EVALUATION OF ABOVE GROUND IMPOUNDMENTS (AGIs) FOR REDUCING FARM-SCALE PHOSPHORUS (P) DISCHARGE IN SOUTH FLORIDA

8th Annual Public Meeting on the Long Term Plan for Achieving Water Quality Goals for Everglades Protection Area Tributary Basins

UNIVERSITY OF FLORIDA
IFAS
Southwest Florida Research & Education Center

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SOUTH FLORIDA WATER MANAGEMENT DISTRICT
PROTECTOR OF THE EVERGLADES SINCE 1949

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Introduction

- Above ground impoundments (AGI)
  - History
  - Water quality and quantity benefits
- Considered an important BMP for controlling phosphorus (P) discharges
- Existing AGI not necessarily built for optimum P treatment
- Lack of data on P dynamics and retention
  - Needed for optimizing AGI treatment

Goal

Quantify the P treatment of an AGI and identify structural and management modifications to enhance treatment efficiency

Objectives

- Select and instrument an AGI serving a vegetable farm within the C-139 Basin;
- Identify structural or other design modifications and/or management strategies based on data collected and AGI characteristics; and
- Disseminate the project findings to landowners in the C-139 Basin.

Study Area

- Vegetable farm in the C139 Basin
- Impoundment area = 37 ac
- Drainage area = 276 ac
- Drainage through 3 pumps
- Discharge through 2 culverts
- Contains 3 wetlands

Study Duration

- Phase 1
  - July 2009 – July 2010: Water quantity/quality , soil and plant monitoring
  - August 2010 – February 2011:

    - Data analysis

    - Identification of P treatment enhancements
  - March 15, 2011 – Phase I Report
  - September 10, 2011 – Tracer Study Report

Water Quantity/Quality Monitoring

- Pumped Water Inflow
  - Canal Stage and pump RPM
- Gravity Outflow
  - Stage and weir equation
- P Inflow and outflow
  - Autosampler
  - Combine with the water flows to calculate P loadings
- Storage
  - Impoundment water level

Topography, Vegetation, and Soil

- Topographic survey
  - impoundment storage
  - stage volume relationship
- Soil sampling to quantify impoundment to quantify soil P storage in the impoundment
- Vegetation survey and sampling –Biomass P

Data Collection and Analyses

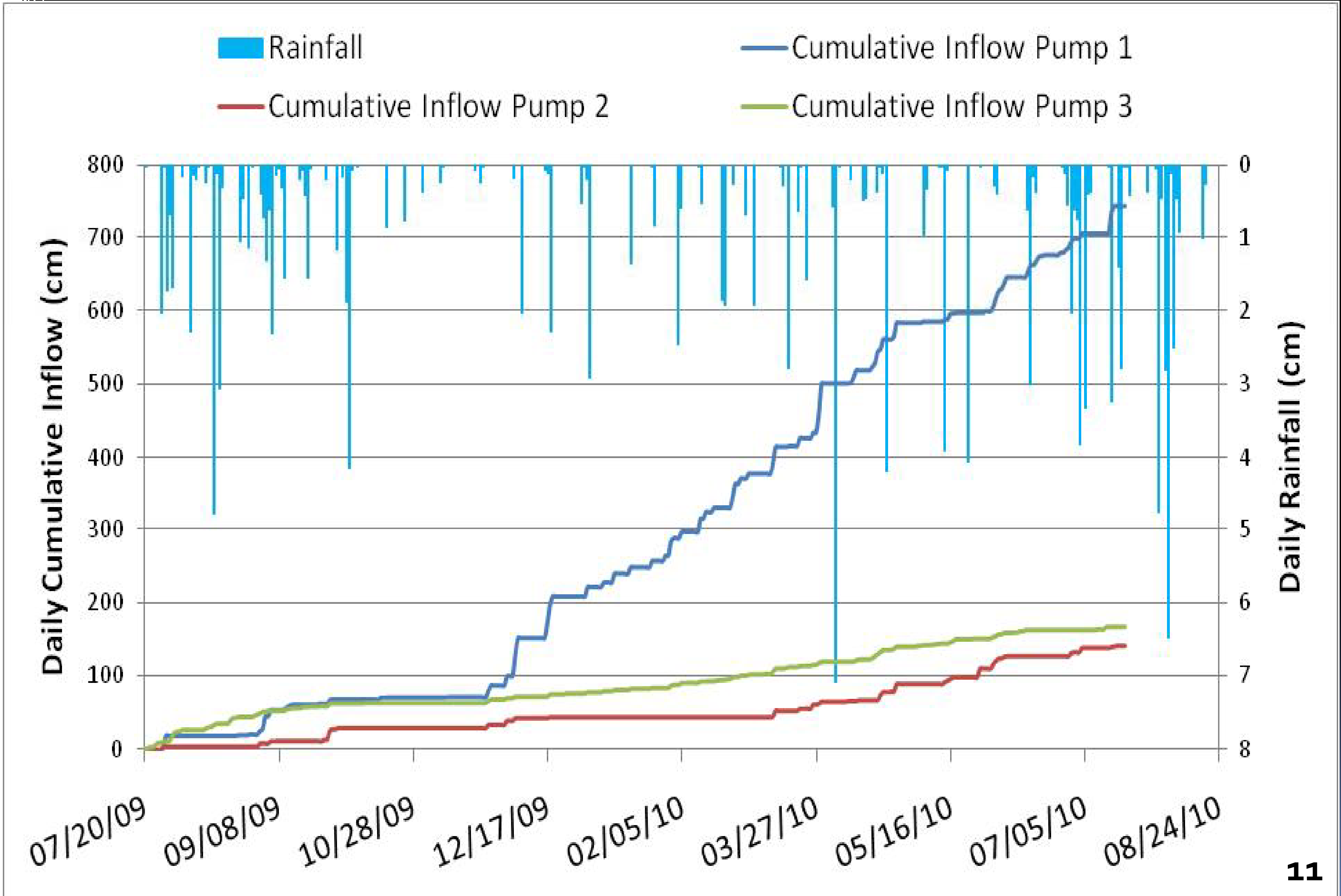
- Water and P dynamics
  - construct balances
  - P treatment efficiency
  - soil and vegetation P
- Tracer Study
  - Flow paths and residence time
- AGI modifications
  - Relate treatment efficiency to hydrology and soil and plant characteristics

Results

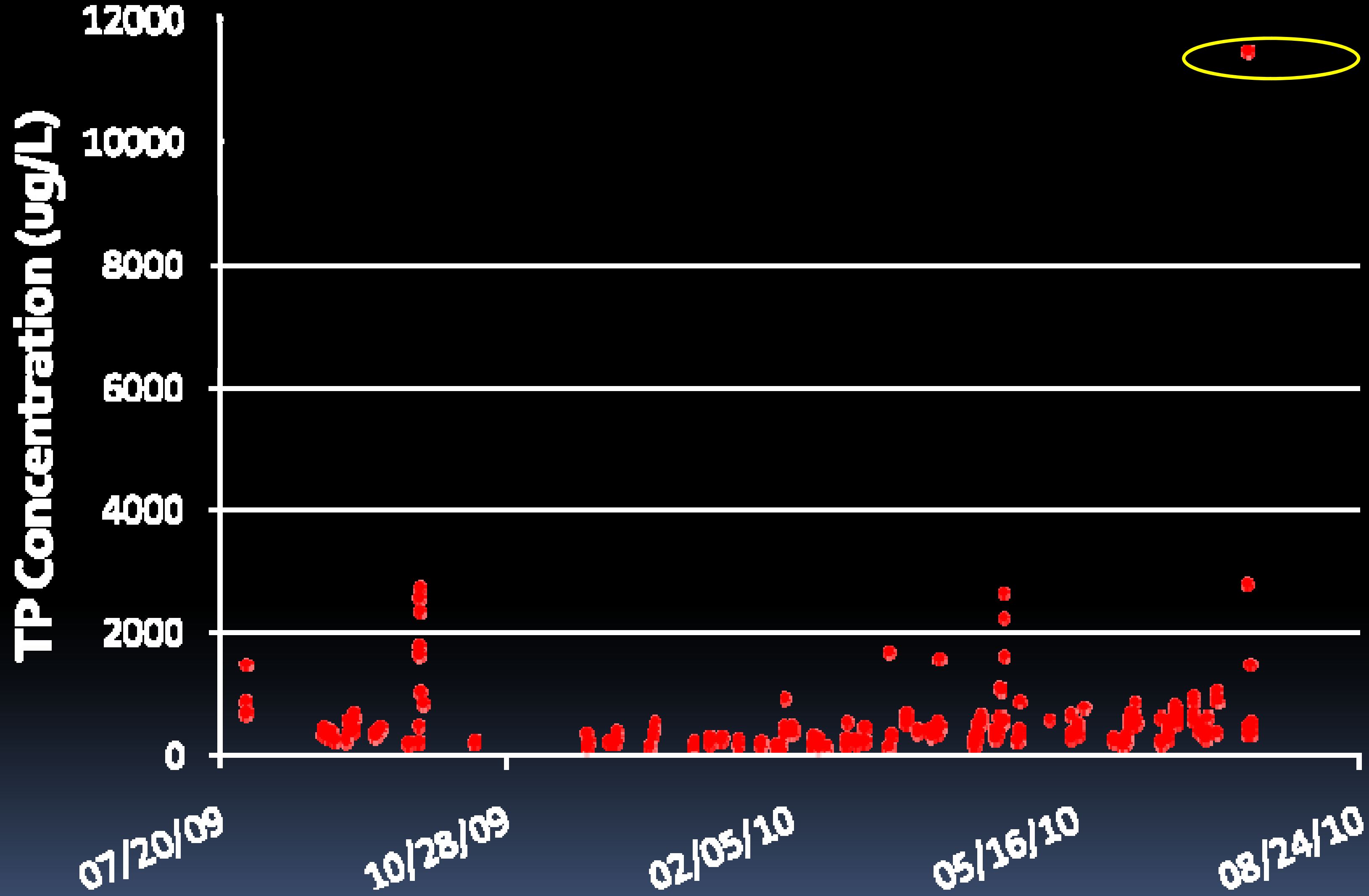
Pump Calibration

- Three inflow pumps
- Propeller type flowmeter
  - Several RPMs and Heads
  - Flow (GPM) and Head (ft)
  - Pump 1:
    - $R^2 = 0.93$
  - Pump 2
    - $R^2 = 0.91$
  - Pump 3
    - $R^2 = 0.90$

Cumulative Flow at Pumps 1,2,and 3

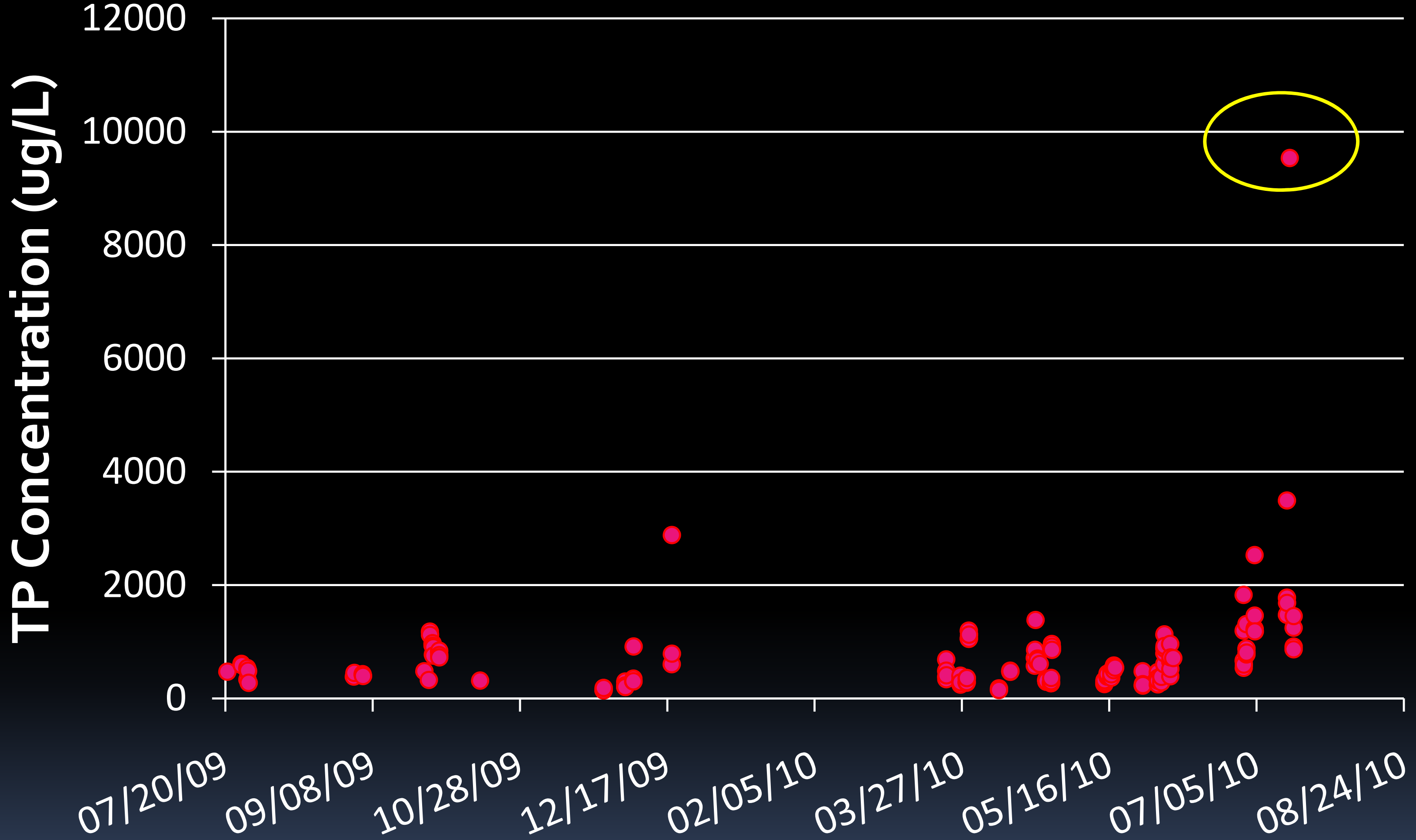


Total P Concentrations – Pump 1



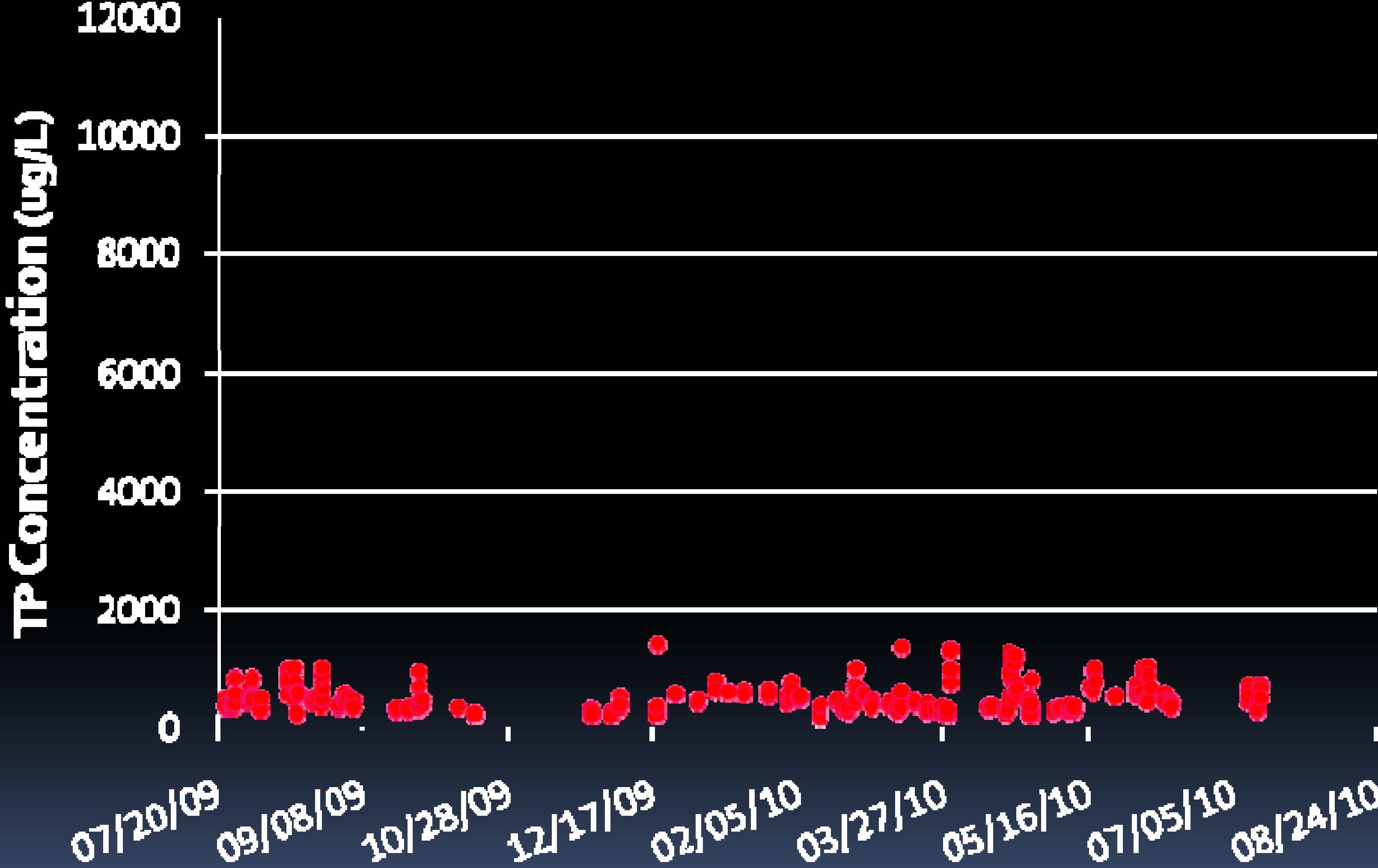
Average= 460 ug/l   Maximum=11,484 ug/l   Minimum=121 ug/l

Total P Concentrations - Pump 2



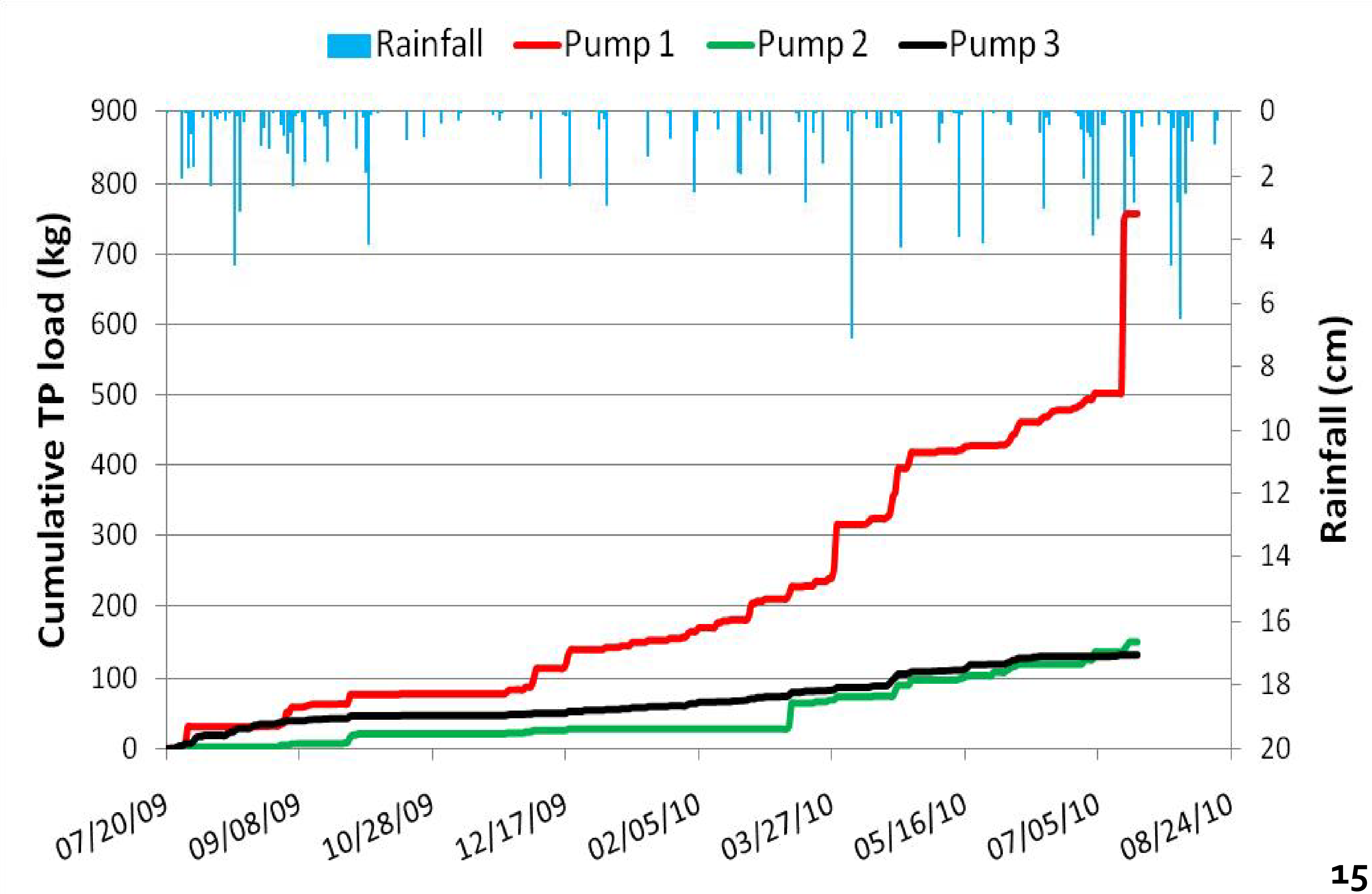
Average = 678 ug/l ***Maximum = 9,536 ug/l*** ***Minimum = 140 ug/l***

Total P Concentrations - Pump 3

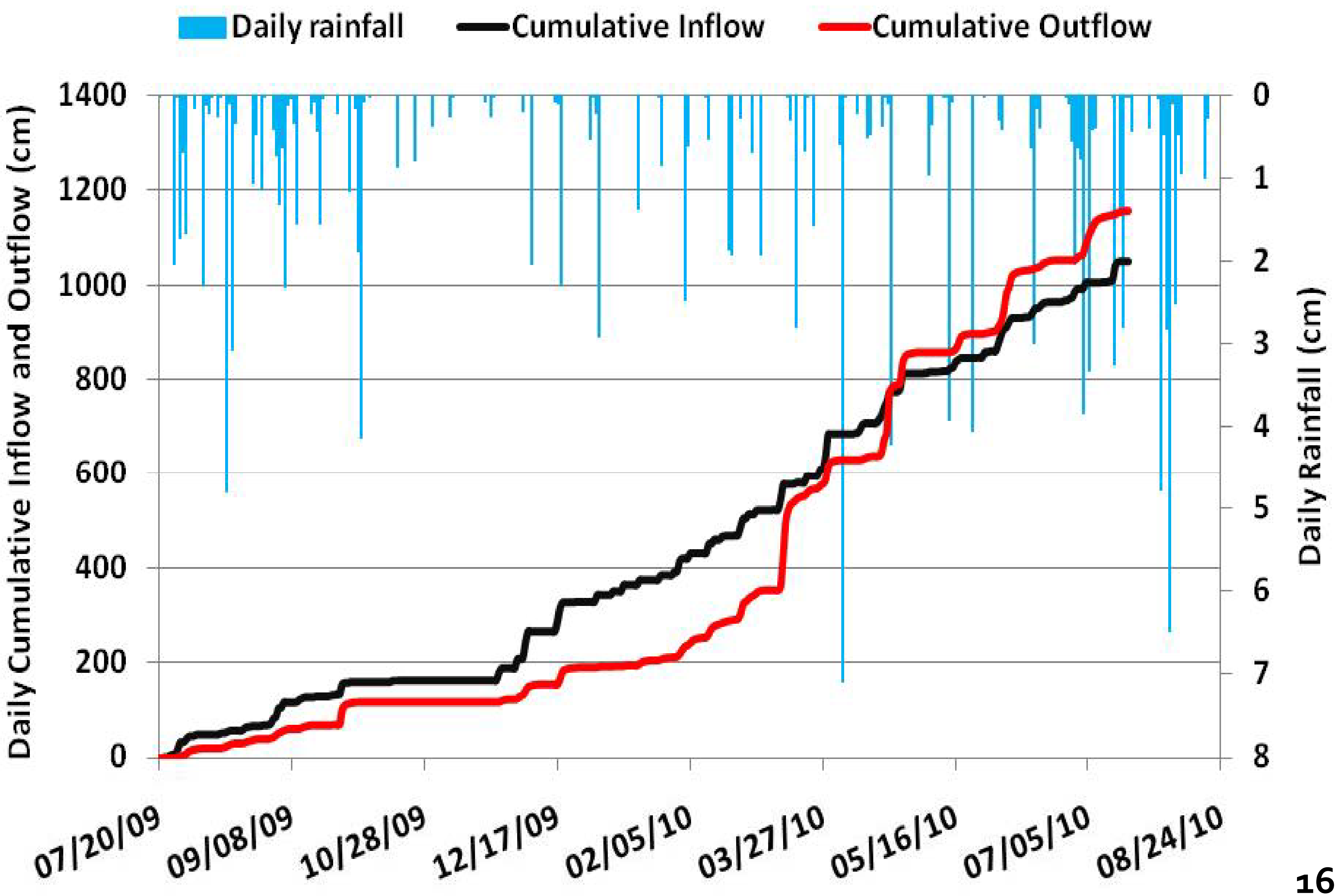


Average = 489 ug/l *Maximum = 1423 ug/l* *Minimum = 160 ug/l*

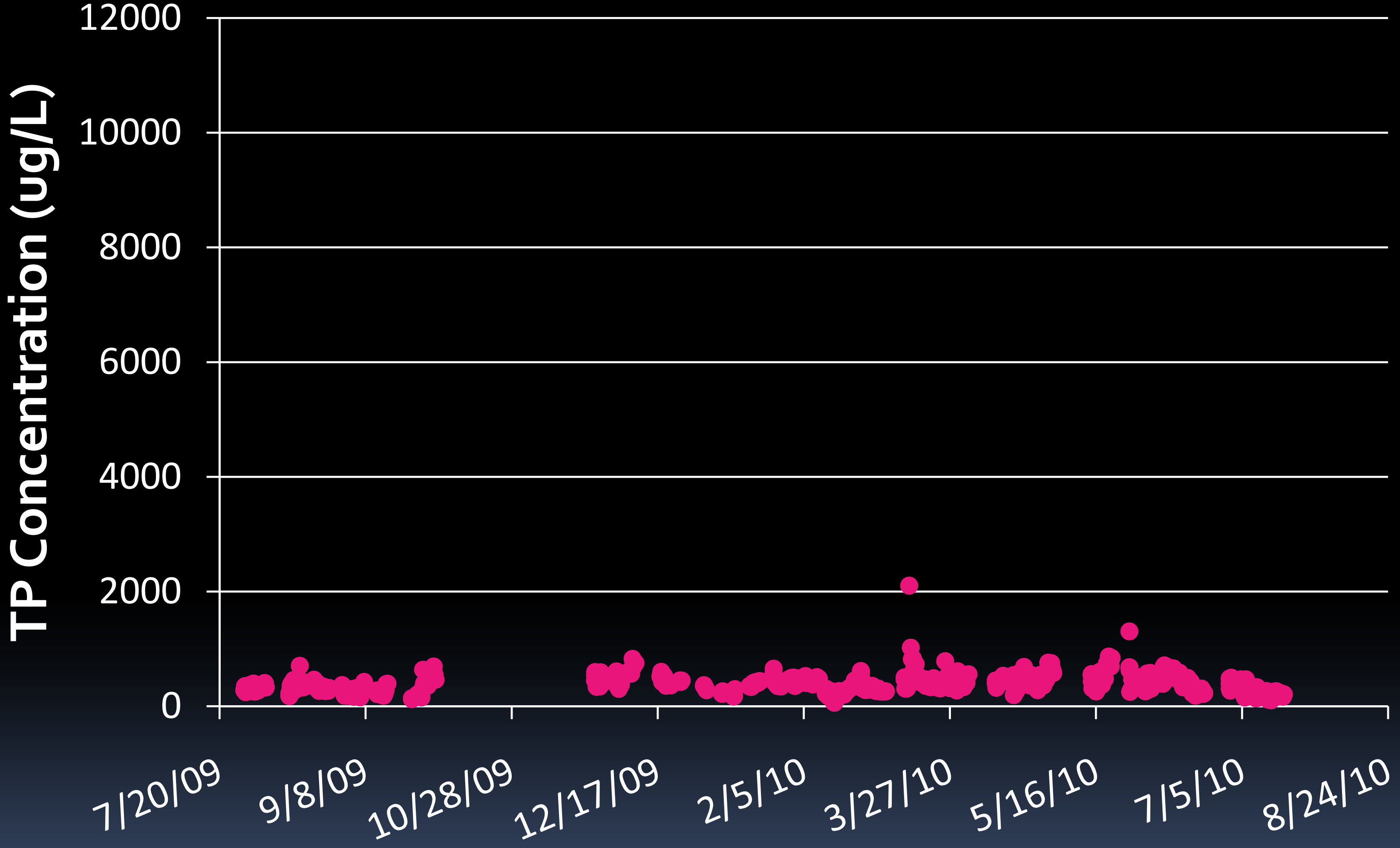
Cumulative Total P Loads from Pumps



Cumulative Inflow and Discharge

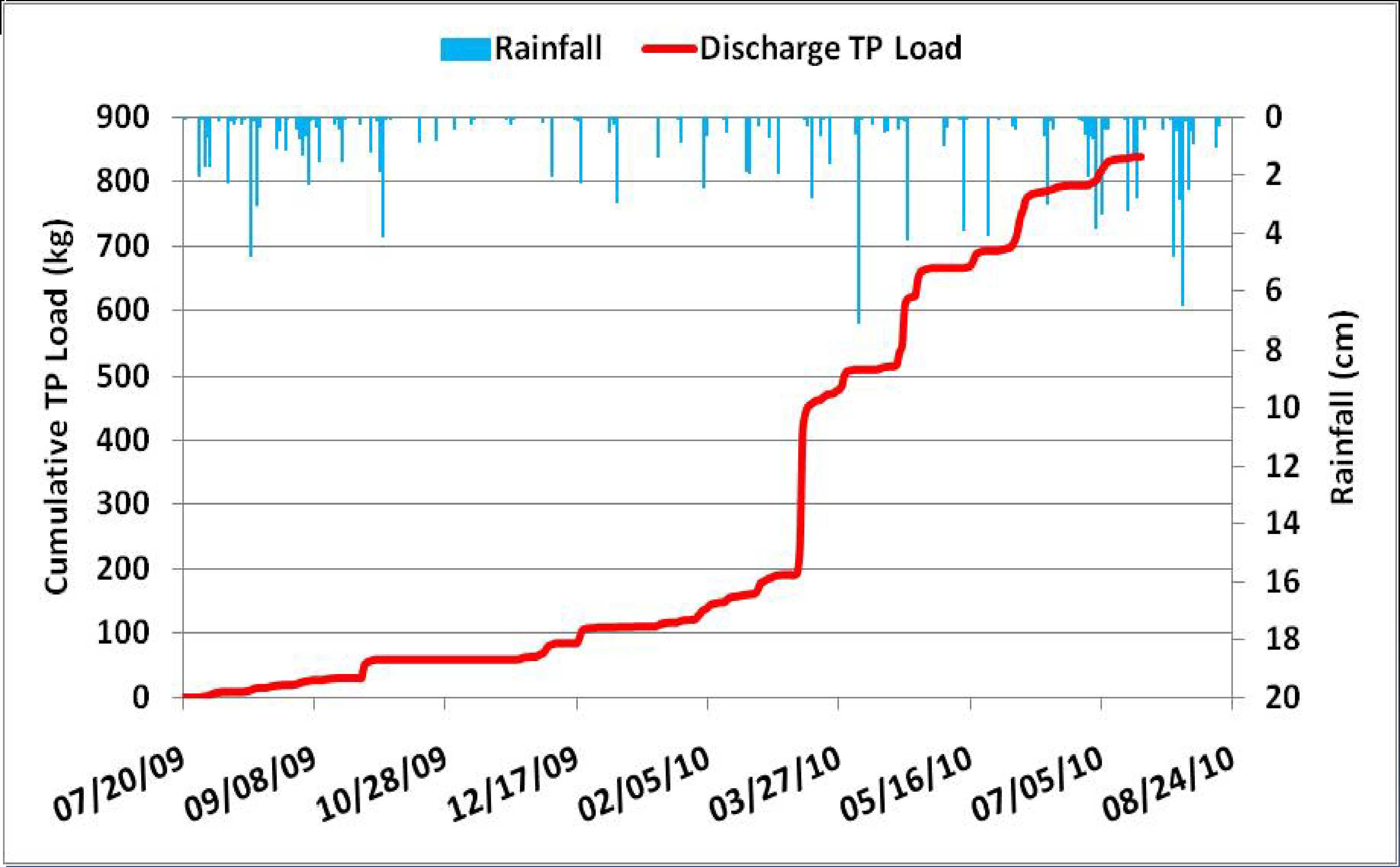


Total P Concentrations - Discharge



Average = 368 ug/L   Maximum = 2102 ug/L   Minimum = 60 ug/L

Cumulative Discharge Total P Loads



Flow Summary (Jul 2009-Jul 2010)

		FLOW (cm)	% OF ALL INPUTS
INPUTS	PUMP 1	742	63
	PUMP 2	141	12
	PUMP 3	168	14
	RAINFALL	135	11
LOSSES		FLOW (cm)	% OF ALL LOSSES
	DISCHARGE	1155	91
	ET*	116	9

* PET

Total P Concentration Summary (Jul 2009 – Jul 2010)

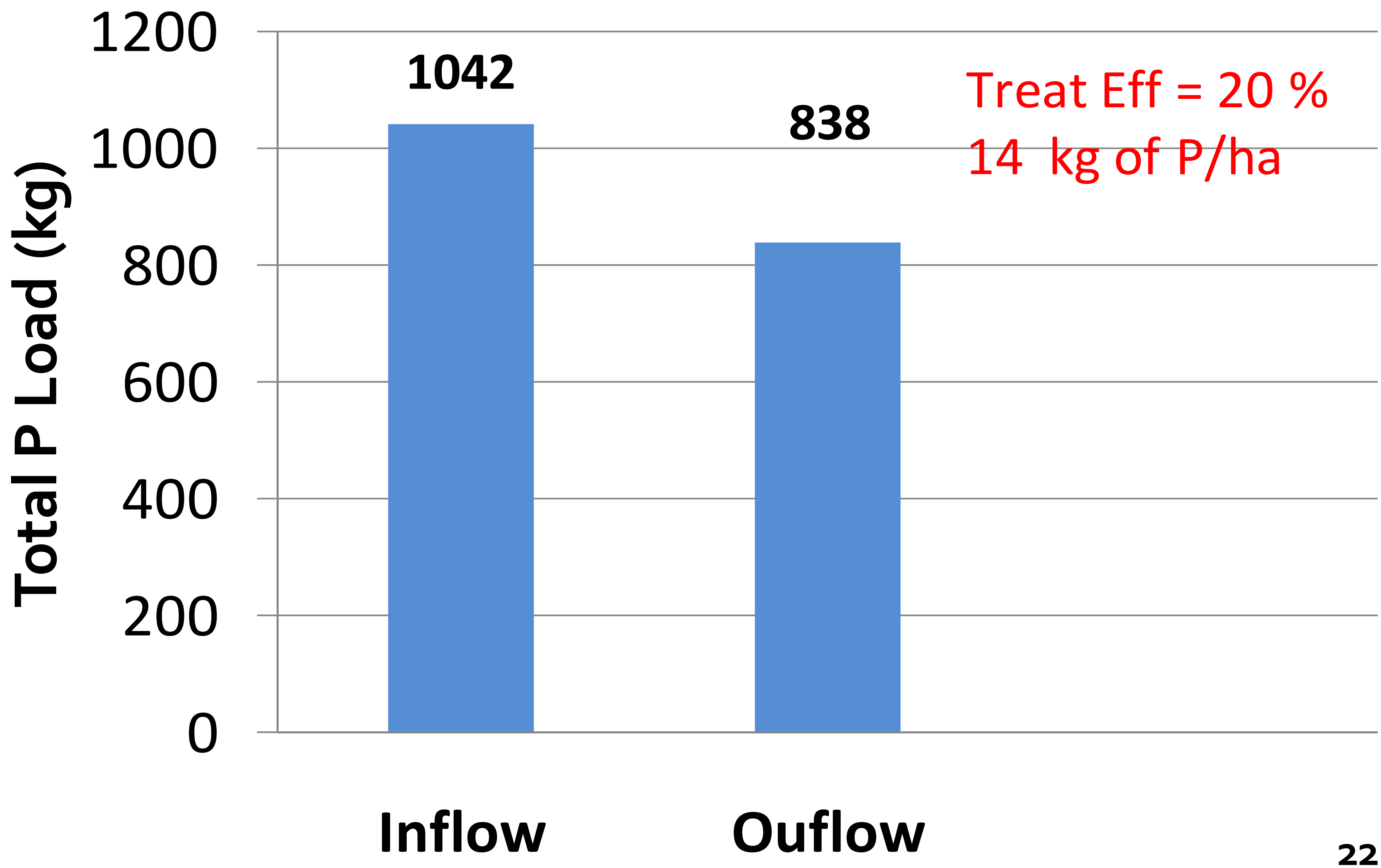
values in µg/L

	MAXIMUM	MINIMUM	AVERAGE
PUMP 1	11,484	121	**460**
PUMP 2	9536	140	**678**
PUMP 3	1423	160	**489**
DISCHARGE	2102	60	**368**

Total P Load Summary (Jul 2009-Jul 2010)

		TOTAL TP LOAD (kg)	% TOTAL INPUT
INPUTS	PUMP 1	757	73
	PUMP 2	151	14
	PUMP 3	133	13
	RAINFALL	2	0.2
LOSSES	DISCHARGE	838	80

P Treatment Efficiency (July 2009- July 2010)



Soil Characteristics (0-10 cm)

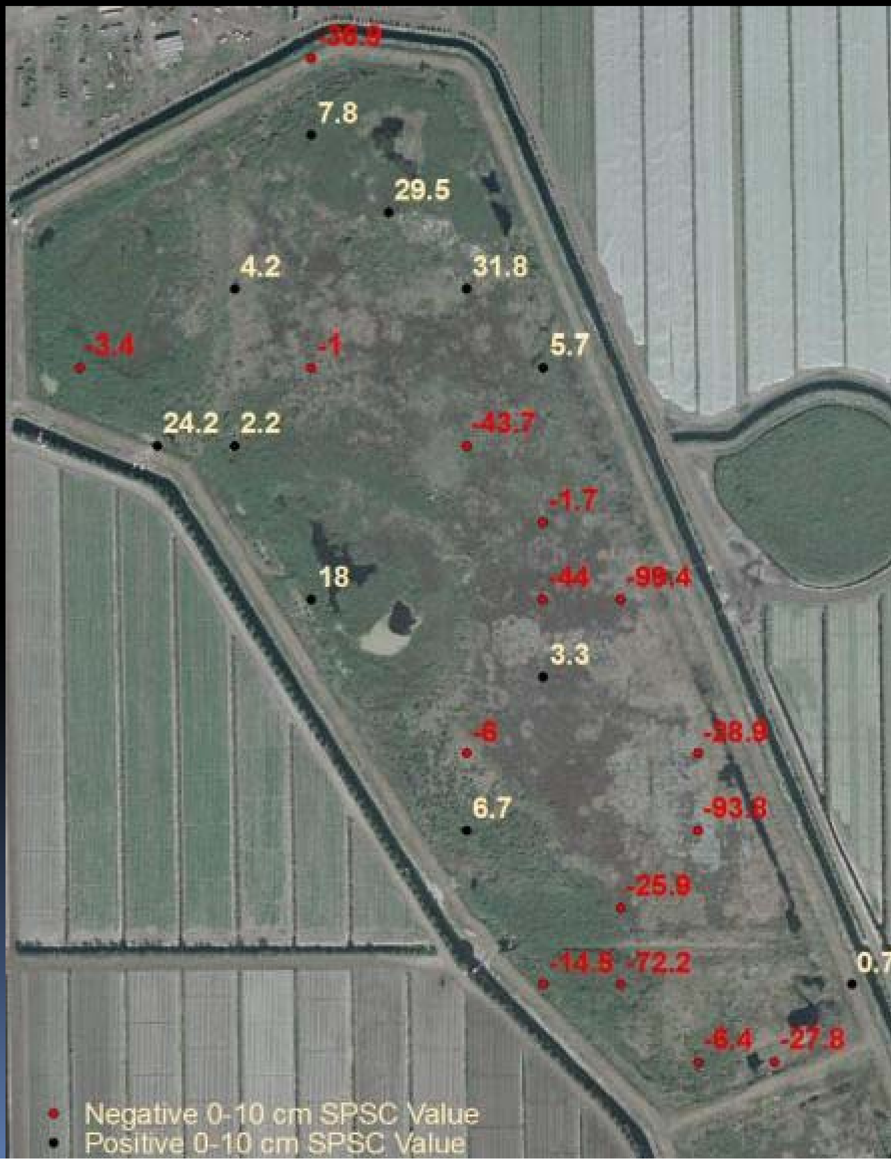
Soil Property	Maximum	Minimum	Average
Mehlich 1-P (mg/kg)	131.8	3.8	43.9
Mehlich 1- Fe (mg/kg)	24.1	ND	6.2
Mehlich 1- Al (mg/kg)	417.6	2.7	169.2
Total P (mg/kg)	3518.0	45.6	326.2
Safe P Storage Capacity (SPSC) (mg/kg)	31.8	-99.3	-14.2
Organic Matter (%)	91.5	1.7	12.9
Bulk Density (g/cc)	1.6	0.6	1.3

Change in Soil TP Concentrations (Before – After)

Soil P Retention Capacity

Safe P Storage Capacity (SPSC)

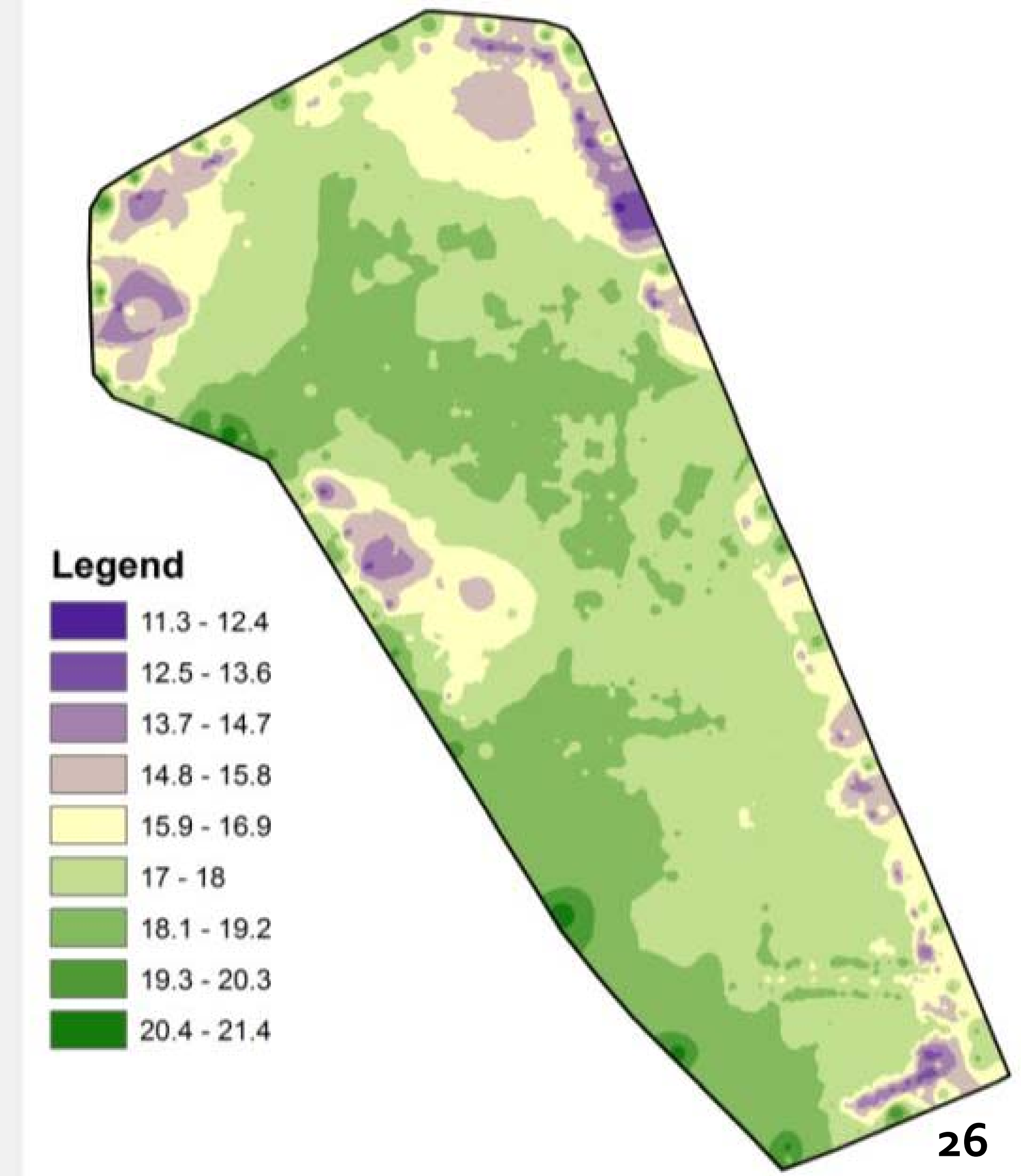
0 – 10 cm



10 – 20 cm

Topography

- Average = 17.4 ft
NAVD88
- Discharge = 18.1 ft
NAVD 88



Biomass P

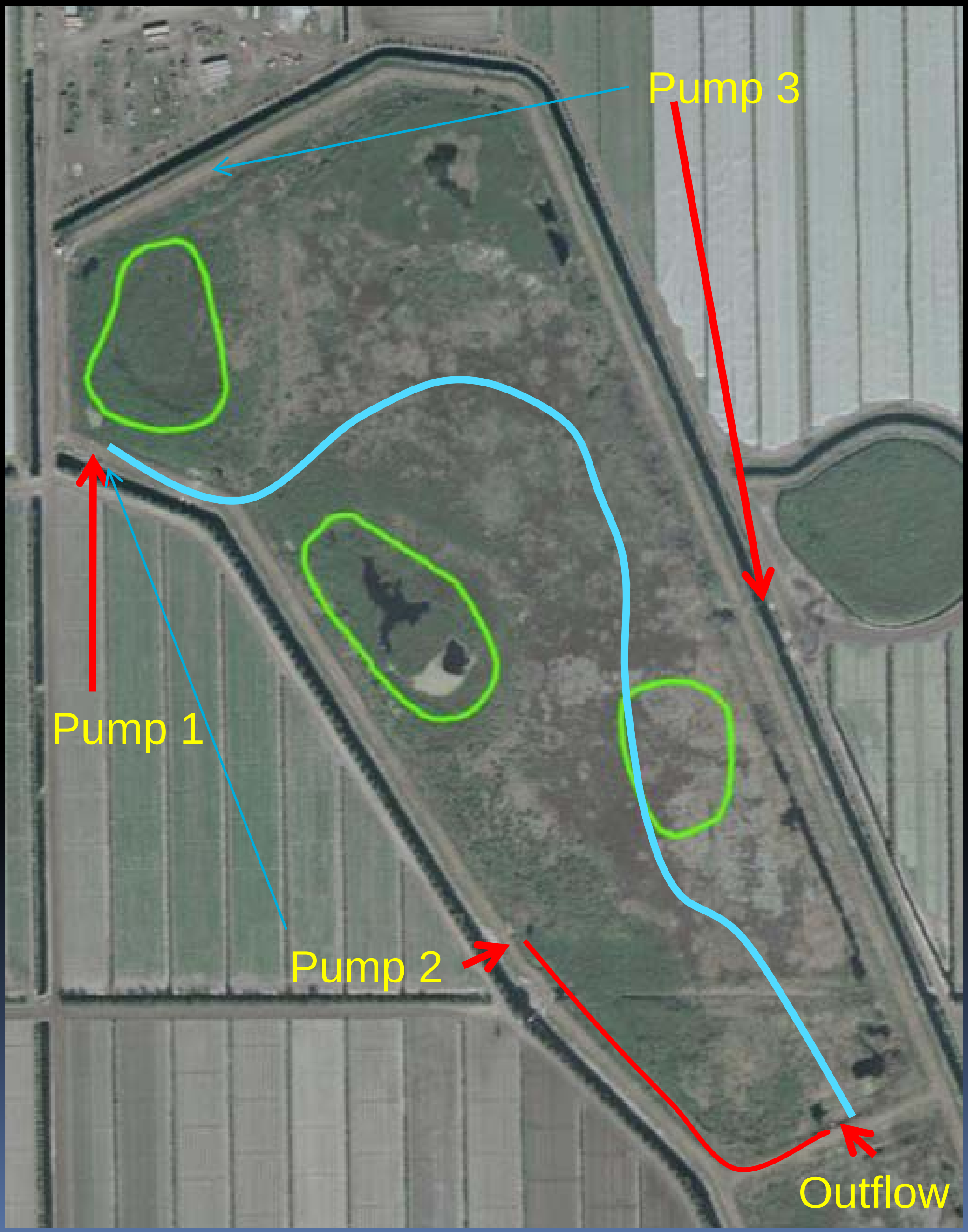
- Above-ground biomass P
  - Smartweed
  - Primrose Willow
  - Cattails
  - Carolina Willow
  - TP Conc
    - 1563 - 4531 mg/kg
  - P (est)
    - Total ≈ 330 kg
    - Biomass P outside wetland ≈ 288 kg (88% of total)
    - Accessible Biomass P ≈ 215 kg (assuming 75% accessibility) 25% of discharge)

Modifications for Increased Water and P Retention

- Enhancing travel time and storage
  - Move P source (pumps) away from outflow – increased flow length
  - Increasing the discharge level (free board) - higher inundation and storage before discharge
  - Multiple cells
    - topographical diversity, non-wetland areas
  - Others : Biomass and water recycling, amendment
- Cost

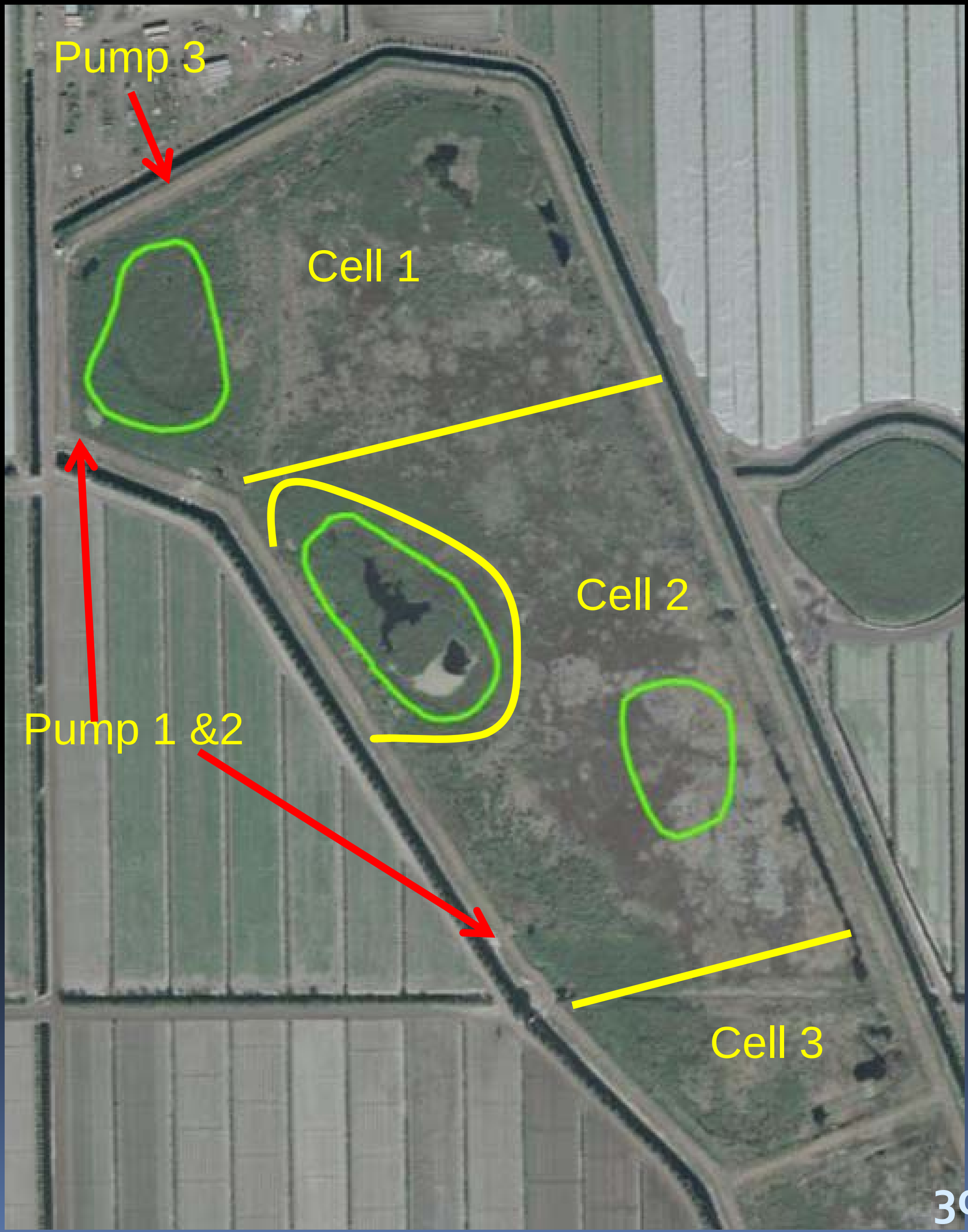
Option 1

- Move pumps 2 and 3 farther from discharge
  - Cost
- Increased residence time and decreased short circuiting
- Longer and more diverse flow path

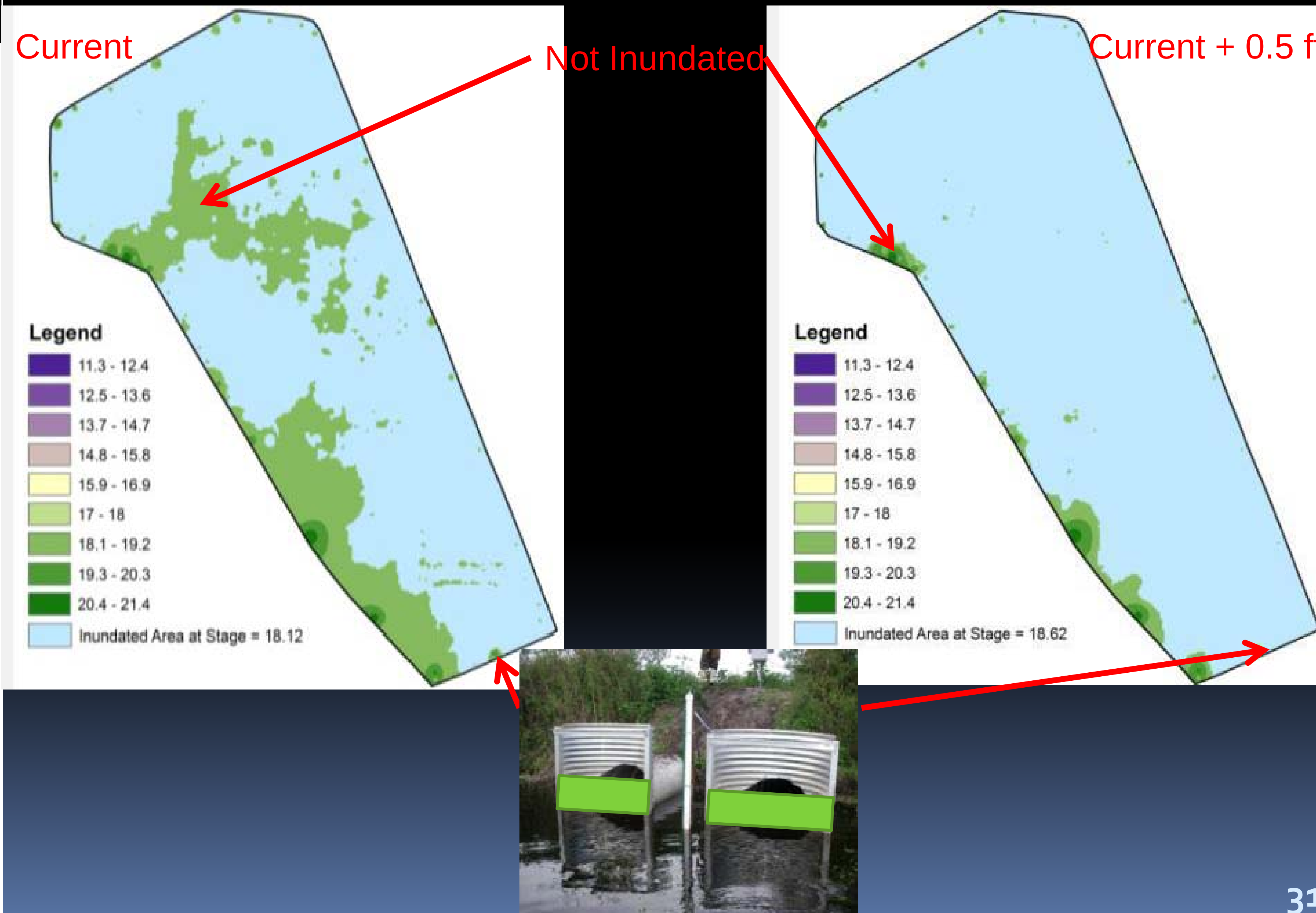


Option 2

- Combination of scenarios
  - Pump movement
  - Multiple cells
    - example
    - no change in elevation at the outlet
  - Higher than current discharge elevation
  - protect wetlands



Discharge Level Modification



Summary

- First study on P treatment efficiency of an in-use agricultural impoundment
- Preliminary results indicate that the AGI has a treatment efficiency of 20%
  - High P retention for sediment bound P
  - Legacy P – more than a decade of pumping – flow paths and low soil P retention - AGI can be a potential source of P
  - Variability (rainfall and drainage) – Drainage - crop specific
  - "wet" dry season of 2010
  - Flow quantification –Pumps and discharge - Accuracy

Continuation...

- Enhancements being evaluated:
  - Move pumps to locations which allows longer flow paths
  - Multiple cells – without impacting wetlands – force water to cover most of the area before discharge occurs
  - Biomass and Water recycling
  - Others
- Cost for enhanced P retention
- Next step: Formally presenting the results and completing the tracer study

QUESTIONS?

Acknowledgement

Grower Cooperator