

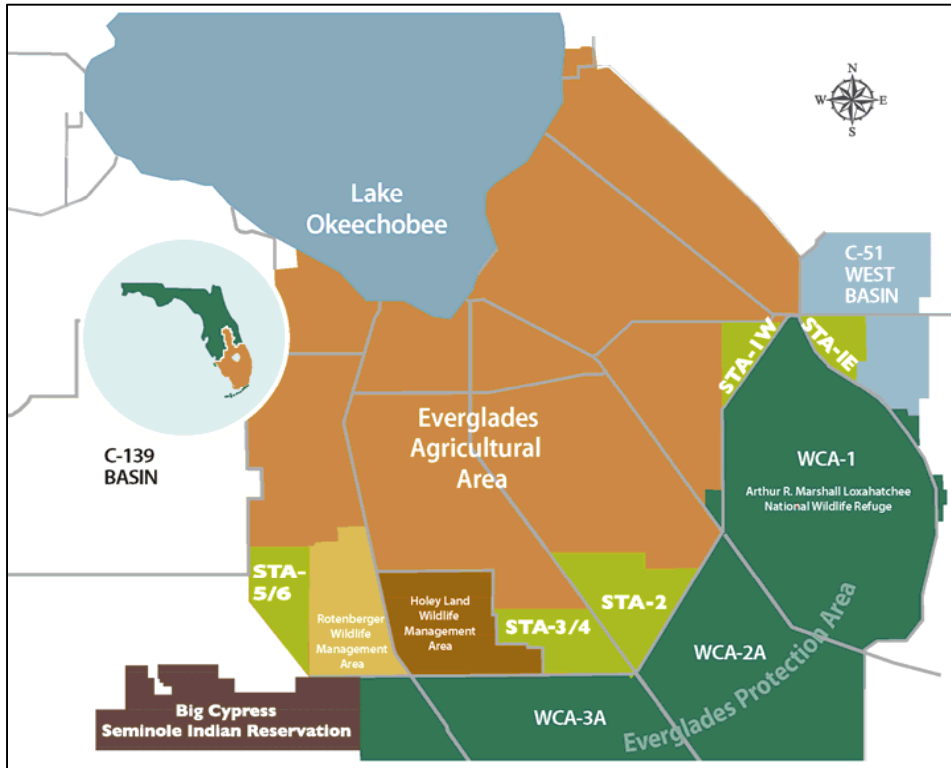
Restoration Strategies

Periphyton-based Stormwater Treatment Area (PSTA) Water and Total Phosphorus Budget Analyses

April 22, 2015

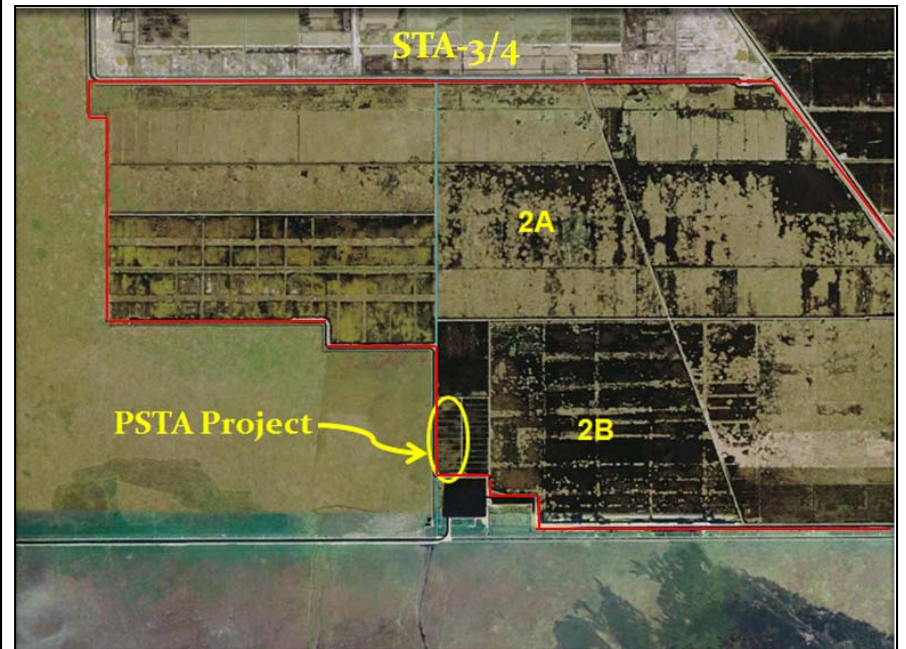
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Project Location



Everglades Stormwater Treatment Areas (STAs)

- 57,000 acres of treatment area



PSTA Cell in STA-3/4

- 100-acre study site

Background and Objective

Background

- PSTA cell achieves very low outflow TP (8-13 ppb)
- Purpose of PSTA Study is to assess bio-geochemical characteristics and operational factors contributing to PSTA Cell's performance
- Lessons learned for potential further PSTA implementation

Objective of this task:

Evaluate PSTA Cell's performance through water and TP budget analyses



PSTA Cell

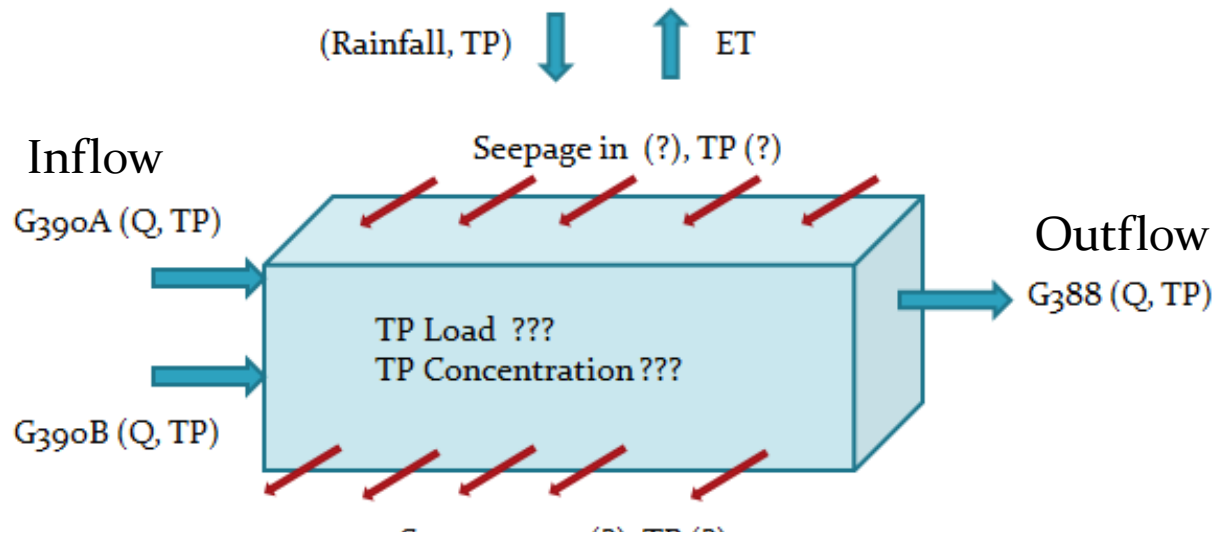
PSTA Cell Water and TP Budget Equations

➤ Water Budget

$$G-390A + G-390B + R - G-388 + \text{seepage} - ET - \Delta S = \varepsilon$$

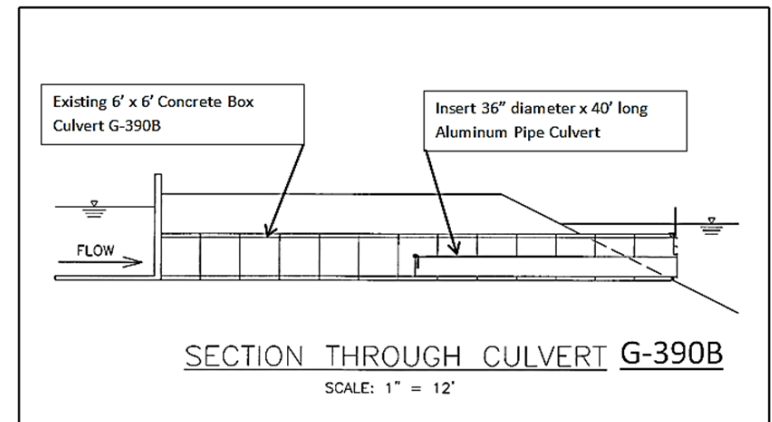
➤ TP Budget

$$\Delta TP = TP \text{ Load}_{G390A+G390B} + TP \text{ Load}_{\text{Rain}} + TP \text{ Load}_{\text{seepage in}} - TP \text{ Load}_{\text{seepage out}} - TP \text{ Load}_{G388}$$



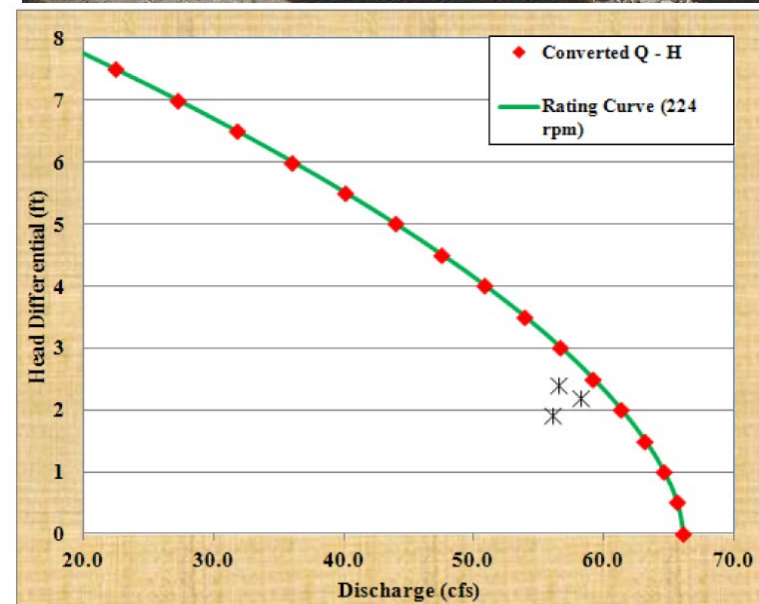
Inflow Culvert Flow Estimate Improvements

- Improved inflow culvert flow estimates for May 2007 to December 2010
- Installed 36-inch diameter aluminum pipe inside existing 6-foot by 6-foot concrete box culvert (2011)
- Developed new flow rating equation



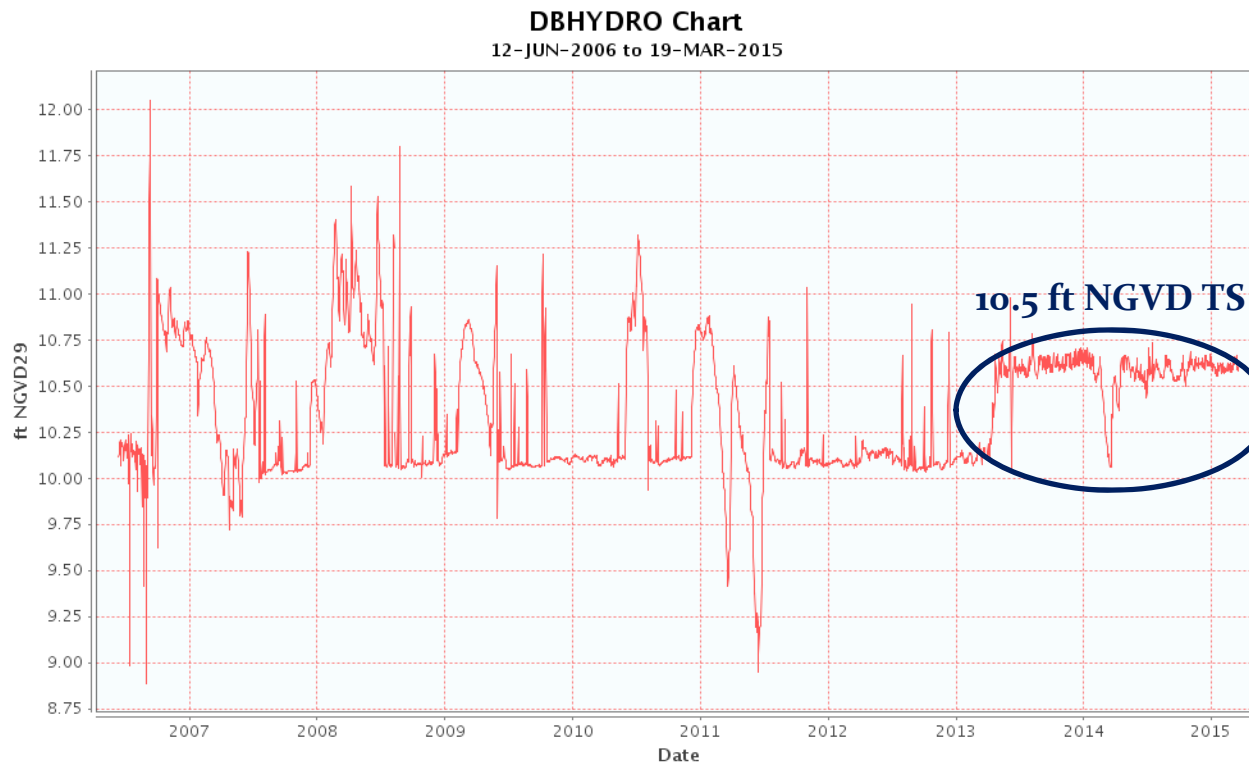
Outflow Pump Flow Estimate Improvements

- **Oversized pumps with frequent on/off cycling produced large errors in flow estimates**
- **Reduced pump speed from 350 to 224 rpm**
- **Developed improved flow rating equation**



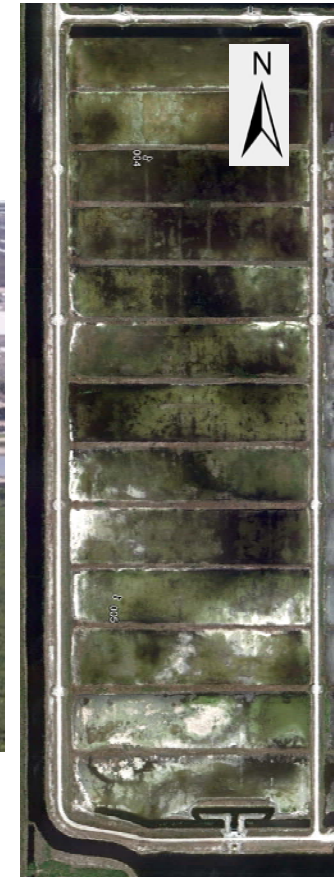
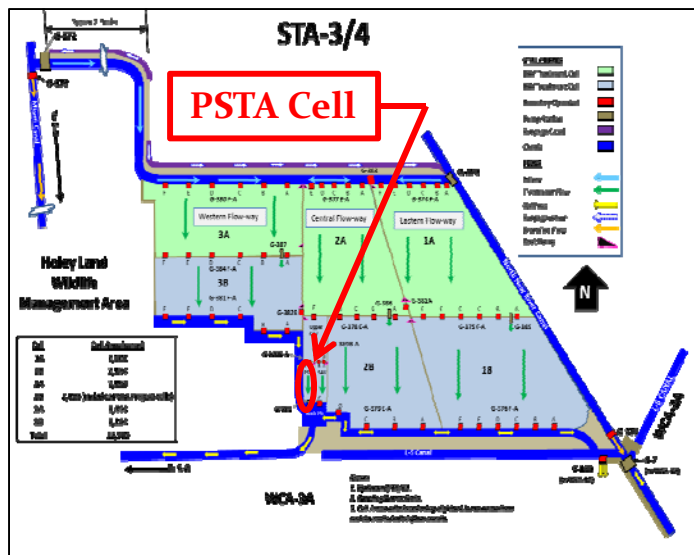
Operational Change

- In April 2013, the target stage was increased from 10.0 to 10.5 ft NGVD
 - Average depths increased from 1.2 ft to 1.7 ft.



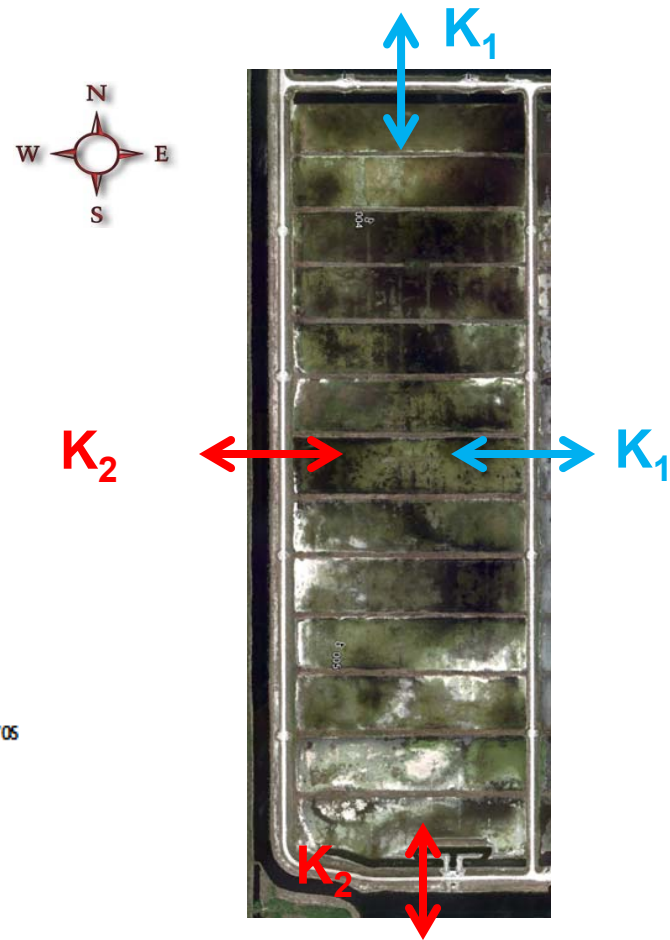
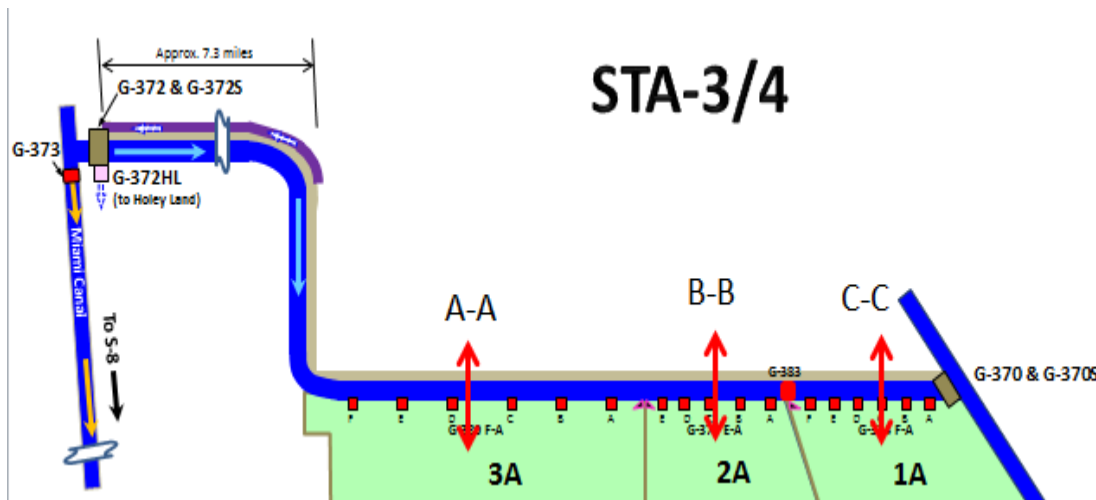
PSTA Cell Seepage Calibration

- North and East levees constructed as part of PSTA project
- South and West levees constructed as part of STA-3/4 according to a higher standard



PSTA Cell Seepage Calibration

- Seep2D model for STA-3/4 levee seepage by Sangoyomi et al. (2011)
 - Calibrated seepage coefficients: 1.3, 2.2 and 2.0 cfs/ft/mi for cross-sections A-A, B-B, C-C
 - Average value of 1.8 cfs/ft/mi (K_2)
- Seepage coefficient (K_1) for North and East PSTA Cell levees was calibrated in this analysis



PSTA Cell Seepage Calibration

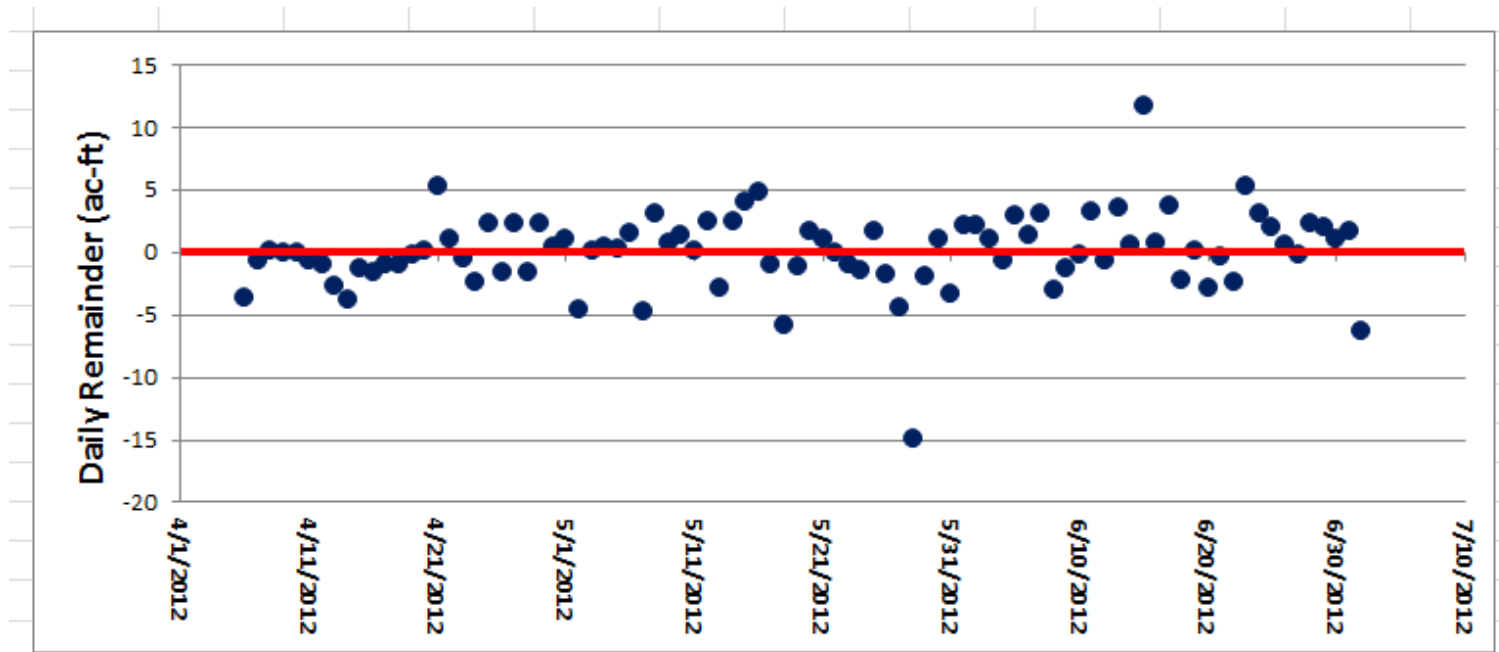
Calibration period: April 6 to July 2, 2012

- **Inflow culverts were closed (no inflow)**
- **Outflow pump was under normal operation to maintain cell target stage**



PSTA Cell Seepage Calibration

Daily Remainder Distribution

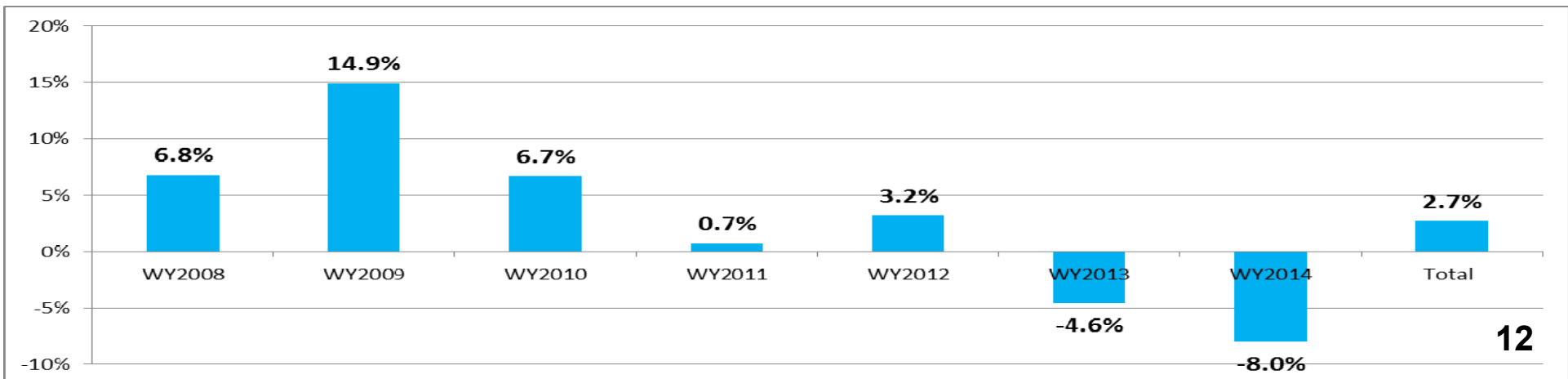


Average remainder: 0.04 ac-ft
Median: 0.09 ac-ft
Standard error: 0.3 ac-ft

**Calibrated seepage coefficient (K_1) for
North and East levees: 6.0 cfs/ft/mi**

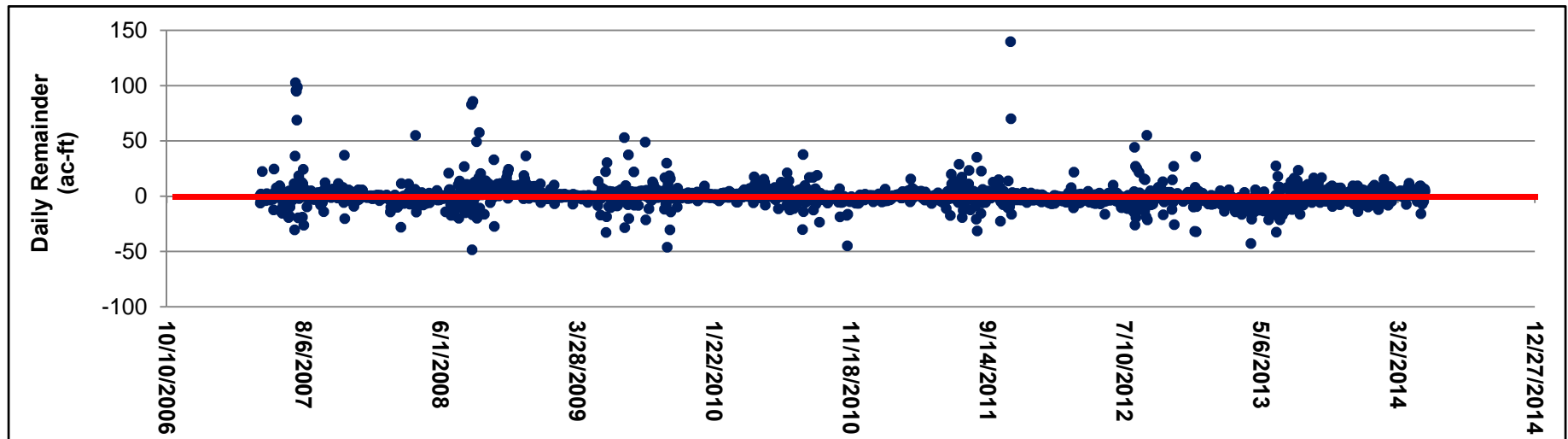
PSTA Cell Water Budget Summary

WY	Culvert Inflow (ac-ft)	Seepage In (ac-ft)	Rain (ac-ft)	Total Inflow (ac-ft)	Pump Outflow (ac-ft)	Seepage out (ac-ft)	ET (ac-ft)	Total Outflow (ac-ft)	Change in Storage (ac-ft)	Remainder (ac-ft)	error %
2008	2,922	1,821	402	5,145	4,905	31	446	5,382	119	355	6.8
2009	3,298	2,108	448	5,854	6,405	2	458	6,864	-66	945	14.9
2010	7,020	2,339	504	9,864	10,080	17	448	10,545	-7	675	6.7
2011	3,289	8,85	340	4,515	3,965	124	464	4,554	-9	30	0.7
2012	7,452	2,122	431	10,005	9,848	29	453	10,331	-7	318	3.2
2013	9,322	2,436	516	12,275	11,219	12	450	11,681	32	-561	-4.6
2014	4,030	432	413	4,875	3,794	236	449	4,479	20	-376	-8
TOTAL	37,334	12,144	3,054	52,533	50,216	450	3,169	53,835	82	1,385	2.7



PSTA Cell Water Budget Summary

Daily Remainder Distribution

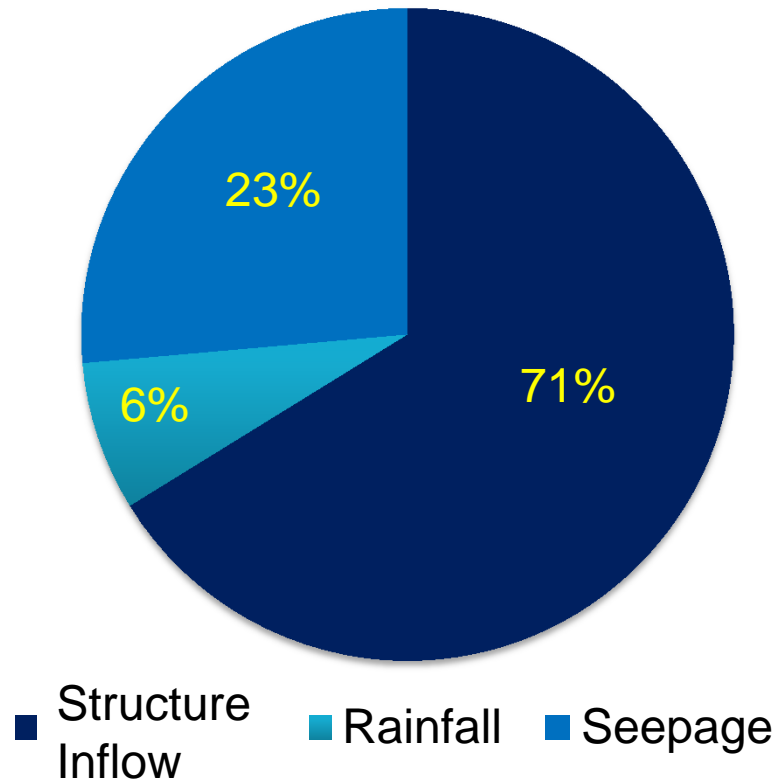


- **Mean (0.54 ac-ft)**
- **Median (0.37 ac-ft)**
- **Standard Error (0.18 ac-ft)**

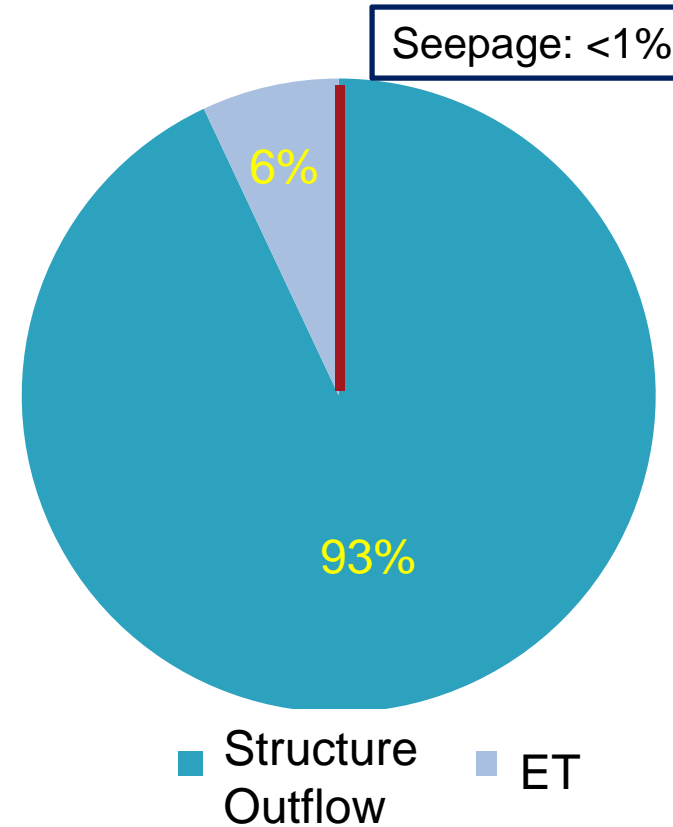
- **75% of time, absolute value of remainder is less than 5 ac-ft, equivalent to 0.6 inch depth in the cell**

PSTA Cell Water Budget Summary

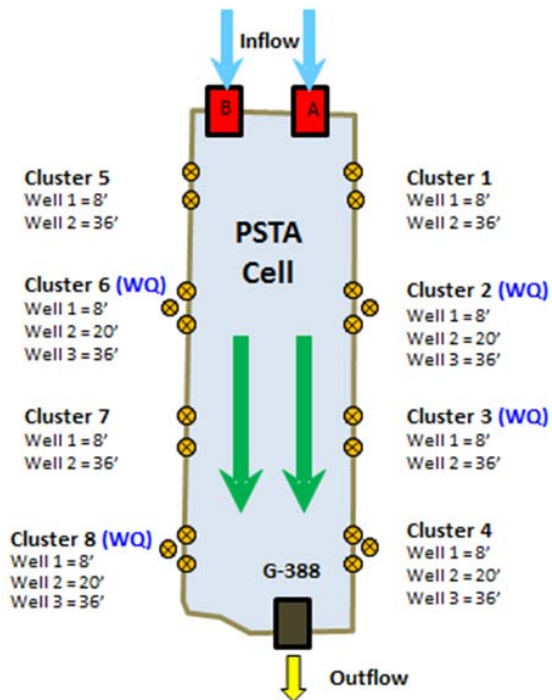
PSTA Cell Inflows



PSTA Cell Outflows



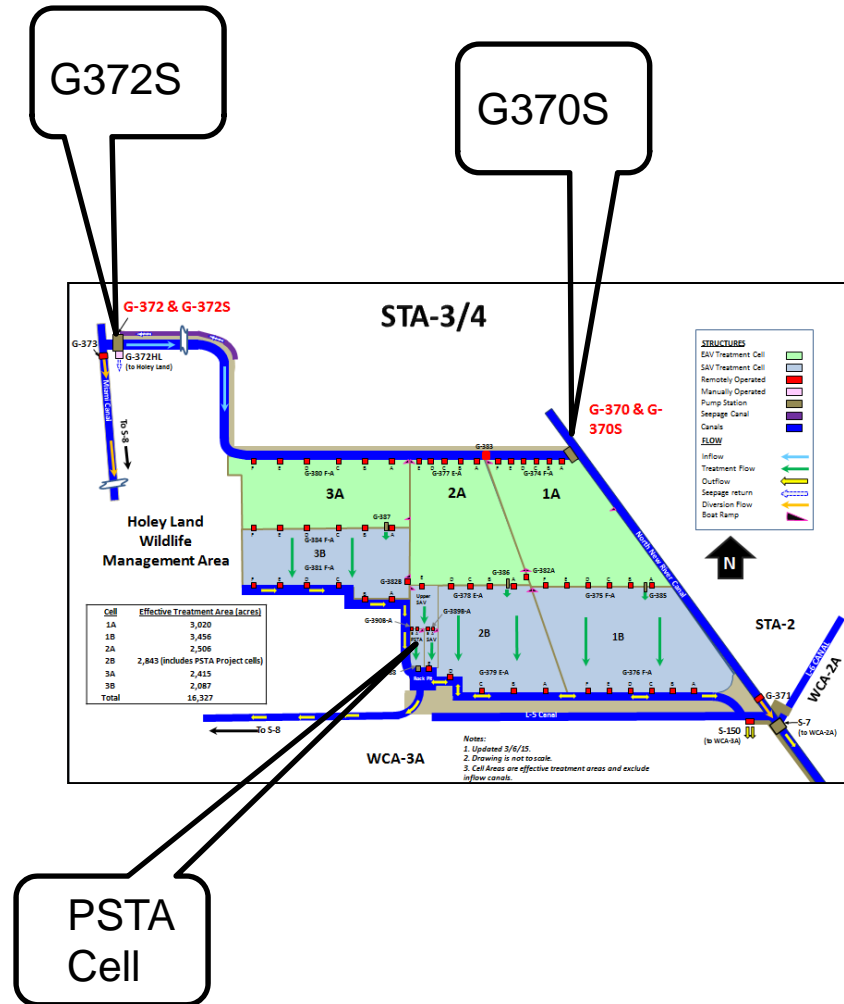
PSTA Well Water Quality Data



- **Number of samples: 27**
- **Range: 3 to 64 ppb**
- **Median TP concentration 10 ppb**
- **Average TP concentration 19 ppb**

G370S and G372S Water Quality Data

	Site G370S	Site G372S
Sample number	682	636
Average TP concentration (ppb)	8	12
Median TP concentration (ppb)	11	10
5 percentile TP concentration (ppb)	7	7



PSTA Cell TP Mass Balance

Base Scenario:

- **Rainfall TP: 6 ppb (wet deposition)**
- **Seepage In TP: 10 ppb**
 - **Median of PSTA Well Data and G-370S/G-372S**
- **Seepage Out TP: Average of inflow and outflow structures**

PSTA Cell Performance Evaluation

$$\Delta TP \% = TP \text{ load reduction \%} = (TP \text{ Load}_{in} - TP \text{ Load}_{out}) / TP \text{ Load}_{in} * 100\%$$

$$\Delta TP \text{ FWMC \%} = TP \text{ FWMC reduction \%} = (FWMC_{in} - FWMC_{out}) / FWMC_{in} * 100\%$$

PSTA Cell TP Mass Balance (Using Seepage In TP Concentration of 10 ppb)

- **Structure Inflow TP concentration range: 14 to 27 ppb**
- **With the effect from the seepage:
The surface flow TP concentration ranged from 12 to 21 ppb**

- **Load reduction percentage**
 - **ranged from 20% to 50%;**
 - **annual average: 34%**
- **Concentration reduction percentage**
 - **ranged from 19% to 41%;**
 - **annual average: 31%**

Sensitivity Analyses

➤ Seepage In TP: 7 ppb and 19 ppb (10 ppb Base)

➤ Rainfall TP: 3 ppb and 9 ppb (6 ppb Base)

Parameter	Annual Average Values Based on 7 years of data				
	Base Value	K ₁ = 6.0, K ₂ = 1.8 Seepage = 10 ppb		K ₁ = 6.0, K ₂ = 1.8 Rainfall = 6 ppb	
	K ₁ = 6.0	Rainfall TP = 3 ppb (-50%)	Rainfall TP = 9 ppb (+50%)	Seepage TP = 7 ppb (-30%)	Seepage TP = 19 ppb (+90%)
	K ₂ = 1.8				
	Rainfall TP=6 ppb Seepage TP=10 ppb				
TP Load Reduction (%)	34%	33%	35%	31%	42%
TP FWMC reduction (%)	31%	30%	32%	28%	39%

Summary

- **7-year annual average water budget error: < 3%**
- **7-year period:**
 - **Inflow: 71% surface flows, 23% seepage, 6% rainfall**
 - **Outflow: 93% structure flow, 6% ET, <1% seepage**

7-year TP reduction using Seepage Concentration of 10 ppb

- **Load reduction percentage: 34%**
- **Concentration reduction percentage: 31%**

PSTA performance results were not sensitive to rainfall TP concentration but were sensitive to the seepage TP concentration

During the 7-year period, PSTA Cell produced annual outflow FWM TP concentrations at or below 13 ppb

Recommendations

- **Continue water quality sampling at the wells located along the West and East levees**
- **Conduct an additional seepage calibration test with inflow gates closed to reflect conditions under the current target stage (10.5 ft. NGVD)**
- **Update the water and TP budget analyses annually**



Questions?