

# West Fork of the White River Stream Restoration Monitoring



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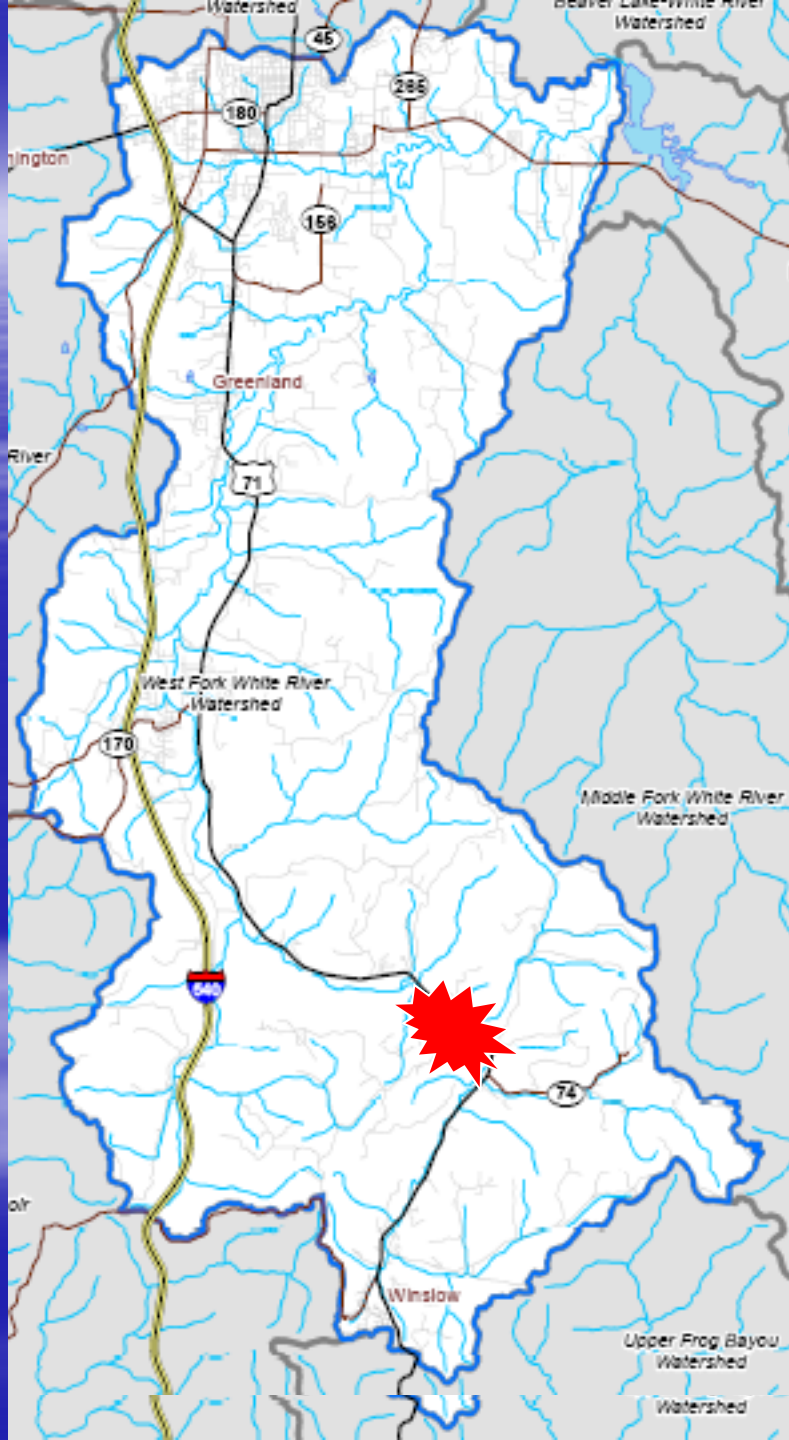
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# Introduction

Collect water quality samples before, during, and after the implementation of the restoration project at locations upstream and downstream of the restoration site.





# Goals/Objectives

- establish two water quality monitoring stations that are representative of the area and the restoration project
- accurately determine nutrient and sediment loading at the monitoring stations
- determine the effects of the restoration project on water quality
- gain a better understanding for the chemical and physical dynamics of project area in the watershed

# LOADING

- Requires daily DISCHARGE data, therefore continuous STAGE data.
- Requires daily sample concentrations.
- No USGS Station
- Flashy River, short and steep hydrograph.
- River has no mercy on costly instruments.

Problems that we face

# Development of Discharge Rating Curve

- Sontec Rivercat
- Marsh McBirnney Flowmate 2000
- Wading Rod

Objective: Determine river's discharge at as many different river stages as possible to generate a correlation between river stage and river discharge.





# Sampling Methods



- Routine Sampling
  - Composite samples
  - One sample every 14 hours
- Storm Sampling
  - Composite samples
  - One sample every two hours
  - Triggers 0.5 ft rise in 3 hours
- Grab sampling
  - ~ 1 every 7 days
- Use auto sampler to continuously Monitor Stage





**WF1** - approximately 1,500 ft upstream  
from the restoration site

West of Hwy 71 Hwy 74 intersection

$35^{\circ} 51' 3.07''$  N

$94^{\circ} 6' 19.87''$  W.





**WF2** - downstream of the restoration site  
Brentwood Mountain Road Bridge at the  
West Fork River

35° 51' 33.18" N

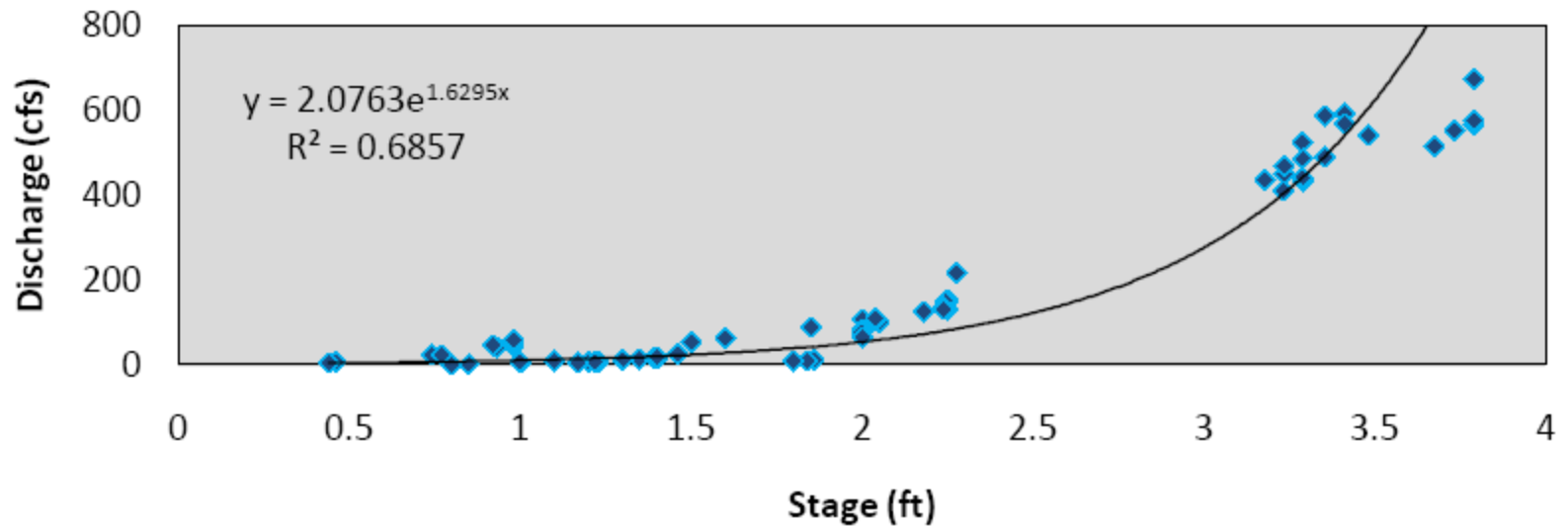
94° 6' 36.22" W.

# Results

- Stage – Discharge Rating Curve
- Sample Concentrations
- Loading Estimations



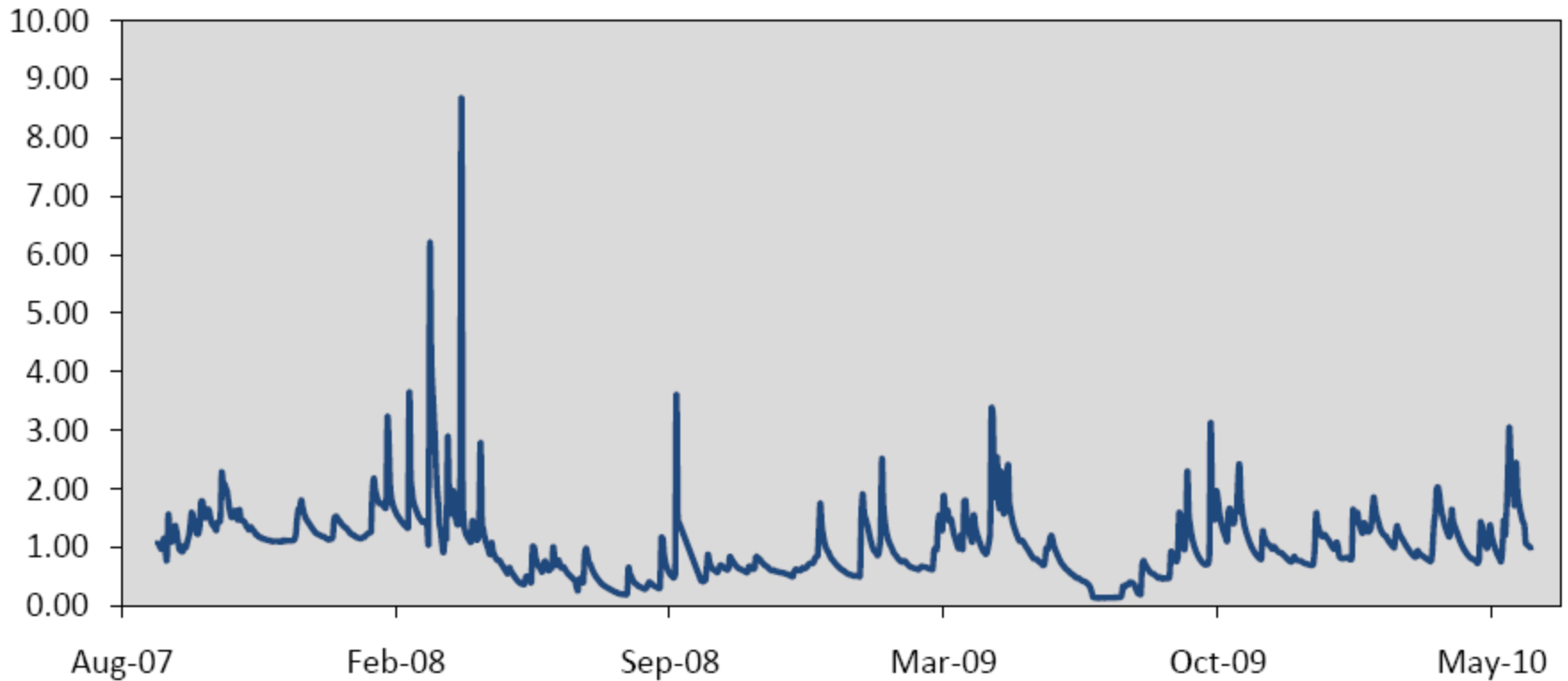
## Stage-Rating Curve



Stage Discharge Rating Curve

# Three Year Hydrograph

## Stage for West Fork Monitoring Stations



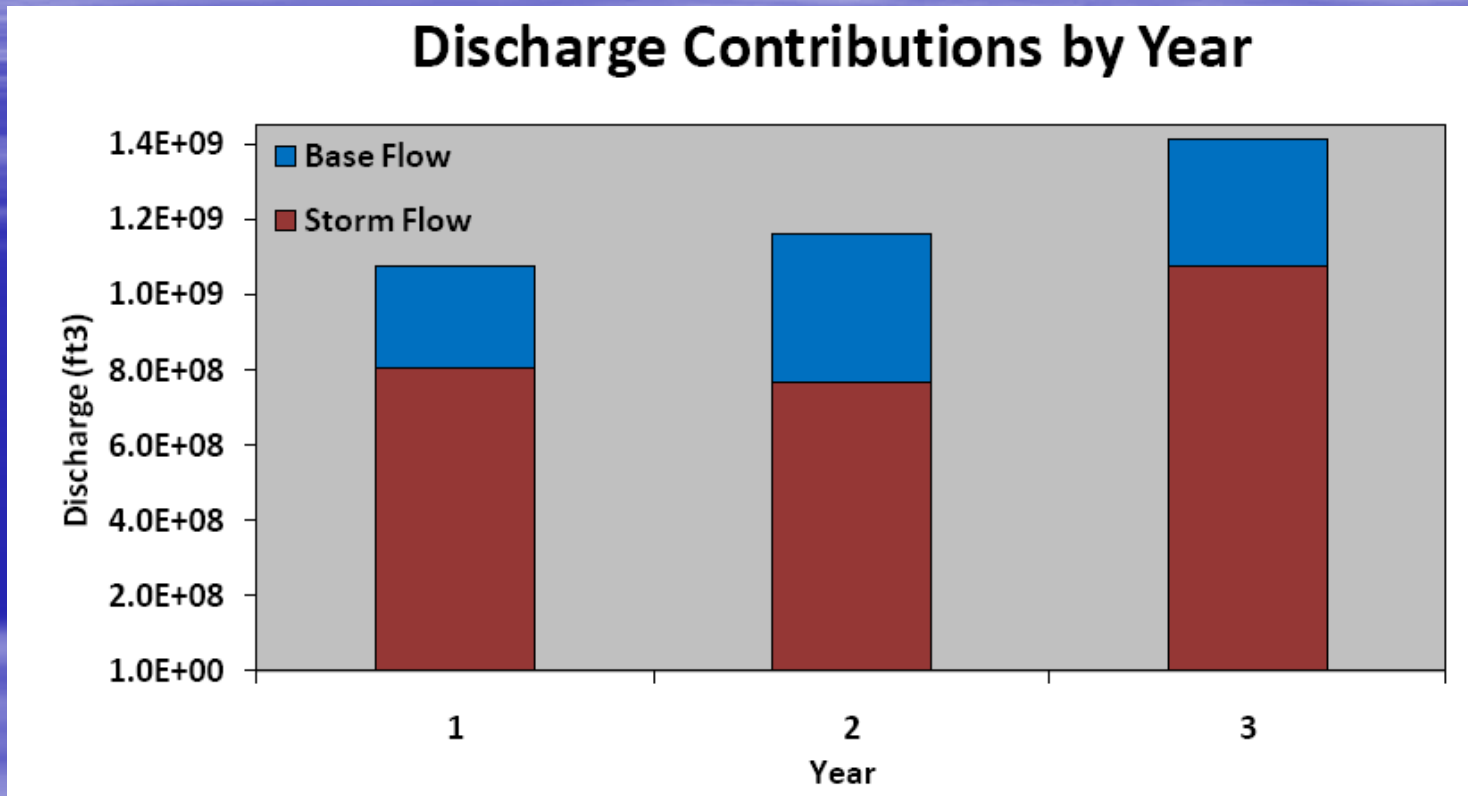


# Discharge Statistics

**Discharge Statistics for West Fork Monitoring Stations**

<b>Year</b>	<b>Maximum Daily Discharge</b>	<b>Minimum Daily Discharge</b>	<b>Average Daily Discharge</b>	<b>Total Discharge</b>
<b>1</b>	149,000,000	542,000	3,530,000	1,070,000,000
<b>2</b>	47,400,000	236,000	3,190,000	1,160,000,000
<b>3</b>	34,800,000	485,000	4,210,000	1,410,000,000
<b>All</b>	149,000,000	236,000	3,630,000	3,650,000,000

# Discharge Statistics



Year	Base Flow (ft <sup>3</sup> )	Storm Event (ft <sup>3</sup> )	Total (ft <sup>3</sup> )
1	270,000,000	803,000,000	1,070,000,000
2	393,000,000	769,000,000	1,160,000,000
3	334,000,000	1,080,000,000	1,410,000,000
<b>Total</b>	999,000,000	2,650,000,000	3,650,000,000



# Sample Concentrations

- Analyses were determined from three types of samples; grab samples, composite samples and storm samples.

Outliers for grab and composite samples were defined and then removed from the data set ( $3 \times \text{STDEV}$ ).

# Comparison of Sample Concentrations

Statistical evaluations determined significance between the sample concentrations of each type of sample and each parameter at WF1 and WF2.

An analysis of variance test (ANOVA) was first used in the evaluations

The Multiple Range Test was also used to investigate the statistical significances between the three sample types using a 95% confidence level.

# Comparison of Sample Concentrations

## WF1 and WF2 - ANOVA

The grab samples and composite sample concentrations are statistically similar and show minimal variance

Mostly, the storm sample concentrations are not equal to composite or grab sample concentrations.



**WF1 Grab Sample Concentrations**

<b>Descriptive Statistics</b>	<b>SRP (mg/L)</b>	<b>NO<sub>3</sub>-N (mg/L)</b>	<b>TSS (mg/L)</b>	<b>Turbidity (NTU)</b>	<b>TP (mg/L)</b>	<b>TKN (mg/L)</b>	<b>NH<sub>3</sub>-N (mg/L)</b>	<b>SO<sub>4</sub> (mg/L)</b>	<b>Cl<sup>-</sup> (mg/L)</b>
Mean	0.01	0.5	3.92	5.05	0.03	0.11	0.02	4.25	3.28
Range	0.12	1.27	26.8	37.8	0.12	0.32	0.13	6.71	3.87
Minimum	0	0.02	0	0.32	0	0.01	0	3.18	1.95
Maximum	0.12	1.29	26.8	38.1	0.12	0.33	0.13	9.89	5.82

**WF2 Grab Sample Concentrations**

<b>Descriptive Statistics</b>	<b>SRP (mg/L)</b>	<b>NO<sub>3</sub>-N (mg/L)</b>	<b>TSS (mg/L)</b>	<b>Turbidity (NTU)</b>	<b>TP (mg/L)</b>	<b>TKN (mg/L)</b>	<b>NH<sub>3</sub>-N (mg/L)</b>	<b>SO<sub>4</sub> (mg/L)</b>	<b>Cl<sup>-</sup> (mg/L)</b>
Mean	0.01	0.51	4.61	5.64	0.03	0.12	0.02	4.43	3.34
Range	0.12	1.21	41.8	33	0.11	0.58	0.08	7.66	5.03
Minimum	0	0.02	0.2	0.31	0	0	0	2.94	0.46
Maximum	0.12	1.23	42	33.3	0.11	0.58	0.08	10.6	5.49

**WF1 Composite Sample Concentrations**

<b>Descriptive Statistics</b>	<b>SRP (mg/L)</b>	<b>NO<sub>3</sub>-N (mg/L)</b>	<b>TSS (mg/L)</b>	<b>Turbidity (NTU)</b>	<b>TP (mg/L)</b>	<b>TKN (mg/L)</b>	<b>NH<sub>3</sub>-N (mg/L)</b>	<b>SO<sub>4</sub> (mg/L)</b>	<b>Cl<sup>-</sup> (mg/L)</b>
Mean	0.01	0.47	5.99	5.69	0.05	0.16	0.03	4.55	3.39
Range	0.06	1.09	69.6	46	0.29	0.56	0.27	6.77	8.3
Minimum	0	0.02	0.4	0.99	0	0.02	0	3.12	2.16
Maximum	0.06	1.11	70	47	0.29	0.58	0.27	9.89	10.5

**WF2 Composite Sample Concentrations**

<b>Descriptive Statistics</b>	<b>SRP (mg/L)</b>	<b>NO<sub>3</sub>-N (mg/L)</b>	<b>TSS (mg/L)</b>	<b>Turbidity (NTU)</b>	<b>TP (mg/L)</b>	<b>TKN (mg/L)</b>	<b>NH<sub>3</sub>-N (mg/L)</b>	<b>SO<sub>4</sub> (mg/L)</b>	<b>Cl<sup>-</sup> (mg/L)</b>
Mean	0.01	0.48	6.28		0.05	0.16	0.03	5.17	3.31
Range	0.08	1.01	69.9	79.4	0.29	0.75	0.1	29.1	4.71
Minimum	0	0.1	0.4	0.61	0.01	0.02	0	3.2	0.42
Maximum	0.08	1.11	70.3	80	0.3	0.77	0.1	32.3	5.13

**WF1 Storm Sample Concentrations**

<b>Descriptive Statistics</b>	<b>SRP (mg/L)</b>	<b>NO<sub>3</sub>-N (mg/L)</b>	<b>TSS (mg/L)</b>	<b>Turbidity (NTU)</b>	<b>TP (mg/L)</b>	<b>TKN (mg/L)</b>	<b>NH<sub>3</sub>-N (mg/L)</b>	<b>SO<sub>4</sub> (mg/L)</b>	<b>Cl<sup>-</sup> (mg/L)</b>
Mean	0.02	0.66	118	104	0.34	0.77	0.04	4.06	2.99
Range	0.08	0.91	876	448	1.46	2.8	0.29	2.77	5.26
Minimum	0	0.15	3.2	1.59	0	0.04	0	3.17	1.3
Maximum	0.08	1.06	879	449	1.46	2.84	0.29	5.94	6.56

**WF2 Storm Sample Concentrations**

<b>Descriptive Statistics</b>	<b>SRP (mg/L)</b>	<b>NO<sub>3</sub>-N (mg/L)</b>	<b>TSS (mg/L)</b>	<b>Turbidity (NTU)</b>	<b>TP (mg/L)</b>	<b>TKN (mg/L)</b>	<b>NH<sub>3</sub>-N (mg/L)</b>	<b>SO<sub>4</sub> (mg/L)</b>	<b>Cl<sup>-</sup> (mg/L)</b>
Mean	0.02	0.59	134	137	0.34	0.74	0.04	4.33	3.02
Range	0.05	1.02	891	869	1.58	3.4	0.36	2.52	3.32
Minimum	0	0.15	6.4	1.04	0.02	0.09	0	3.26	1.58
Maximum	0.06	1.17	897	870	1.6	3.49	0.36	5.78	4.9



# Comparison between WF1 and WF2 Sample Concentrations

Three statistical tests were performed to examine the correspondence between samples collected at WF1 and WF2.

The t-test

The sign test

The signed rank test

# WF1 compared to WF2 Grab Samples

WF1 grab sample concentrations compared to the WF2 grab sample concentrations were all equal with the exception of SO<sub>4</sub> concentrations at the 95% confidence level.

### Comparison between WF1 and WF2 Grab Sample Concentrations

Parameter	T-test		Sign Test		Sign ranked Test	
	t-stat	P Value	t-stat	P Value	t-stat	P Value
SRP	0.944	0.622	1.31	0.189	0.806	0.420
NO <sub>3</sub> -N	0.362	0.718	1.50	0.134	0.814	0.416
TSS	0.597	0.552	0.099	0.921	0.418	0.676
Turbidity	0.764	0.447	0.098	0.922	0.454	0.650
TP	0.227	0.821	0.00	1.00	0.00	1.00
TKN	1.43	0.156	1.01	0.315	1.50	0.134
NH <sub>3</sub> -N	-0.436	0.664	0.00	1.00	0.00	1.00
SO <sub>4</sub>	1.18	0.242	2.26	0.02	2.70	0.007
Cl <sup>-</sup>	0.599	0.550	0.985	0.324	0.798	0.425



# WF1 compared to WF2 Composite Samples

WF1 composite sample concentrations compared to the WF2 composite sample concentrations were all equal with the exception of turbidity values at the 95% confidence level.

### Comparison between WF1 and WF2 Composite Sample Concentrations

Parameter	T-test		Sign Test		Sign ranked Test	
	t-stat	P Value	t-stat	P Value	t-stat	P Value
SRP	0.265	0.792	0.108	0.914	0.099	0.920
NO <sub>3</sub> -N	0.413	0.681	0.868	0.386	0.622	0.534
TSS	0.087	0.931	0.868	0.386	0.325	0.746
Turbidity	0.090	0.929	2.34	0.025	1.02	0.304
TP	0.289	0.773	0.231	0.817	0.00	1.00
TKN	0.235	0.815	0.220	0.826	0.117	0.907
NH <sub>3</sub> -N	1.52	0.131	1.05	0.295	1.24	0.214
SO <sub>4</sub>	1.18	0.241	0.00	1.00	0.969	0.332
Cl <sup>-</sup>	-0.692	0.491	1.39	0.166	0.381	0.703

# WF1 compared to WF2 Storm Samples

WF1 storm sample  
concentrations compared to the  
WF2 storm sample  
concentrations were all equal at  
the 95% confidence level.

### Comparison between WF1 and WF2 Storm Sample Concentrations

Parameter	T-test		Sign Test		Sign ranked Test	
	t-stat	P Value	t-stat	P Value	t-stat	P Value
SRP	-0.711	0.482	0.177	0.860	0.458	0.647
NO <sub>3</sub> -N	-1.52	0.140	1.24	0.216	1.53	0.125
TSS	0.581	0.566	0.530	0.596	0.533	0.594
Turbidity	0.964	0.342	0.177	0.860	0.103	0.918
TP	0.187	0.853	0.00	1.00	0.00	1.00
TKN	0.002	0.999	1.24	0.216	0.776	0.438
NH <sub>3</sub> -N	0.205	0.839	0.00	1.00	0.253	0.800
SO <sub>4</sub>	1.74	0.092	0.177	0.850	1.40	0.161
Cl <sup>-</sup>	-0.075	0.951	0.530	0.596	0.533	0.594



# Loading Estimations

Pollutant loading was calculated at both monitoring sites from parameter concentrations and daily average discharge.

Loadings were calculated for SRP, NO<sub>3</sub>-N, TSS, TP, TKN, NH<sub>3</sub>-N, SO<sub>4</sub> and Cl<sup>-</sup>.

Concentrations from the grab, composite, and storm event samples were used to make the estimation.

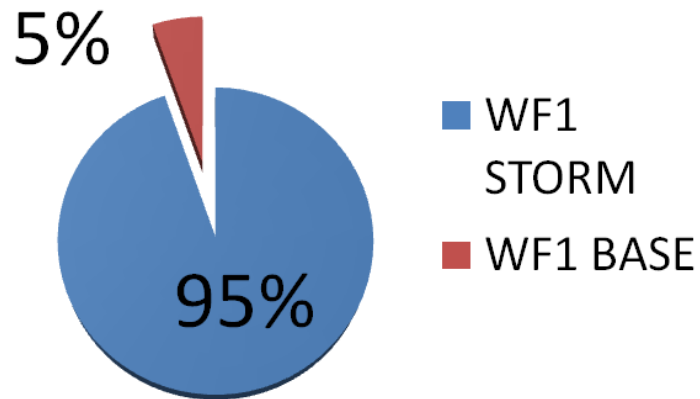
The period-weighted loading method was used.

	<b>SRP (lbs)</b>	<b>NO<sub>3</sub>-N (lbs)</b>	<b>TSS (lbs)</b>	<b>TP (lbs)</b>	<b>TKN (lbs)</b>	<b>NH<sub>3</sub>-N (lbs)</b>	<b>SO<sub>4</sub> (lbs)</b>	<b>Cl<sup>-</sup> (lbs)</b>
<b>WF1 STORM</b>								
YEAR 1	1,760	18,000	5,690,000	11,600	25,000	1,130	231,000	130,000
YEAR 2	760	28,300	1,360,000	8,340	18,500	1,210	181,000	112,000
YEAR 3	554	43,000	544,000	4,590	13,900	2,160	254,000	189,000
<b>TOTAL</b>	<b>3,070</b>	<b>89,400</b>	<b>7,590,000</b>	<b>24,500</b>	<b>57,400</b>	<b>4,500</b>	<b>665,000</b>	<b>432,000</b>
<b>WF2 STORM</b>								
YEAR 1	1,900	19,400	5,530,000	11,900	24,900	1,150	216,000	150,000
YEAR 2	708	28,800	1,600,000	9,800	20,800	1,580	174,000	110,000
YEAR 3	622	44,300	1,050,000	4,660	21,200	2,010	259,000	185,000
<b>TOTAL</b>	<b>3,230</b>	<b>92,400</b>	<b>8,190,000</b>	<b>26,300</b>	<b>66,900</b>	<b>4,730</b>	<b>649,000</b>	<b>445,000</b>
<b>WF1 BASE</b>								
YEAR 1	175	7,370	171,000	1,140	2,580	372	75,200	63,100
YEAR 2	316	11,400	119,000	1,330	4,210	745	105,000	72,500
YEAR 3	173	12,200	140,000	694	4,720	993	86,500	63,600
<b>TOTAL</b>	<b>663</b>	<b>30,900</b>	<b>429,000</b>	<b>3,160</b>	<b>11,500</b>	<b>2,110</b>	<b>266,000</b>	<b>199,000</b>
<b>WF2 BASE</b>								
YEAR 1	284	7,310	434,000	1,510	3,120	334	78,900	63,600
YEAR 2	329	12,200	148,000	1,310	4,320	605	109,000	75,800
YEAR 3	176	11,900	159,000	736	4,850	955	94,300	62,900
<b>TOTAL</b>	<b>789</b>	<b>31,500</b>	<b>741,000</b>	<b>3,560</b>	<b>12,300</b>	<b>1,890</b>	<b>283,000</b>	<b>202,000</b>

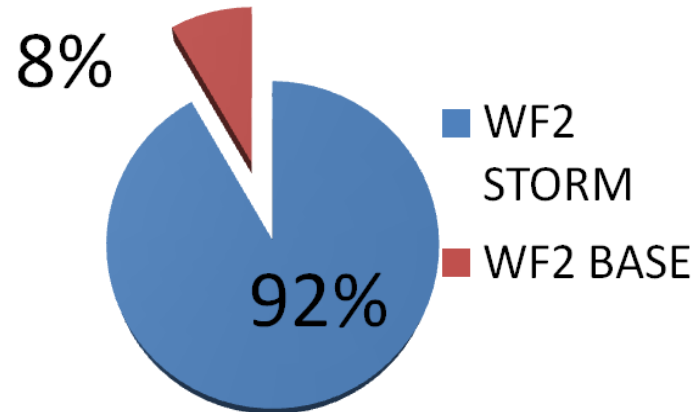
# TSS Loading

## Storm Events verses Base Flow

WF1 - Contribution of TSS total load from storm events



WF2 - Contribution of TSS total load from storm events



# Results

## Reg. 2 Turbidity Standard

Base Flow <10 NTU

WF1- 11% exceeded base flow target

WF2 – 11% exceeded base flow target

All Flow <19 NTU

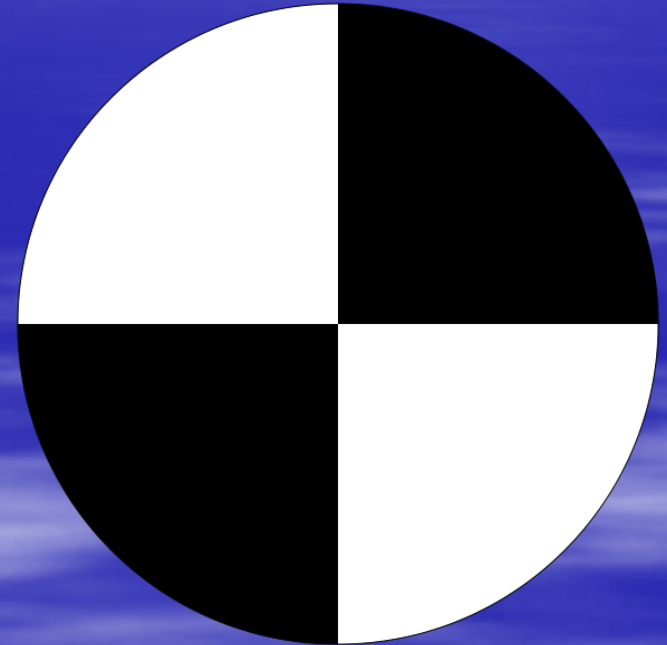
WF1- 5% exceeded all flow target

WF2- 6% exceeded all flow target

Storm Samples

WF1 – 81% exceeded all flow target

WF2 – 80% exceed all flow target





# Questions