EVALUATION OF SEDIMENT TRANSPORT MECHANICS USING LANTHANIDE TRACERS AND RADIOMETRIC FINGERPRINTING

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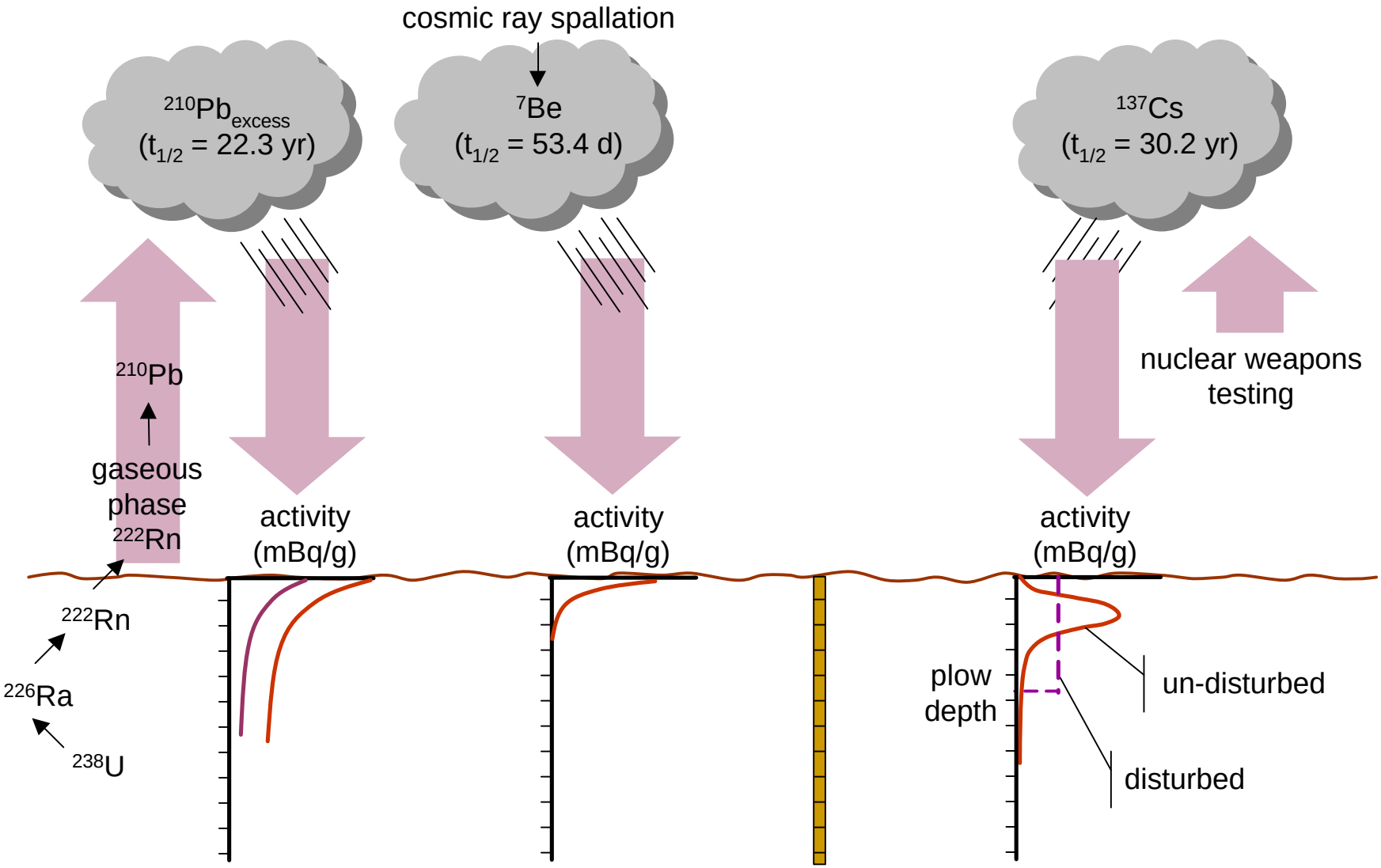
PROBLEM STATEMENT

- Erosion and sediment transport studies have relied on spatially-averaged measurements.

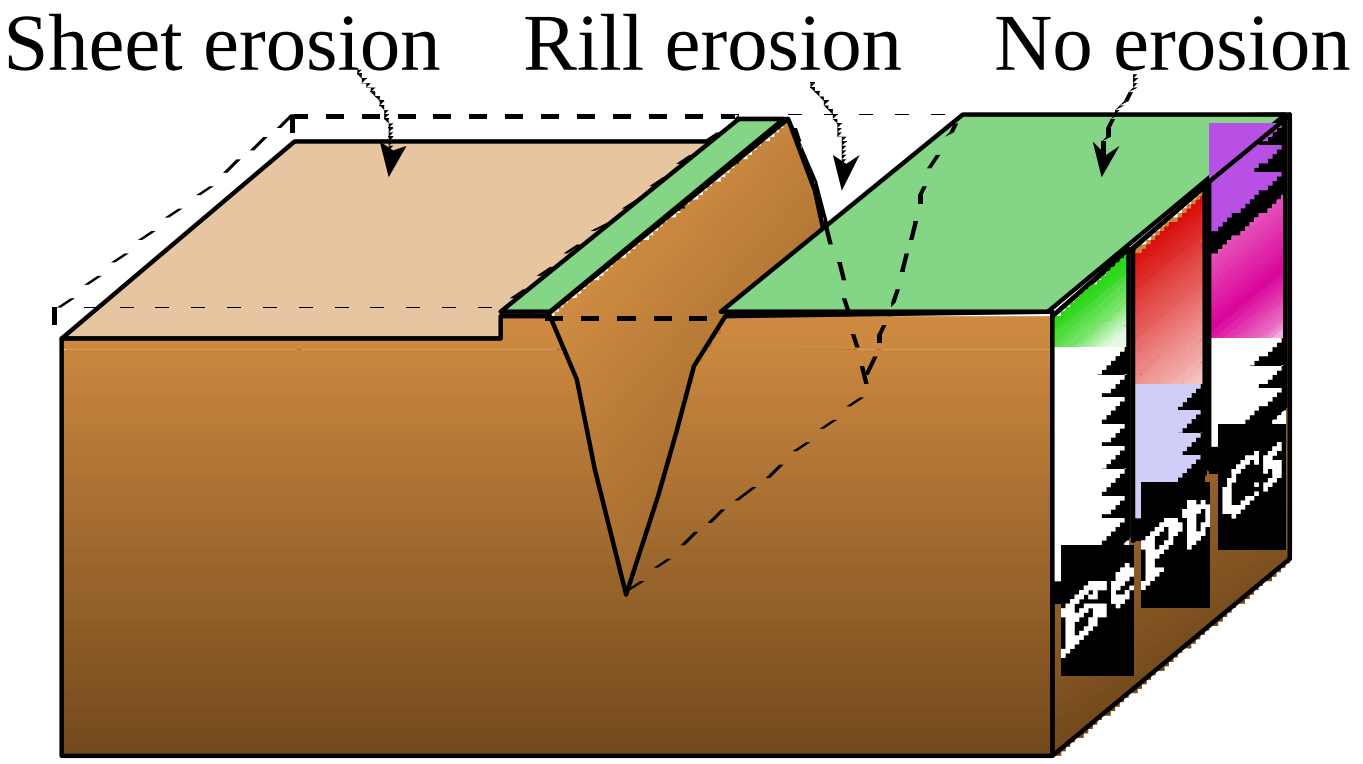
- Not much information available on sediment-contributing areas and underlying erosion mechanisms.

- Radiometric fingerprinting and tagging soils with REEs enable delineating spatial and temporal patterns of sediment movement.

RADIOMETRIC “FINGERPRINTING”



EROSION MECHANISMS AND RADIONUCLIDE YIELD

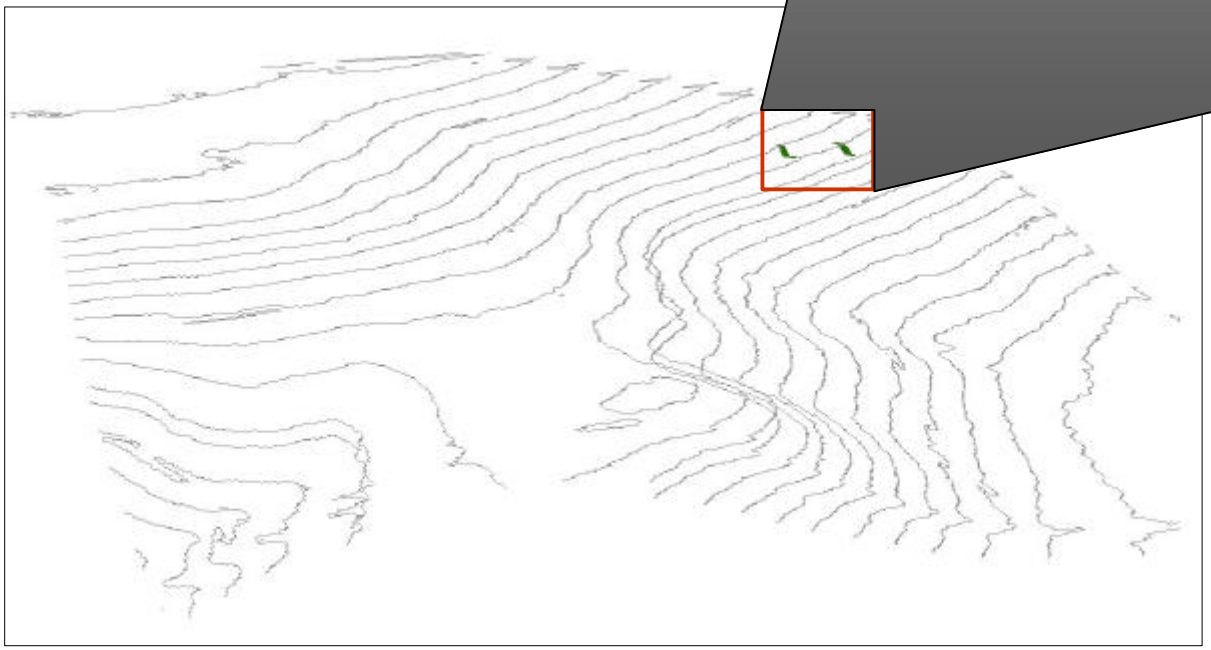


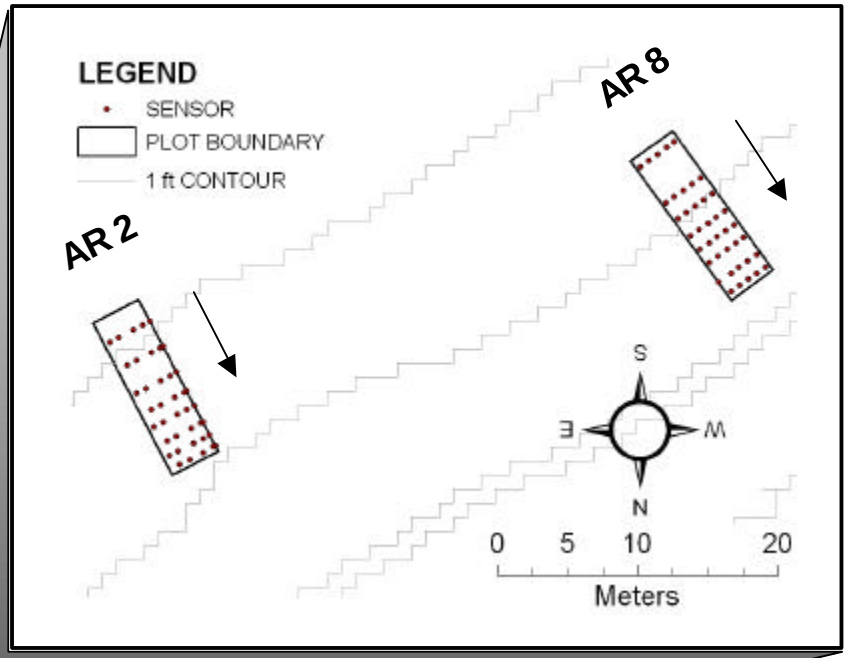
OBJECTIVES

- To determine spatial patterns of runoff generation and sediment movement for different agricultural management systems.

- To elucidate underlying erosion mechanisms and quantify their relative areal impact.

STUDY SITE



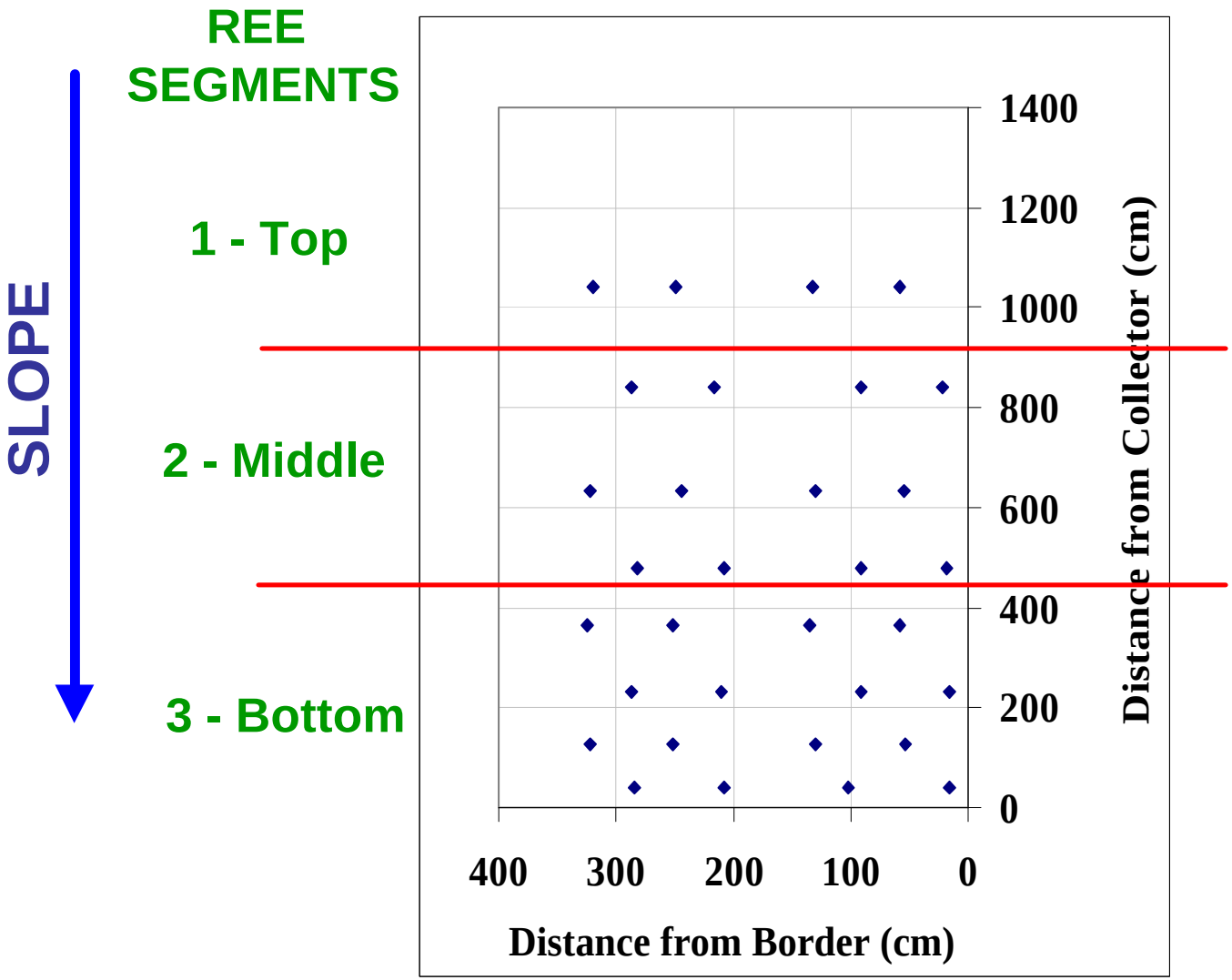

LEGEND
SENSOR
PLOT BOUNDARY
1 ft CONTOUR
AR 2
AR 8
S
E
W
N
0
5
10
20
Meters

TREATMENTS

Contour Tillage

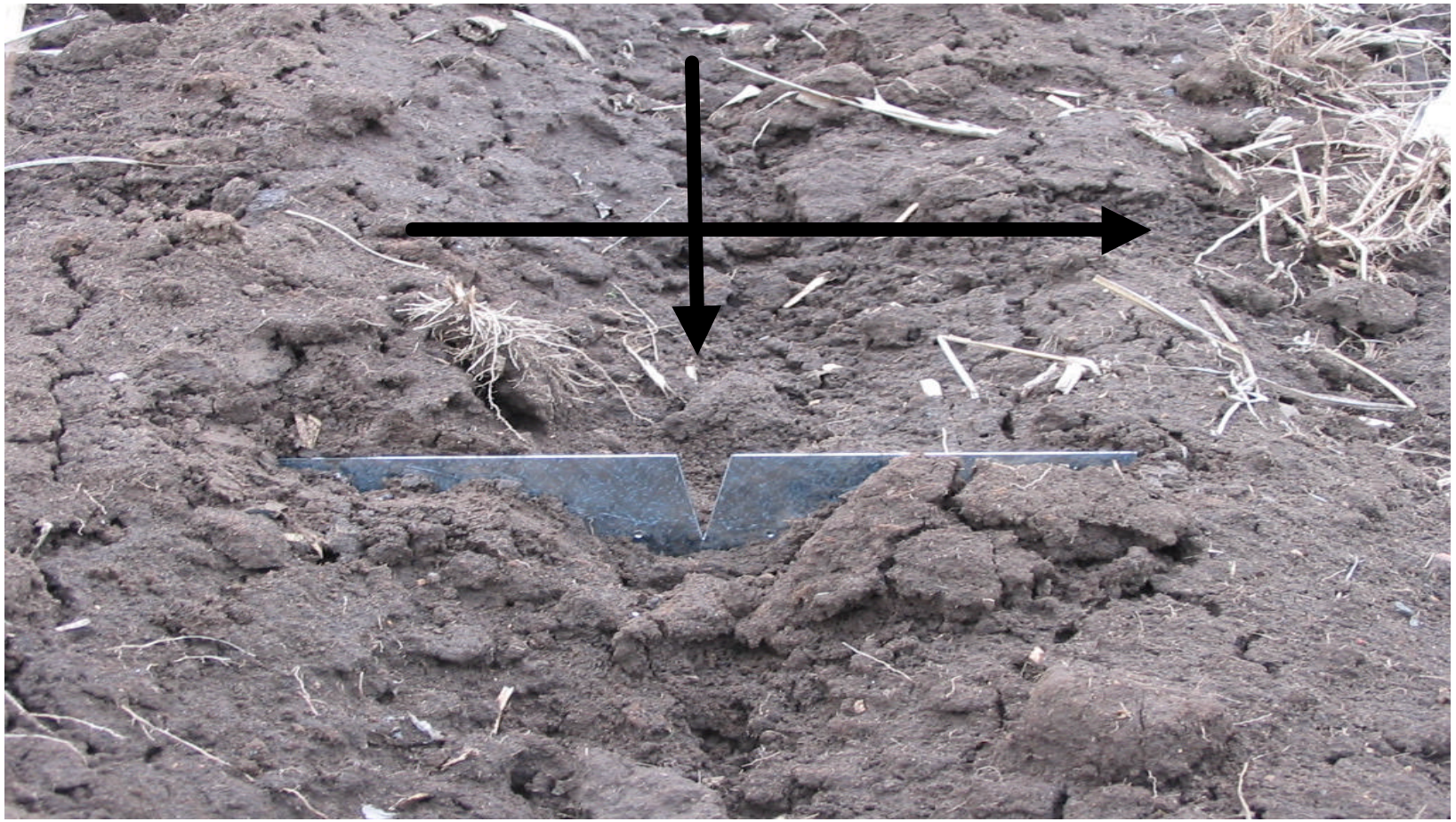
Up-and-Down Tillage

EXPERIMENTAL DESIGN

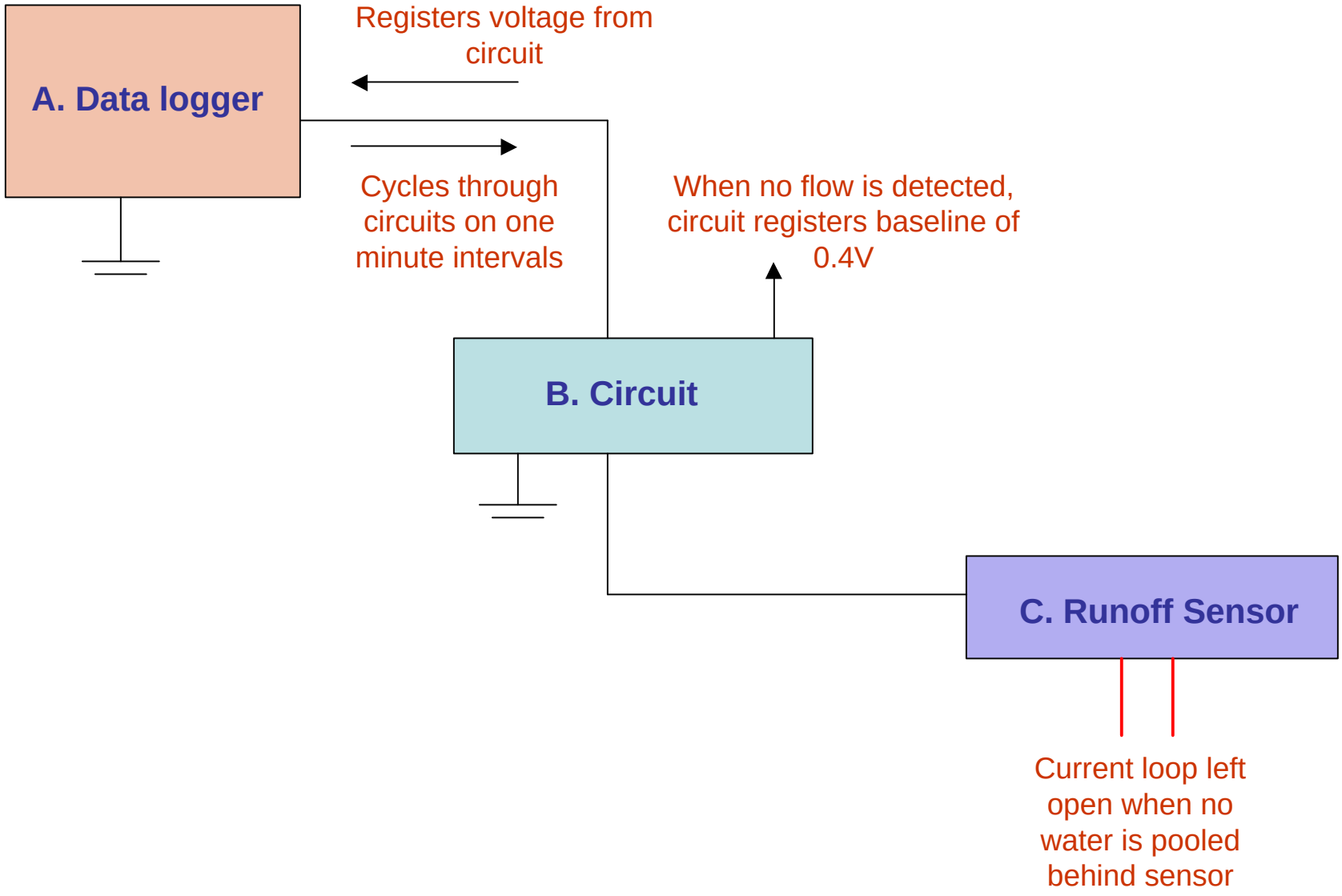


32 sensors placed in furrows and staggered from row to row.

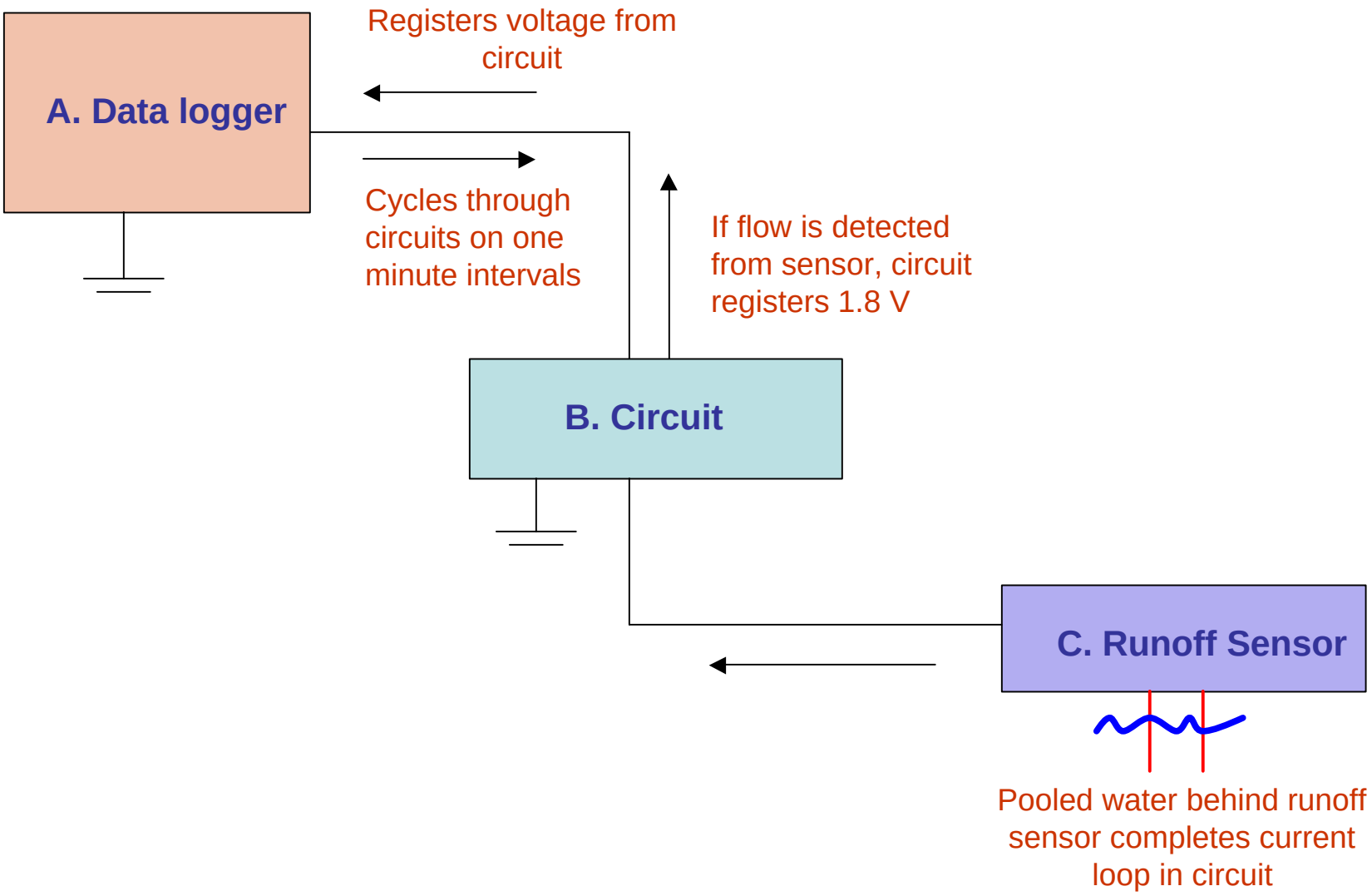
RUNOFF SENSORS



RUNOFF SENSORS



RUNOFF SENSORS



REE TAGGING

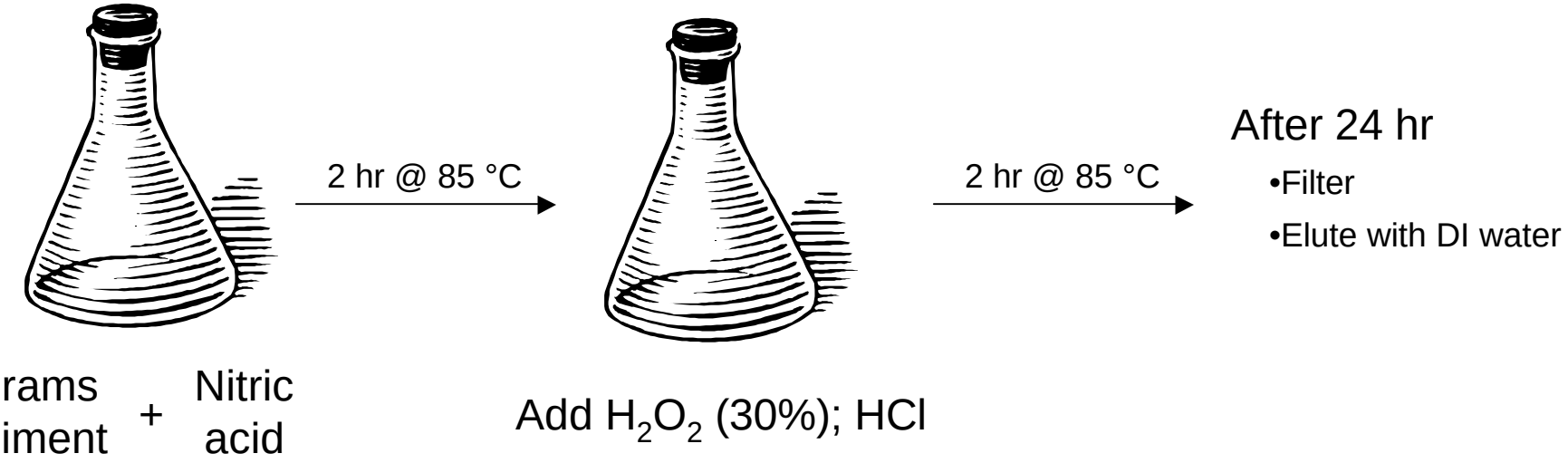
- Plano silt loam soil (Arlington, WI)
- Three Rare Earth Element (REE) oxide tracers
  - Gd_2O_3 (Top Segment)
  - Pr_2O_3 (Middle Segment)
  - Nd_2O_3 (Bottom Segment)

- Soil tagging procedure followed Zhang et al. (2003)

REE	Background	REE Applied	
	mg/kg	gram	mg/kg
Gd	4.30	16.2	452
Pr	5.57	21.8	594
Nd	23.14	88.7	2399

REE TAGGING

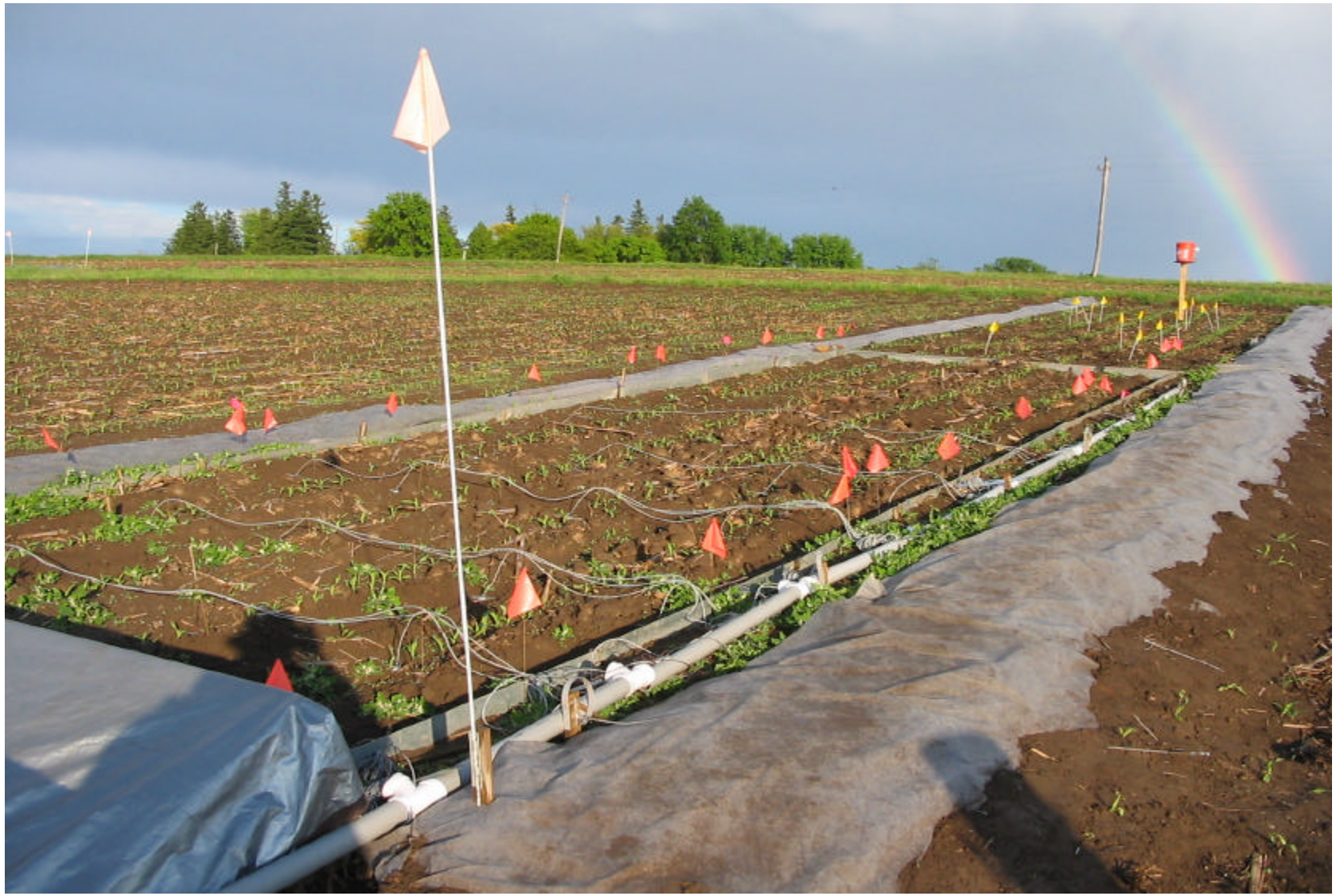
- REE extraction described by Zhang *et al.* (2003); Polyakov *et al.* (2004)



- REE concentration determined by ICP-MS

REE TAGGING

COMPLETE FIELD INSTALLATION



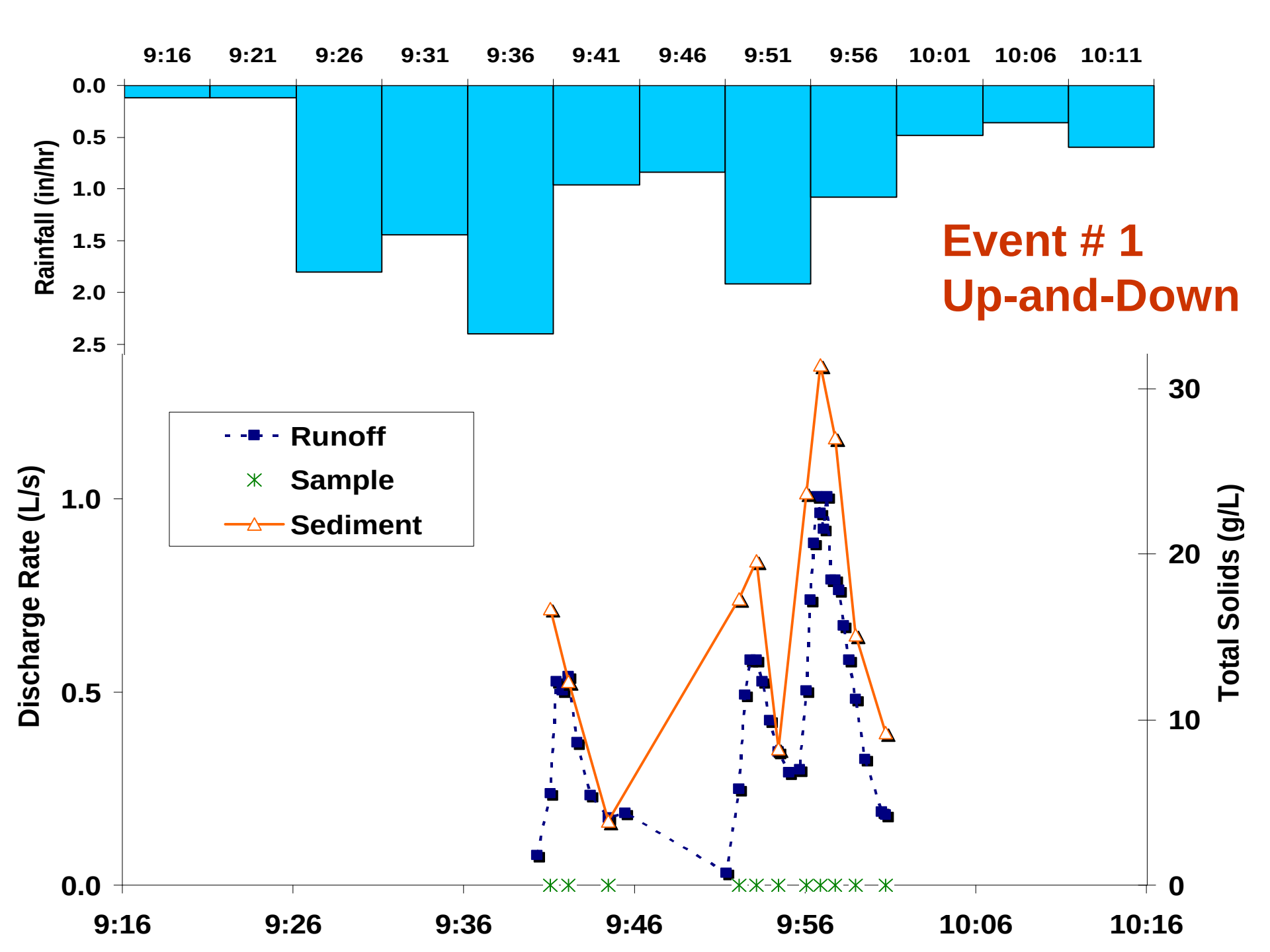
FLOW MONITORING

SAMPLE COLLECTION

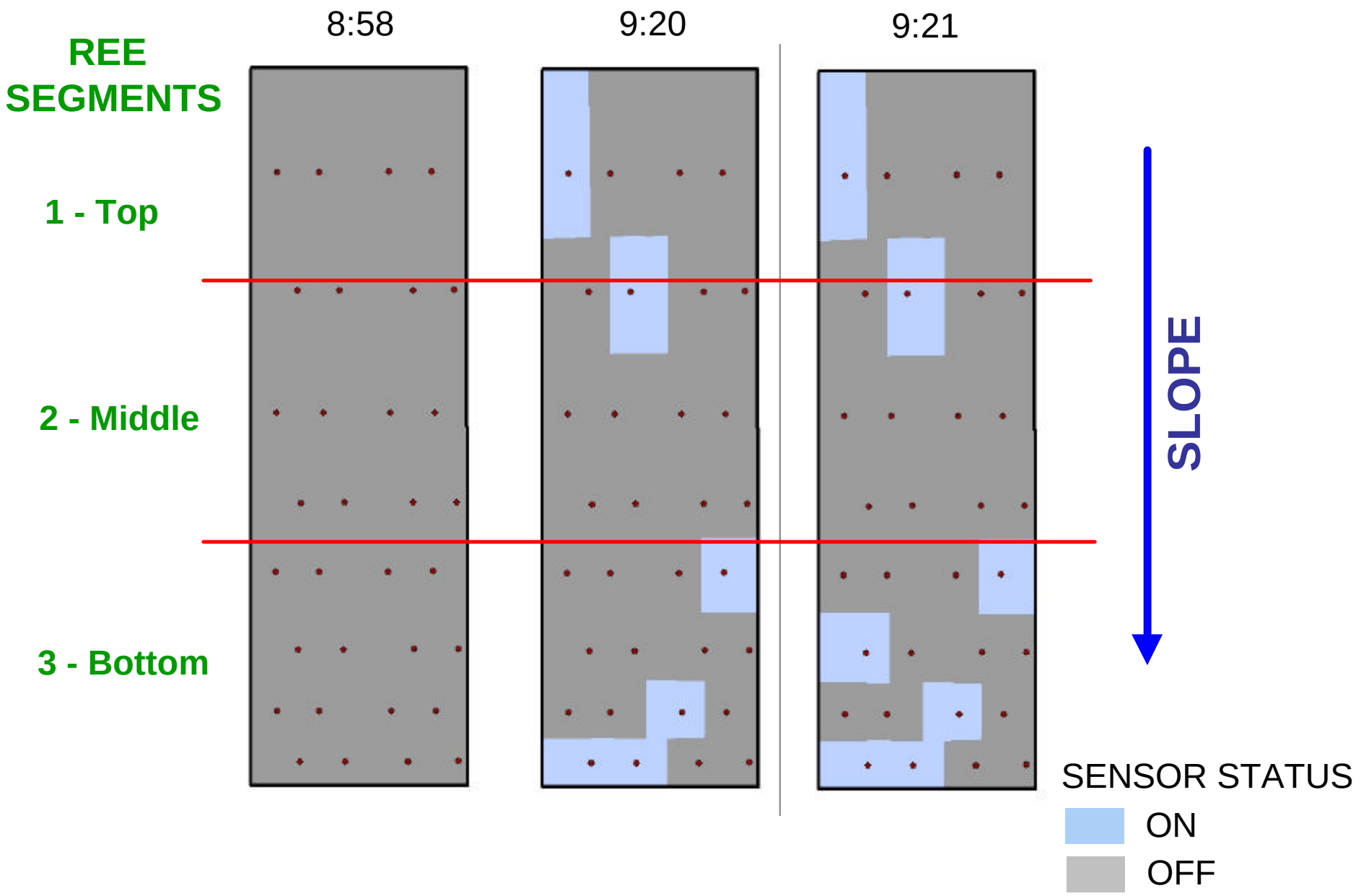
EVENTS SUMMARY

Up-and-Down						
	Precipitation			Runoff		
Event	Depth (cm)	Duration (hrs)	Intensity (cm/hr)	Volume (L)	Peak Flow (L/s)	Runoff Coefficient
07.20.05	2.5654	1.00	2.5654	208.98	1.007	0.183
07.23.05	0.508	0.38	1.3252	106.26	0.504	0.469
07.26.05	1.3716	0.75	1.8288	520.76	1.847	0.851

Contouring						
	Precipitation			Runoff		
Event	Depth (cm)	Duration (hrs)	Intensity (cm/hr)	Volume (L)	Peak Flow (L/s)	Runoff Coefficient
07.26.05	1.3716	0.75	1.8288	199.44	0.852	0.326


9:16
9:21
9:26
9:31
9:36
9:41
9:46
9:51
9:56
10:01
10:06
10:11
Rainfall (in/hr)
0.0
0.5
1.0
1.5
2.0
2.5
Event # 1
Up-and-Down
Runoff
Sample
Sediment
Discharge Rate (L/s)
0.0
0.5
1.0
Total Solids (g/L)
0
10
20
30
9:16
9:26
9:36
9:46
9:56
10:06
10:16

Event # 1 (Up-and-Down Tillage) – Runoff Sensors



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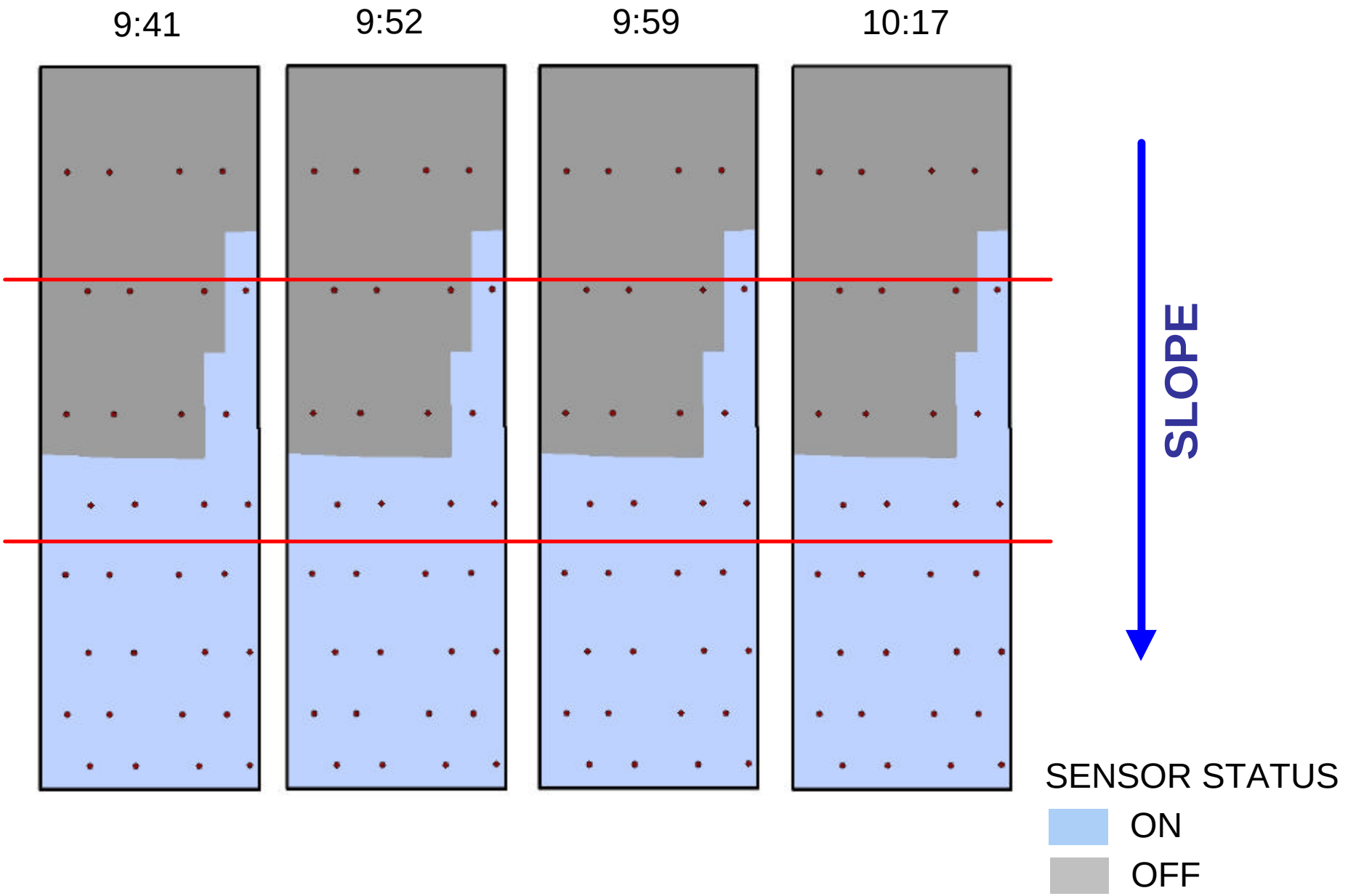
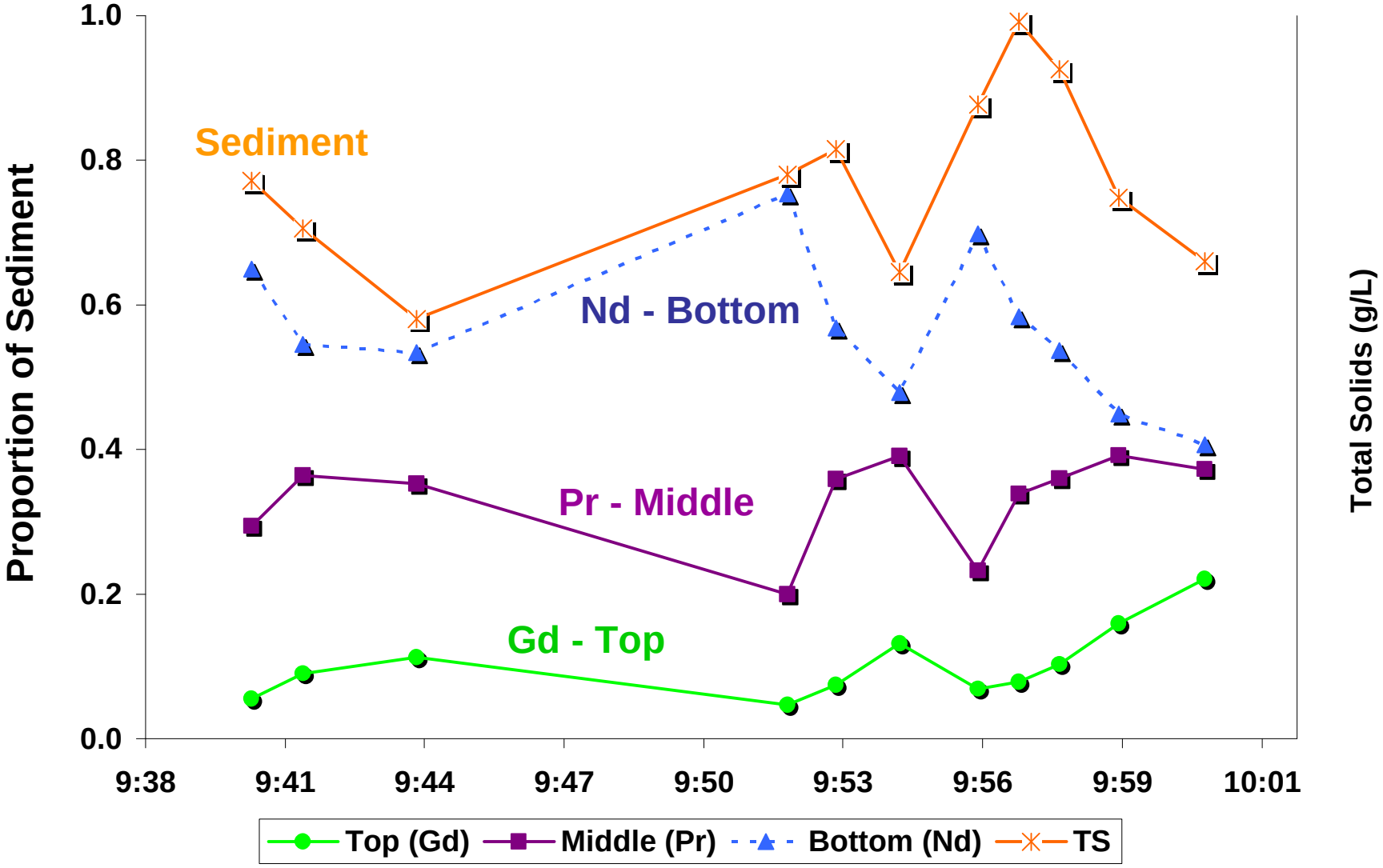
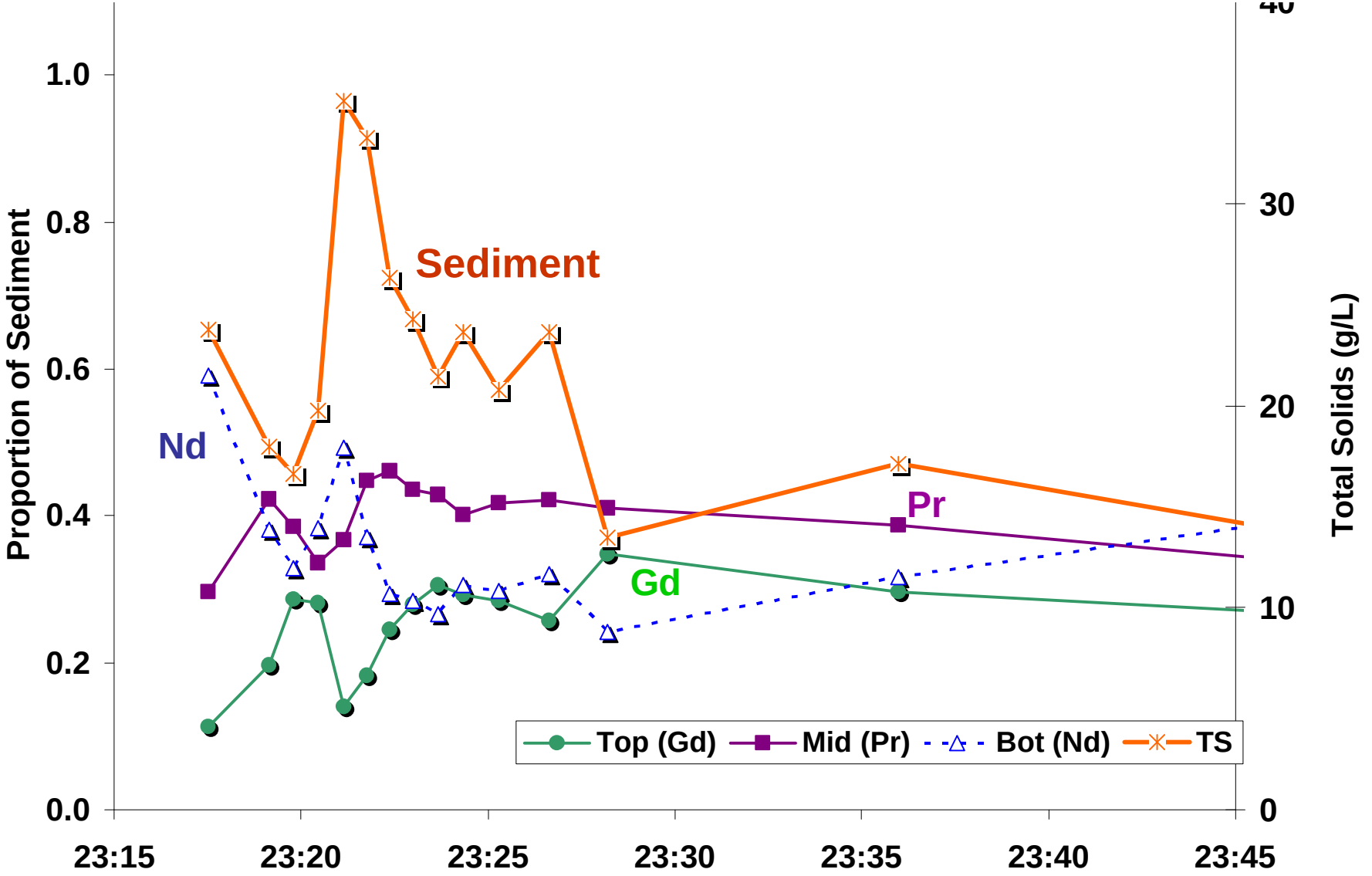


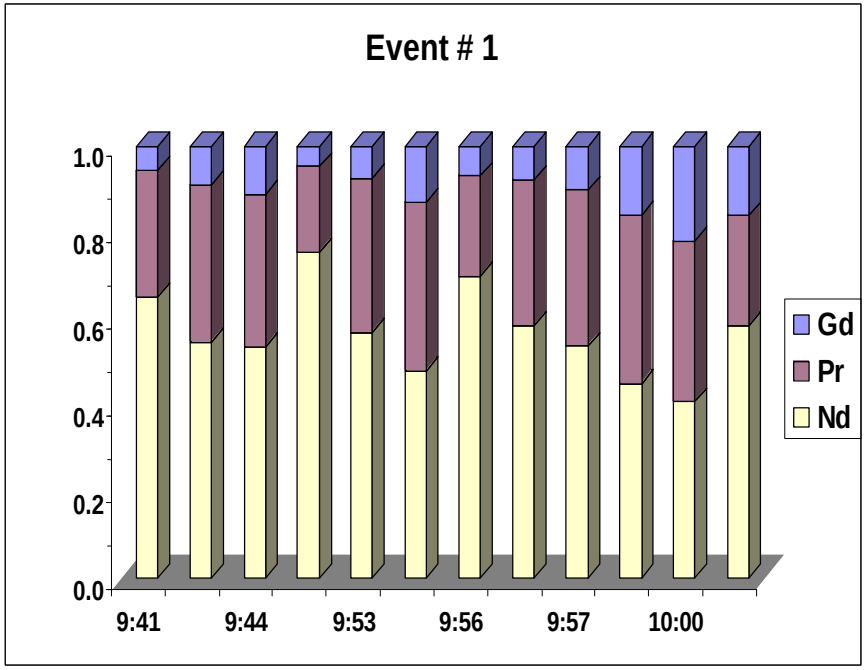
Event # 1 (Up-and-Down Tillage) – REE Distribution

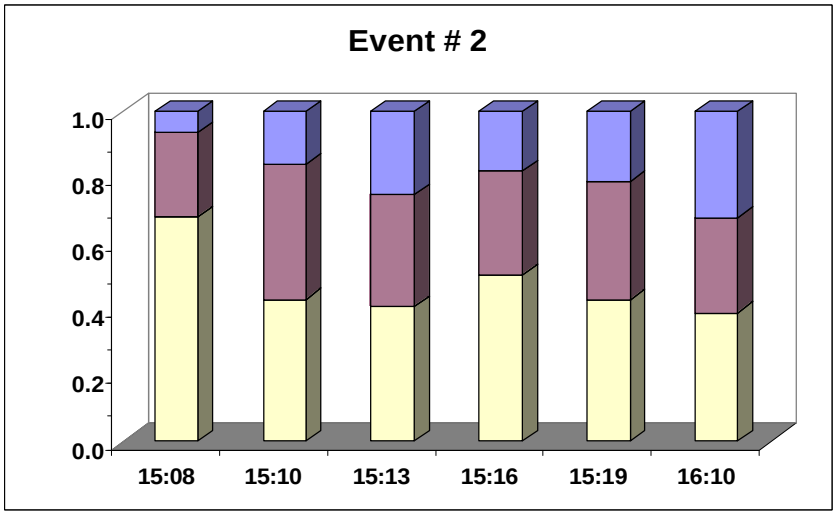


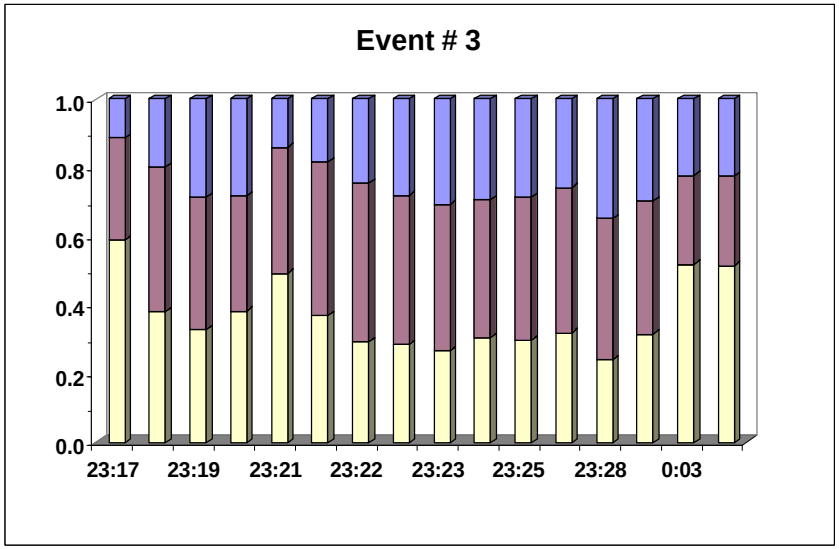
Event # 3 (Up-and-Down Tillage) – REE Distribution



Time Series – Relative Contribution from REE Segments





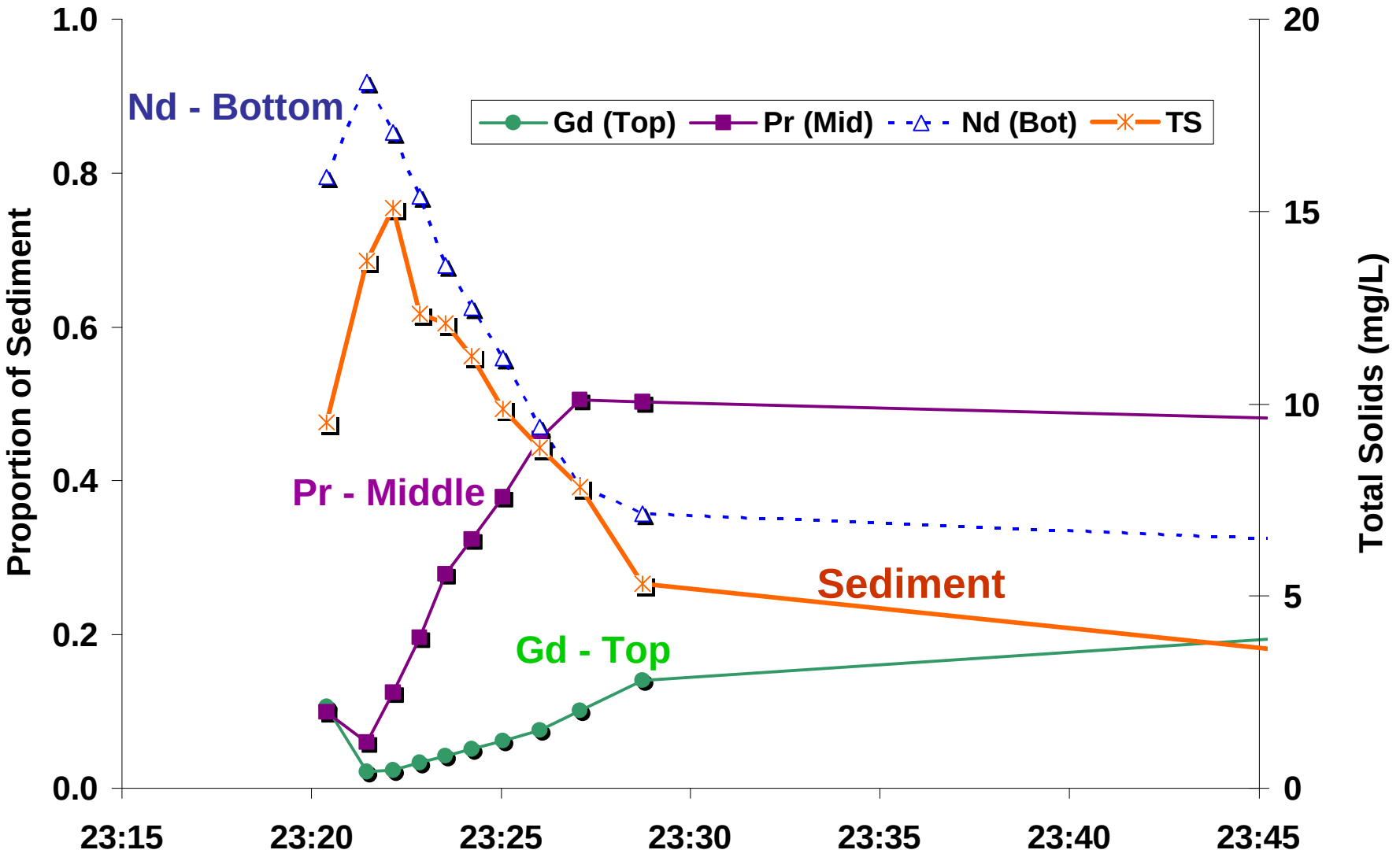


SUMMARY - REE TRACERS

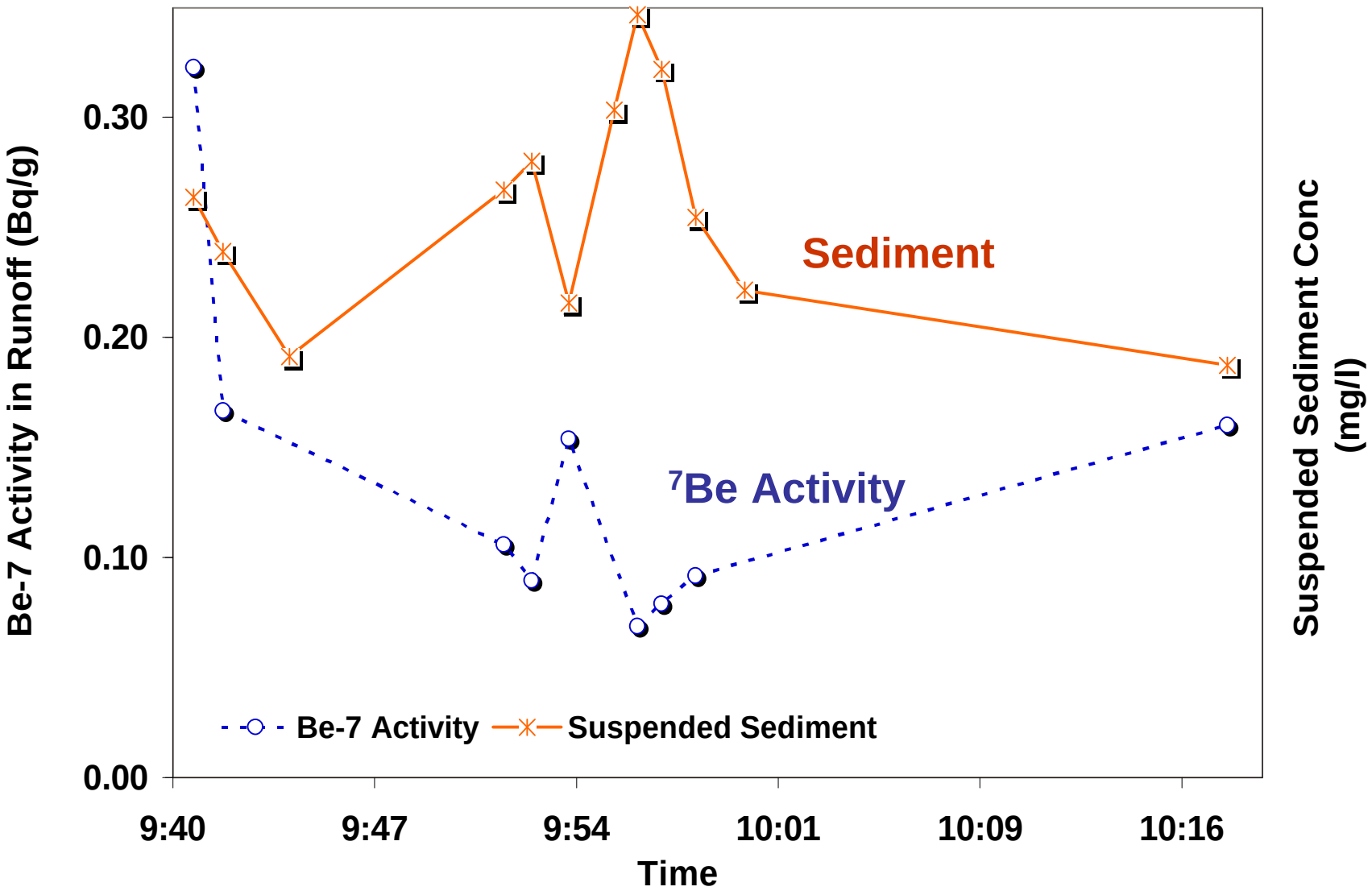
Total amount and percent of applied REE found in sediment for 3 runoff events

REE	July 20, 2005		July 23, 2005		July 26, 2005		
	mg	%	mg	%	mg	%	
Gd	47.8	0.29%	23.9	0.15%	186.2	1.15%	**1.59%**
Pr	154.1	0.71%	53.1	0.24%	355.0	1.62%	**2.57%**
Nd	1196.2	1.35%	362.1	0.41%	1470.5	1.66%	**3.42%**

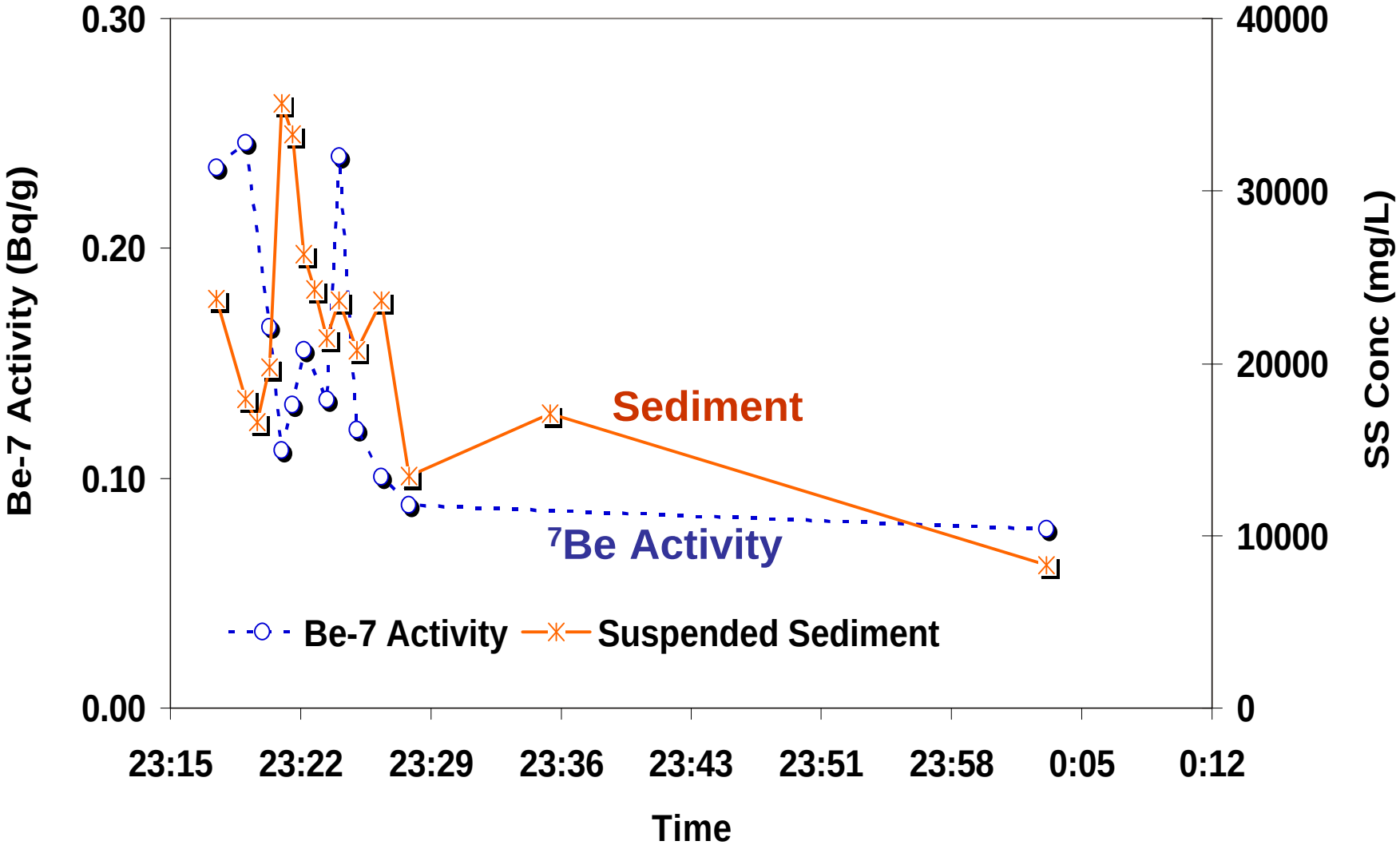
Event # 3 (Contouring) – REE Distribution



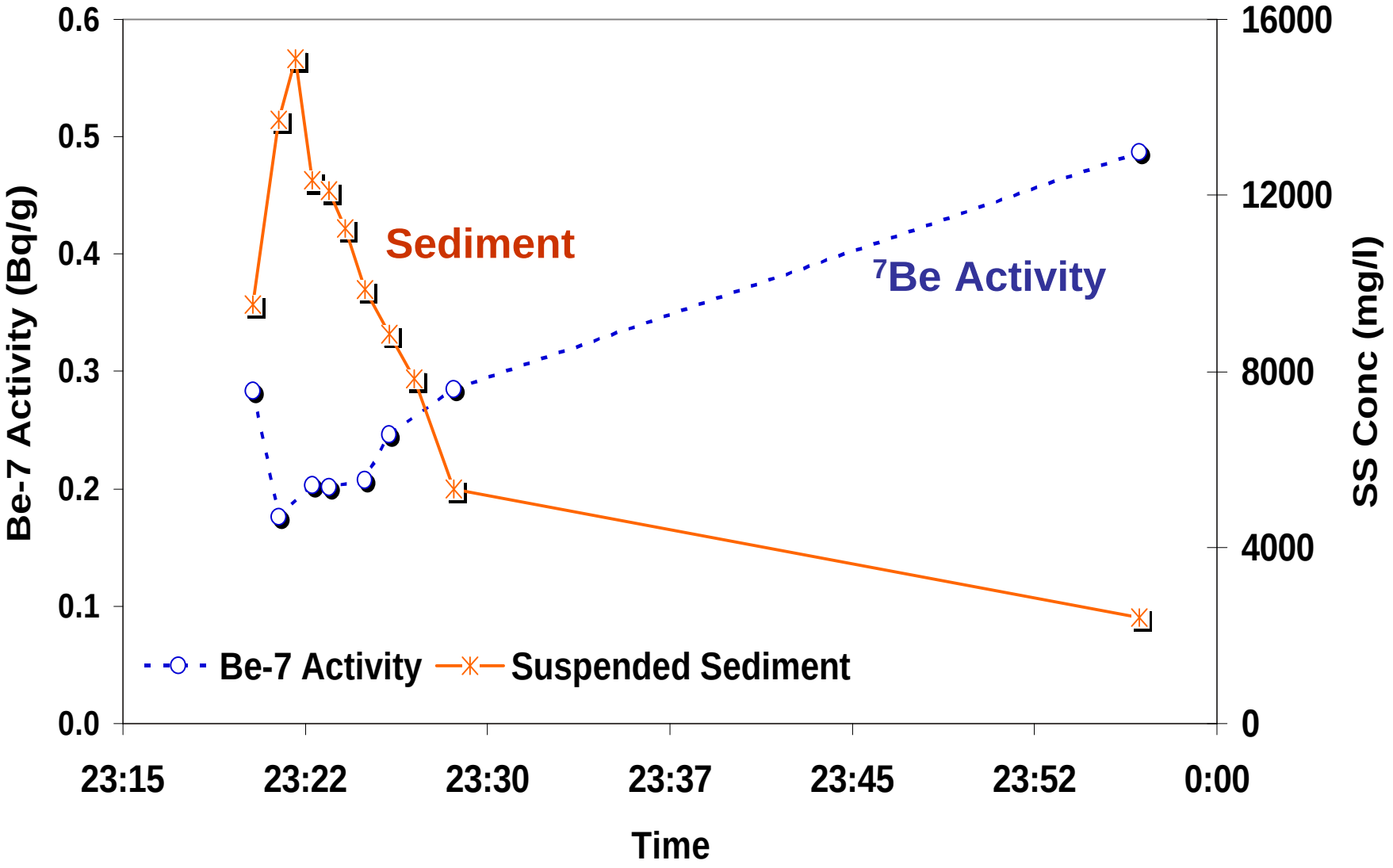
Event # 1 (Up-and-Down Tillage) – ^{7}Be Activity



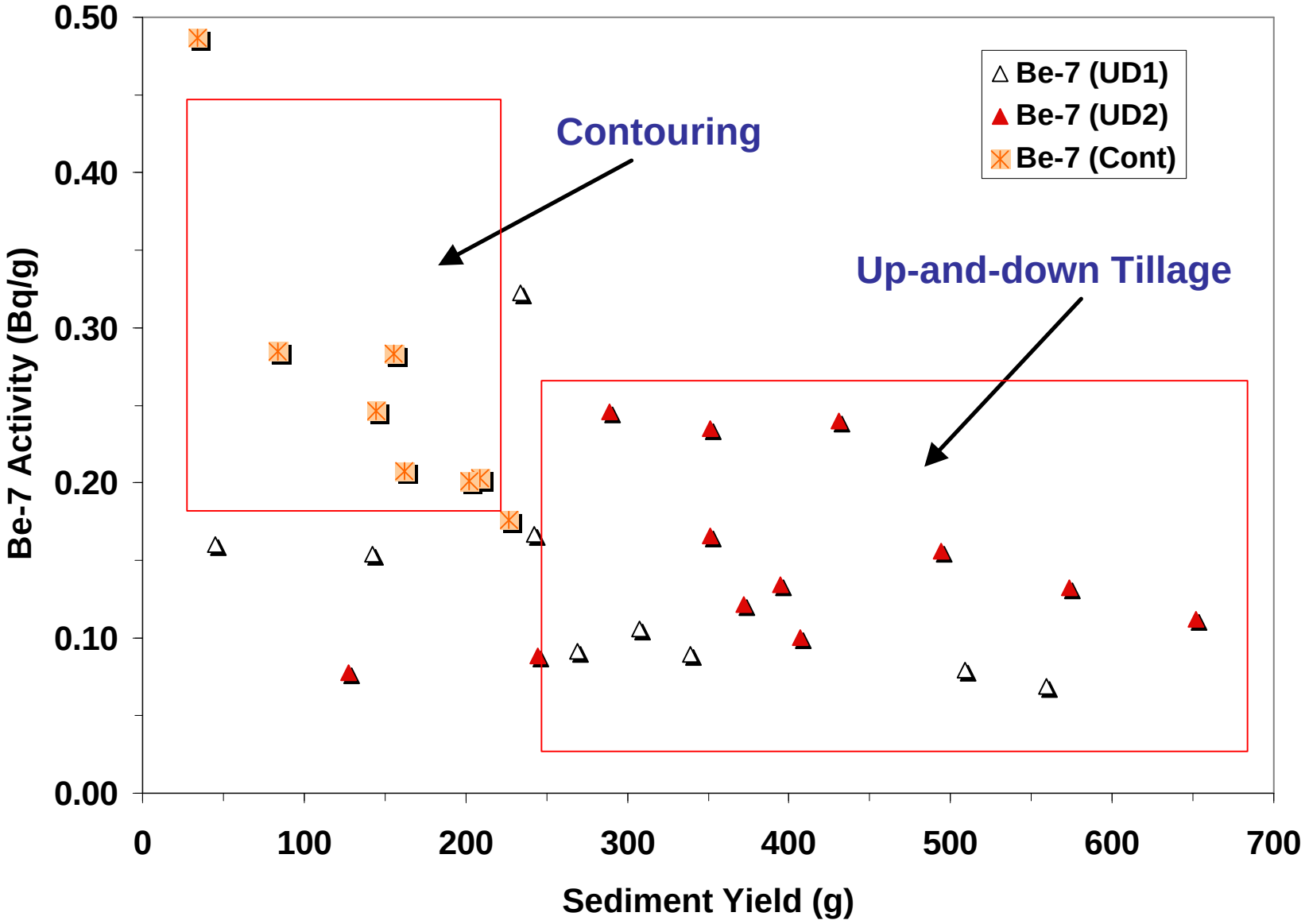
Event # 3 (Up-and-Down Tillage) – ^{7}Be Activity



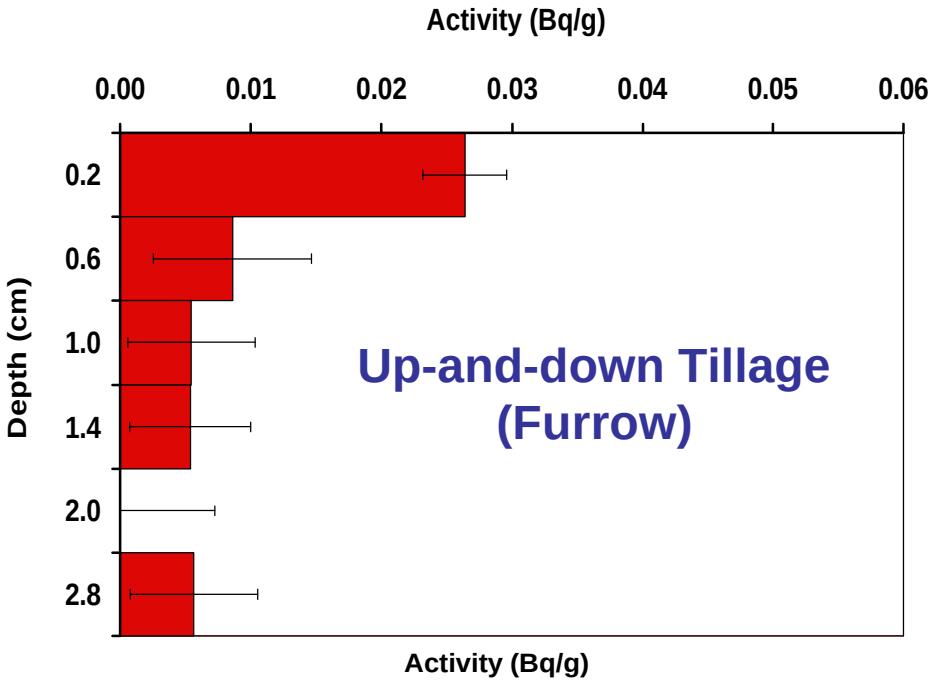
Event # 3 (Contouring) – ^{7}Be Activity

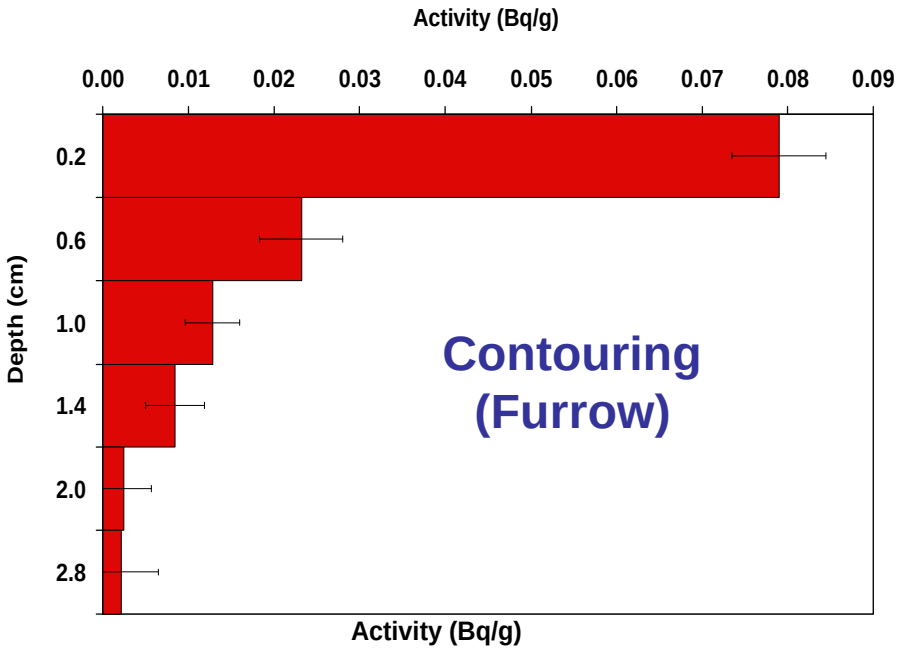


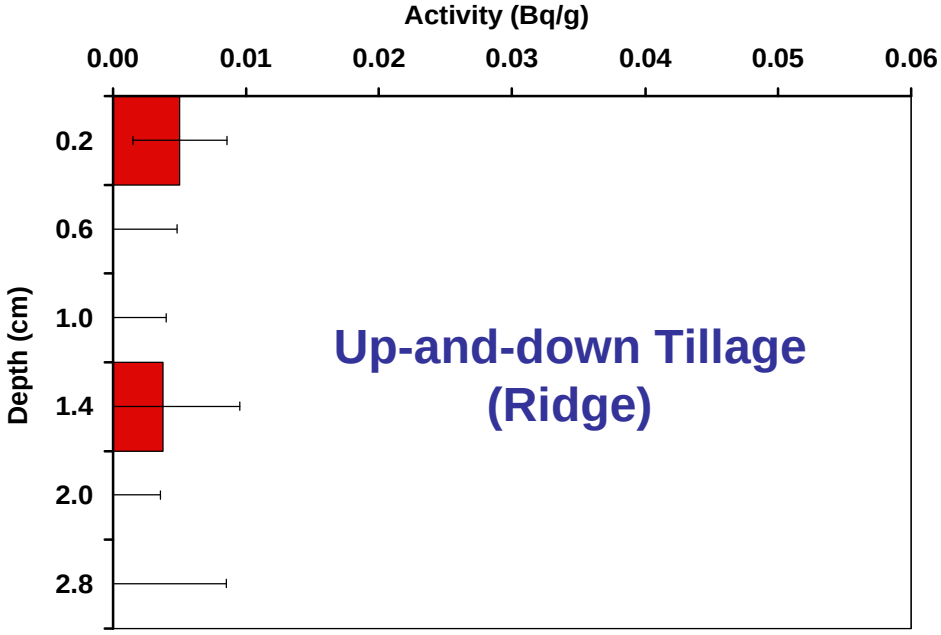
Sediment Yield vs. ^{7}Be Activity

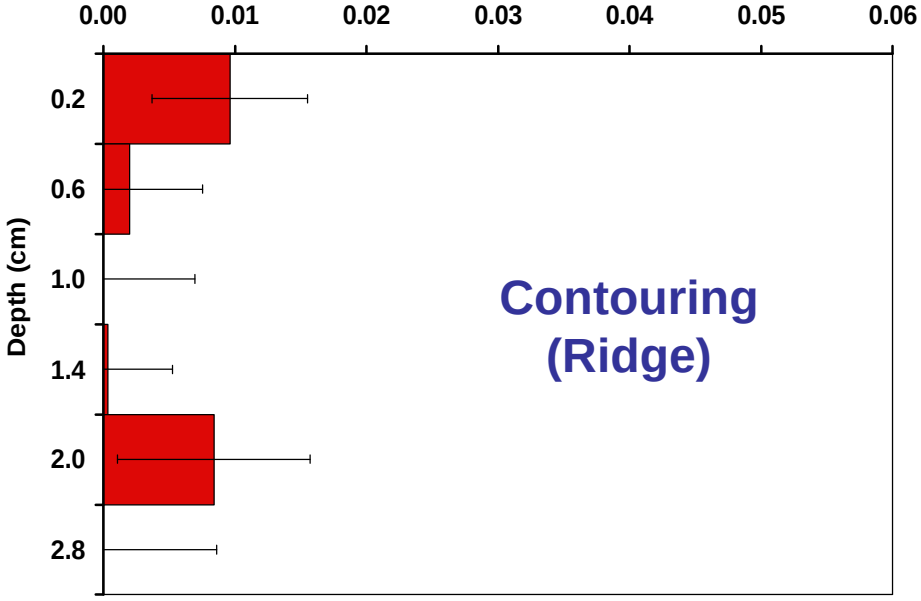


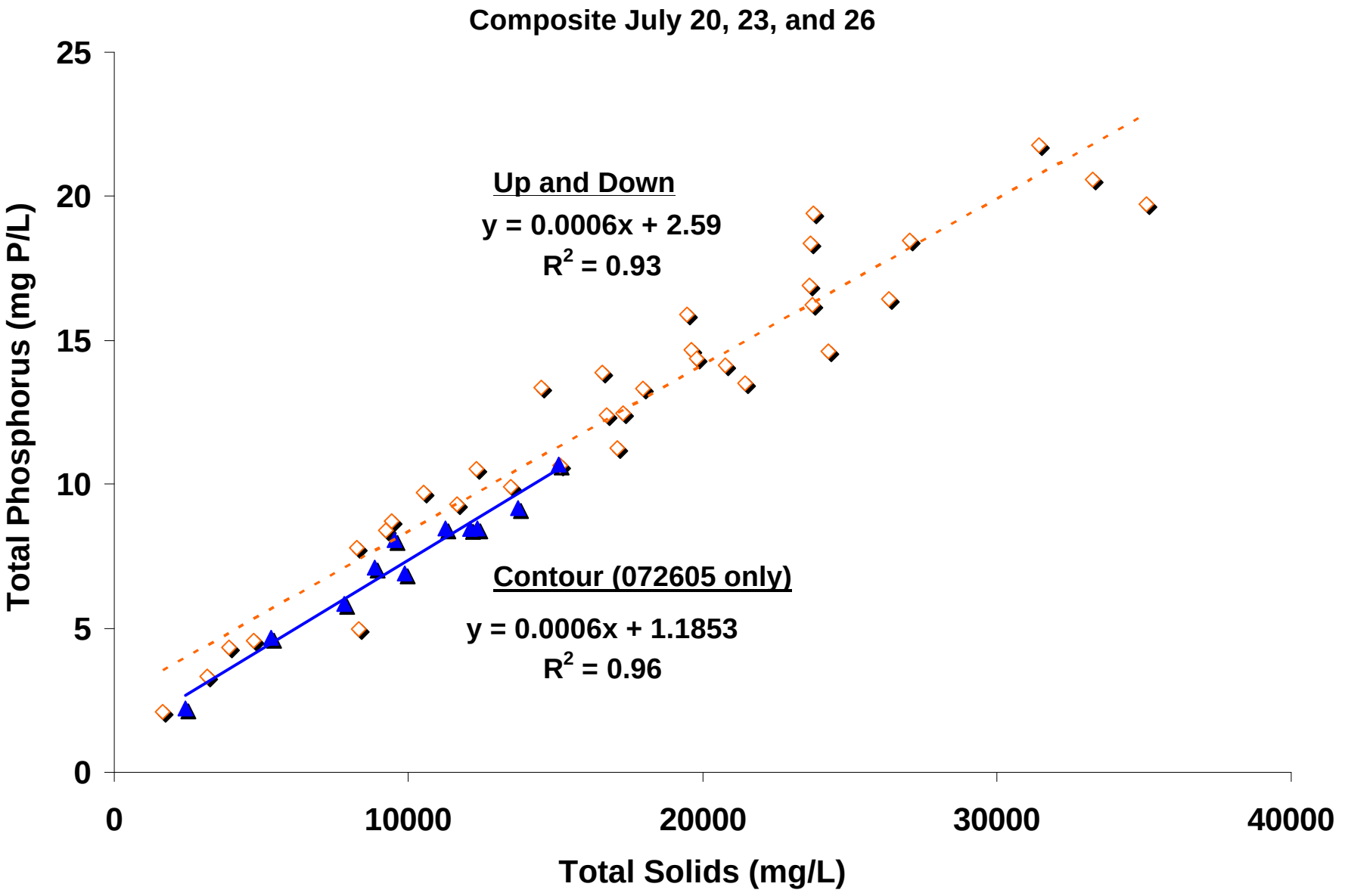
Depth Distribution of ^{7}Be










Composite July 20, 23, and 26
Total Phosphorus (mg P/L)
25
20
15
10
5
0
0
10000
20000
30000
40000
Total Solids (mg/L)
Up and Down
y = 0.0006x + 2.59
R2 = 0.93
Contour (072605 only)
y = 0.0006x + 1.1853
R2 = 0.96

SUMMARY

- Radiometric fingerprinting and REE tagging techniques provide information on erosion mechanisms and spatial and temporal patterns.

- Up-and-down tillage system dominated by rill erosion process whereas contributions from surficial sediments important for contour tillage.

- Future work on determining particle transport distances and areal extent for different erosion mechanisms.

ACKNOWLEDGMENTS

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