Water Quality of Agricultural Runoff in the Lake Champlain Basin of New York

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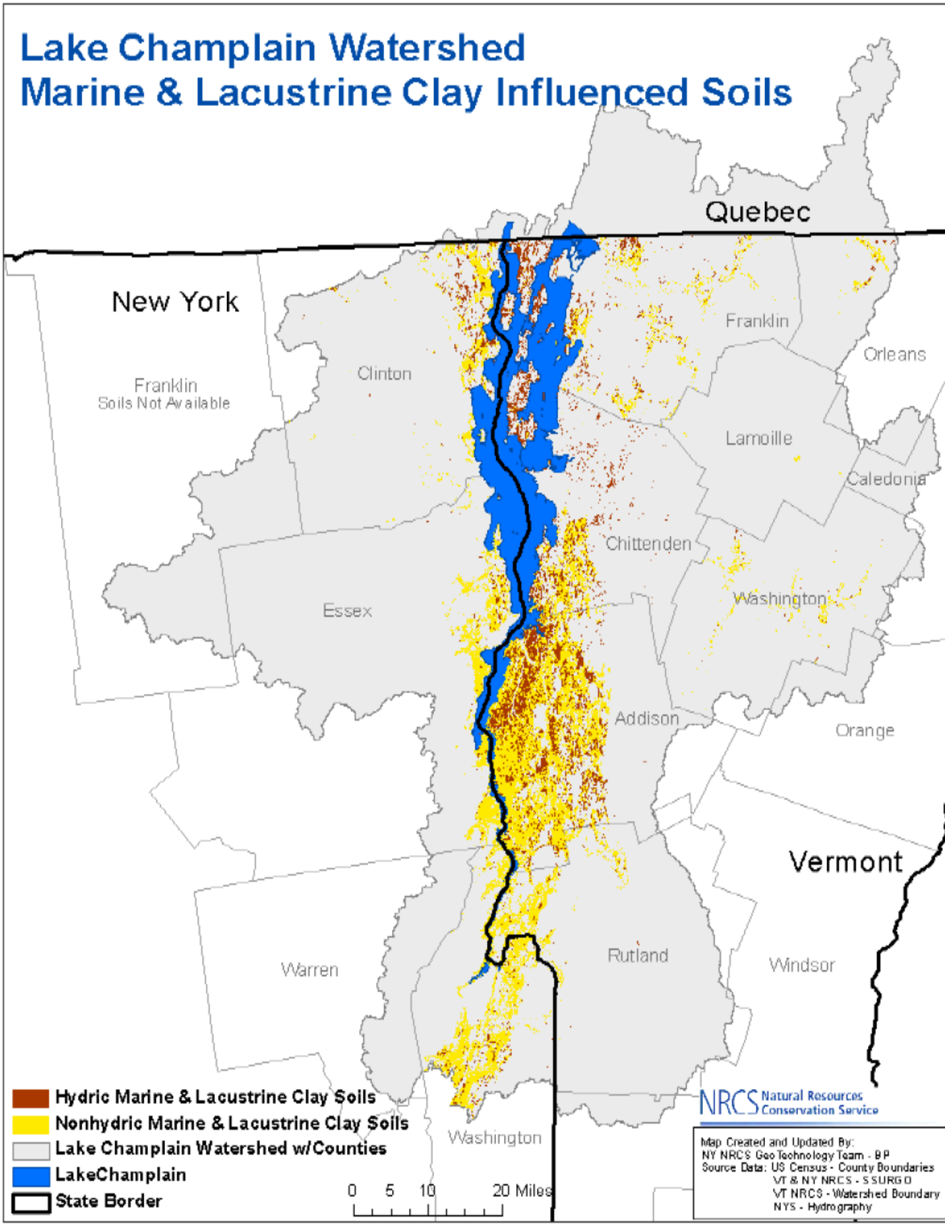
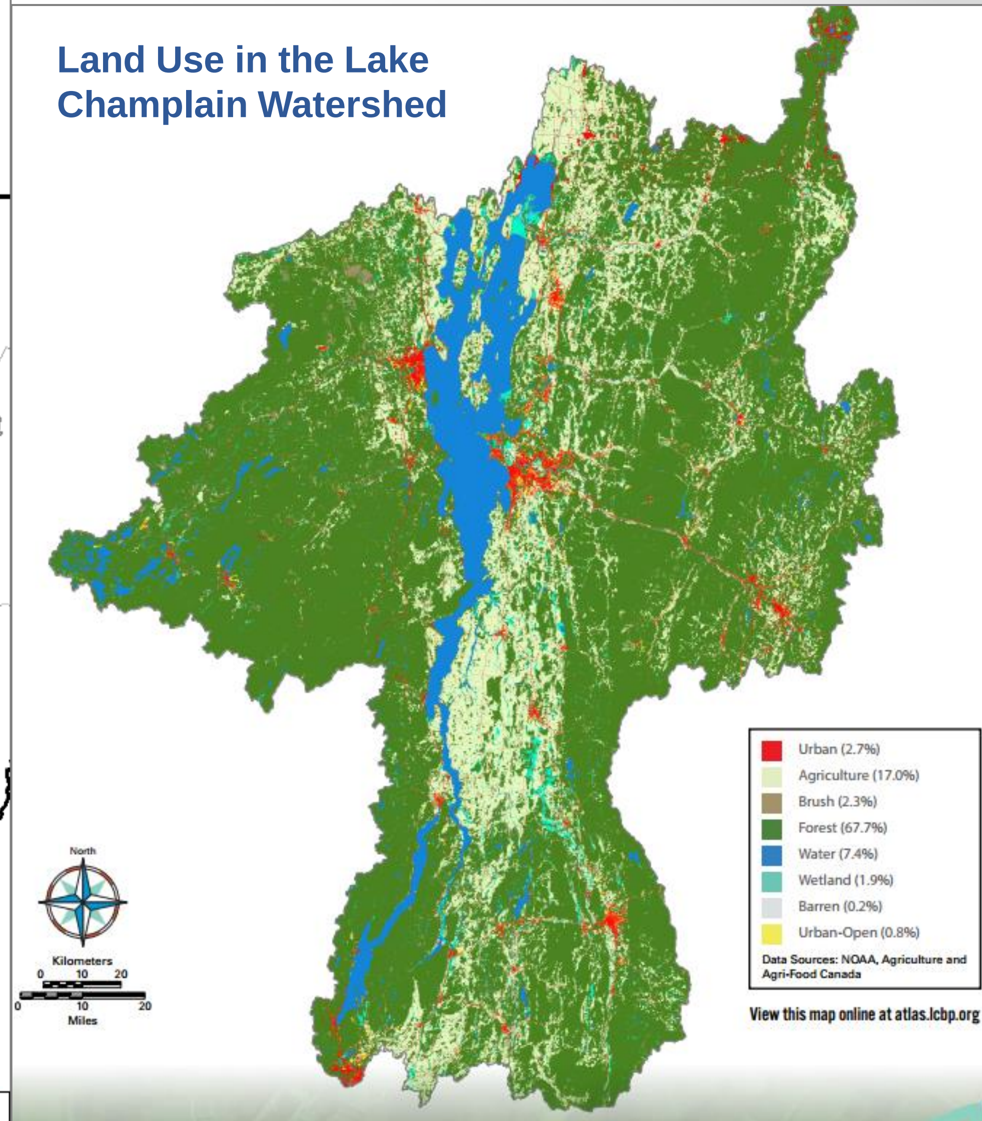
Vermont House Agriculture and Forestry Committee
February 15, 2019

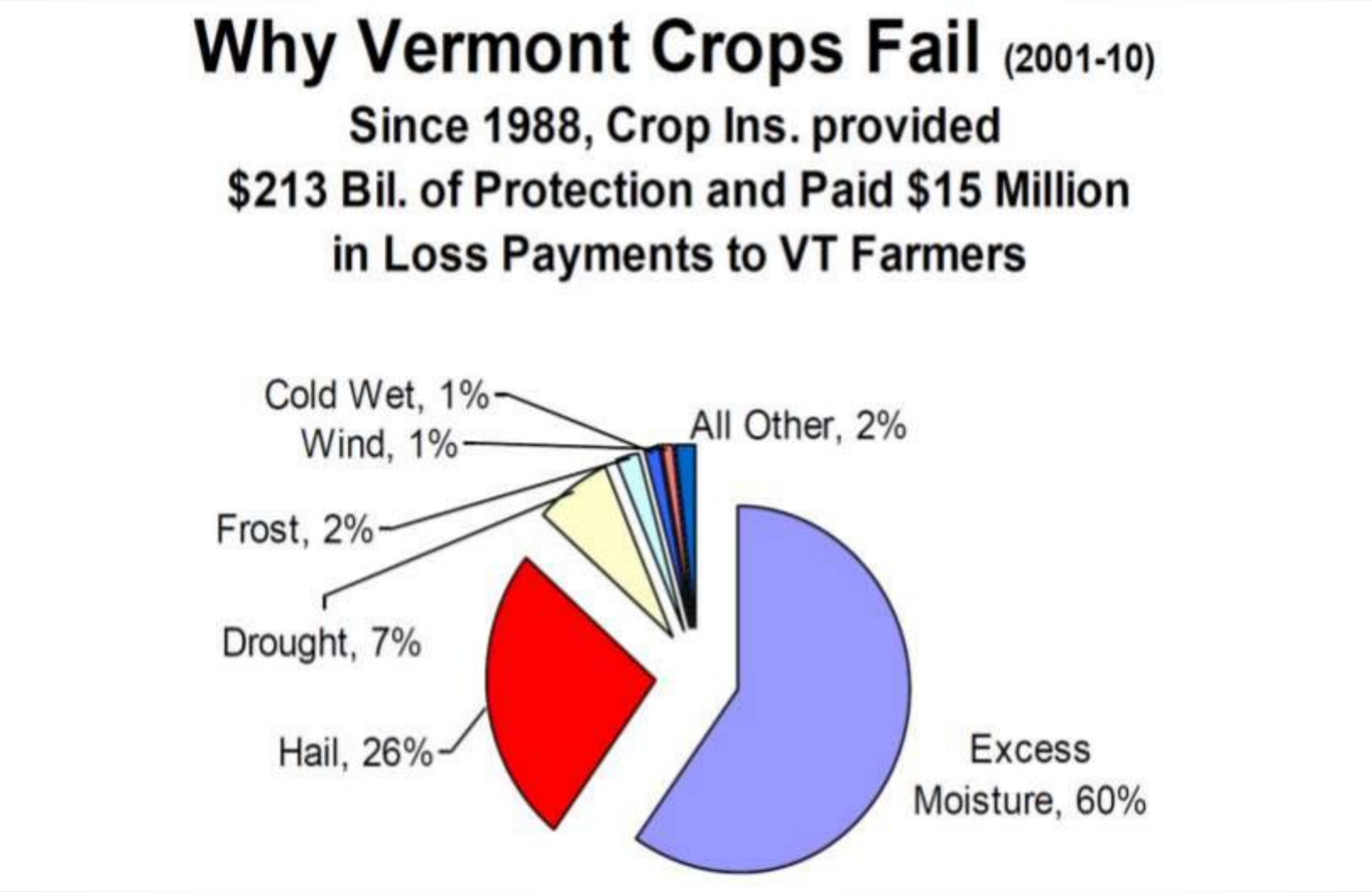


Lake Champlain Watershed
Marine & Lacustrine Clay Influenced Soils
Quebec
New York
Franklin
Soils Not Available
Clinton
Essex
Warren
Washington
Franklin
Orleans
Lamoille
Caledonia
Chittenden
Washington
Addison
Orange
Vermont
Rutland
Windsor
Hydric Marine & Lacustrine Clay Soils
Nonhydric Marine & Lacustrine Clay Soils
Lake Champlain Watershed w/Counties
LakeChamplain
State Border
0 5 10 20 Miles
NRCS Natural Resources Conservation Service
Map Created and Updated By:
NY NRCS Geo Technology Team - BP
Source Data: US Census - County Boundaries
VT & NY NRCS - SSURGO
VT NRCS - Watershed Boundary
NYS - Hydrography



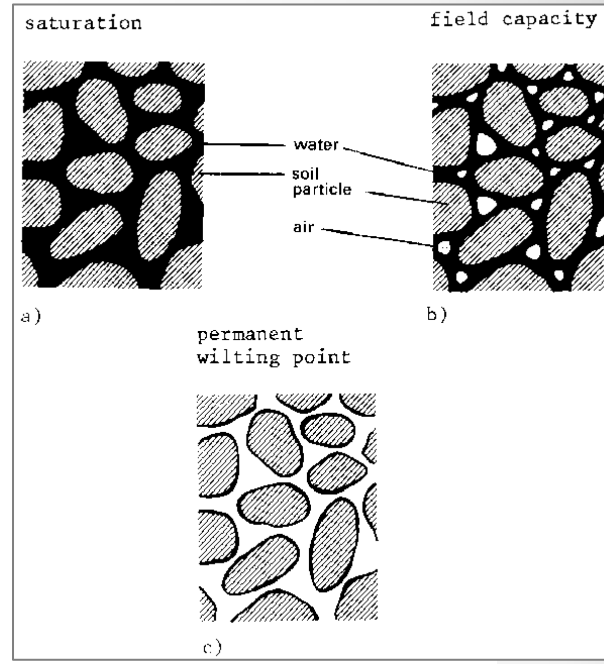
Land Use in the Lake Champlain Watershed
Urban (2.7%)
Agriculture (17.0%)
Brush (2.3%)
Forest (67.7%)
Water (7.4%)
Wetland (1.9%)
Barren (0.2%)
Urban-Open (0.8%)
Data Sources: NOAA, Agriculture and Agri-Food Canada
North
Kilometers
0 10 20
0 10 20
Miles
View this map online at atlas.lcbp.org

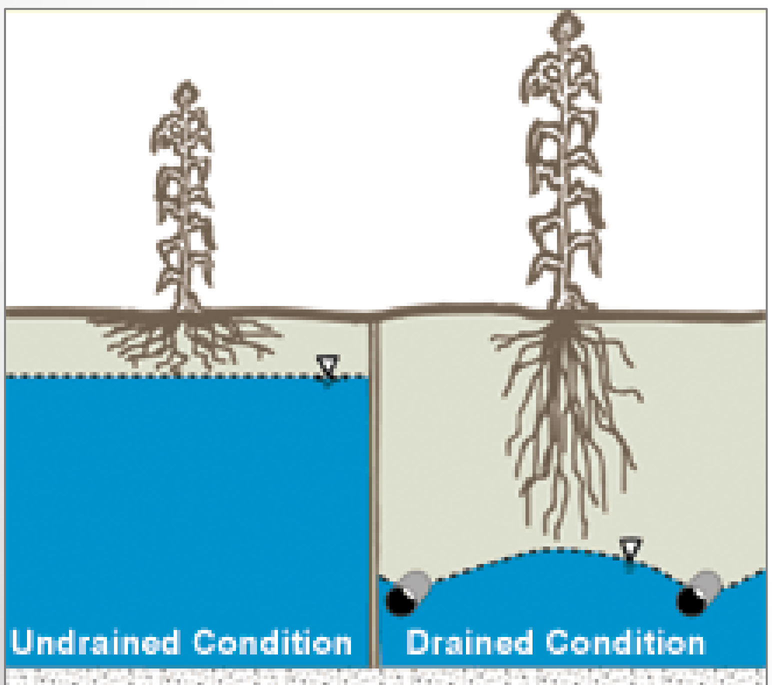
Need for improved drainage



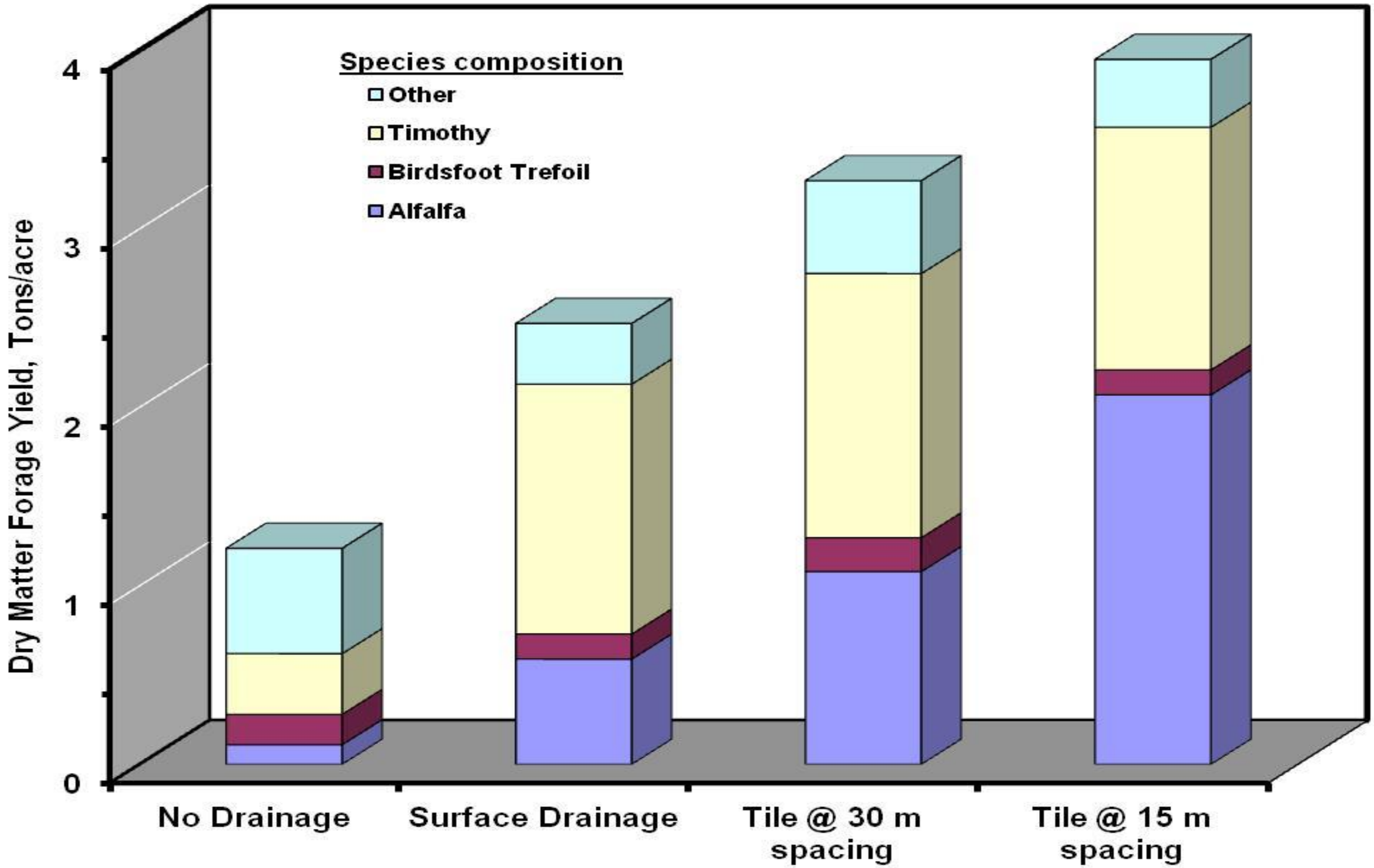
Benefits of Tile Drainage

- Drains excess water from fields
- Reduces compaction potential
- Improves water and nutrient efficiencies
- Higher crop yield and quality
  - Reduces need for imported feed
- ***Lengthens growing season***





Yield benefits in NNY



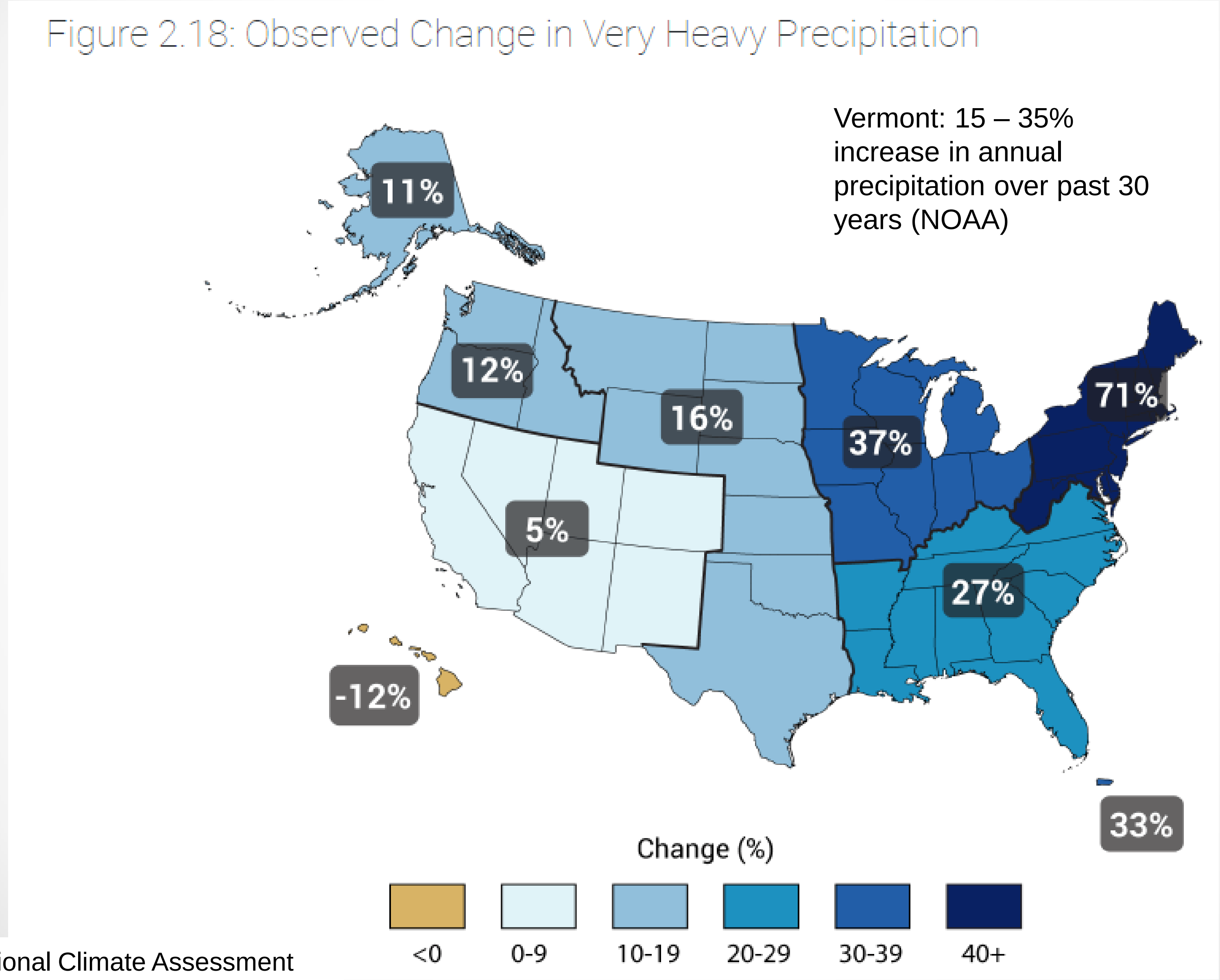
Geohring et al., 1985

Reducing uncertainty

Table 1. Corn Yields with Various Drainage Systems on Toledo Silty Clay Soil in North Central Ohio, 13 Years of Record.

	Drainage system			
Crop	None	Surface only	Tile only	Surface and tile
Corn (bu/ac)	60	92	116	121
Yield Variation	46%	33%	18%	18%

Extreme Events



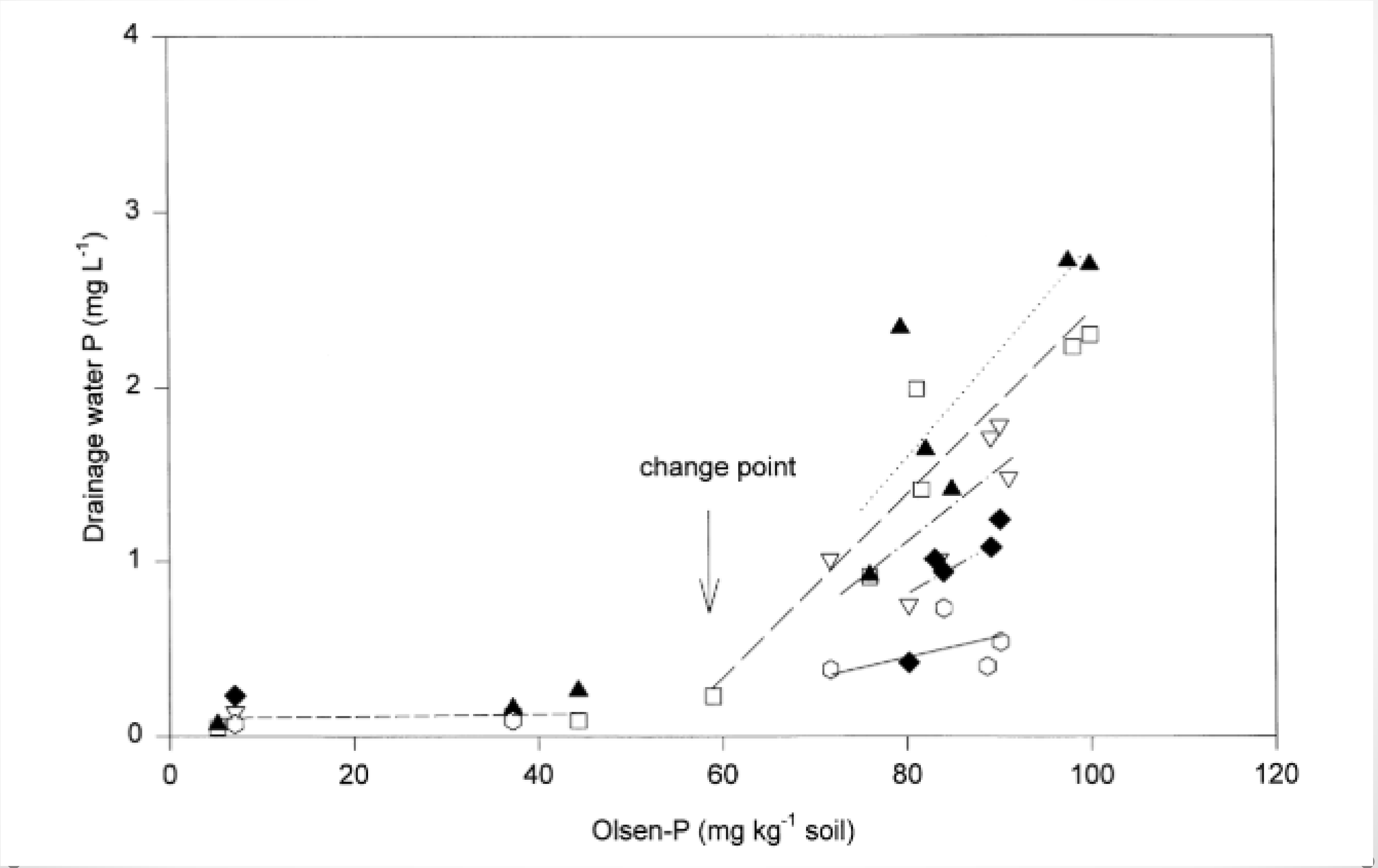
Vermont: 15 – 35% increase in annual precipitation over past 30 years (NOAA)

Figure: National Climate Assessment (GlobalChange.gov)

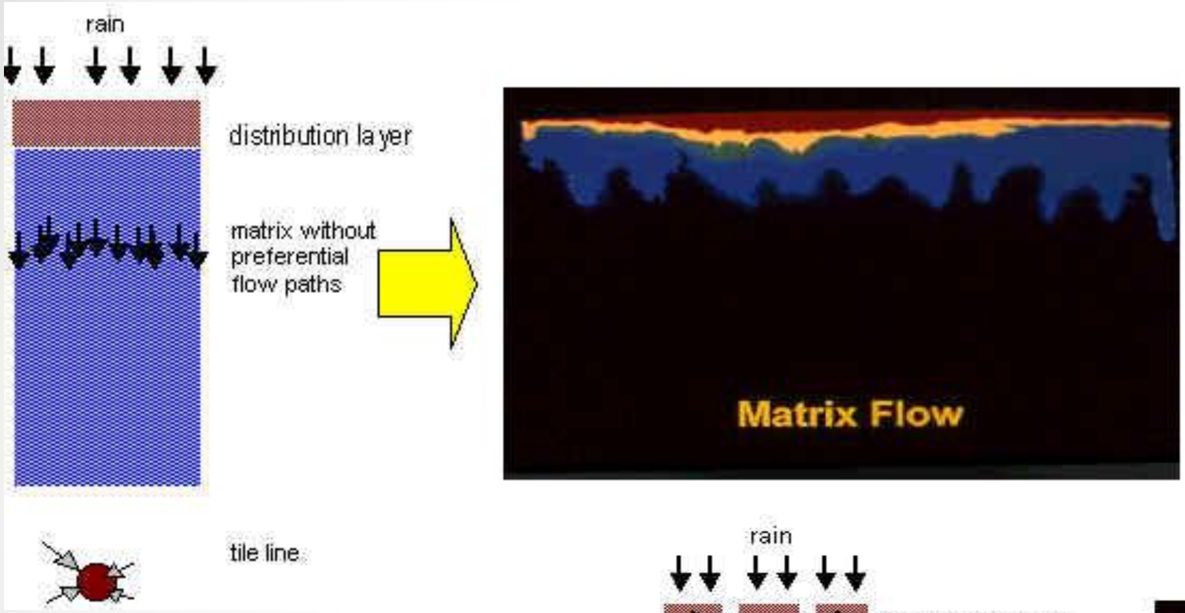
Tile Drainage and Water Quality

- Results mixed – site, climate, and management dependent (King et al., 2015)
- Tile drainage water – lower concentrations of P and sediment than surface runoff; but higher flow volumes (Gilliam et al., 1999)
- TP export from tiles (mineral soils) – 0.35 lb/ac to 1.4 lb/ac (King et al., 2015)
- Nitrate-N export (leaching) tends to increase from tiled fields
- Denitrification rates decrease (Nitrate → gaseous N forms) – lower N volatilization; weather dependent

Understand the risks: Nutrient management is key

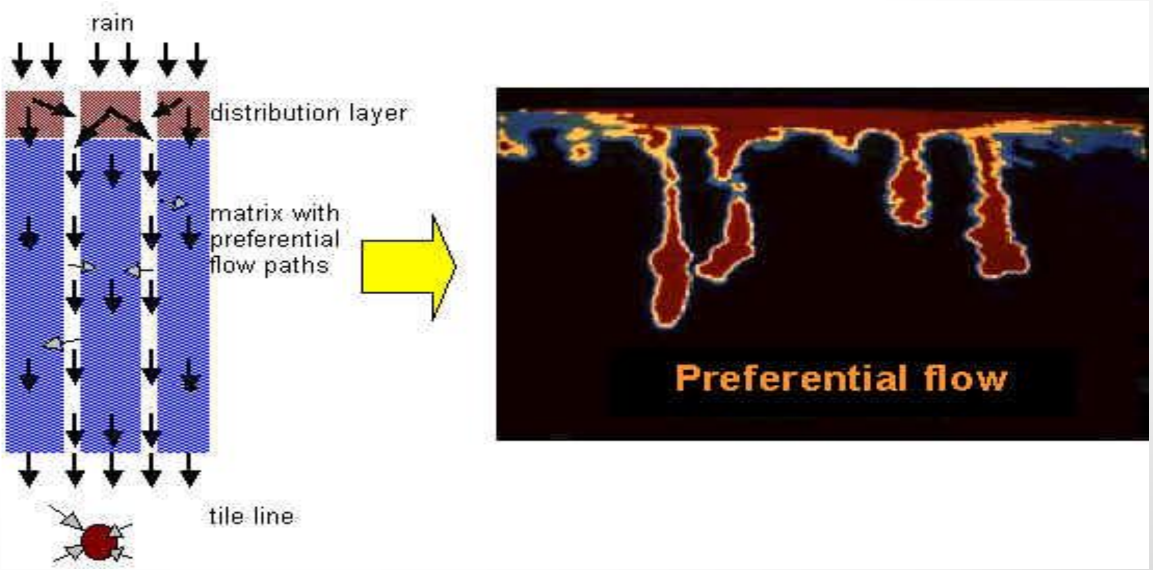


Tiles and Preferential flow

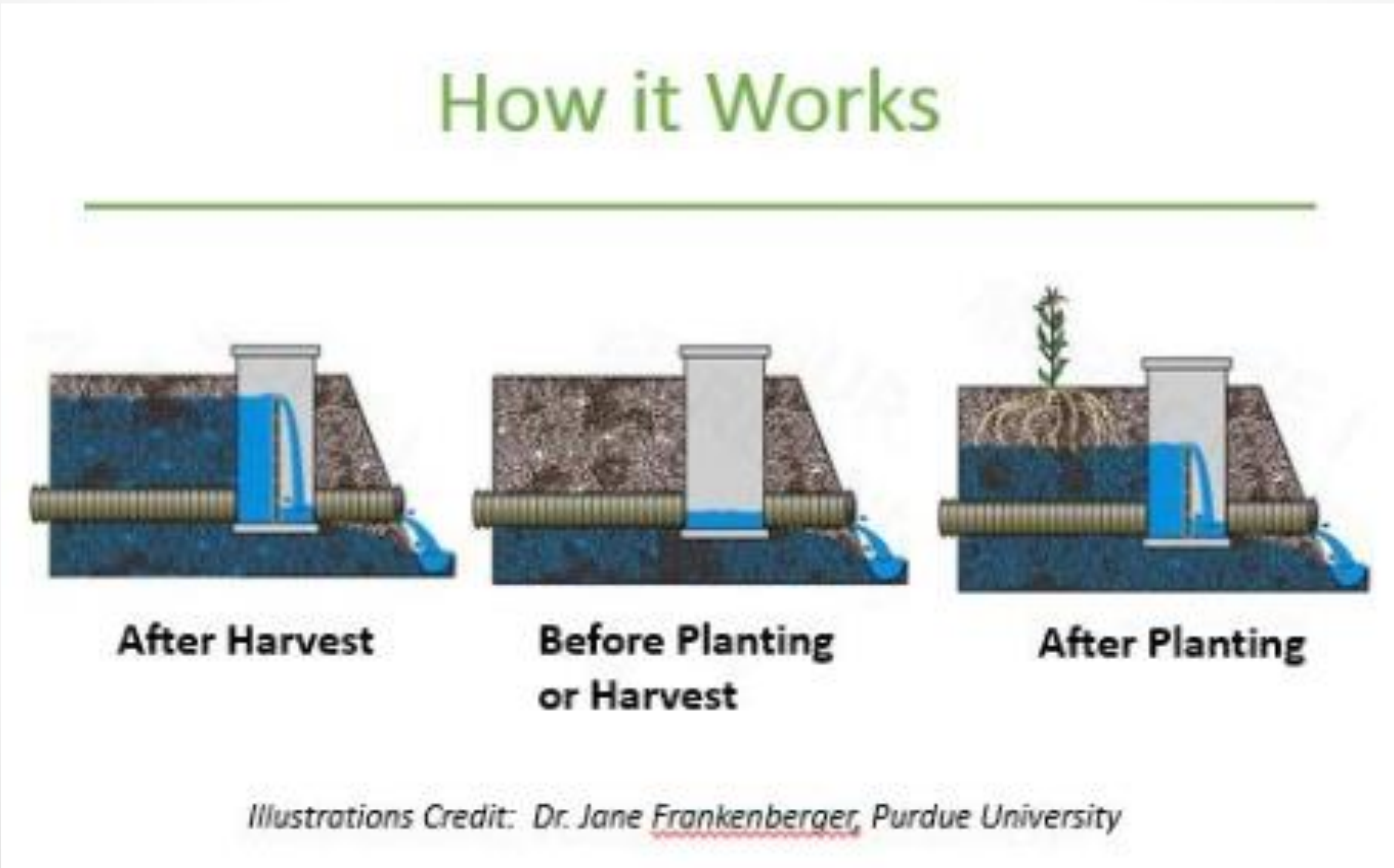


<u>Macropores</u>

- Shrink/swell clays
- Earthworm burrows
- Root channels



Drainage water management aka Controlled drainage



Drainage water management

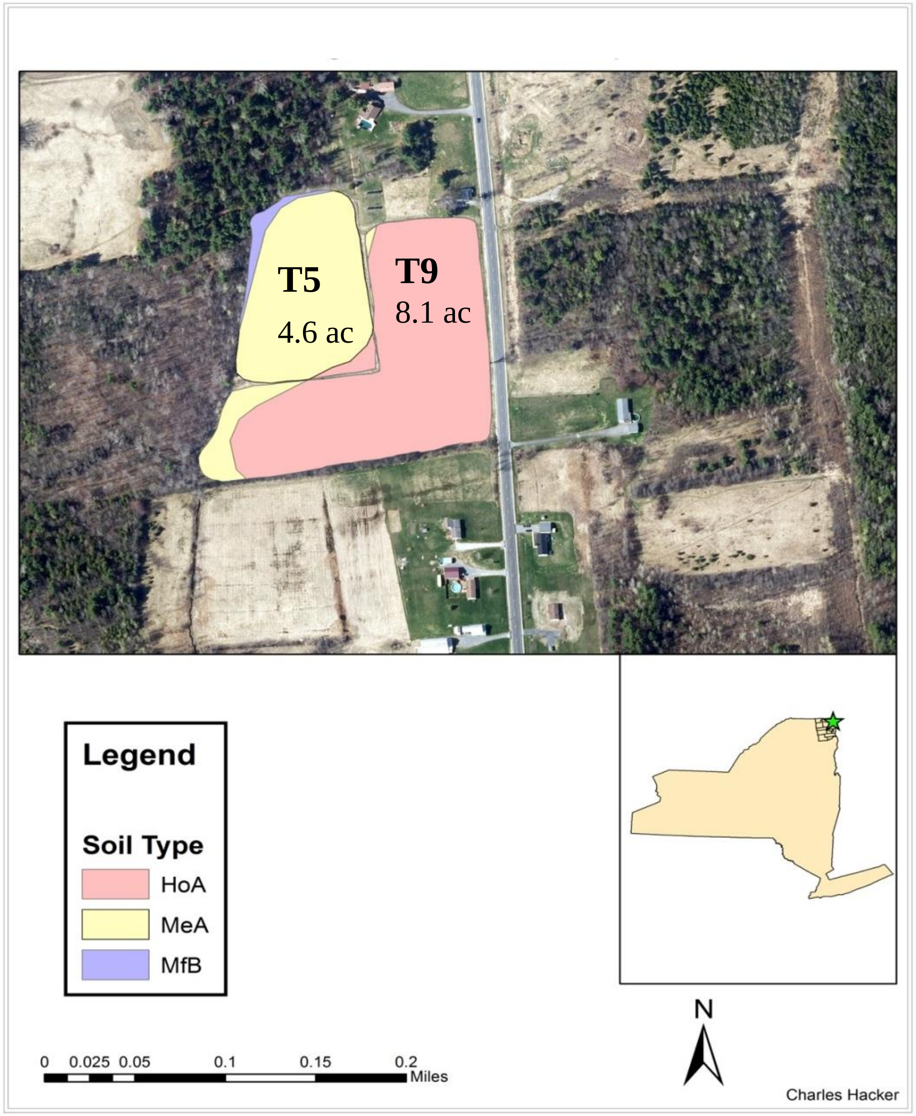
NRCS Edge-of-field Study
Drainage water management

Objective:

- Measure P, N, and TSS exports from tile and surface runoff
- 2-year baseline, 4-year treatment period
- Drainage water management (DWM) initiated Dec. 2017

Site:

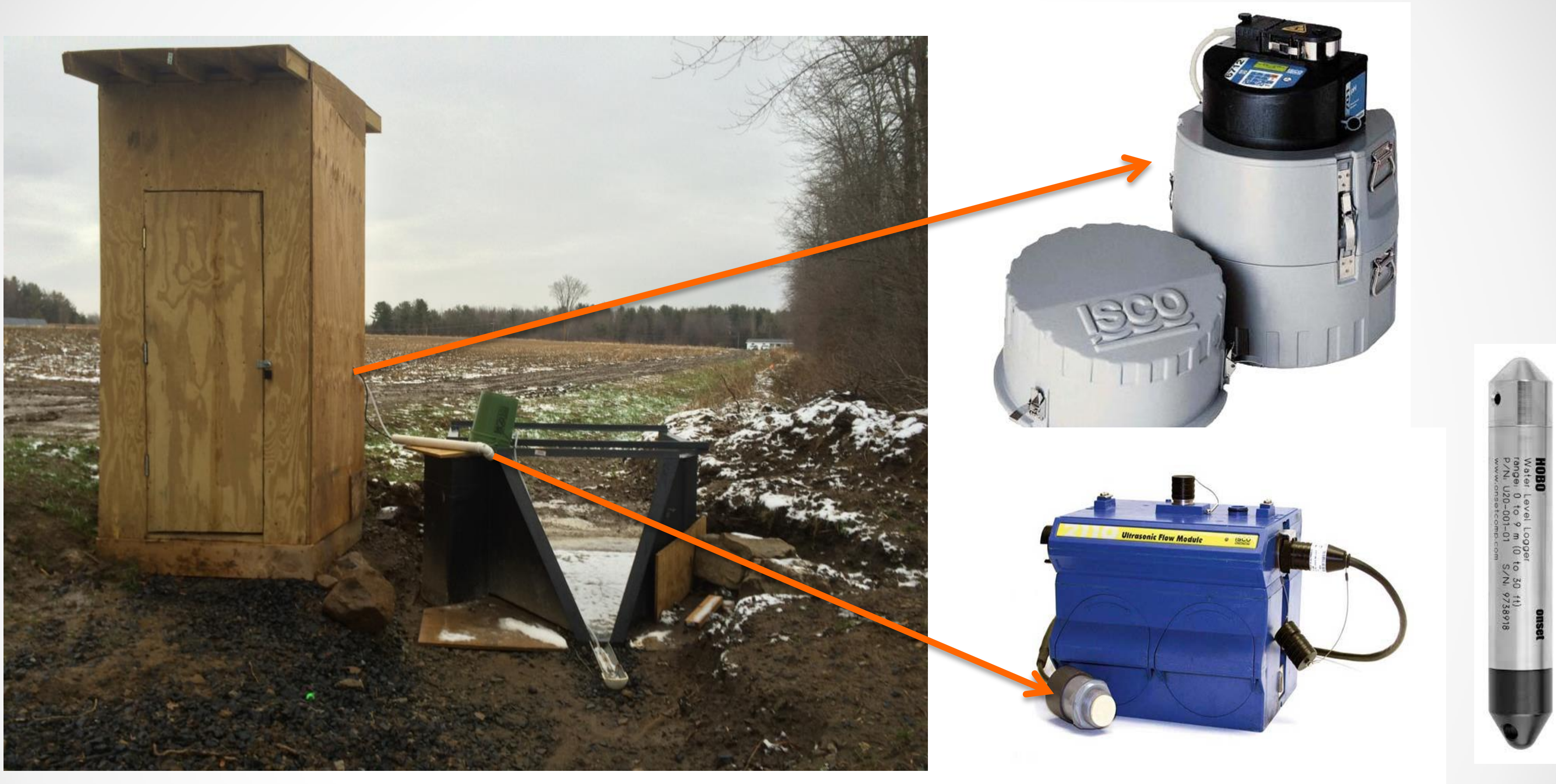
- Chazy, NY
- Small paired watersheds (4.6 & 8.1 ac fields)
- 4 ft tile depth; 35 ft lateral spacing
- 1-2% field slope



Agronomic Considerations

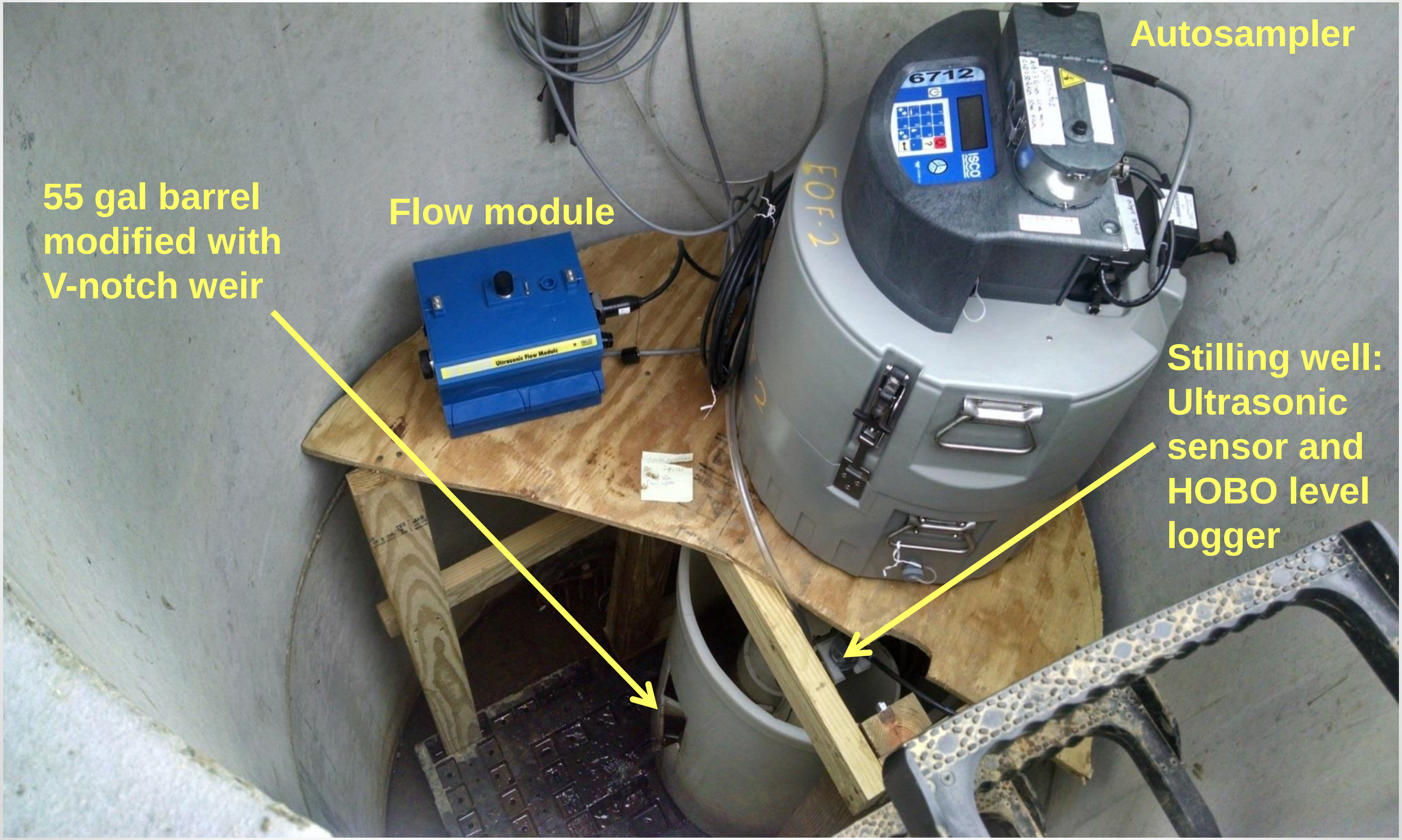
- Fields managed as corn for silage
- Modifed Morgan Soil test P: medium (2.2-3.0 lb ac^{-1}) Fertilizer application 2016-2018
    - 100 lb ac^{-1} of 23-12-18 fertilizer at planting
    - 32% UAN as sidedress: 80 lb ac^{-1} (2016, 2017), 60 lb ac^{-1} (2018)
- Fall 2015, 2017: 5,000 L ha^{-1} liquid dairy manure
- Spring 2017: 22 ton ac^{-1} composted dairy manure
- Manure applications surface applied and incorporated within 2 days

Surface Runoff Monitoring

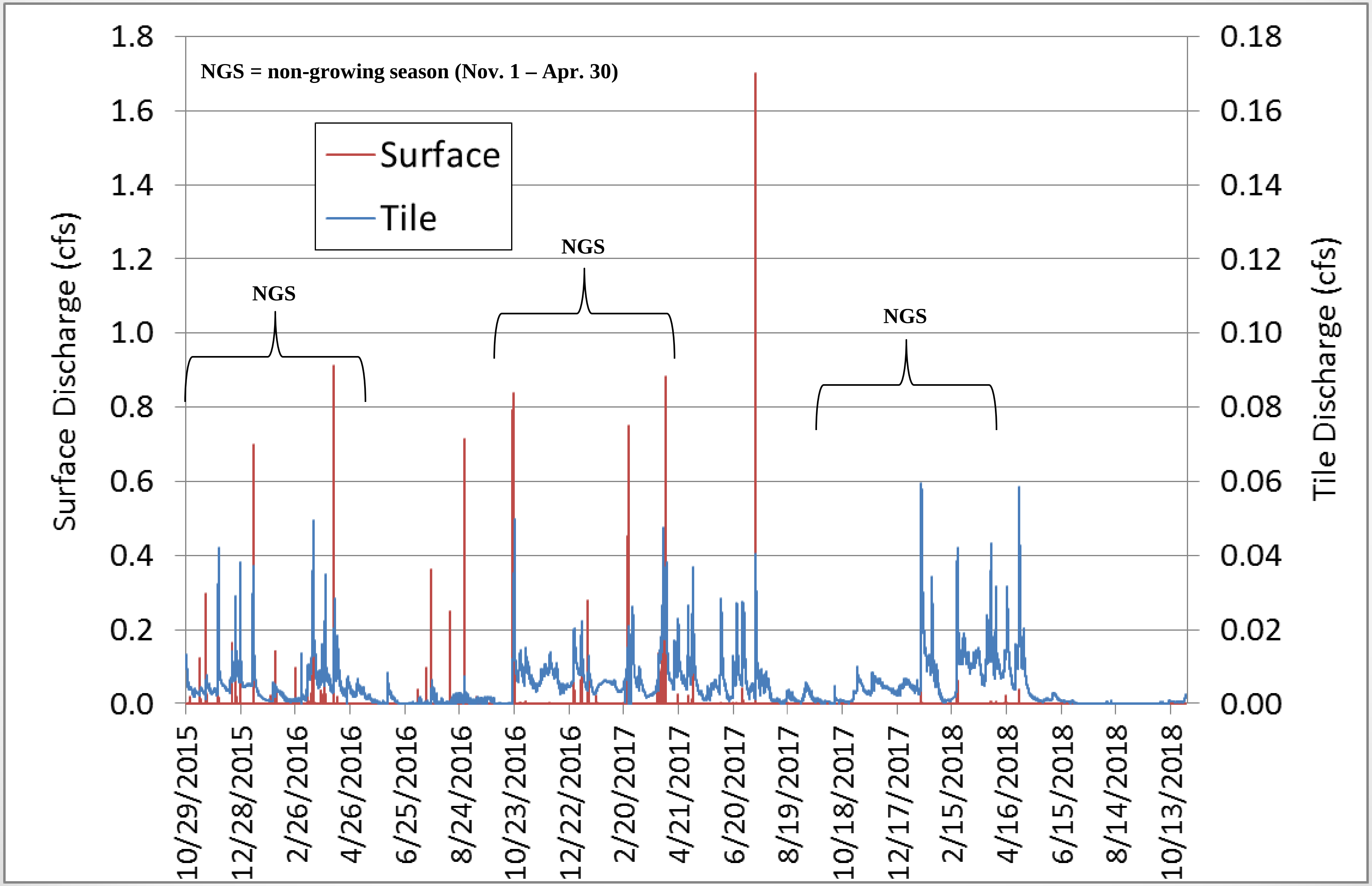


- Flow-based sampling: sample/0.35 mm of runoff
- Composite sample collected 2x/week minimum
- Total suspended solids, total P, dissolved reactive P, total N, nitrate-N, ammonium-N,

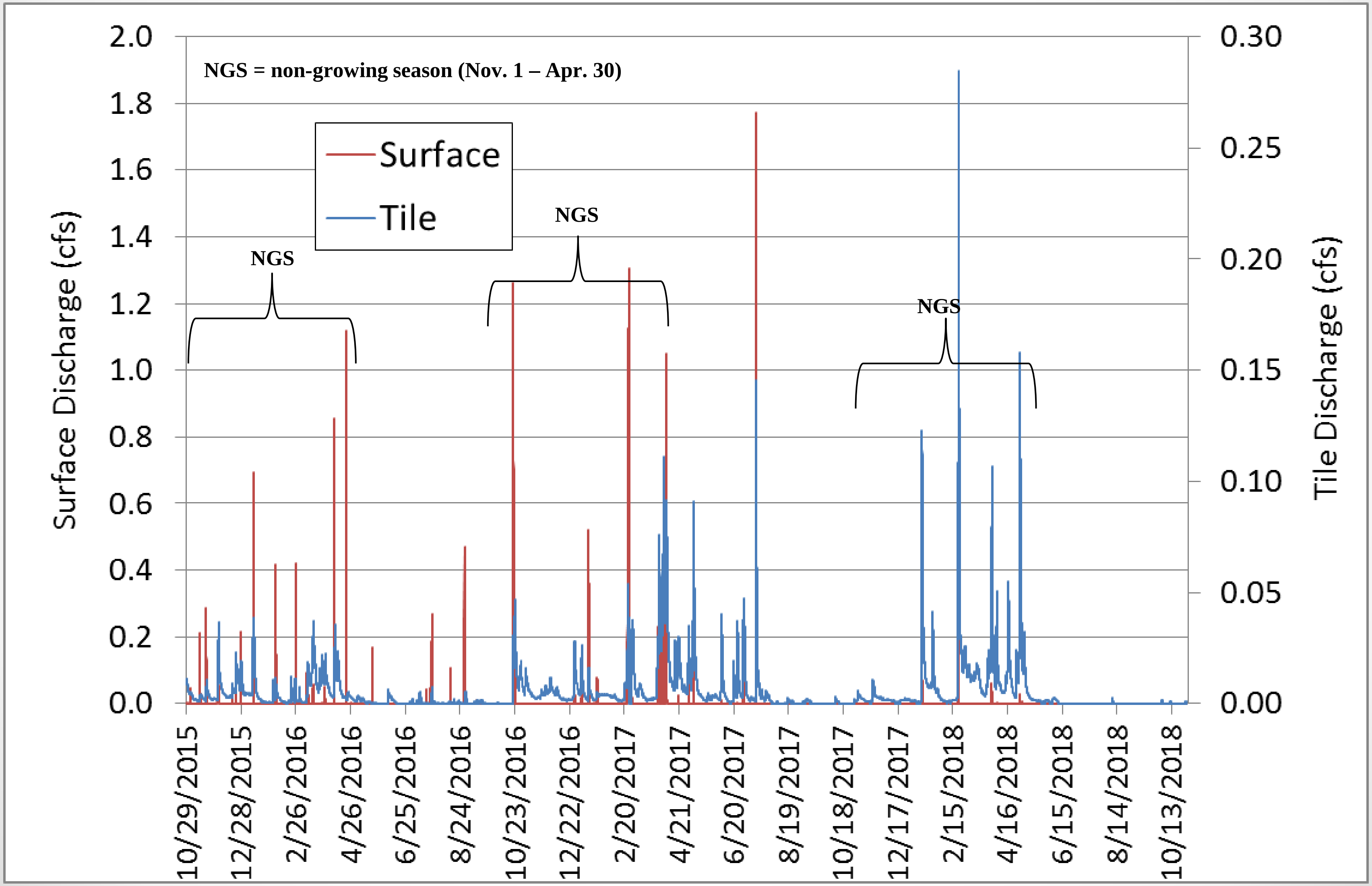
Tile Drainage Monitoring

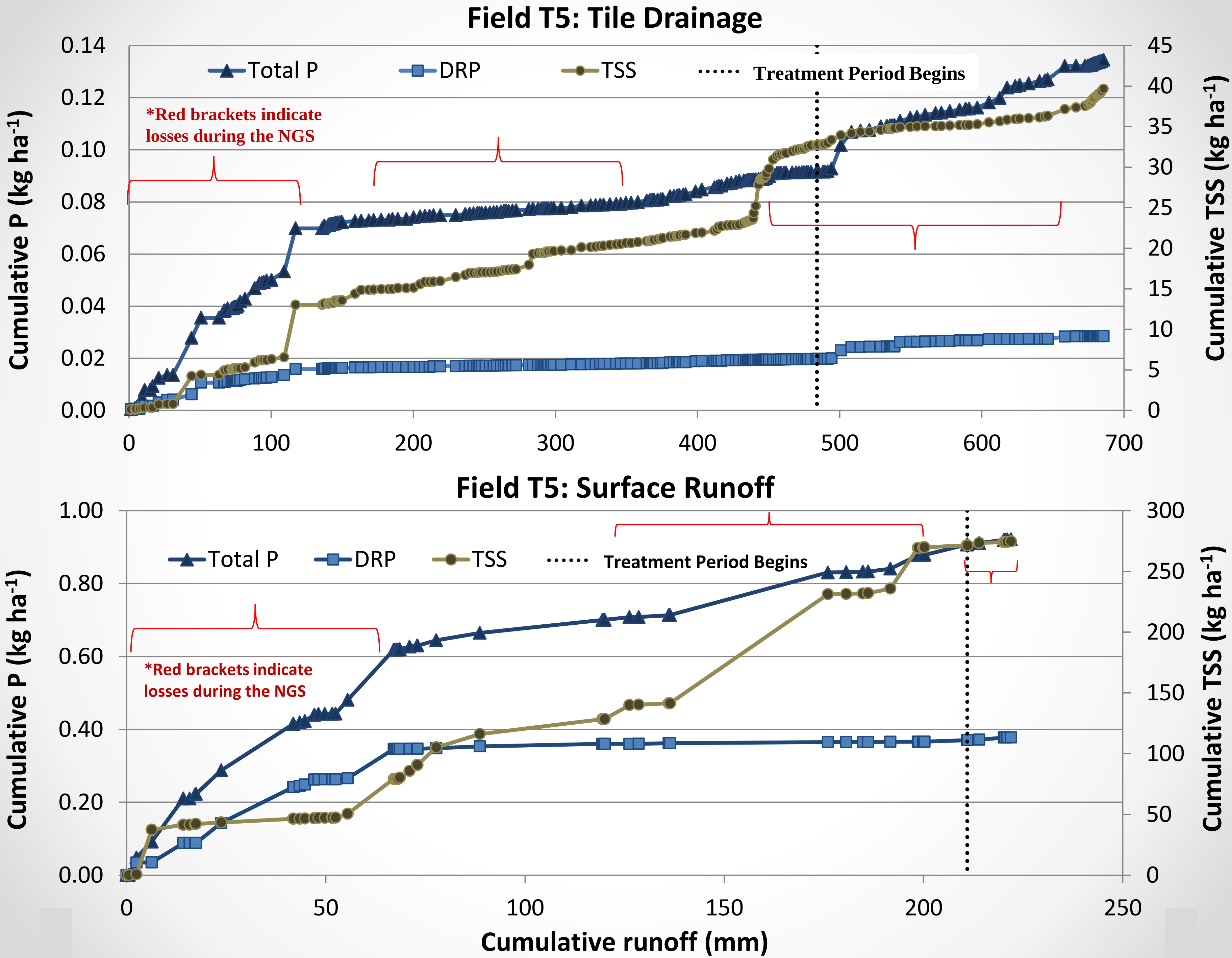


Field T5 Discharge

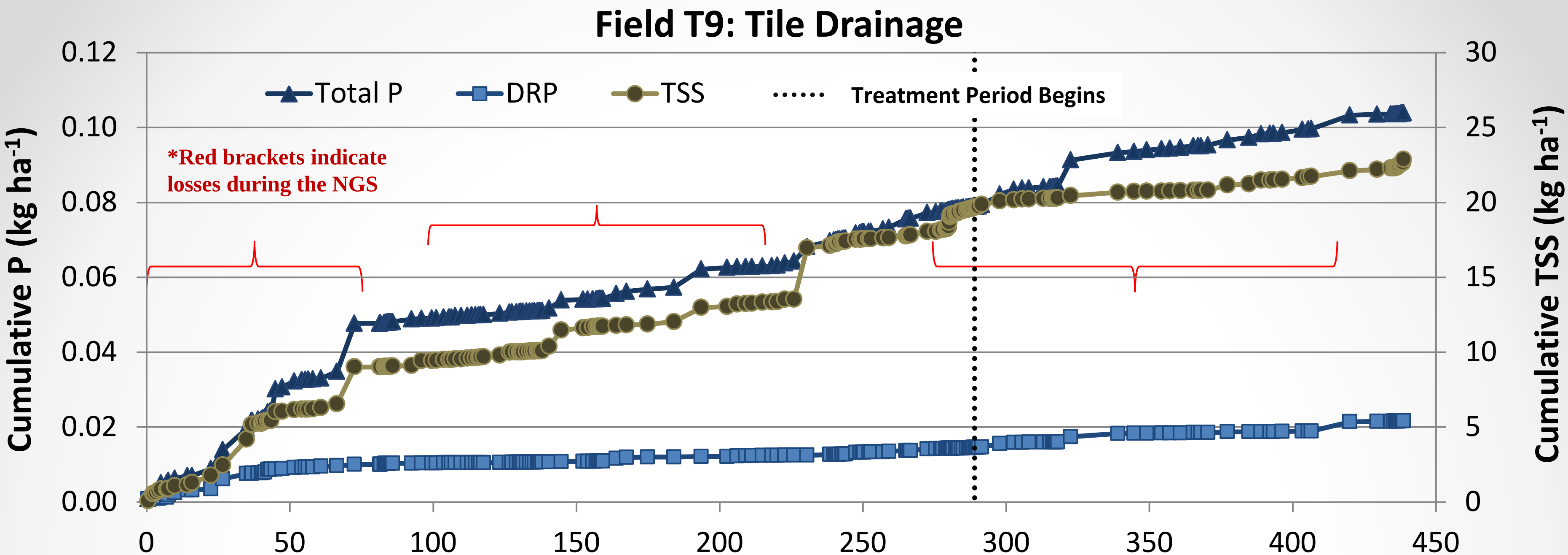


Field T9 Discharge

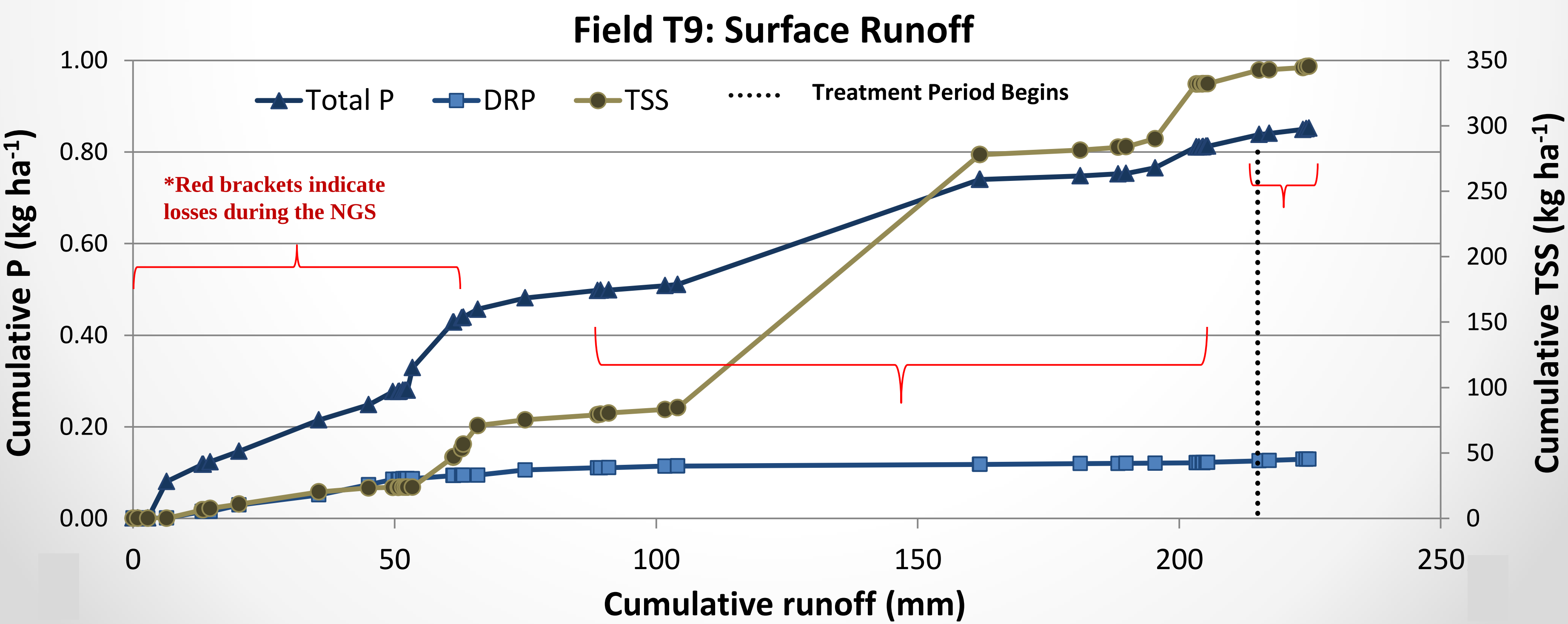




Field T5: Tile Drainage
Total P
DRP
TSS
Treatment Period Begins
*Red brackets indicate losses during the NGS
Cumulative P (kg ha-1)
Cumulative TSS (kg ha-1)
0.00
0.02
0.04
0.06
0.08
0.10
0.12
0.14
0
5
10
15
20
25
30
35
40
45
0
100
200
300
400
500
600
700
Field T5: Surface Runoff
Total P
DRP
TSS
Treatment Period Begins
*Red brackets indicate losses during the NGS
Cumulative P (kg ha-1)
Cumulative TSS (kg ha-1)
0.00
0.20
0.40
0.60
0.80
1.00
0
50
100
150
200
250
300
0
50
100
150
200
250
Cumulative runoff (mm)



Field T9: Tile Drainage
Total P
DRP
TSS
Treatment Period Begins
*Red brackets indicate losses during the NGS
Cumulative P (kg ha-1)
Cumulative TSS (kg ha-1)
0.12
0.10
0.08
0.06
0.04
0.02
0.00
30
25
20
15
10
5
0
0
50
100
150
200
250
300
350
400
450



Field T9: Surface Runoff
Total P
DRP
TSS
Treatment Period Begins
*Red brackets indicate losses during the NGS
Cumulative P (kg ha-1)
Cumulative TSS (kg ha-1)
1.00
0.80
0.60
0.40
0.20
0.00
350
300
250
200
150
100
50
0
0
50
100
150
200
250
Cumulative runoff (mm)

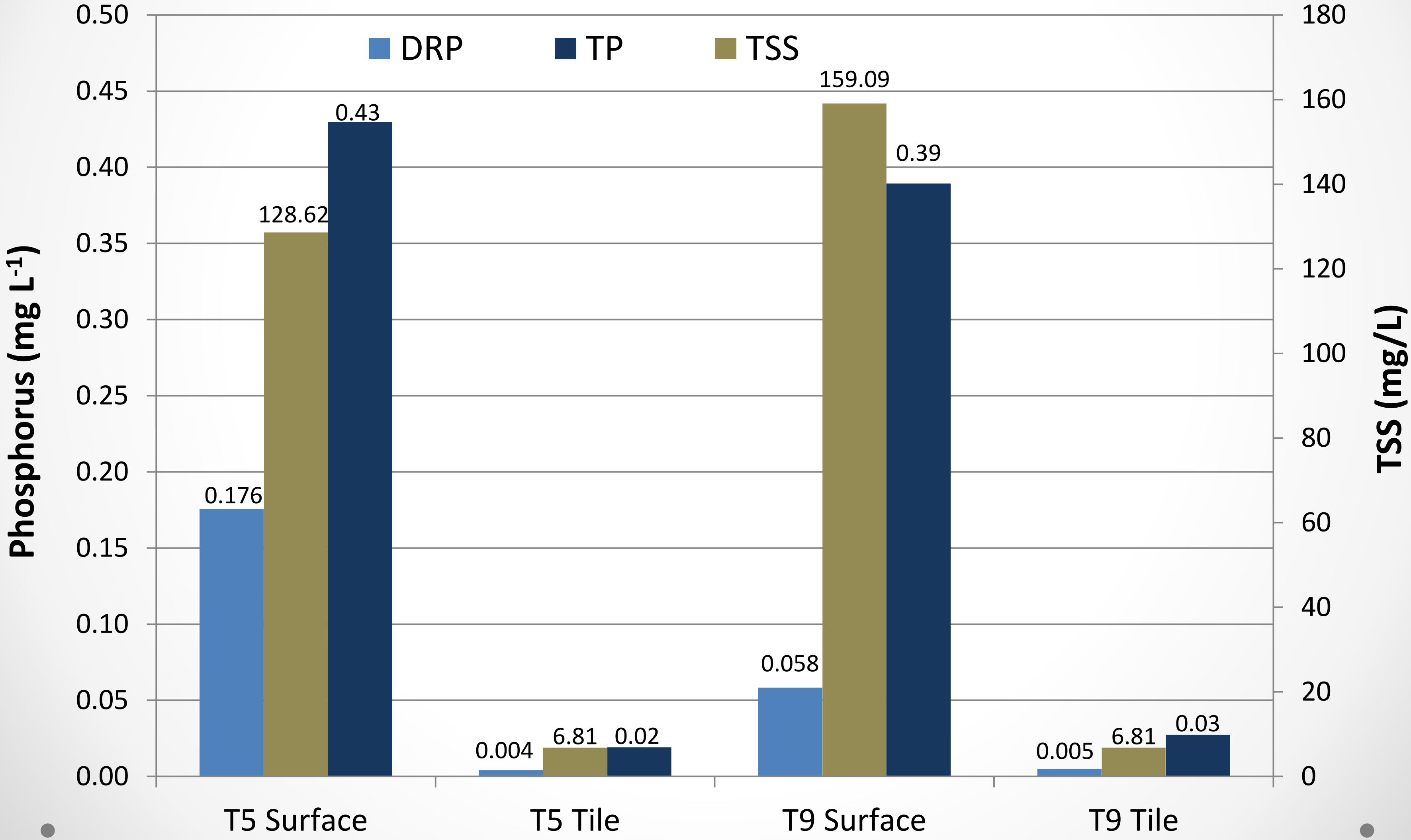
Nutrient Exports in Runoff

B = baseline; T = treatment

Field	Runoff		DRP		TP		TSS		Nitrate-N		Total N	
	mm yr^{-1}		---kg ha^{-1} yr^{-1}---									
	B	T	B	T	B	T	B	T	B	T	B	T
T5 Surface	106	5	0.18	0.01	0.45	0.01	135.75	3.10	1.65	0.55	3.36	0.65
T5 Tile	240	103	0.01	0.01	0.04	0.04	16.34	6.97	17.22	26.67	19.99	28.25
T9 Surface	107	5	0.06	< 0.01	0.42	0.01	171.28	3.00	1.12	0.02	3.20	0.27
T9 Tile	144	75	0.01	0.01	0.04	0.02	9.84	3.21	10.64	21.11	12.11	22.02
Field T5	**345**	**108**	**0.19**	**0.02**	**0.50**	**0.06**	**152.09**	**10.08**	**18.87**	**27.21**	**23.35**	**28.90**
Field T9	**252**	**80**	**0.07**	**0.01**	**0.46**	**0.04**	**181.11**	**6.21**	**11.75**	**21.13**	**15.31**	**22.29**

- 25-36% of total runoff occurs as surface runoff
- 87-89% of total P and 86-93% TSS export from surface runoff
- 91% of total N export from subsurface runoff

Flow-weighted mean concentrations



Nutrient Efficiency

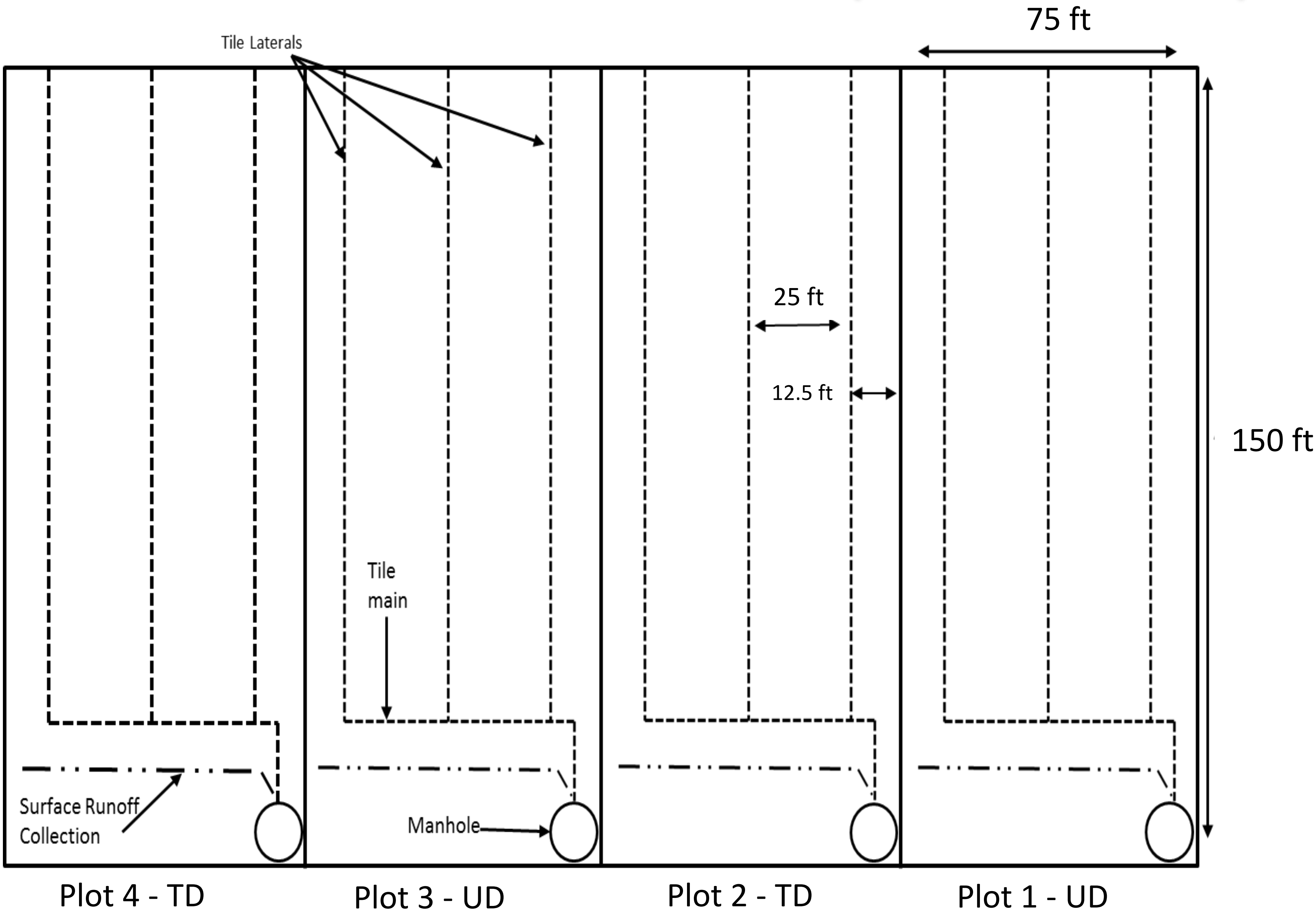
Year/Field	Total P_2O_5 inputs lb/ac	Total N inputs lb/ac	Corn yield tons DM/ac	P_2O_5 removal lb/ac	N removal lb/ac	P Efficiency %	N Efficiency %
2016							
T5	12	123	1.60	16	36	133.3	29.3
T9	12	123	2.56	26	57	216.7	46.3
2017							
T5	102	257	3.05	31	68	30.4	26.5
T9	102	257	4.23	43	95	42.2	37.0
2018							
T5	37	126	5.09	51	112	138.8	89.1
T9	37	144	5.54	66	135	178.6	93.5

Year/Field	% P loss	% N loss
2016		
T5	1.7	16.4
T9	1.5	11
2017		
T5	0.2	7.8
T9	0.2	5.3
2018		
T5	0.3	22.0
T9	0.2	14.1

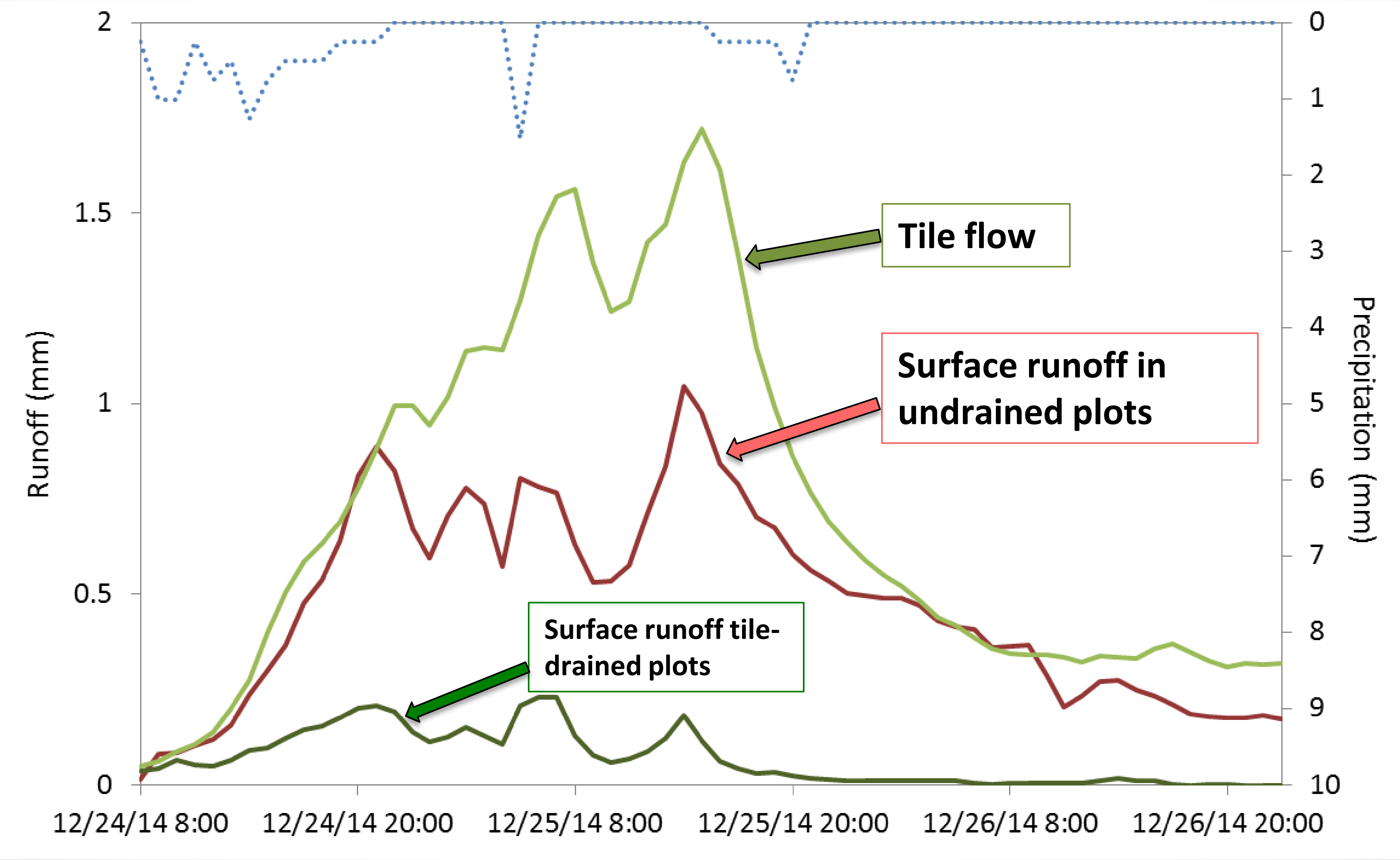
Summary & Ongoing Work

- Total P and TSS losses primarily driven by field hydrology; DRP by nutrient applications (timing and method)
- Majority of runoff and nutrient losses occurred during the NGS
- Surface runoff was primary pathway of loss
- BMPs (e.g., DWM, cover crops) targeting the NGS are necessary to reduce export of nutrients in northern climates
- Quantify possible tradeoffs in N and P exports in surface vs. tile with alteration of field hydrology after DWM implementation

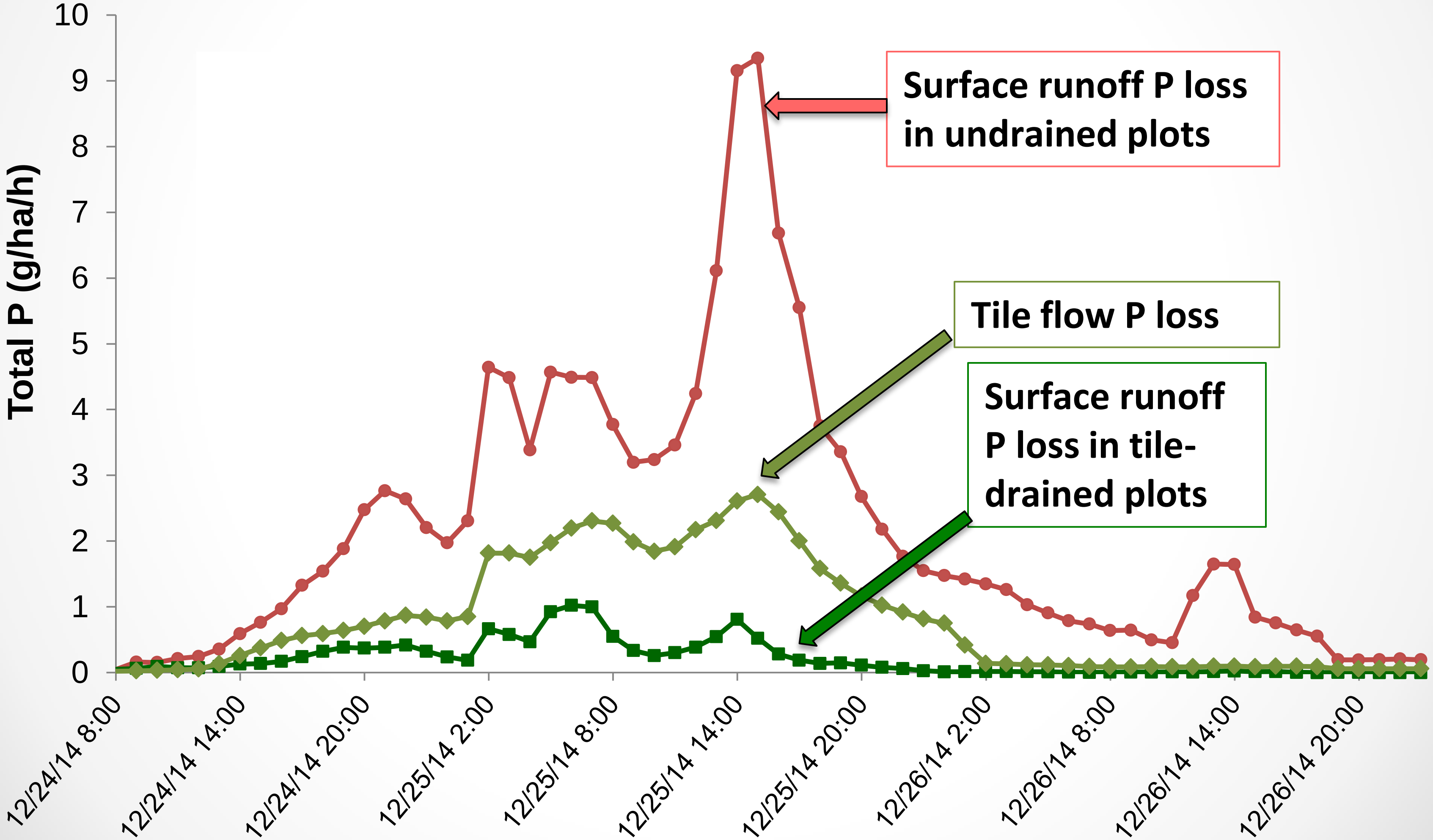
Lake Alice Runoff Plots (2014-2015)



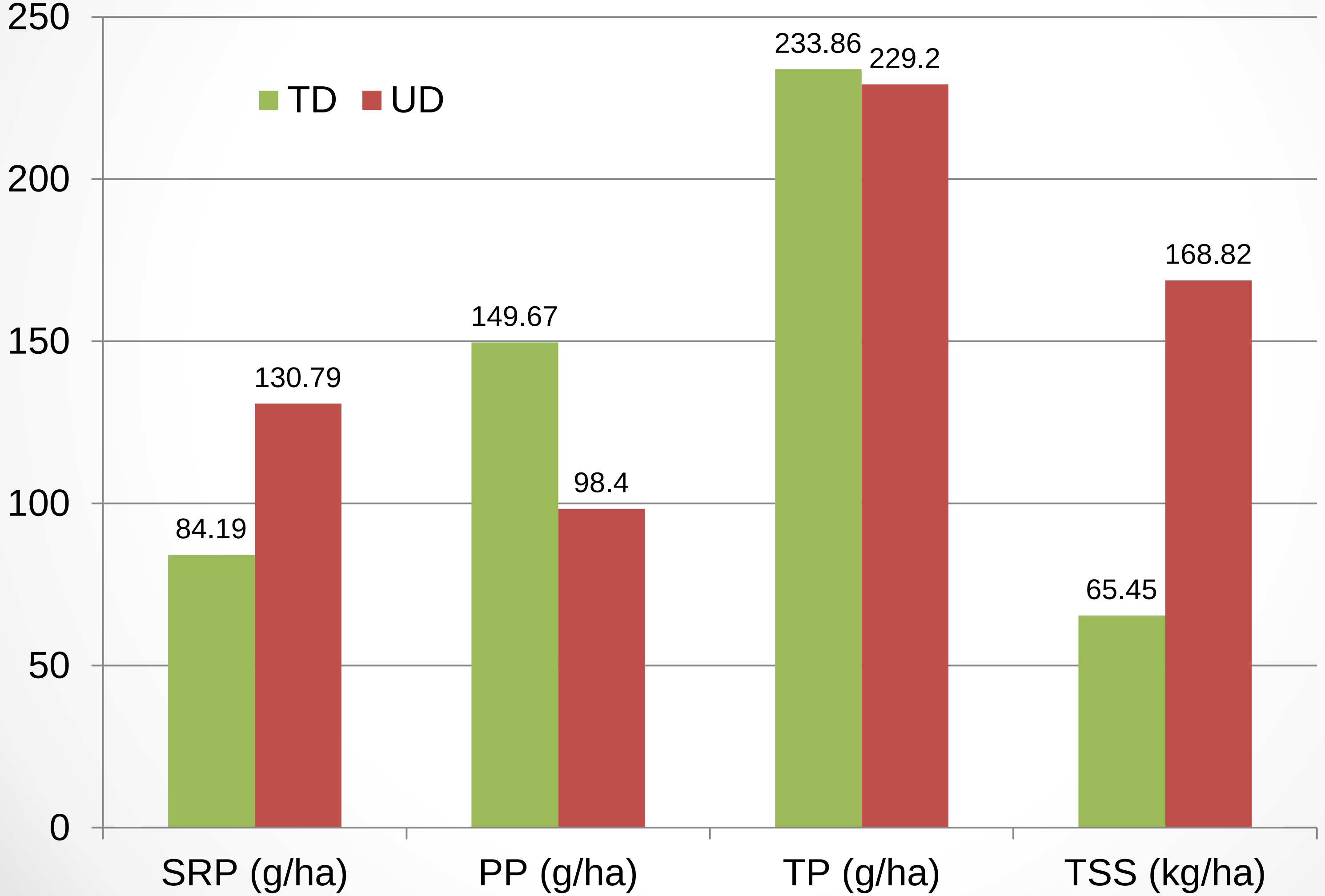
Tile drainage and snowmelt



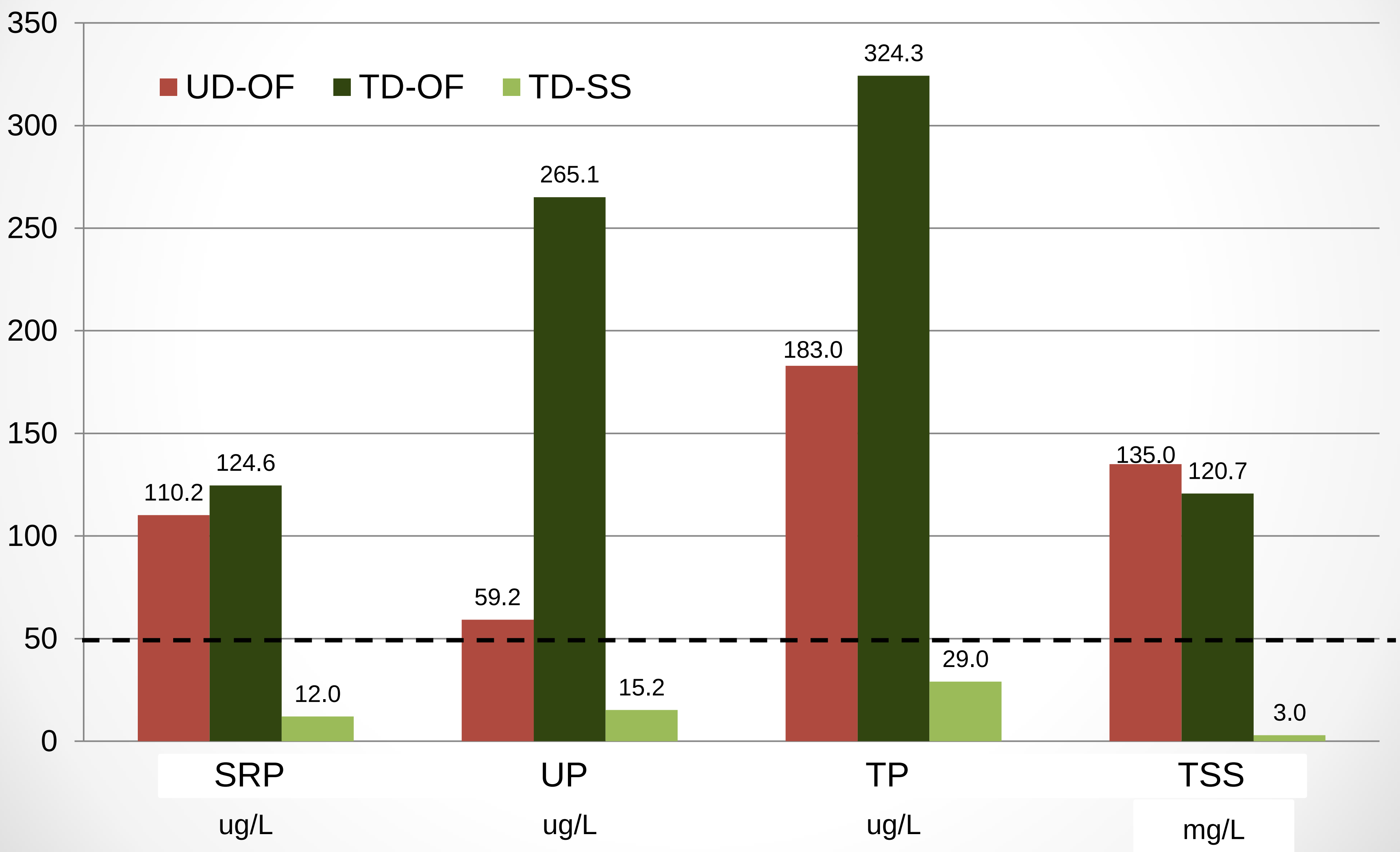
Total P loss from snowmelt



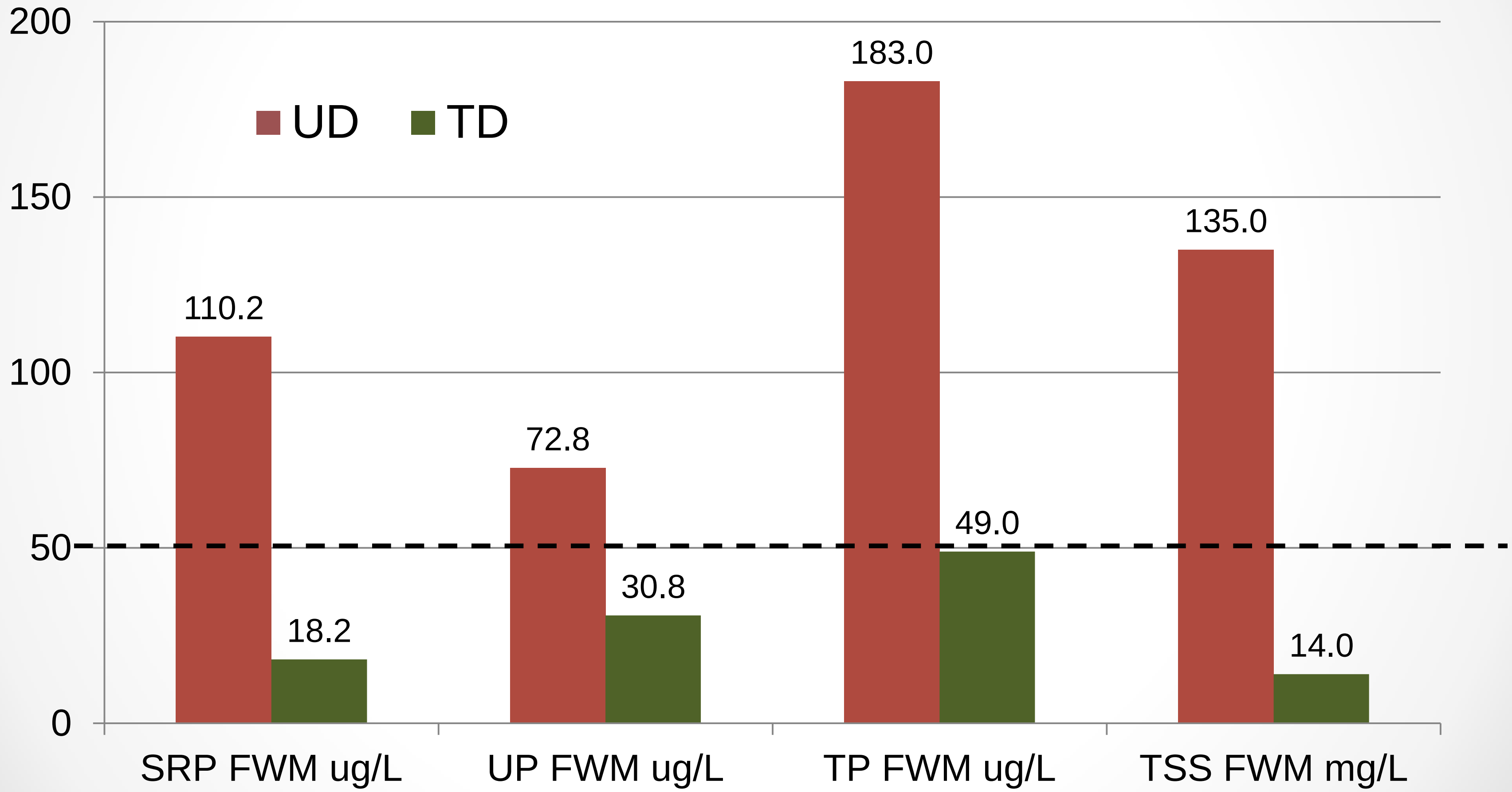
Cumulative P and TSS Loads by Treatment



Flow-Weighted Mean Concentrations



Flow-Weighted Mean Concentrations



Lake Alice Runoff Plots 2018

Source	Runoff	SRP	Total P	TSS
	in	--------------	lb/ac	--------------
Tile	9.8	0.02	0.05	9.38
Surface	3.6	0.53	0.75	15.98
Tile+Surface	13.4	0.54	0.80	25.37

- 1st year alfalfa
- 2 cuttings taken
- No manure applied in 2018

Conclusions

- Phosphorus losses driven by surface runoff events
- Nitrogen losses exported primarily through tile flow
- Majority of losses occur during non-growing season and from small number of events
- Promote/develop BMPs that address these high risk periods
  - Drainage water management
  - Cover crops
- Tile drainage may reduce P export from snowmelt-driven runoff events
- Nutrient management is key:
  - Maintaining fields at agronomically optimum phosphorus levels
  - Avoiding nutrient applications prior to high risk events

Ongoing Trials at Miner Institute

- NRCS Edge-of-field paired field study: Drainage Water Management (2 more years)
- NRCS Edge-of-field paired field study: Till vs. No-till
  - monitoring began 10/1/18, ~2 year baseline, 3-4 year treatment
- Tiled vs. Untiled Fields: ~6 ac fields (corn for silage) in Keeseville, NY; 1 tiled & 1 untiled (2nd year of funding by Northern NY Agricultural Development Program)
- Lake Alice Runoff Plots: four 0.25 ac plots, monitoring surface runoff and tile drainage (alfalfa-grass, managed for hay crop silage) (2nd year of funding by Northern NY Agricultural Development Program)

- Understanding transport mechanisms
  - How does antecedent moisture affect erosion and nutrient exports?
  - Interaction of antecedent moisture and freeze/thaw cycles on nutrient and sediment losses
  - Contribution of macropore flow to nutrient and sediment losses

Thank you to our funding sources

Northern New York
Agricultural Development Program
Farmer-Driven Research • Real-World Results

USDA NRCS
United States Department of Agriculture
Natural Resources Conservation Service

Lake Champlain
Basin Program