Changes In The Riparian Water Table With Channel Incision

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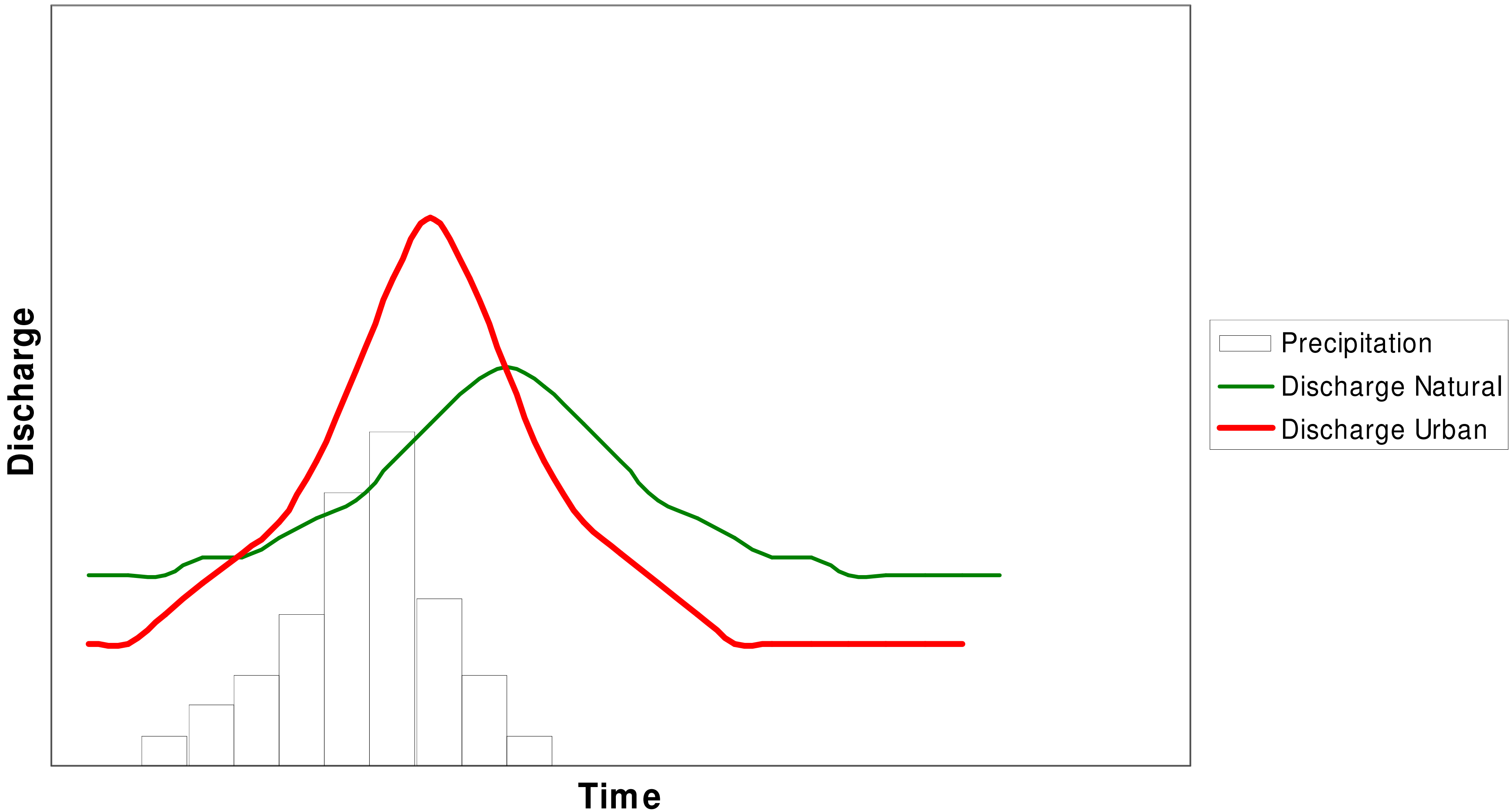
College of William and Mary

Stream Incision, part II

Nora Matell

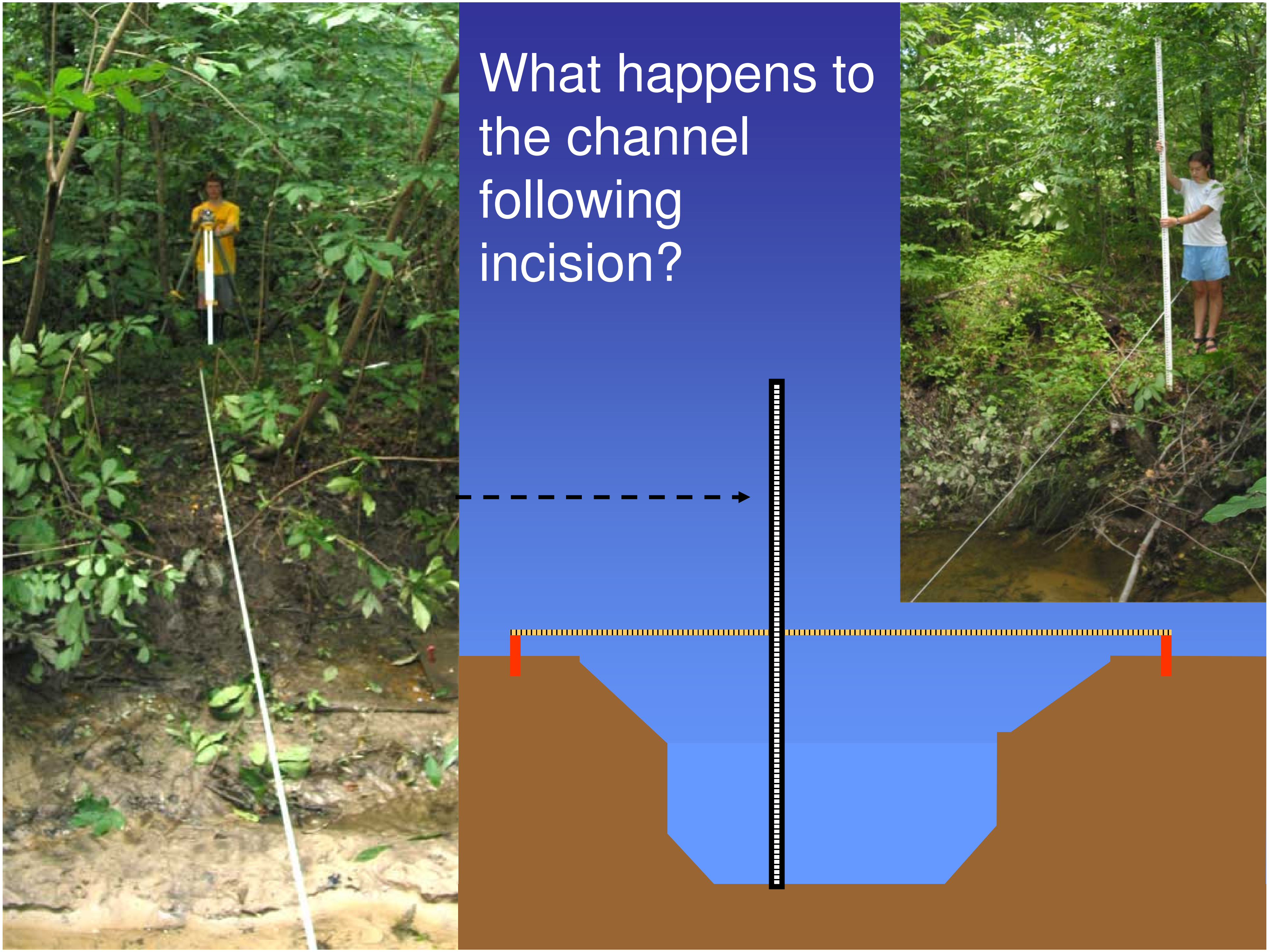
Natural vs. Urban Stream Response



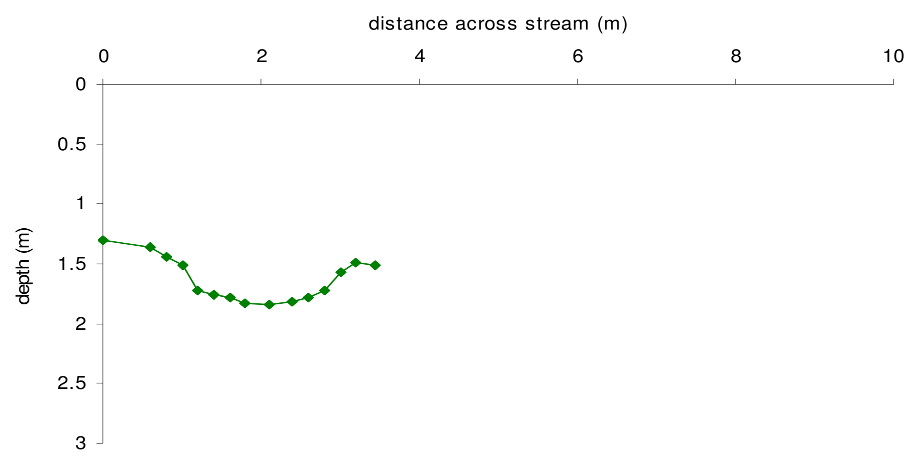
Following stream incision:

- What happens to the riparian water table?
  - How much does it change?
  - At what rate does it change?

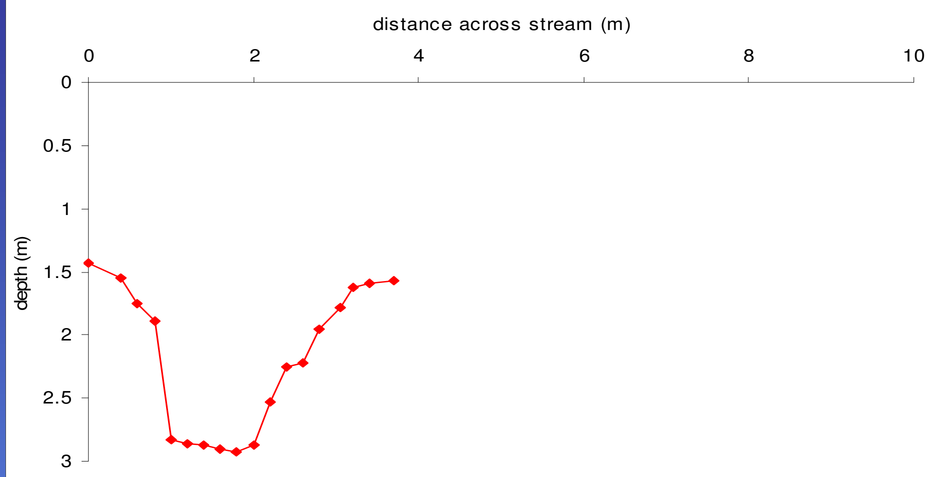
- **What happens to the channel?**
- **What happens to floodplain/channel interaction?**
- **What happens during and after storms?**


What happens to the channel following incision?

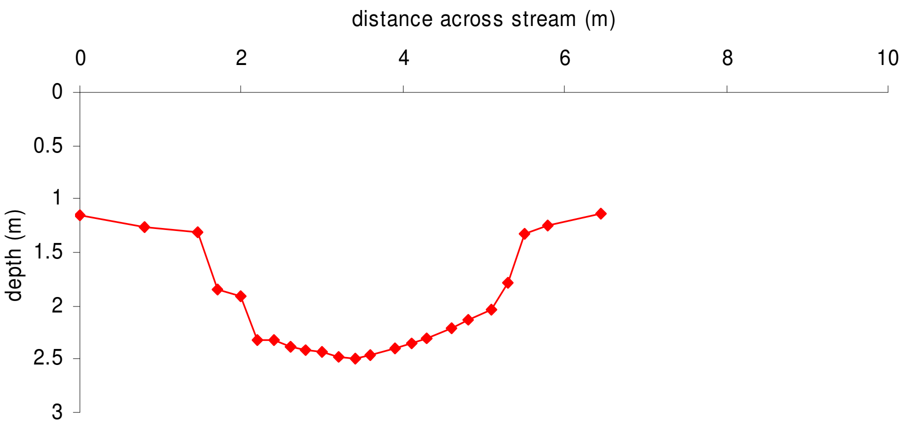
Changes in channel shape and size



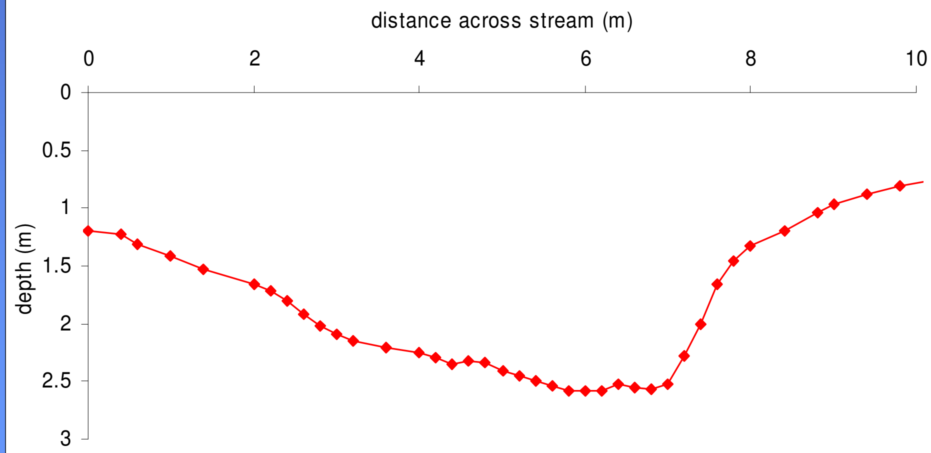
upstream of knickpoint



just downstream of knickpoint

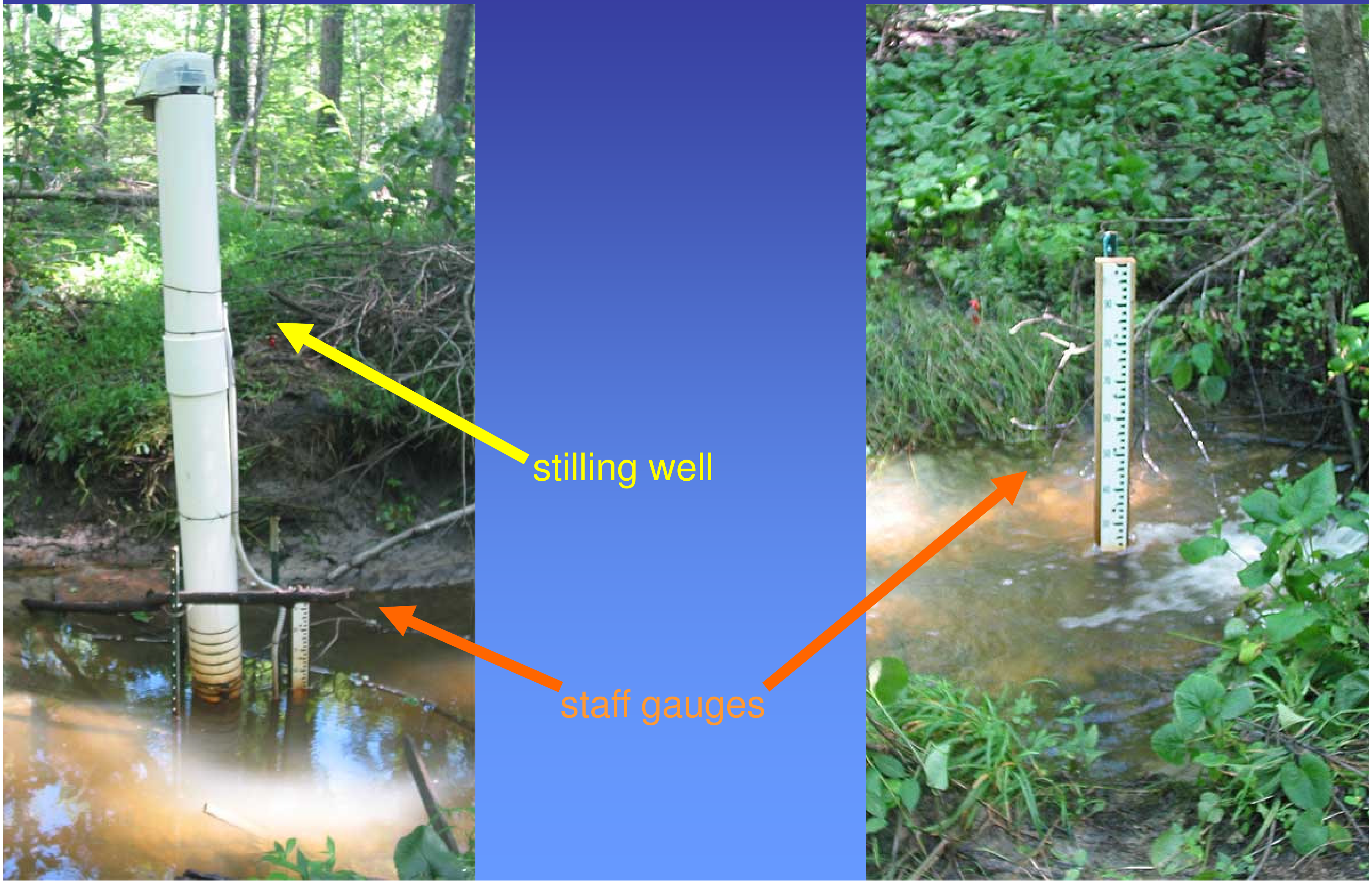


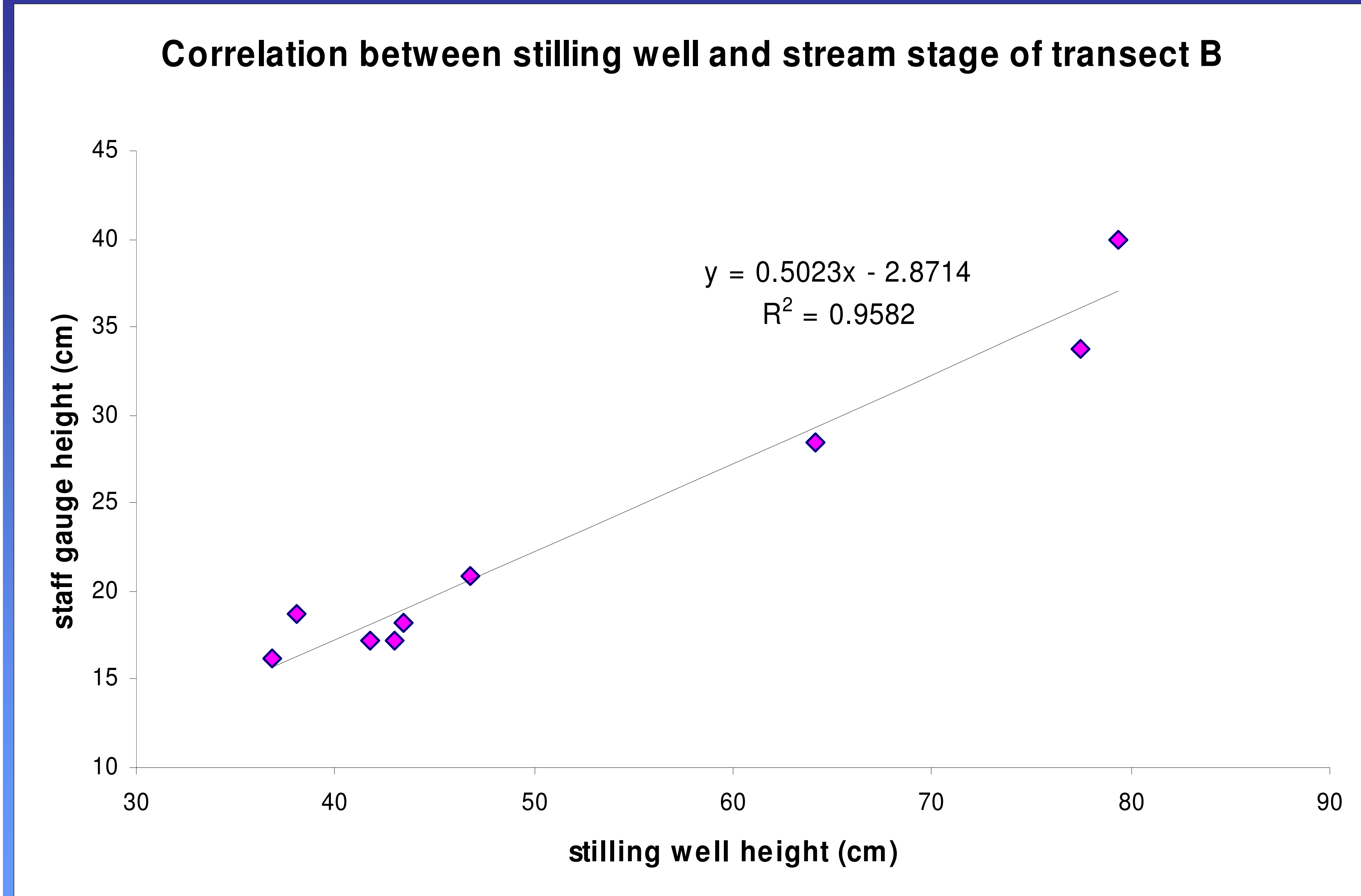
further downstream of knickpoint



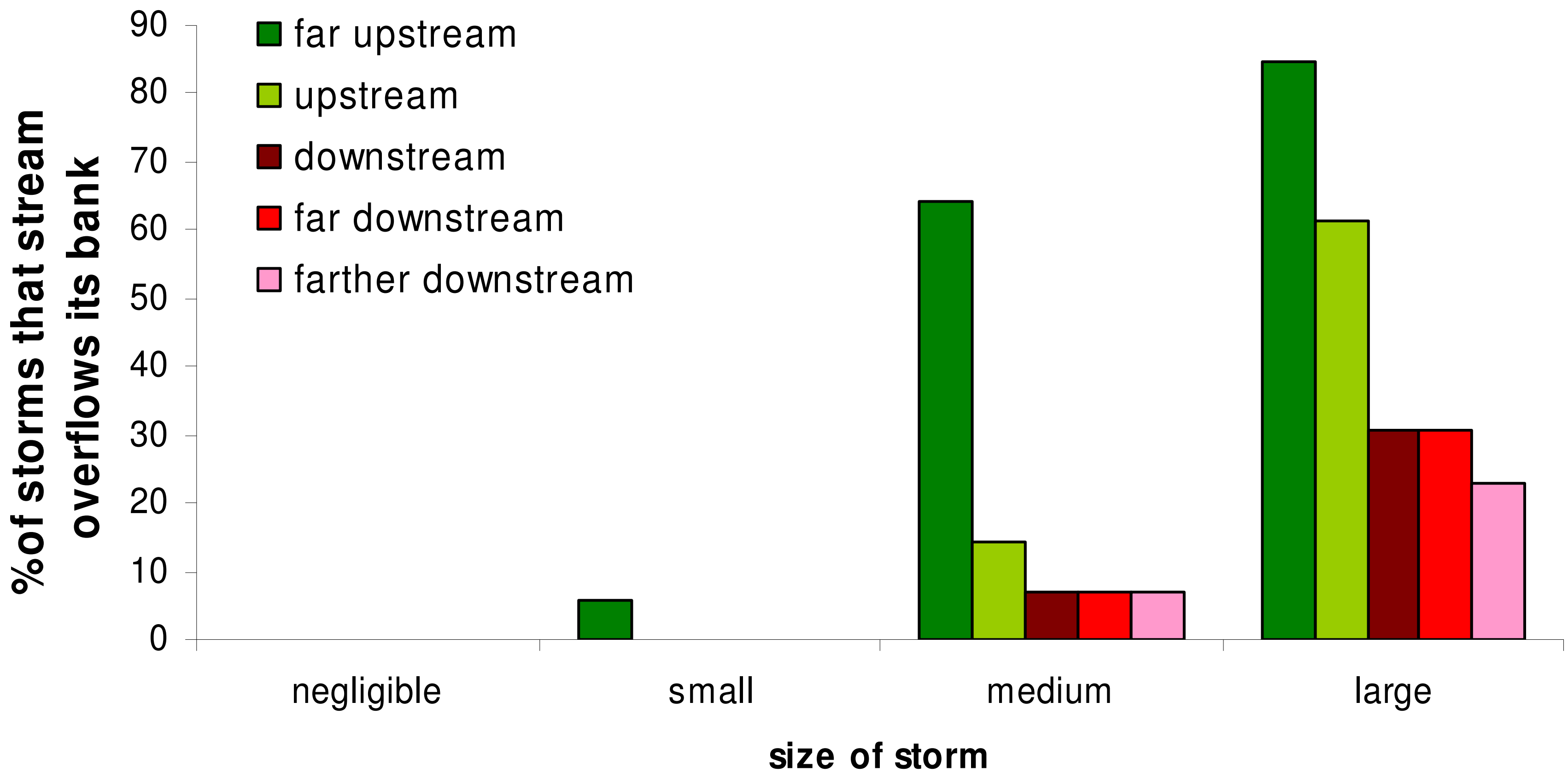
farthest downstream of knickpoint

What happens to floodplain/channel interaction following incision?



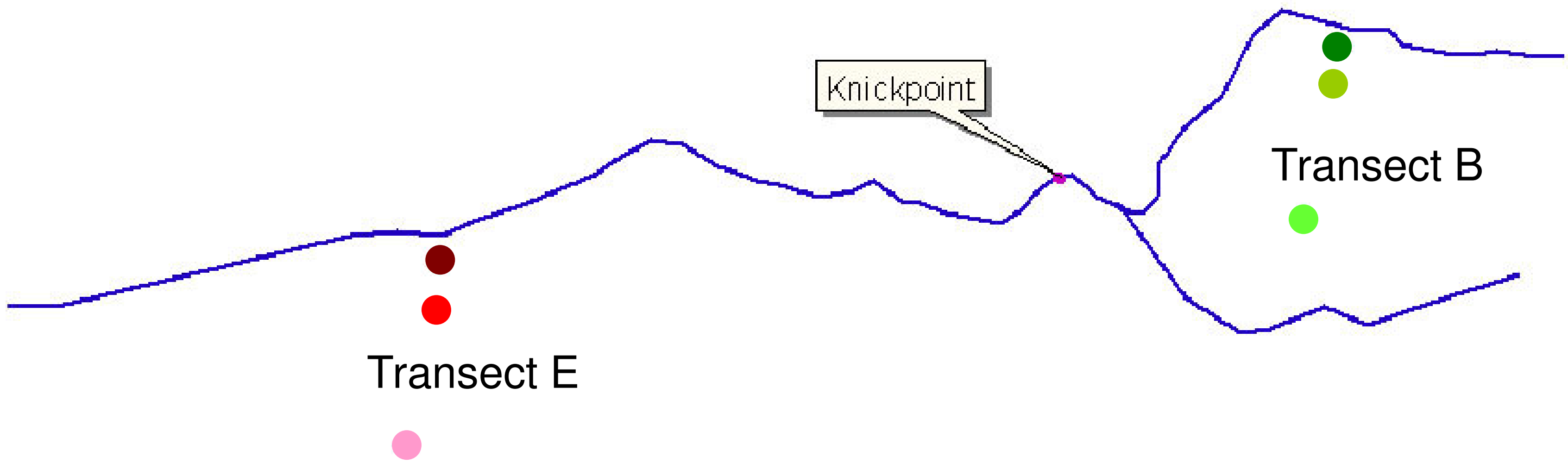

Correlation between stilling well and stream stage of transect B
y = 0.5023x - 2.8714
R2 = 0.9582
staff gauge height (cm)
stilling well height (cm)
45
40
35
30
25
20
15
10
30
40
50
60
70
80
90

Changes in flooding frequency



What happens to the water table when it storms?

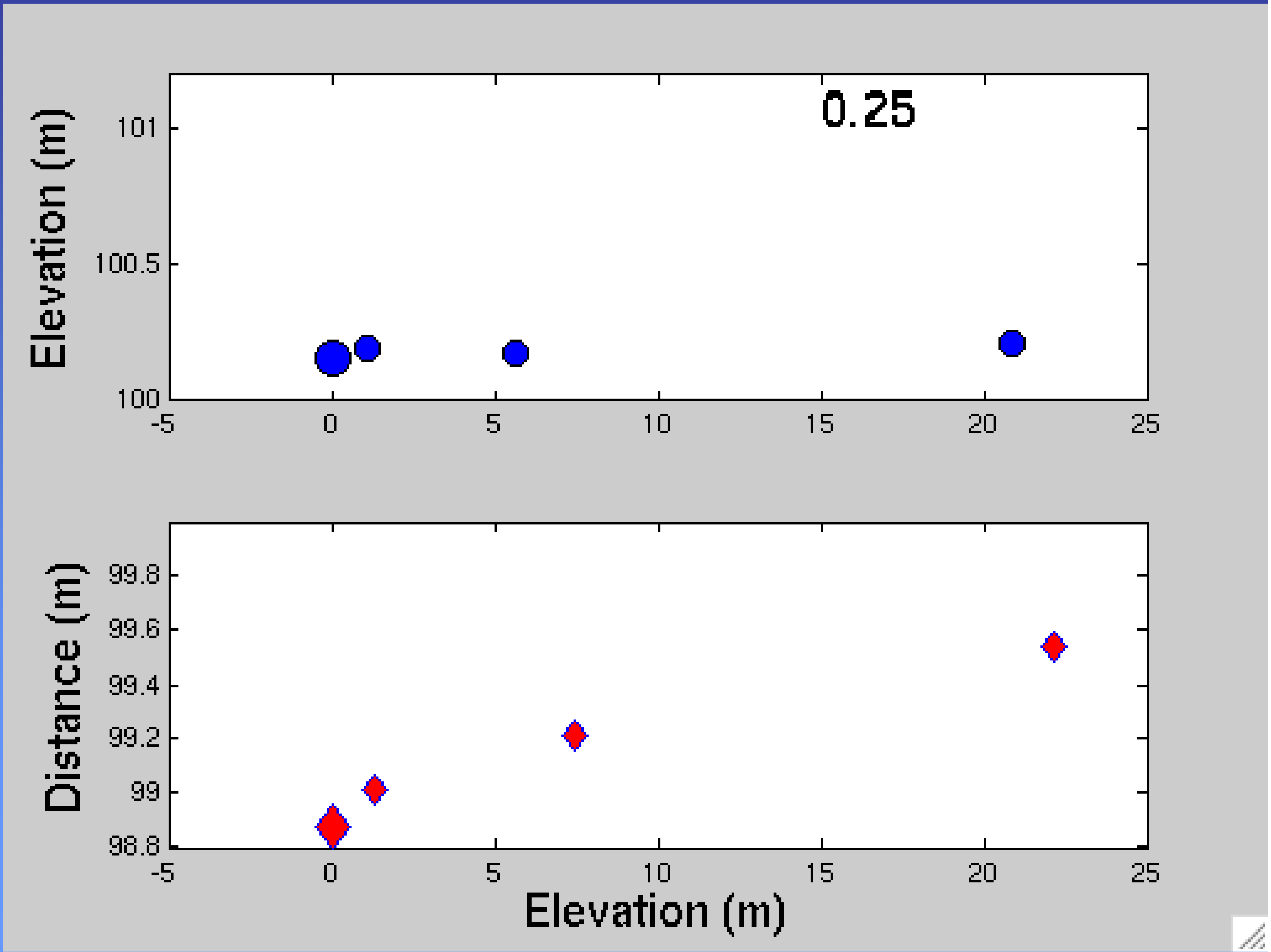
Wells with pressure transducers installed



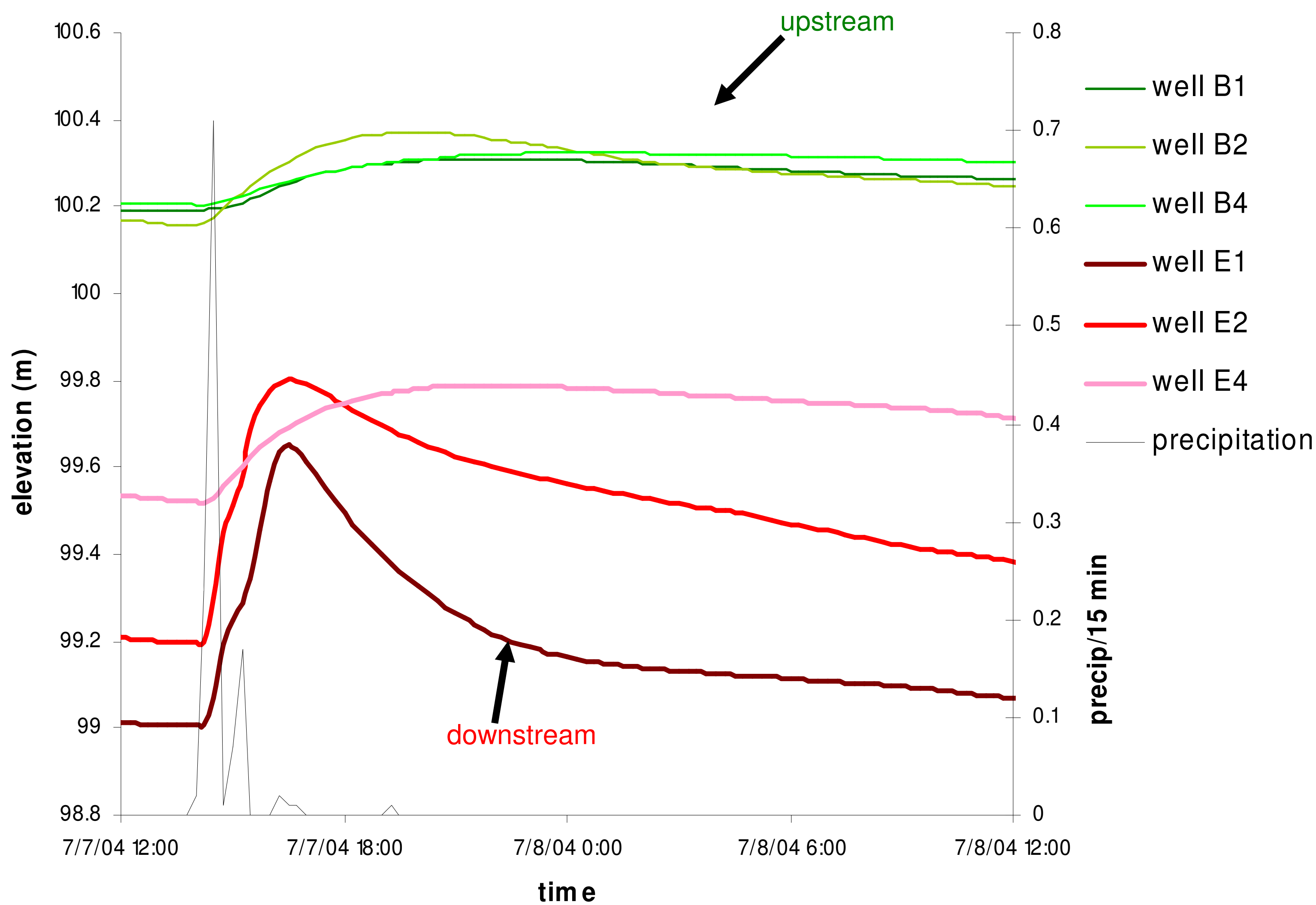
Time – precipitation occurs from hour 3 to 5

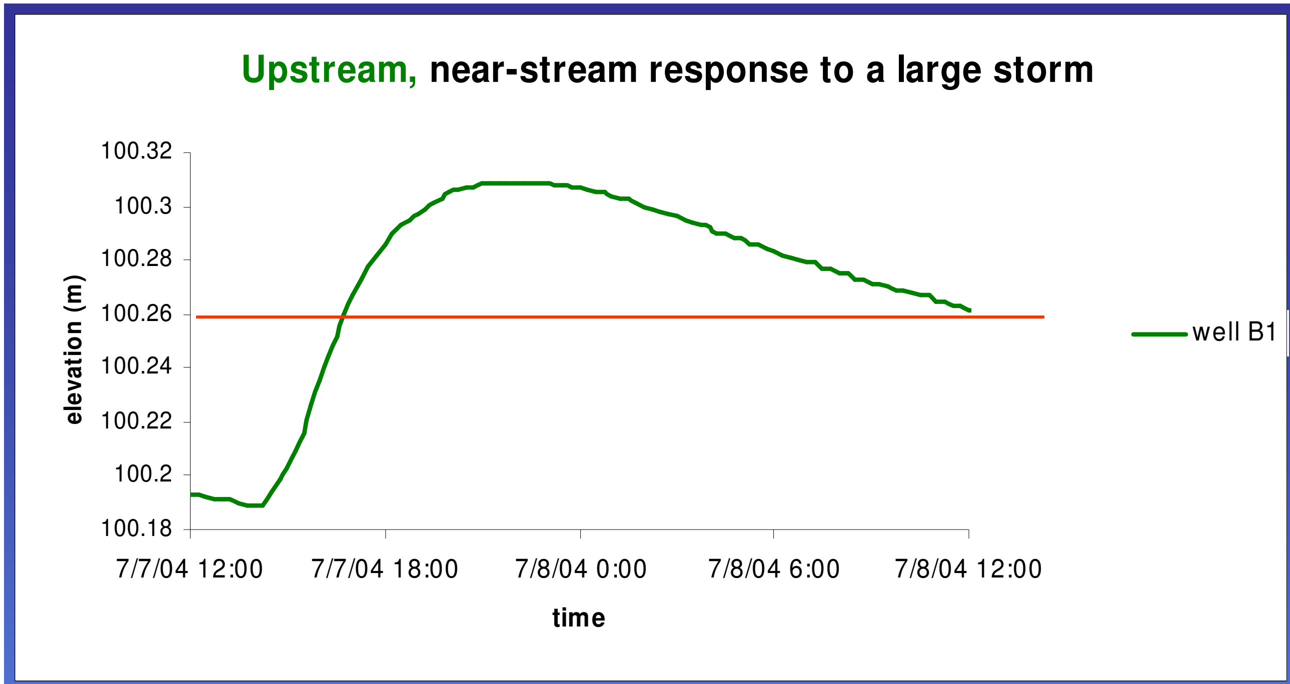
upstream

downstream

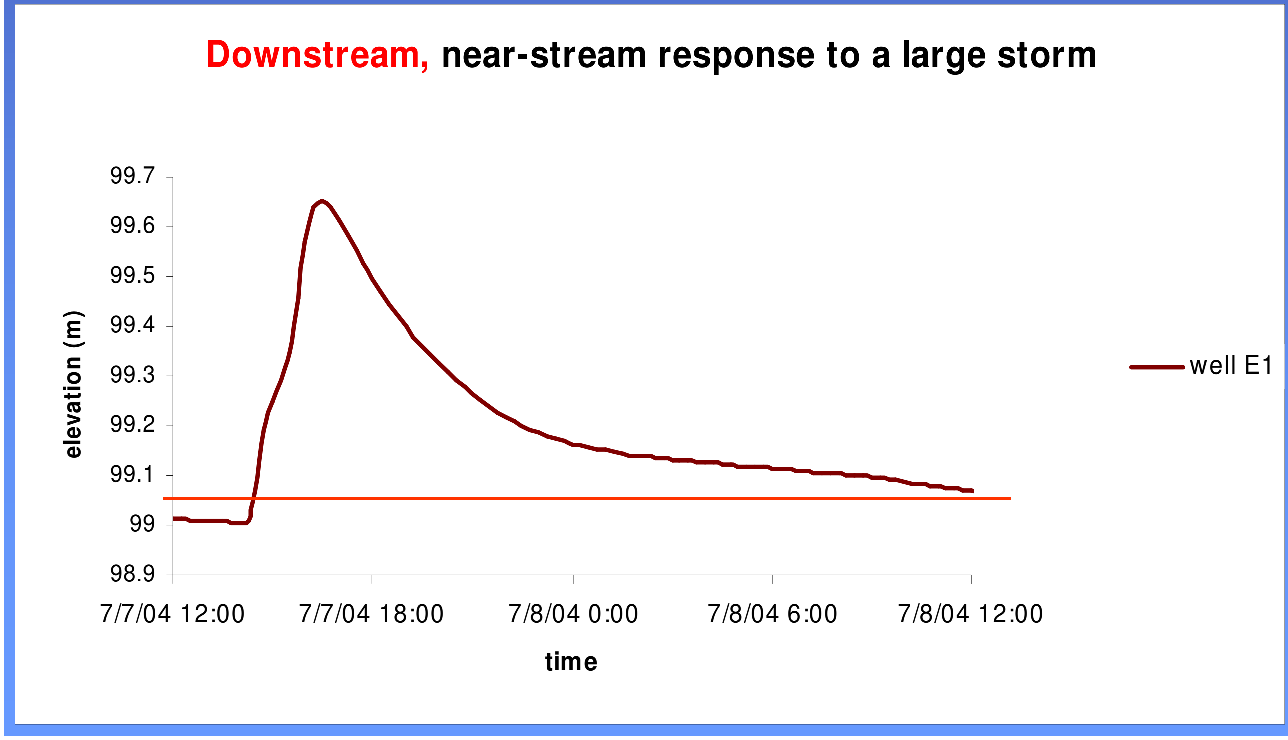


Comparative affect of a large storm on upstream and downstream water tables

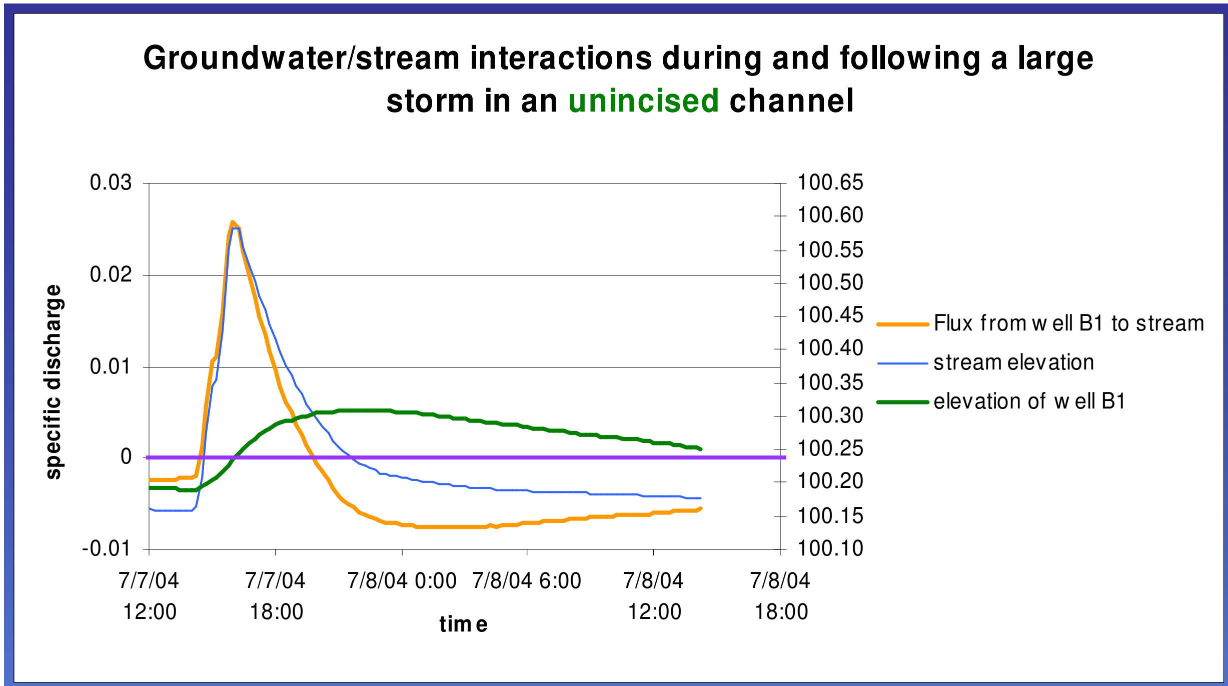


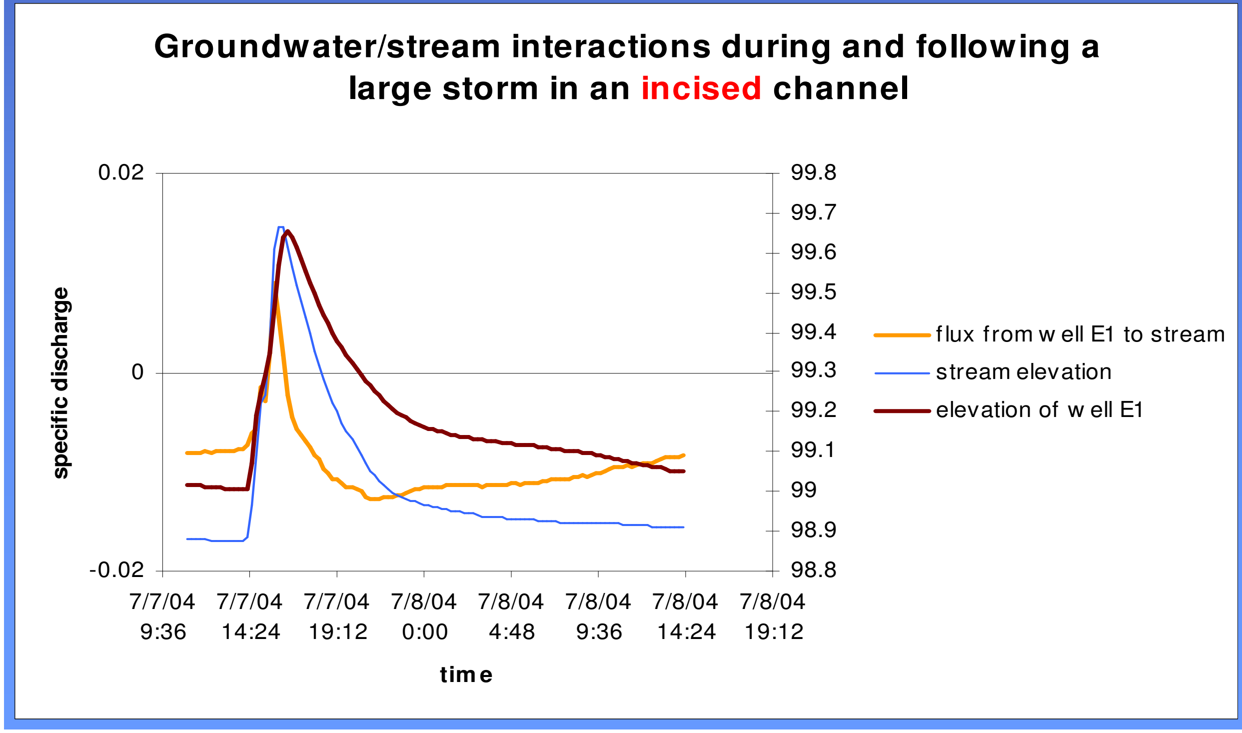


Upstream, near-stream response to a large storm
100.32
100.3
100.28
100.26
100.24
100.22
100.2
100.18
elevation (m)
7/7/04 12:00
7/7/04 18:00
7/8/04 0:00
7/8/04 6:00
7/8/04 12:00
time
well B1



Downstream, near-stream response to a large storm
99.7
99.6
99.5
99.4
99.3
99.2
99.1
99
98.9
elevation (m)
7/7/04 12:00
7/7/04 18:00
7/8/04 0:00
7/8/04 6:00
7/8/04 12:00
time
well E1





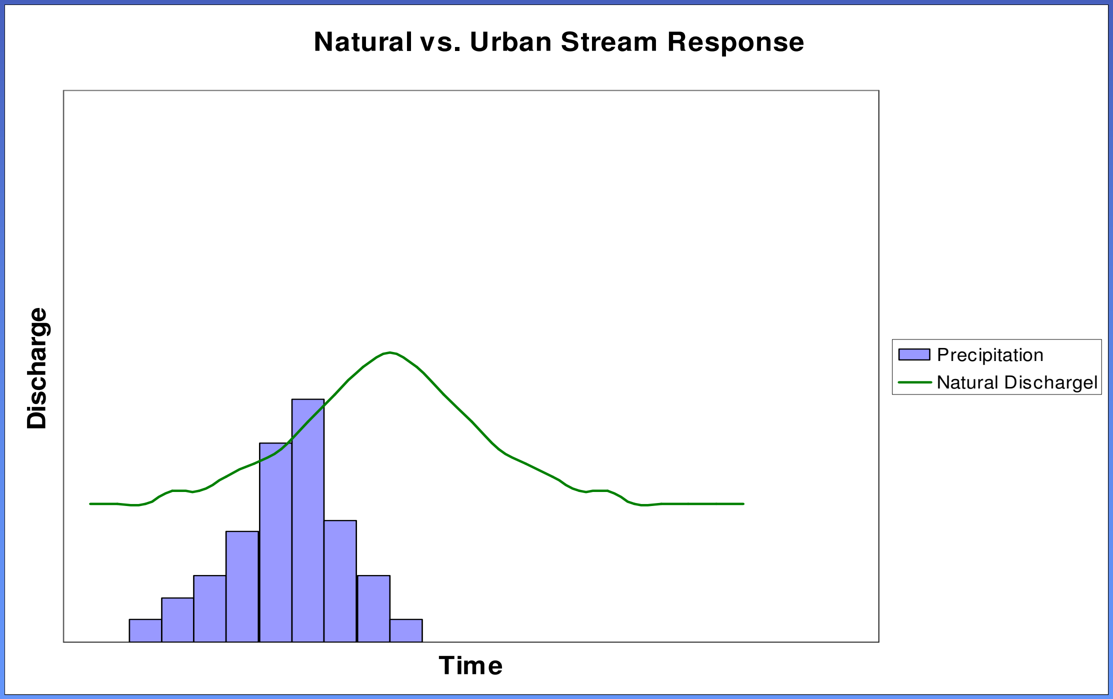
Specific discharge, based on Darcy's Law:

$q = -K\ (dh/dl)$

Channel incision contributes to exacerbating the “urban” hydrograph:

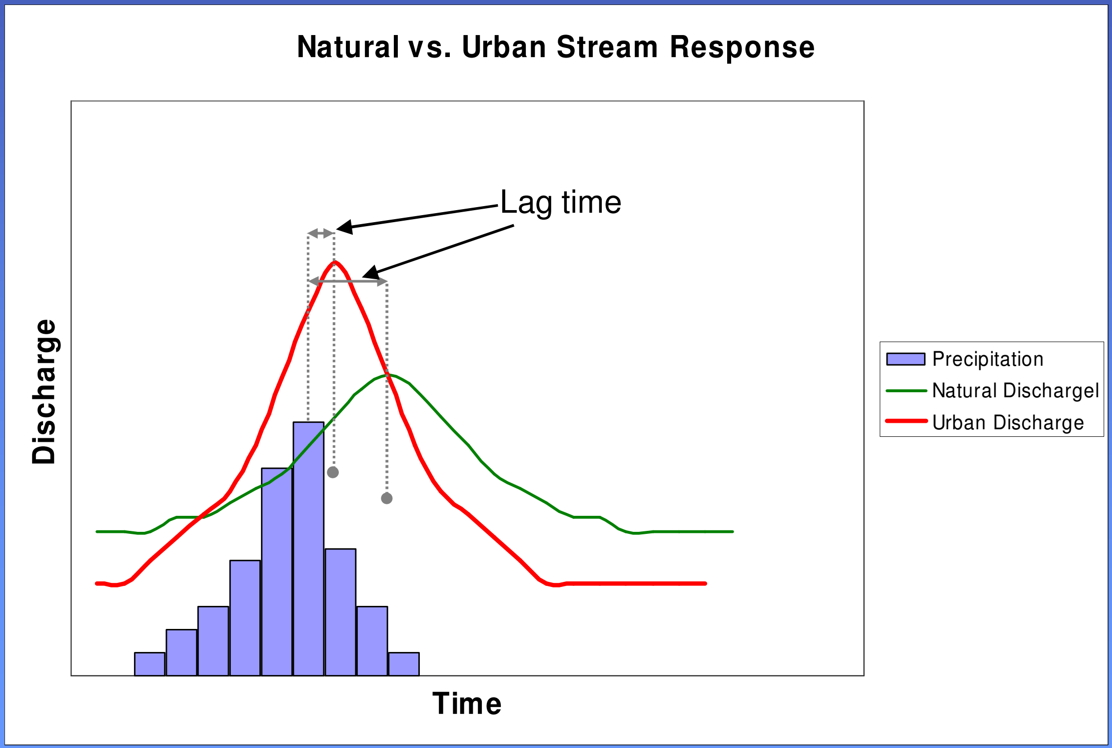
- Channel volume increases significantly
    - Storm flow contained within channel – floodplain inundation rare
- Lowered groundwater levels allow for significant storage of storm water – but this storage is only for the short term

Effects of Urbanization



Effects of Urbanization

- Increased impervious surface
  - Higher peak flow
  - Reduced lag time
  - Reduced base flow



Greater discharge often leads to channel incision

What Are The Effects Of Channel Incision?

1.) How is the riparian water table effected?
How much does it change?
At what rate?

2.) Effects on channel geometry?

3.) Changes in the floodplain/channel interaction?

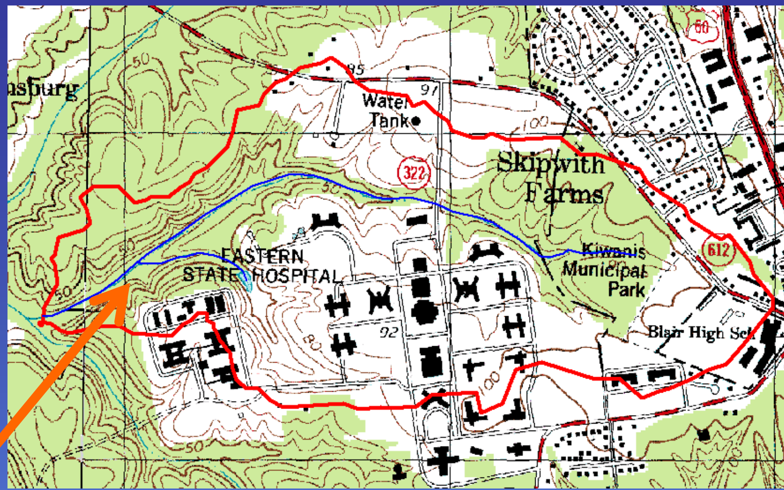
4.) Storm response?

The Watershed at Eastern State

Unincised (above the knickpoint)

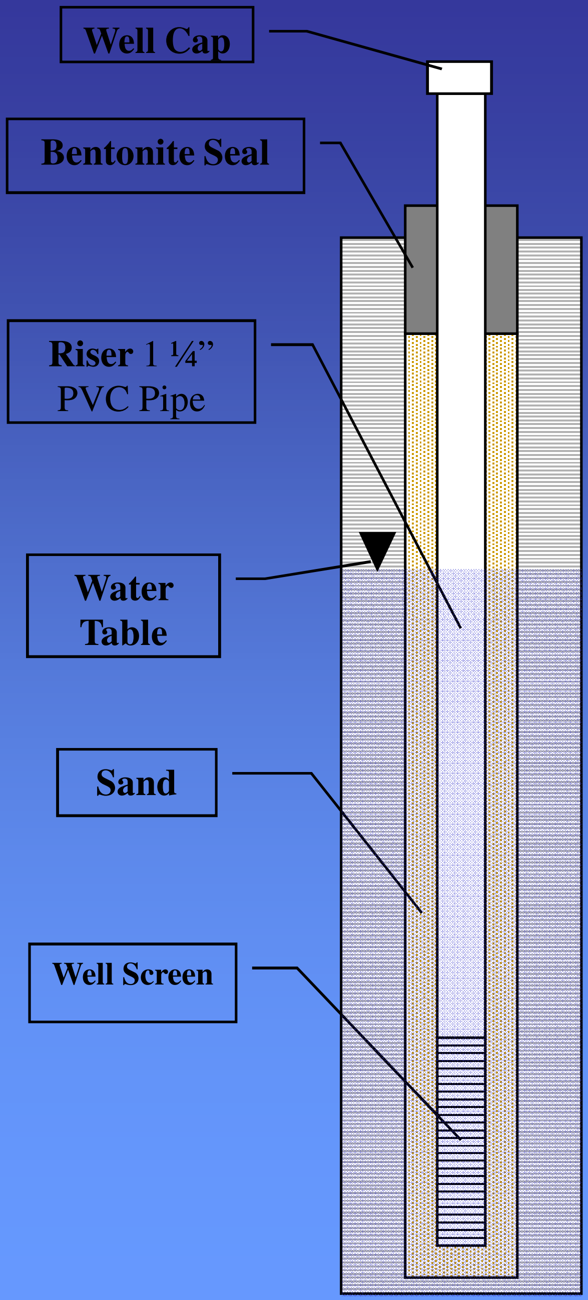
Incised (below the knickpoint)

Area of Study



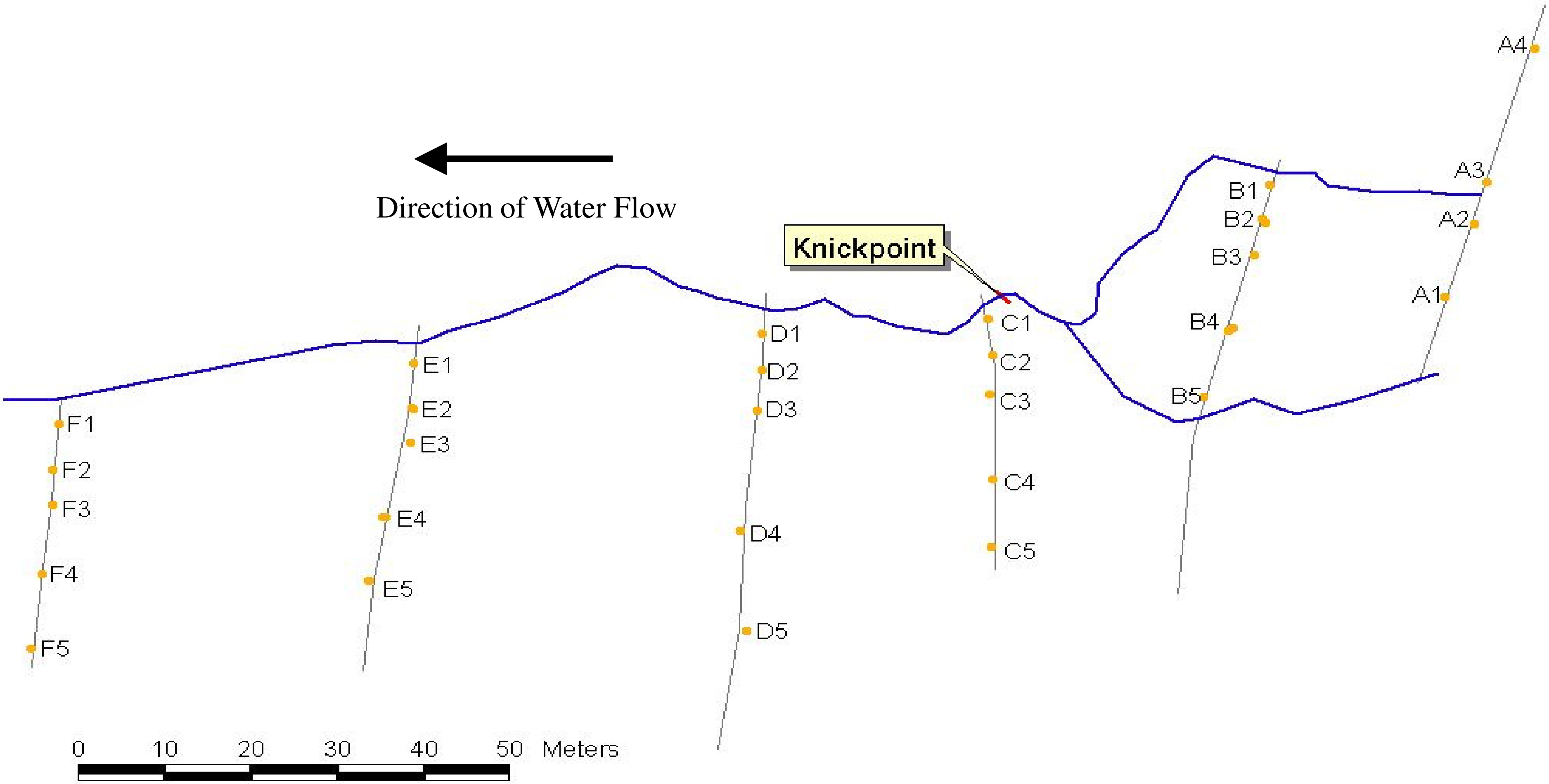
- Area = 1.5 km^2
  - •1.3 km^2 upstream of knickpoint
- ~15% impervious

Methods

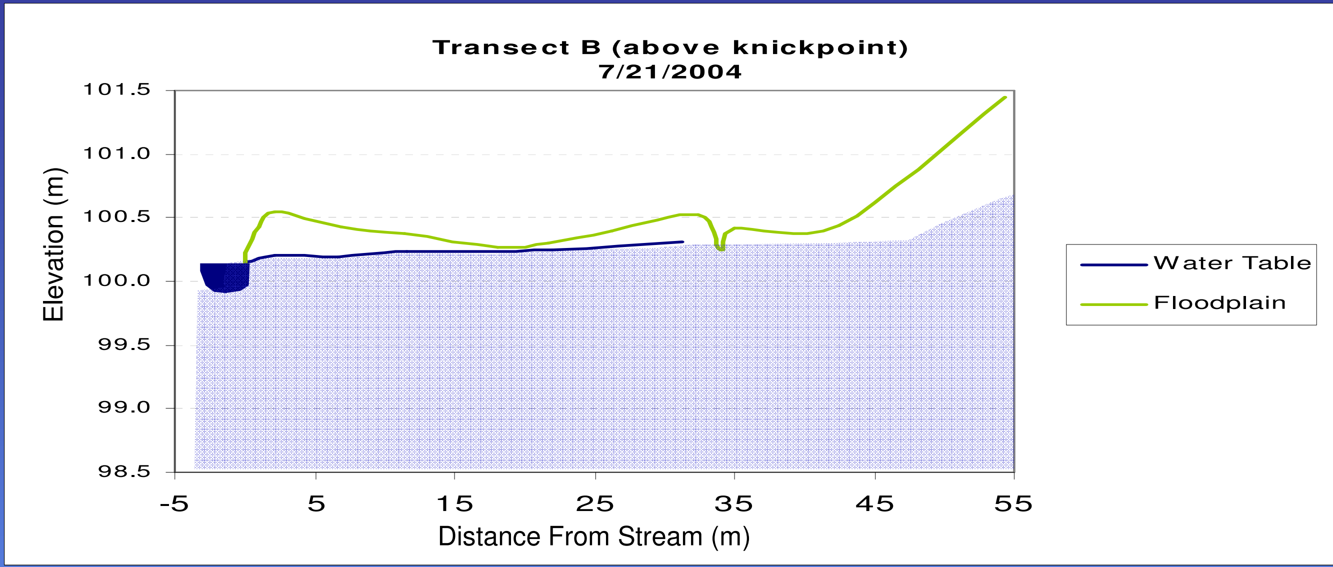


- 34 Wells installed in 6 transects
- Surveyed all wells, floodplain, and stream
- Wells measured with water level meter ~3 times a week

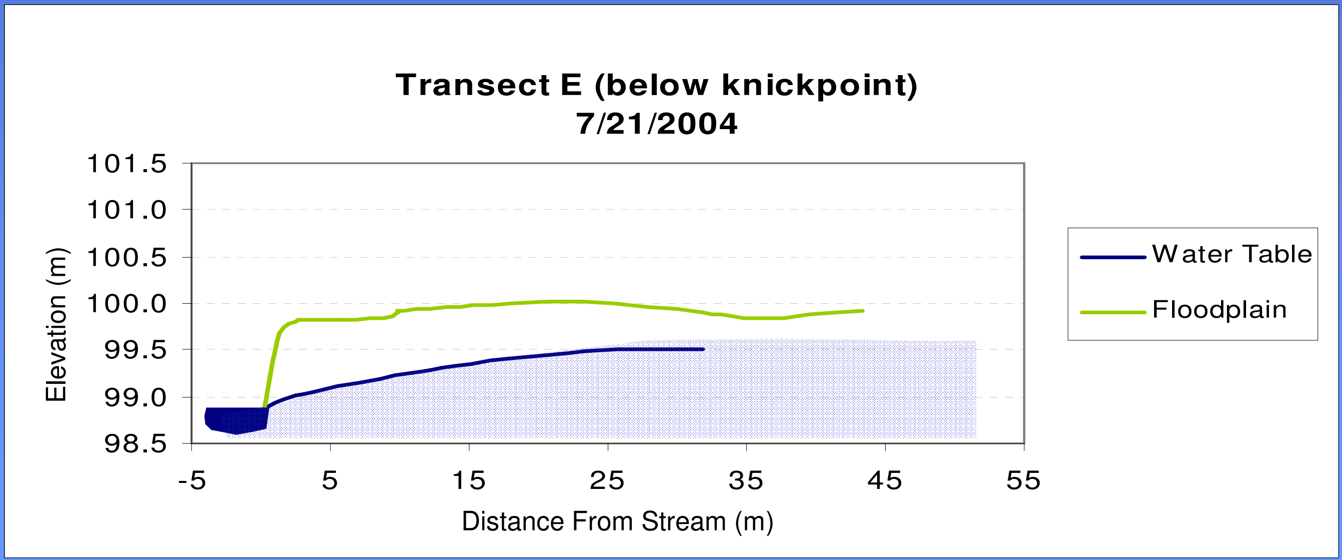
Well Field at Eastern State



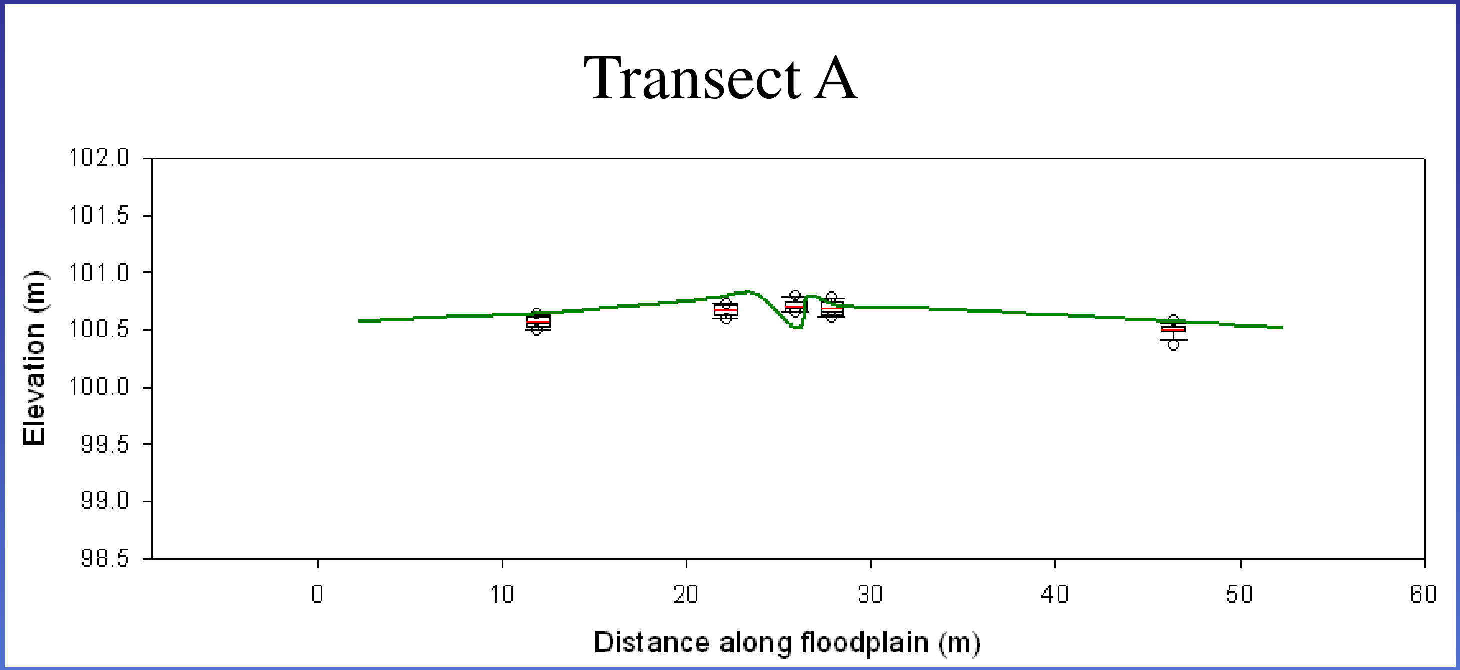
Typical Water Table Levels

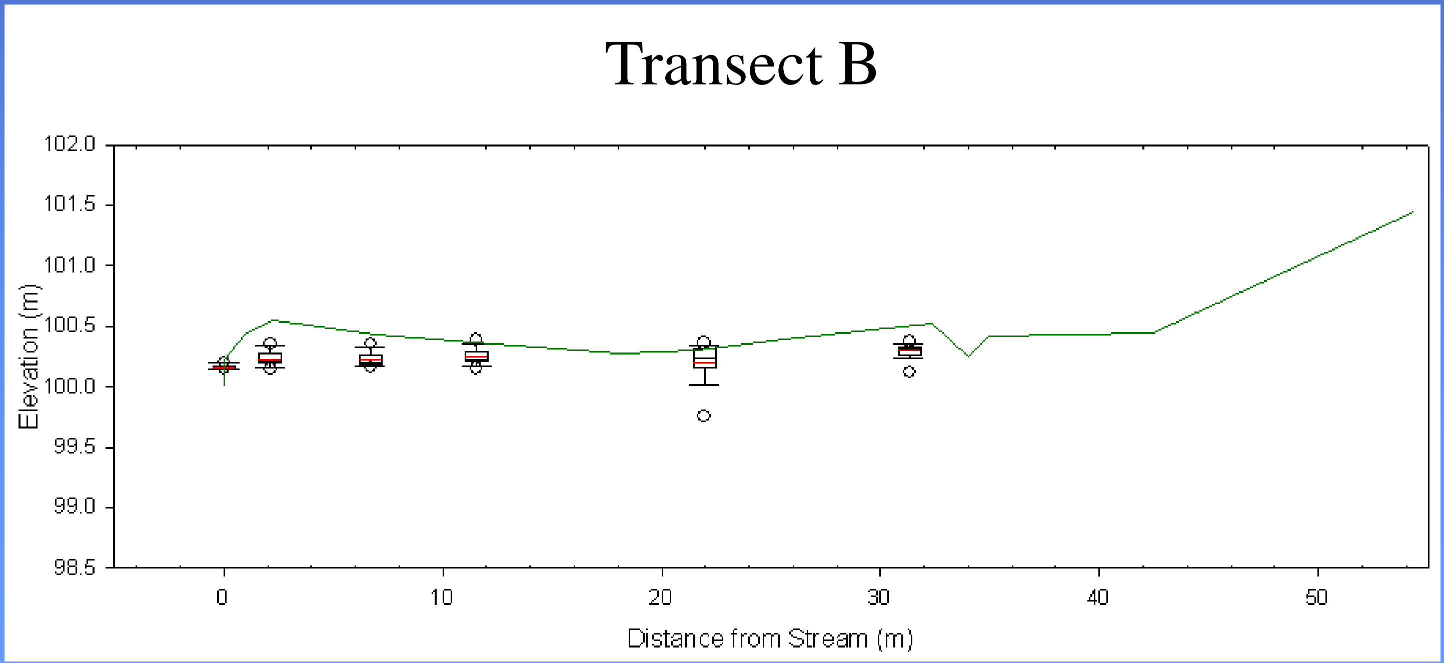


- ➢Close to surface
- ➢Low Gradient

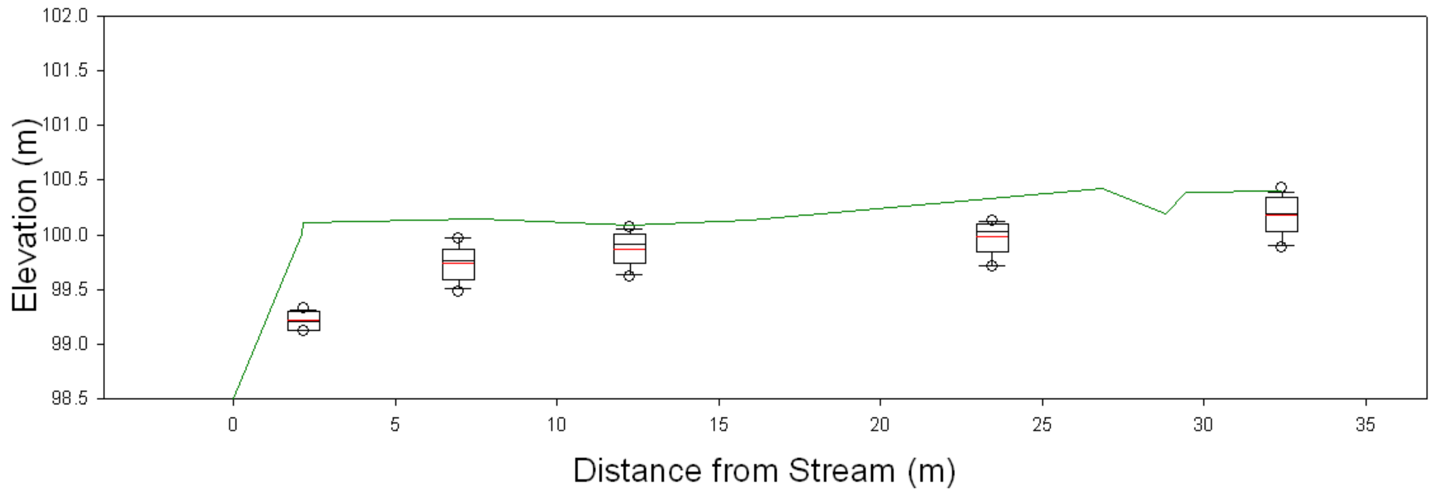


- ➢Lowered
- ➢Higher Gradient

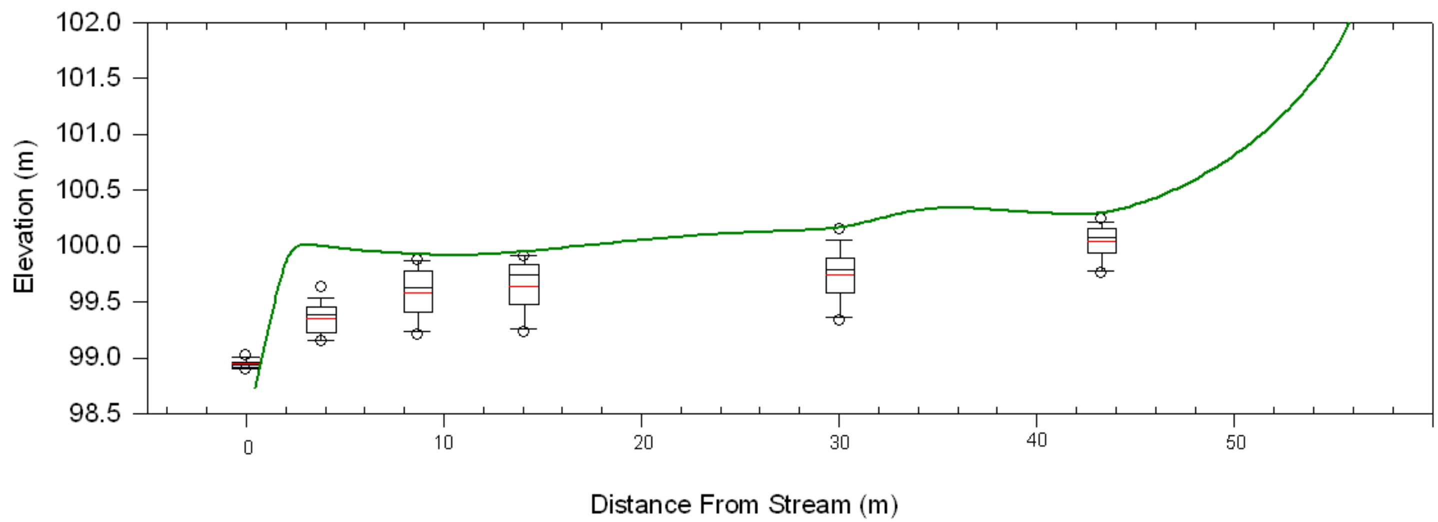

Transect A
Elevation (m)
102.0
101.5
101.0
100.5
100.0
99.5
99.0
98.5
0
10
20
30
40
50
60
Distance along floodplain (m)

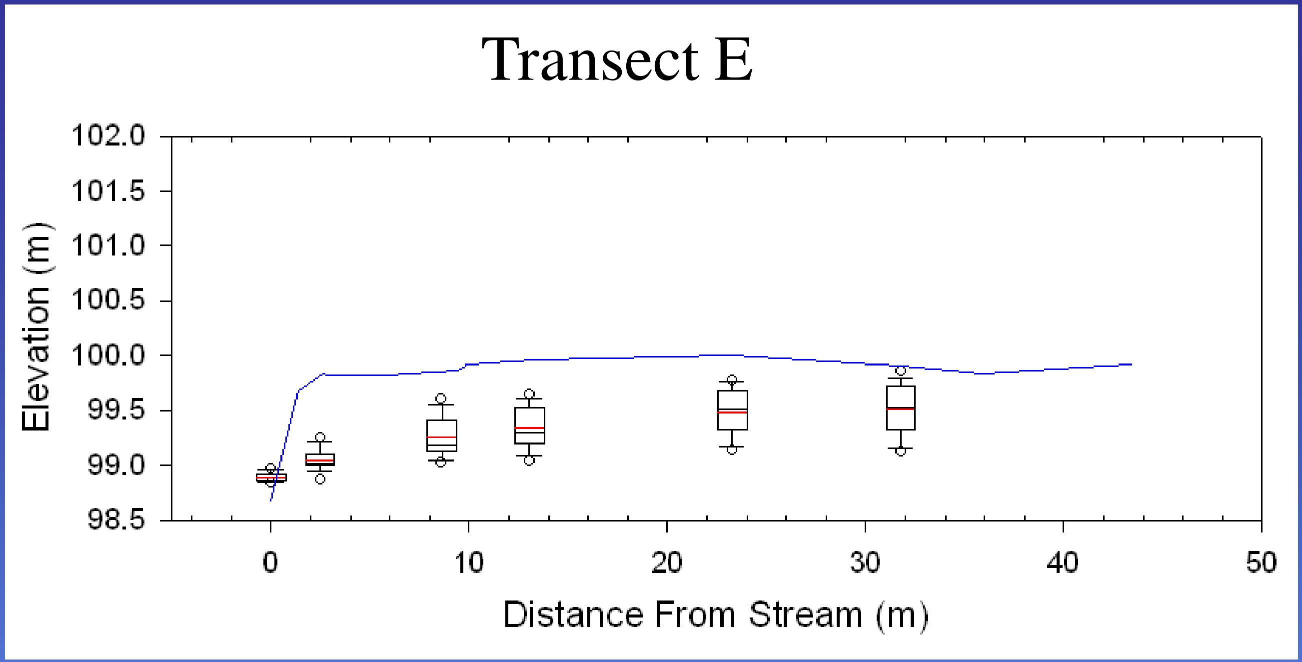

Transect B
Elevation (m)
102.0
101.5
101.0
100.5
100.0
99.5
99.0
98.5
0
10
20
30
40
50
Distance from Stream (m)

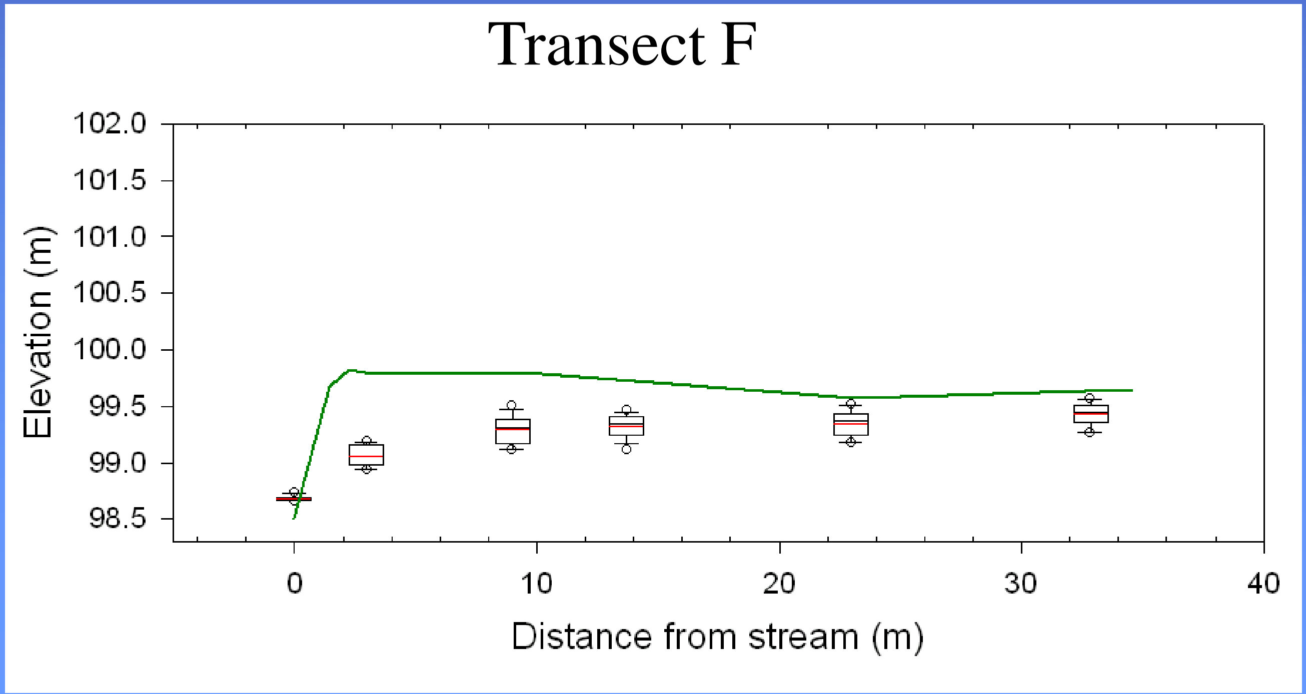
Transect C



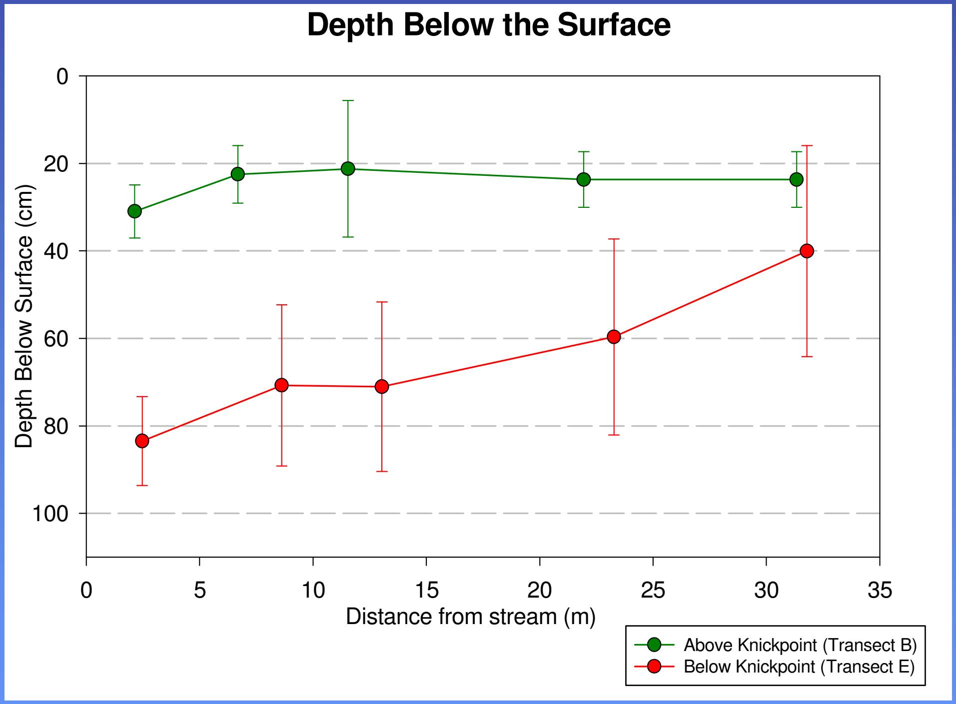
Transect D




Transect E
102.0
101.5
101.0
100.5
100.0
99.5
99.0
98.5
Elevation (m)
0
10
20
30
40
50
Distance From Stream (m)


Transect F
102.0
101.5
101.0
100.5
100.0
99.5
99.0
98.5
Elevation (m)
0
10
20
30
40
Distance from stream (m)

Summary of Measured Water Table Levels



Upstream/unincised regions show:

- Water table close to surface
- Little variance in head
- Low Gradient

Downstream/incised regions show:

- Lowered water table
- Greater variance in head
- Steeper gradient

Water table lowers near stream first then slowly propagates out

- Wells farthest from stream lowered the least

Analytical Model

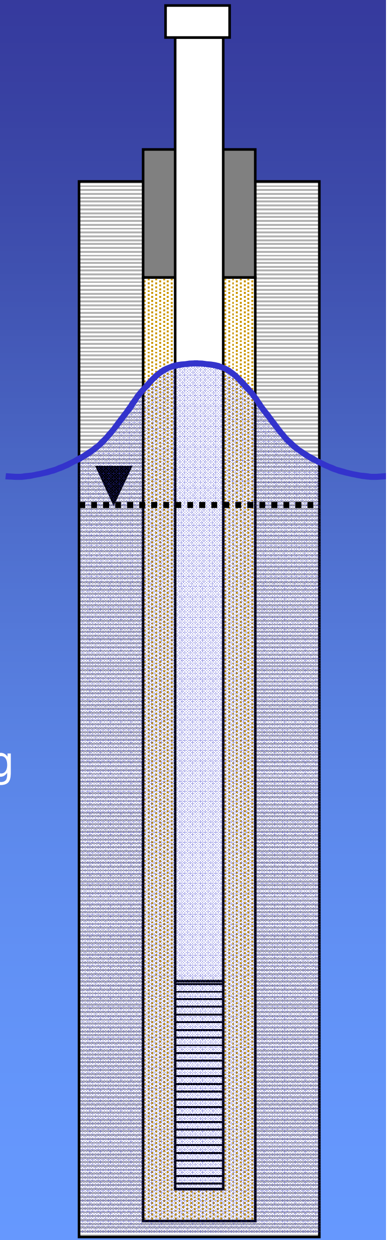
Boussinesq Equation

$$\frac{\partial^2 h}{\partial x^2} + \frac{\partial^2 h}{\partial y^2} = \frac{Sy}{Kb}\frac{\partial h}{\partial t}$$

One Dimensional

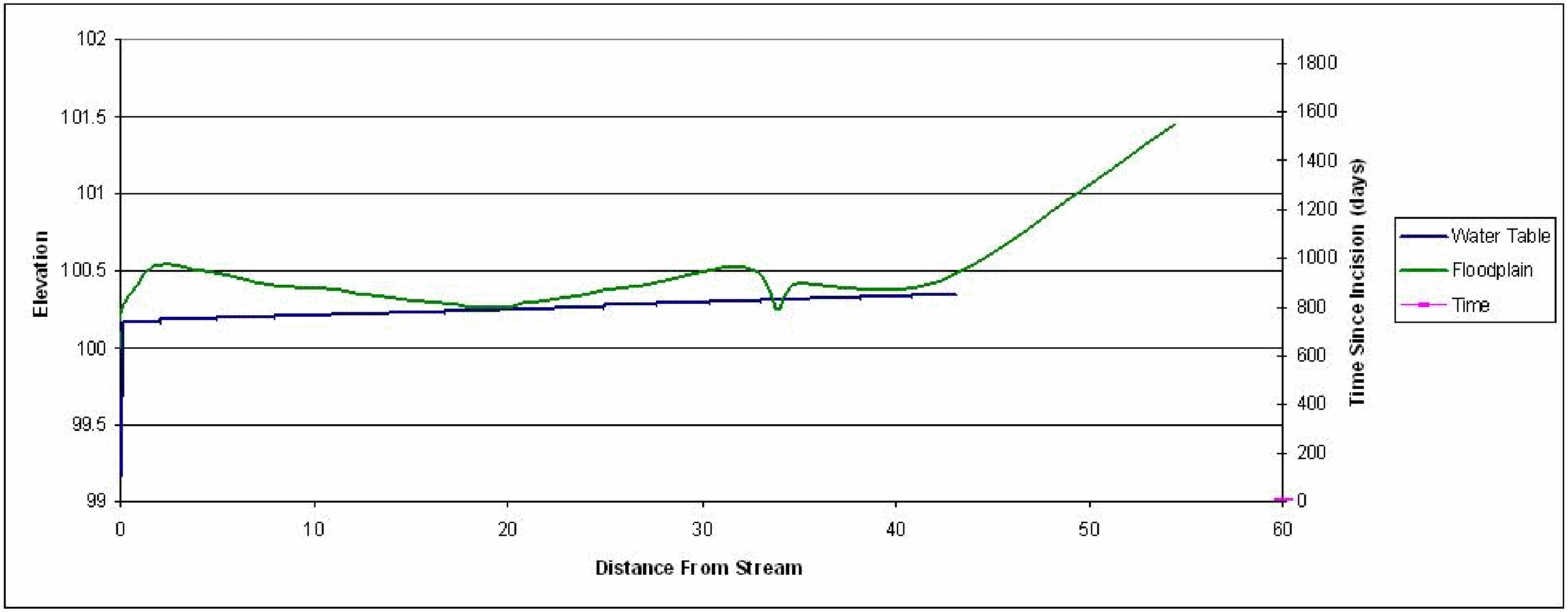
$$\left(\frac{\partial^2 h}{\partial x^2}\frac{Kb}{Sy}\right)\partial t = \partial h$$

h = head
t = time
x = distance
K = hydraulic conductivity
b = aquifer thickness
Sy = specific yield



- Hydraulic conductivity found by conducting slug tests
  - Values range from: 0.03-0.1 m/day
- Aquifer thickness estimated to be 2 meters
- Specific yield estimated to range from .10-.18

Model Results

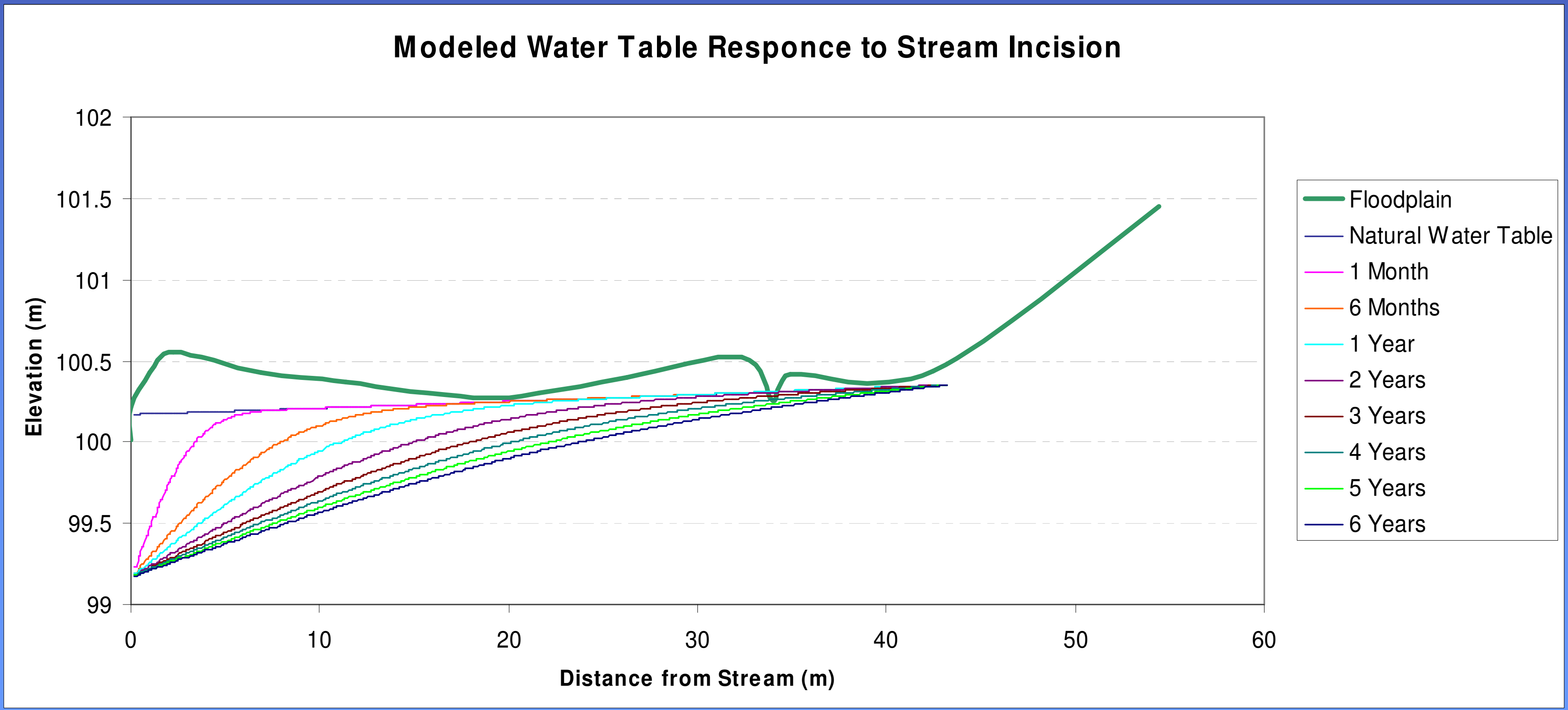


K = 0.08 m/day
Sy = 0.15
b = 2m

Original Water Table based off of transect B

Summary of Model

- Quick Response near the stream
- As gradient is reduced lowering of the water table is slowed
- Areas further from stream have a minimal and delayed response



Conclusions

- Channel incision lowers the riparian water table, and increases variance.

- This lowering is most dramatic near the stream and propagates inland through time as the gradient is reduced.

Further Work

- Continue to monitor wells
- Calibrate model to more accurately simulate real conditions
- Use model to predict future changes and to understand what conditions were like in the past