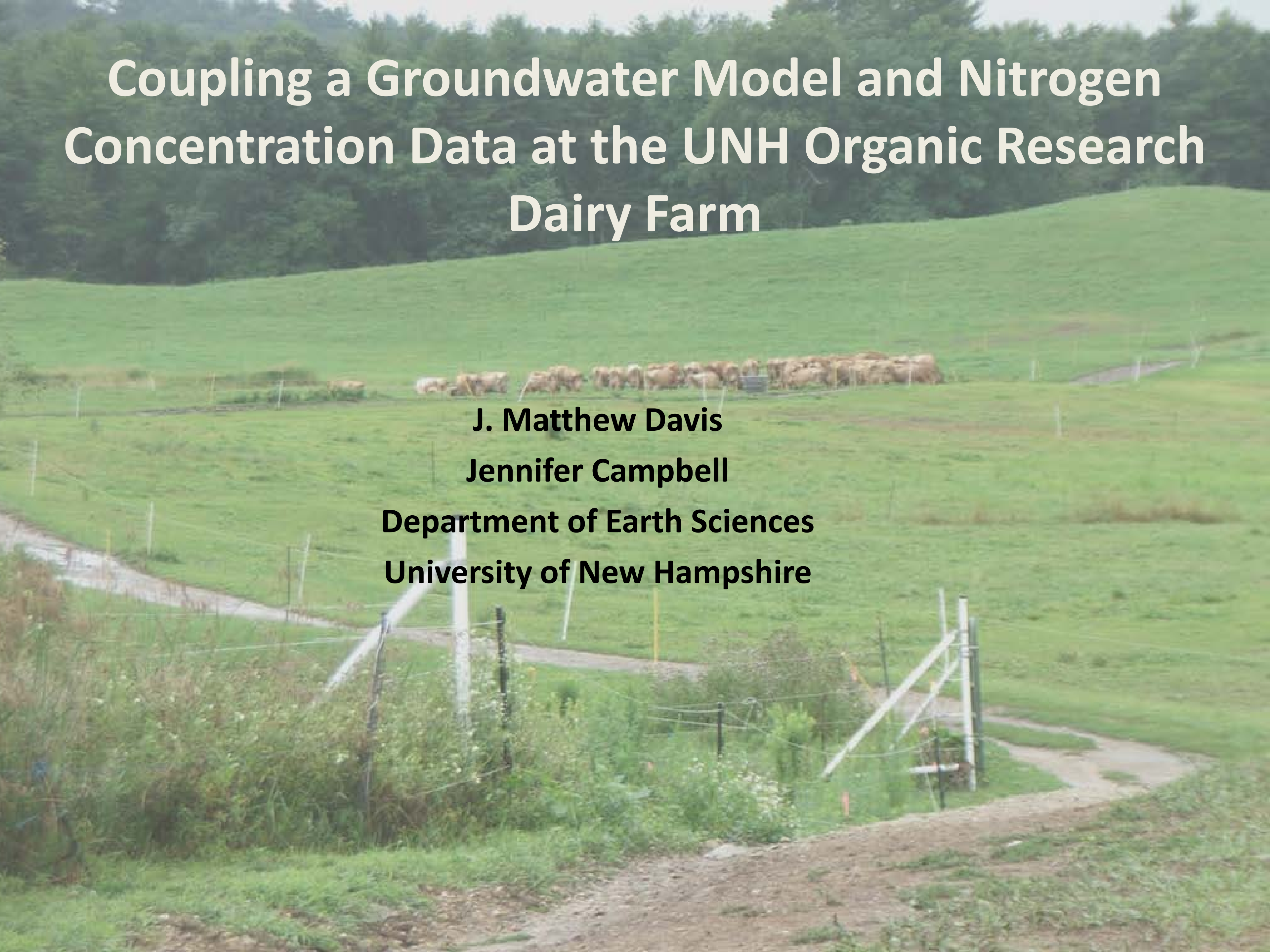


Coupling a Groundwater Model and Nitrogen Concentration Data at the UNH Organic Research Dairy Farm

J. Matthew Davis
Jennifer Campbell
Department of Earth Sciences
University of New Hampshire

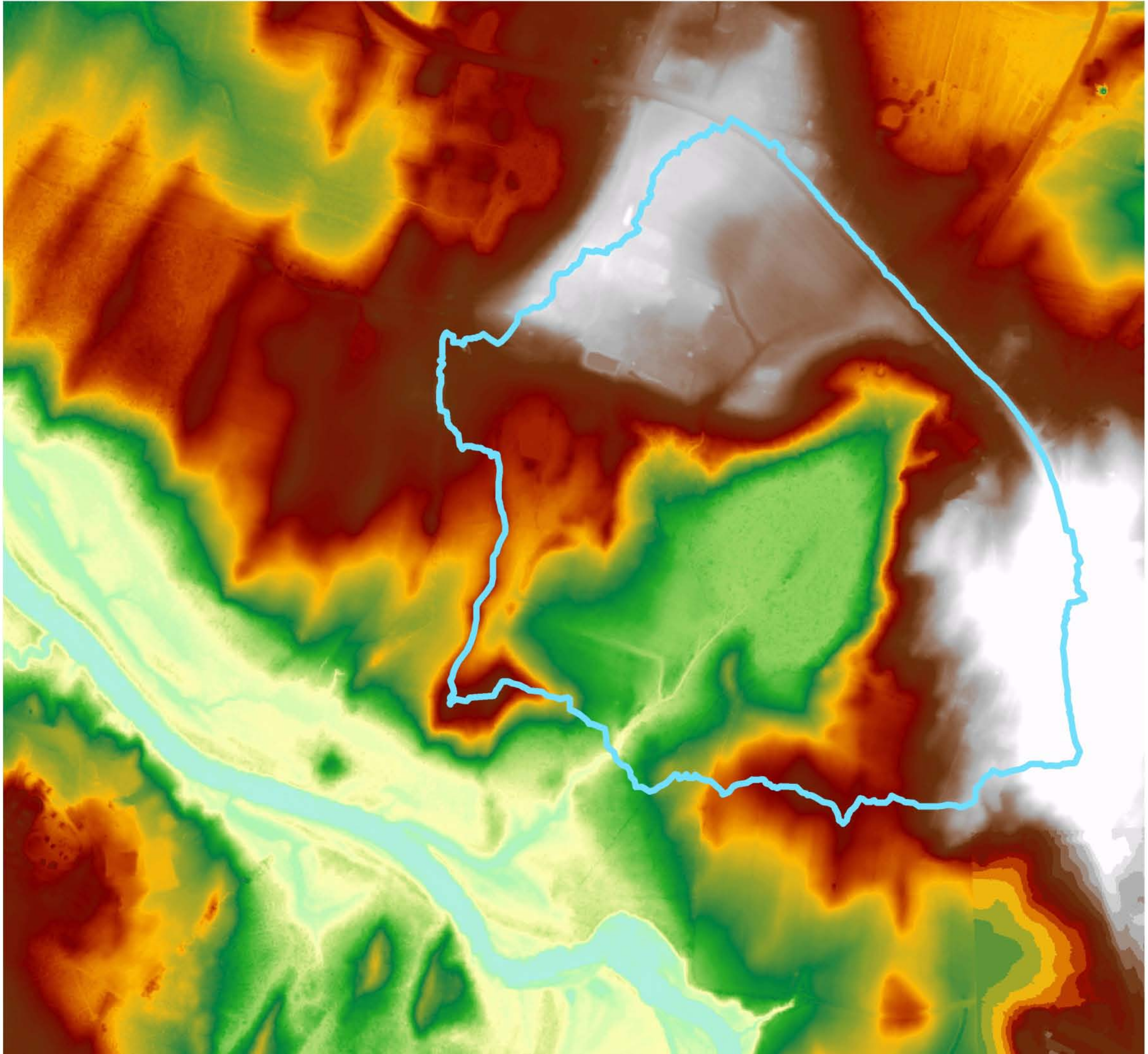
USDA Sustainable Agriculture Research and Education (SARE)

PIs: John Aber, Bill McDowell, Matt Davis

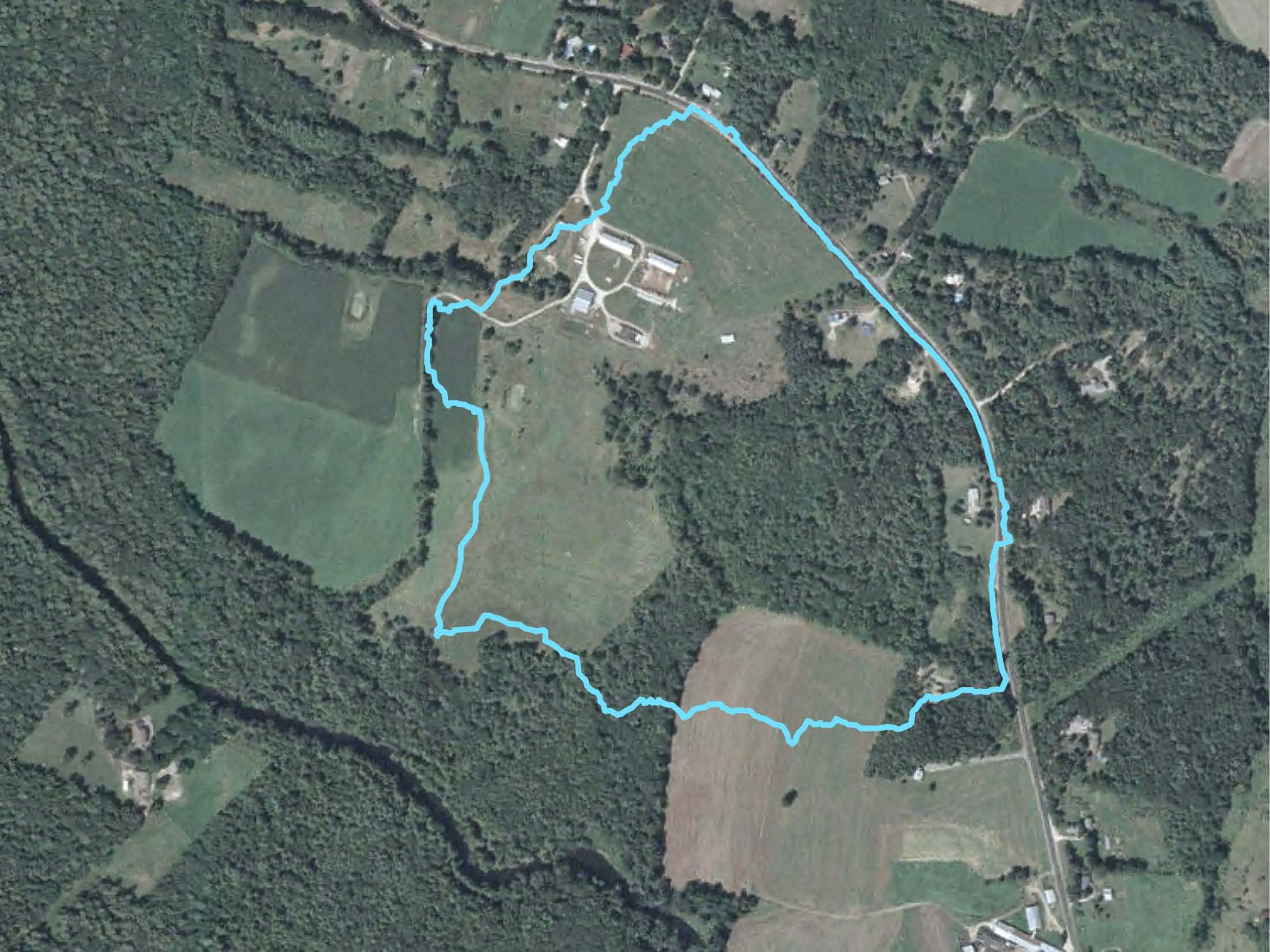
Location: UNH Organic Research Dairy Farm in Lee, NH

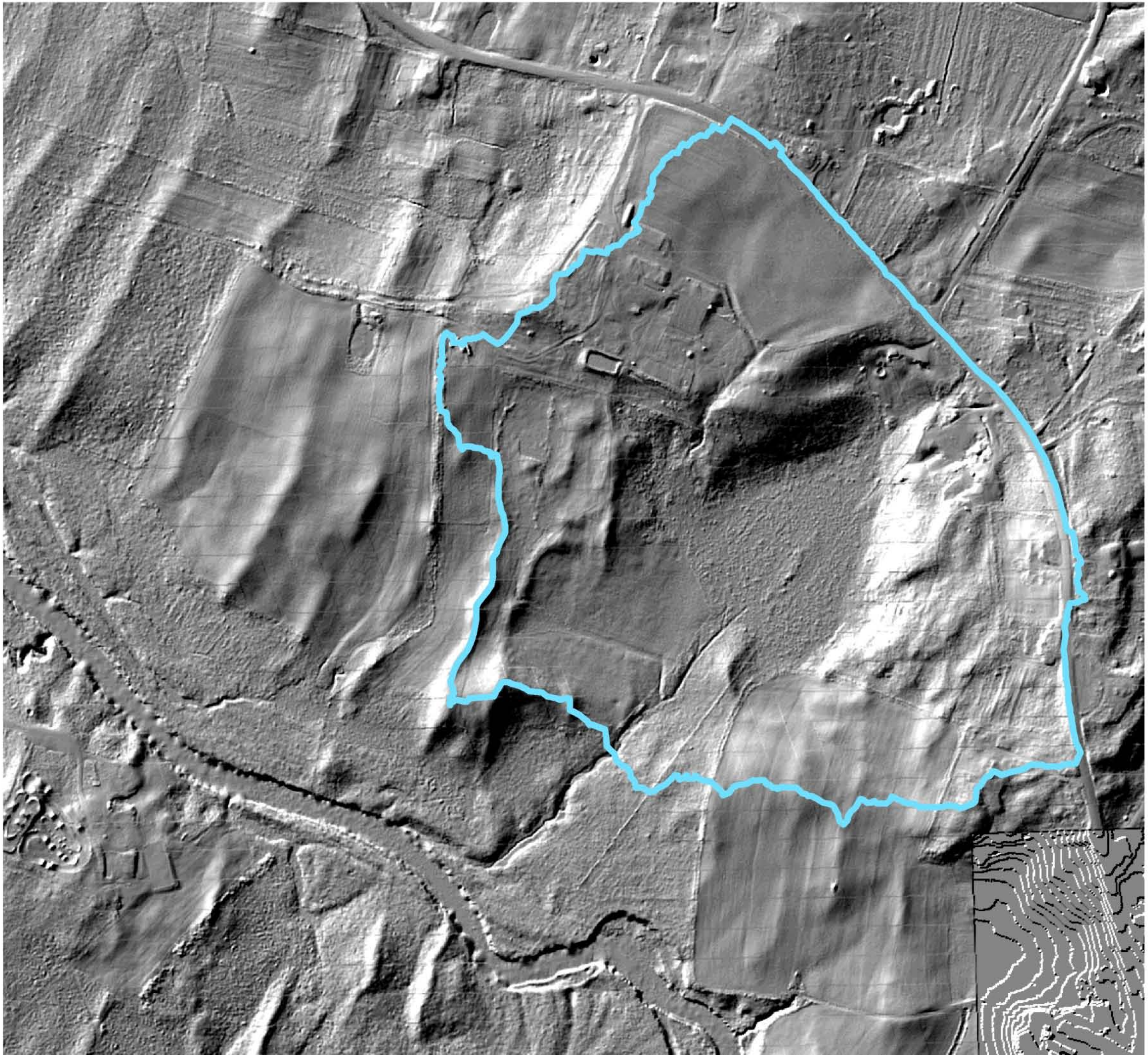
Project Objective: First phase is to measure all material and energy flows across the farm

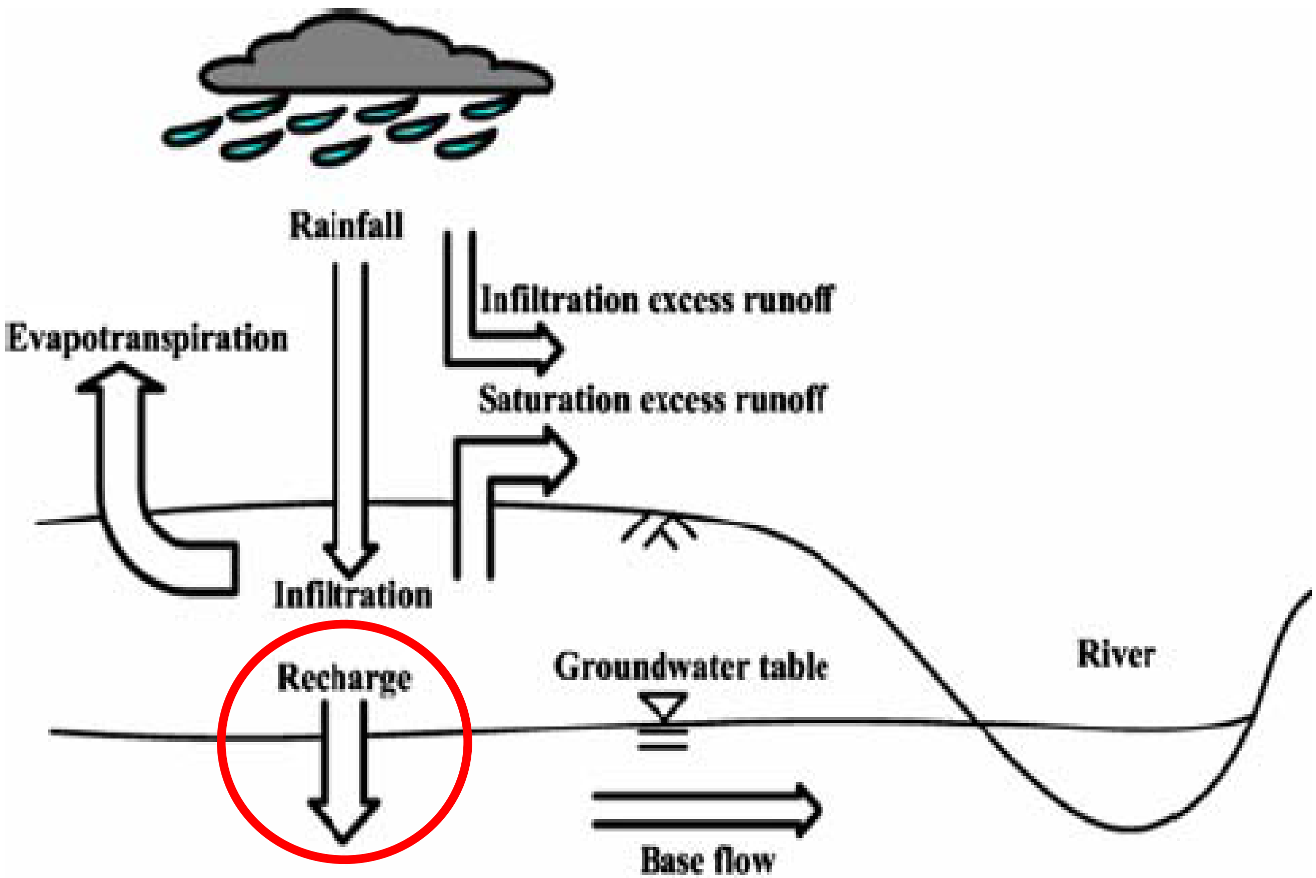
Our Part: Characterize the hydrology (water budget / groundwater model)



LiDAR data: National Center for Airborne Laser Mapping (NCALM)

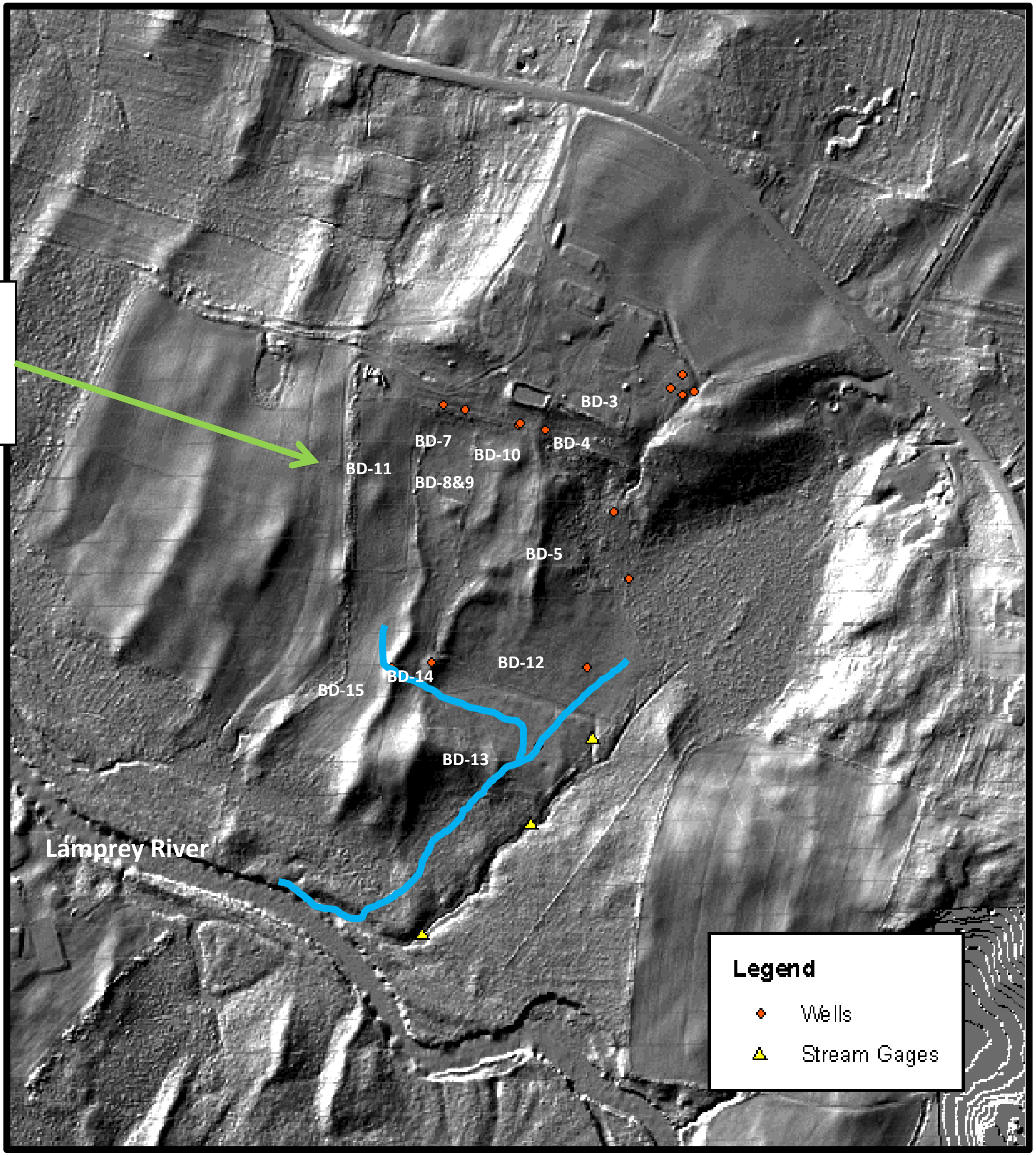




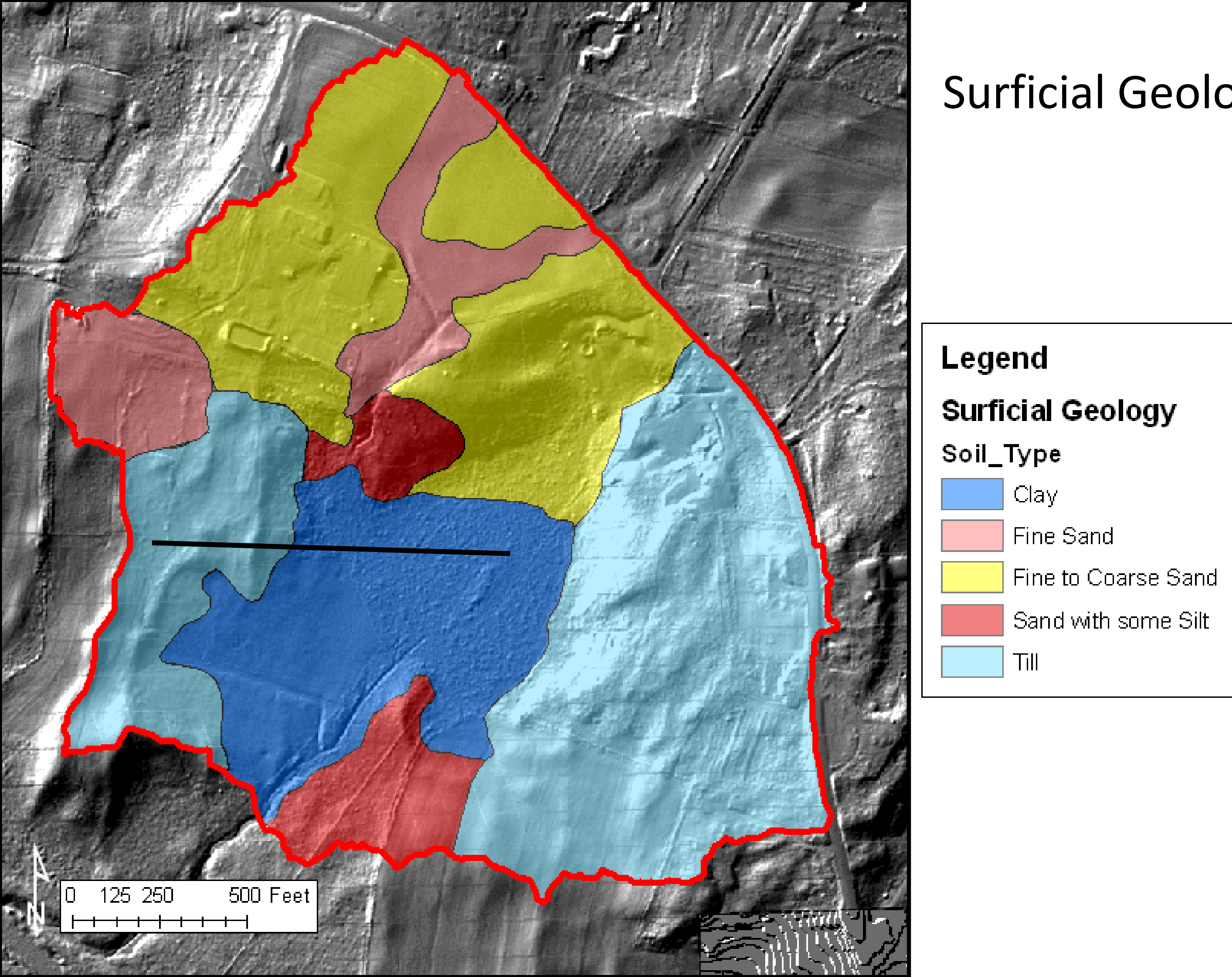

Rainfall
Infiltration excess runoff
Evapotranspiration
Saturation excess runoff
Infiltration
Recharge
Groundwater table
River
Base flow

Hydrologic Monitoring

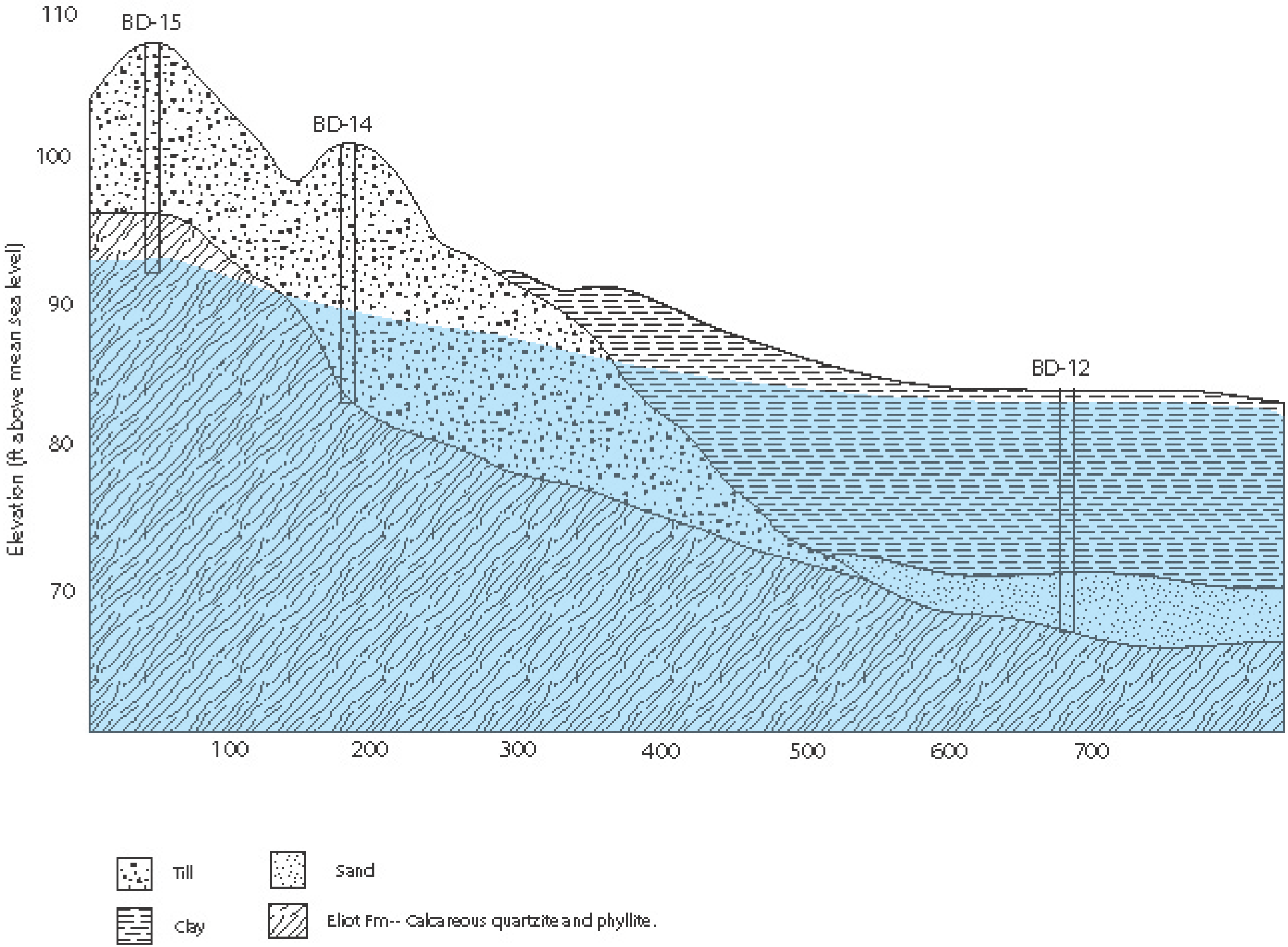
Records hydraulic head measurements every hour



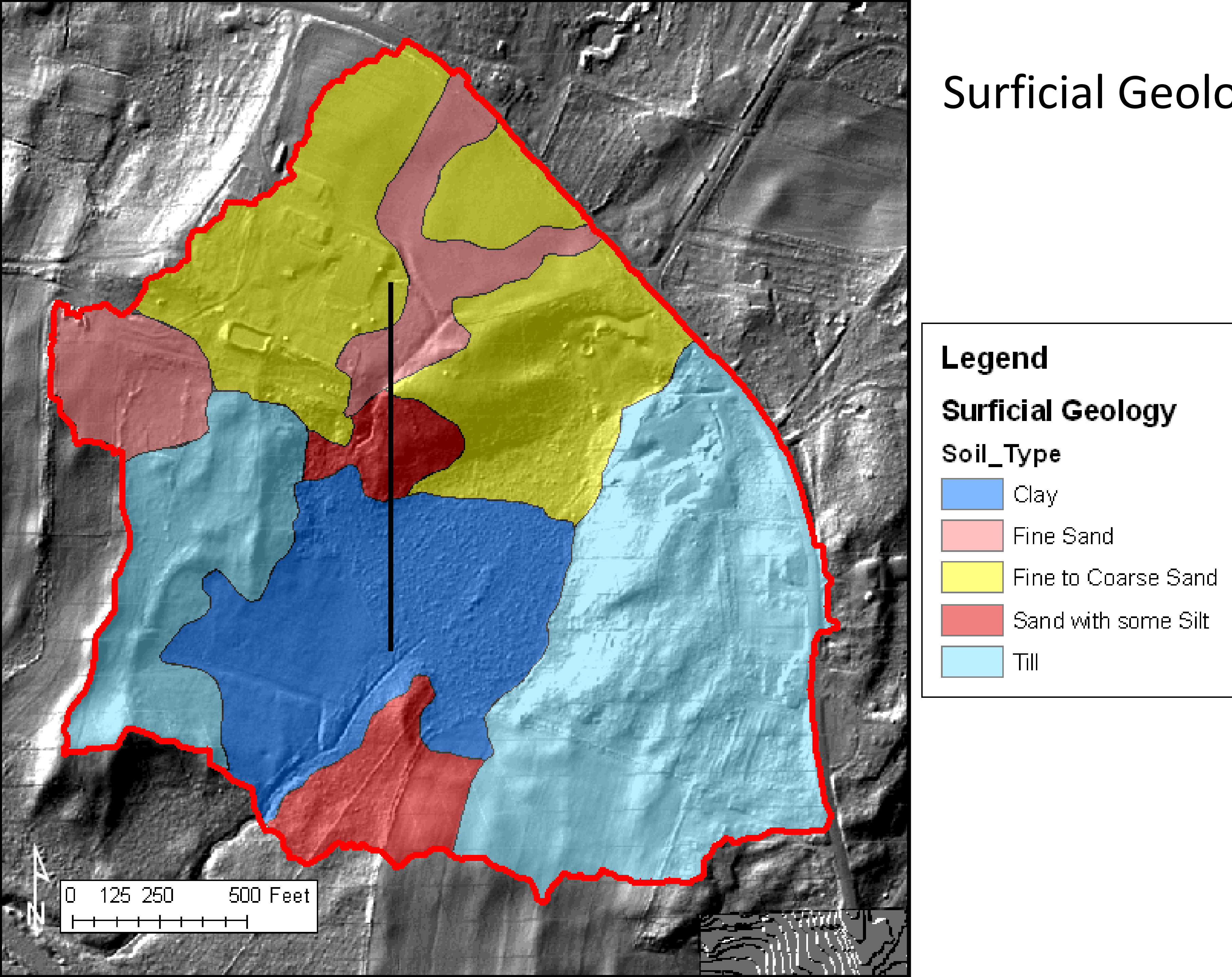
Surficial Geology



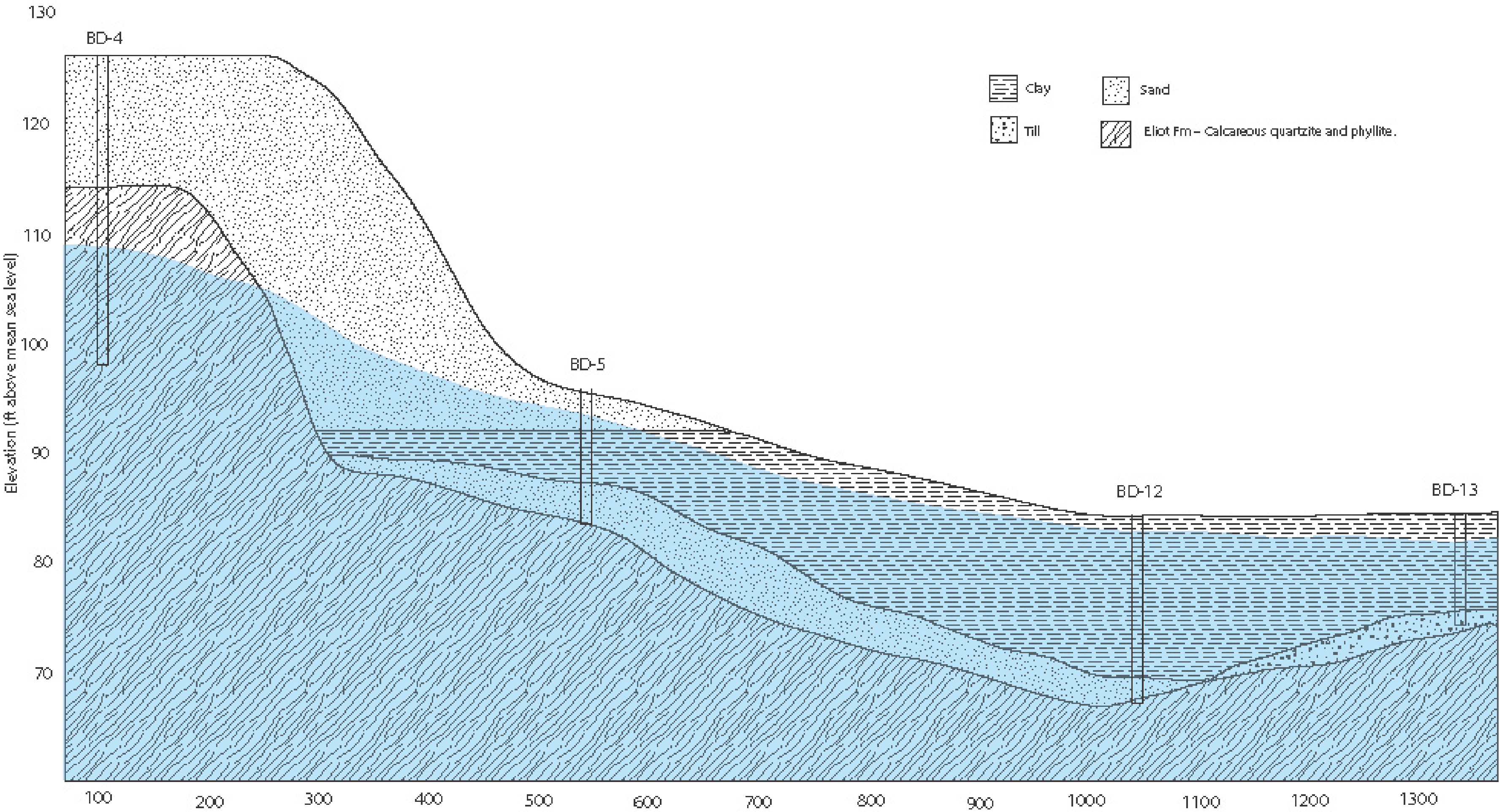
West to East Cross-sectional View of the Back Field at the Burley-Demerrit Farm

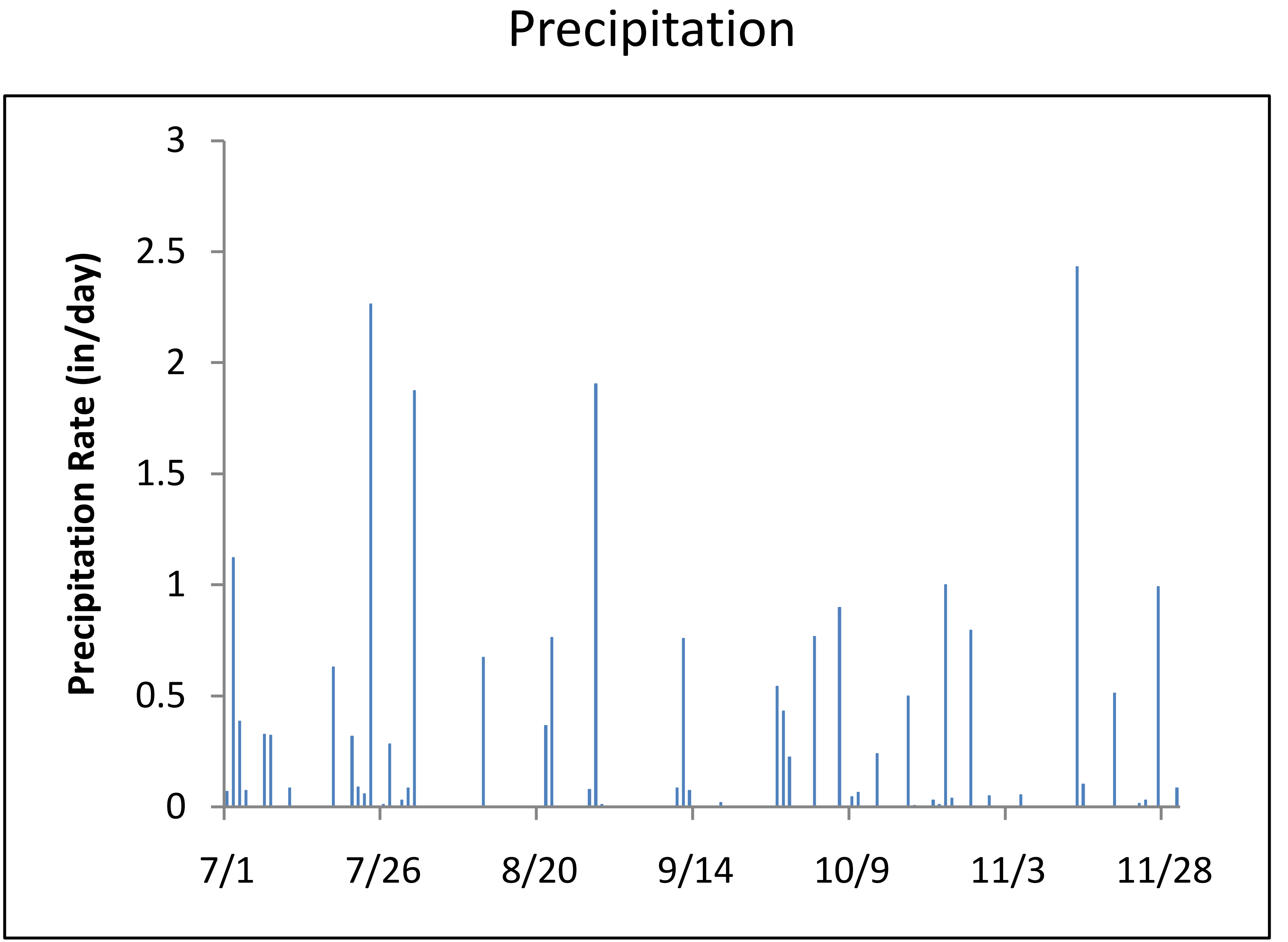


Surficial Geology



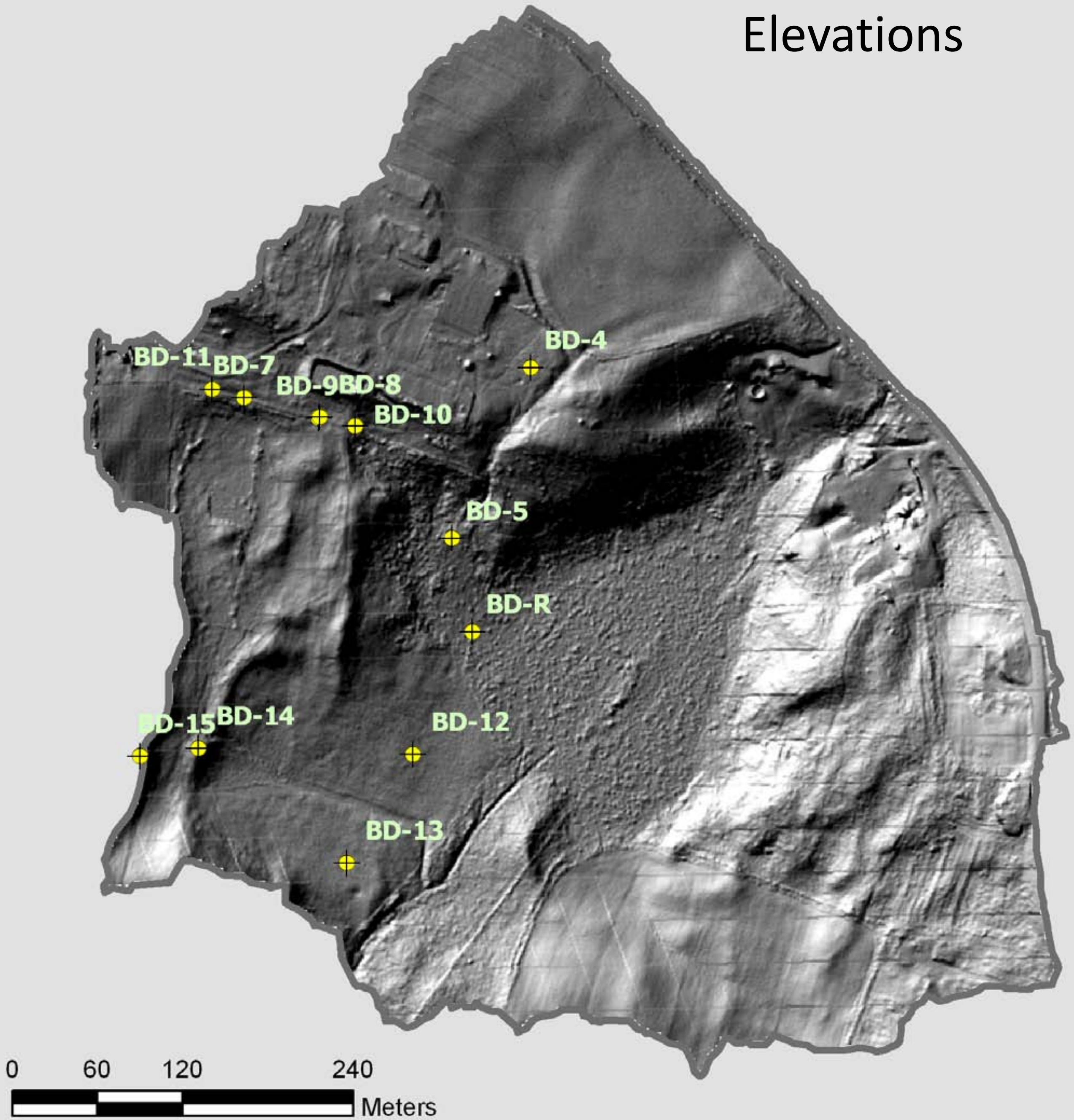
North-South Cross-sectional View at the Burley-Demerrit Farm



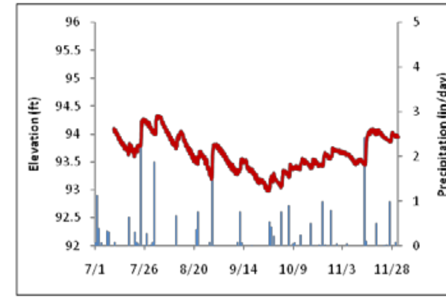


Precipitation
Precipitation Rate (in/day)
3
2.5
2
1.5
1
0.5
0
7/1
7/26
8/20
9/14
10/9
11/3
11/28

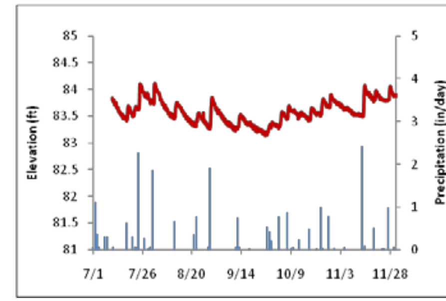
Groundwater Elevations



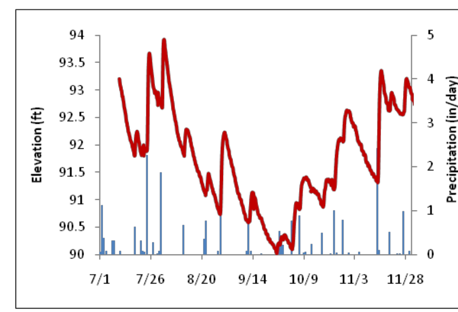
BD-5



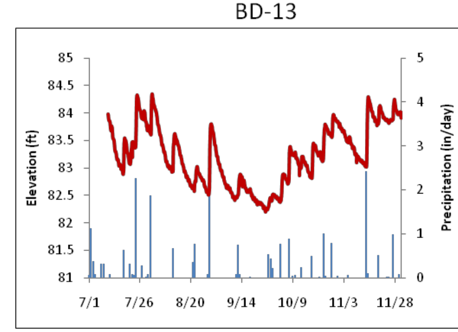
BD-12



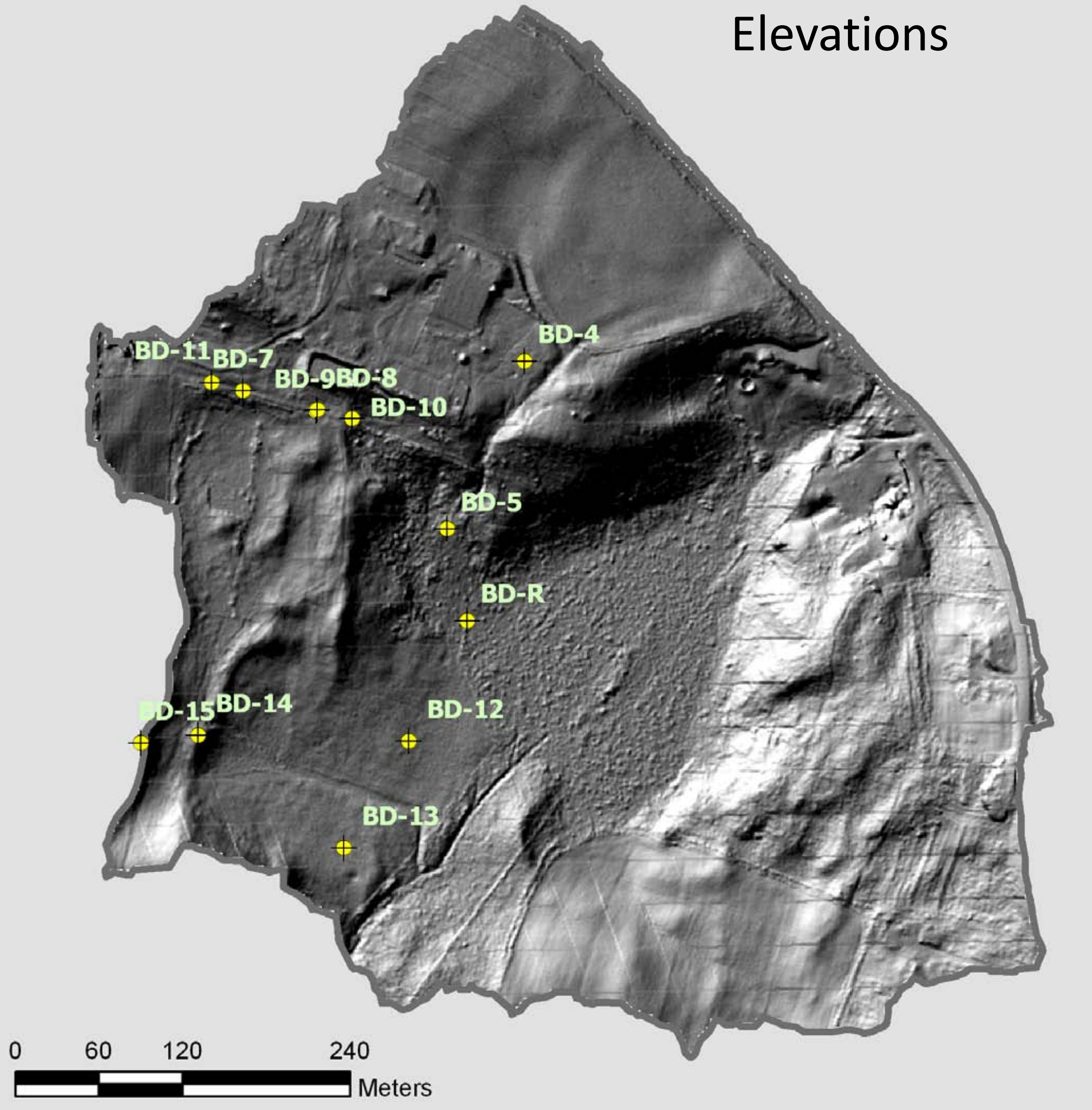
BD-14

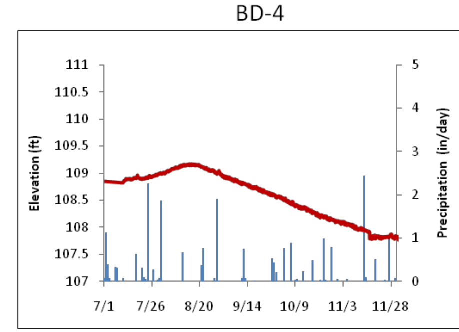


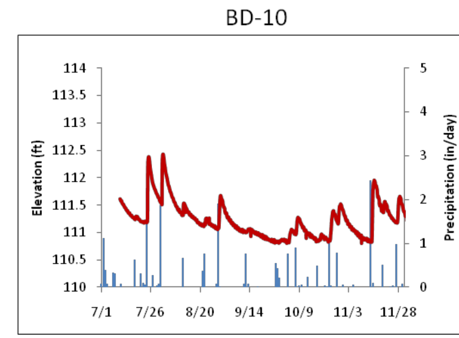
BD-13

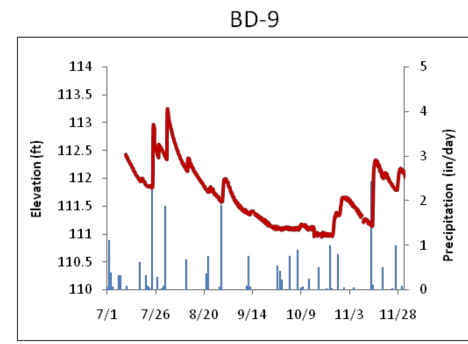


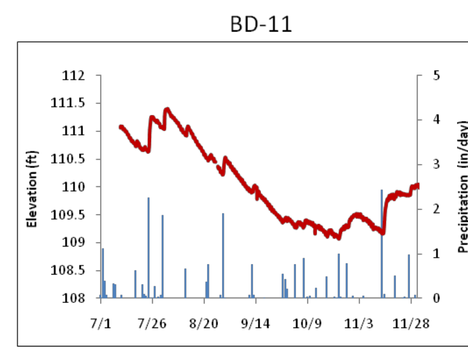
Groundwater Elevations

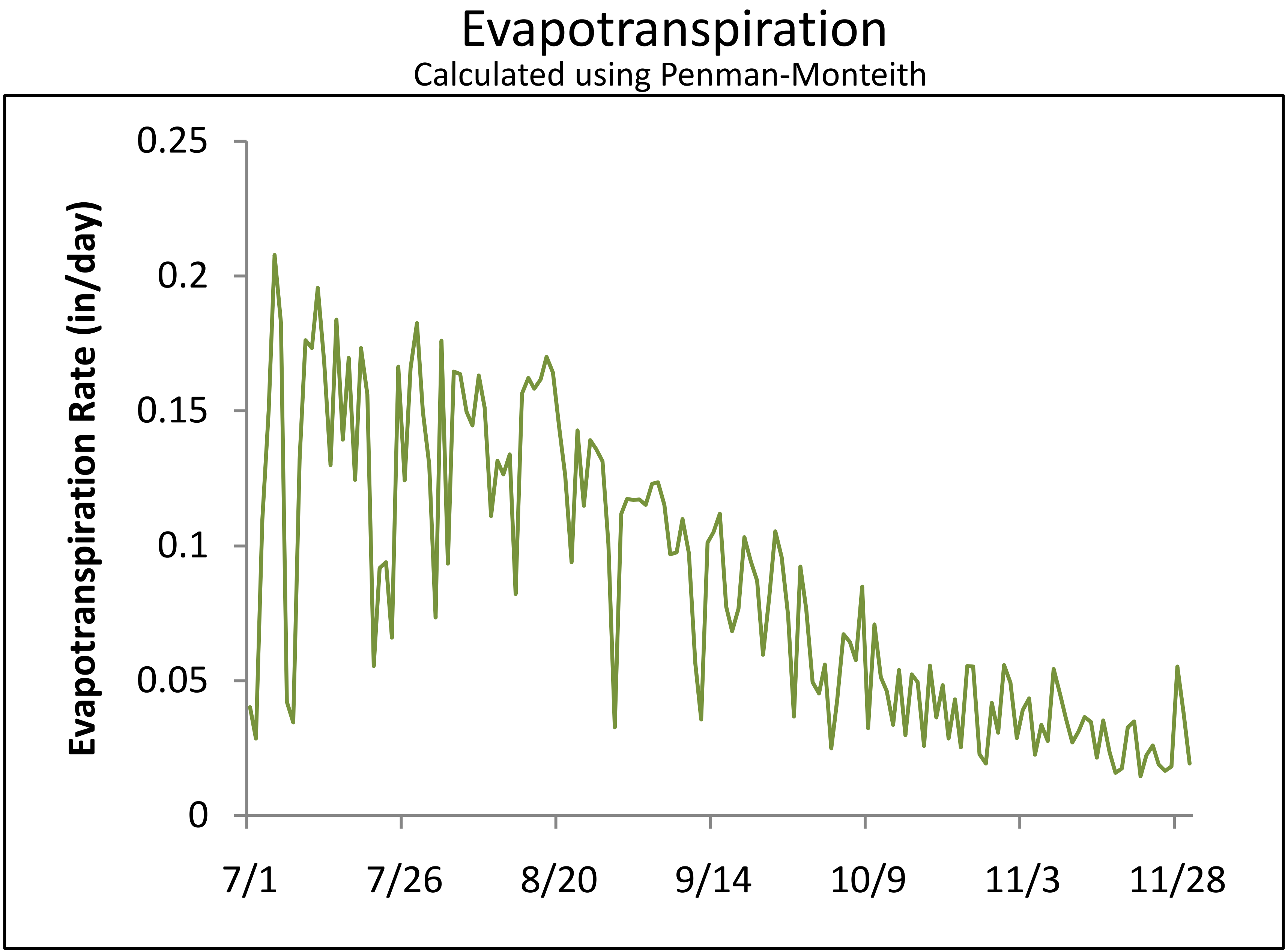








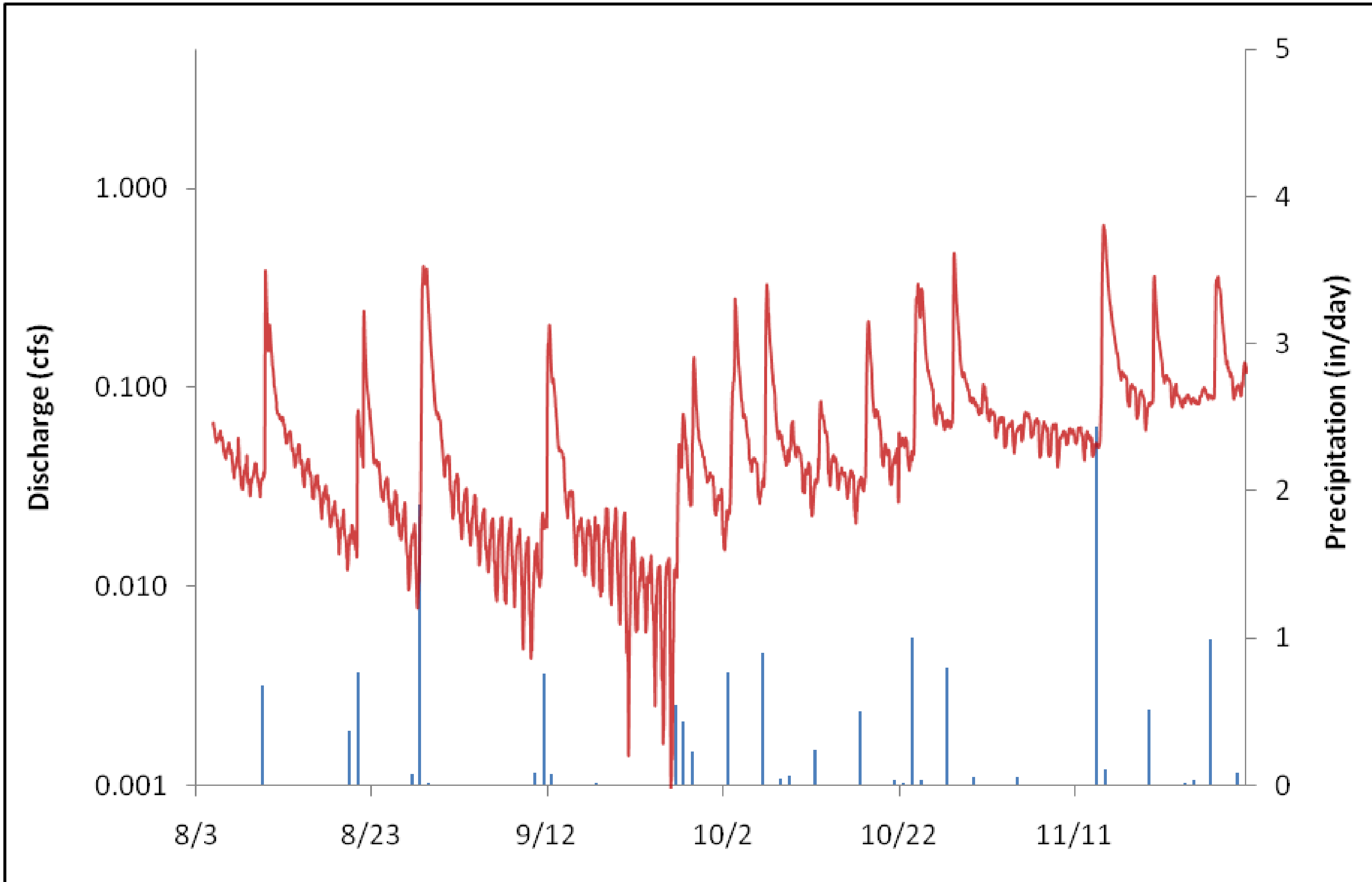



Evapotranspiration
Calculated using Penman-Monteith
Evapotranspiration Rate (in/day)
0.25
0.2
0.15
0.1
0.05
0
7/1
7/26
8/20
9/14
10/9
11/3
11/28

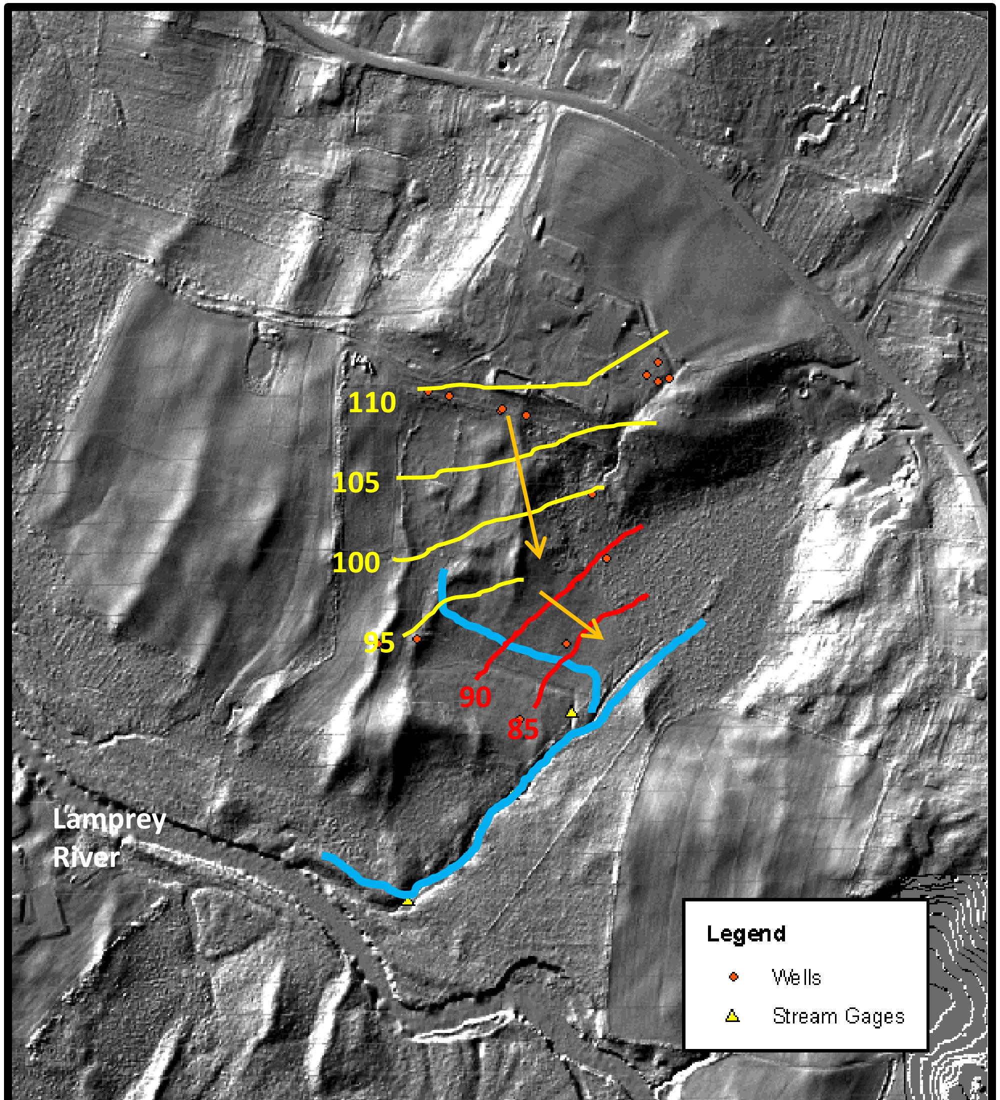
V-notch Weir

Parshall Flume

Streamflow at Watershed Outlet



Groundwater Contour Map: Unconfined / Confined Aquifer



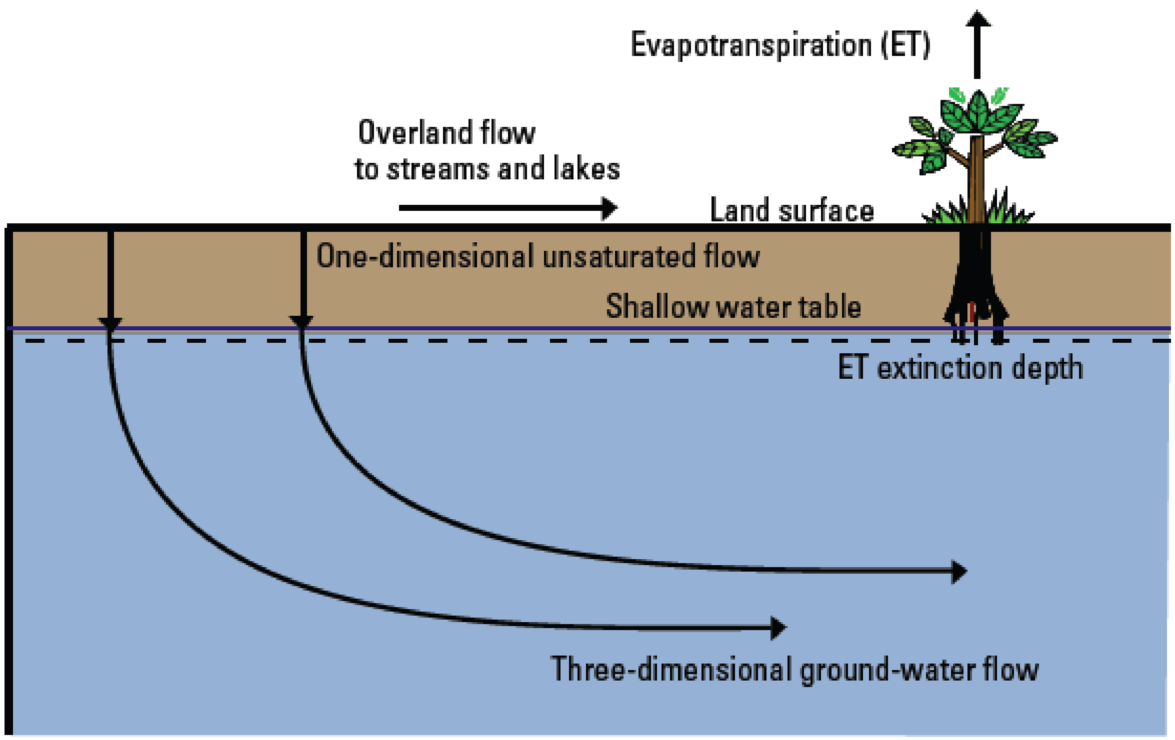
Unconfined Aquifer

Confined Aquifer

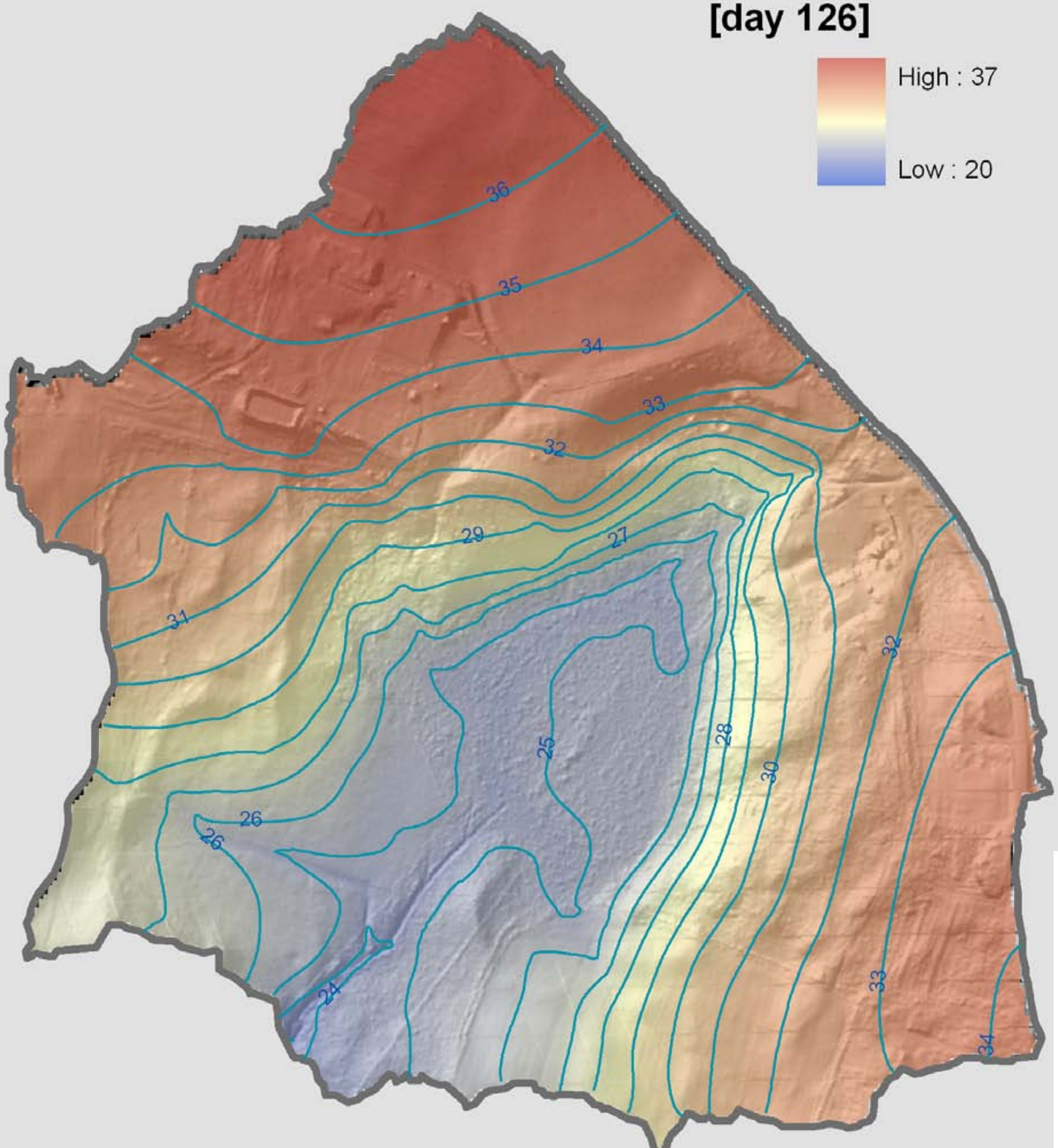
Elevations in feet

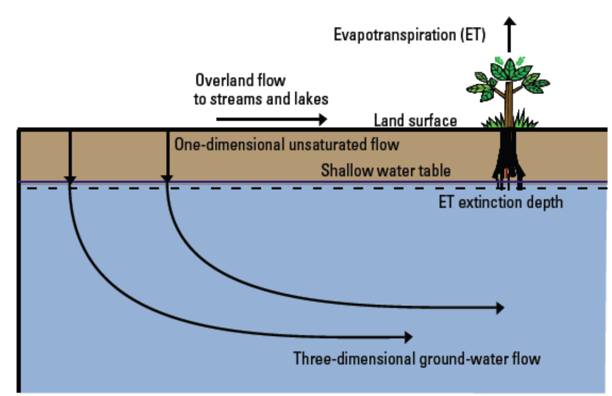
Development of Groundwater Model

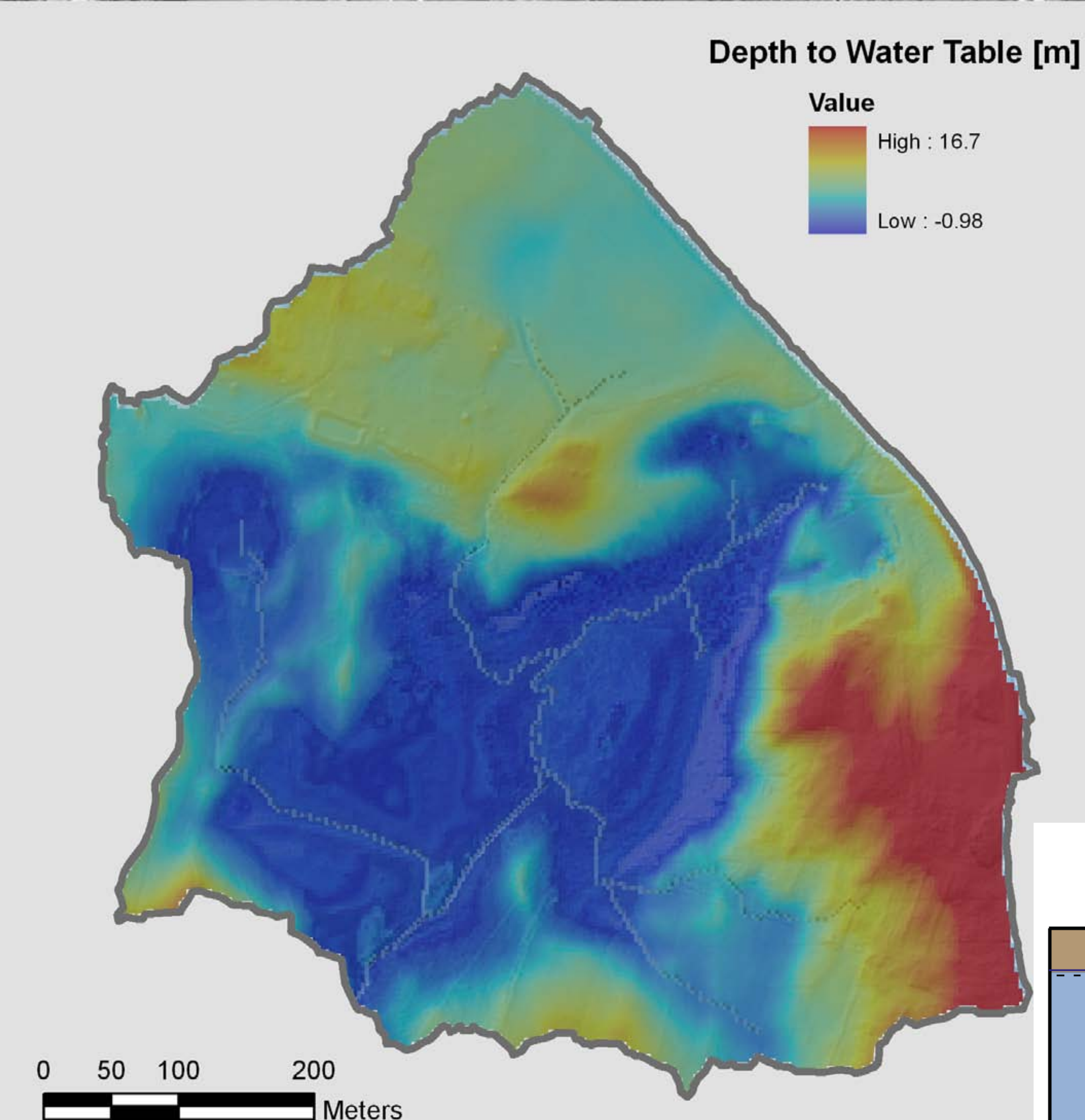
- Objectives:
  1. Develop understanding of spatial distribution of groundwater recharge and factors that affect its magnitude
  2. Provide a platform for simulating solute fluxes
- Utilize near surface capabilities of MODFLOW 2005 (UZF Package)

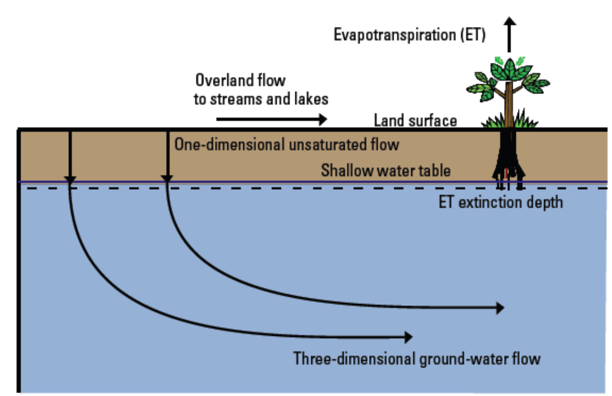


Simulated Water Table [day 126]

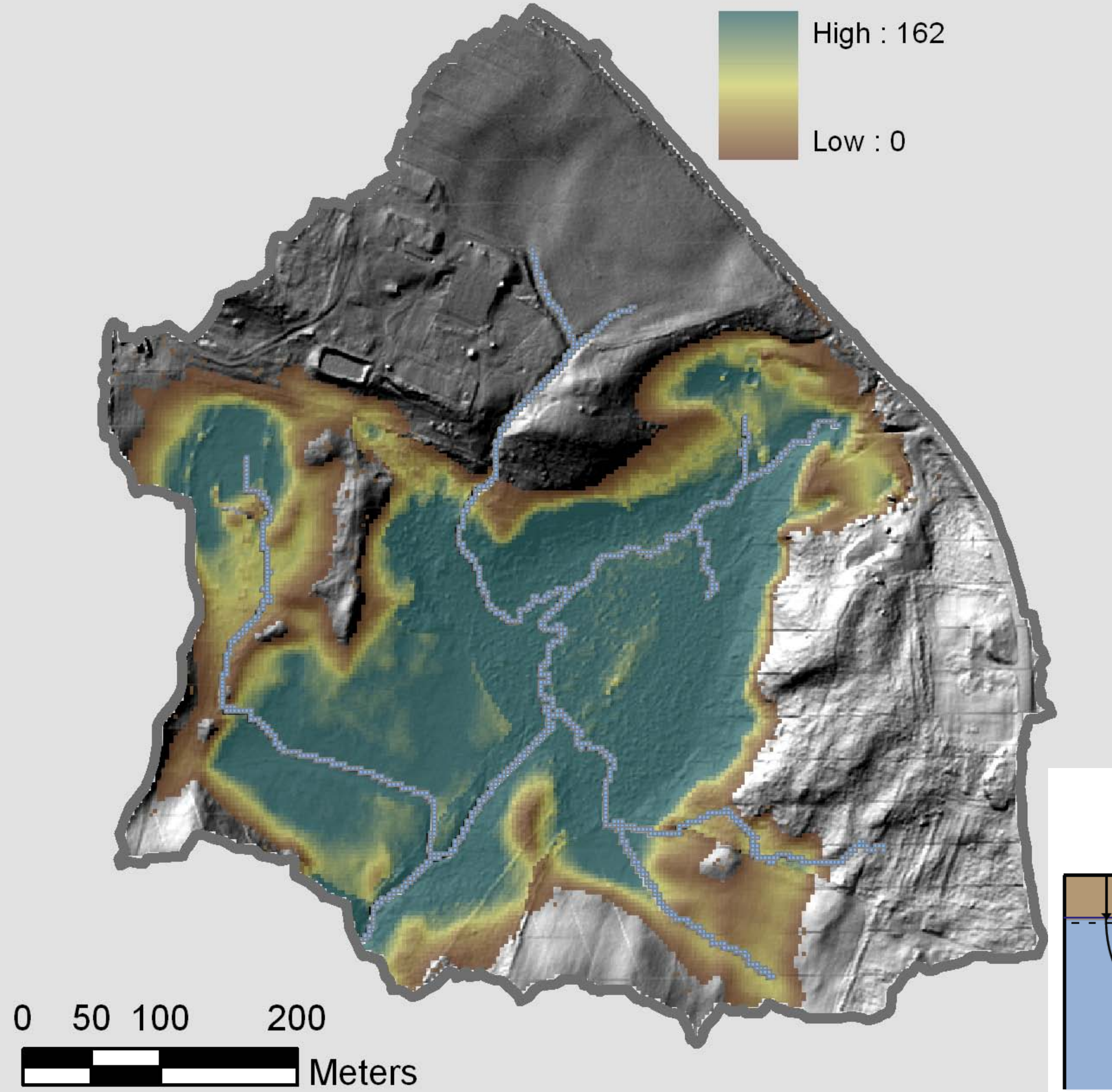


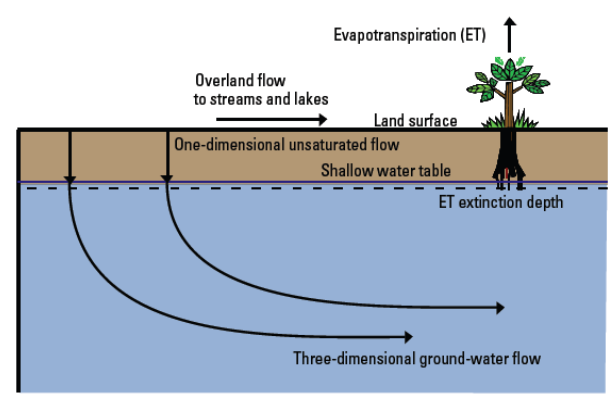


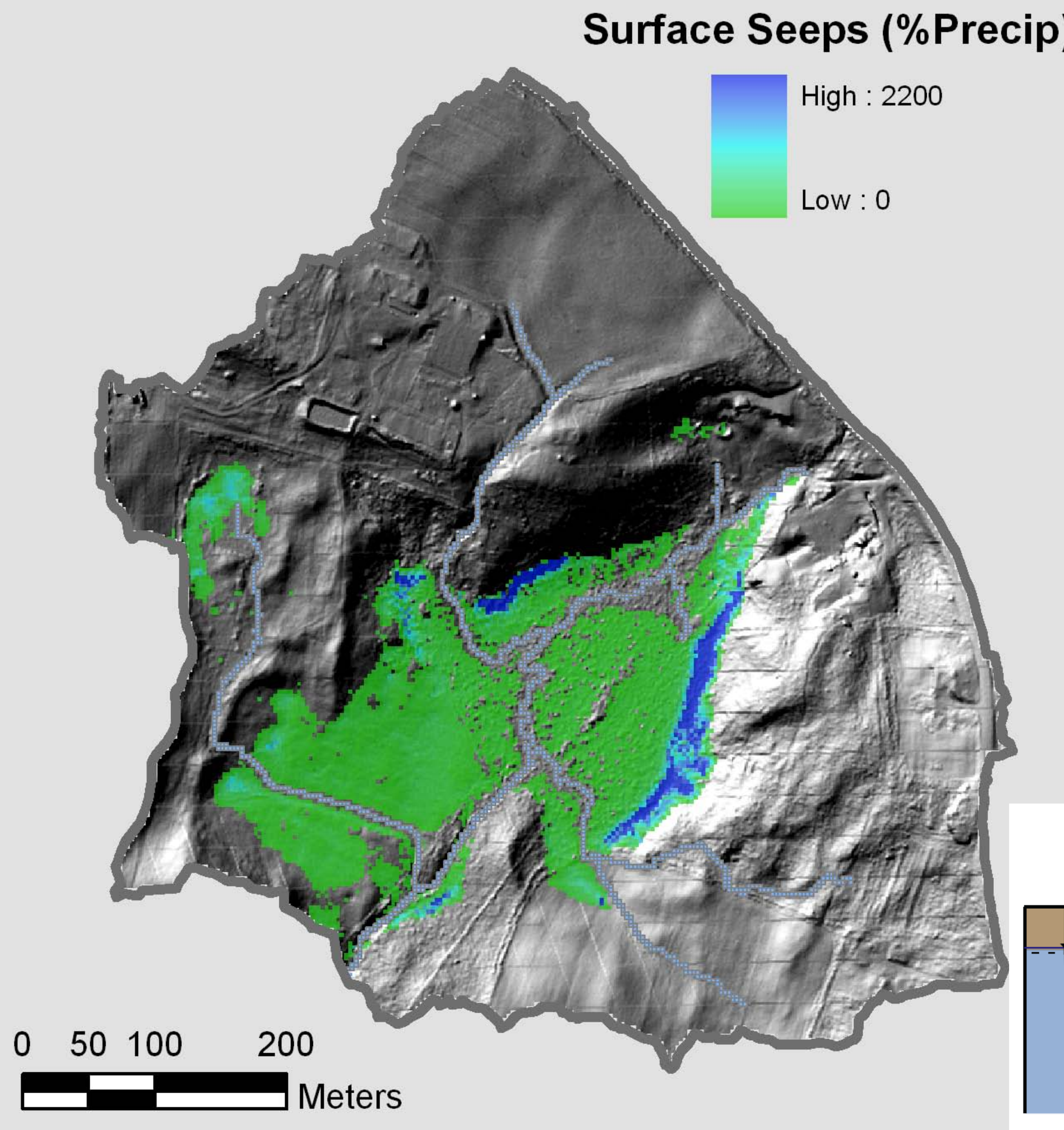

Depth to Water Table [m]
Value
High : 16.7
Low : -0.98
0 50 100 200
Meters

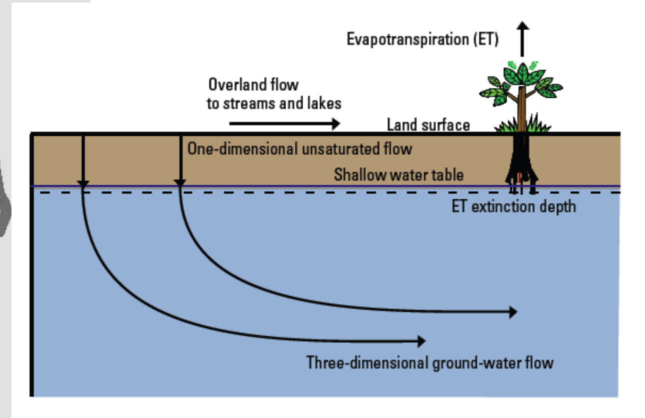

Evapotranspiration (ET)
Overland flow
to streams and lakes
Land surface
One-dimensional unsaturated flow
Shallow water table
ET extinction depth
Three-dimensional ground-water flow

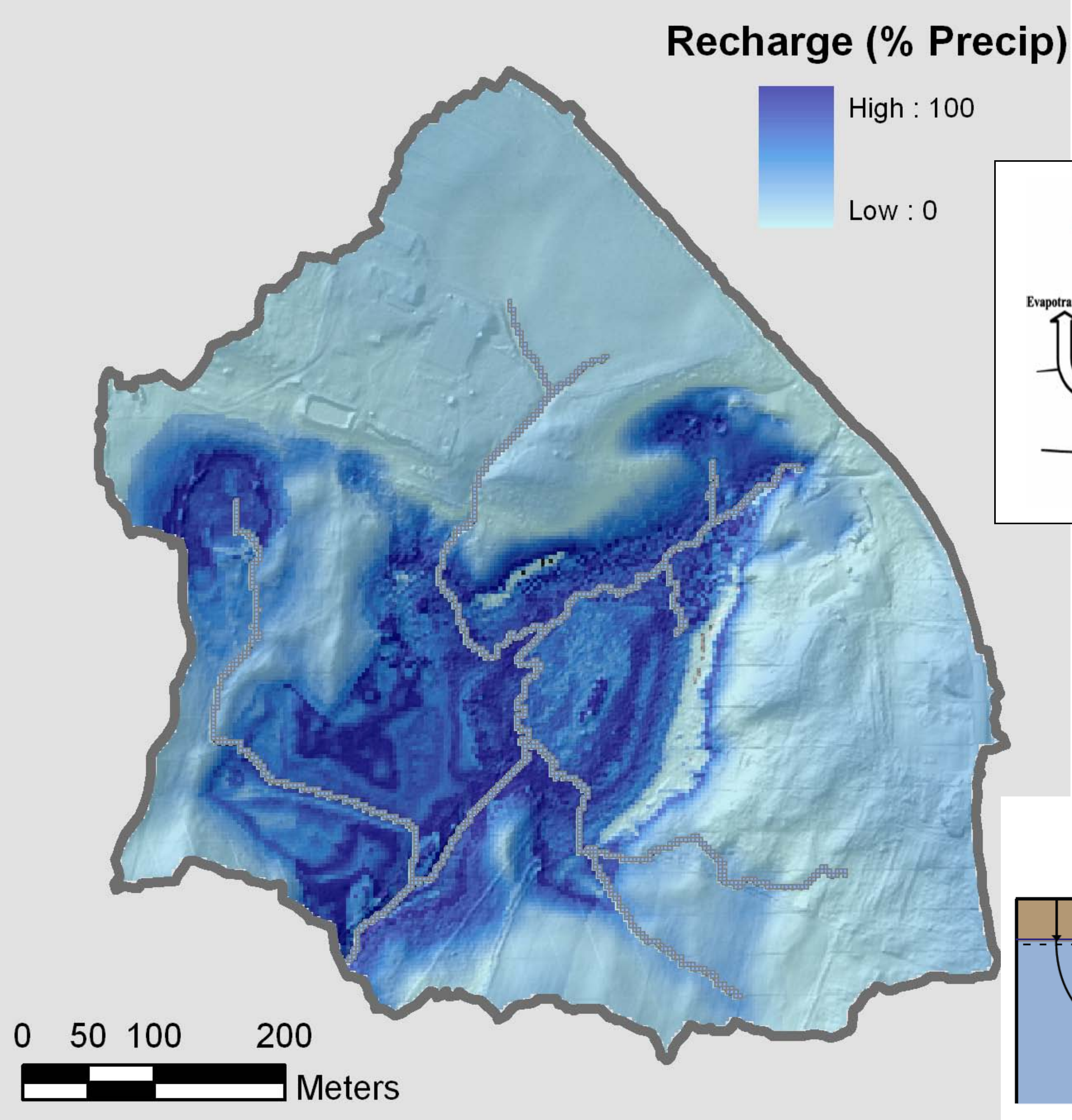
Groundwater ET (% Precip)

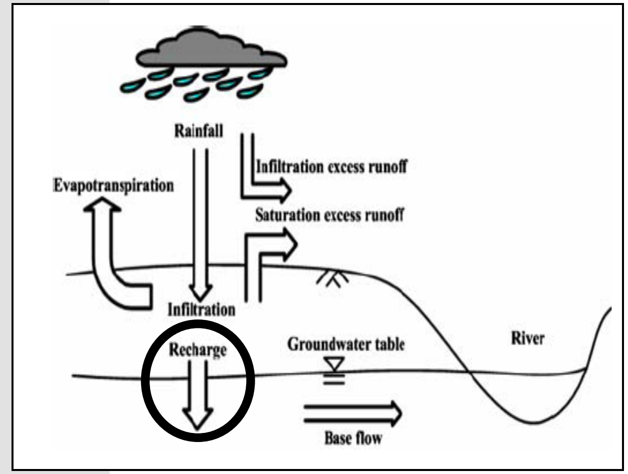


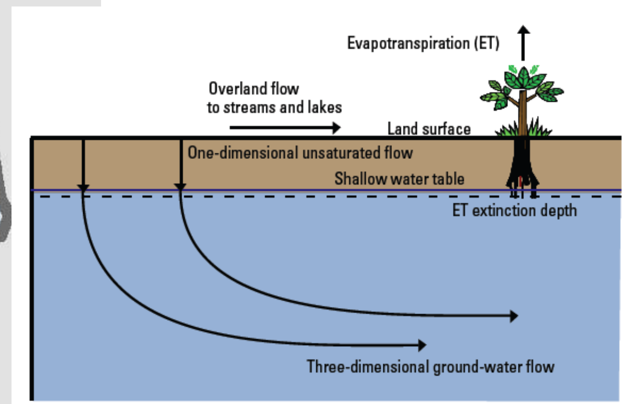



Surface Seeps (%Precip)
High : 2200
Low : 0
0 50 100 200
Meters

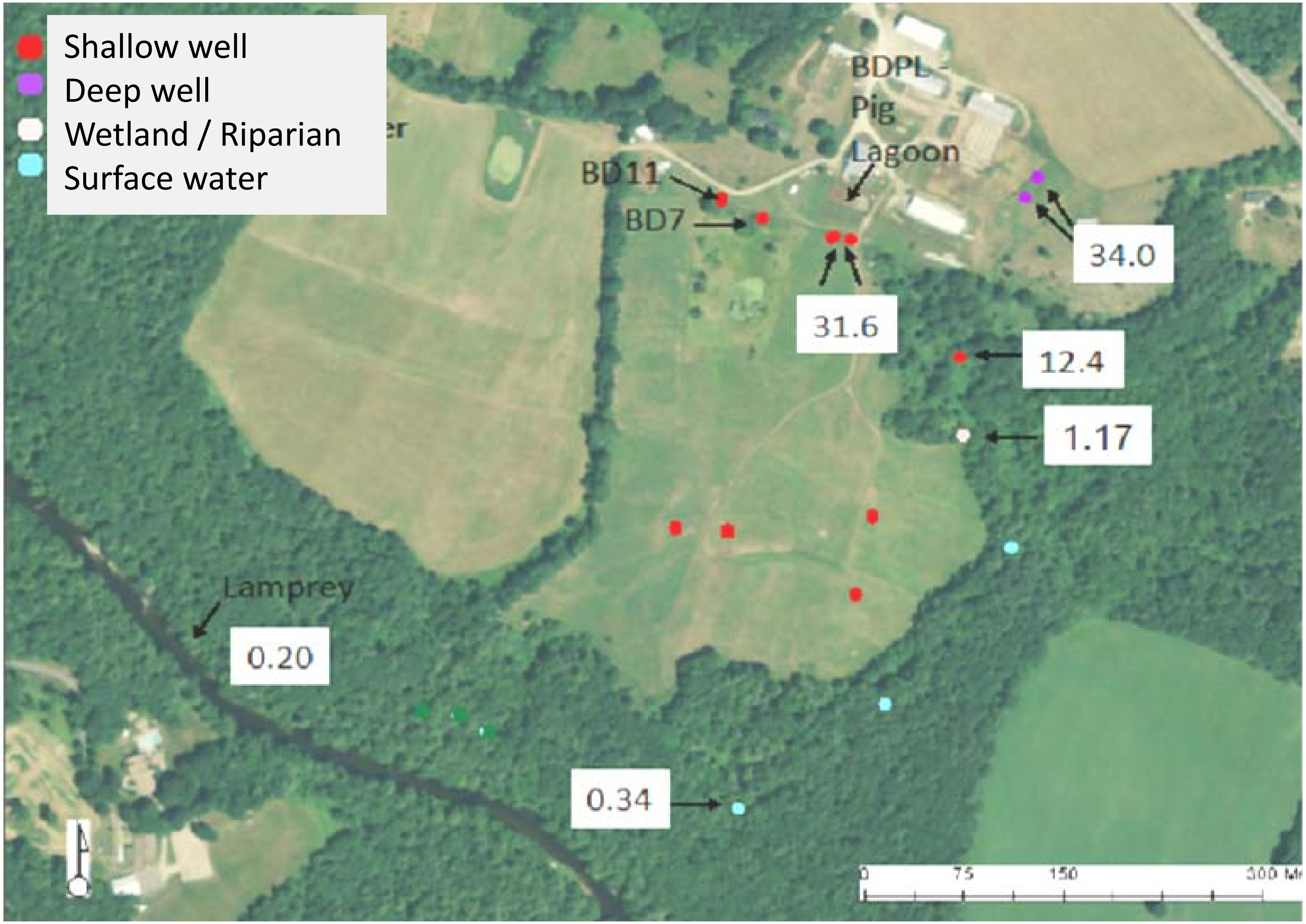

Evapotranspiration (ET)
Overland flow
to streams and lakes
Land surface
One-dimensional unsaturated flow
Shallow water table
ET extinction depth
Three-dimensional ground-water flow


Recharge (% Precip)
High : 100
Low : 0
0 50 100 200
Meters


Rainfall
Infiltration excess runoff
Evapotranspiration
Saturation excess runoff
Infiltration
Recharge
Groundwater table
River
Base flow


Evapotranspiration (ET)
Overland flow
to streams and lakes
Land surface
One-dimensional unsaturated flow
Shallow water table
ET extinction depth
Three-dimensional ground-water flow

Nitrate concentrations [mg/L]



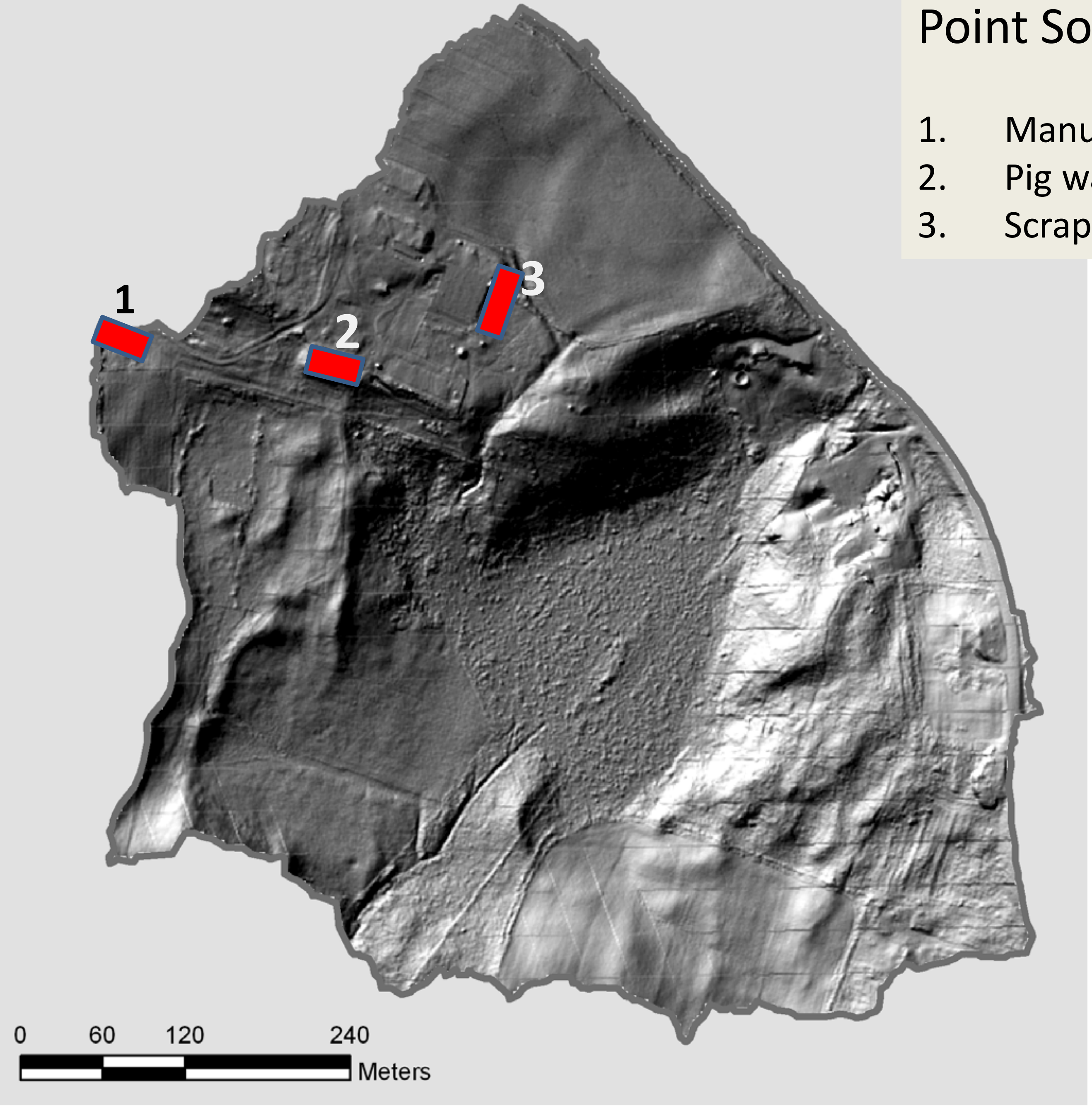
Source: McDowell

Nitrogen Flows (Dairy Only)		
#	**Description**	**Nitrogen**
INPUTS		**(kg/yr)**
1	Hay/Silage/Baleage	2060
2	Grain	1799
3	Feed Additives	796
4	Deposition	381
INTERNAL		
5	Manure	6716
6	Hay/Silage/Baleage	1849
7	Forage	1256
Outputs		
8	Milk	997

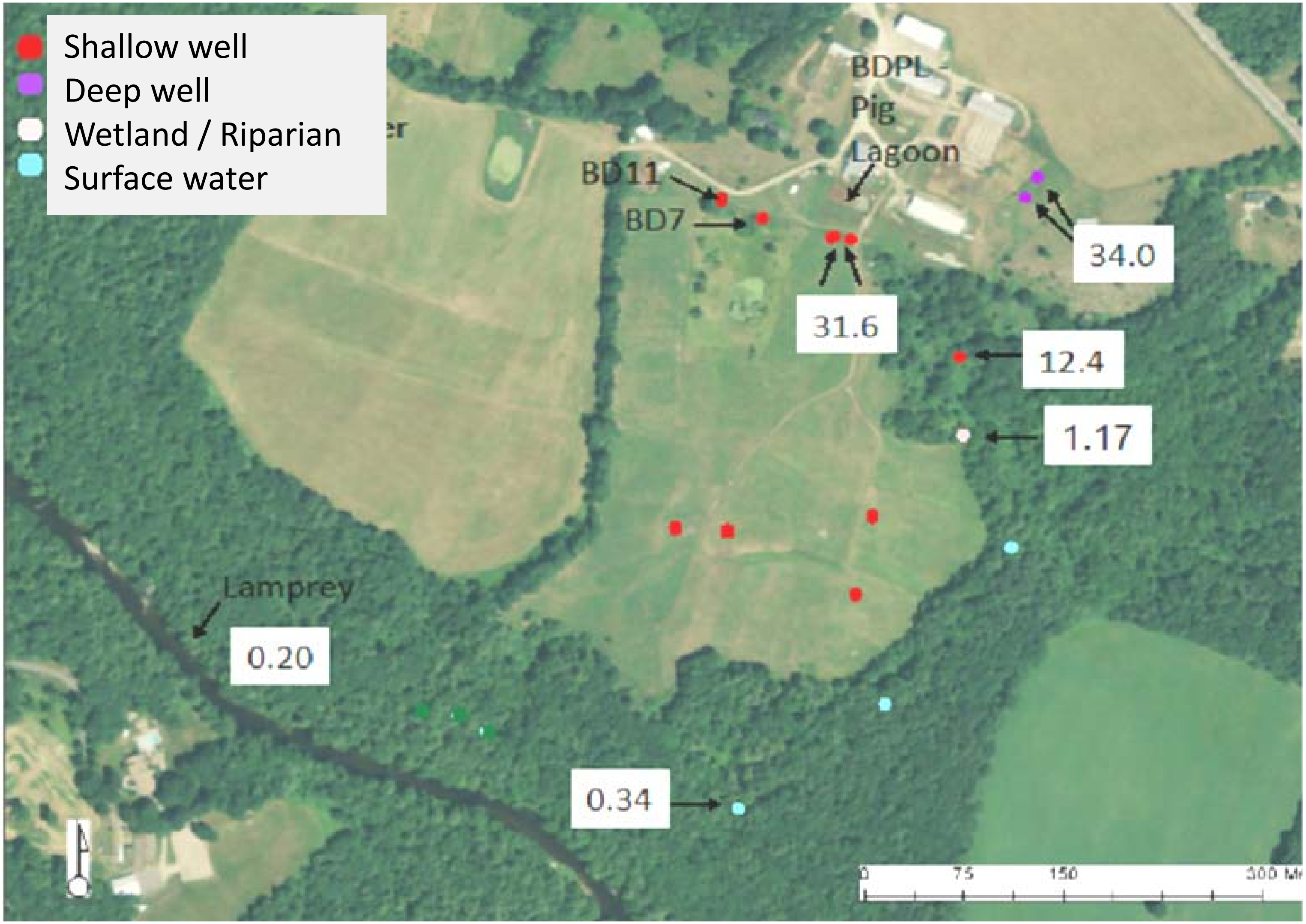
Gabriel Perkins & John Aber

Point Sources of Nitrogen

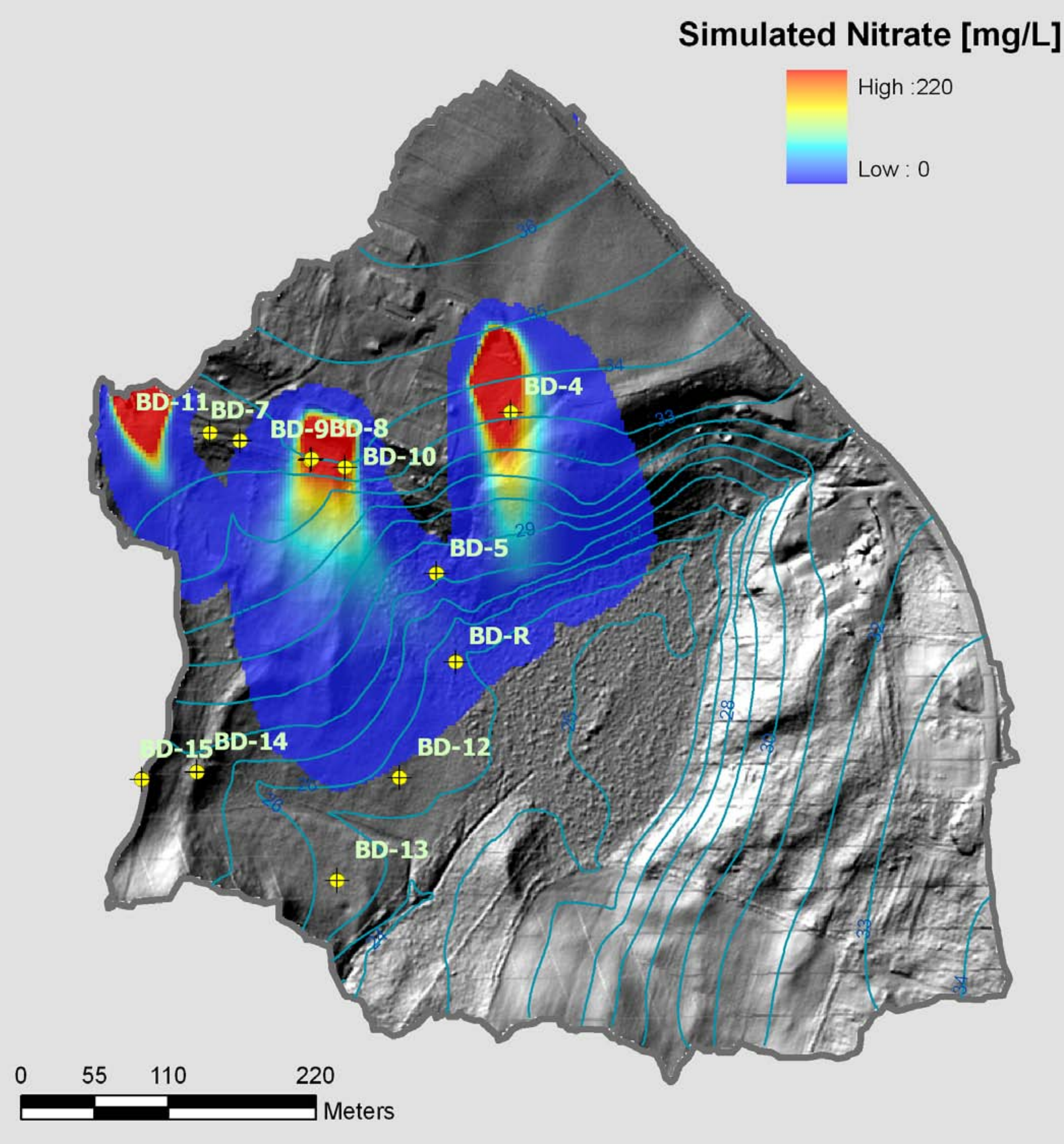
1. Manure compost pile
2. Pig waste lagoon (abandoned)
3. Scrapings from barn & feed area



Nitrate concentrations [mg/L]



Source: McDowell

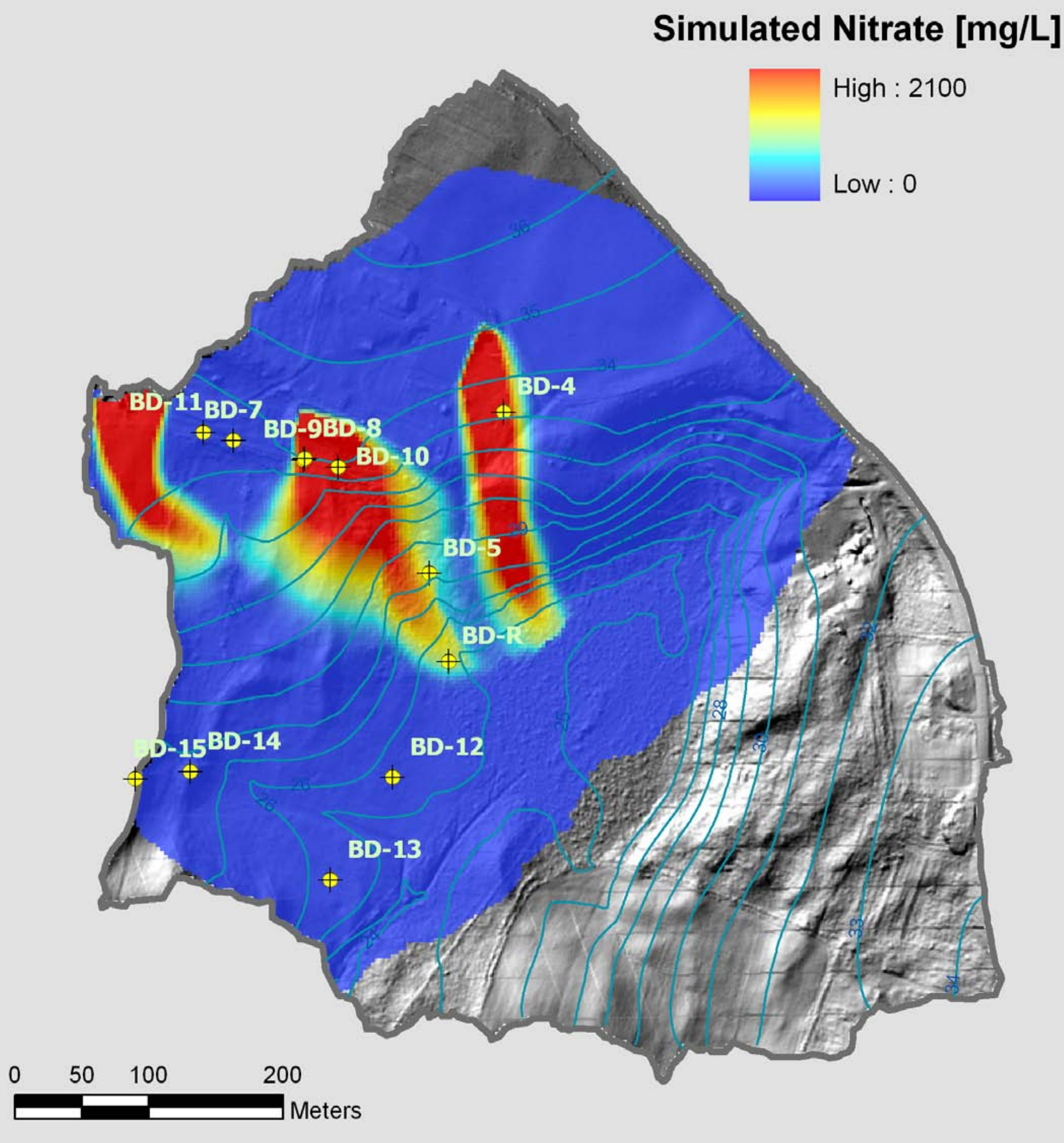


Quasi-steady state (t=10 years)

Nitrate as "conservative" solute – no decay

Simulated concentrations match those observed in wells fairly well.

However, is manure loading rate ~200 kg N/ year unrealistic?



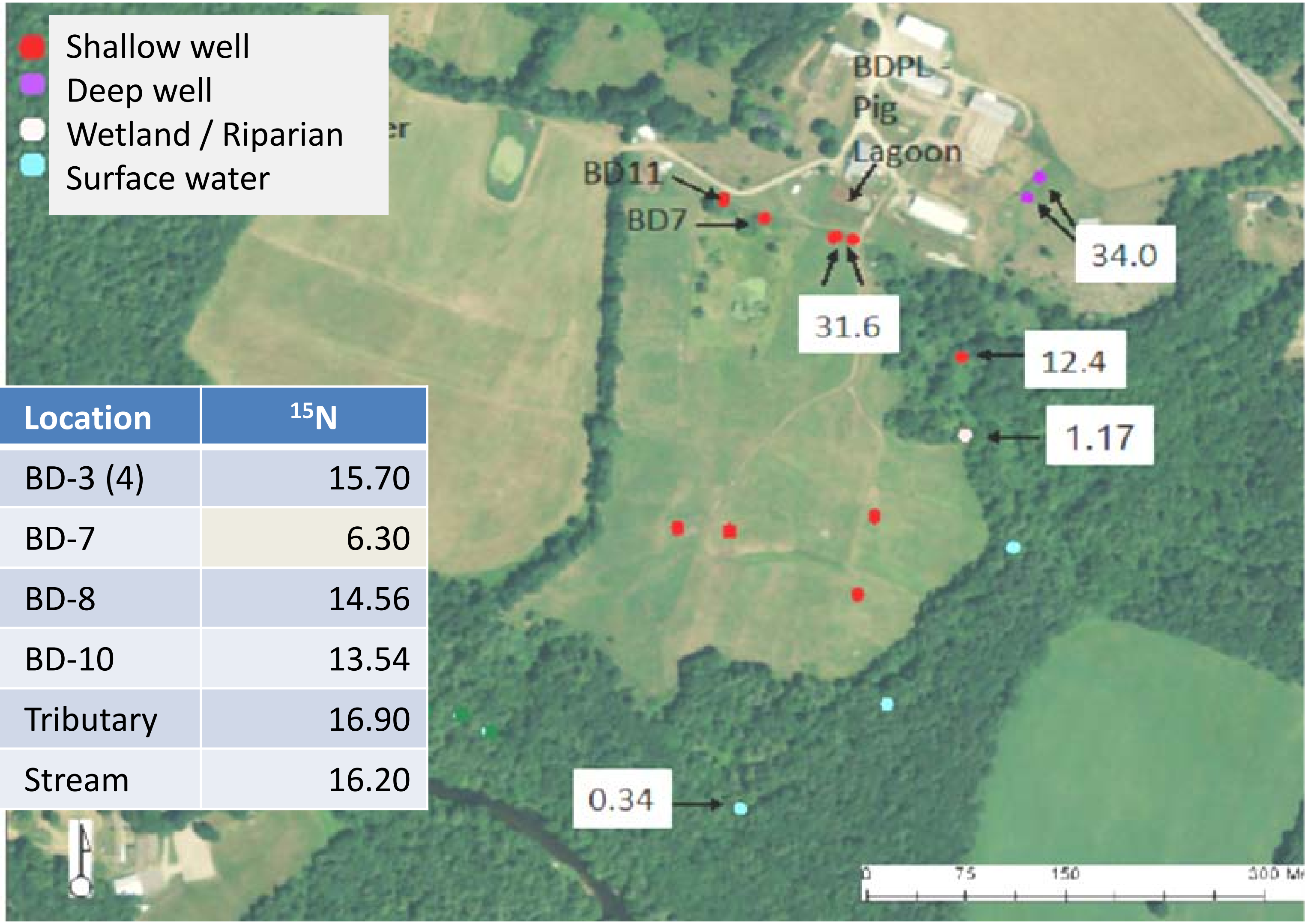
Quasi-steady state (t=10 years)

Denitrification as a first order decay process ($k=0.3\ yr^{-1}$)

More realistic loading rate of 2000 kg/N per year.

Simulated concentrations in wells are much higher than observed.

Nitrate concentrations [mg/L]



Location	^{15}N
BD-3 (4)	15.70
BD-7	6.30
BD-8	14.56
BD-10	13.54
Tributary	16.90
Stream	16.20

Sources: B. McDowell, A. Hristov

Conclusions & Future Work

- Spatial distribution of recharge is strongly dependent on depth to water table and ability of plants to utilize groundwater for ET.
- Need to:
  1) upscale high resolution (space and time) groundwater model to simulate long-term solute fluxes and
  2) characterize winter and spring conditions
- Preliminary solute transport simulations suggest that the system takes ~ 10 years to reach steady state.
- Source characterization will be one important component of resolving occurrence and rate of denitrification.