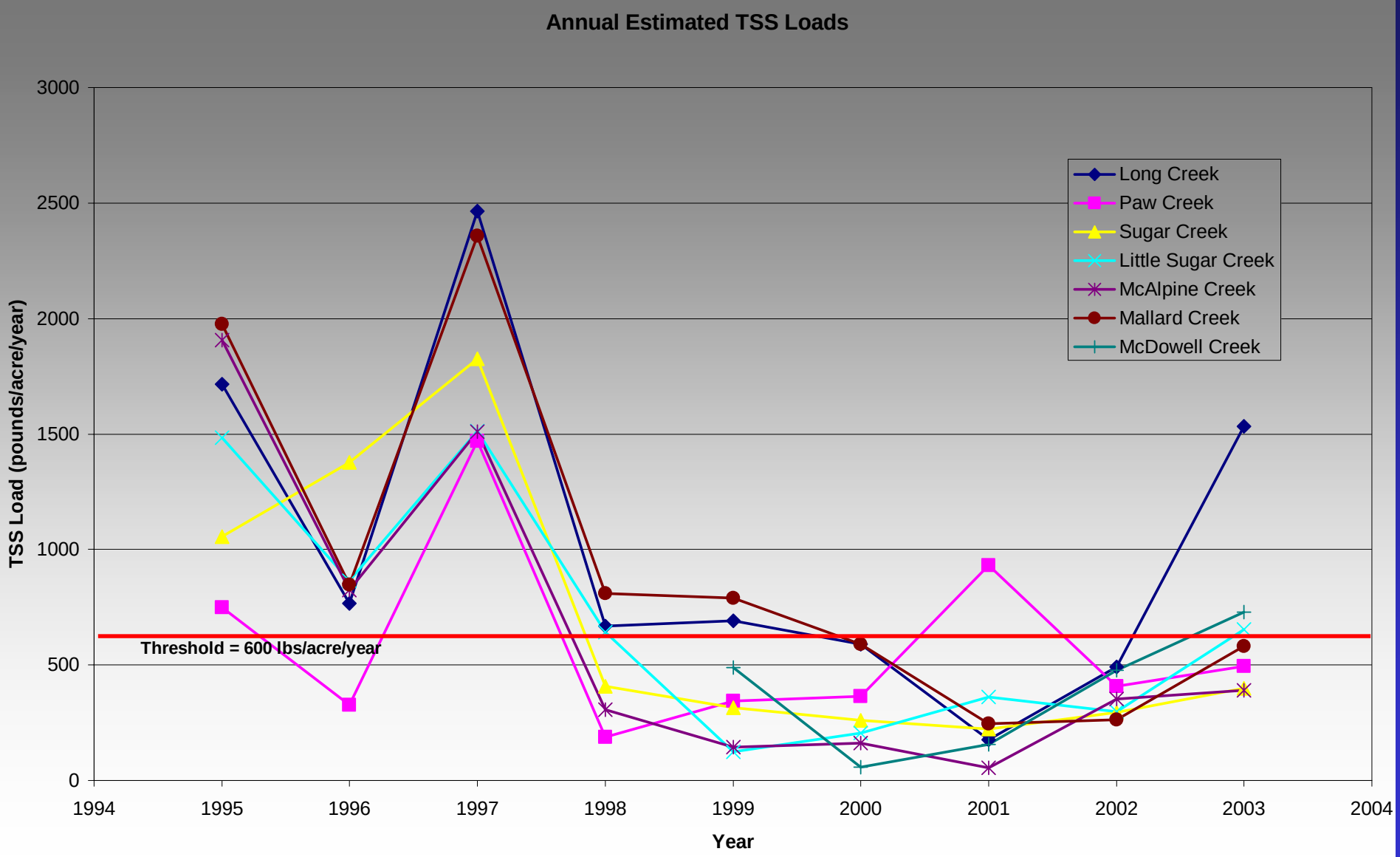
What is the Current Storm Water Sample Collection Method

- These are In-Stream Storm Water Samples
  - Upon 0.5 Foot Rise in Stage…
    - Sample Grab is Collected
    - Begins the Collection of 4 Hour Composite
      - 3 Liters Collected Every 20 Minutes
      - Manual Flow Weighted Composite Prepared in the Lab

Did the Current Sampling Meet the Goals?

	Grab	Composite
ID Pollution Sources	No	No
Support Modeling	Maybe	Sorta
Characterize General WQ	No	Yes…Wrong Answer
Support Watershed Mgmt	No	Yes…Wrong Answer
NPDES Permit	**YES**	**YES**

Tough to Change When the News is Good



Bugs Tell a Different Story…
Were we Listening?

- Steadily Declining Populations over several years
- Minimal Habitat
- Approximately two thirds of Mecklenburg County Streams Listed for Turbidity or Biological Impairment
  - Show the State the Data and We are Done!
- Didn’t Pass the Gut Check

Was our Methodology Flawed

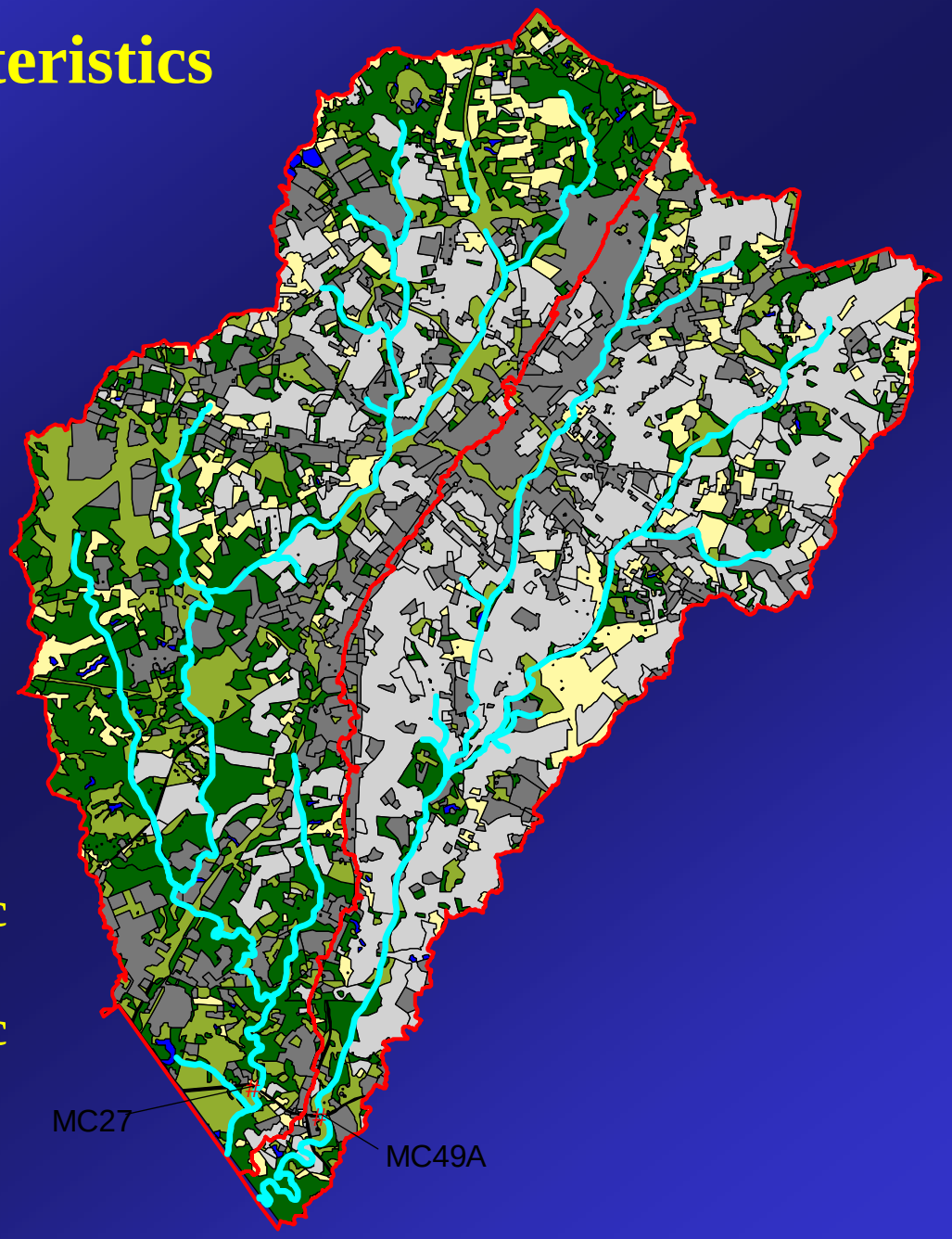
- The 4 hour composite did not sample to the peak in many watersheds
- Our method was the same when sampling a 1 mi^2 or 70mi^2 Watershed
- The creeks ran red and our samples were clear
- We tended to sample small storms

A Test!

- Compare Methods for 2 Storms in Sugar Creek Watershed and Little Sugar Creek Watershed
  - Individual Aliquots Hourly Over Entire Storm
  - Full Storm Composite
    - Break the entire storm up into small packages
    - Requires a bit of forecasting
  - Current Method
    - 4 Hour Composite after 0.5 Foot Rise in Stage

Location of Little Sugar and Sugar Creek Watersheds

Watershed Characteristics

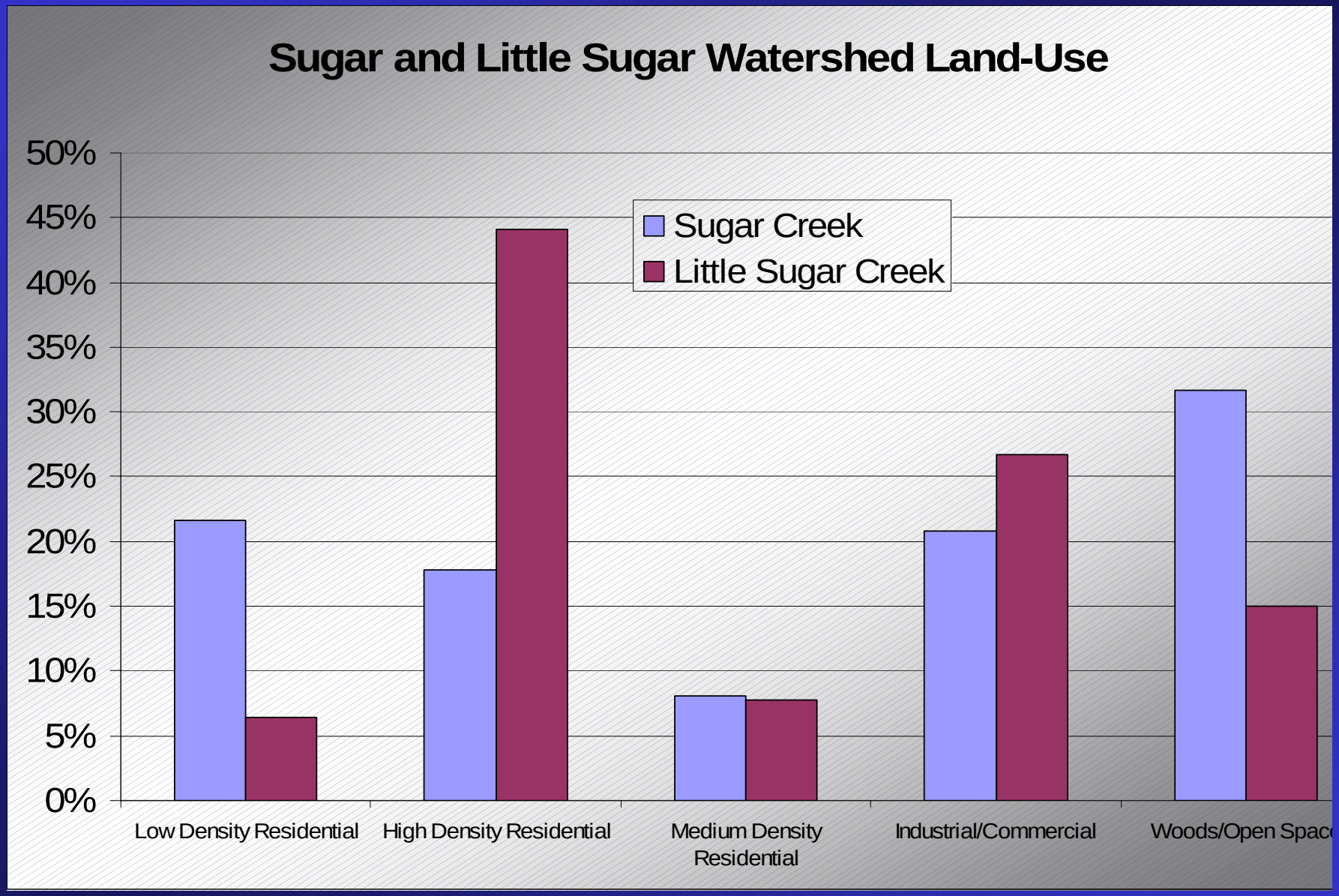


Sugar Creek

- **Watershed Area = 41,500 ac**

Little Sugar Creek

- **Watershed Area = 31,500 ac**


Sugar and Little Sugar Watershed Land-Use
50%
45%
40%
35%
30%
25%
20%
15%
10%
5%
0%
Sugar Creek
Little Sugar Creek
Low Density Residential
High Density Residential
Medium Density Residential
Industrial/Commercial
Woods/Open Spac

Two Perfect Storms Sampled

- Storm 1: September 4-5, 2003 at MC49A
  - Smaller storm ~0.2 inches (maybe)
- Storm 2: Approximately 0.6 inches
  - March 30, 2004 – April 1, 2004 at MC49A
  - March 30, 2004 – April 2, 2004 at MC27

Method

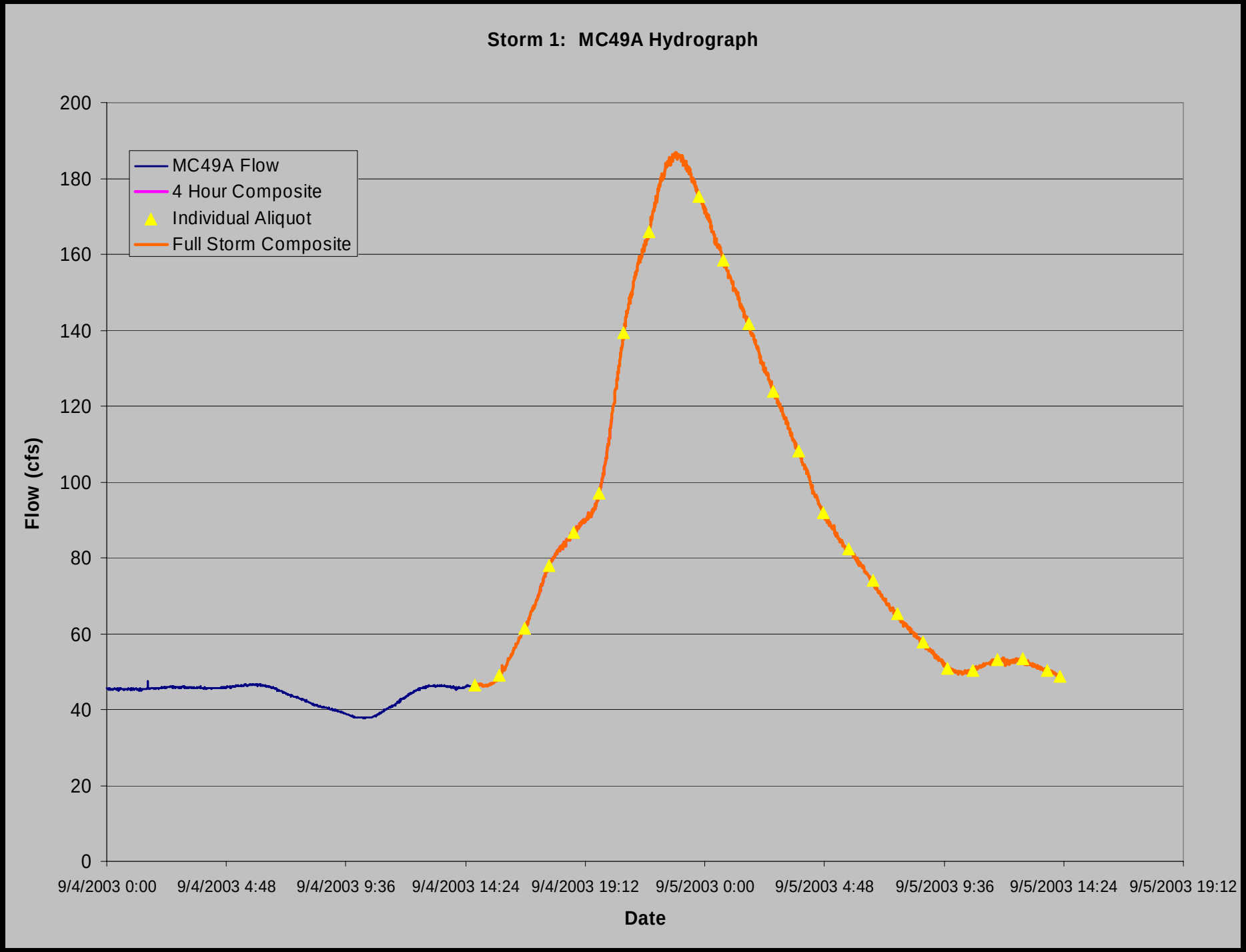
- Several Automated Samplers Were Used
- 1 For 4 Hour Composite
- 2 For Individual Aliquots
- 1 For Full Storm Composite
  - Forecast

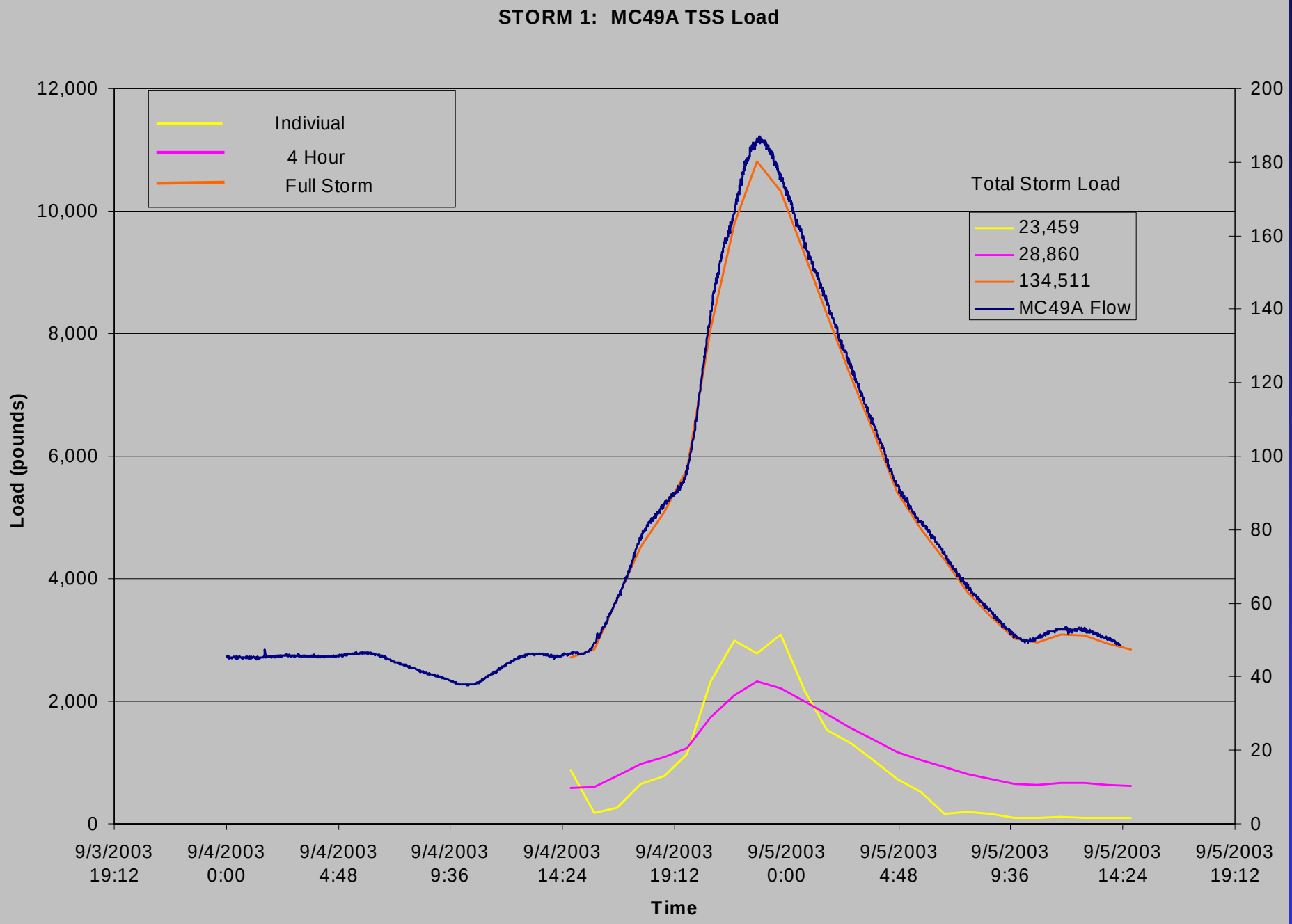
STORM 1

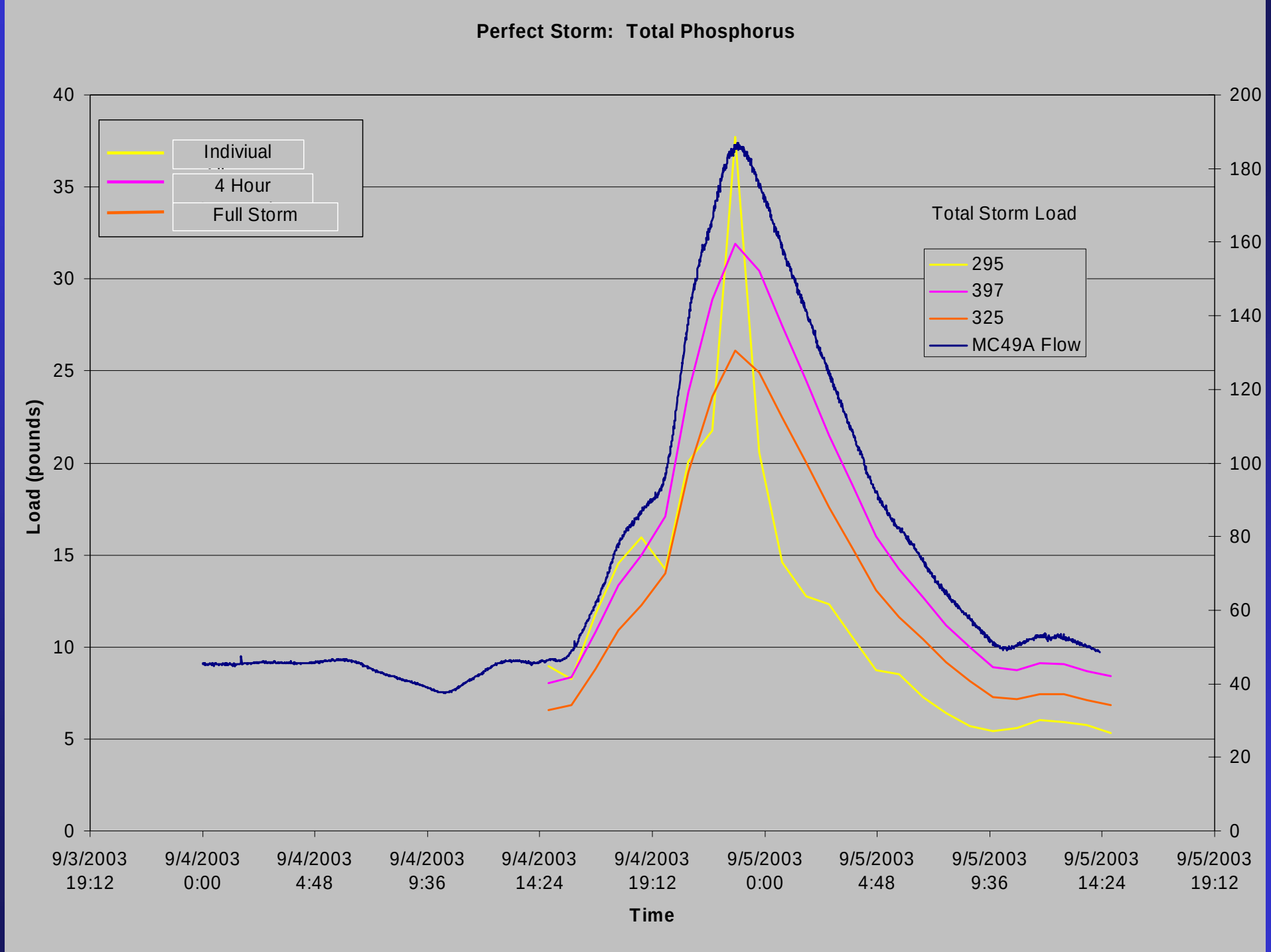
MC49A (Little Sugar Creek)

~0.2 inches of rainfall

~82 million c.f. of runoff


Storm 1: MC49A Hydrograph
MC49A Flow
4 Hour Composite
Individual Aliquot
Full Storm Composite
Flow (cfs)
200
180
160
140
120
100
80
60
40
20
0
9/4/2003 0:00
9/4/2003 4:48
9/4/2003 9:36
9/4/2003 14:24
9/4/2003 19:12
9/5/2003 0:00
9/5/2003 4:48
9/5/2003 9:36
9/5/2003 14:24
9/5/2003 19:12
Date


STORM 1: MC49A TSS Load
Indiviual
4 Hour
Full Storm
Total Storm Load
23,459
28,860
134,511
MC49A Flow
Load (pounds)
12,000
10,000
8,000
6,000
4,000
2,000
0
200
180
160
140
120
100
80
60
40
20
0
9/3/2003 19:12
9/4/2003 0:00
9/4/2003 4:48
9/4/2003 9:36
9/4/2003 14:24
9/4/2003 19:12
9/5/2003 0:00
9/5/2003 4:48
9/5/2003 9:36
9/5/2003 14:24
9/5/2003 19:12
Time


Perfect Storm: Total Phosphorus
Indiviual
4 Hour
Full Storm
Total Storm Load
295
397
325
MC49A Flow
Load (pounds)
0
5
10
15
20
25
30
35
40
0
20
40
60
80
100
120
140
160
180
200
9/3/2003 19:12
9/4/2003 0:00
9/4/2003 4:48
9/4/2003 9:36
9/4/2003 14:24
9/4/2003 19:12
9/5/2003 0:00
9/5/2003 4:48
9/5/2003 9:36
9/5/2003 14:24
9/5/2003 19:12
Time

Storm 1: MC49A Summary Table

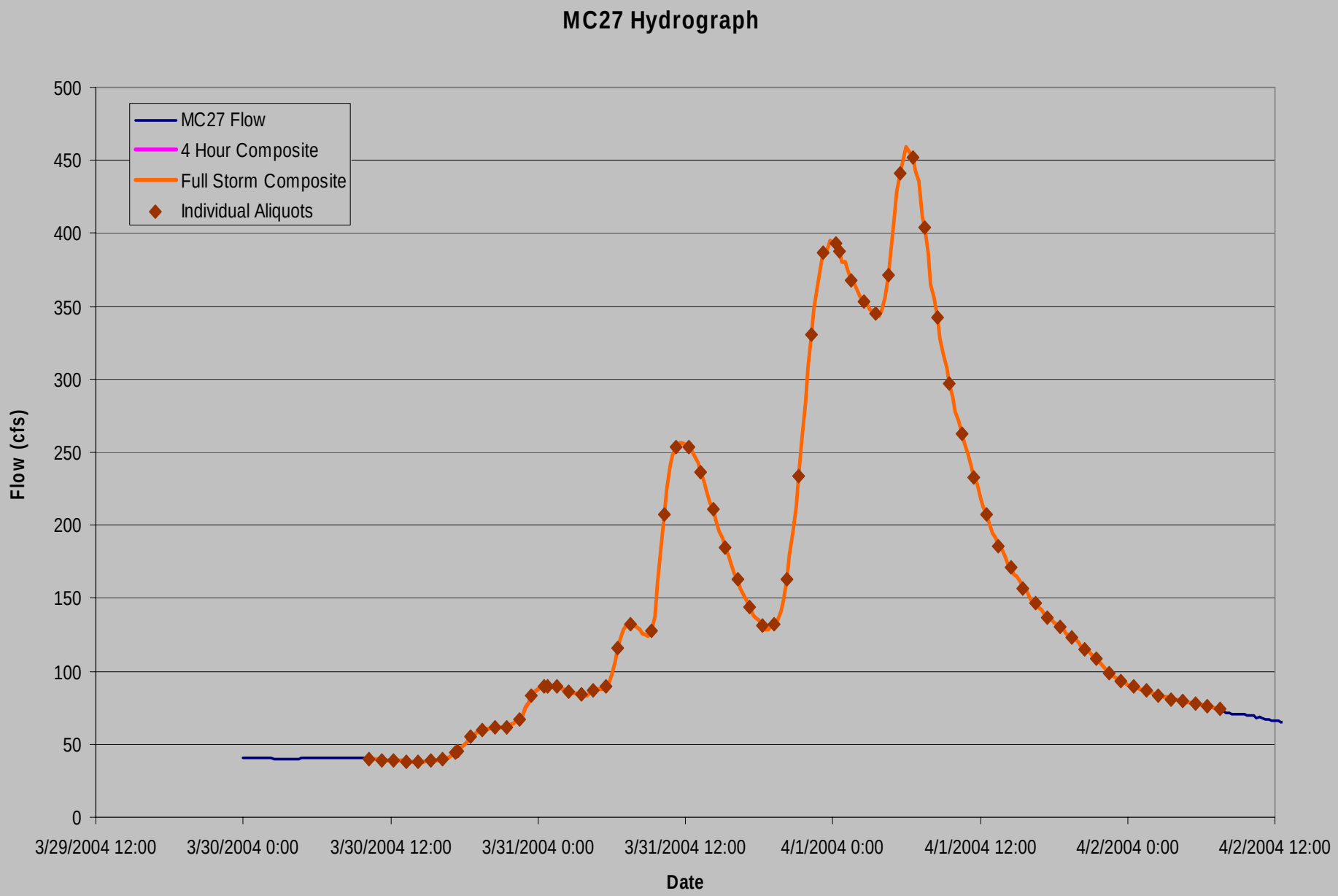
	TSS (pounds)	TP (pounds)
Individual Aliquots	23,459 (<1 lb/ac)	295
Full Storm Composite	134,511 (4 lb/ac)	325
4-Hour Composite	28,860 (<1 lb/ac)	397

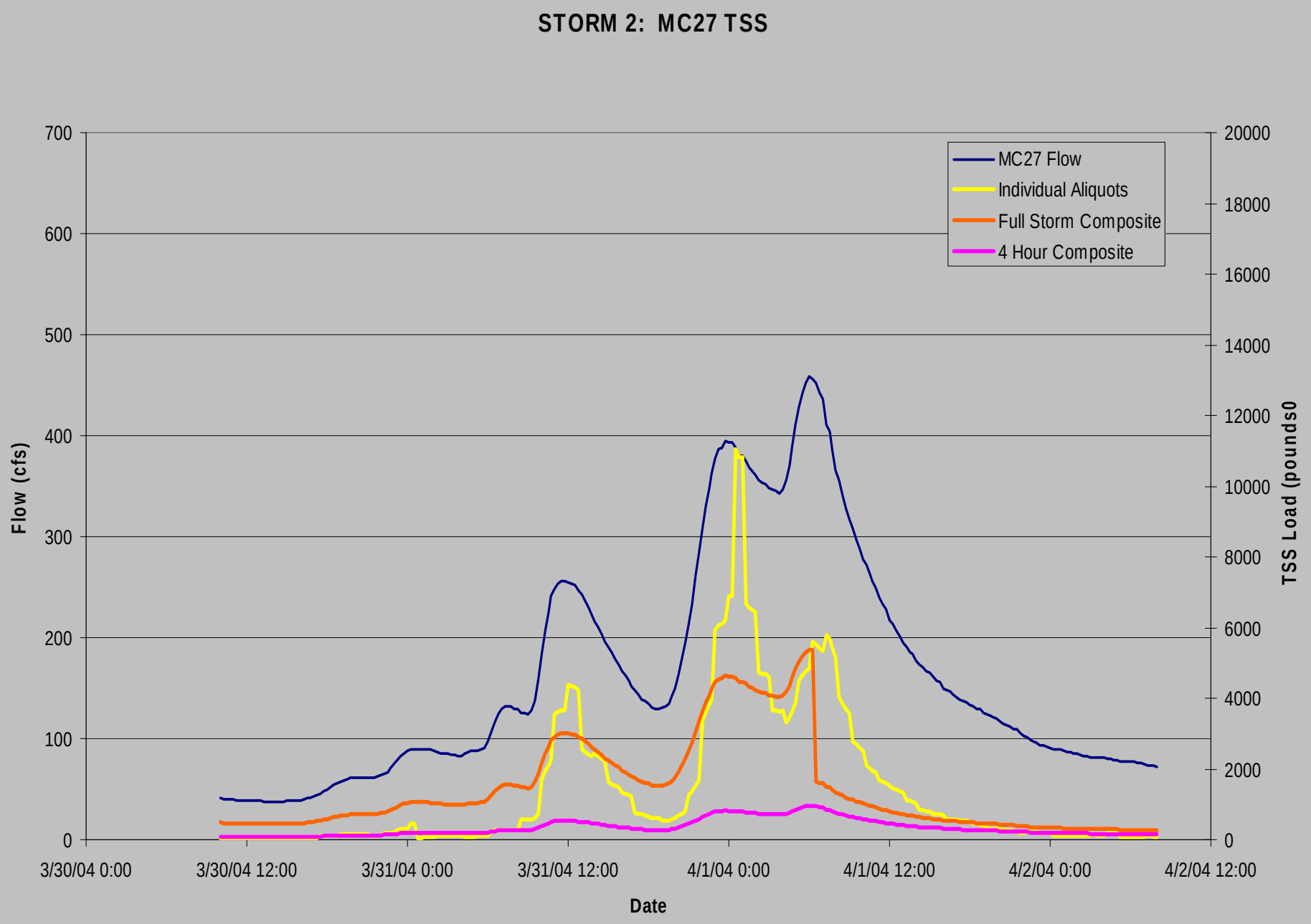
STORM 2

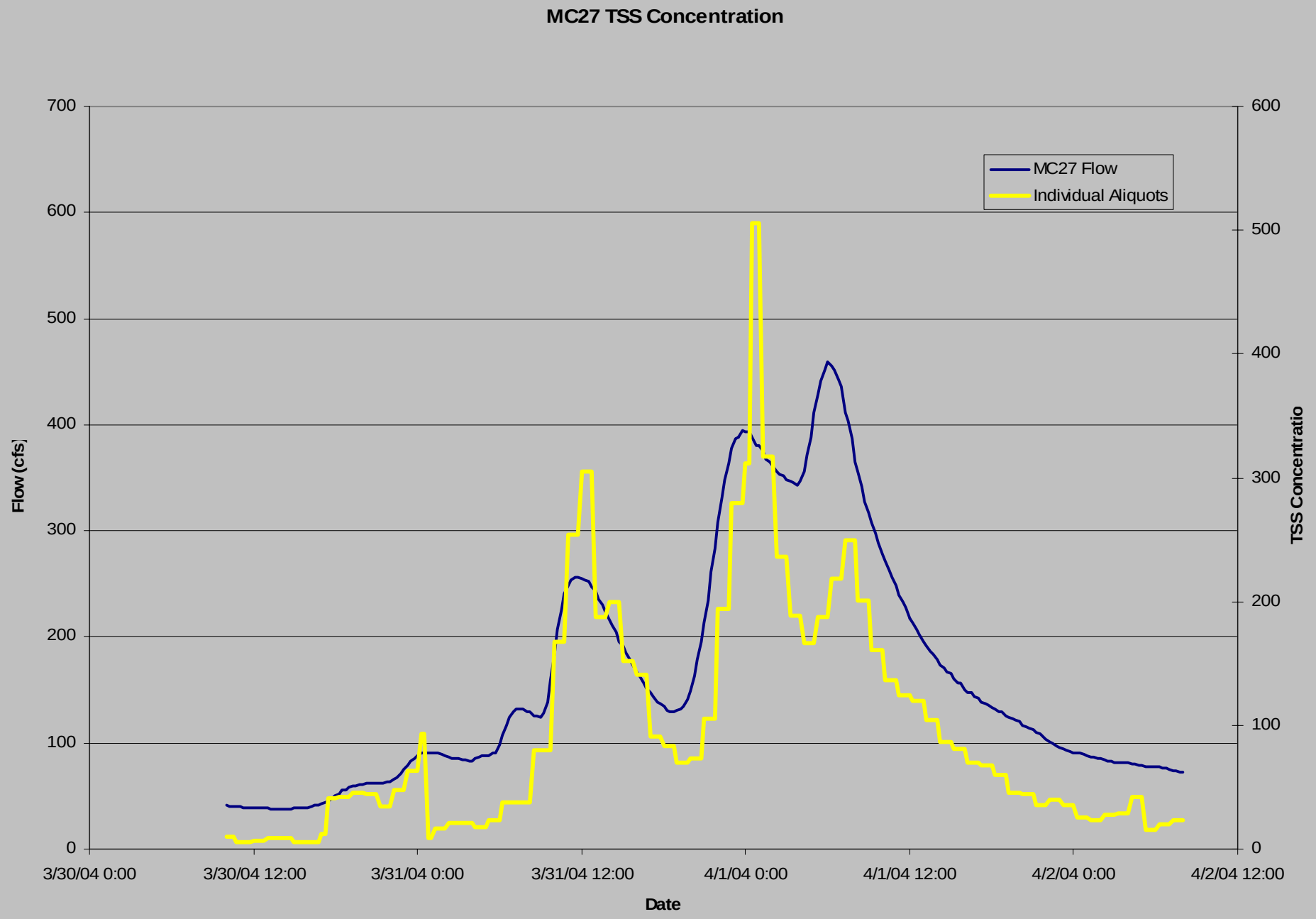
MC49A (Little Sugar Creek) and

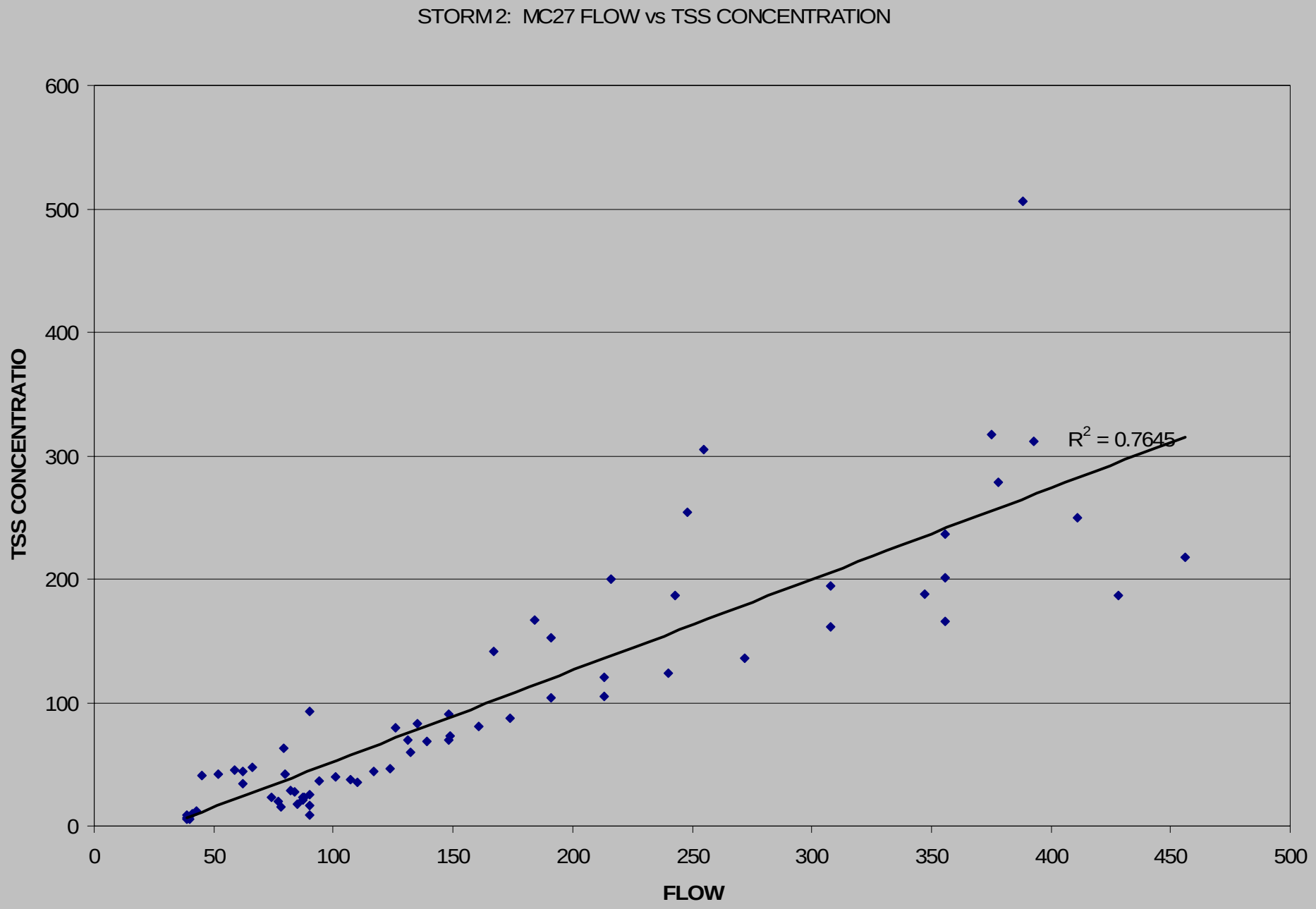
MC27 (Sugar Creek)

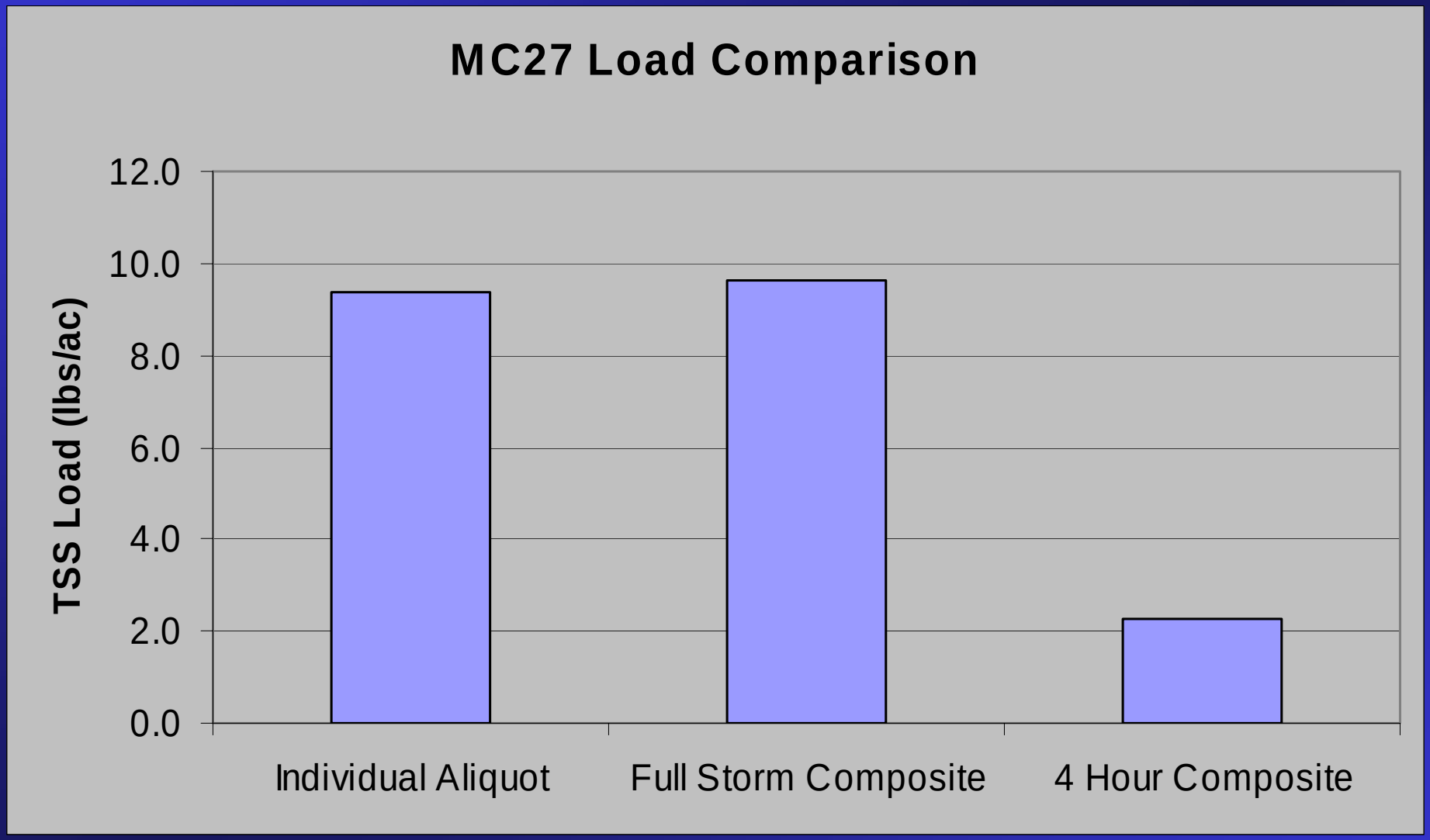
~0.6 inches of rainfall

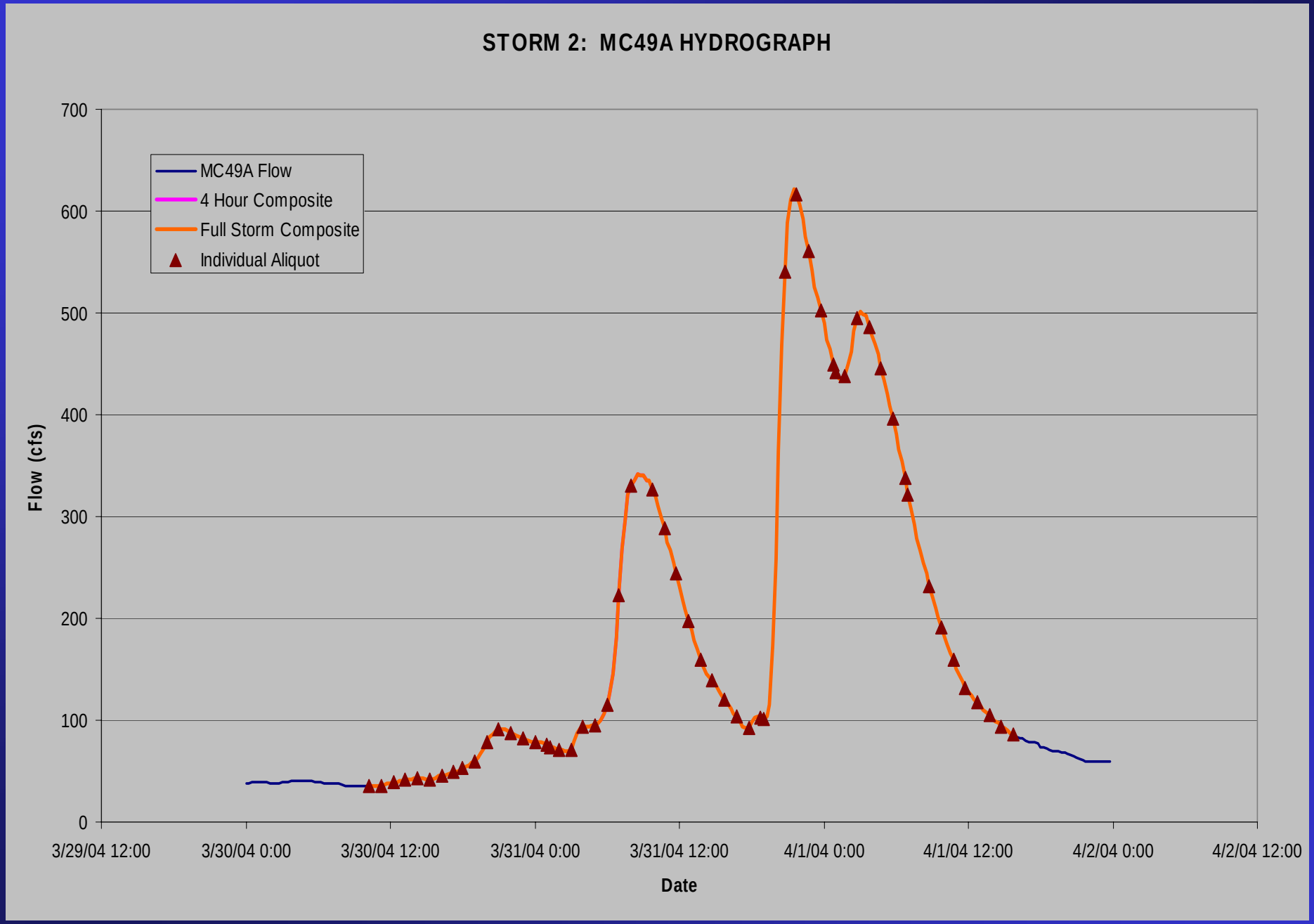

MC27 Hydrograph
MC27 Flow
4 Hour Composite
Full Storm Composite
Individual Aliquots
Flow (cfs)
500
450
400
350
300
250
200
150
100
50
0
3/29/2004 12:00
3/30/2004 0:00
3/30/2004 12:00
3/31/2004 0:00
3/31/2004 12:00
4/1/2004 0:00
4/1/2004 12:00
4/2/2004 0:00
4/2/2004 12:00
Date

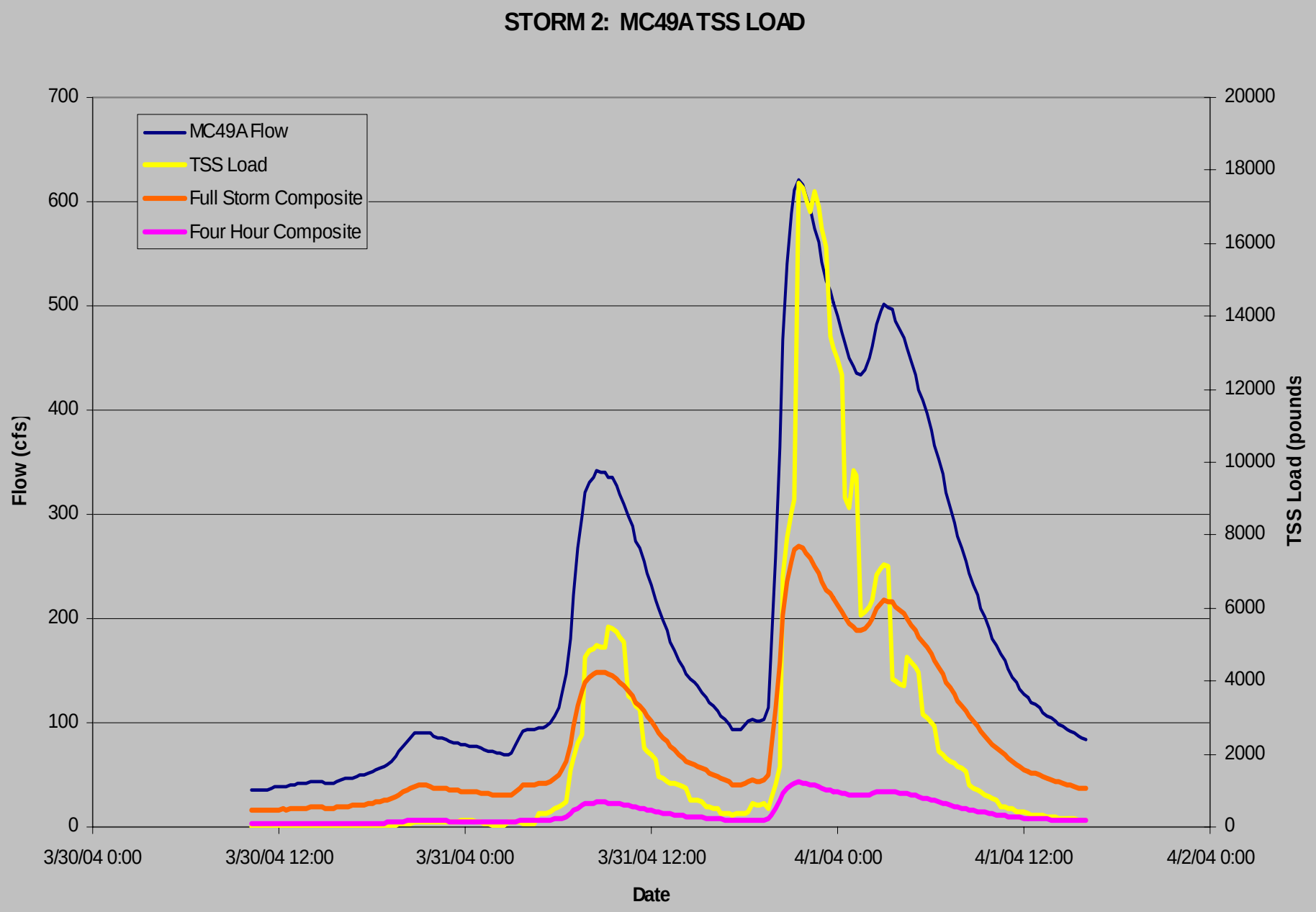

STORM 2: MC27 TSS
MC27 Flow
Individual Aliquots
Full Storm Composite
4 Hour Composite
Flow (cfs)
TSS Load (pounds0
Date
700
600
500
400
300
200
100
0
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
3/30/04 0:00
3/30/04 12:00
3/31/04 0:00
3/31/04 12:00
4/1/04 0:00
4/1/04 12:00
4/2/04 0:00
4/2/04 12:00

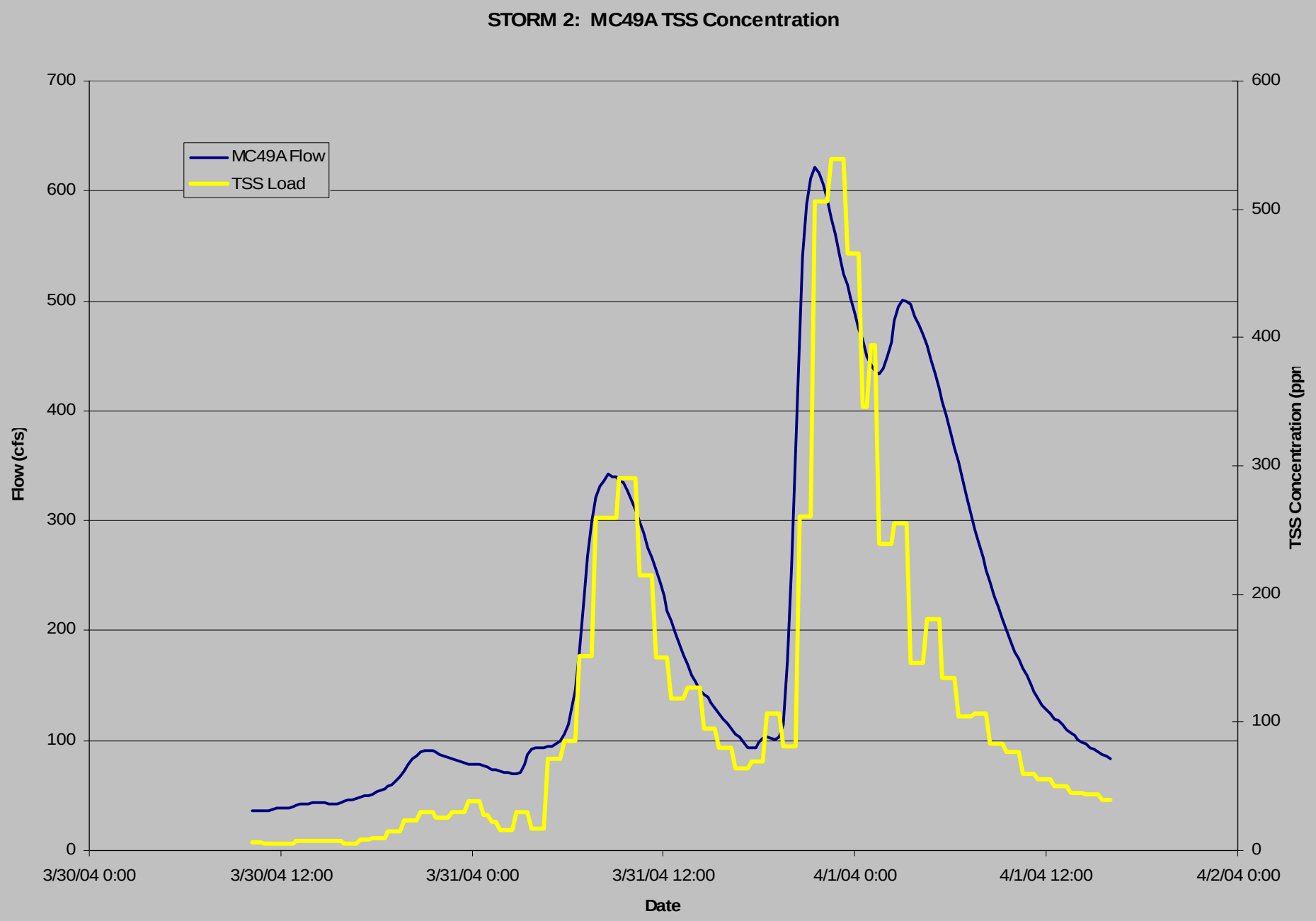

MC27 TSS Concentration
MC27 Flow
Individual Aliquots
Flow (cfs)
TSS Concentratio
Date
700
600
500
400
300
200
100
0
600
500
400
300
200
100
0
3/30/04 0:00
3/30/04 12:00
3/31/04 0:00
3/31/04 12:00
4/1/04 0:00
4/1/04 12:00
4/2/04 0:00
4/2/04 12:00

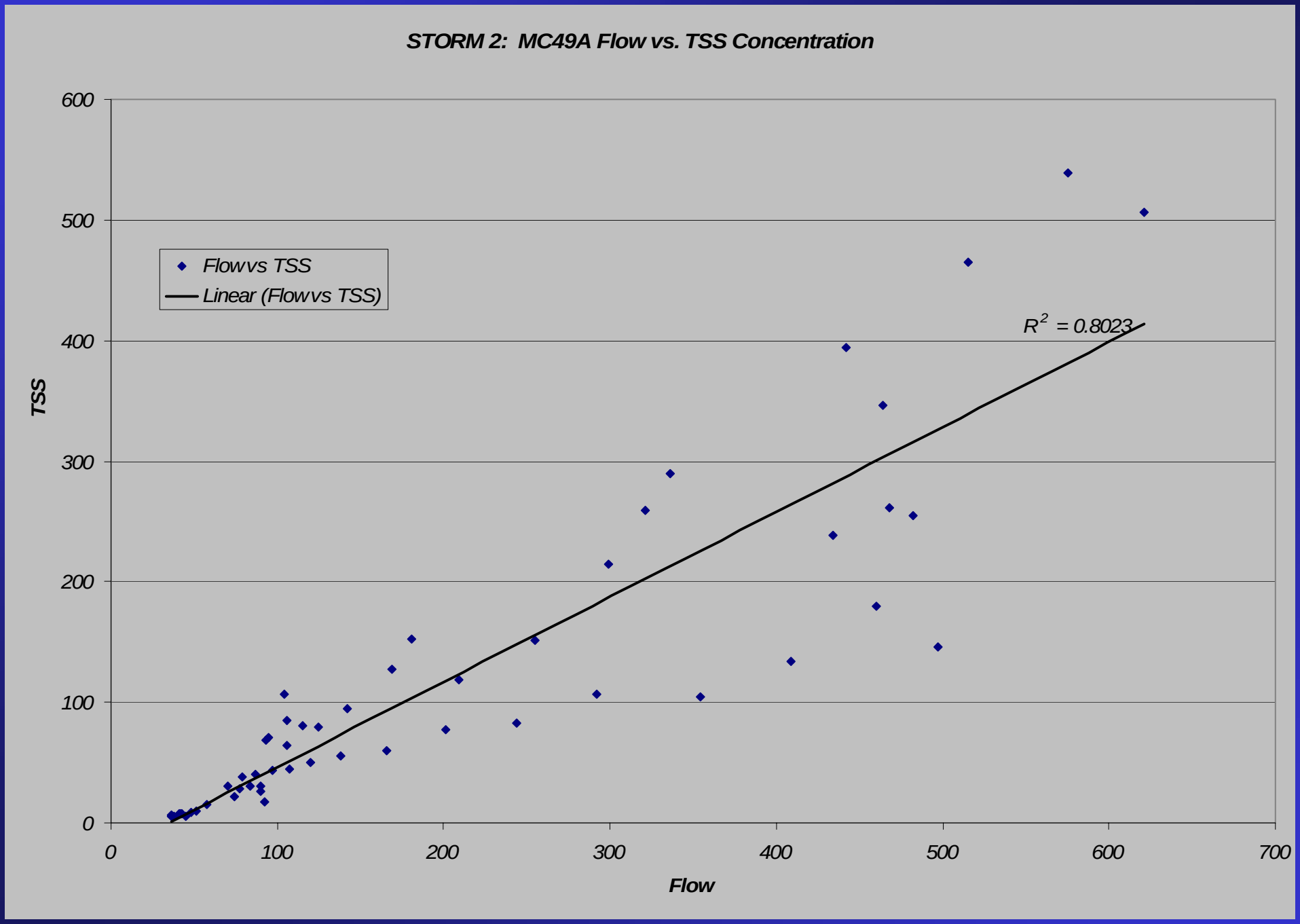

STORM 2: MC27 FLOW vs TSS CONCENTRATION
TSS CONCENTRATIO
FLOW
0
100
200
300
400
500
600
0
50
100
150
200
250
300
350
400
450
500
R2 = 0.7645

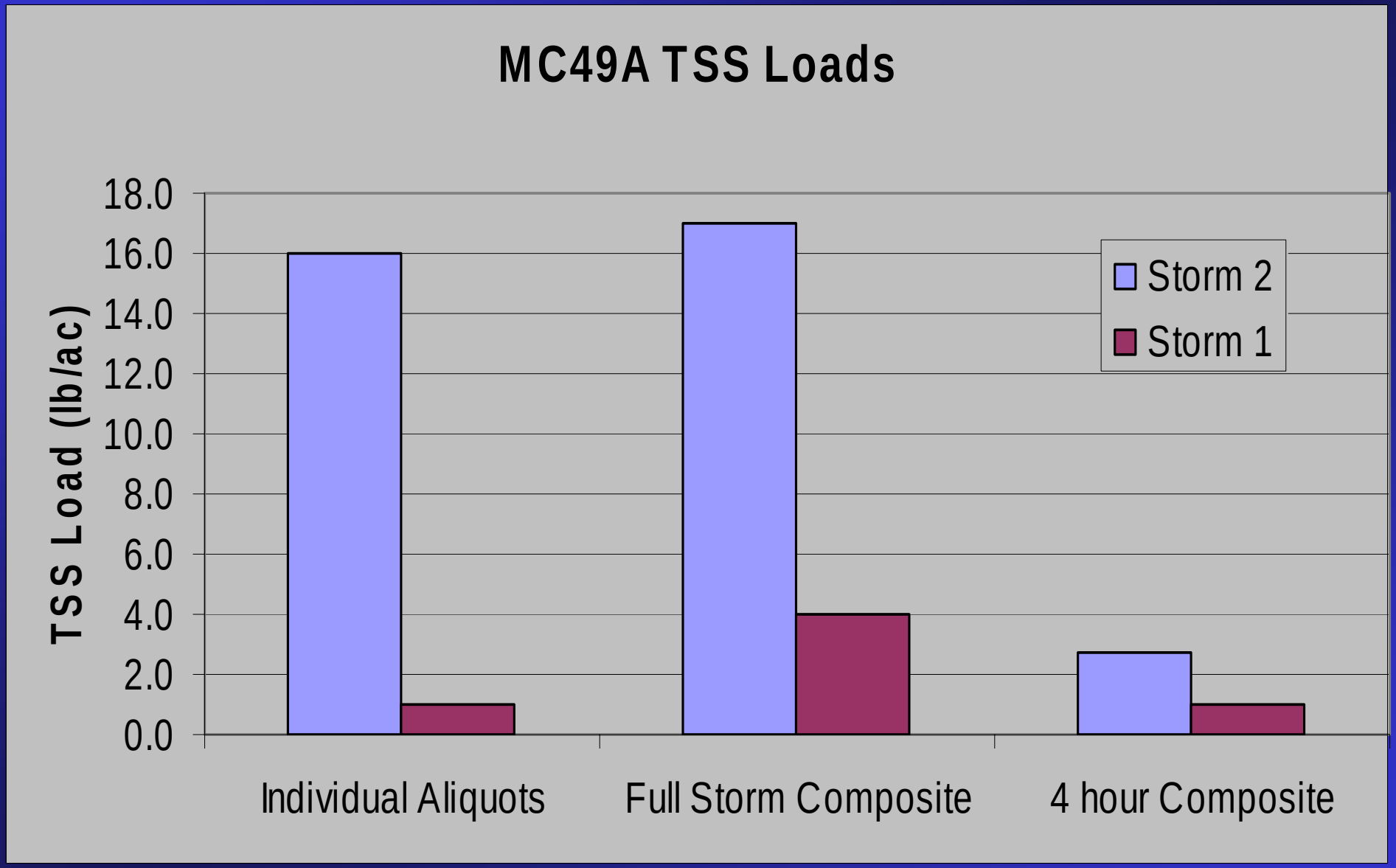

MC27 Load Comparison
TSS Load (lbs/ac)
12.0
10.0
8.0
6.0
4.0
2.0
0.0
Individual Aliquot
Full Storm Composite
4 Hour Composite

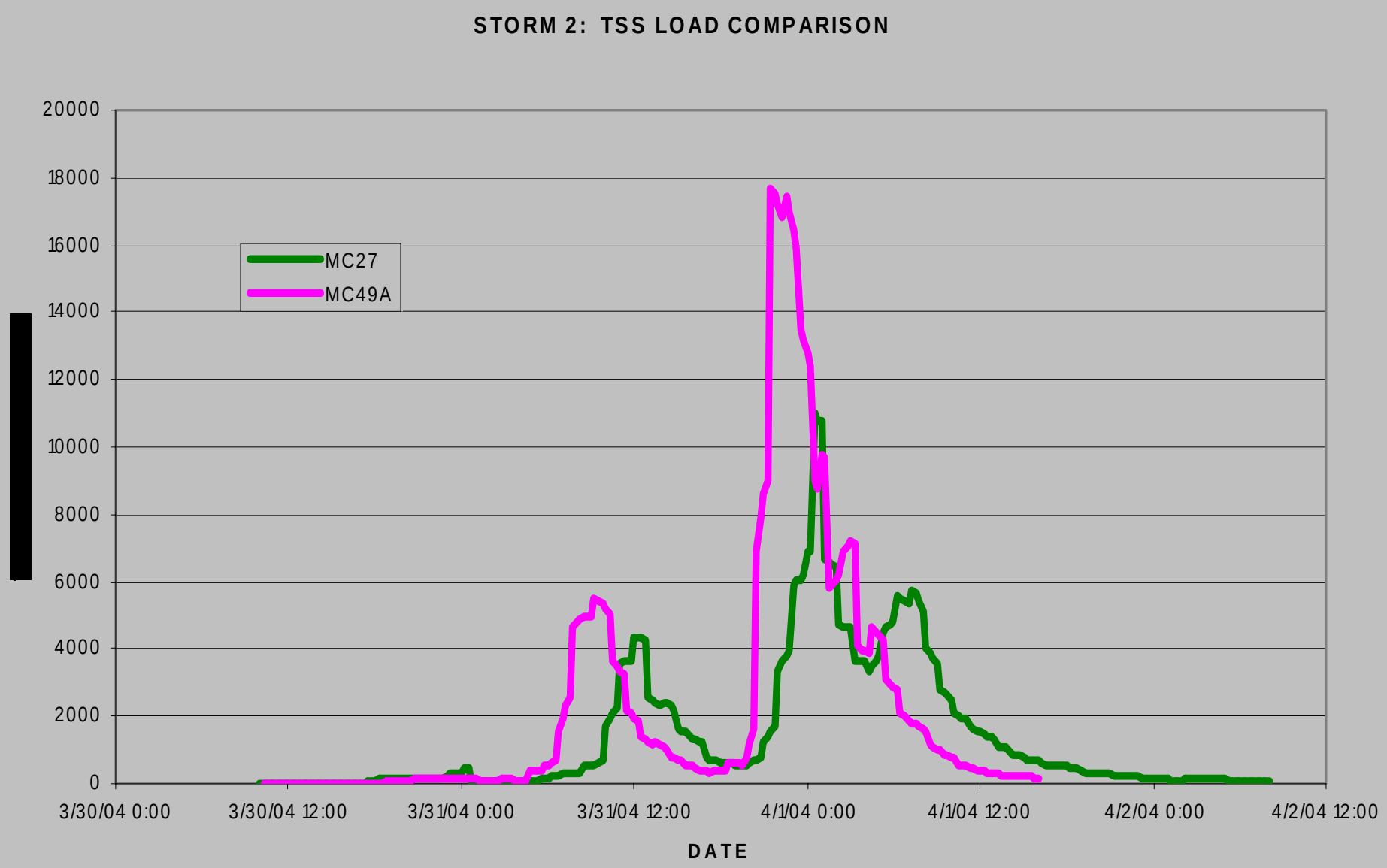

STORM 2: MC49A HYDROGRAPH
MC49A Flow
4 Hour Composite
Full Storm Composite
Individual Aliquot
Flow (cfs)
0
100
200
300
400
500
600
700
3/29/04 12:00
3/30/04 0:00
3/30/04 12:00
3/31/04 0:00
3/31/04 12:00
4/1/04 0:00
4/1/04 12:00
4/2/04 0:00
4/2/04 12:00
Date

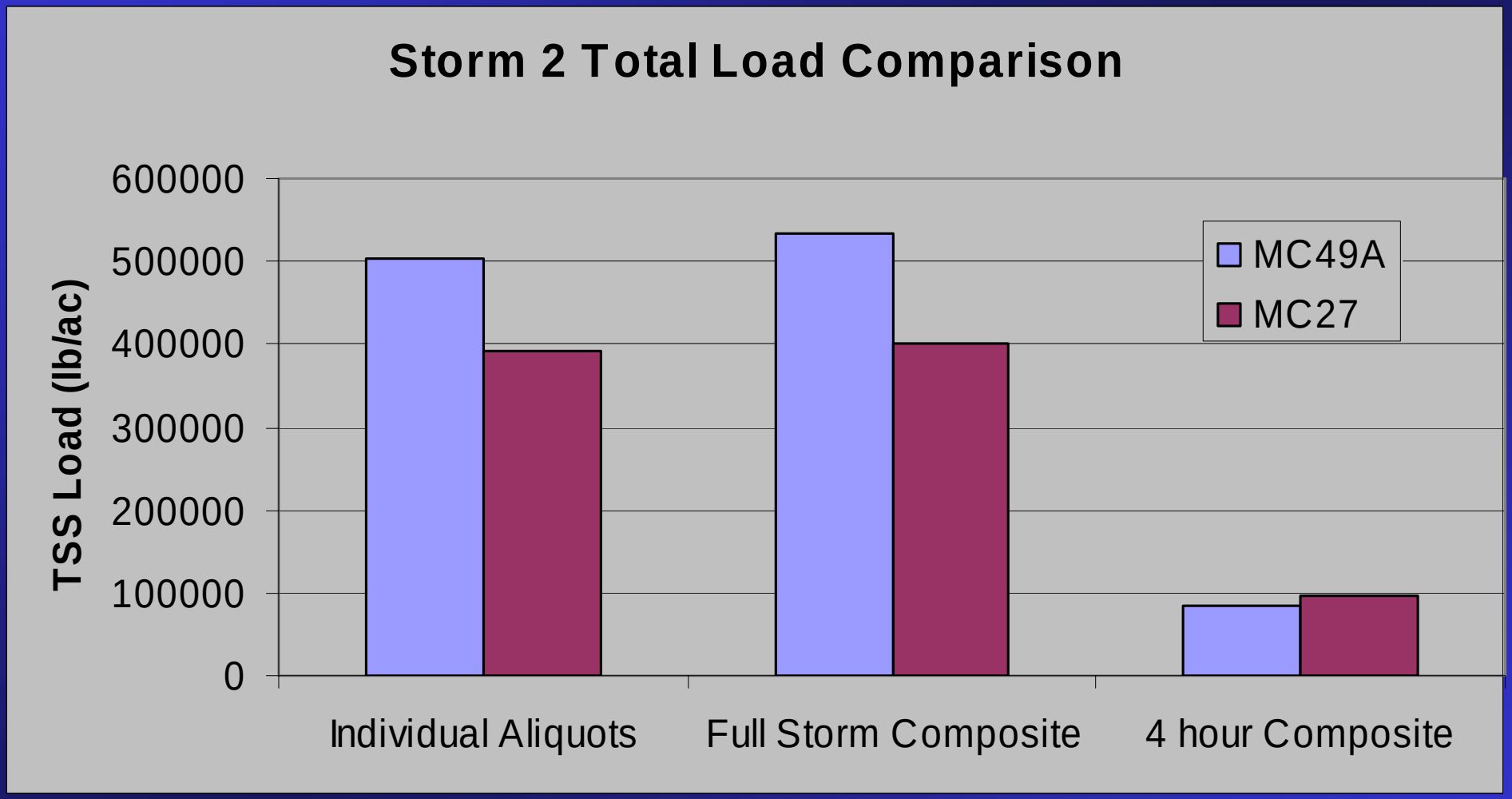

STORM 2: MC49A TSS LOAD
MC49A Flow
TSS Load
Full Storm Composite
Four Hour Composite
Flow (cfs)
TSS Load (pounds
Date
0
100
200
300
400
500
600
700
0
2000
4000
6000
8000
10000
12000
14000
16000
18000
20000
3/30/04 0:00
3/30/04 12:00
3/31/04 0:00
3/31/04 12:00
4/1/04 0:00
4/1/04 12:00
4/2/04 0:00


STORM 2: MC49A TSS Concentration
MC49A Flow
TSS Load
Flow (cfs)
TSS Concentration (ppm
Date
700
600
500
400
300
200
100
0
600
500
400
300
200
100
0
3/30/04 0:00
3/30/04 12:00
3/31/04 0:00
3/31/04 12:00
4/1/04 0:00
4/1/04 12:00
4/2/04 0:00

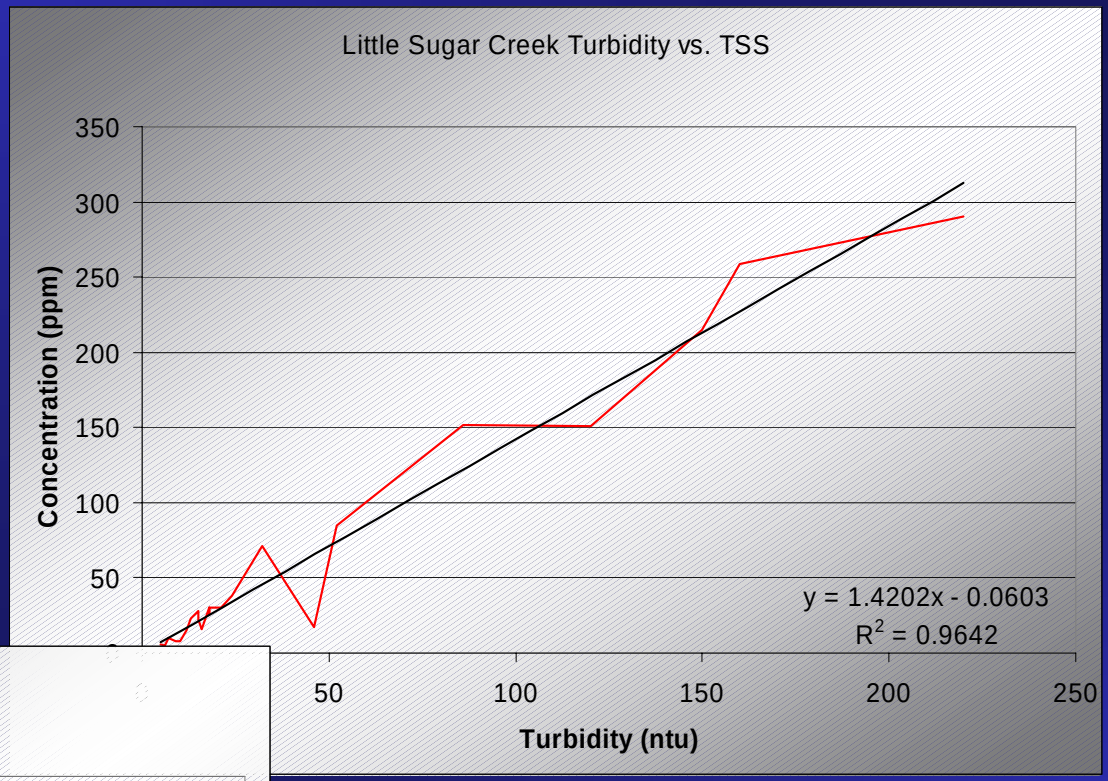

STORM 2: MC49A Flow vs. TSS Concentration
Flow vs TSS
Linear (Flow vs TSS)
R^2 = 0.8023
TSS
Flow
0
100
200
300
400
500
600
700

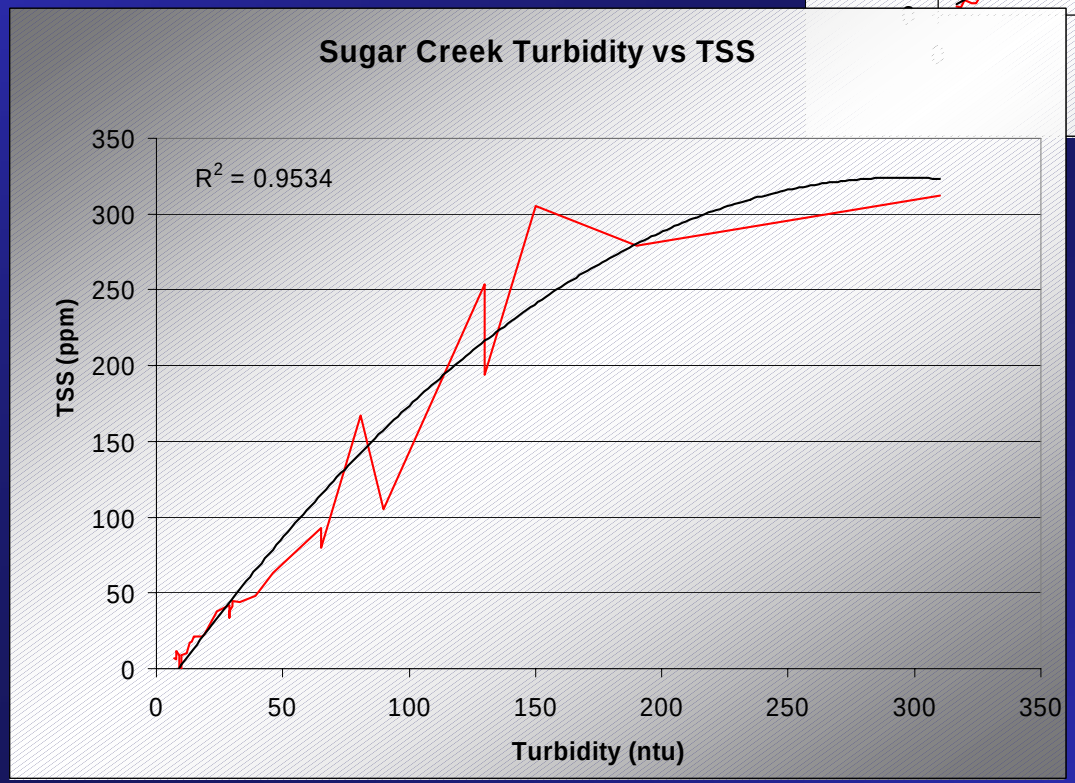

MC49A TSS Loads
TSS Load (lb/ac)
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
Storm 2
Storm 1
Individual Aliquots
Full Storm Composite
4 hour Composite


STORM 2: TSS LOAD COMPARISON
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
MC27
MC49A
3/30/04 0:00
3/30/04 12:00
3/31/04 0:00
3/31/04 12:00
4/1/04 0:00
4/1/04 12:00
4/2/04 0:00
4/2/04 12:00
DATE


Storm 2 Total Load Comparison
TSS Load (lb/ac)
600000
500000
400000
300000
200000
100000
0
MC49A
MC27
Individual Aliquots
Full Storm Composite
4 hour Composite

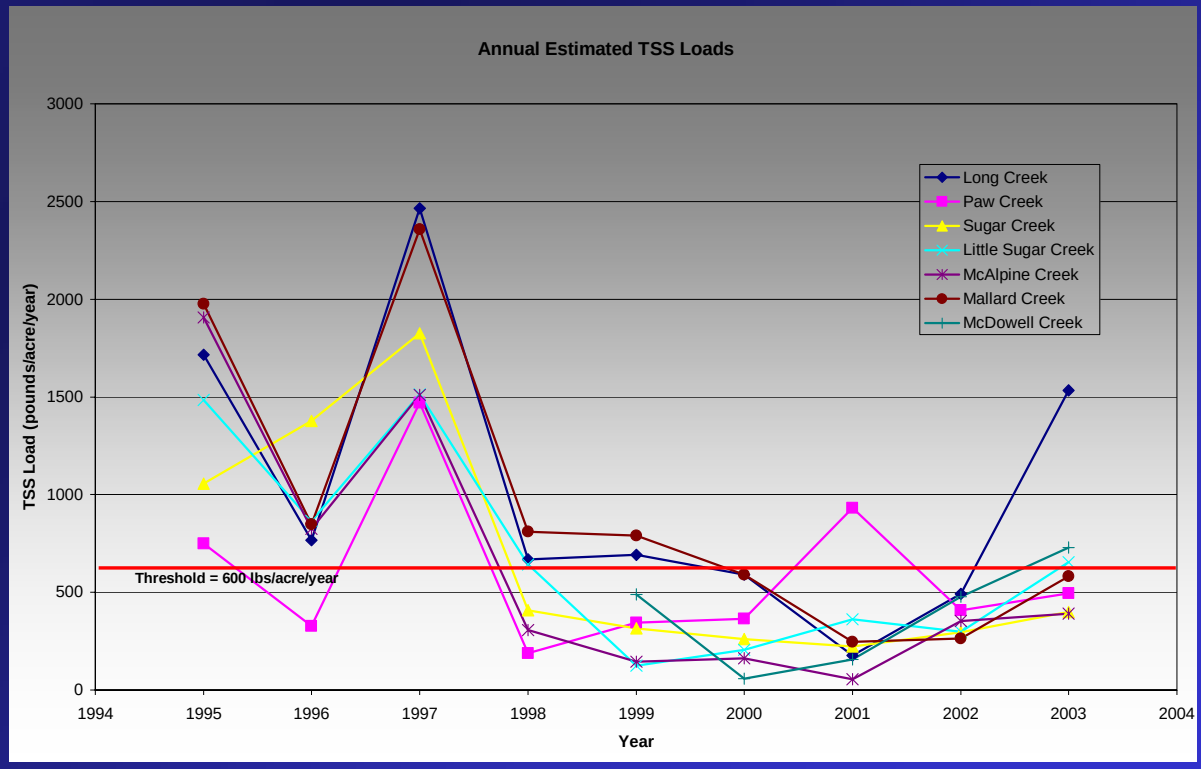
Turbidity vs TSS Concentration





Conclusions

- 4 Hour Composite Does not Represent Watershed Scale Pollutant Delivery Characteristics
- Whole Storm Composite Samples Seem to be a reasonable approach to in-stream storm water sampling
- MUST Sample Peak Flows!

The Real Message

- Trust Your GUT!
  - If it seems to good to be true it probably is..
  - No free lunch…