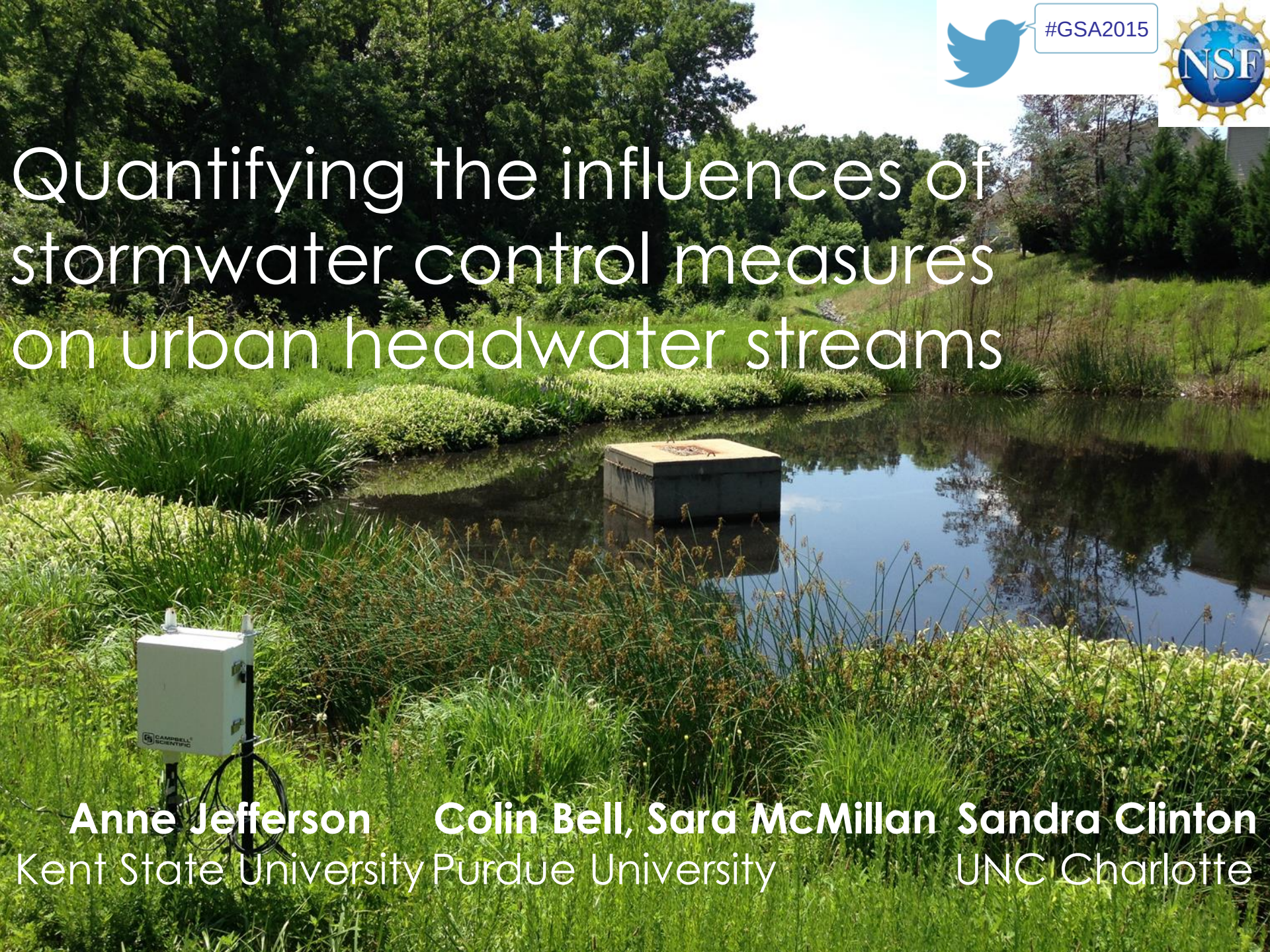
#GSA2015

Quantifying the influences of stormwater control measures on urban headwater streams

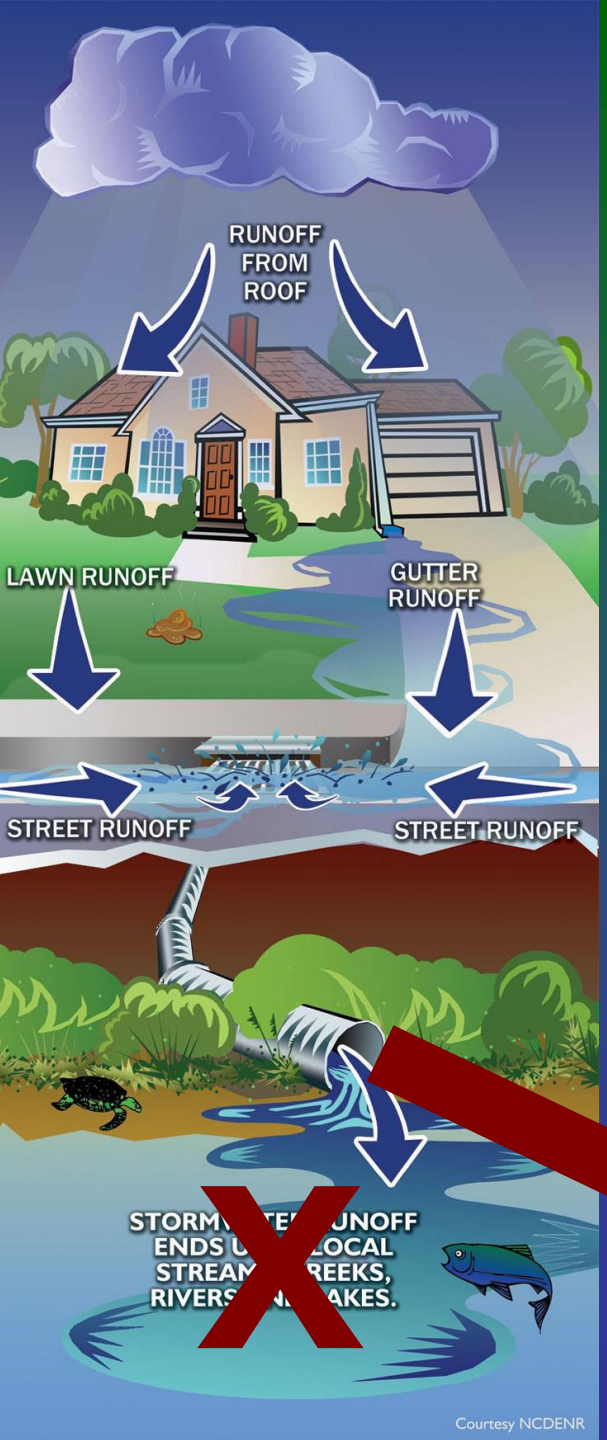


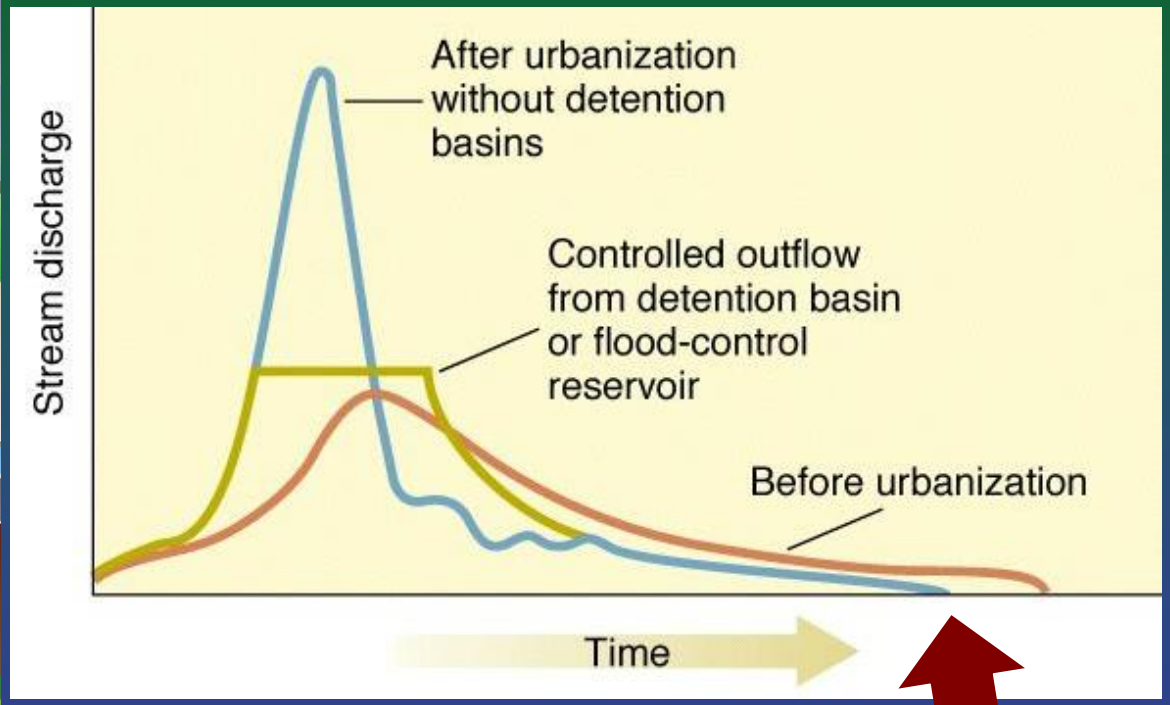
Anne Jefferson Kent State University

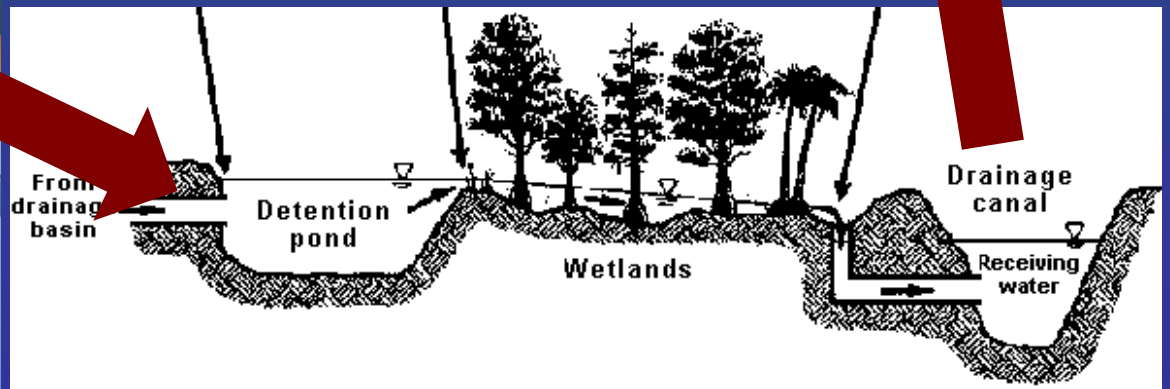
Colin Bell, Sara McMillan Purdue University

Sandra Clinton UNC Charlotte

How stormwater control measures (SCMs) work







http://serc.carleton.edu

http://environment.fhwa.dot.gov/

In most urban watersheds, not all stormwater runoff is mitigated.

1. How do SCMs modulate hydrographs, if <100% of the watershed is treated?

SCM discharges are difficult to quantify, because most aren't designed for monitoring.

2. Can isotope hydrograph separation serve as a tool for quantifying SCM discharge?

Results in subsequent slides are described in:

Jefferson, A., Bell, C., Clinton, S., and McMillan, S. Application of isotope hydrograph separation to understand urban stormwater dynamics, Hydrological Processes, DOI: 10.1002/hyp.10680.

Please refer to and cite that paper for full details.

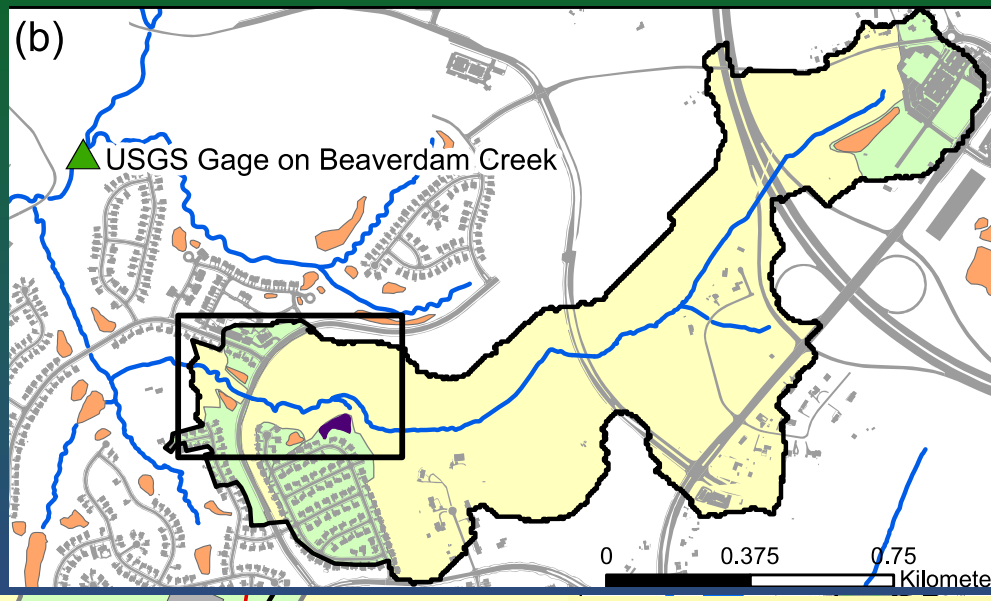
Can isotope hydrograph separation serve as a tool for quantifying SCM discharge?

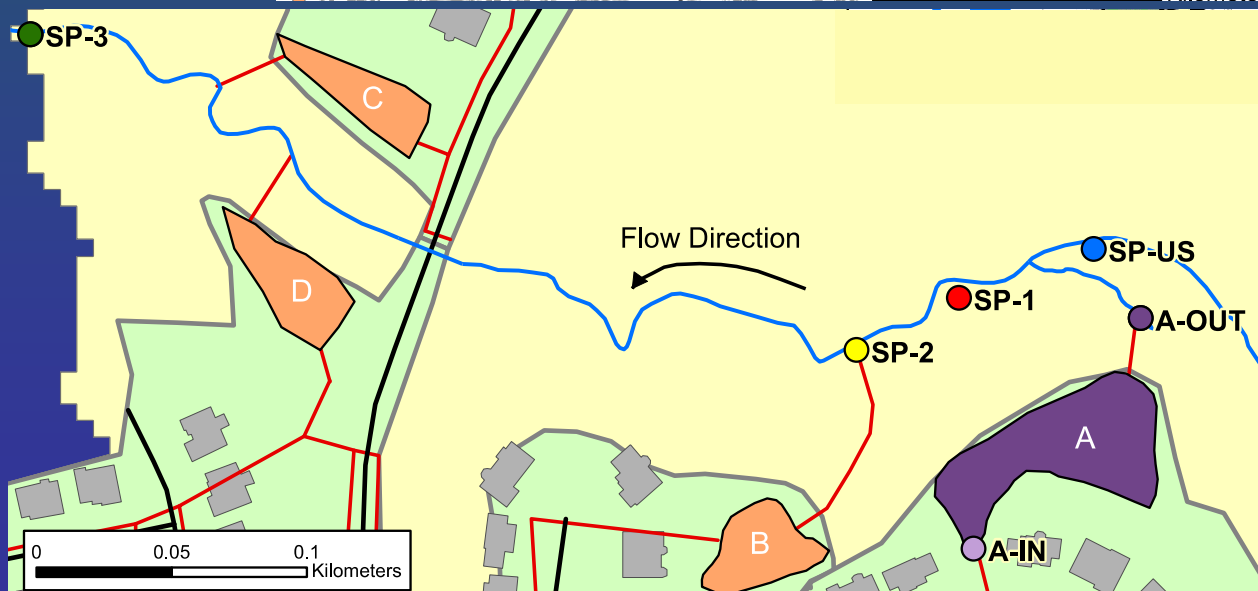
Mixing of conservative endmembers used to separate water sources.

Unknowns:

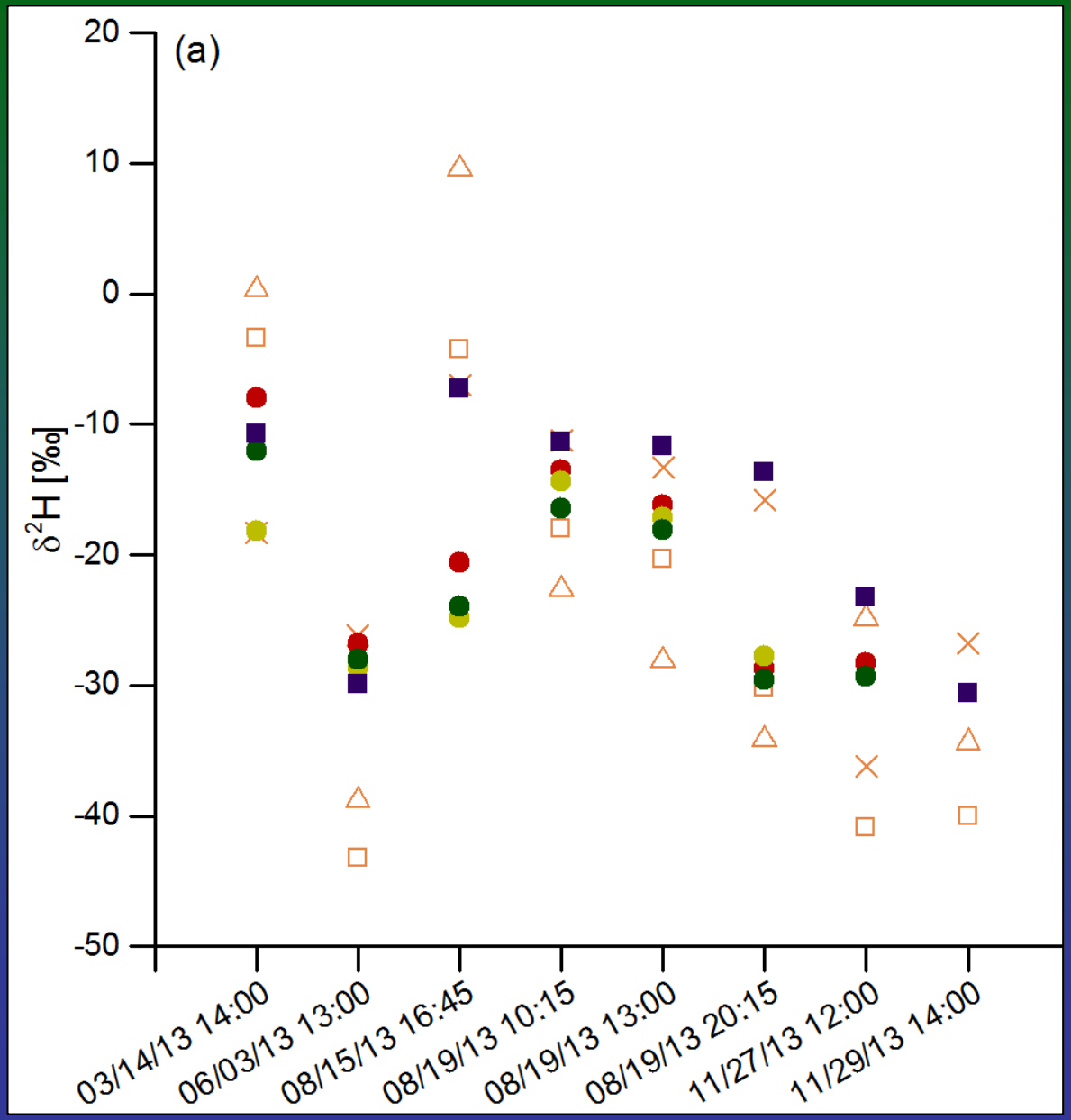
- Do SCMs have distinct signature?
- Are SCMs isotopically similar?

If it works:
Grab + lab



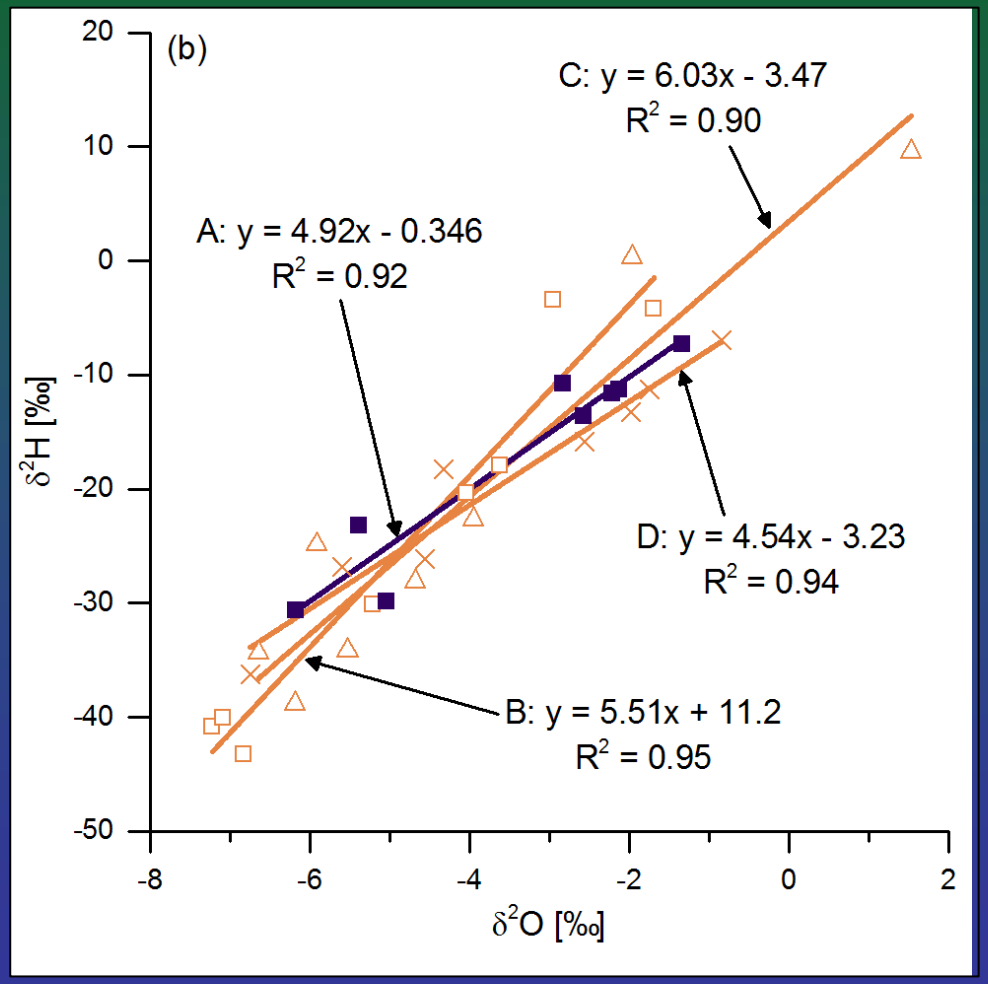


SCM outflows are distinct.



- Across range of flows, SCMs are different from the stream – and from each other.

SCM isotopes may depend on storage volume.



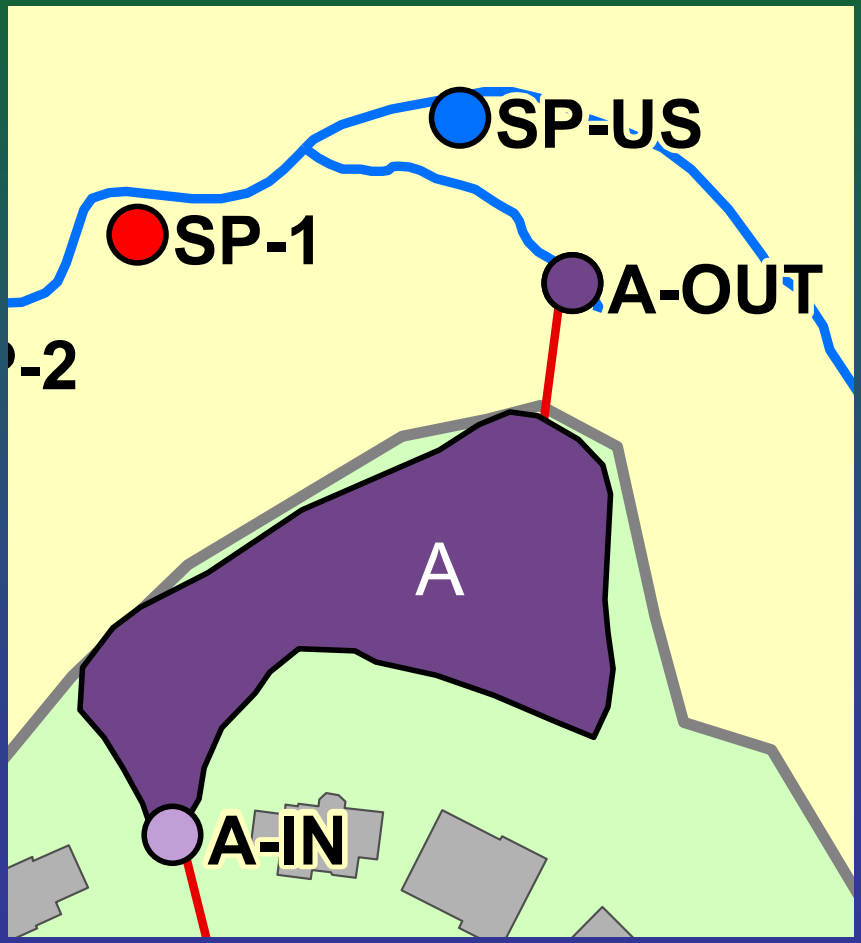
- Slope of $\delta^{18}O$-$\delta^{2}H$ line is evaporative.
- Ponds (A & D) are more evaporative than wetland (B) and bioretention (C).
- More evaporative waters from higher volume SCMs.

SCM A SCM B SCM C SCM D SP-1 SP-2 SP-3

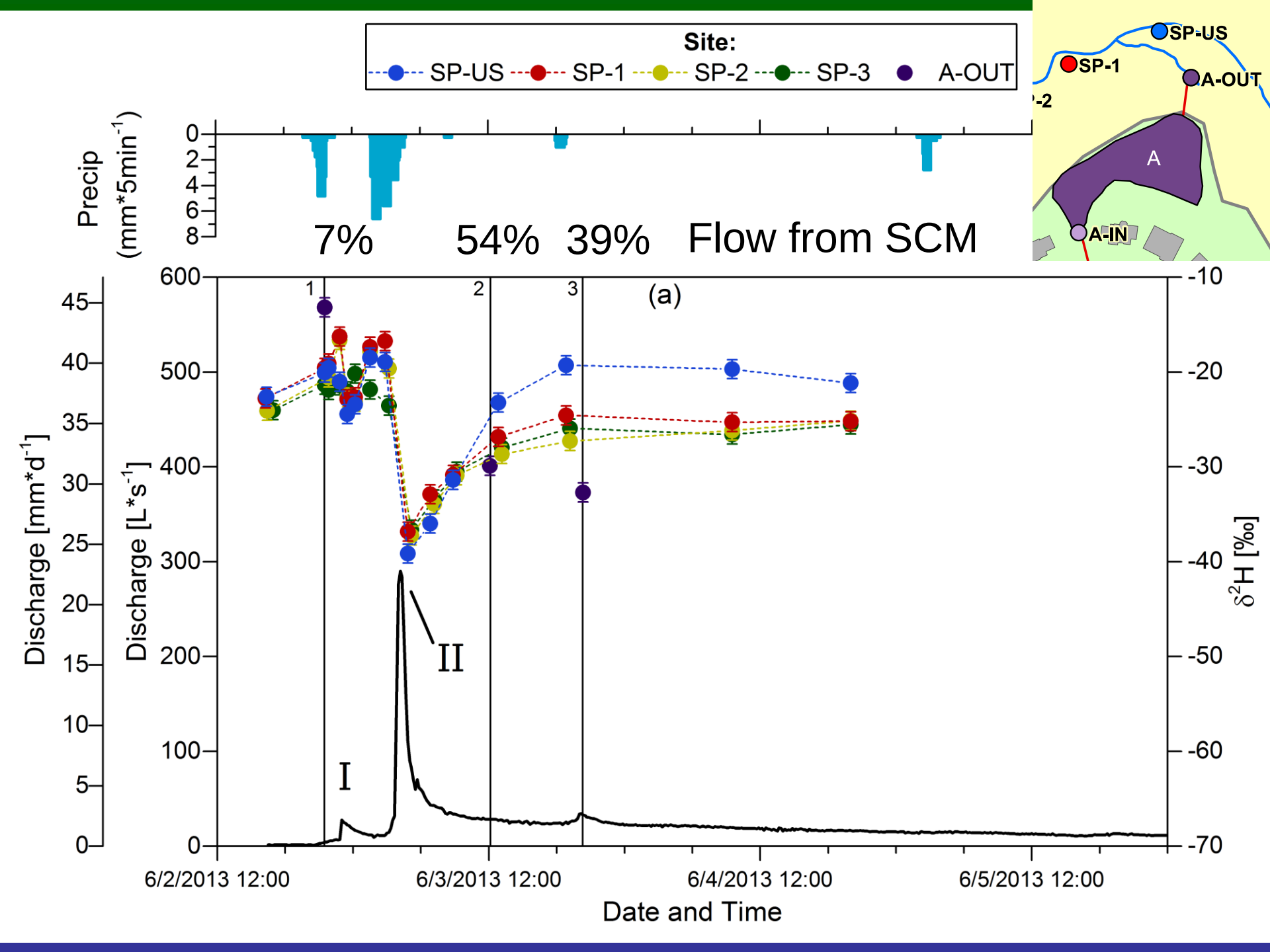
Applying isotope hydrograph separation

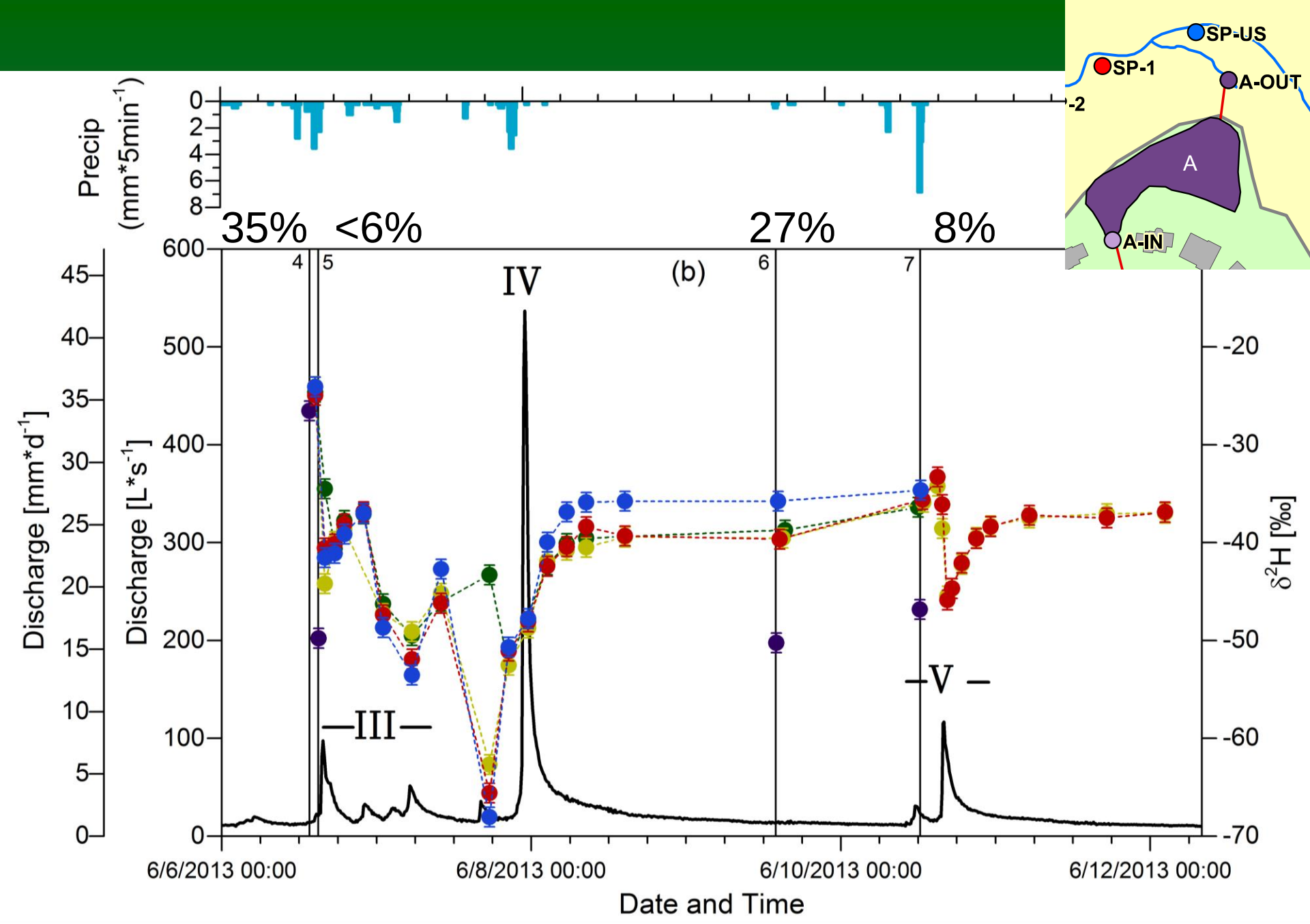
	Area (ha)	**TI** (%)
SP-US	101	12
A-OUT	9.5	42

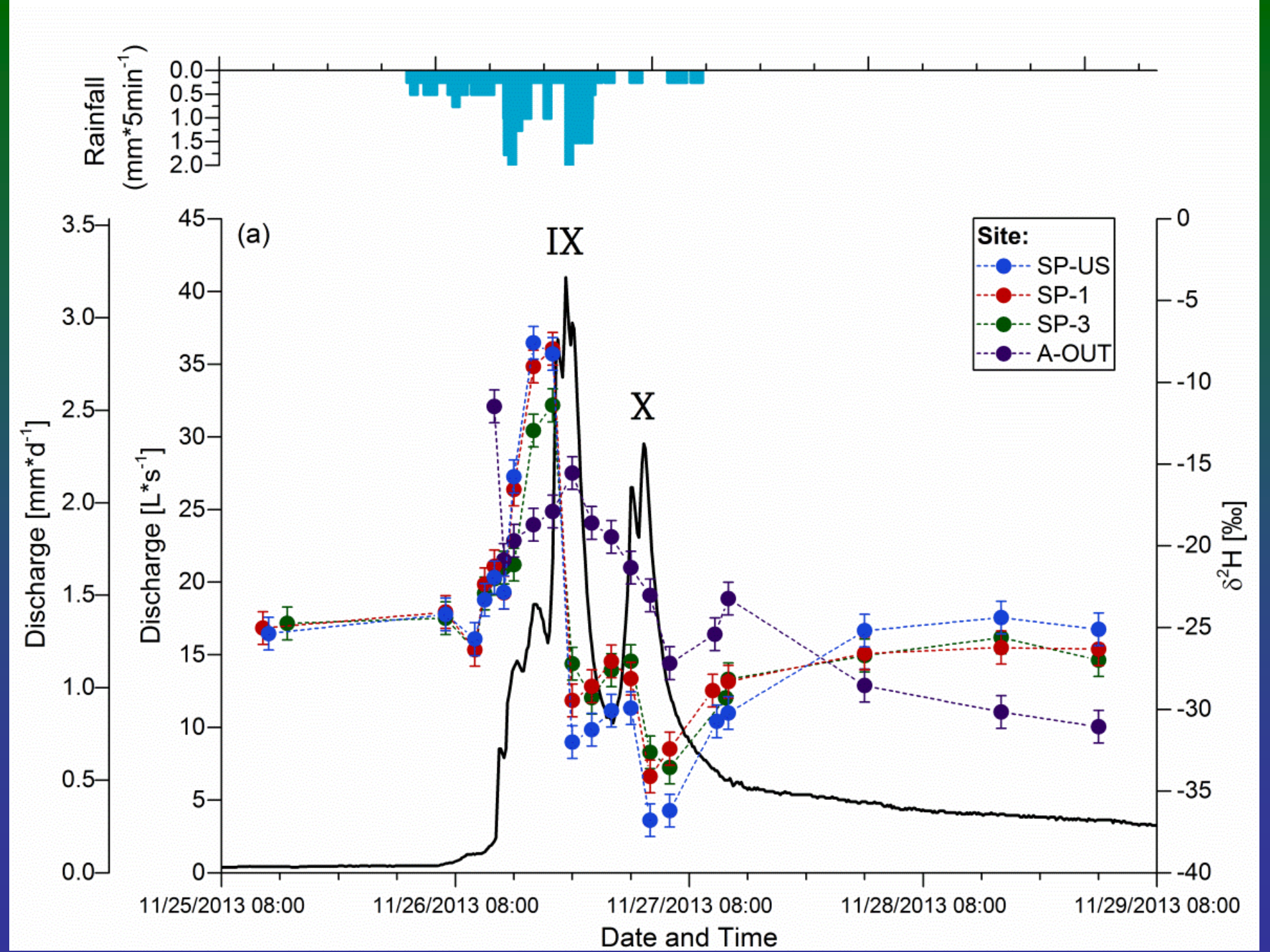
Pond A drains 25% of watershed impervious area



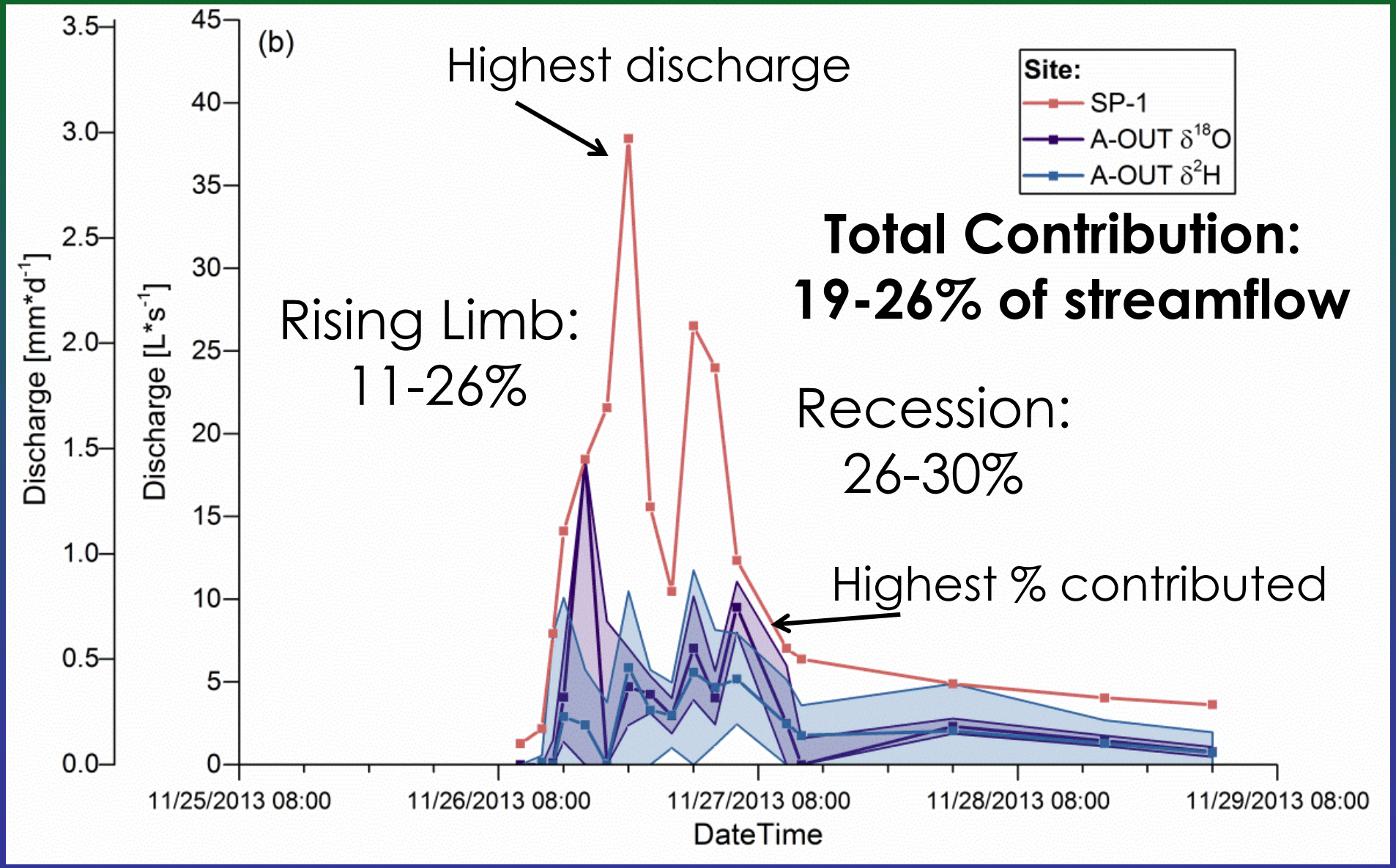
Jefferson, A., Bell, C., Clinton, S., and McMillan, S. Application of isotope hydrograph separation to understand urban stormwater dynamics, Hydrological Processes, DOI: 10.1002/hyp.10680.


Site:
SP-US
SP-1
SP-2
SP-3
A-OUT
Precip (mm*5min-1)
7%
54%
39%
Flow from SCM
SP-US
SP-1
A-OUT
A
A-IN
(a)
1
2
3
I
II
Discharge [mm*d-1]
Discharge [L*s-1]
δ2H [‰]
6/2/2013 12:00
6/3/2013 12:00
6/4/2013 12:00
6/5/2013 12:00
Date and Time


Precip
(mm*5min-1)
0
2
4
6
8
35%
<6%
27%
8%
SP-US
SP-1
A-OUT
A
A-IN
-2
600
500
400
300
200
100
0
4
5
6
7
(b)
IV
III
V
Discharge [L*s-1]
Discharge [mm*d-1]
45
40
35
30
25
20
15
10
5
0
-20
-30
-40
-50
-60
-70
δ2H [‰]
6/6/2013 00:00
6/8/2013 00:00
6/10/2013 00:00
6/12/2013 00:00
Date and Time


Rainfall
(mm*5min-1)
0.0
0.5
1.0
1.5
2.0
(a)
IX
X
Site:
SP-US
SP-1
SP-3
A-OUT
Discharge [mm*d-1]
Discharge [L*s-1]
δ2H [‰]
11/25/2013 08:00
11/26/2013 08:00
11/27/2013 08:00
11/28/2013 08:00
11/29/2013 08:00
Date and Time

Hydrograph separation reveals stormwater-stream dynamics.



- Our SCM drains 10% of watershed area, and 25% of imperviousness.

Isotope hydrograph separation reveals…

- Pond mitigates effects of imperviousness, contributing 10% of flow to rising limb and 12% to peak flow.
- During recession, pond contributed average of 32% and up to 54% of water in stream.
- Detention ponds detain.

Variable storage time in SCMs has implications for water quality.

- >24 hour residence time prescribed for WQ goals
- Isotope data show residence time from 2 hrs to ~1 week.
- Settling, biogeochemical processing, evaporation and heating all affected by residence time.

http://www.fairfaxcounty.gov/nvswcd/newsletter/understanding-stormwater-ponds.htm

Take Home Points

- At watershed scale, hydrologic signal of stormwater control may be tough to detect, but…
- Stable water isotopes offer potential for synoptic sampling to determine SCM influence: "grab and lab."
- Outflow from SCMs can be significant component of stream water, especially during recession.
- Effects on water quality and ecosystems likely.