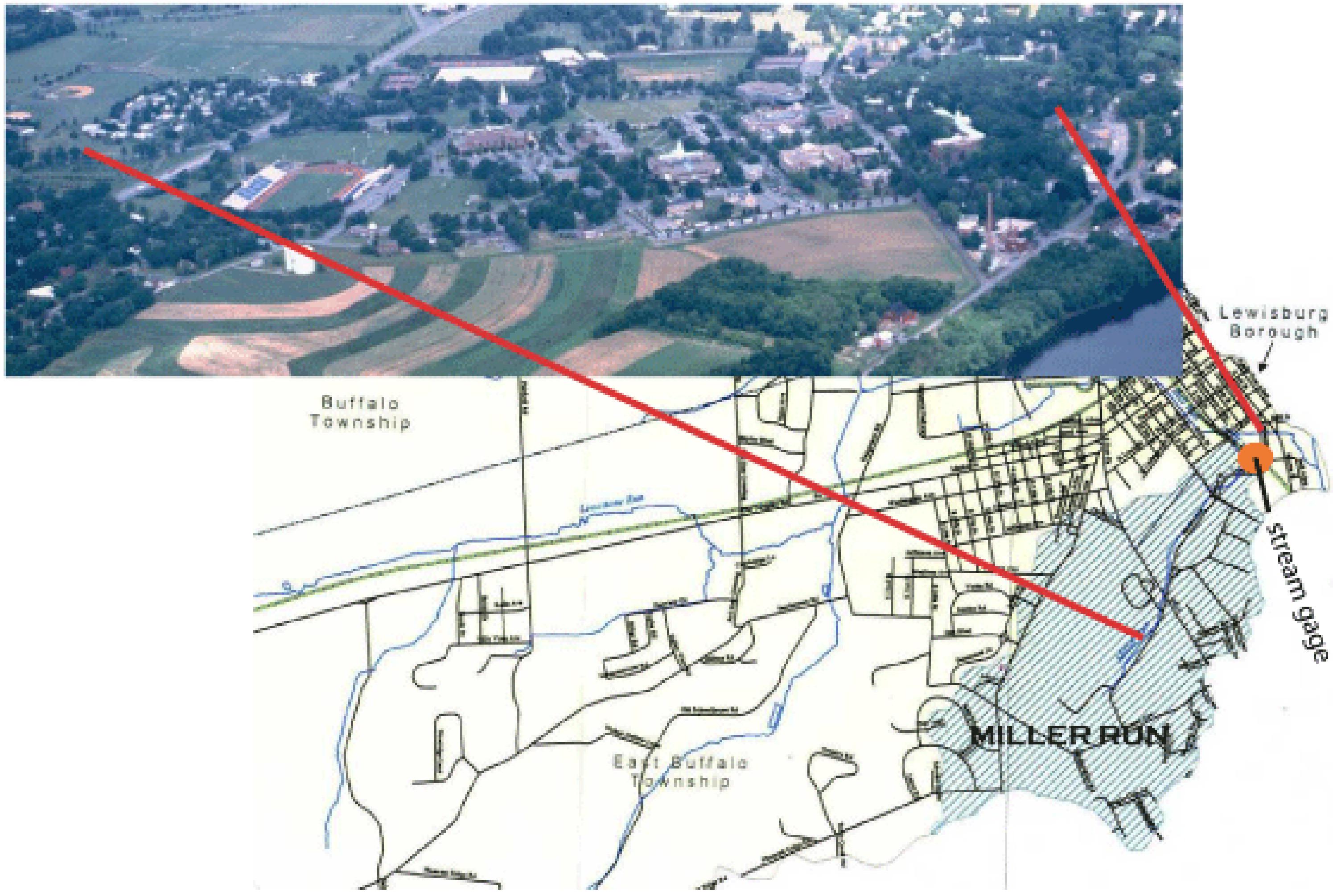


Characterization of Miller Run and Conceptual Plan for Watershed Restoration

UNIV 298

Spring 2009

Miller Run: An Overview



Miller Run Statistics

- 80% of Miller Run is owned by Bucknell.
- The runoff from the new housing developments also contribute to the stream.
- Length of Stream: 2,000m
- Percent Forest: 13.1% (The Grove and the Golf Course)
- Percent Urban: 37.5% (Buildings and Roads)
- **Channelized: 75-100%**
- **50% Rip-rap**

Source: streamstats.usgs.gov (2009)

Introduction to the Presentation

- Characterization of Miller Run
  - The impairment of the stream:
    - The Channel
    - The Water
- Conceptual Plan
  - Our Proposed Solutions
  - The Costs of Our Proposed Solutions
- Conclusions
  - What Miller Run Could Be

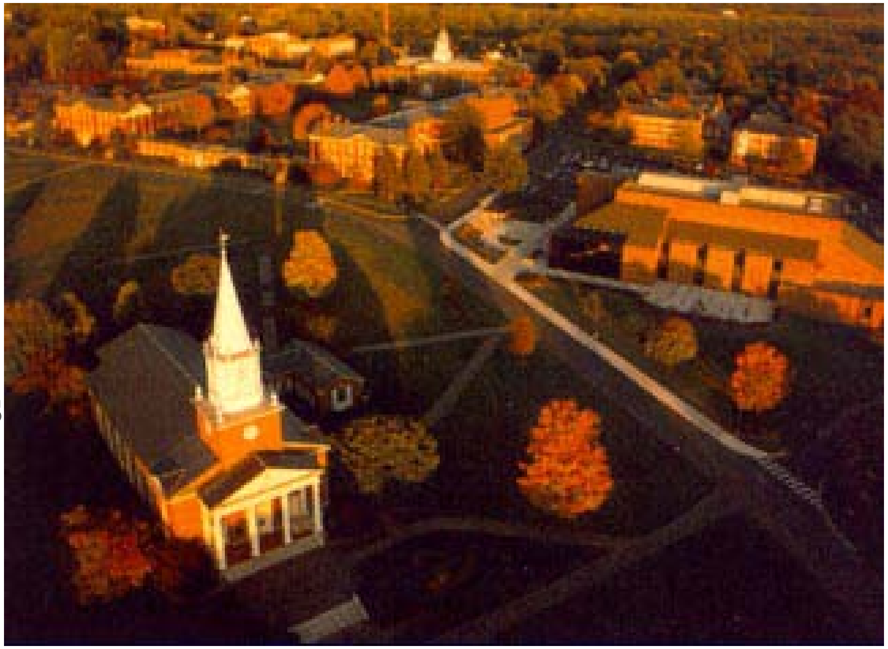


Photo Courtesy of: http://www.facstaff.bucknell.edu

Project Goals

- Flood Control
  - Storm Water Management
  - Retention
  - Infiltration
- Aesthetic Appeal
  - Native Species
  - Riparian Health
  - Recreation
- Improve Ecological Health
  - Year-Round Flow
  - Sewage Recycling
  - Habitat- Diversity
  - Water Quality
  - Target Species
- Channel Sustainability
  - Space for Migration
  - Structure Renewal
- Environmental Education
  - Watershed Management
  - Learning and Teaching

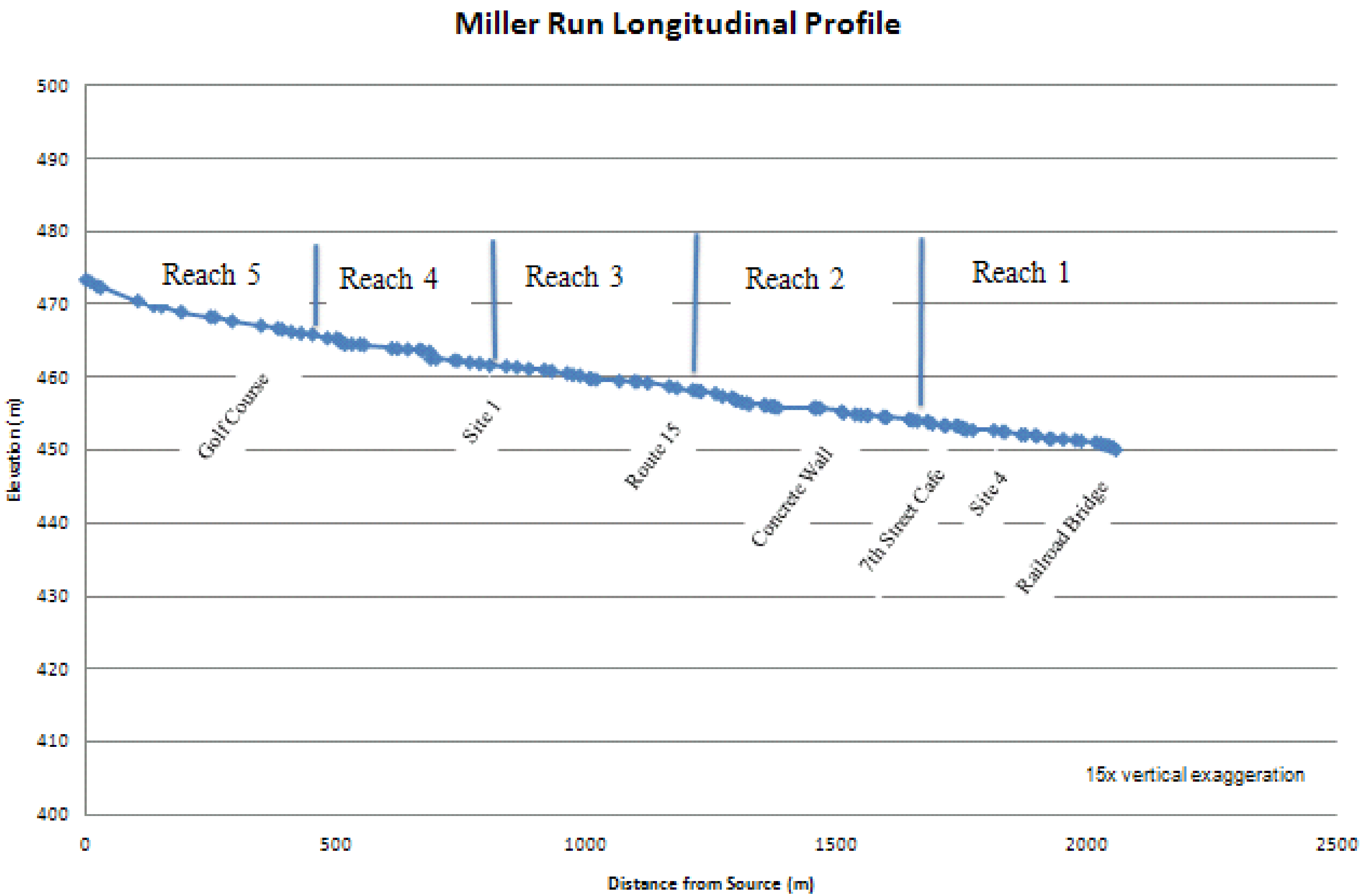
Miller Run Today

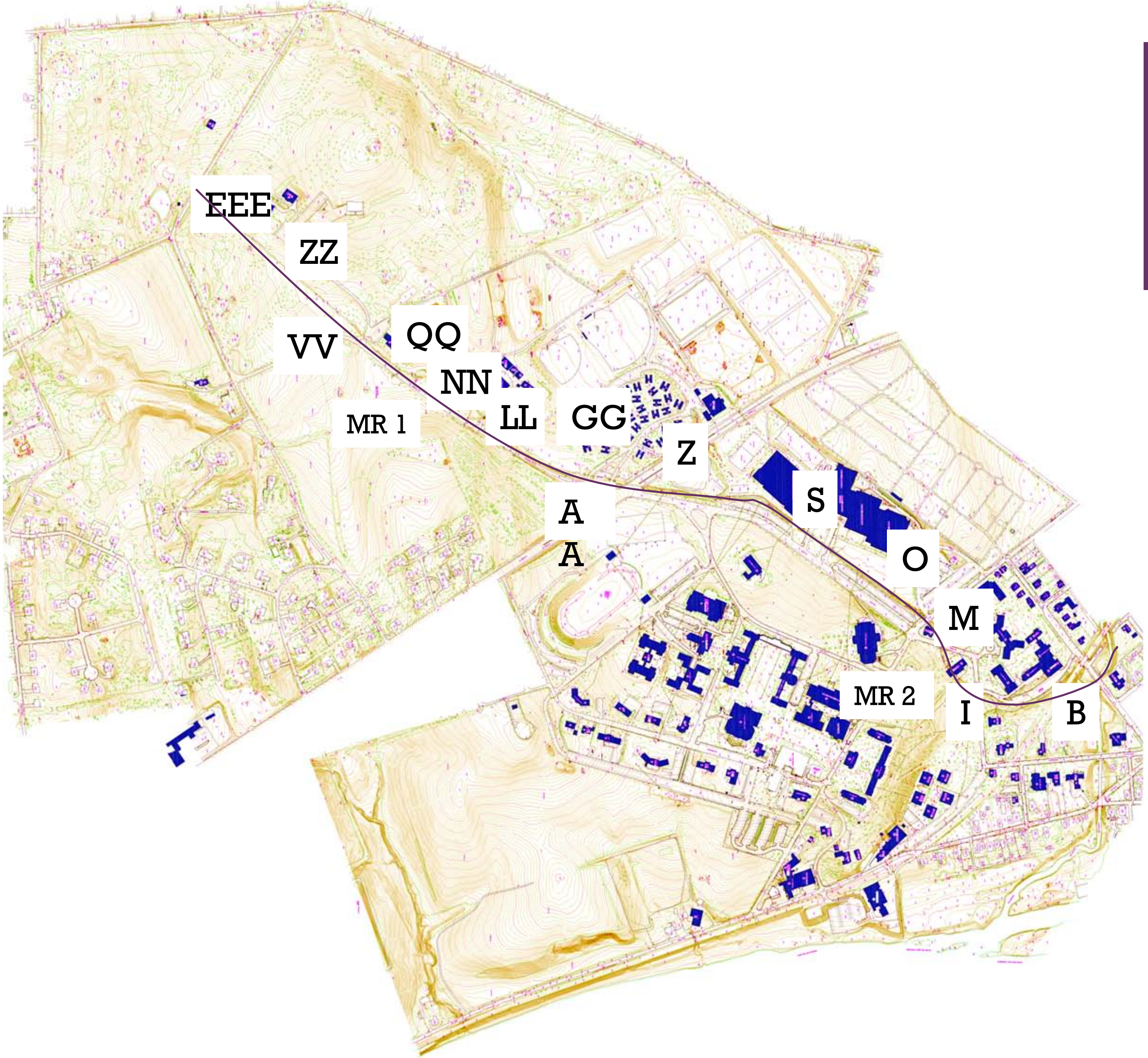
What Miller Run Could Be

Photo Taken by Dina El-Mogazi at Wellesley College

The Characterization of Miller Run

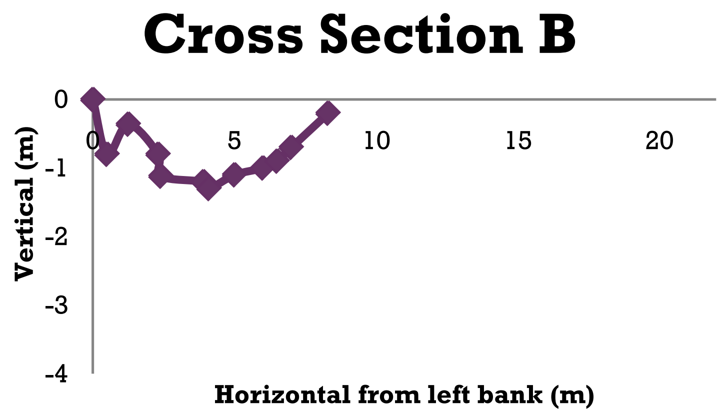
Miller Run Put Into Perspective


Miller Run Longitudinal Profile
Reach 5
Reach 4
Reach 3
Reach 2
Reach 1
Golf Course
Site 1
Route 15
Concrete Wall
7th Street Cafe
Site 4
Railroad Bridge
15x vertical exaggeration
Elevation (m)
Distance from Source (m)
500
490
480
470
460
450
440
430
420
410
400
0
500
1000
1500
2000
2500

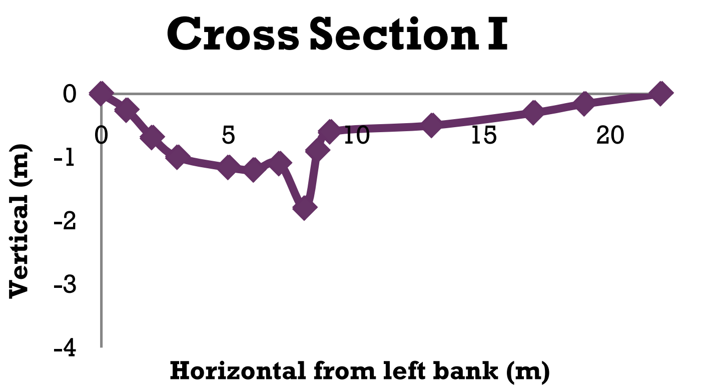

EEE
ZZ
VV
QQ
NN
MR 1
LL
GG
Z
S
A
A
O
M
MR 2
I
B

Reach 1

+



Cross Section B
0
-1
-2
-3
-4
0
5
10
15
20
Vertical (m)
Horizontal from left bank (m)



Cross Section I
0
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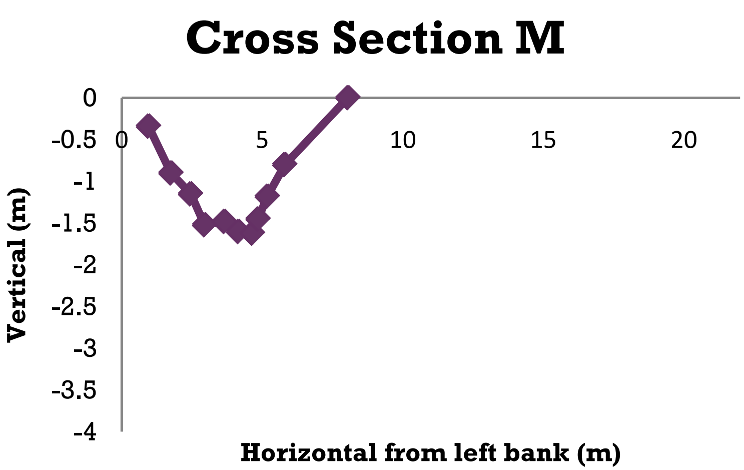
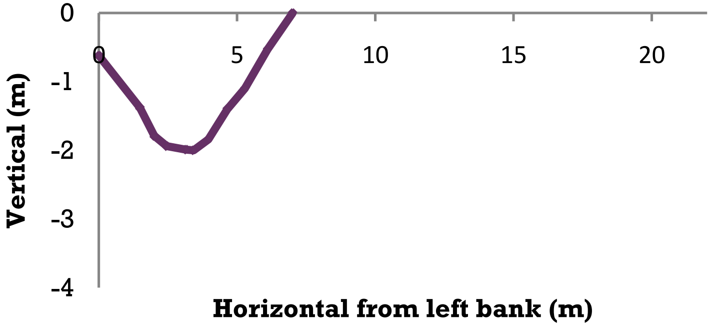
-2
-3
-4
0
5
10
15
20
Vertical (m)
Horizontal from left bank (m)



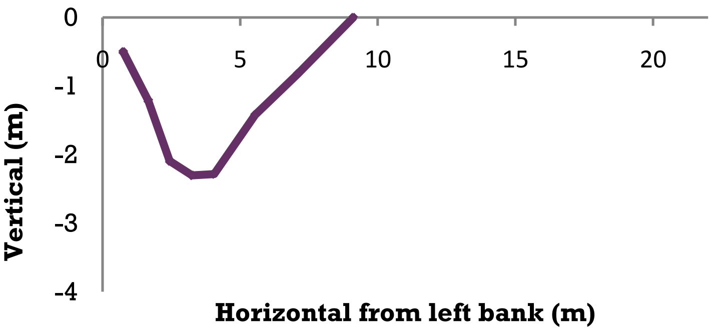
Cross Section M
0
-0.5
-1
-1.5
-2
-2.5
-3
-3.5
-4
0
5
10
15
20
Vertical (m)
Horizontal from left bank (m)

Reach 2

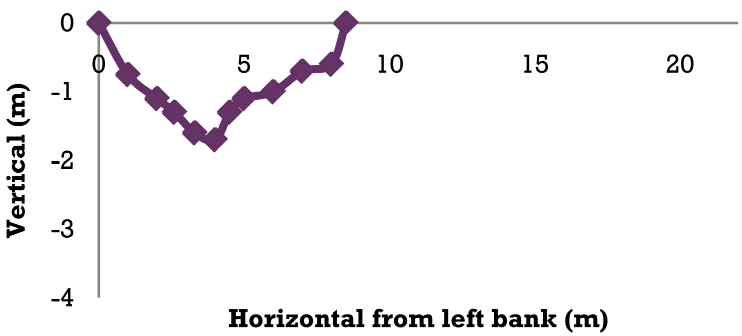
Cross Section O



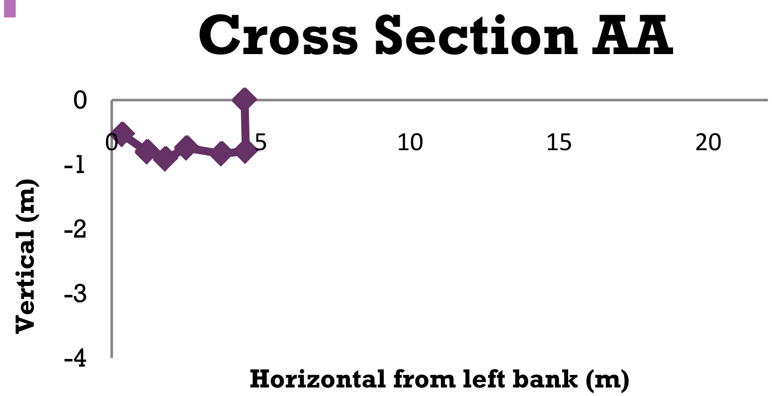
Cross Section S



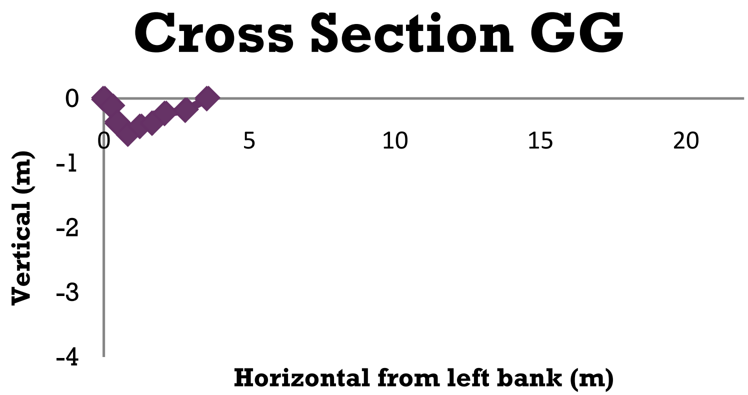
Cross Section Z



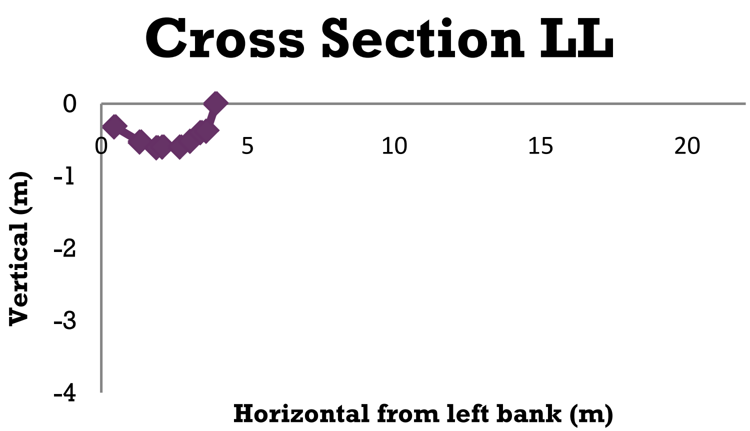
Reach 3



Cross Section AA
0
-1
-2
-3
-4
0
5
10
15
20
Vertical (m)
Horizontal from left bank (m)



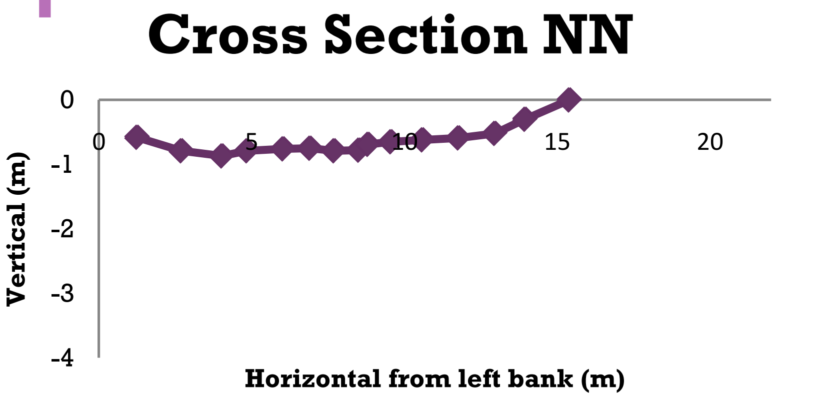
Cross Section GG
0
-1
-2
-3
-4
0
5
10
15
20
Vertical (m)
Horizontal from left bank (m)



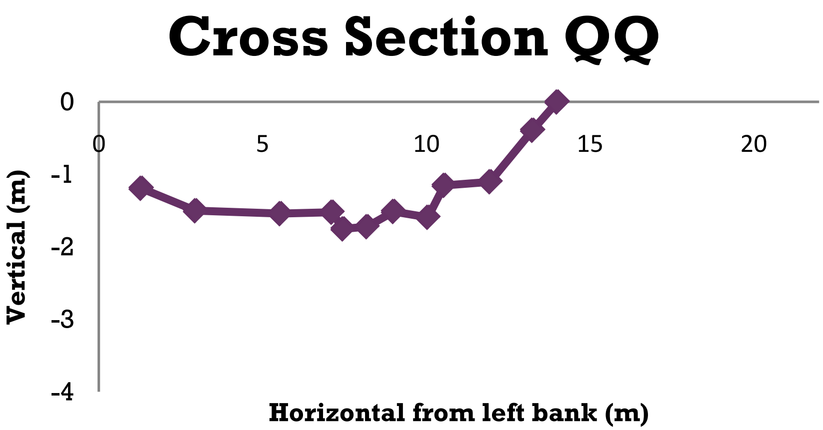
Cross Section LL
0
-1
-2
-3
-4
0
5
10
15
20
Vertical (m)
Horizontal from left bank (m)

Reach 4

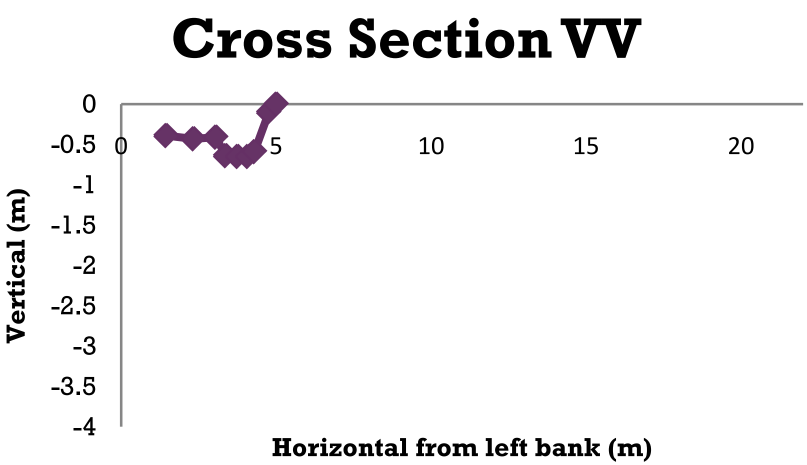
+



Cross Section NN
0
-1
-2
-3
-4
0
5
10
15
20
Vertical (m)
Horizontal from left bank (m)



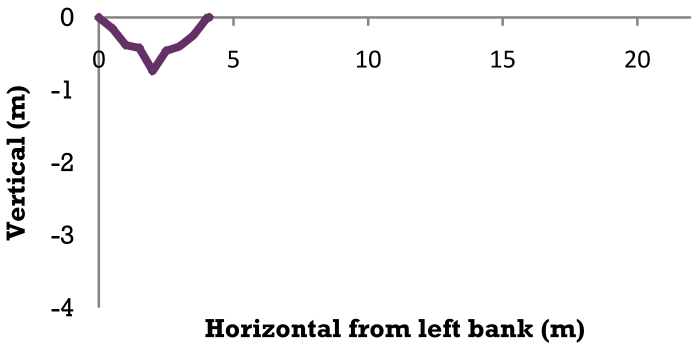
Cross Section QQ
0
-1
-2
-3
-4
0
5
10
15
20
Vertical (m)
Horizontal from left bank (m)



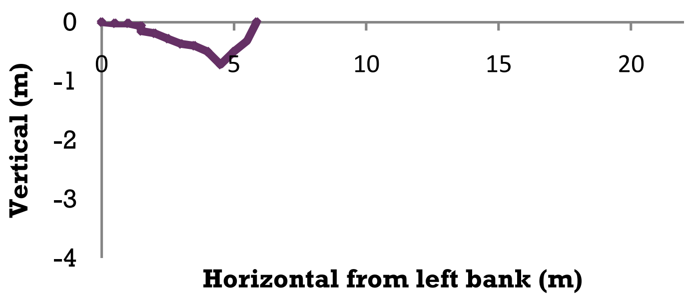
Cross Section VV
0
-0.5
-1
-1.5
-2
-2.5
-3
-3.5
-4
0
5
10
15
20
Vertical (m)
Horizontal from left bank (m)

Reach 5

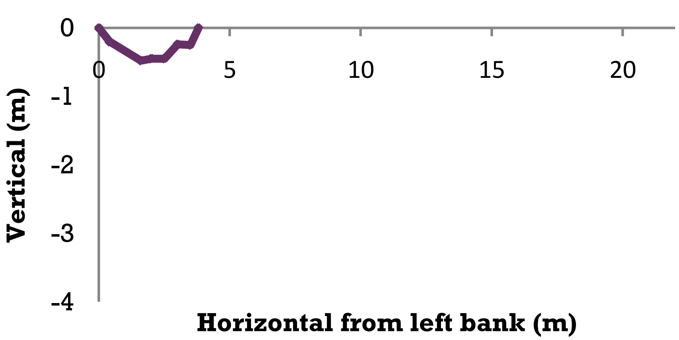
Cross Section XX



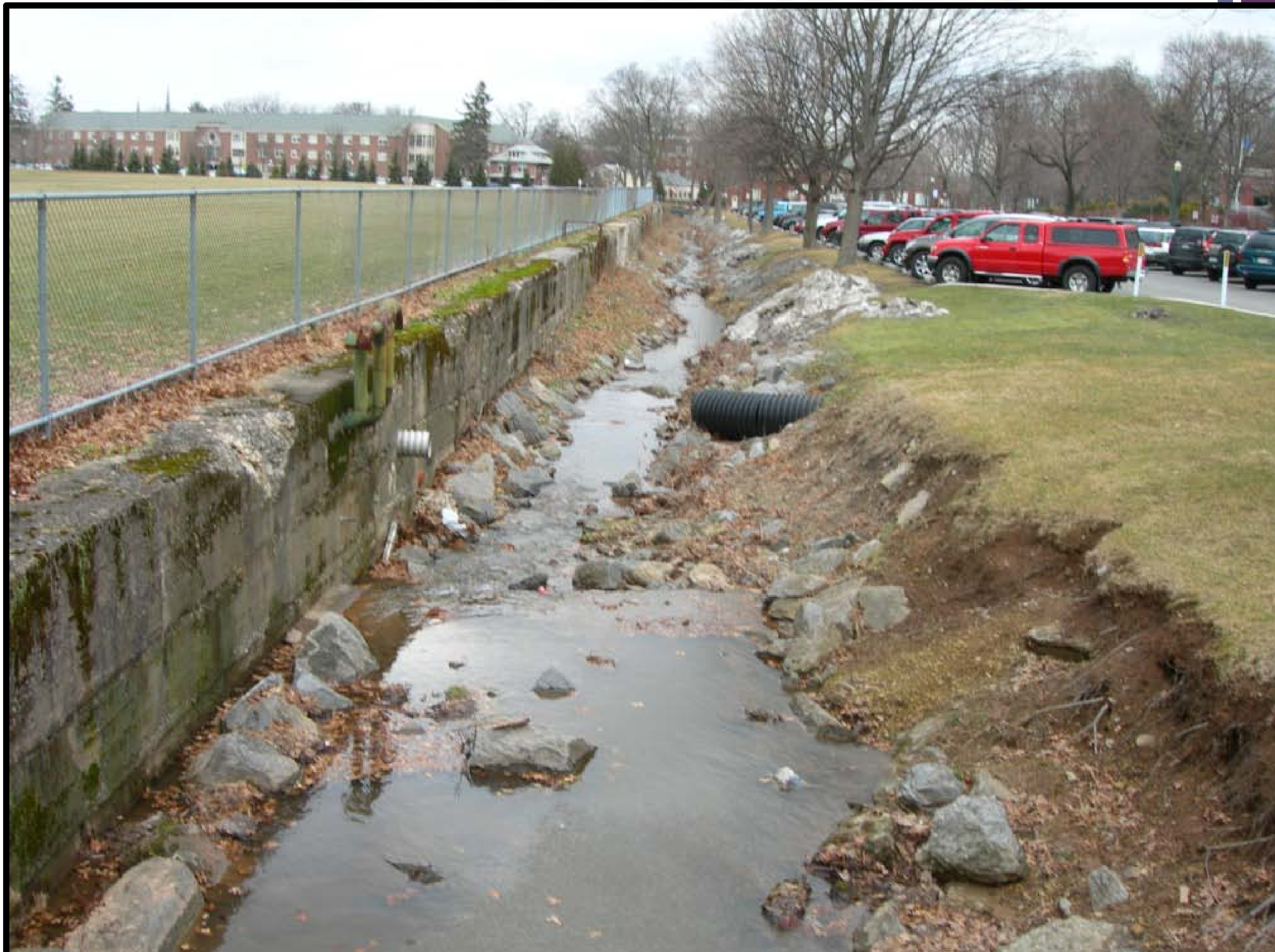
Cross Section ZZ



Cross Section EEE

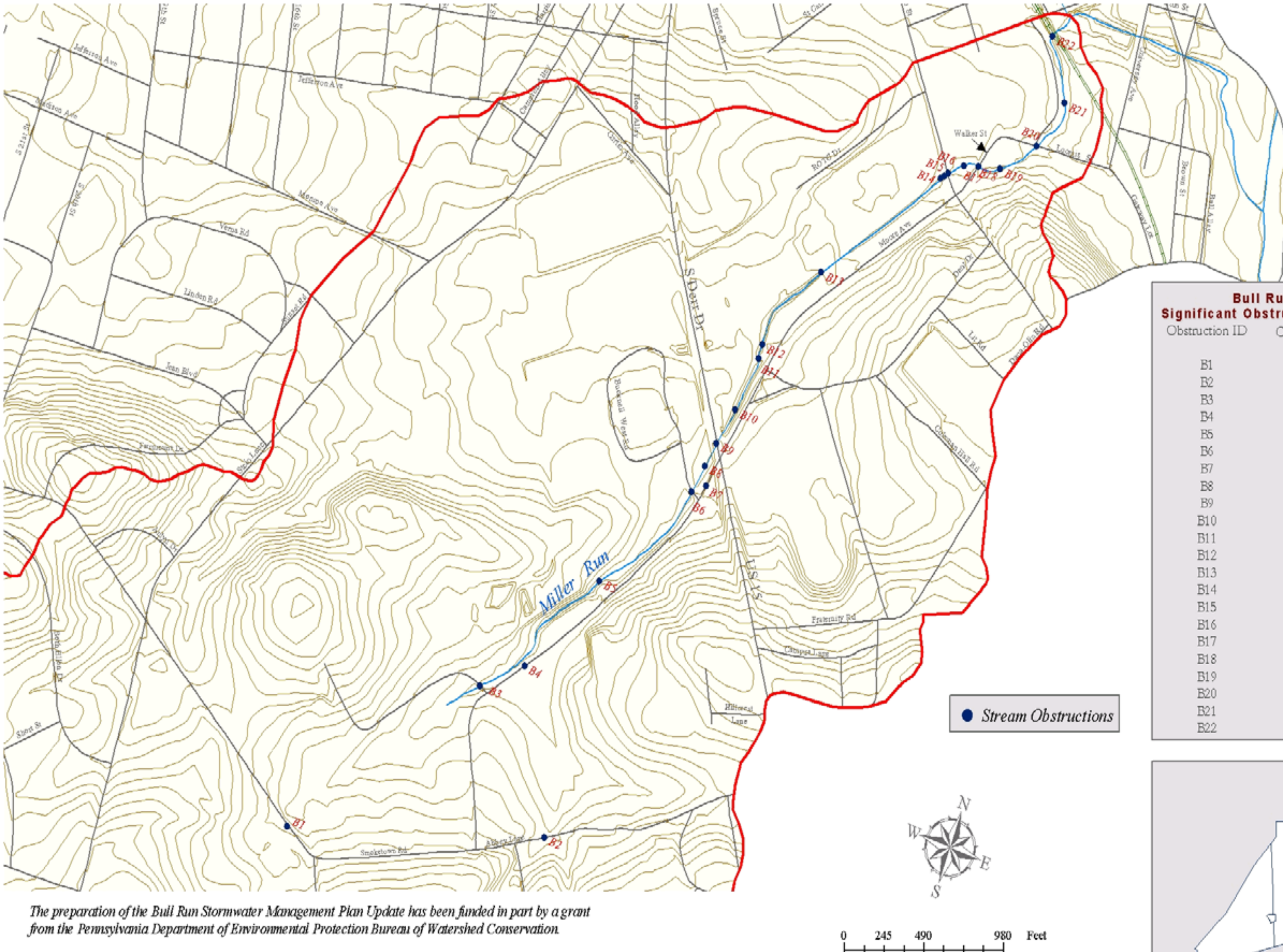


Obstructions



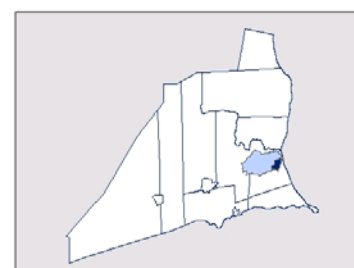
Bull Run Stormwater Management Plan

PLATE 5 - SIGNIFICANT OBSTRUCTIONS



Bull Run Watershed
Significant Obstructions and Capacities

Obstruction ID	Capacity (cfs)	Storm Event (Return pd)
B1	64	< 5 year
B2	45	< 5 year
B3	47	< 5 year
B4	49	< 2 year
B5	330	< 10 year
B6	151	< 2 year
B7	31	< 2 year
B8	85	< 2 year
B9	1060	> 100 year
B10	648	< 25 year
B11	512	< 10 year
B12	665	< 25 year
B13	860	< 100 year
B14	3633	> 100 year
B15	883	< 5 year
B16	426	< 2 year
B17	2246	> 100 year
B18	498	< 5 year
B19	751	< 5 year
B20	198	< 2 year
B21	1068	< 10 year
B22	347	< 2 year

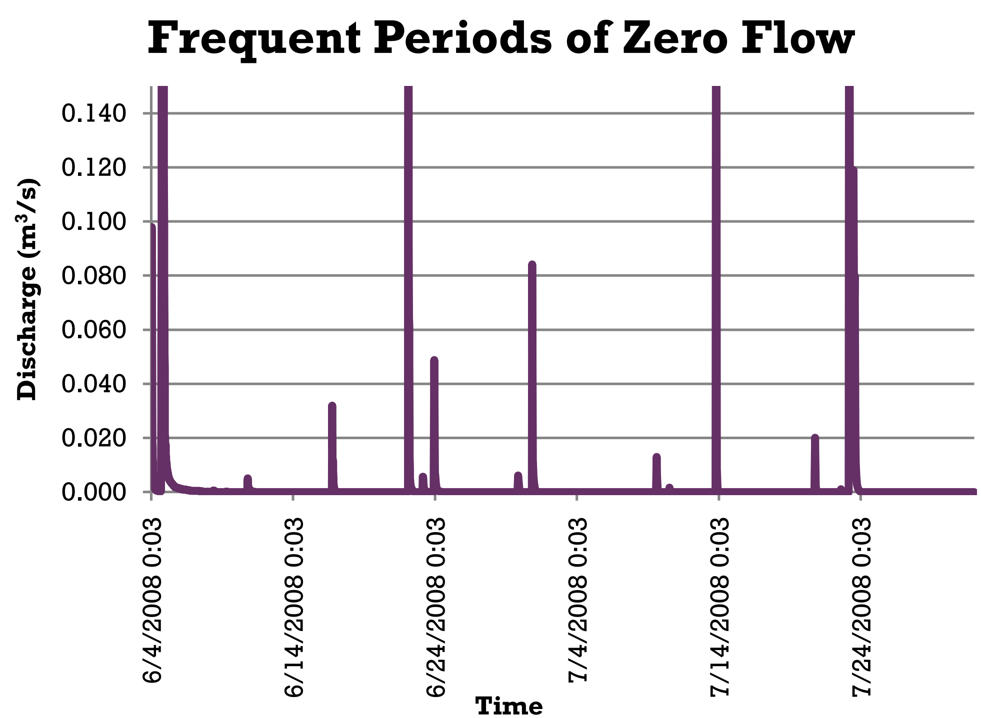


The preparation of the Bull Run Stormwater Management Plan Update has been funded in part by a grant from the Pennsylvania Department of Environmental Protection Bureau of Watershed Conservation.

Source: Union County GIS Department, January 2002
State Plane Coordinates, North Zone, NAD 83

Hydrologic Issues

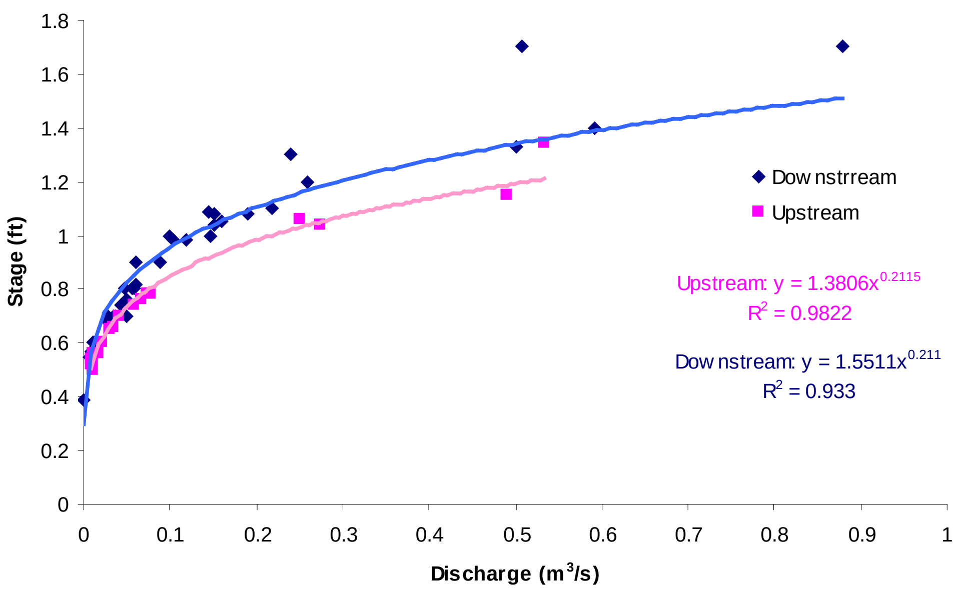
- Portions of Miller Run frequently go dry
- Water quickly enters and exits the system
- High sediment content: hinders life, destroys restoration structures

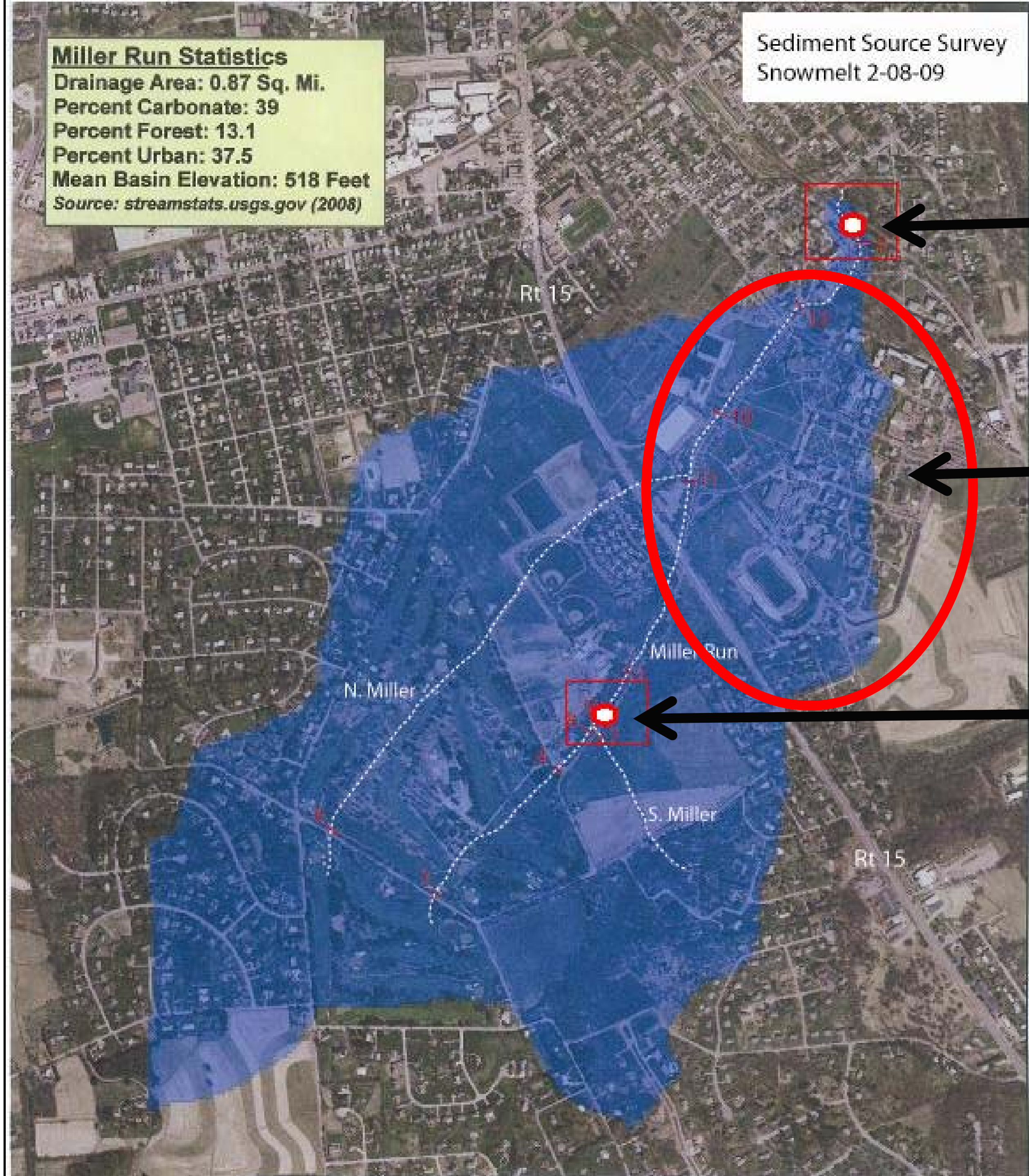


Methodology

- Established gauges upstream and downstream to measure the height of the water

- Used rating curve and Manning Equation to calculate discharge (flow of water over time)





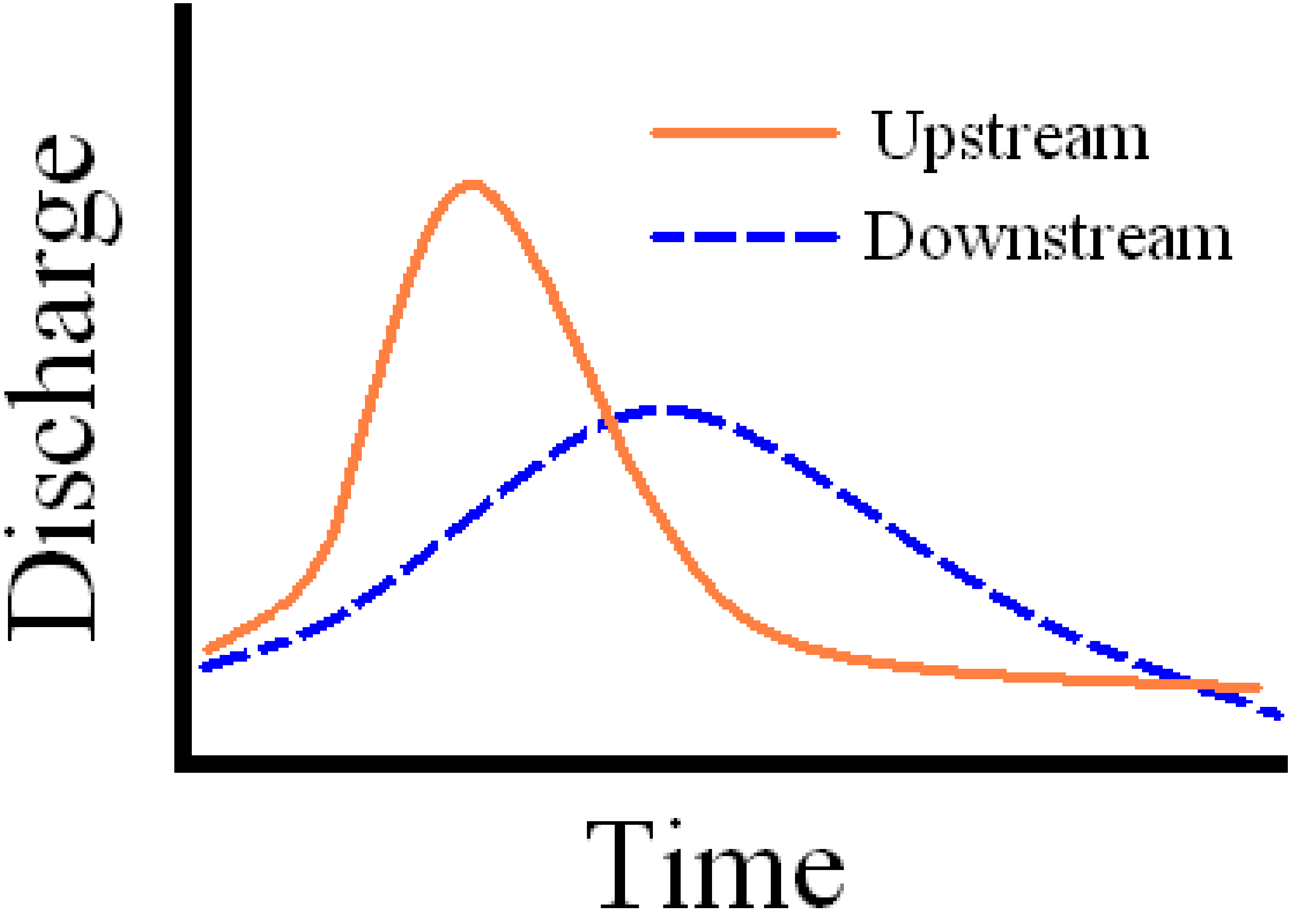
DOWNSTRE AM MR2 GAUGE

CAMPUS

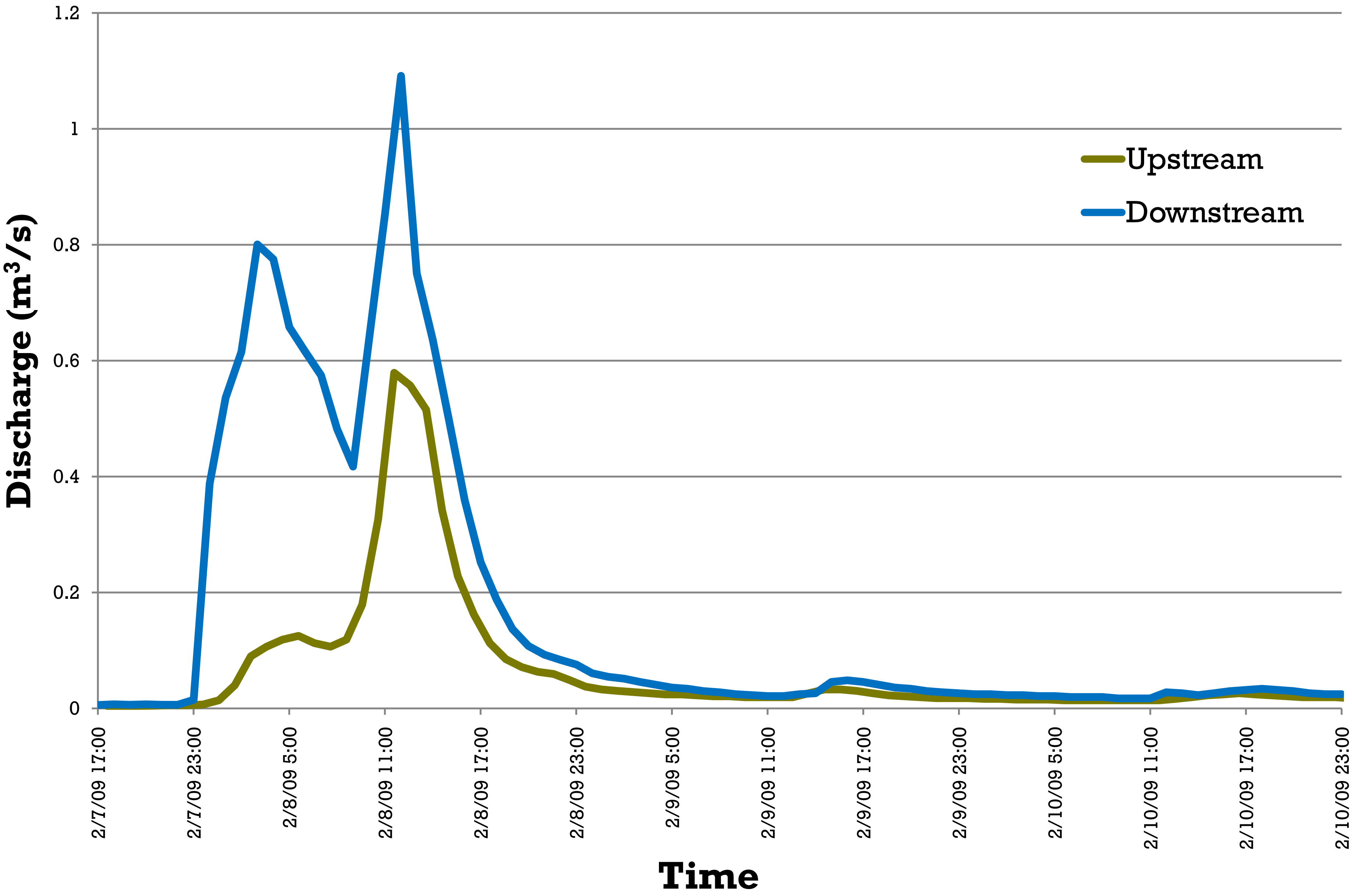
UPSTREA M MR1 GAUGE

Flow

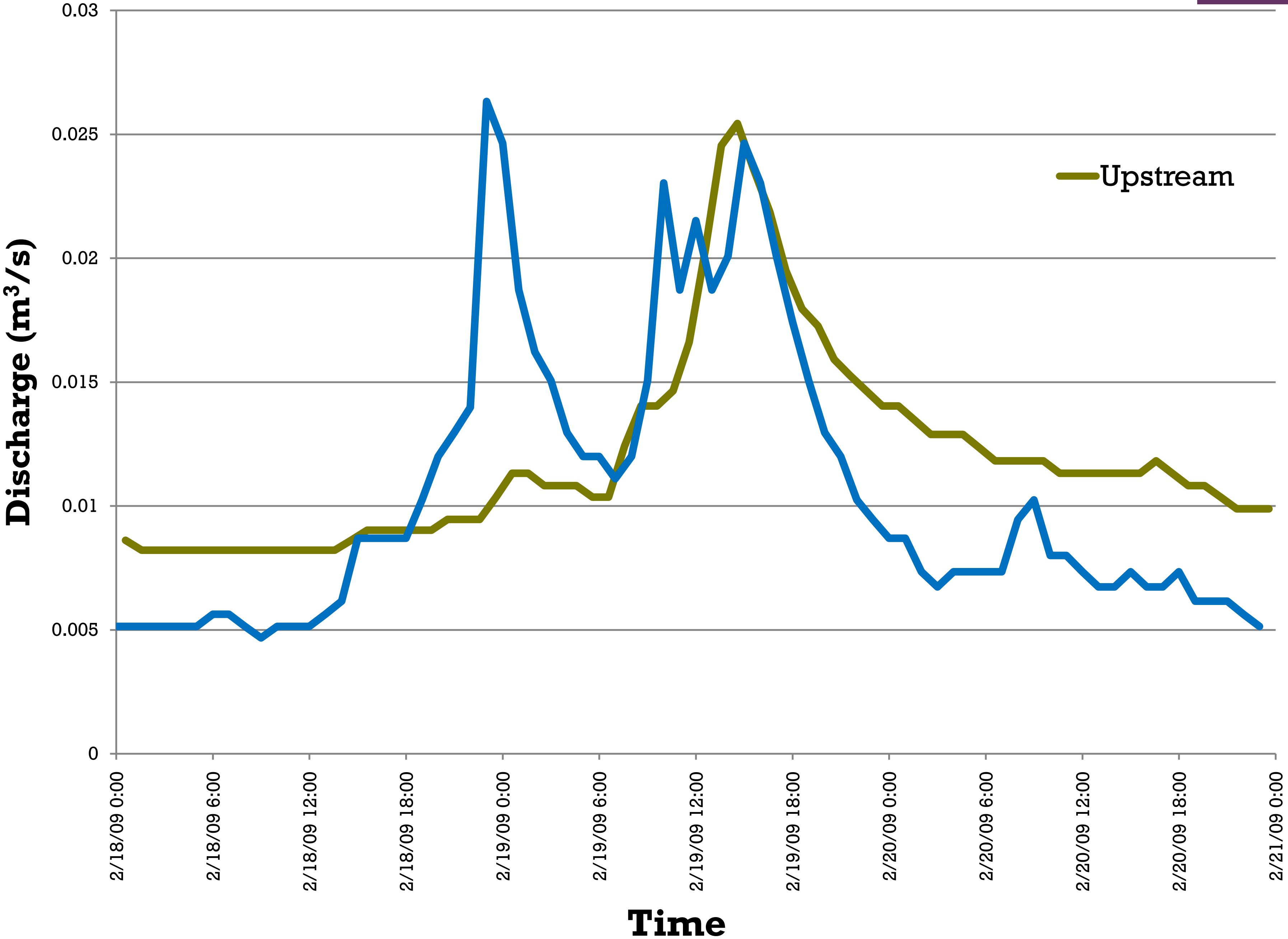
Typical Hydrograph



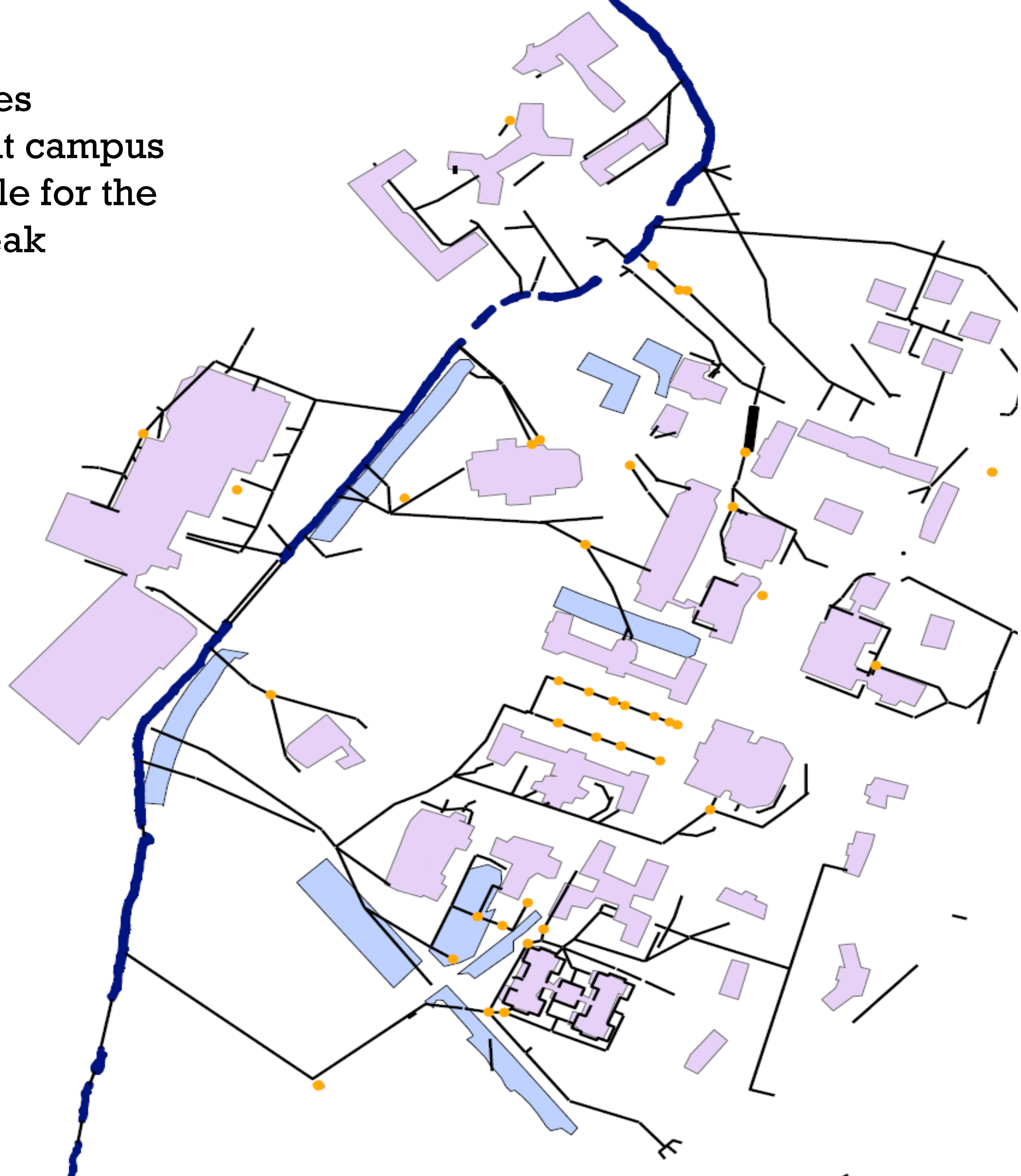
February Snow Melt Hydrograph



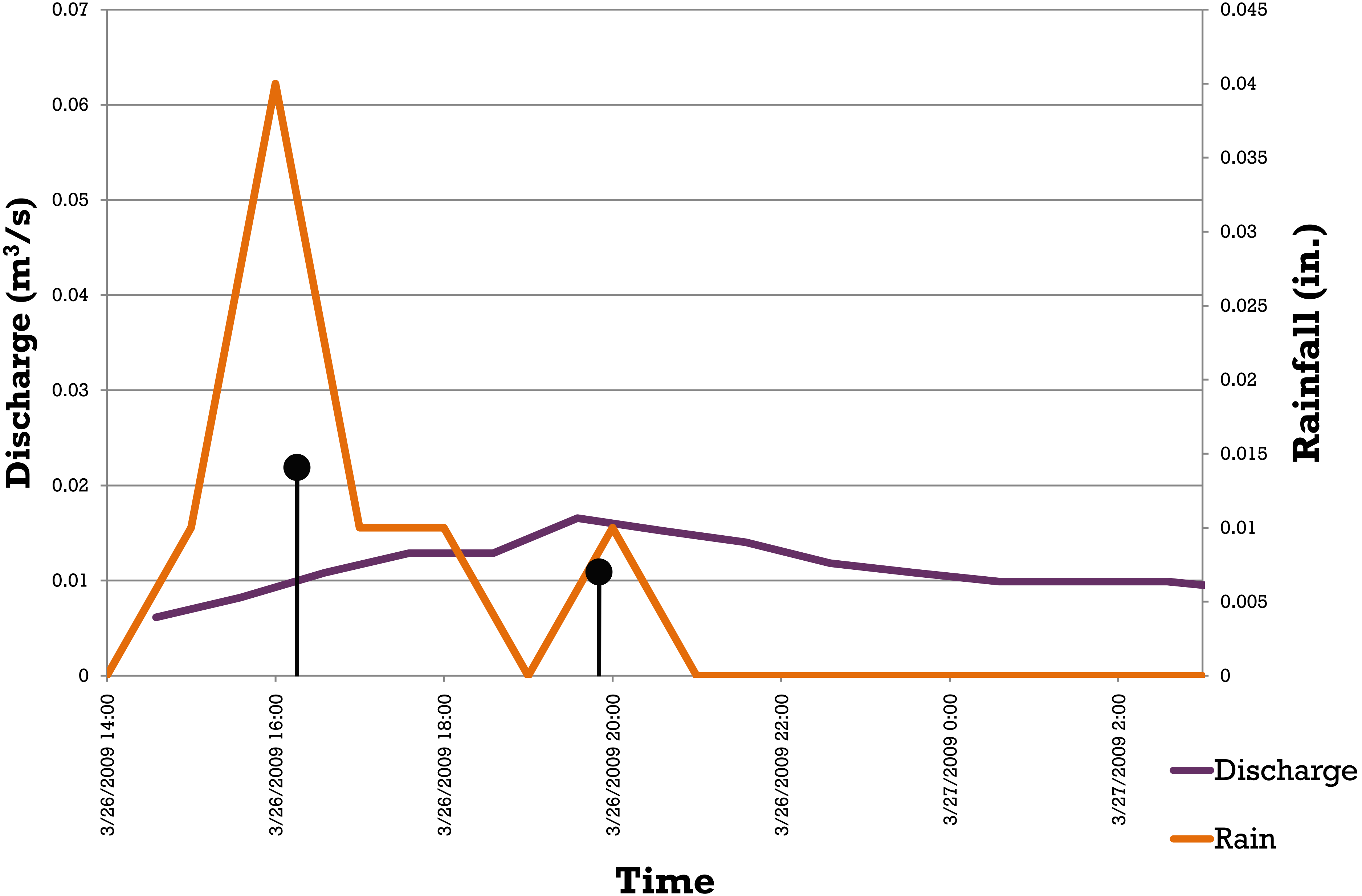
Feb 18 Snowmelt and Rain Event Hydrograph



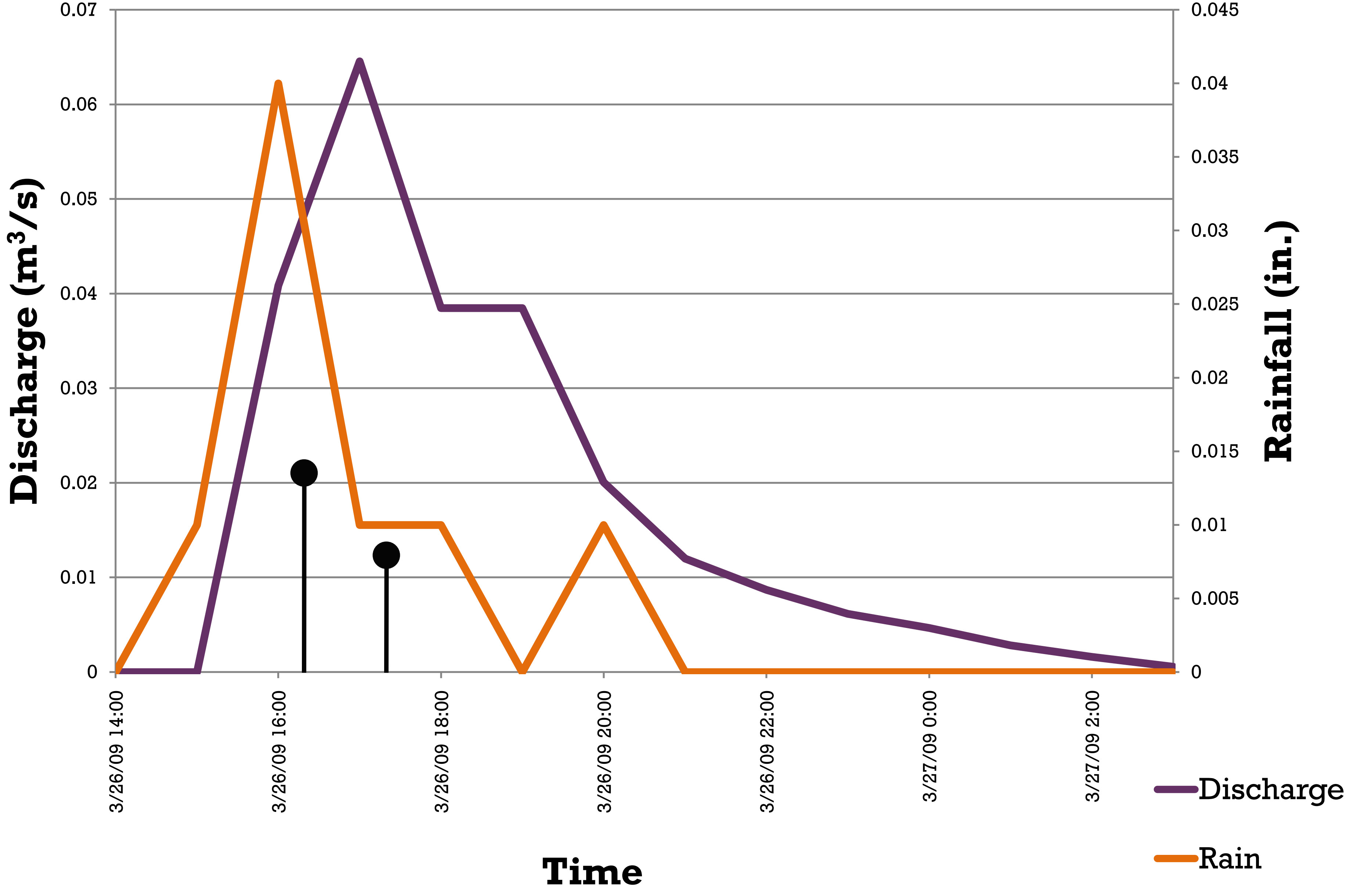
Storm Pipes throughout campus responsible for the double peak



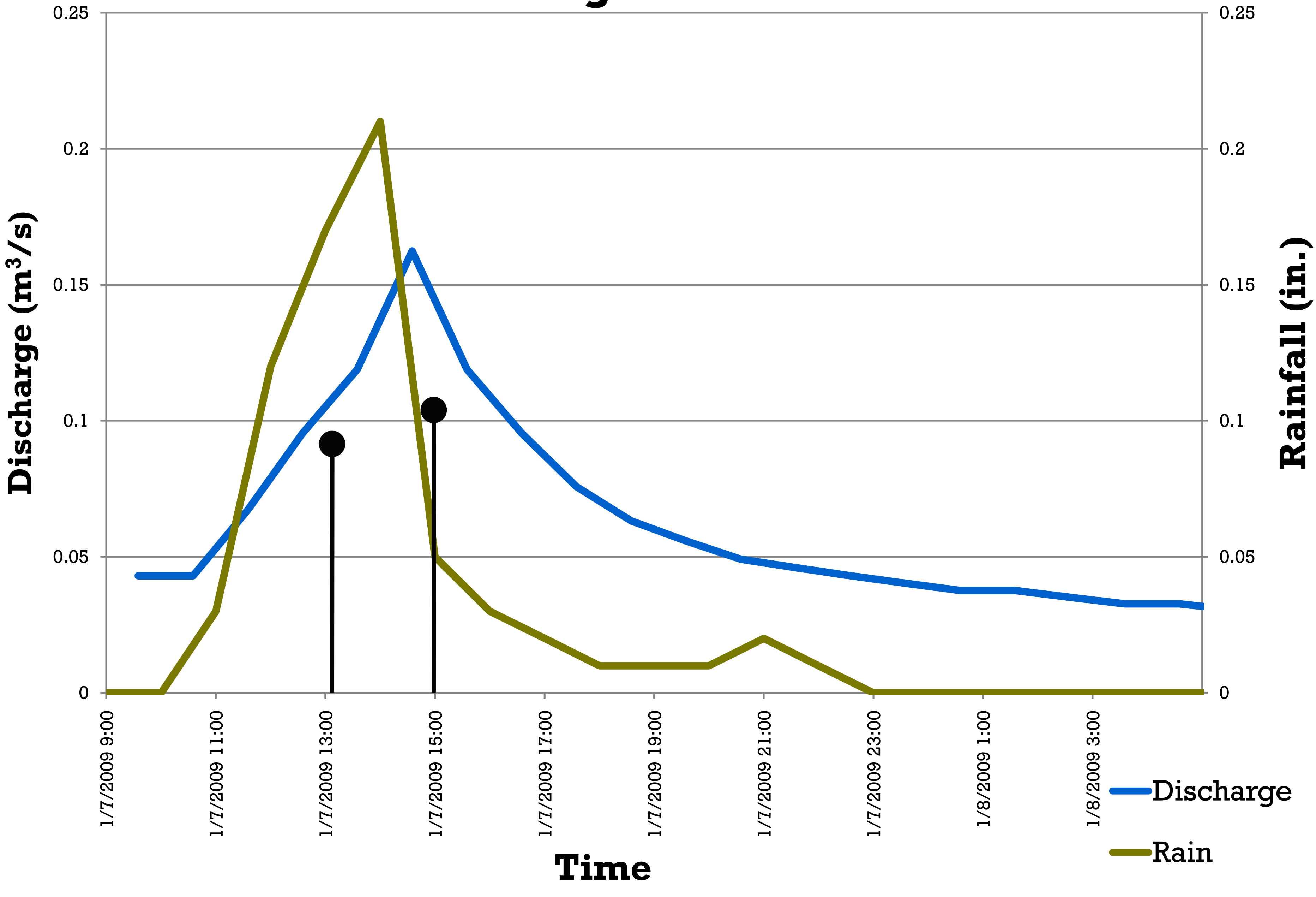
Upstream Discharge Lag Time For Small Rainfall Event



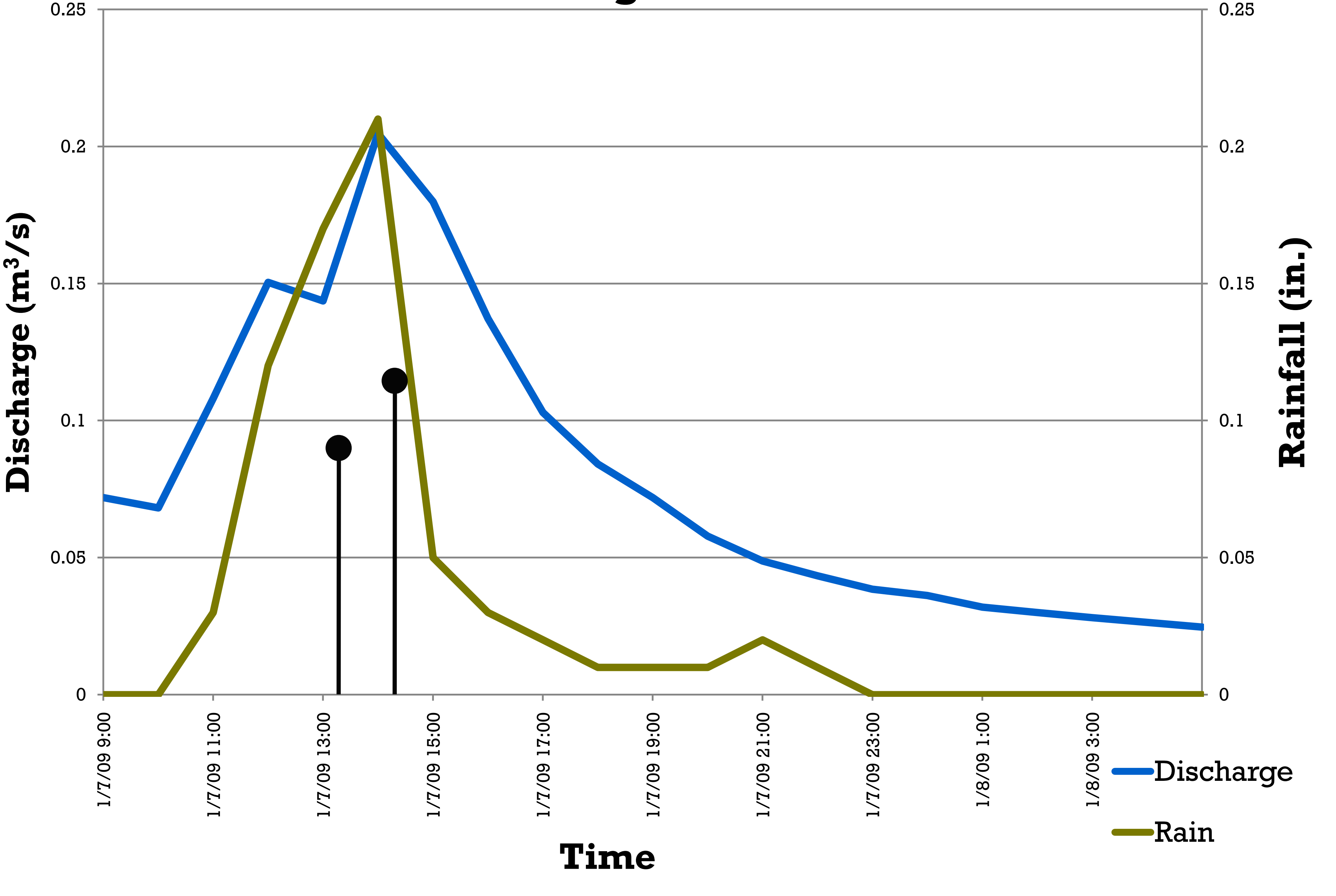
Downstream Discharge Lag Time For Small Rainfall Event



Upstream Discharge Lag Time For Large Rainfall Event

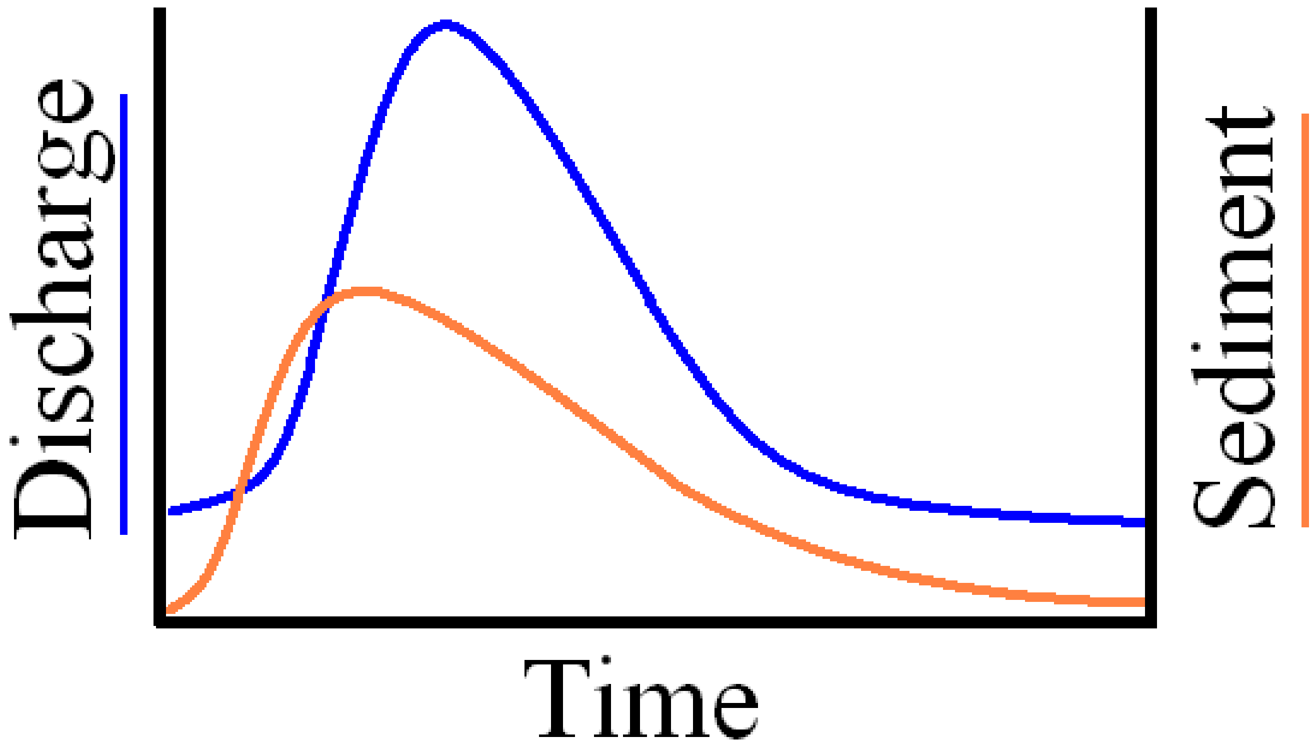


Downstream Discharge Lag Time For Large Rainfall Event

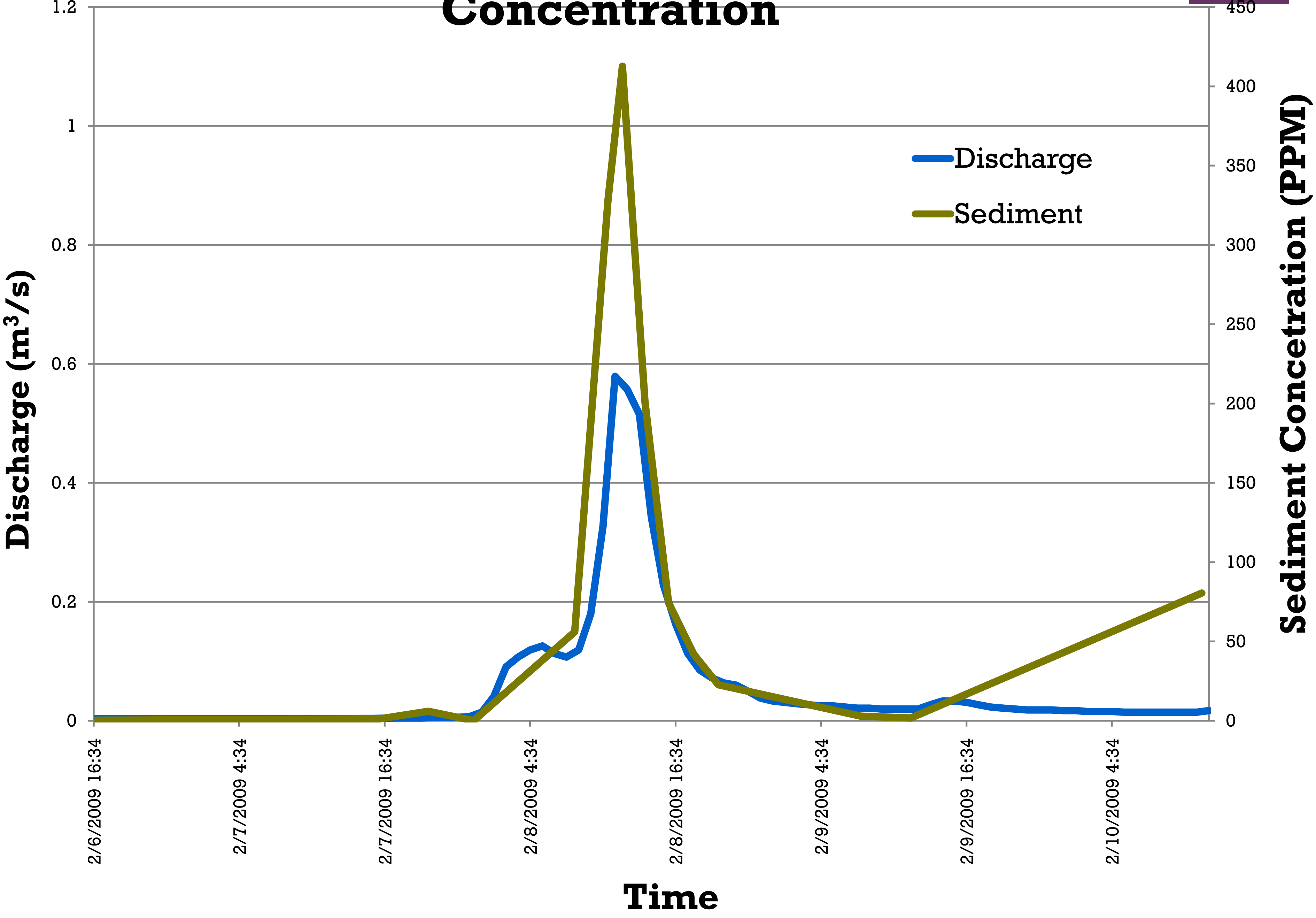


Sediment

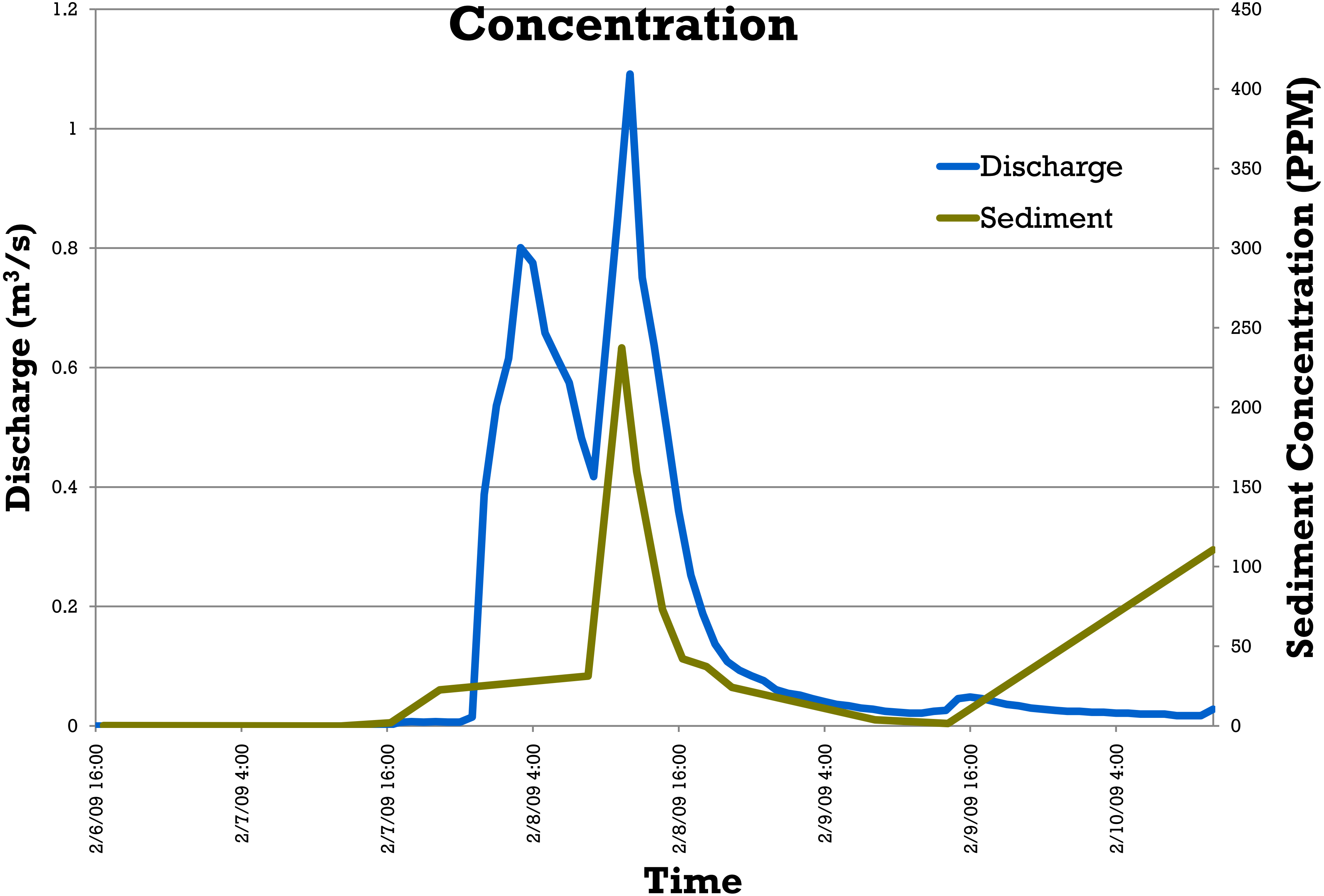
Discharge vs Sediment



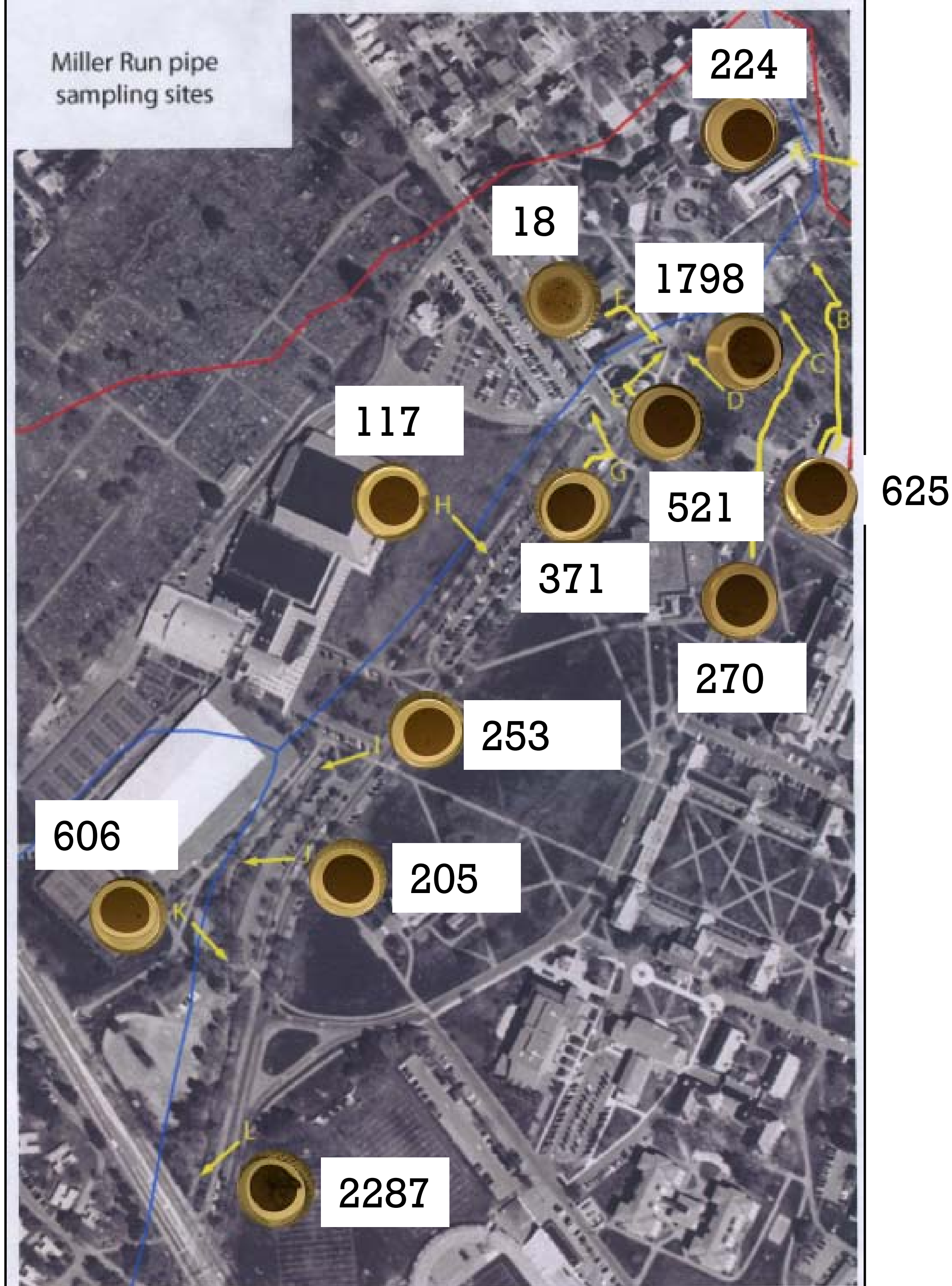
Upstream Discharge and Sediment Concentration



Downstream Discharge and Sediment Concentration



Concentrations In Parts Per Million



Water Quality

Water Chemistry

- Tests Used:
  - Sondes were used to automatically record stream conditions such as temperature, pH, specific conductivity, and dissolved oxygen.
  - Water samples were also taken manually during normal flow and high flow events, and analyzed for chemical composition.
  - Two sites were sampled for each reading; MR-1 was upstream at the Art Barn crossing and MR-2 was downstream at Bucknell Hall.

Baseline Ion Concentrations

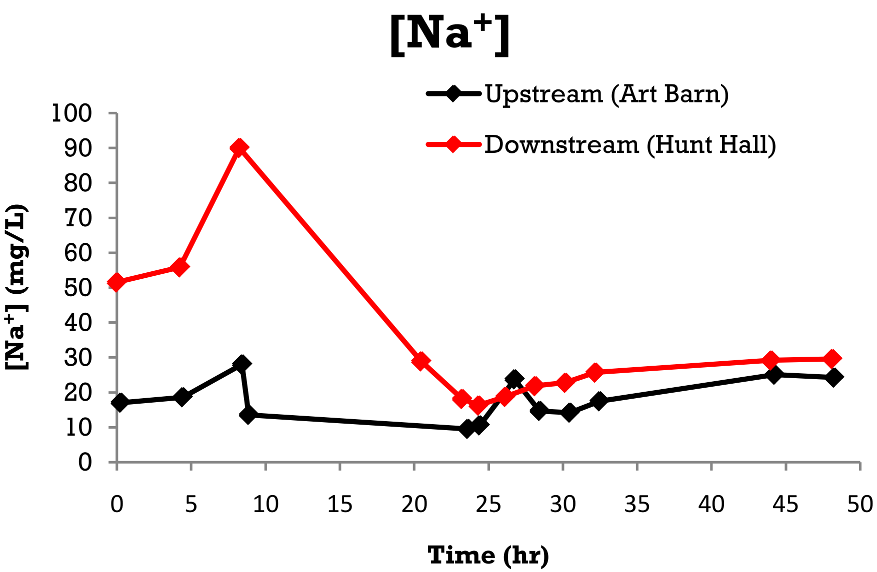
Upstream Site February 17, 2009

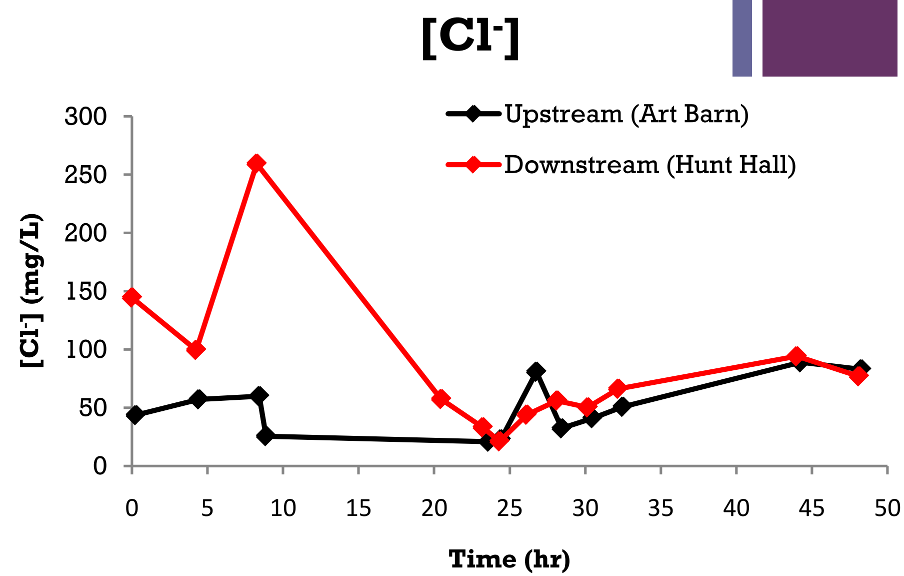
Dissolved Solid	Concentration (mg/L)
Ammonium	<10
Sulfate	34
Chloride	81.7
Nitrate	1.9
Phosphorous	<0.1
Sodium	32.2
Potassium	3.2
Magnesium	9.7
Calcium	57.9
Manganese	0.05
Iron	0.2
Lead	<0.01
Zinc	<0.02
Chromium	<0.004
Copper	<0.04
Nickel	<0.005
Cadmium	<0.001
Arsenic	<0.005

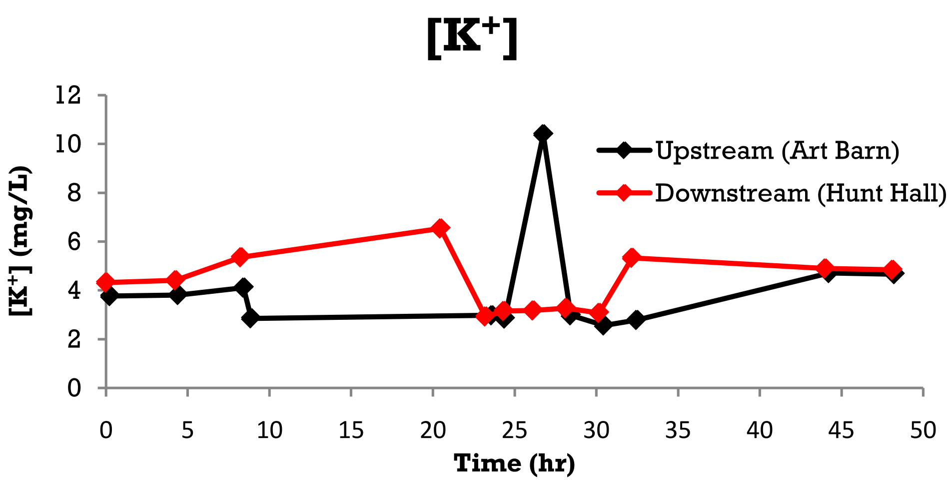
Downstream Site- February 17, 2009

Dissolved Solid	Concentration (mg/L)
Ammonium	<10
Sulfate	48
Chloride	47.9
Nitrate	1.98
Phosphorous	<0.1
Sodium	21.9
Potassium	2.8
Magnesium	9.9
Calcium	53.5
Manganese	<0.03
Iron	0.23
Lead	<0.01
Zinc	<0.02
Chromium	<0.004
Copper	<0.04
Nickel	<0.005
Cadmium	<0.001
Arsenic	<0.005

Sodium, Chloride, and Potassium Fluctuations (February 7-9, 2009 Snowmel

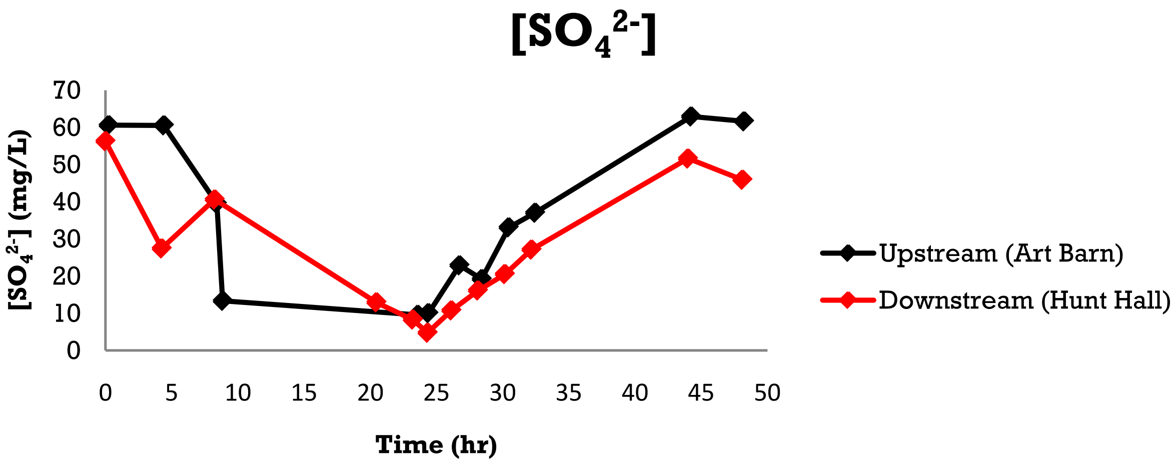


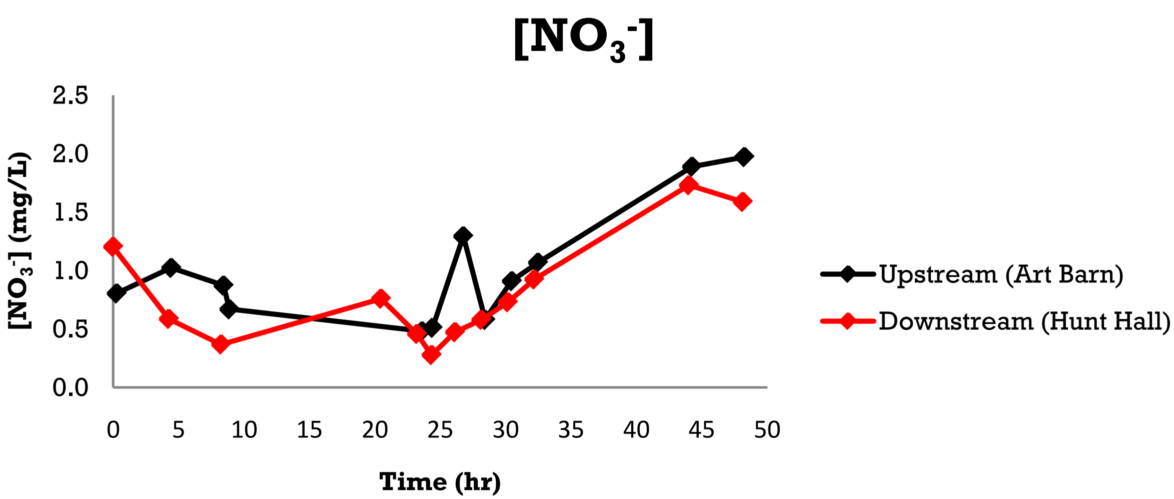




Negative Impacts: Surface runoff and interflow carry high ion loads into the waterway from road salts and fertilizers.

+ Sulfate and Nitrate Fluctuations (February 7-9, 2009 Snowmelt)





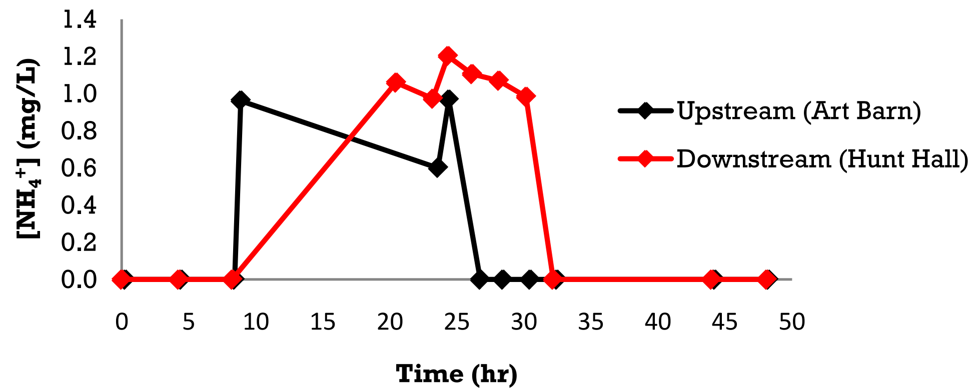
Negative Impacts:

•Initial decrease is due to simple dilution.

•Increase is due to an underground contaminant located near the upstream site- probably fertilizer accumulation or a broken sewage line.

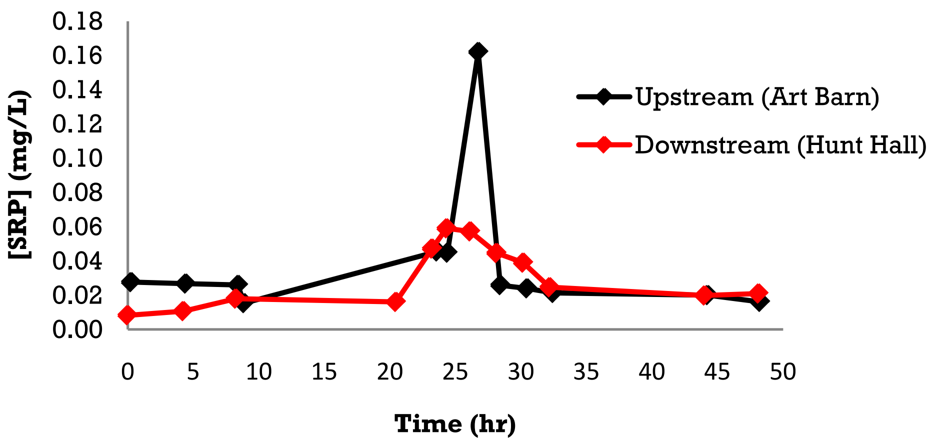
Ammonium and Phosphorous Fluctuation (February 7-9, 2009 Snowmelt)

[NH_4^+]

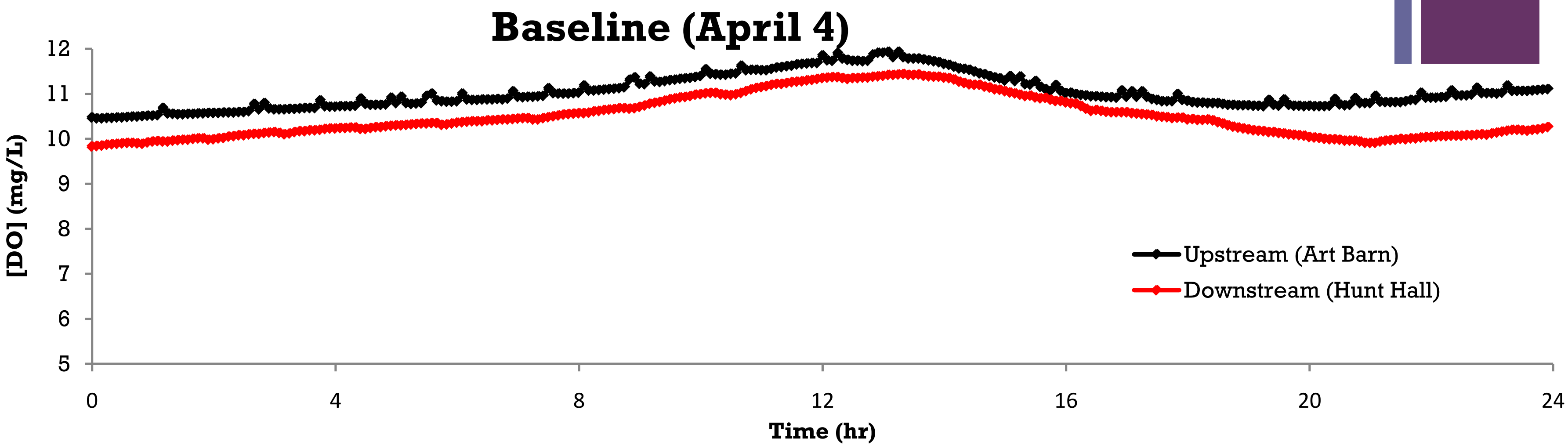


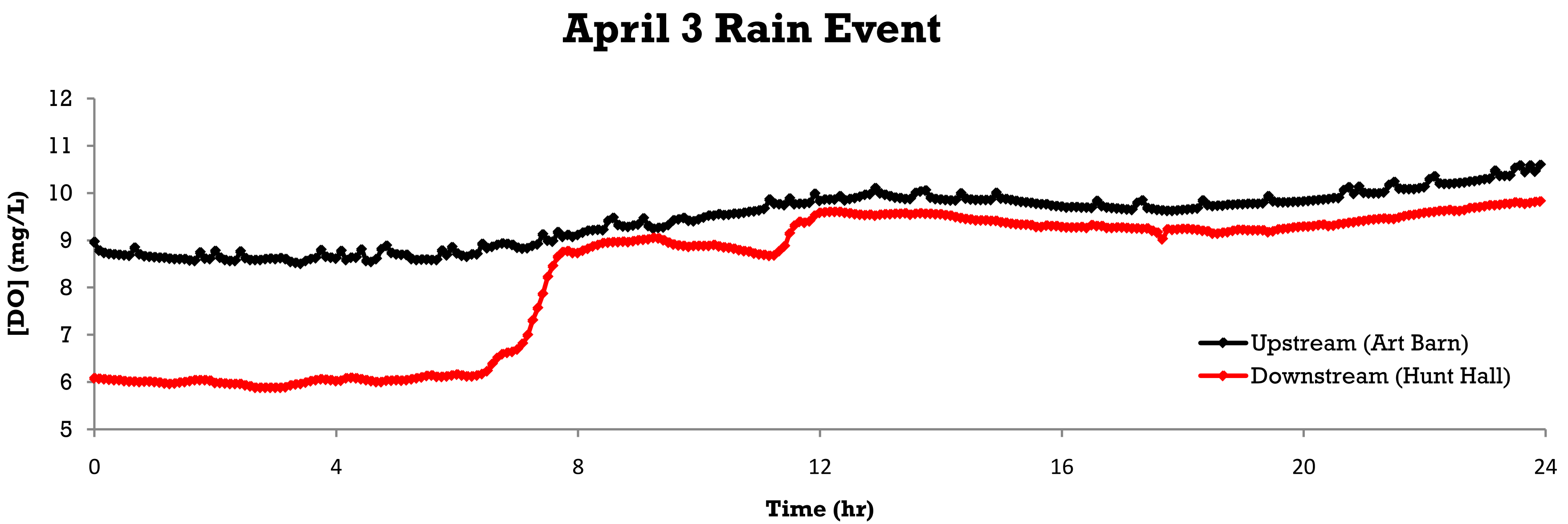
Delayed peak reveals an underground source of contamination near the upstream site.

[Soluble Reactive Phosphorous]



+ Dissolved Oxygen- Baseline and April 3, 2009 Rain event Comparisons





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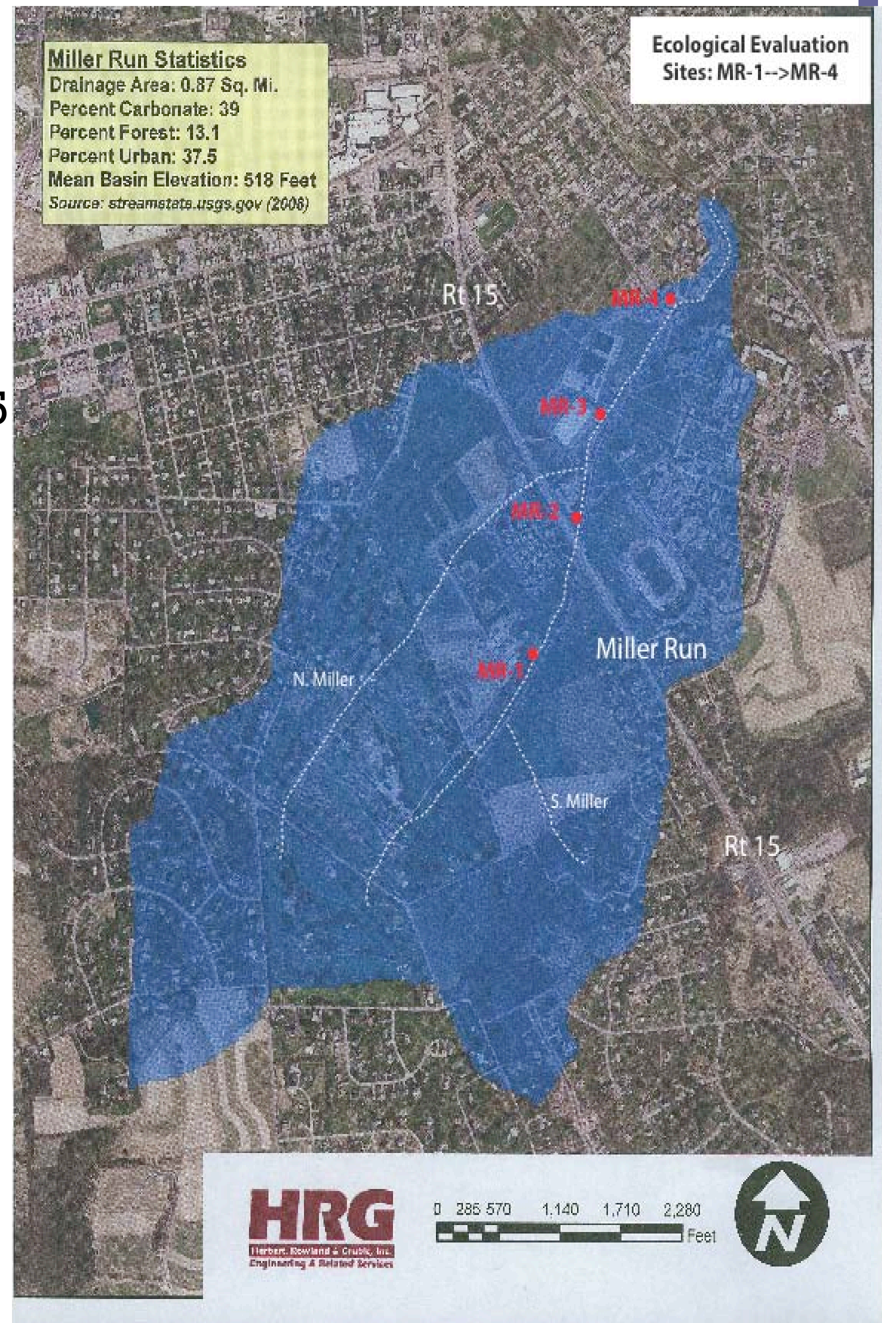
MR-1: Art Barn
MR-2: Gerhard Field House- Rt. 15
MR-3: KLARC Building
MR-4: Loomis St./Art Building



Habitat Assessment

Site	MR-1 (Art Barn)	MR-2 (Gerhard Fieldhouse - U.S. 15)	MR-3 (Kenneth G. Langone Athletics and Recreation Center)	MR-4 (Loomis Street – Art Building)
Instream Cover(fish)	6 (Marginal)	8 (Marginal)	10 (Marginal)	7 (Marginal)
Epifaunal Substrate	8 (Marginal)	12 (Suboptimal)	7 (Marginal)	8 (Marginal)
Embeddedness	18 (Optimal)	3 (Poor)	3 (Poor)	3 (Poor)
Velocity/Depth Regimes	7 (Marginal)	7 (Marginal)	9 (Marginal)	8 (Marginal)
Channel Alteration	14 (Suboptimal)	3 (Poor)	1 (Poor)	3 (Poor)
Sediment Deposition	13 (Suboptimal)	7 (Marginal)	10 (Marginal)	8 (Marginal)
Frequency of Riffles	8 (Marginal)	12 (Suboptimal)	10 (Marginal)	3 (Poor)
Channel Flow Status	16 (Optimal)	14 (Suboptimal)	14 (Suboptimal)	7 (Marginal)
Condition of Banks	10 (Marginal)	14 (Suboptimal)	11 (Suboptimal)	7 (Marginal)
Bank Vegetative Protection	9 (Marginal)	5 (Poor)	1 (Poor)	1 (Poor)
Grazing or Other Disruptive Pressure	10 (Marginal)	6 (Marginal)	3(Poor)	3 (Poor)
Riparian Vegetative Zone Width	3 (Poor)	4 (Poor)	1 (Poor)	1 (Poor)
Total	122	95	80	59
Habitat Assessment	Marginal	Marginal	Marginal	Poor

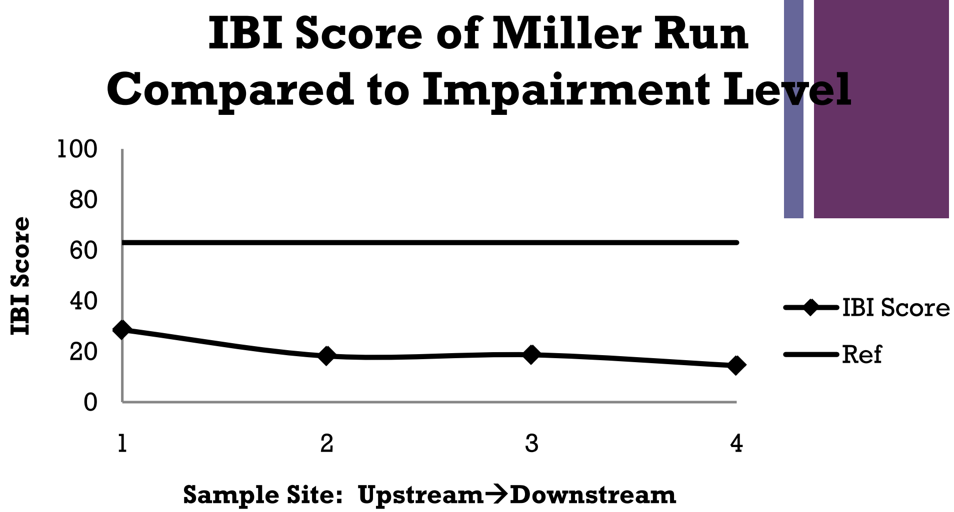
Biological Sampling

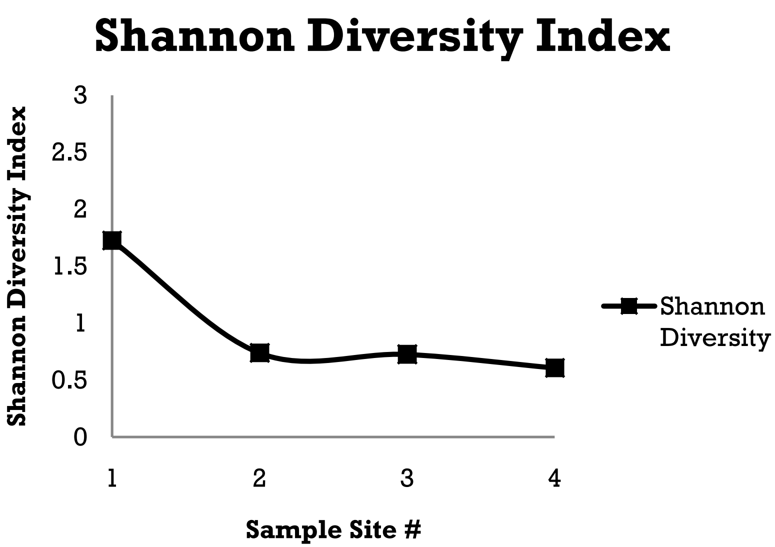
- Reasons for Biotic Sampling:
  - Aquatic macroinvertebrates are highly variable in their sensitivity to water pollution. These differences can be used by biologists to evaluate the overall health of a stream.
  - The link between fish species composition and water quality provides an important assessment of stream ecosystem health.
  - Algae analyses allow us to determine gain information about the biomass of algae, which is related to water chemistry and conditions of riparian vegetation.

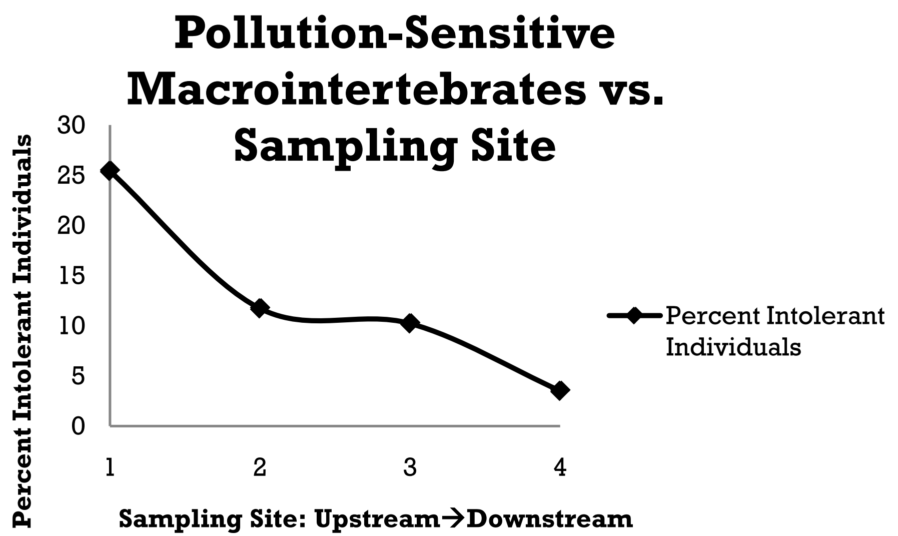
Macroinvertebrates

+ Macroinvertebrate Results

- IBI Scores are used by the DEP to measure the degree of a stream's impairment.
- Miller Run's IBI score is significantly lower than the impairment threshold.
- The downstream samples showed much lower biodiversity and fewer pollution-sensitive species.



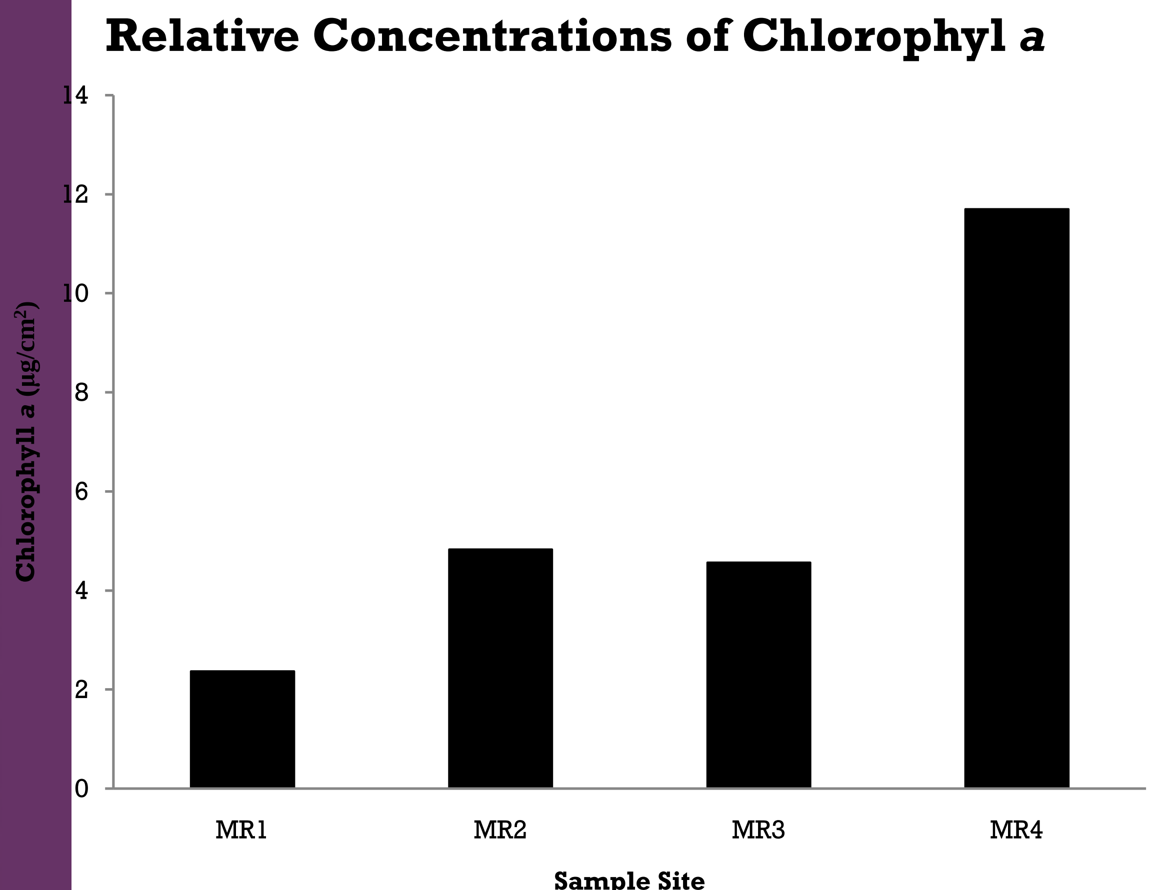




Algae Sampling

The data show a general trend of increasing algal biomass downstream, which may indicate increasing nutrient or light availability along Miller Run.

Alternatively, lower algal biomass in upstream reaches of Miller Run might be caused by grazing by benthic macroinvertebrates or herbivorous fishes.



Electro-Fishing

Electro-Fishing

Twenty-three fish were collected at the two sample sites , with six species represented

There was a >88% decrease in fish numbers at the downstream sampling site, and a decrease in total species diversity by >83%.

We expected that there would be more species near Bull Run, due to colonization.

This indicates a substantial difference in the quality of habitat available at downstream versus upstream locations.

Upstream Site

Family	Genus	Species	Adult	Juvenile	**Tot al**
Centrarchidae	*Lepomis*	*macrochirus*	1	3	**4**
		gibbosus	1	0	**1**
Cyprinidae	*Campostoma*	*anomalum*	1	0	**1**
	Semotilus	*atromaculatus*	11	0	**11**
	Exoglossum	*maxillingua*	2	0	**2**
	Luxilis	*cornutus*	1	0	**1**
Total			**17**	**3**	**20**

Downstream Site

Family	Genus	Species	Adult	Juvenile	**Total**
Cyprinidae	*Semotilus*	*atromaculatus*	3	0	**3**
Total			**3**	**0**	**3**

Conceptual Plan For Miller Run

Proposed Solutions for the Lasting Health of Miller Run

Goals & Proposed Solutions For Miller Run

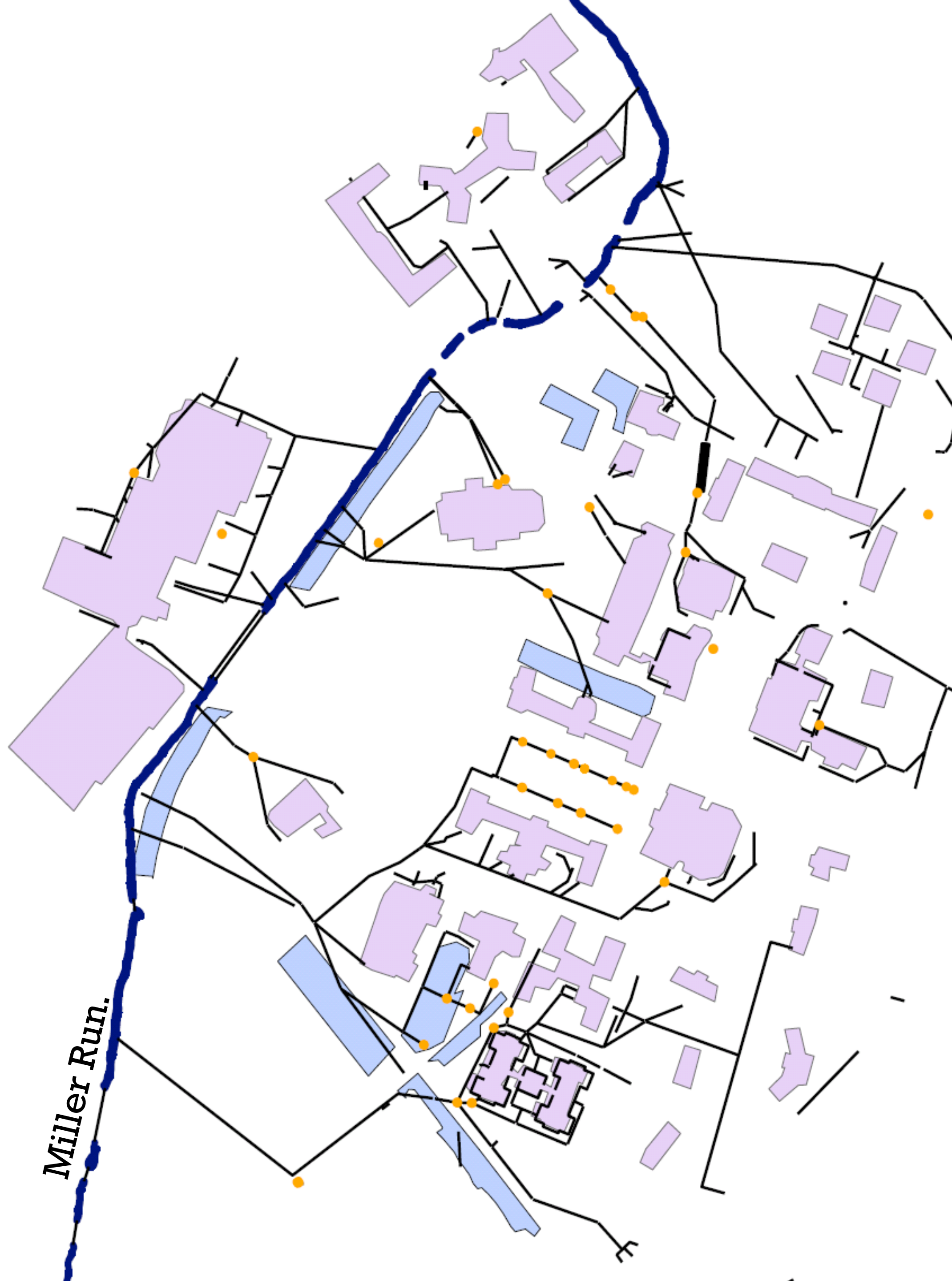
- **Flood control** – Stormwater management, Water retention, low flow augmentation, out-of-channel solutions
- **Aesthetic appeal** – Appropriate stream landscaping, recreational (walking/biking) & meditation space, Bucknell as an example, community green space
- **Environmental education** – Watershed management, "outdoor classroom", research opportunities
- **Ecological health and sustainability** – Maintain year-round flow, provide habitat for target species, encourage native species growth
- **Channel sustainability** – Space for migration/channel evolution, structure/obstruction removal or replacement, bank stability measures, floodplain reconnection

Bucknell is what we call an impermeable jungle.

The campus is covered with ugly asphalt walkways and parking lots and large buildings which do not have efficient storm water management structures.

This needs to change to help replenish the ground water and reduce runoff.

- Buildings and storm drains feed directly into Miller Run.
  - Large amount of storm water produced.
  - Explains why downstream peaks before upstream.
- Structures that could help cut down on surplus of water.
  - Porous Pavements
    - Asphalt, concrete, and block pavers
  - Infiltration trenches
  - Rain Gardens



Permeable Pavements

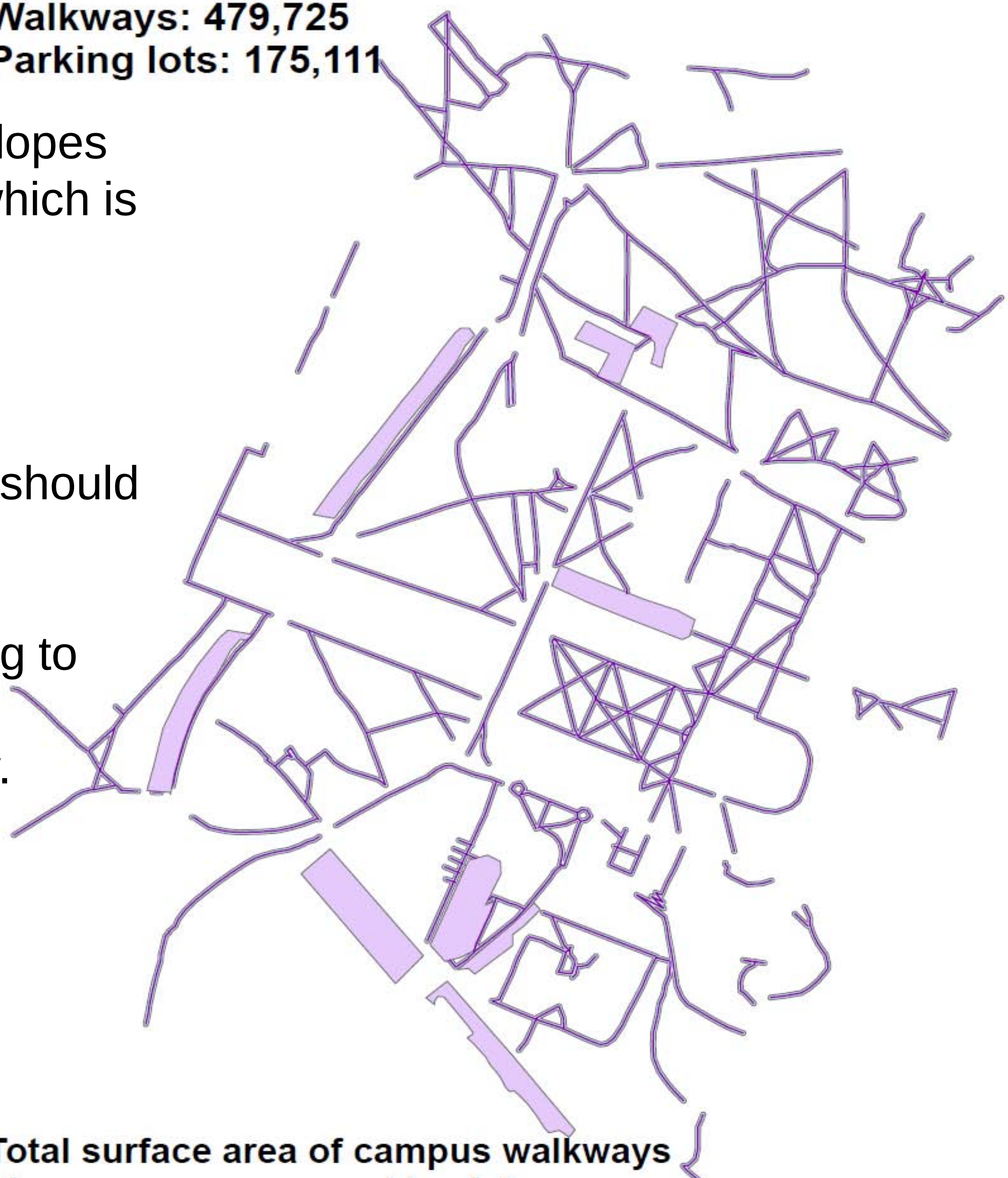
- Pavements can be placed on slopes no greater than 5-20 degrees, which is a great deal of campus.

- Greatly reduce runoff.

- To keep pores clean walkways should be maintained.

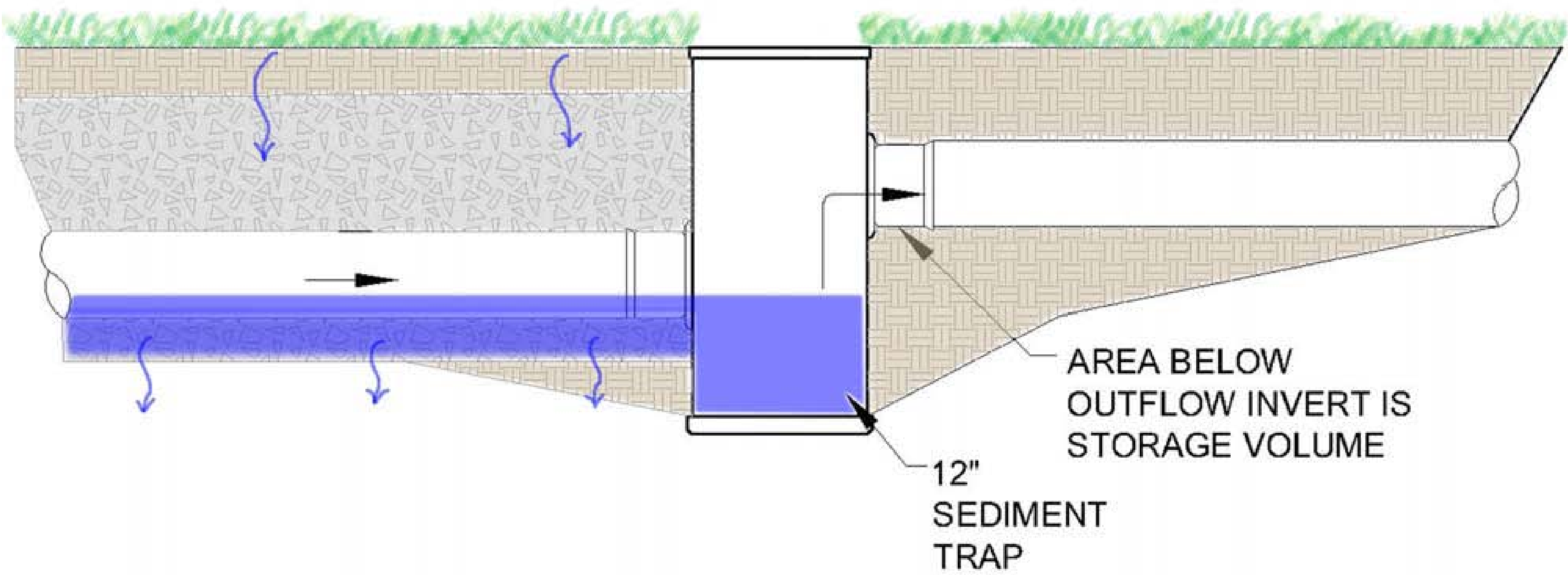
- Some pavements more pleasing to the eye than others, but all are better than the ugly asphalt now.

Walkways: 479,725
Parking lots: 175,111

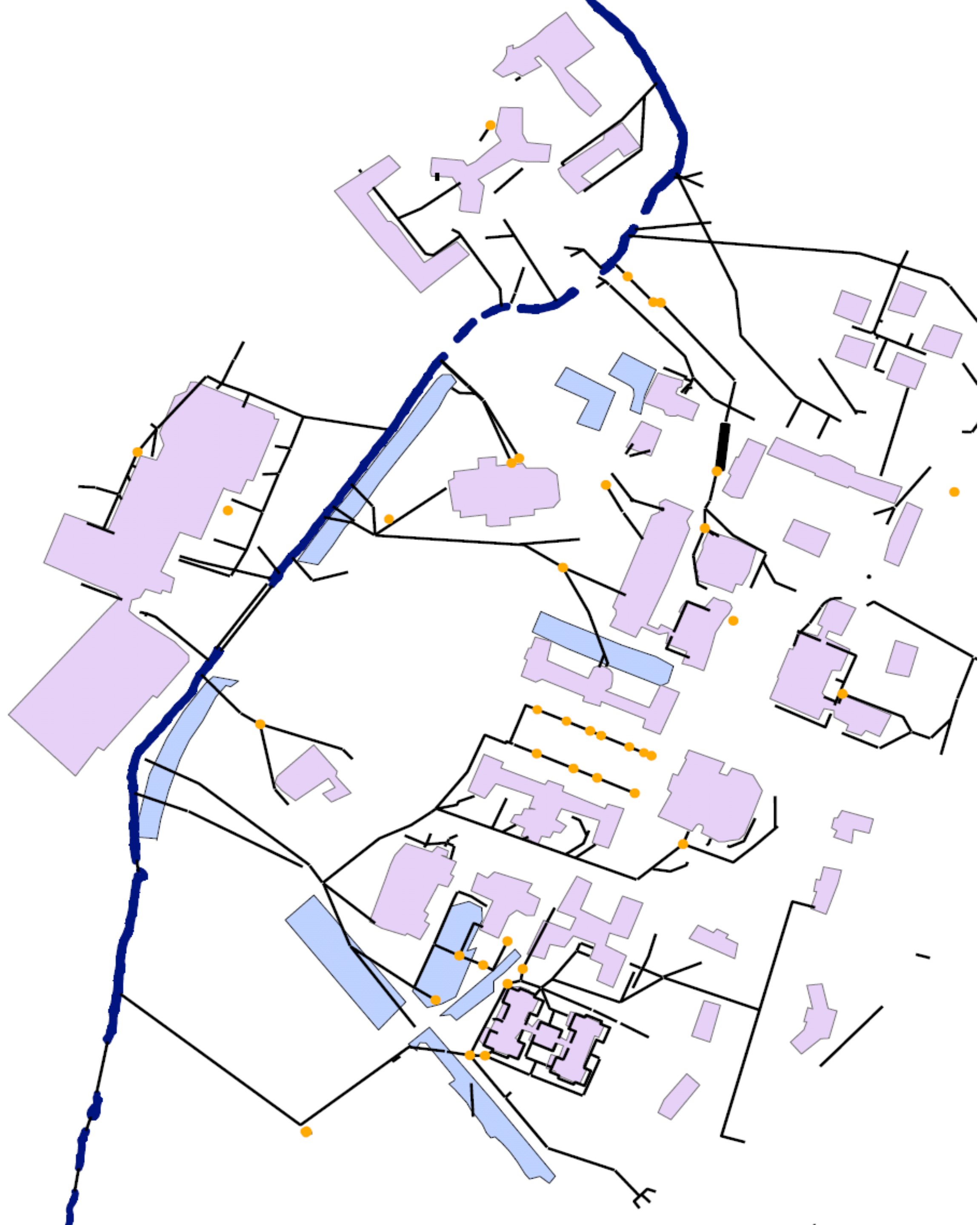


Total surface area of campus walkways plus some campus parking lots : around 654,836 square feet.

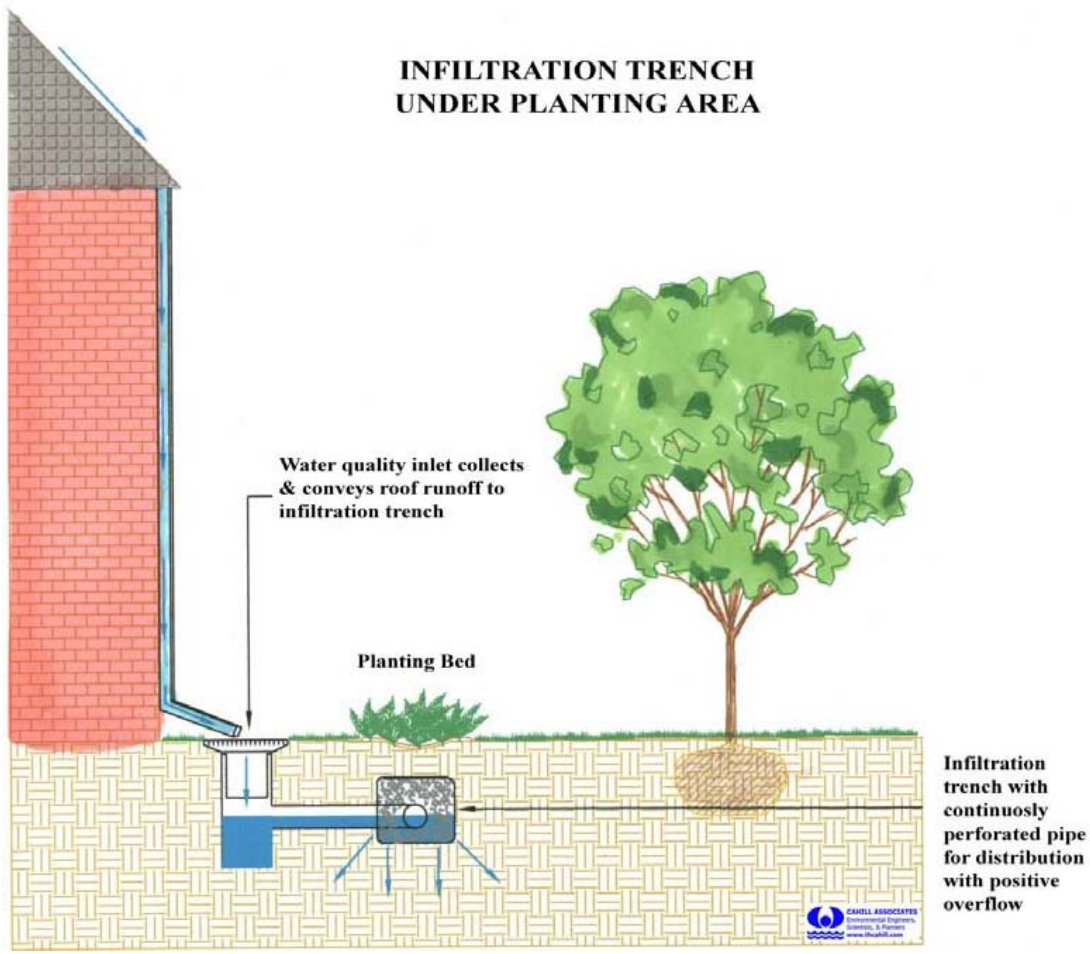
Stepped Infiltration Trenches



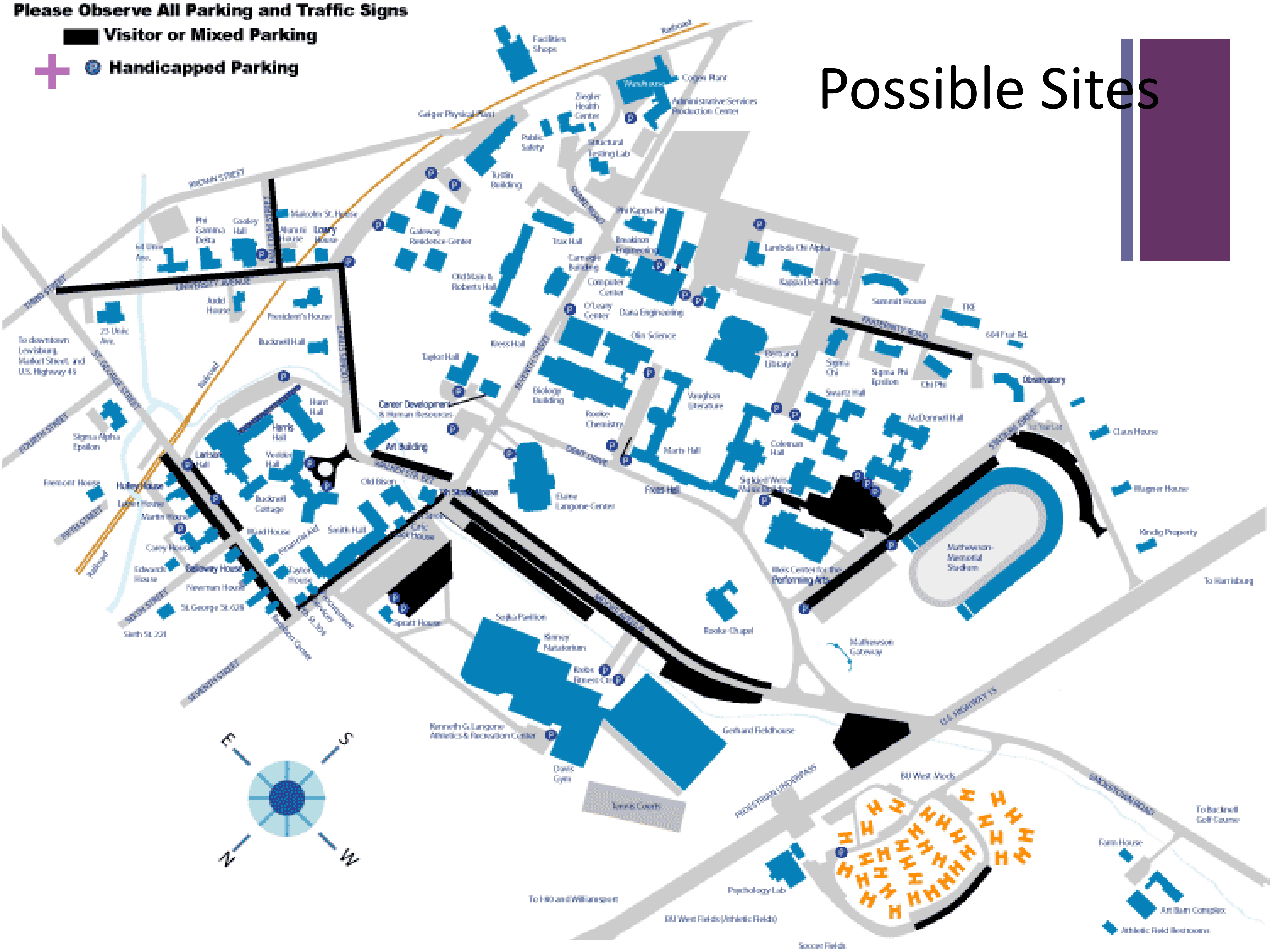
Possible Sites



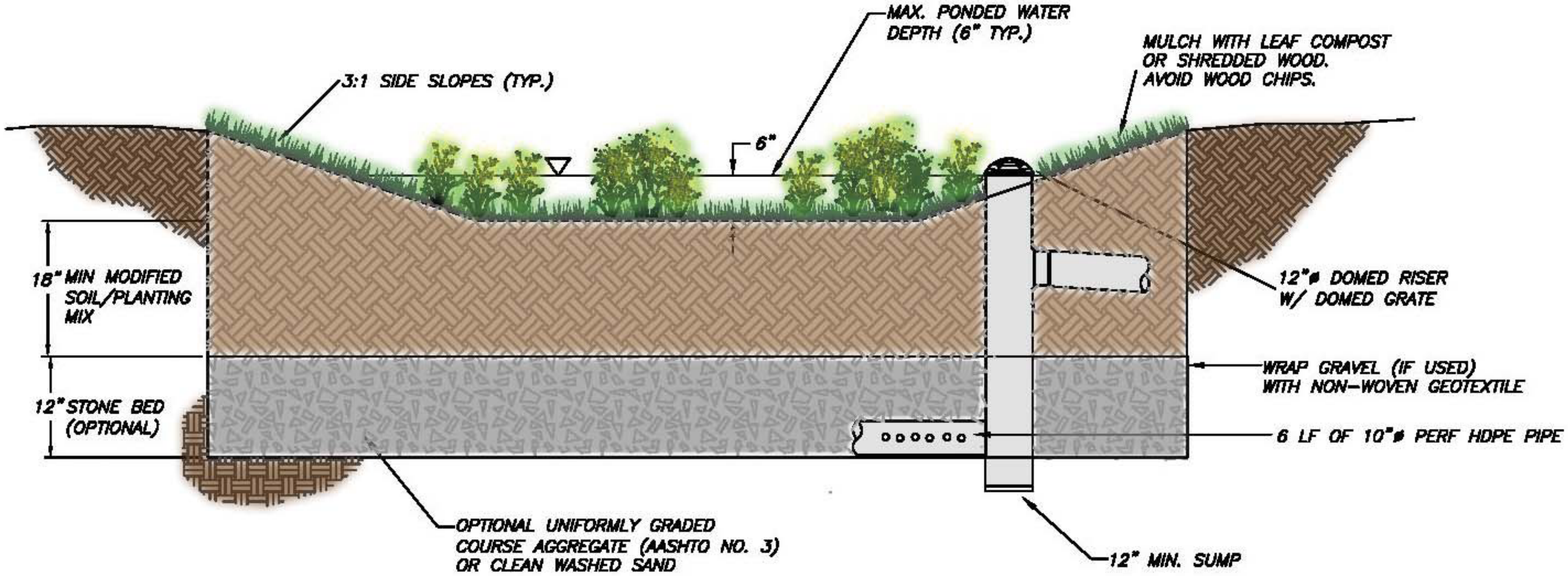
Roof Runoff feeding into Infiltration Trenches



Possible Sites

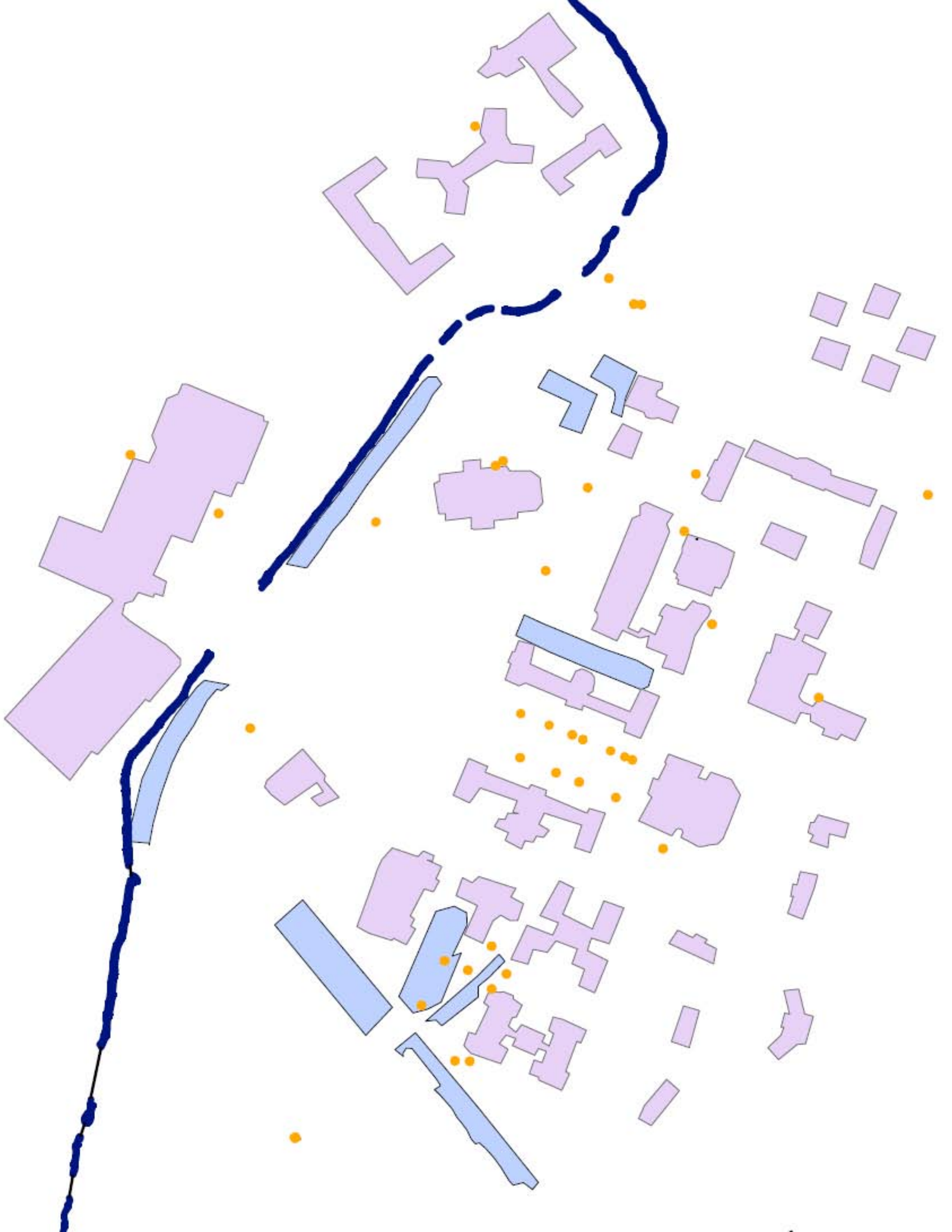


Rain Garden

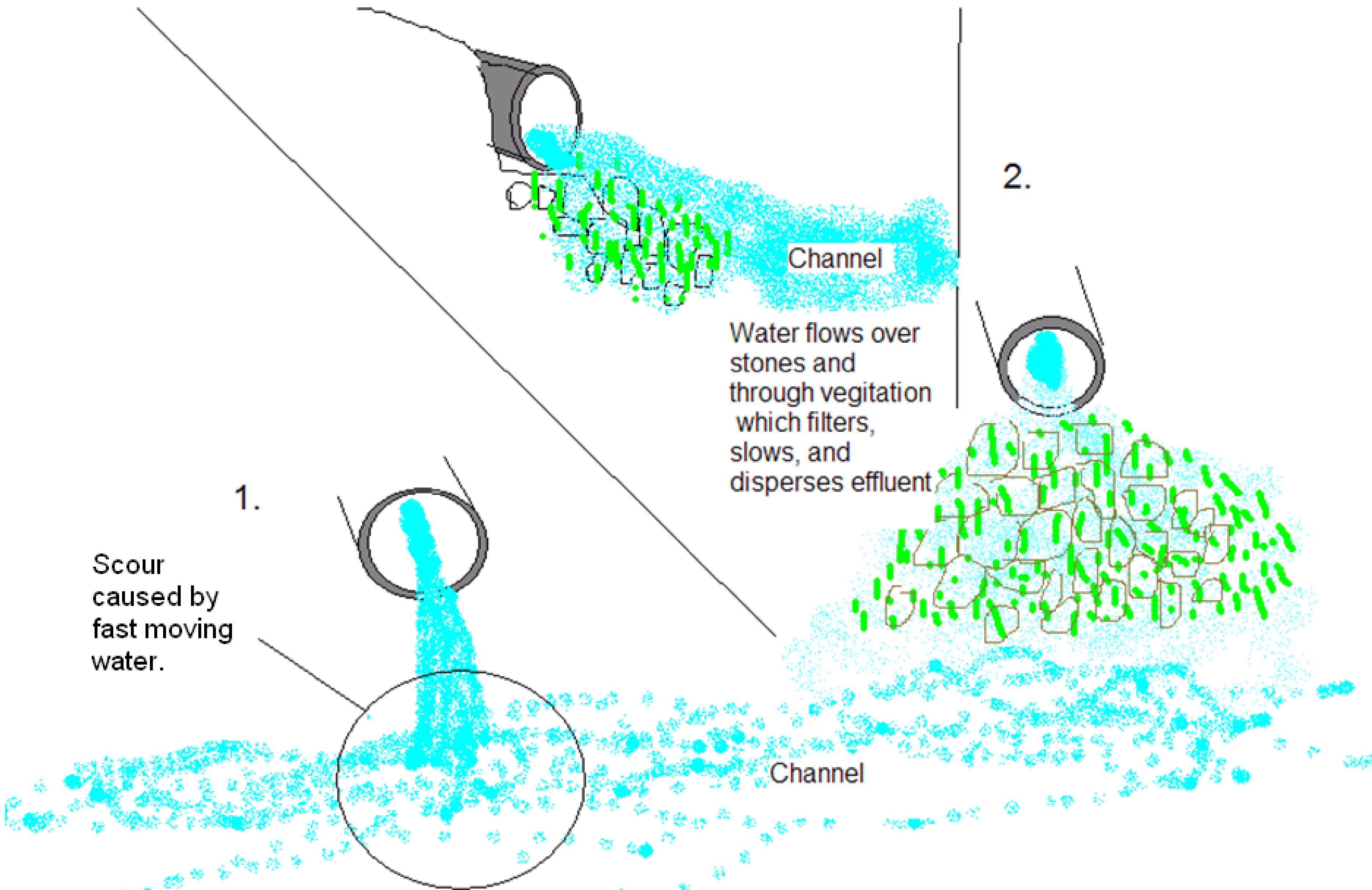

MAX. PONDED WATER DEPTH (6" TYP.)
MULCH WITH LEAF COMPOST OR SHREDDED WOOD. AVOID WOOD CHIPS.
3:1 SIDE SLOPES (TYP.)
6"
18" MIN MODIFIED SOIL/PLANTING MIX
12"ø DOMED RISER W/ DOMED GRATE
WRAP GRAVEL (IF USED) WITH NON-WOVEN GEOTEXTILE
12" STONE BED (OPTIONAL)
6 LF OF 10"ø PERF HDPE PIPE
OPTIONAL UNIFORMLY GRADED COURSE AGGREGATE (AASHTO NO. 3) OR CLEAN WASHED SAND
12" MIN. SUMP

Rain Garden

Possible Sites



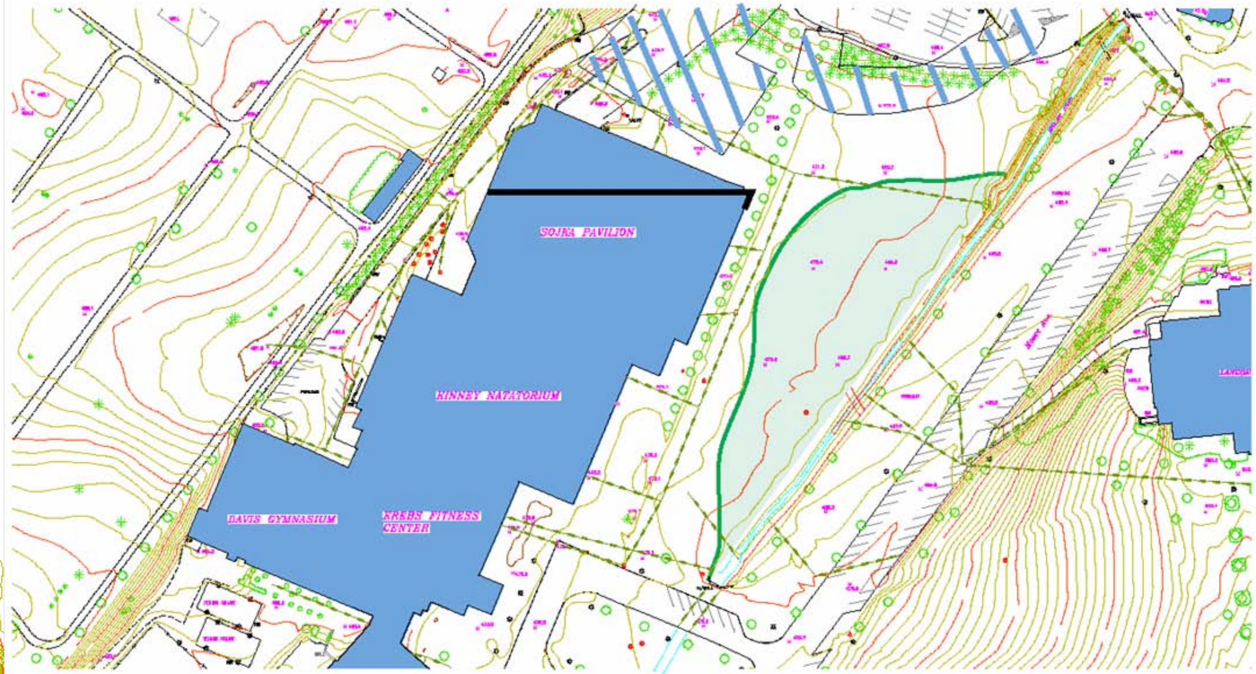
Diffusers at Storm Drain Pipe Outlets

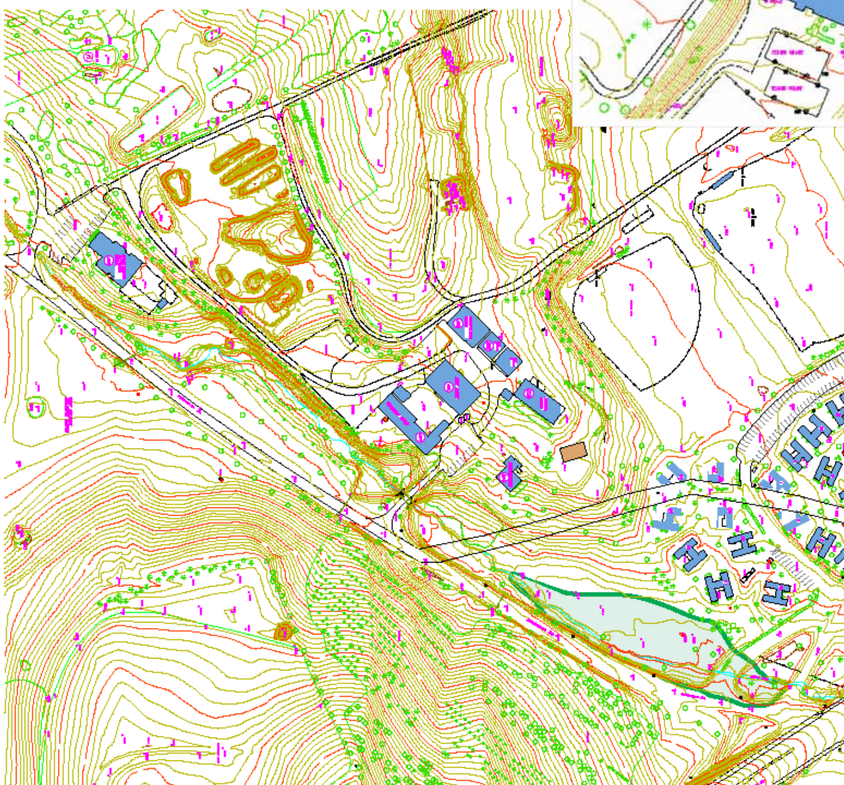


Flood Control

- Two wetland areas
  - Sojka Lawn
  - Mod Field area
- Floodplain reconnection
- Stream corridor/vegetation
  - Biodegradable fabrics
  - Plant natives

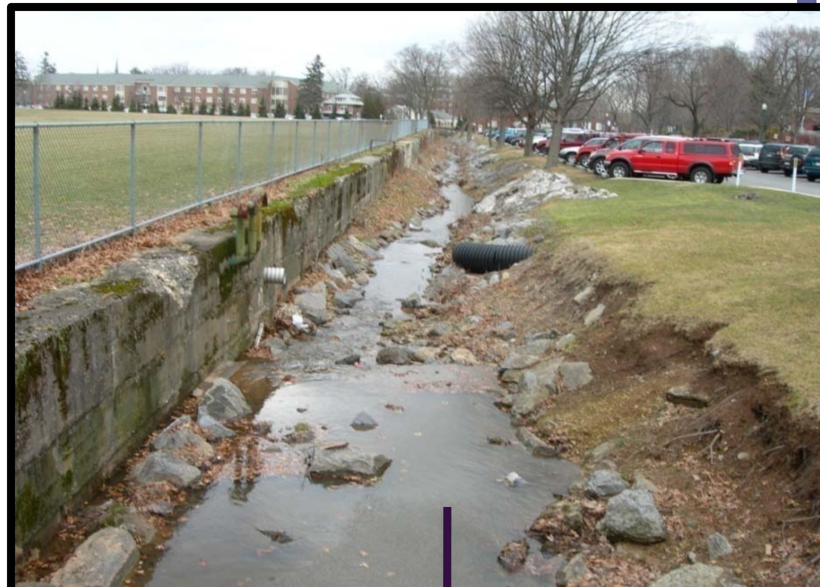
Reach 2A- 3

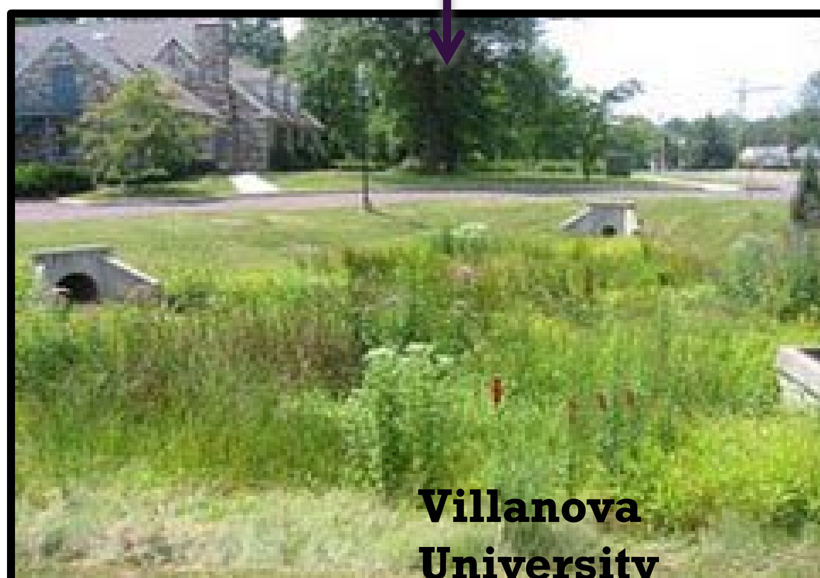

SOJKA PAVILION
KINNEY NATATORIUM
DAVIS GYMNASIUM
KREBS FITNESS CENTER



Aesthetic Appeal

- Rip-rap/obstructions
- Expand natural areas
- Restoring and fostering native habitats
- Recreation & meditation space
- Bucknell as an example





+ Environmental Education

- "outdoor classrooms"
  - Biology
  - Engineering
  - Geology
  - Environmental Studies
  - The Arts
- Bike/walking path- increase community interaction with stream/environment

University of Delaware

Ecological Health and Sustainability

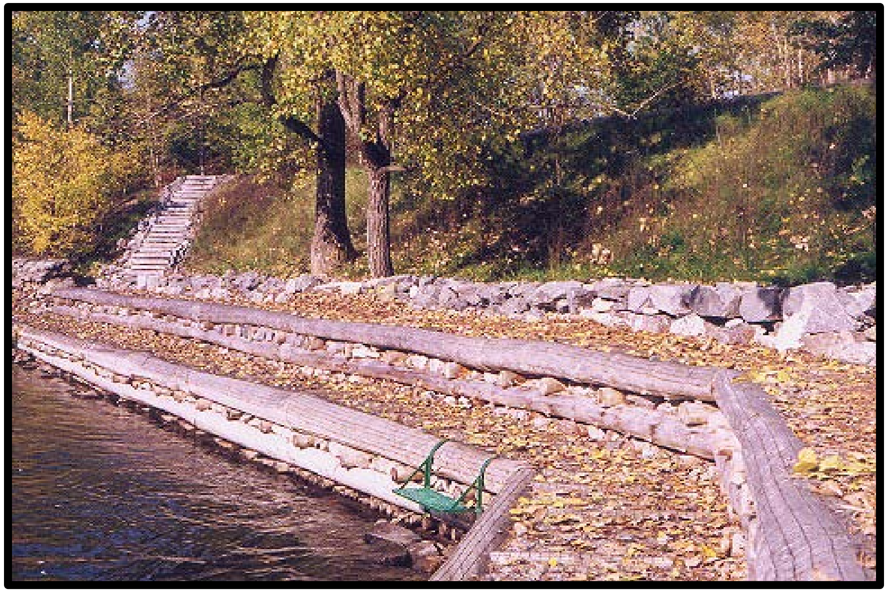
- Widening of stream corridor allows for formation of diverse habitat- both biota (fish, etc.)& abiota

- Year-round stream flow (low flow augmentation)

www.creativehabitatcorp.com/stream.html

Channel Sustainability

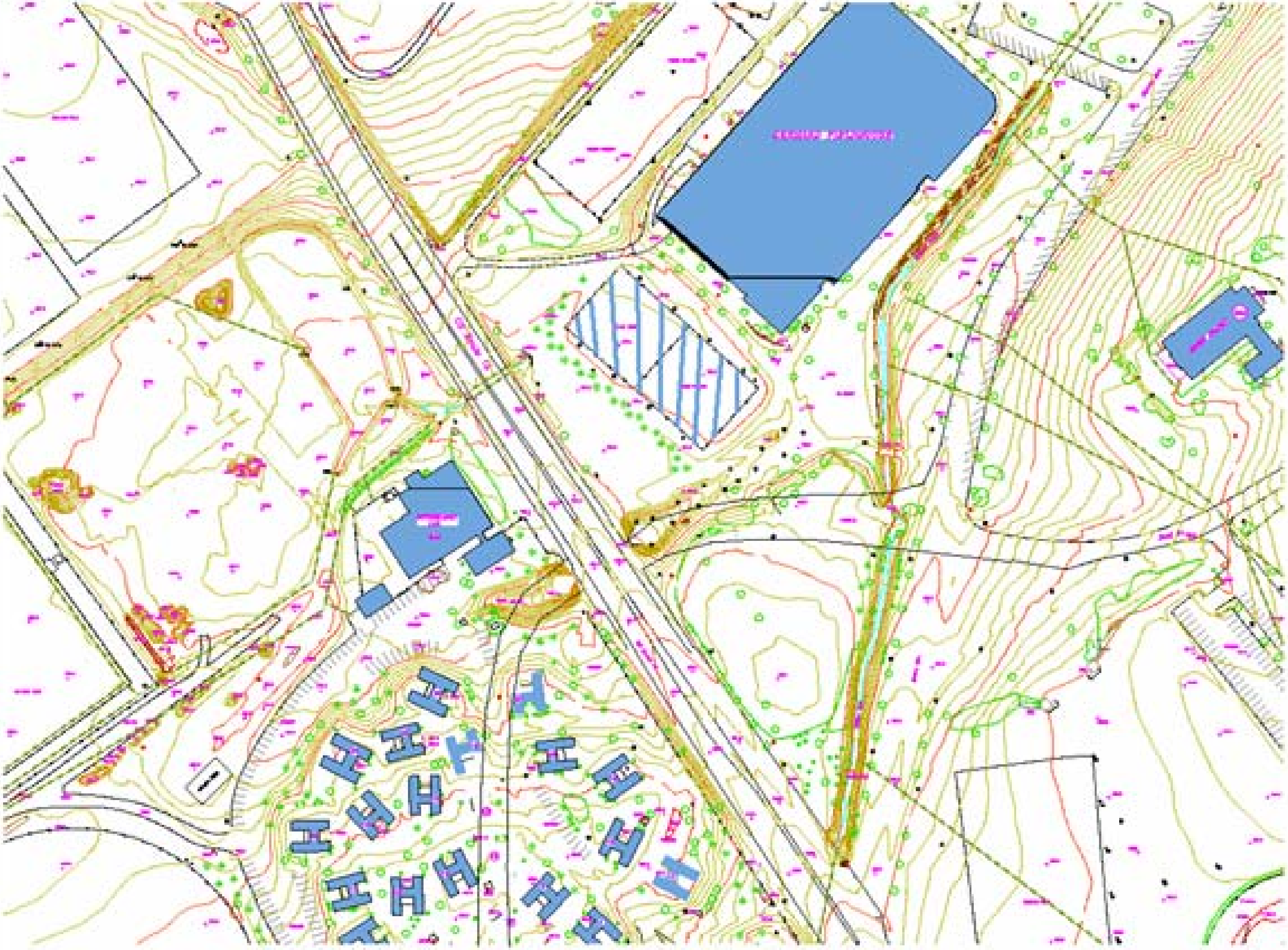
- Space for channel evolution and migration
- Removal/replacement of structures
- Floodplain reconnection



http://www.fws.gov/midwest/Fisheries/streamcrossings/ReplacementStruct

http://www.boquetriver.org/newswillsborocrib.ht

+ Reach 2b



Economic Feasibility of Restoration

Out of Stream Structures

COST ANALYSIS						
Storm Water Management						
Construction:						
	Rain Gardens	$	6	1000	$	6,000
	Infiltration Trenches		7	30,000		210,000
	Permeable Pavement		6	175,111		1,050,866
	Grand Total:	**$**	**19**		**$**	**1,266,666**

In Stream Structures

COST ANALYSIS				
Channel Restoration				
Demolition:		**Unit Cost**	**Units est.**	**Total Cost**
	Rip Rap	$ 42	2,400	$ 100,440
	Parking Surfaces:	0	2,250	923
	Concrete Walls:	150	300	45,000
	Culverts and Pipes:	290	20	5,791
	Sub Totals:	**$ 482**		**$ 152,154**
Construction:				
	Log Cribbing	$ 286	315	$ 90,090
	Culvert	289.5	2	579
	Wetlands: Sojka	150000	1	75,000
	Wetlands: Mods	57100	1	57,100
	Sub Totals:	$207,676		$ 222,769
	Grand Total:	**$208,157**		**$ 374,923**

Total Project

COST ANALYSIS			
Channel Restoration			
Demolition:	**Unit Cost**	**Units est.**	**Total Cost**
Sub Totals:	**$ 482**		**$ 152,154**
Construction:			
Sub Totals:	$207,676		$ 222,769
Grand Total:	**$208,157**		**$ 374,923**
Storm Water Management			
Construction:			
Grand Total:	**$ 19**		**$ 1,266,666**
Misc. Inputs			
Permits			8,500
Legal Council			4,250.00
BU Facility Cost			17,000.00
Sub Totals:			**$ 1,671,339**
Escalation & Contingency			50,140.17
Grand Total:			**$ 1,721,479**

Non-Scientific Benefits

- The restoration of Miller Run dovetails with both campus and community initiatives
  - Campus Master Plan
  - Creation of green space and bike paths
- Offers educational facilities to students and members of the Lewisburg community
- Sets Bucknell apart from peer schools
- Unique and exciting atmosphere to both live and work