STA-1E Periphyton Stormwater Treatment Area (PSTA) Final Report

Presented
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Technical Oversight Committee Meeting

by:
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Scope of Work

Provide an independent analysis and presentation of the PSTA data for the Flying Cow Road Test Facility (FCRTF) and Field Scale Demonstration (FSD) projects

- Assemble and compile available data from both research platforms
- Prepare outline for final report
- Analyze/interpret available data
- Summary report of findings

Assemble Available Information

- Identified existing data
- Acquired archive laboratory records from original contract lab
- Retrieved additional data files from PSTA field computer
- Converted over 6,700 raw data files from proprietary VTS system DAT format to TXT format
- Imported data into Access/Excel to generate summaries
- Developed multiple working databases of all available data used for report preparation

Background Review

- Reviewed FCRTF and FSD project documents
  - Design documents and drawings
  - Operations and Monitoring Plans
  - Monthly, quarterly, and interim updates and presentation materials
- Site visit to document existing layout of FCRTF and FSD
- Site visit to STA-3/4 PSTA demonstration project

Types of Data Reviewed

- Meteorological data (Rain, ET, Air Temp, etc.)
- Physical water quality parameters (DO, pH, T, Cond., etc.)
- Analytical water quality parameters (P, N, Ca, N, Metals, etc.)
- Hydrologic data (stage, discharge, weir elevations)
- Sediment and periphyton chemistry
- Periphyton taxonomy
- Vegetation/wildlife management

Data Analysis

- Summary statistics for water quality parameters by sampling station
- Water balances
  - FCRTF underdrains
  - FSD seepage
  - FSD submerged weirs
- Comparison of inflow/outflow phosphorus mean concentrations (arithmetic and flow-weighted)
- Phosphorus mass balances
- Phosphorus settling rates
- Scale-up estimates

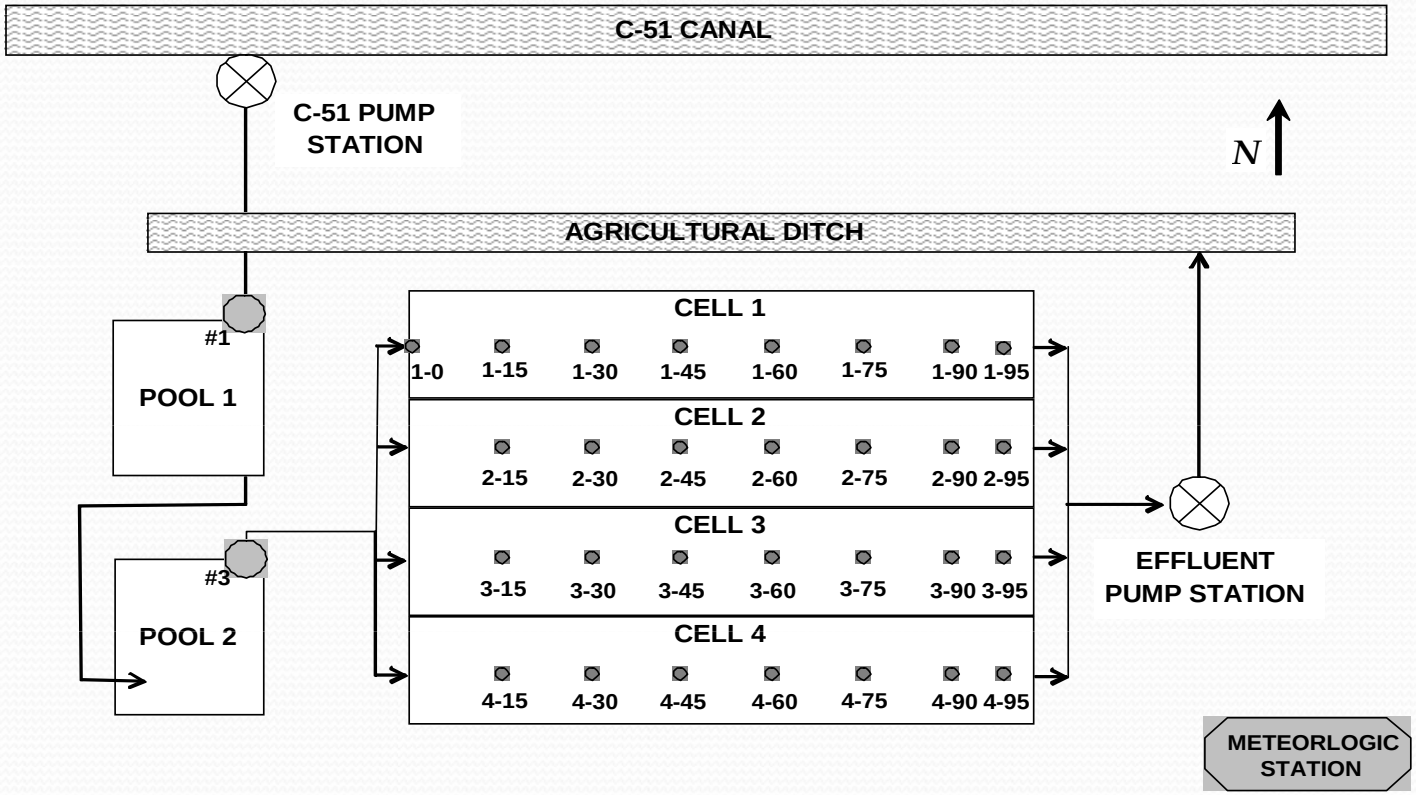
Data Limitations

- QC issues with some electronic data
  - Hydrolab data not corrected or screened for erroneous values
  - Limited calibration data
  - Measurement units not displayed in files and undocumented changes in units
- Routine electronic and field data records not available
- Potential interpretation issues with prior reports
  - Use of synoptic inflow and outflow data
  - Use of design instead of measured inflow and outflow
- Large uncertainty of FSD inflow and outflow rates
- Large unmeasured seepage losses from FSD PSTA cells

Summary of Results

FCRTF and FSD

Flying Cow Road Test Facility



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FCRTF Operational History

- 3-6/2003
- 3/06 – 2/08
- Cell 4

Flow Regime	Period[2]	Duration (days)	Water Depth (ft)	Nominal HRT (days)	Flow (gpm)
1	03/06/06 – 04/10/06	36	1.0	14	0.37
2	04/11/06 – 07/07/06	88	1.0	7	0.74
3	07/08/06 – 11/01/06	117	0.5	7	0.37
4	11/02/06 – 02/14/07	105	2.0	14	0.74
5	02/15/07 – 03/12/07	26	2.0	7	1.48
6	03/13/07 – 04/16/07	35	1.25	14	0.46
7	04/17/07 – 05/02/07	16	1.25	7	0.93
8	05/03/07 – 05/17/07	15	1.25	3.5	1.86
9[1]	05/17/07 – 09/28/07	135	1.25	7	0.93
10[1]	10/19/07 – 02/29/08	134	0.5	14	0.19

[1]Cells 1 and 3 were operated at these flow regimes. Cell 2 was operated from July 10, 2007 to December 3, 2007 at 0.5-feet depth and 7-day HRT. Cell 2 operated from December 3, 2007 to the end of the reporting period at 1-foot depth and 21-day HRT. Cell 4 operated from June 26, 2007 to the end of the reporting period at 0.5-feet depth and 7-day HRT.

[2]Any planned flow regimes beyond February 29, 2008 are undocumented.

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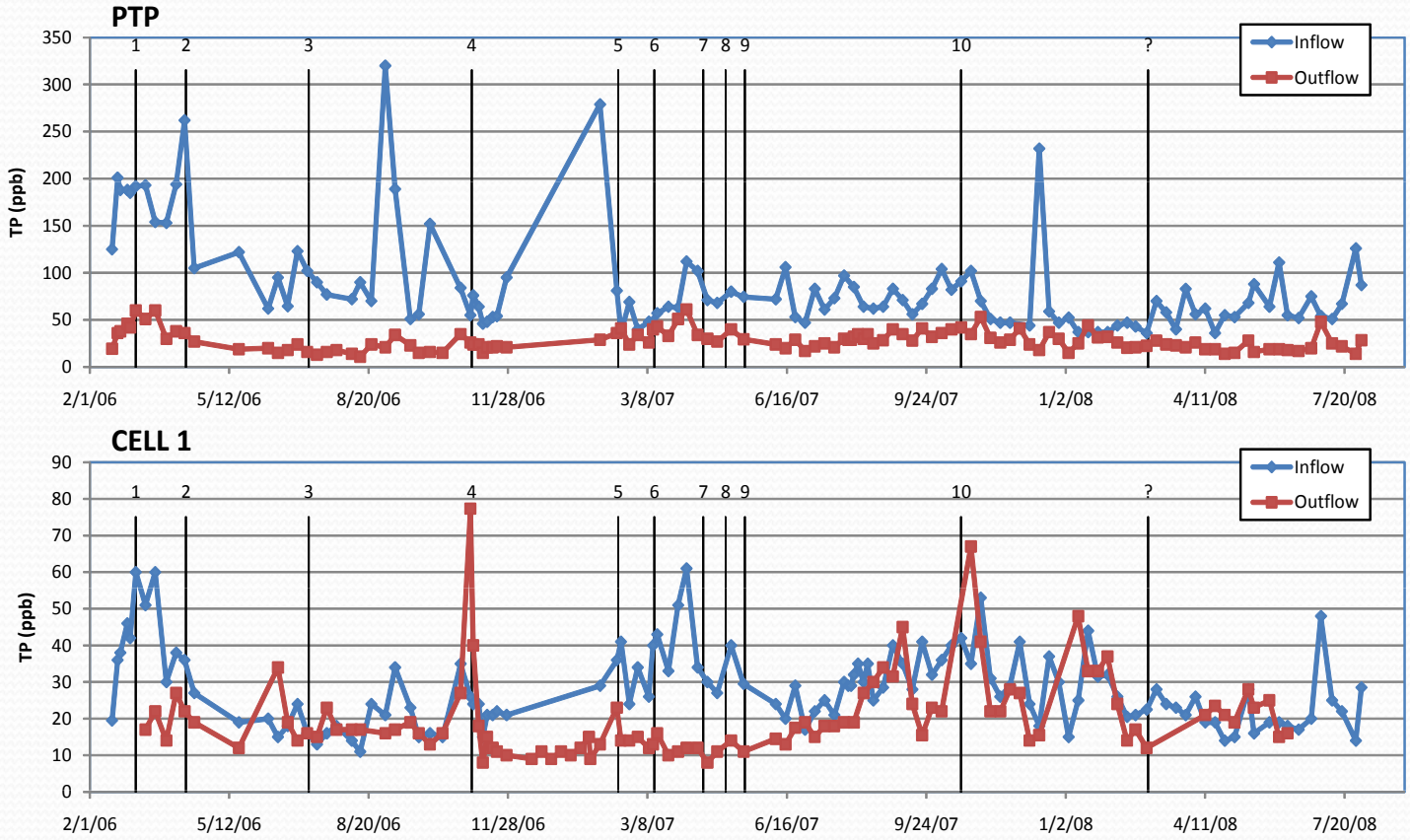
FCRTF Results



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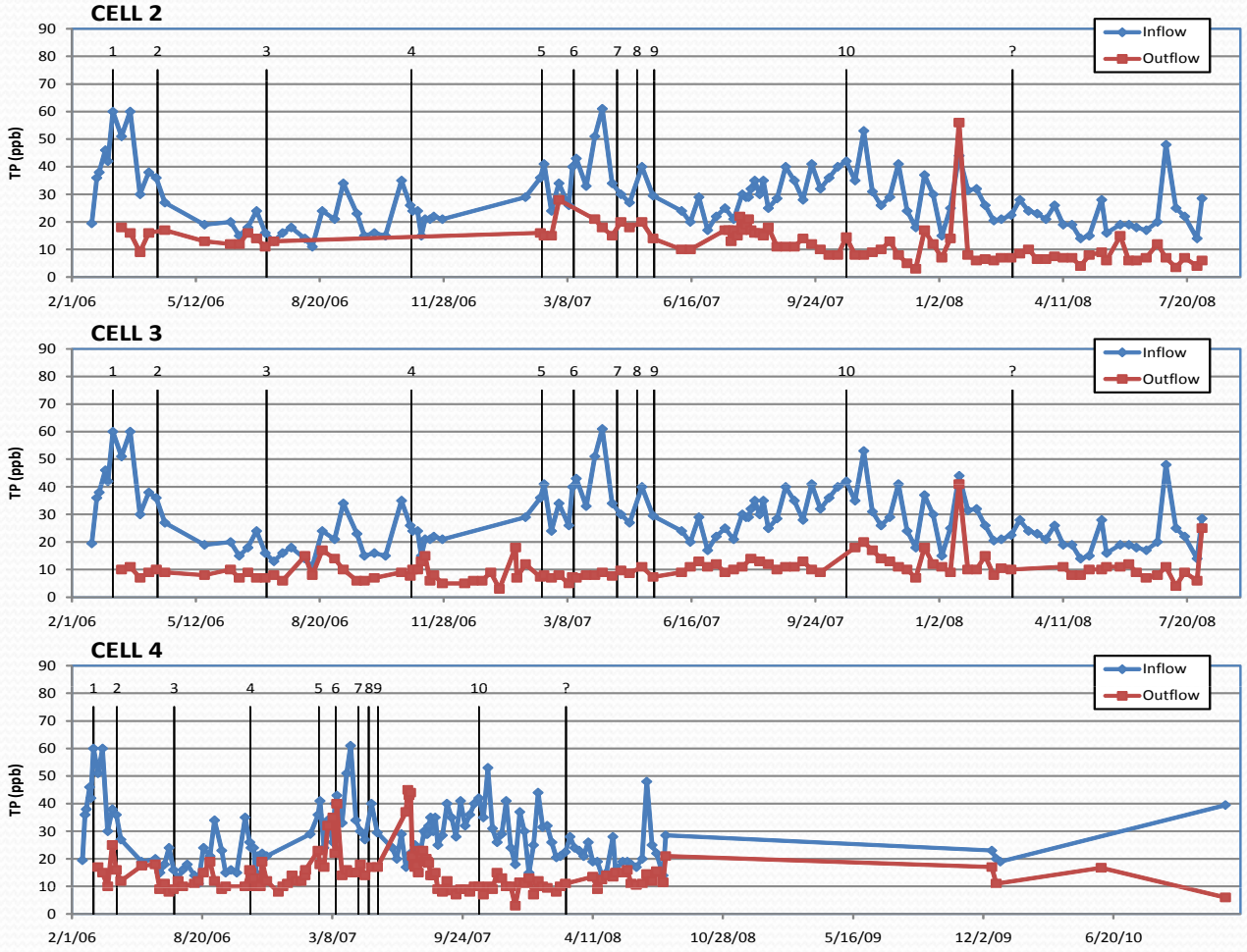
FCRTF Results



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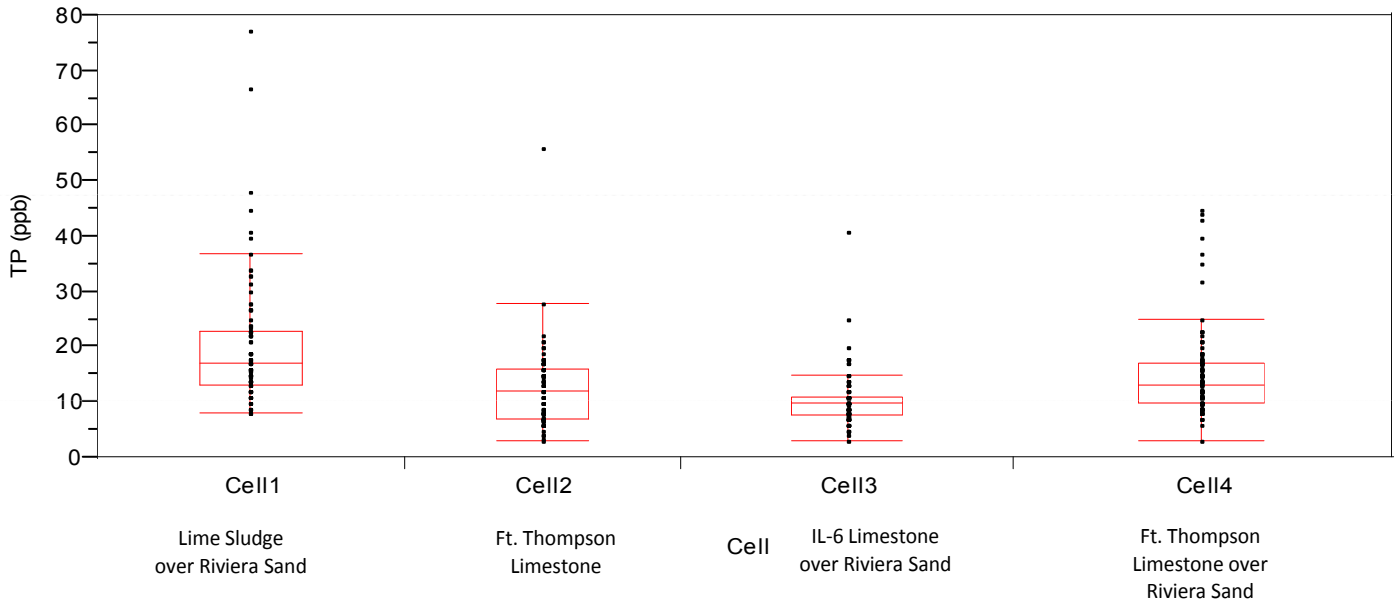
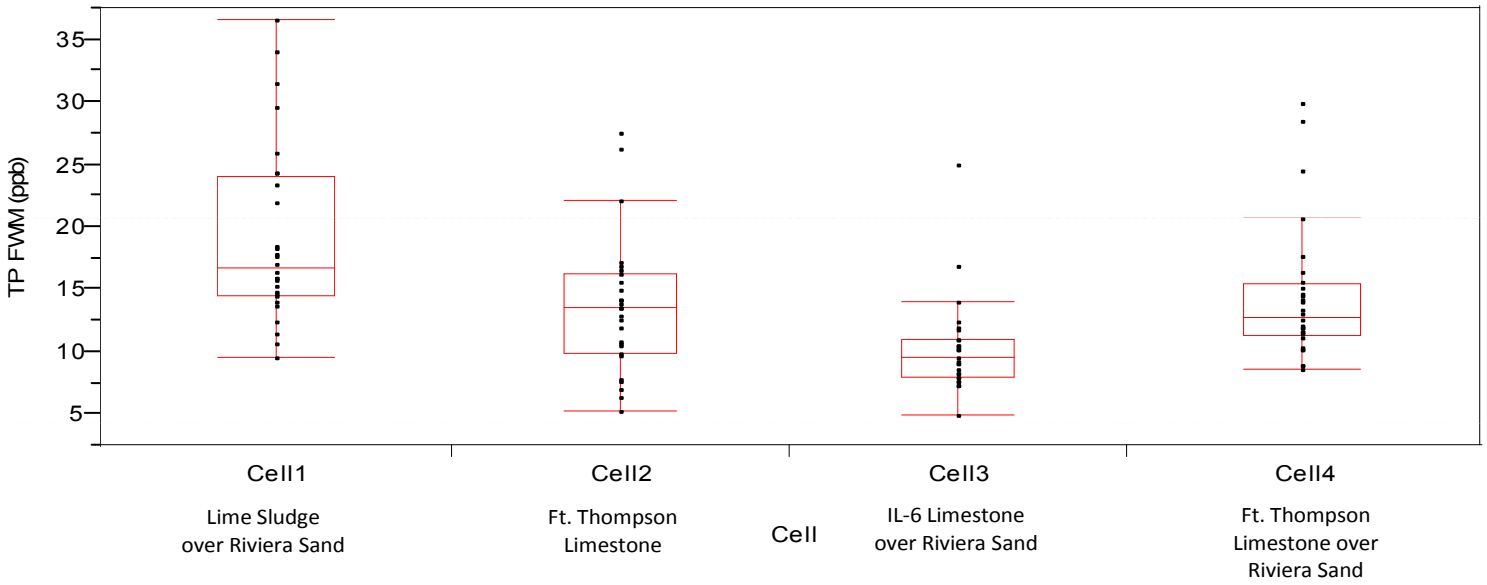
FCRTF Arithmetic Means



Location	Minimum	10%	25%	Median	75%	90%	Maximum	Student's t-test*	Mean
Cell1	8	11	13	17	23	33	77	A	20.1
Cell2	3	6	7	12	16	18	56	B	14.9
Cell3	3	6	8	10	11	15	41	C	12.4
Cell4	3	9	10	13	17	22	45	C	10.2

* Levels not connected by same letter are significantly different (α = 0.05)

FCRTF Outflow FWM TP



Location	Minimum	10%	25%	Median	75%	90%	Maximum	Student's t-test*	Mean
Cell1	10	11	15	17	24	32	37	A	19.2
Cell2	5	7	10	13	16	23	28	B	13.6
Cell3	5	7	8	10	11	15	25	C	10.4
Cell4	9	9	11	13	16	25	30	B	14.4

* Levels not connected by same letter are significantly different (α = 0.05)

Note: All differences between inflows and outflows were statistically significant

FCRTF Summary Results

Cell	FWM In (ppb)	FWM Out (ppb)	HLR (cm/d)	MLR ($g/m^2/yr$)	Mass Removal (%)	k (m/yr)
1	27	17	5.0	0.50	46	11.4
2	24	13	2.9	0.26	54	9.5
3	26	9	6.0	0.57	68	38.4
4	24	14	5.1	0.46	51	14.8

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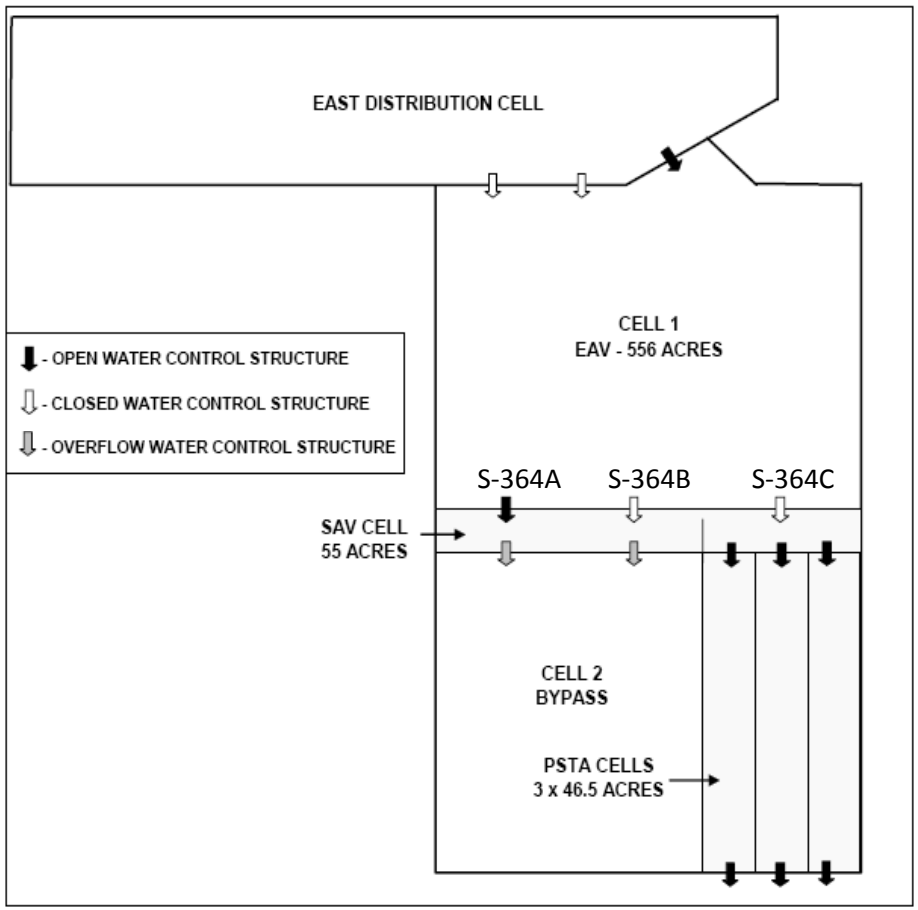
Field Scale Demonstration



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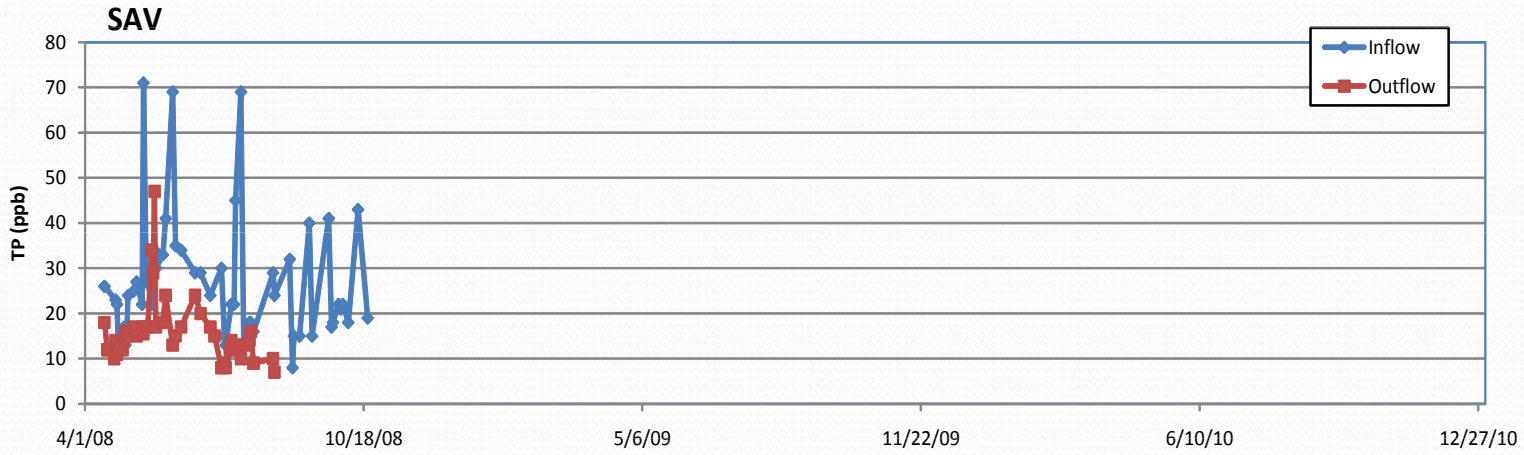
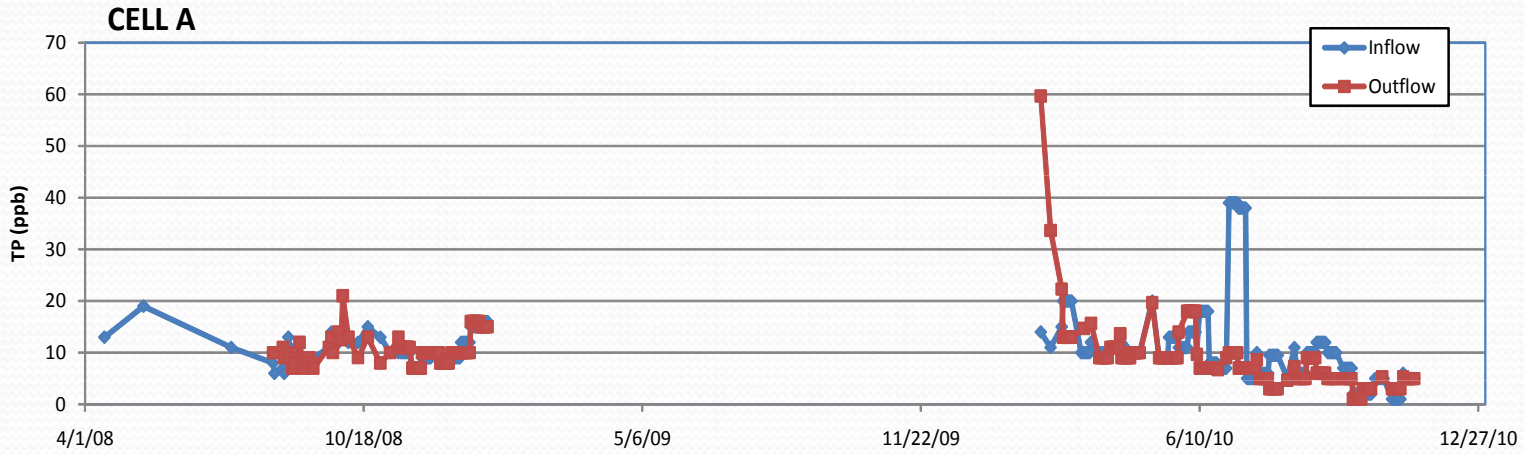
FSD Operational History

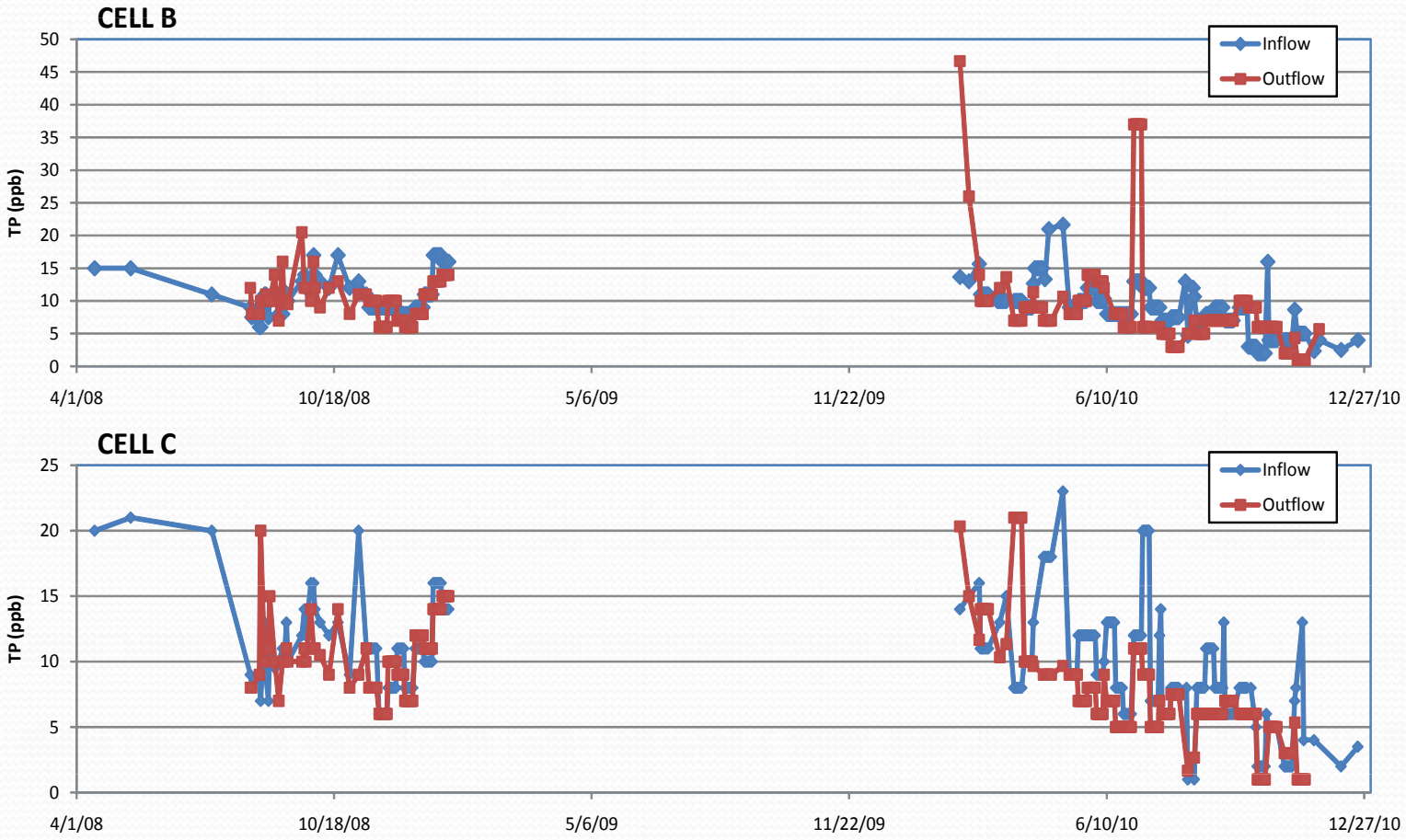
- Construction 2005 – 2006
- Activation 7/2007 – 9/2008
- Operational sampling 10/08 – 12/08
- Drought 2009
- Operational sampling 2/2010 – 12/2010

FSD Results

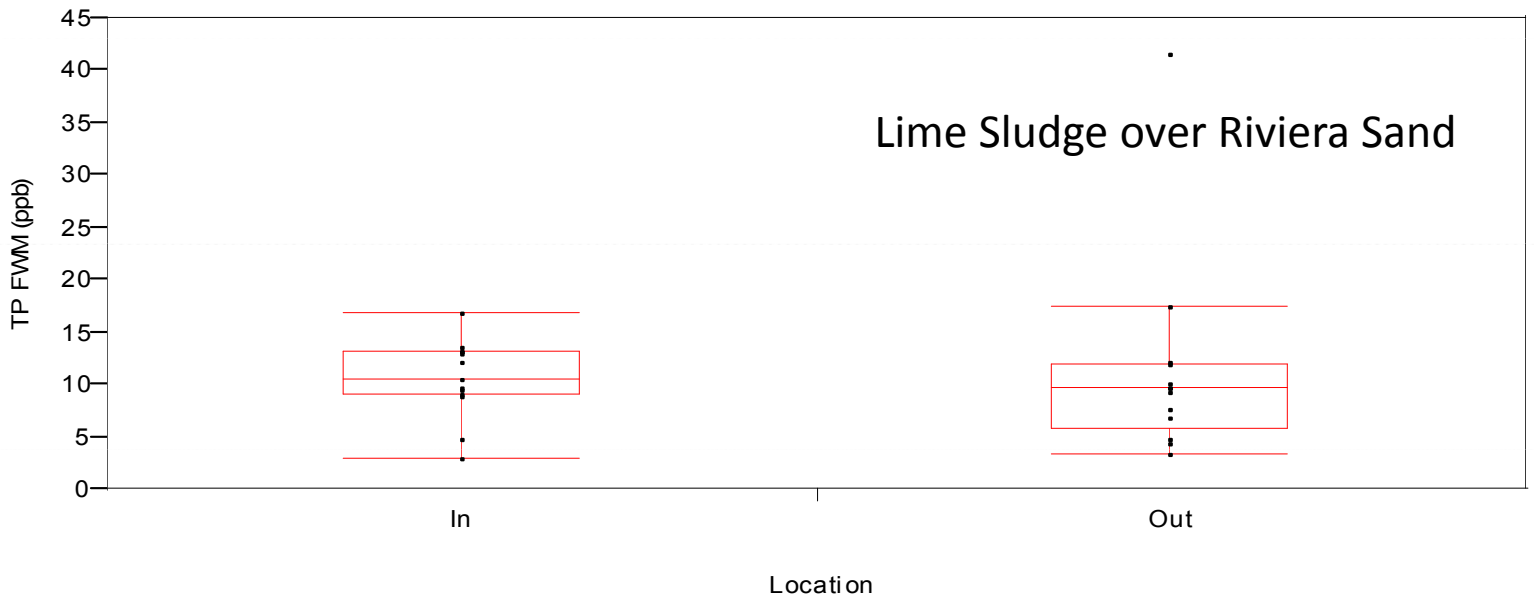

SAV
TP (ppb)
80
70
60
50
40
30
20
10
0
4/1/08
10/18/08
5/6/09
11/22/09
6/10/10
12/27/10
Inflow
Outflow


CELL A
TP (ppb)
70
60
50
40
30
20
10
0
4/1/08
10/18/08
5/6/09
11/22/09
6/10/10
12/27/10
Inflow
Outflow

FSD Results


CELL B
TP (ppb)
50
45
40
35
30
25
20
15
10
5
0
4/1/08
10/18/08
5/6/09
11/22/09
6/10/10
12/27/10
Inflow
Outflow
CELL C
TP (ppb)
25
20
15
10
5
0
4/1/08
10/18/08
5/6/09
11/22/09
6/10/10
12/27/10
Inflow
Outflow

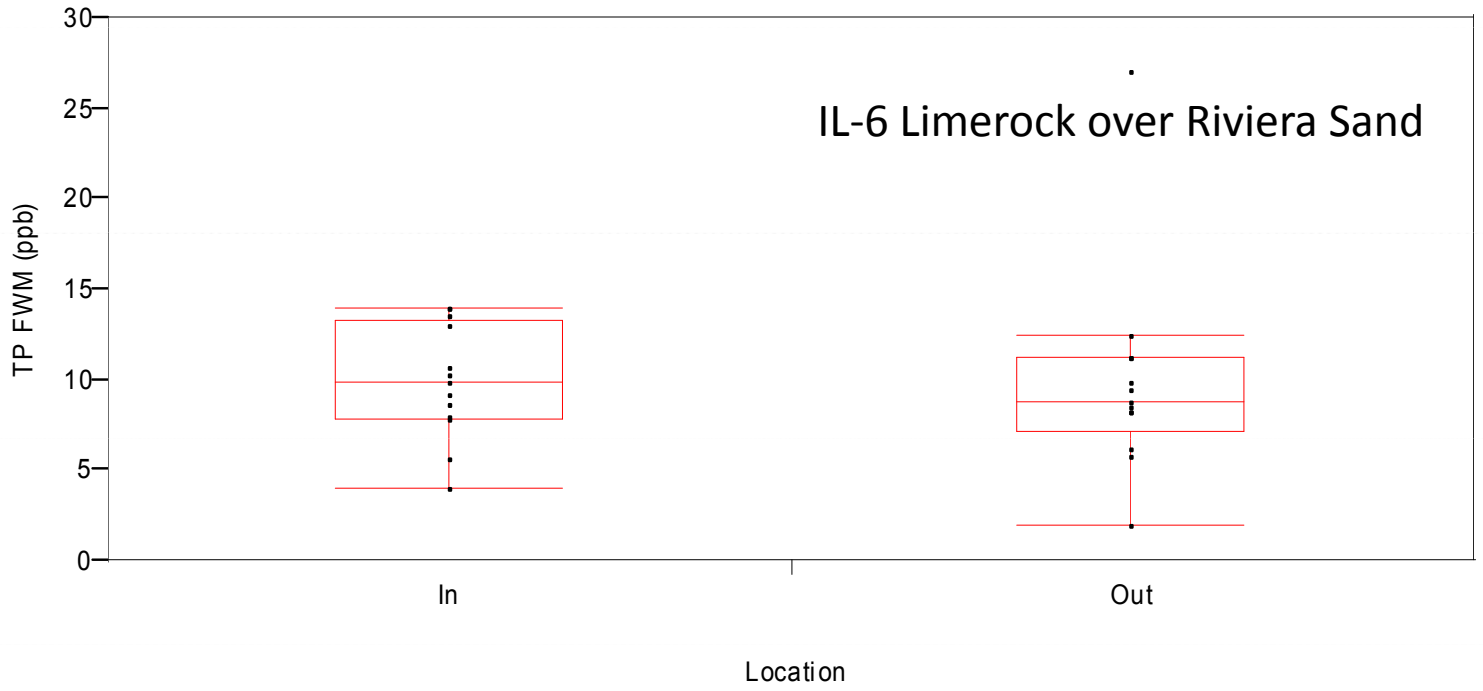
FSD Cell 2A FWM TP



Location	Minimum	10%	25%	Median	75%	90%	Maximum	Student's t-test*	Mean
In	3.0	3.7	9.0	10.6	13.1	15.5	16.8	A	10.6
Out	3.3	3.8	5.8	9.8	12.0	32.0	41.7	A	11.5

* Levels not connected by same letter are significantly different (α = 0.05)

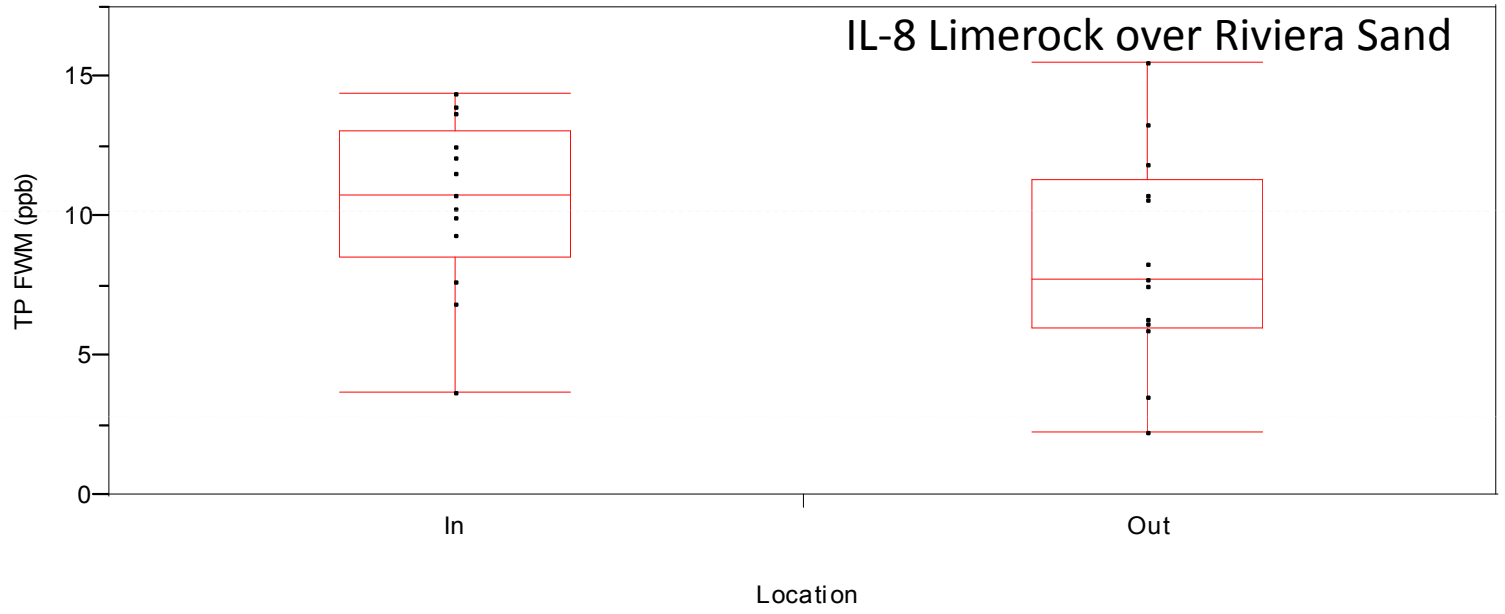
FSD Cell 2B FWM TP



Location	Minimum	10%	25%	Median	75%	90%	Maximum	Student's t-test*	Mean
In	4.0	4.6	7.9	9.8	13.3	14.0	14.0	A	9.9
Out	1.9	3.5	7.2	8.9	11.2	21.2	27.1	A	9.9

* Levels not connected by same letter are significantly different (α = 0.05)

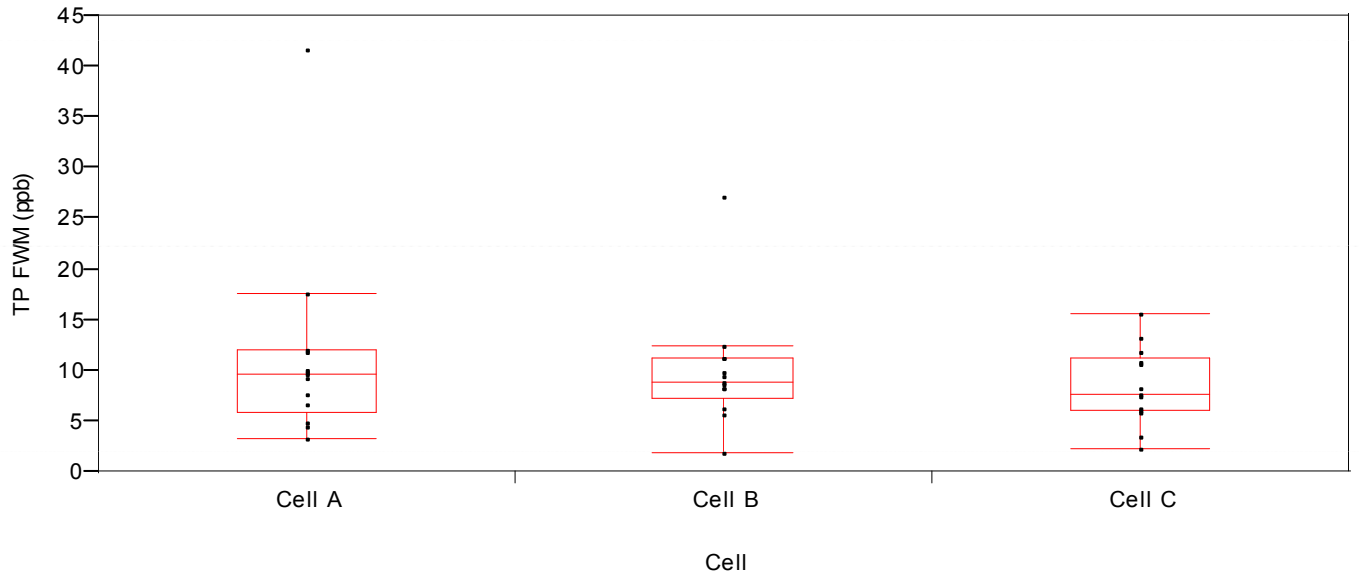
FSD Cell 2C FWM TP



Location	Minimum	10%	25%	Median	75%	90%	Maximum	Student's t-test*	Mean
In	3.7	5.0	8.5	10.7	13.1	14.2	14.4	A	10.5
Out	2.3	2.8	6.0	7.7	11.3	14.7	15.6	A	8.5

* Levels not connected by same letter are significantly different (α = 0.05)

FSD Outflow FWM TP



Location	Minimum	10%	25%	Median	75%	90%	Maximum	Student's t-test*	Mean
Cell A	3.3	3.8	5.8	9.8	12.0	32.0	41.7	A	11.5
Cell B	1.9	3.5	7.2	8.9	11.2	21.2	27.1	A	9.9
Cell C	2.3	2.8	6.0	7.7	11.3	14.7	15.6	A	8.5

* Levels not connected by same letter are significantly different (α = 0.05)

Field Scale Demonstration Summary Results

Cell	FWM In (ppb)	FWM Out (ppb)	HLR (cm/d)	MLR ($g/m^2/yr$)	Mass Removal (%)	k (m/yr)
A	7.9	10.2	11.4	0.34	-28	--
B	9.6	9.6	6.5	0.23	3	3.4
C	9.9	8.2	6.5	0.24	17	14.4

Full Scale PSTA Implementation

Design and Operational Considerations

PSTA Design Considerations

- Shallow, level impoundment
- Substrate/sediment with low phosphorus
- Inflow phosphorus <20 ppb
- Adequate dissolved calcium in source water and/or substrate
- Maintain low density of emergent or floating vegetation

Full-Scale Area Design Assumptions

- Inflow volume of 124,900 acre-ft/yr (design flow for STA-1E)
- Inflow flow-weighted mean (FWM) phosphorus concentration of 193 ppb
- The total effective area of STA-1E is 5,132 acres
- Outflow from upstream cells (inflow to PSTA) ranges from 12 to 30 ppb based on possible improvements to STA-1E and other facilities
- P = 4 tanks for all cells
- C* = 4 ppb for all vegetation types

Full-Scale Additional Area Requirements

PSTA Inflow Concentration (ppb)	PSTA Area Required (acres)	
	k = 14.4 m/yr (FSD PSTA Cell C)	k = 31.0 m/yr (STA-3/4 PSTA)
12	800	370
15	1,700	810
20	3,000	1,400
25	3,900	1,800
30	4,700	2,200

Conclusions and Recomendations

Analysis of FCRTF and FSD Data

- FCRTF cells generally performed well although under controlled conditions
  - Estimated net settling rates were in the range of data from other PSTA research platforms.
  - The FCRTF PSTA cell results for Cell 3 (IL-6 Limestone over Riviera sand) show that, under controlled hydrologic conditions, and depending on the inflow concentration, PSTA can achieve relatively long-term FWM outflow concentrations at or near 10 ppb.
  - Direct use of the FCRTF data for scale-up calculations is not recommended as many factors do not translate from the mesocosm scale to the size of PSTA cells that would be necessary in the EAA.
- Performance of FSD cells limited by flow and inflow phosphorous concentration

Analysis of FCRTF and FSD Data

- Performance of FSD cells limited by flow and inflow phosphorous concentration
  - The data from both projects indicate that lime sludge is an inferior substrate compared to locally available limerock.
  - FSD PSTA Cell C performed best with a POR net settling rate (k) of about 14 m/yr.
  - However, the operational conditions experienced were not representative of the fluctuations in hydraulic loading rate, water depth, and inflow concentration typical of the EAA STAs.

Recommendations for Full Scale PSTA Implementation

- PSTA should receive additional consideration as a tool to achieve the permitted total phosphorous goal of 10 ppb
- Land area requirements and site soil conditions are key determinants in any analysis of costs for full-scale PSTA implementation.
- Data from the FSD project should not be used in isolation for the future design of a full-scale PSTA.
- At this time it is recommended that the next generation of PSTA should be at an approximate scale of 500 to 1,000 acres per cell.

Future Use of FCRTF and FSD

- FCRTF has likely served its purpose for PSTA research
- Additional data may be generated by reestablishing flow to FSD prior to scheduled decommissioning in 2012
- Consider a minimalist decommissioning strategy for FSD
  - Remove PSTA water control structures
  - Remove E/W levee, place fill in low portions of Cell 2
  - Leave N/S internal levees
  - Inoculate former PSTA cells with SAV
  - Transition remainder of Cell 2 to SAV