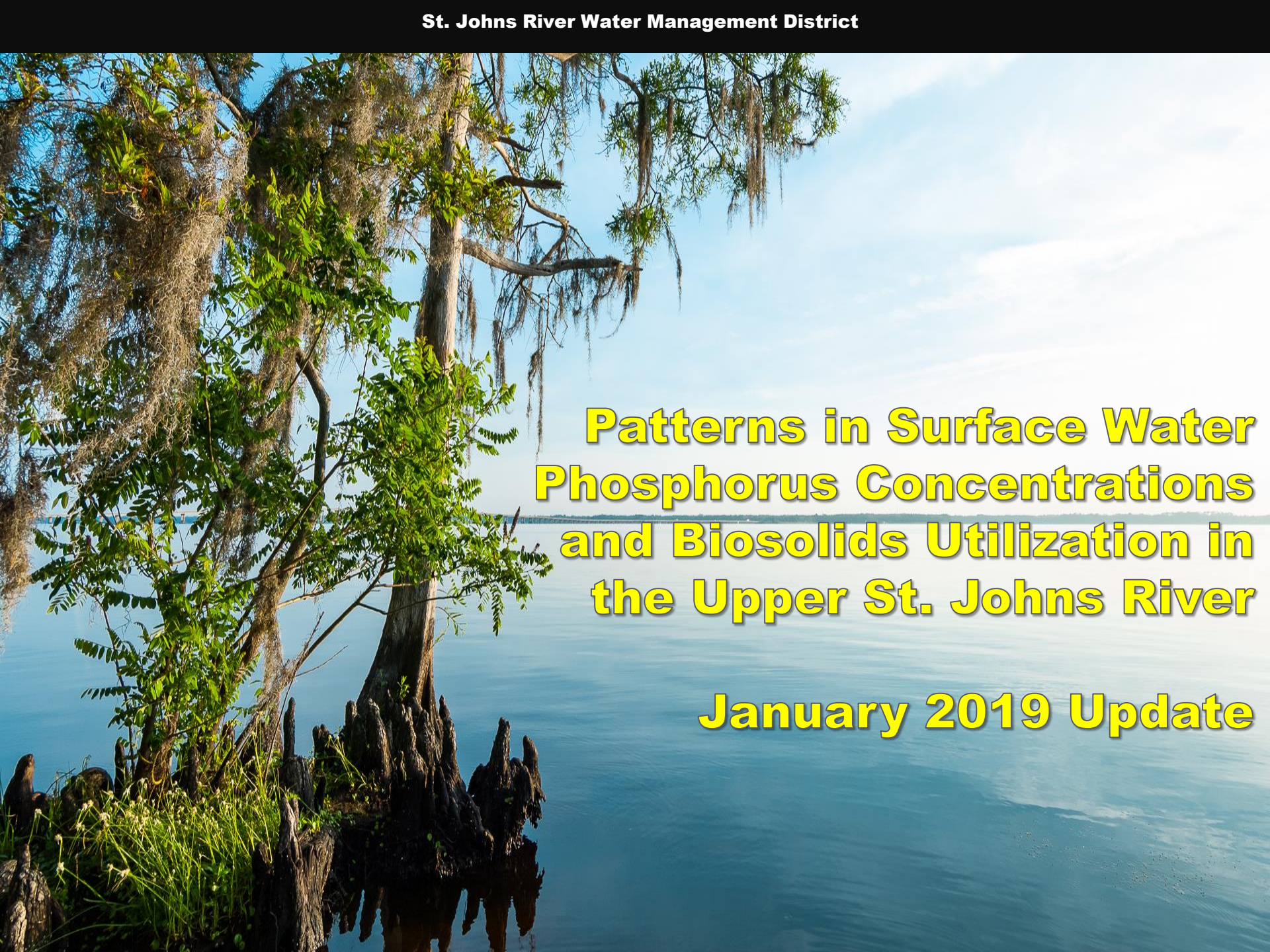


A scenic view of the St. Johns River. In the foreground, a large, gnarled tree trunk with green foliage and Spanish moss hangs over the water. The river is calm and blue, reflecting the sky. In the distance, a small boat is visible on the water under a clear blue sky with light clouds.

Patterns in Surface Water Phosphorus Concentrations and Biosolids Utilization in the Upper St. Johns River

January 2019 Update

Topics from November TAC Meeting

- Relative fraction of PO₄-D in TP
- Change in erosion and runoff
- Change in fertilizer use
- Departure in relationship with TOC

Forms of Phosphorus and Analyses

- Measured Forms of Phosphorus
 - TP-T unfiltered sample, digested (all forms of P)
 - TP-D filtered sample, digested (all dissolved forms of P)
 - PO4-D filtered undigested, (dissolved PO4)
- Calculated Forms
 - PP Particulate P (PP) = $TP-T - TP-D$

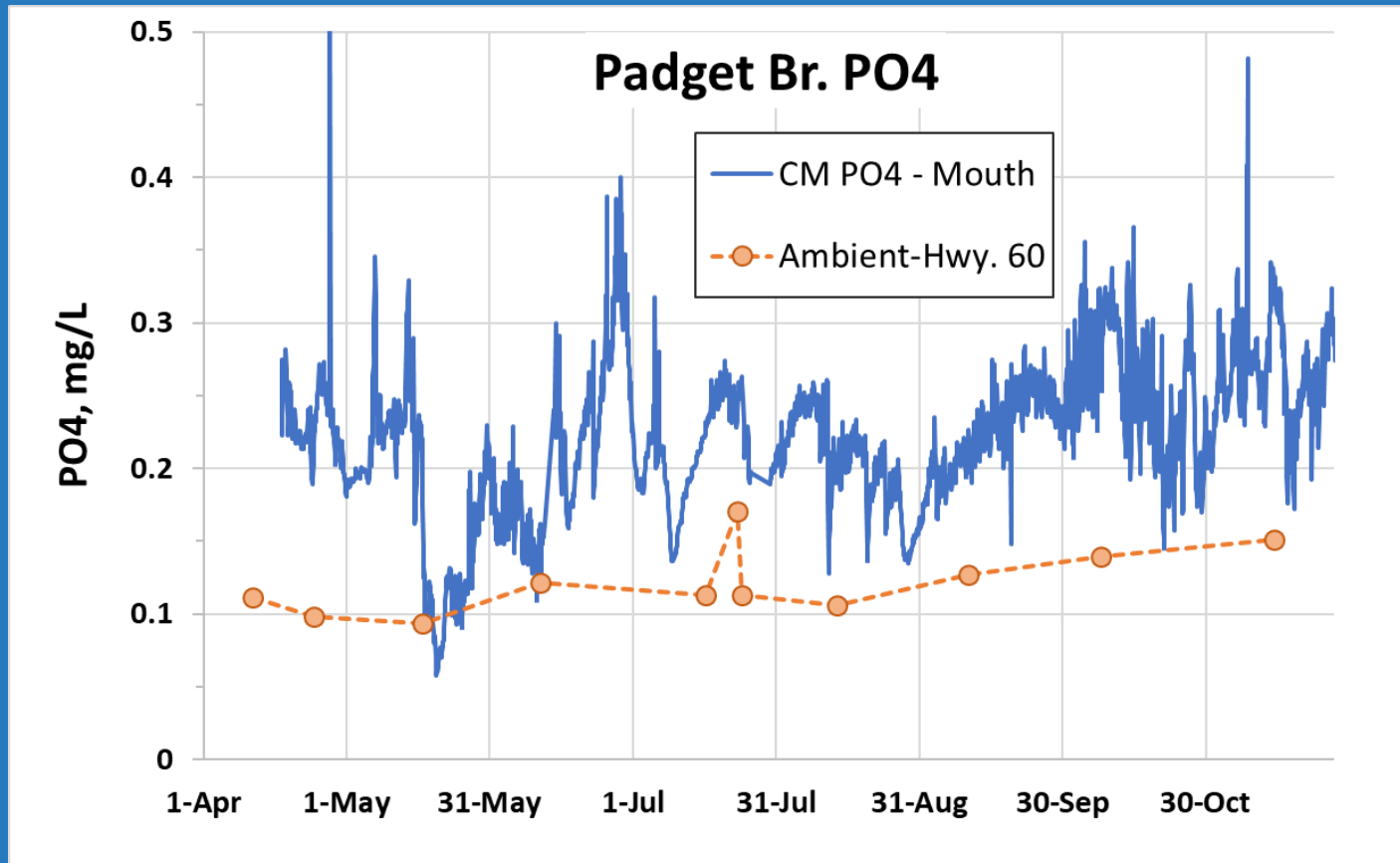
For simplicity due to the high observed SRP concentrations we are assuming that SRP is a good and appropriate estimate of PO4-D.

Thus $SRP = PO4-D$

-
- Orthophosphate**
- Mean High-Flow Conc., mg/L
- Watershed Cumulative Biosolids P, kg/ha
- Legend:
- Jane Green
 - North Wolf
 - Pennywash
 - South Wolf
 - Ten Mile

Padgett Branch April – November 2018

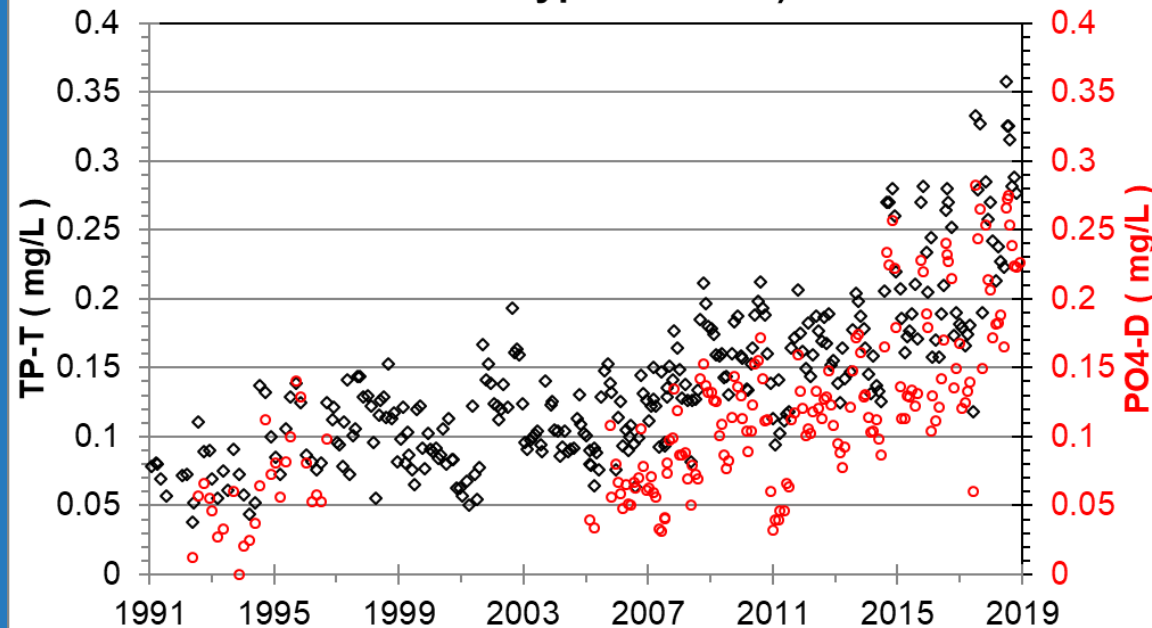
Mouth $\text{PO}_4 \approx$ twice that measured upstream at Hwy. 60



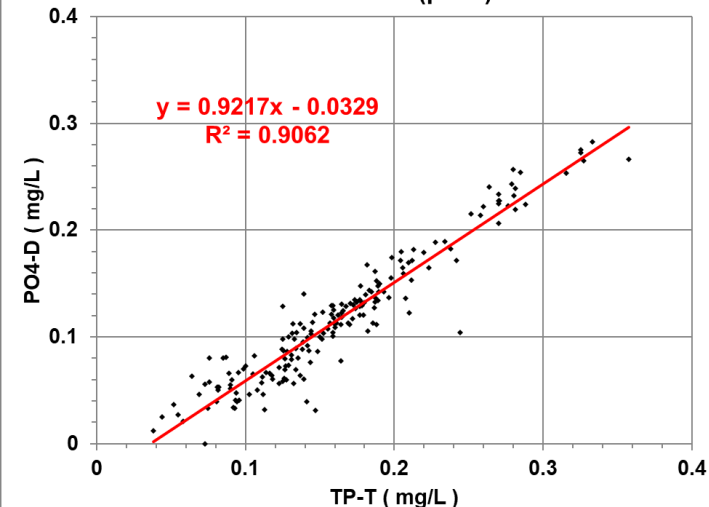
Hwy. 60 – Monthly ambient samples
Mouth – Continuous monitoring platform

Blue Cypress Lake Phosphorus

Time Series of Total Phosphorus & Ortho-Phosphate-Dissolved for site BCL (Center of Blue Cypress Lake)



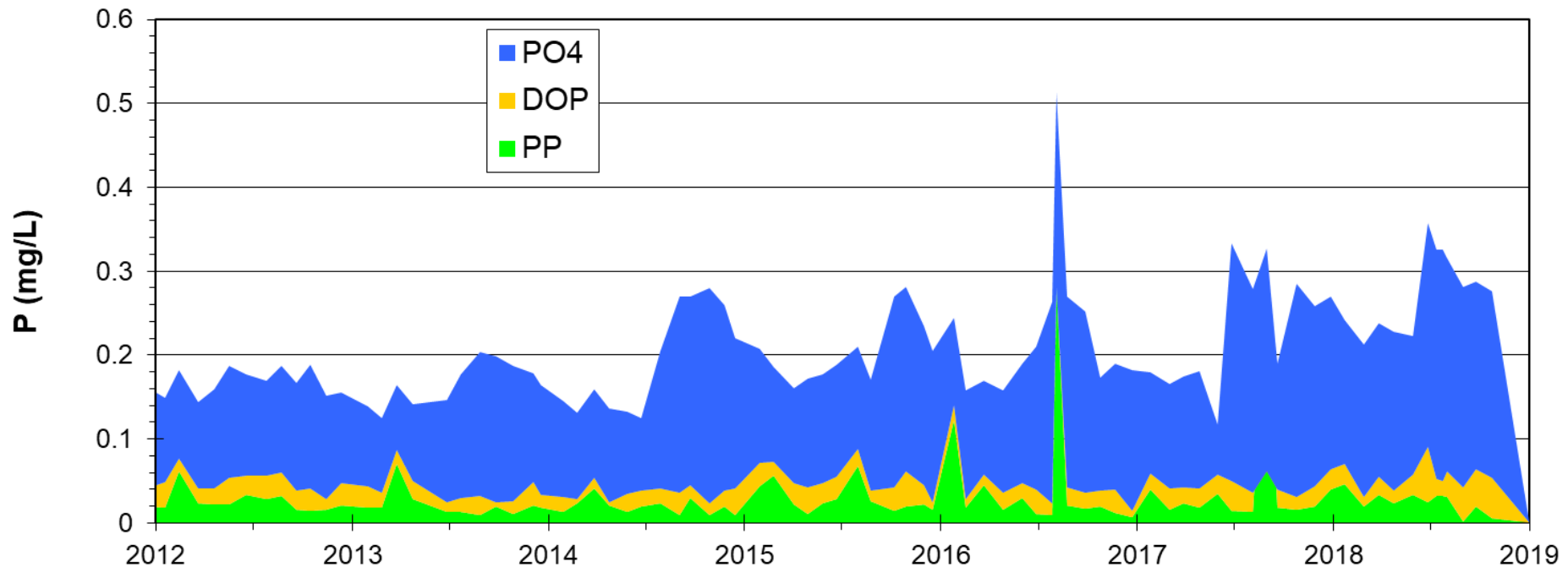
Scatterplot of Total Phosphorus & Ortho-Phosphate-Dissolved for site BCL ; Significant Trend (p ~ 0)



Recent phosphorus increase is reflected by an increase in PO4-D

Blue Cypress Lake

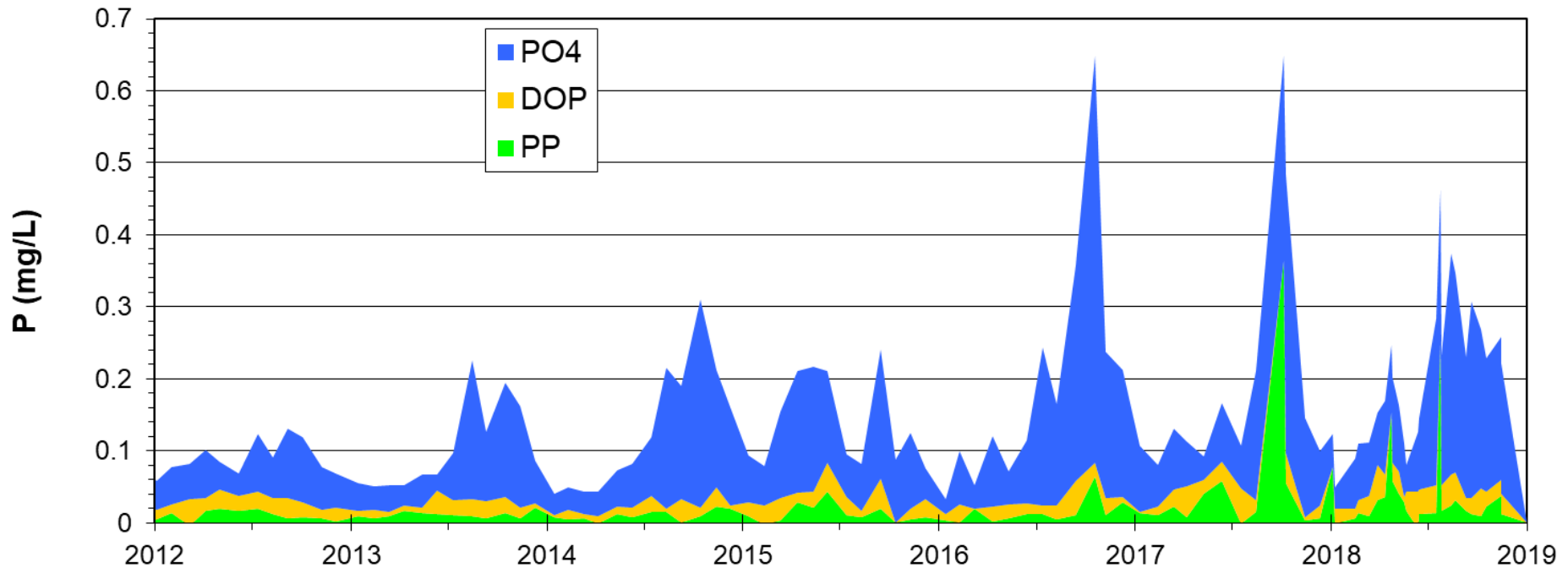
Mean monthly phosphorus fractions for site: BCL



Recent phosphorus increase is reflected by an increase in dissolved phosphate. Other P fractions remain similar.

SJRWMD – P Fractions Jane Green South

Mean monthly phosphorus fractions for site: JGS



PP Trend Not Significant

$p = 0.69$

$R^2 = 0.002$

PO₄ Trend Significant

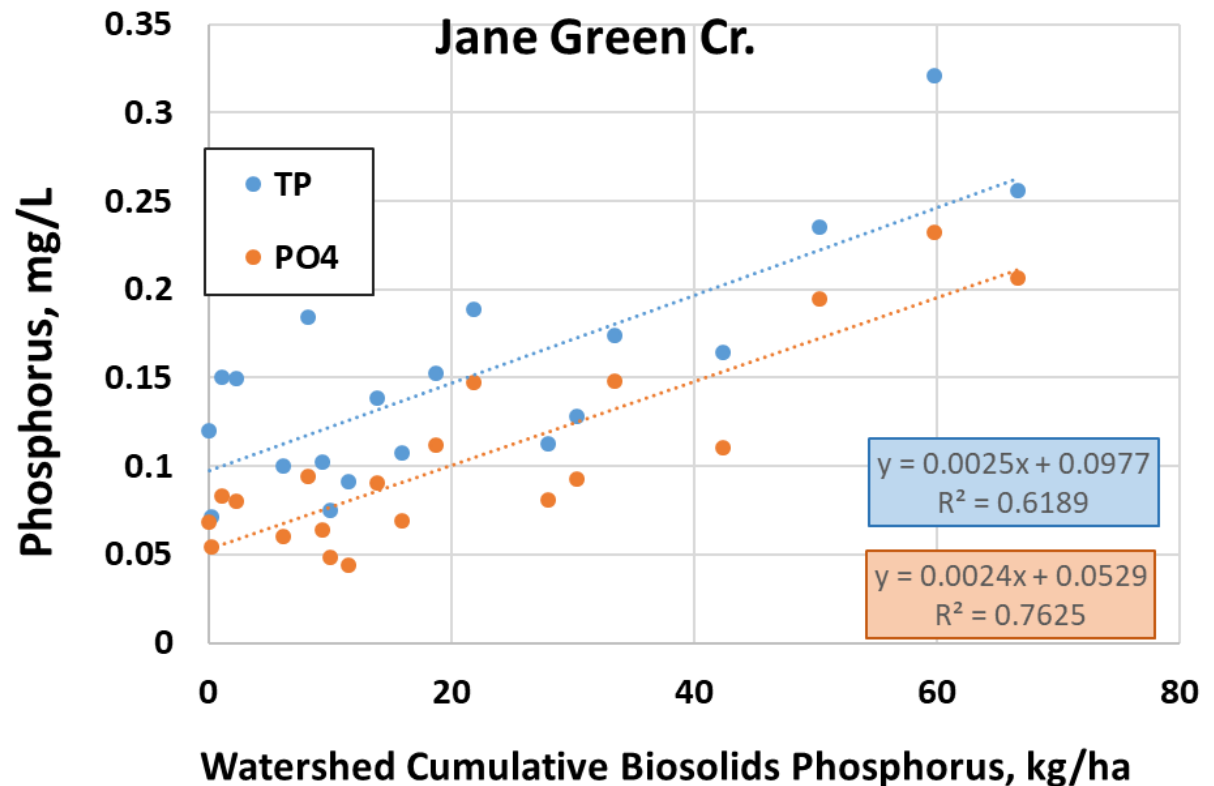
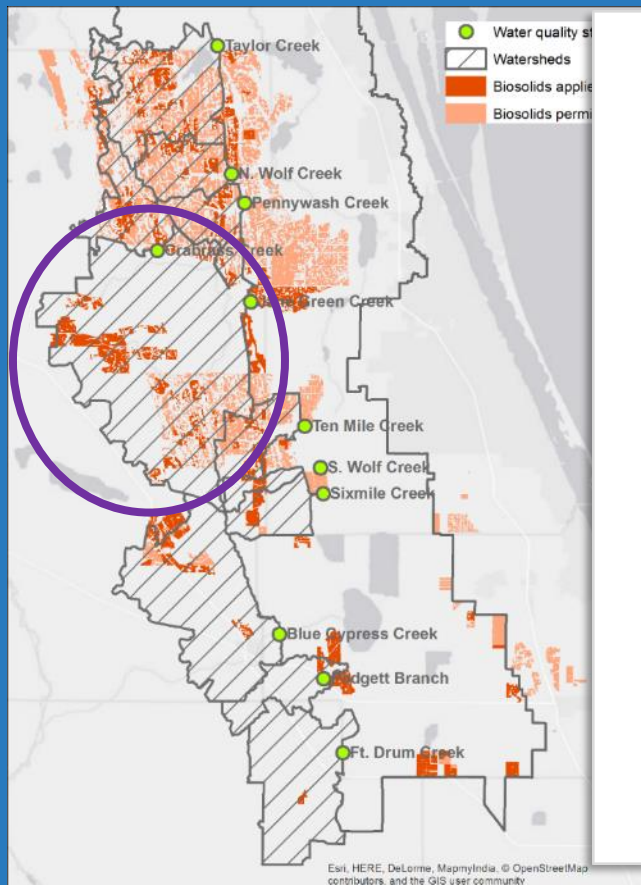
$p = 0.00014$

$R^2 = 0.15$

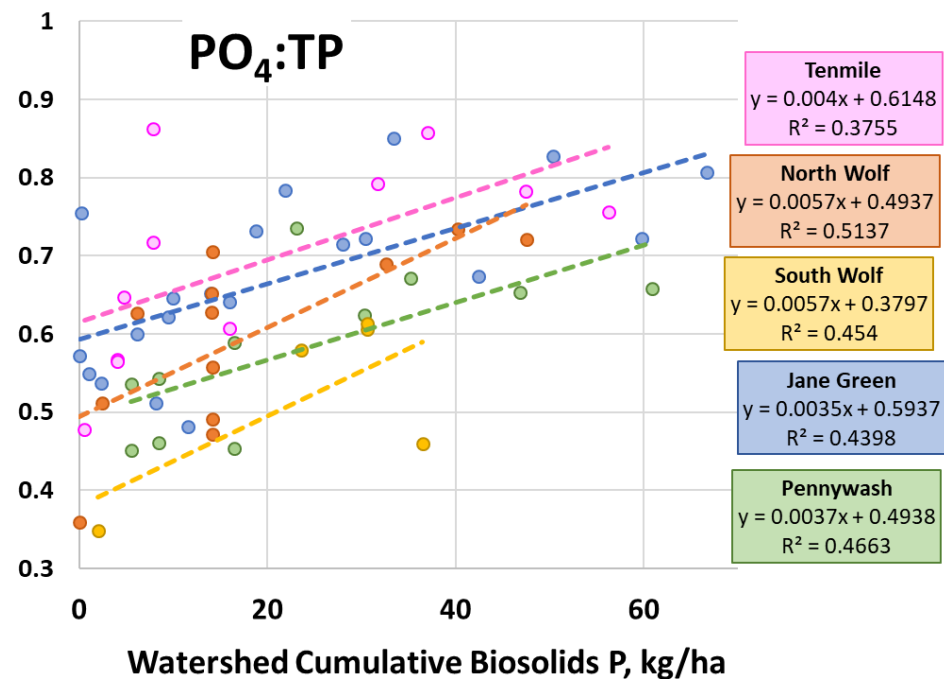
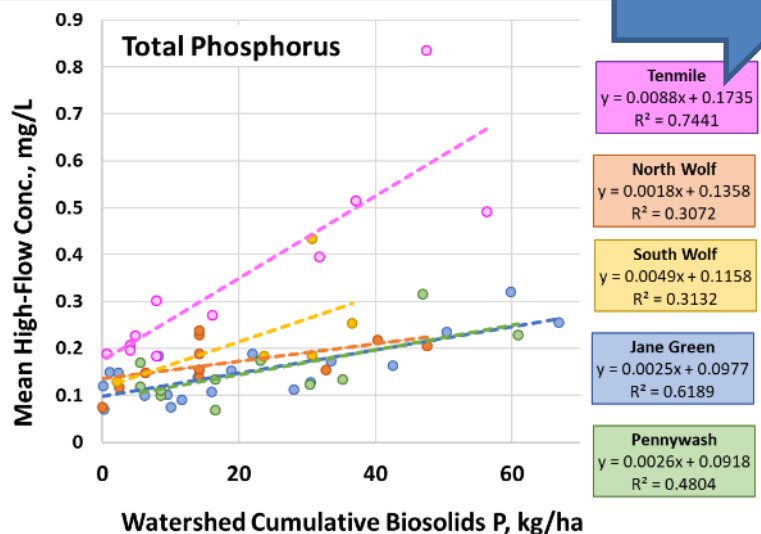
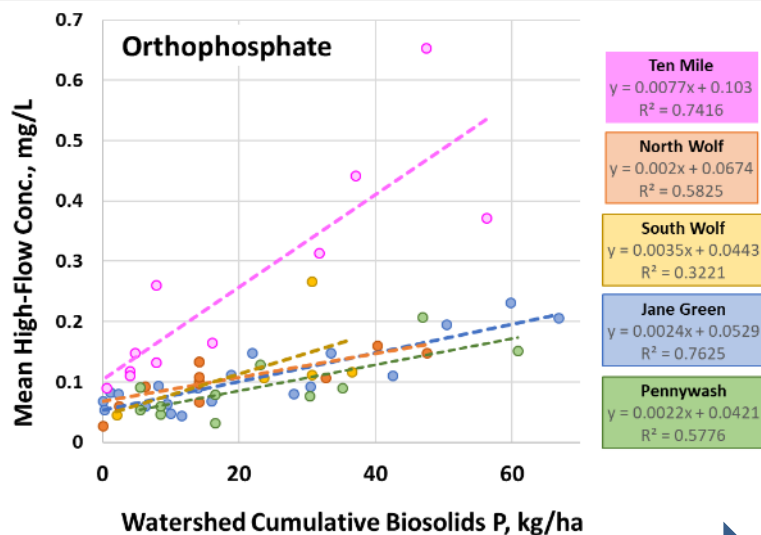
-
- Orthophosphate**
- Mean High-Flow Conc., mg/L
- Watershed Cumulative Biosolids P, kg/ha
- Legend:
- Jane Green
 - North Wolf
 - Pennywash
 - South Wolf
 - Ten Mile

Orthophosphate vs. Total Phosphorus

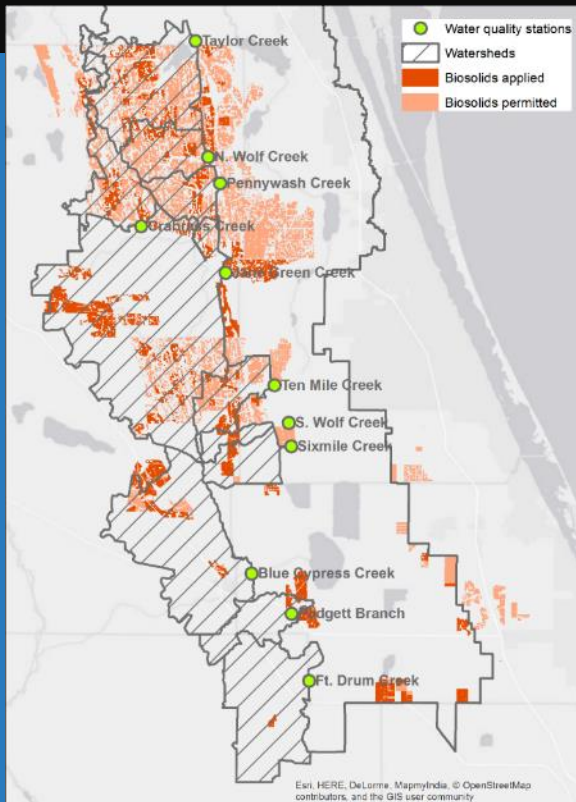
Relationship between concentration and watershed biosolids applications stronger with PO₄ than with TP – Indicative of leachate migration?



Basin-Wide Phosphorus Patterns

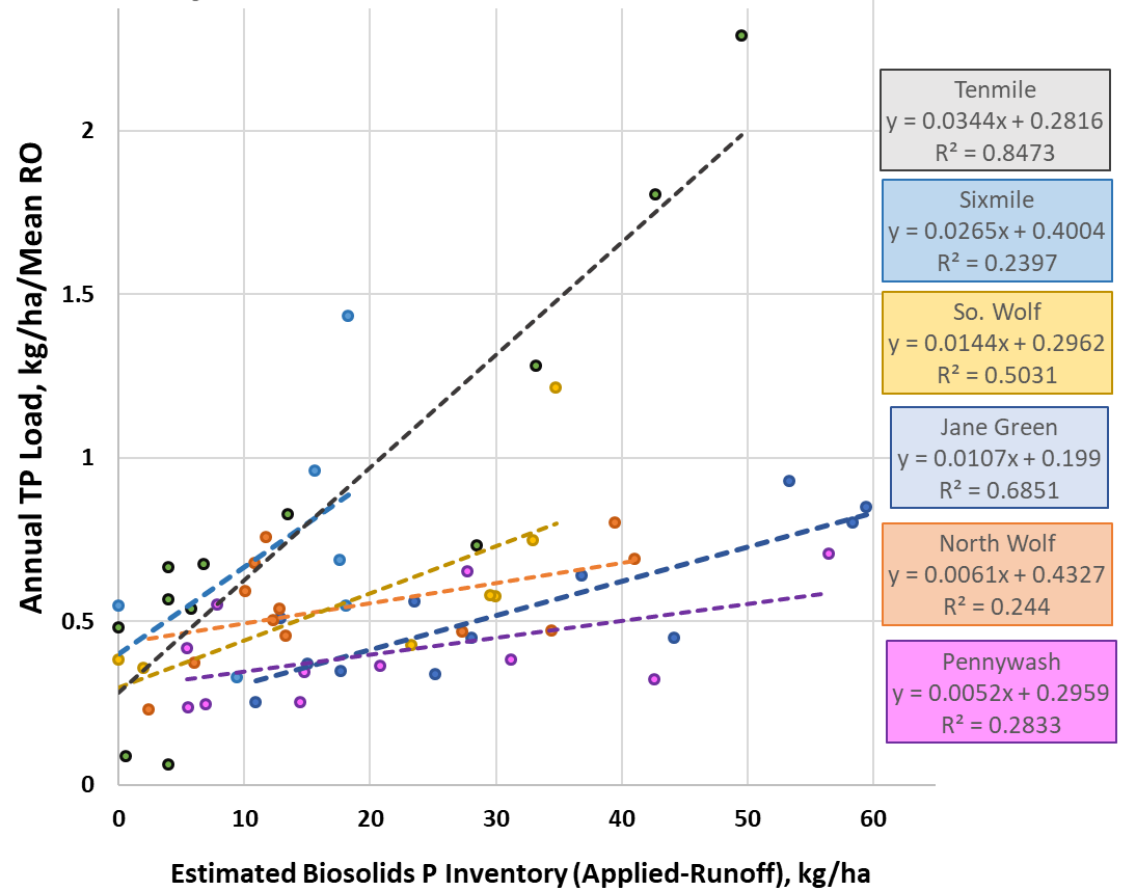


U:\>WLR>WR>>>ELD>Biosolids>USJ>USJ-Biosolids-Amb-creeks_12-13-18_TOC-Trends Analysis for JanTAC.xls



- Flow-relativized annual loads increasing
- Increase > for smaller watersheds (proximity)

Tributary Annual TP Loads, 2007-2017

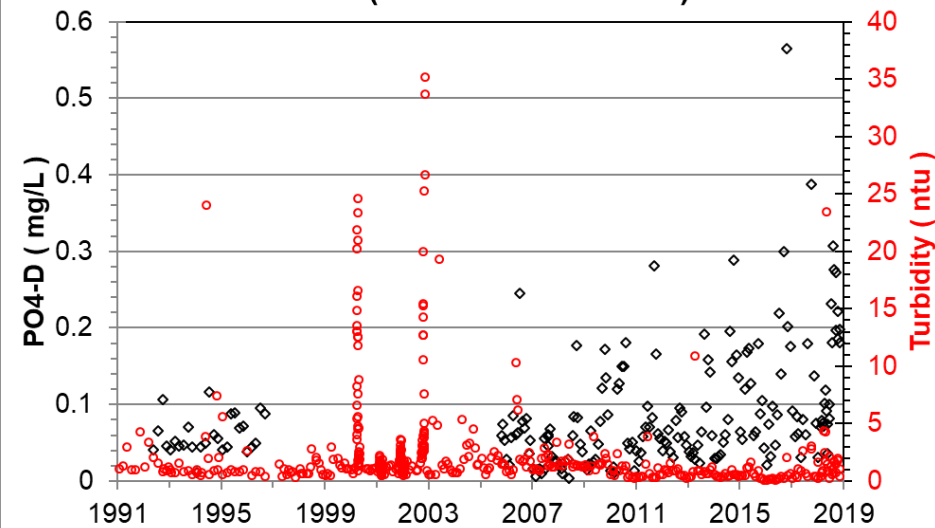


1. Annual loads expressed per mean runoff = 0.32 m.
2. WS Biosolids inventory = annual cumulative total - annual application, as kg/ha.

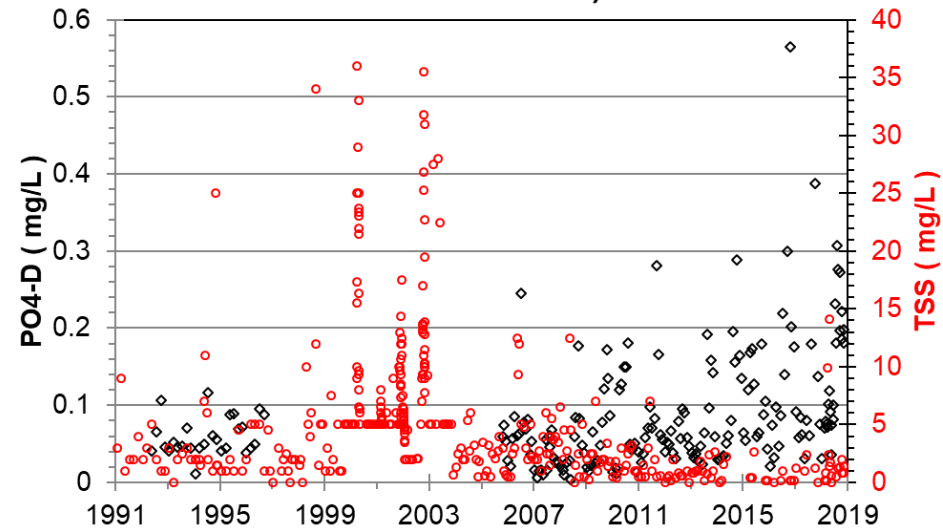
Erosion Indicators

Turbidity and Total Suspended Solids

Time Series of Ortho-Phosphate-Dissolved & Turbidity, Laboratory Nephelometric for site JGS (Jane Green South)



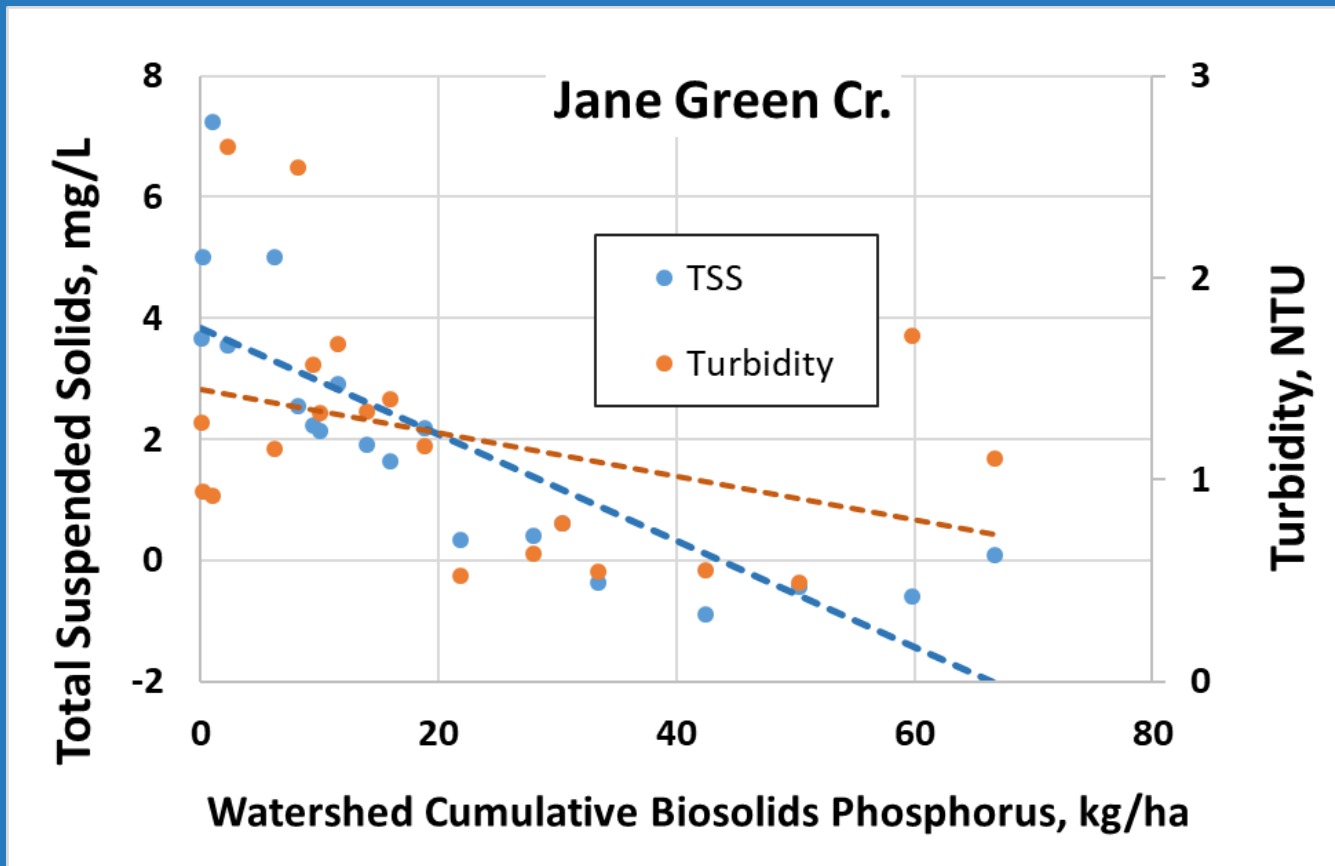
Time Series of Ortho-Phosphate-Dissolved & Total Suspended Solids for site JGS (Jane Green South)



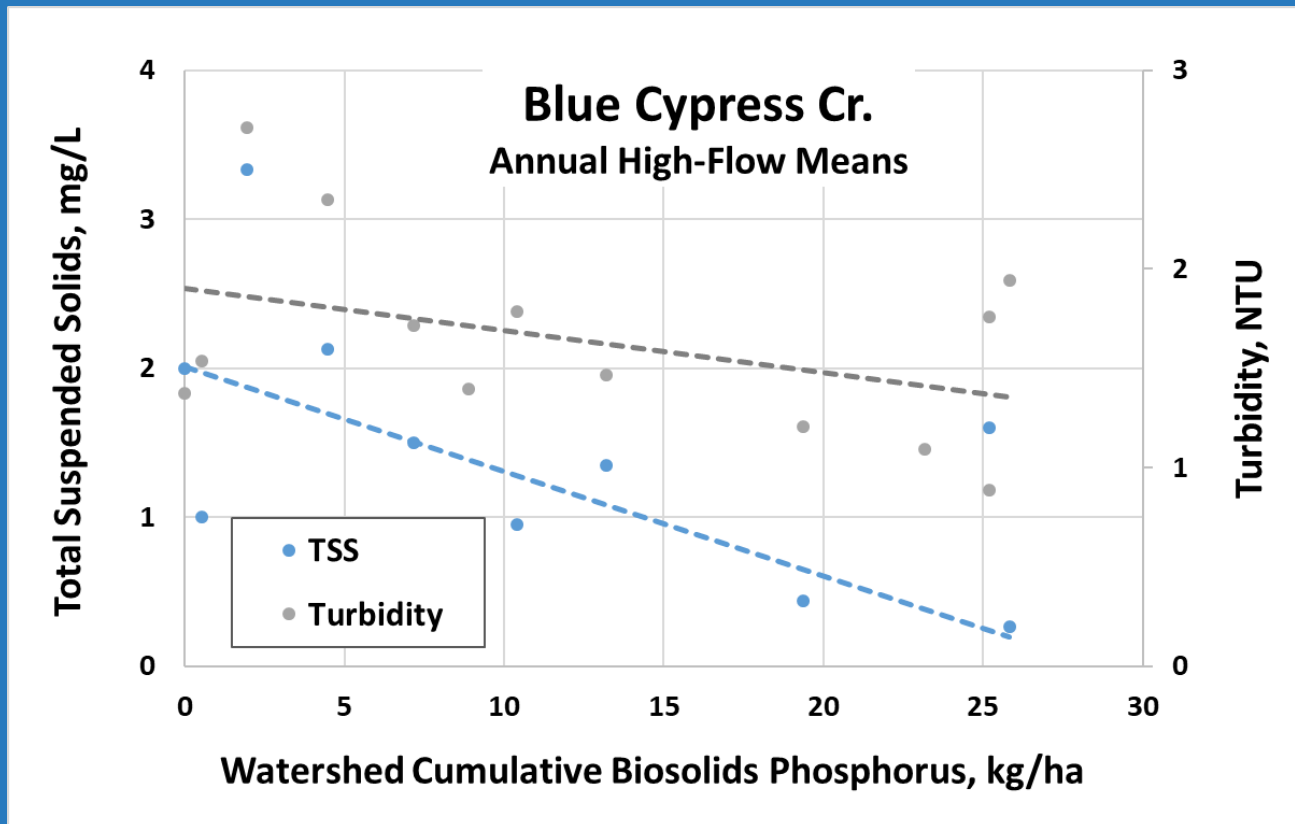
Two potential indicators of erosion are Turbidity and TSS. In Jane Green Creek, where we have observed increases in TP, largely driven by PO4-D. We do not observe increases in either Turbidity and TSS. These data are consistent with a biosolids source hypothesis and less with an erosion source hypothesis. Recall Jane Green Creek did not show an increase in K.

Erosion Indicators: TSS and Turbidity

In general, negative relationships between biosolids applications and TSS and turbidity, and trends for both are declining at many sites.



Blue Cypress Creek Patterns in Annual Mean High-Flow Erosion Indicators: Total Suspended Solids and Turbidity



Upper St. Johns River Basin

Status and Trends Assessment 2018

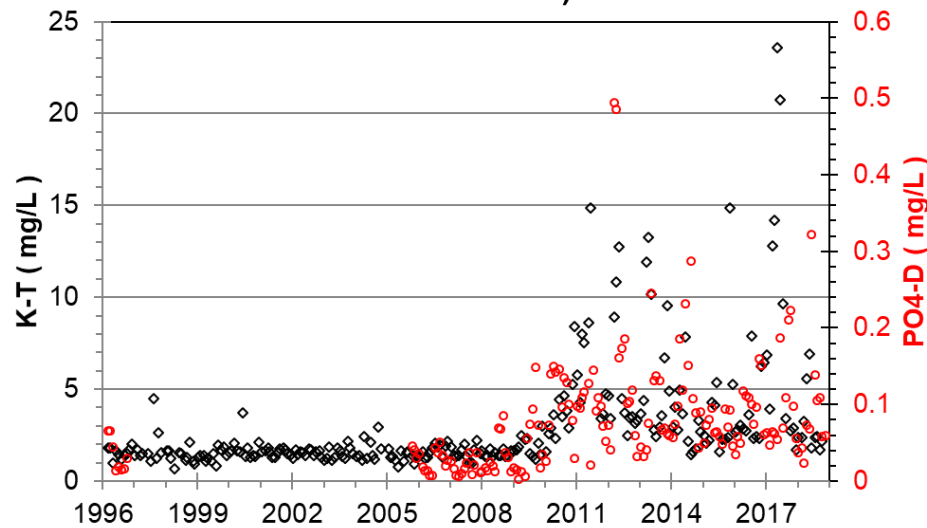
Sites with Sufficient Data

	Number of Sites		
	Decreasing	Stable	Increasing
TP	5	19	13
PO4	4	12	19
TN	22	14	1
TOC	12	24	1
TSS	20	17	0
Turbidity	26	11	0

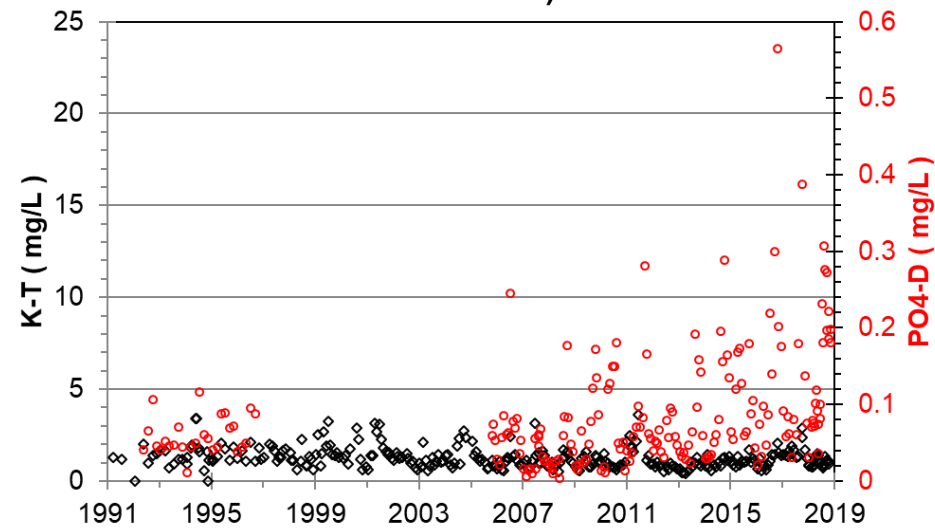
Fertilizer Vs. Biosolids

Use of Potassium to Identify Sources?

Time Series of Potassium-Total & Ortho-Phosphate-Dissolved for site NWOLF (Wolf Creek North)



Time Series of Potassium-Total & Ortho-Phosphate-Dissolved for site JGS (Jane Green South)



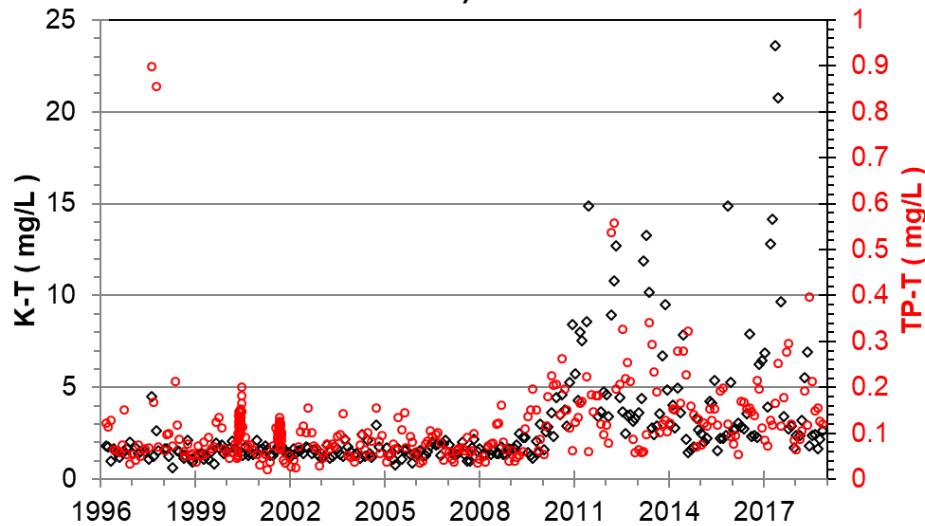
Increase and variance in Potassium (K) is a good indicator of fertilizer source of P.

The lack of K signal is consistent with non-fertilizer source such as biosolids.

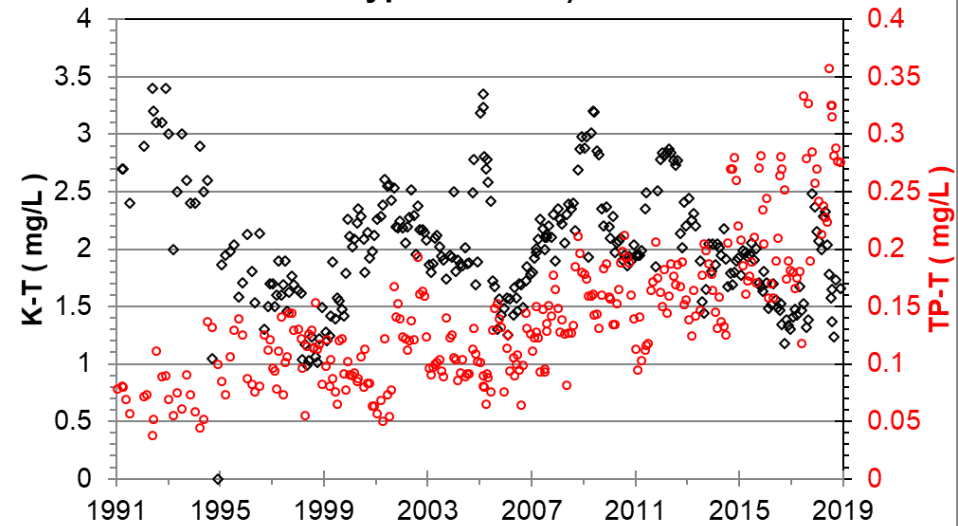
Fertilizer Vs. Biosolids

Use of Potassium to Identify Sources?

Time Series of Potassium-Total & Total Phosphorus for site NWOLF (Wolf Creek North)



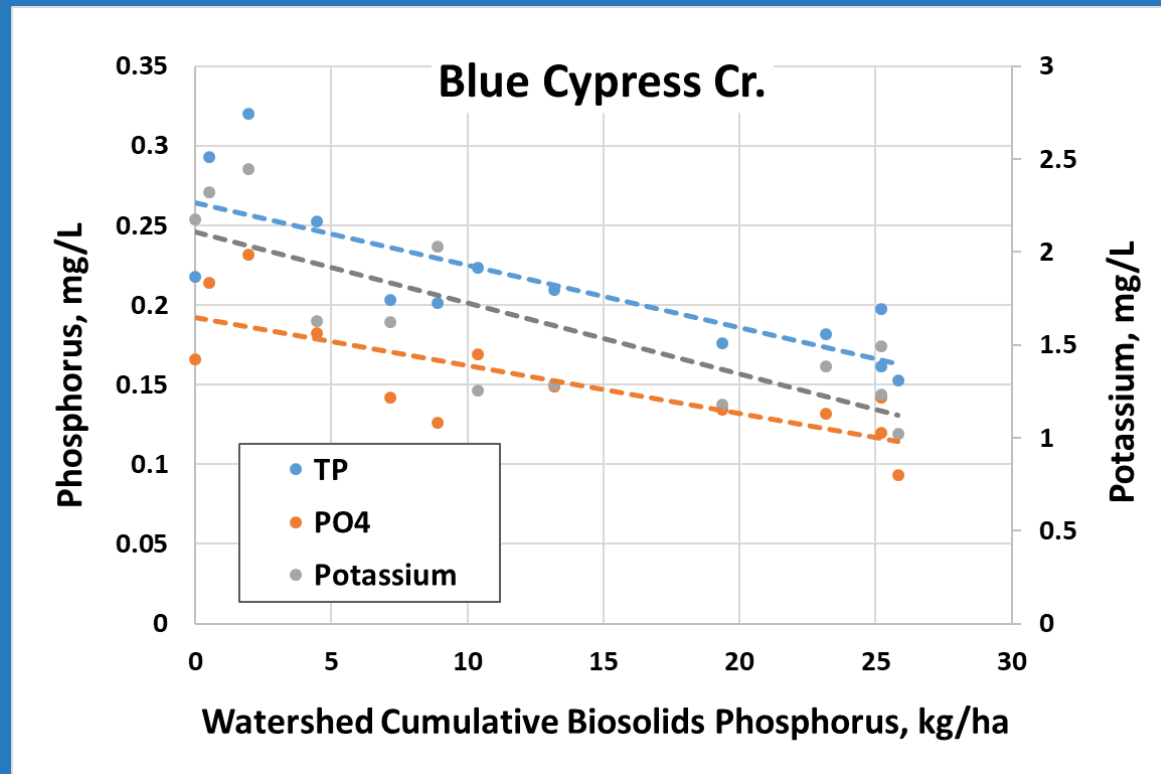
Time Series of Potassium-Total & Total Phosphorus for site BCL (Center of Blue Cypress Lake)



Increase and variance in Potassium (K) is a good indicator of fertilizer source of P.

The lack of positive relationship between K and TP is consistent with non-fertilizer P source such as biosolids.

Blue Cypress Creek Patterns in Annual Mean High Flow Orthophosphate, Total Phosphorus and Potassium



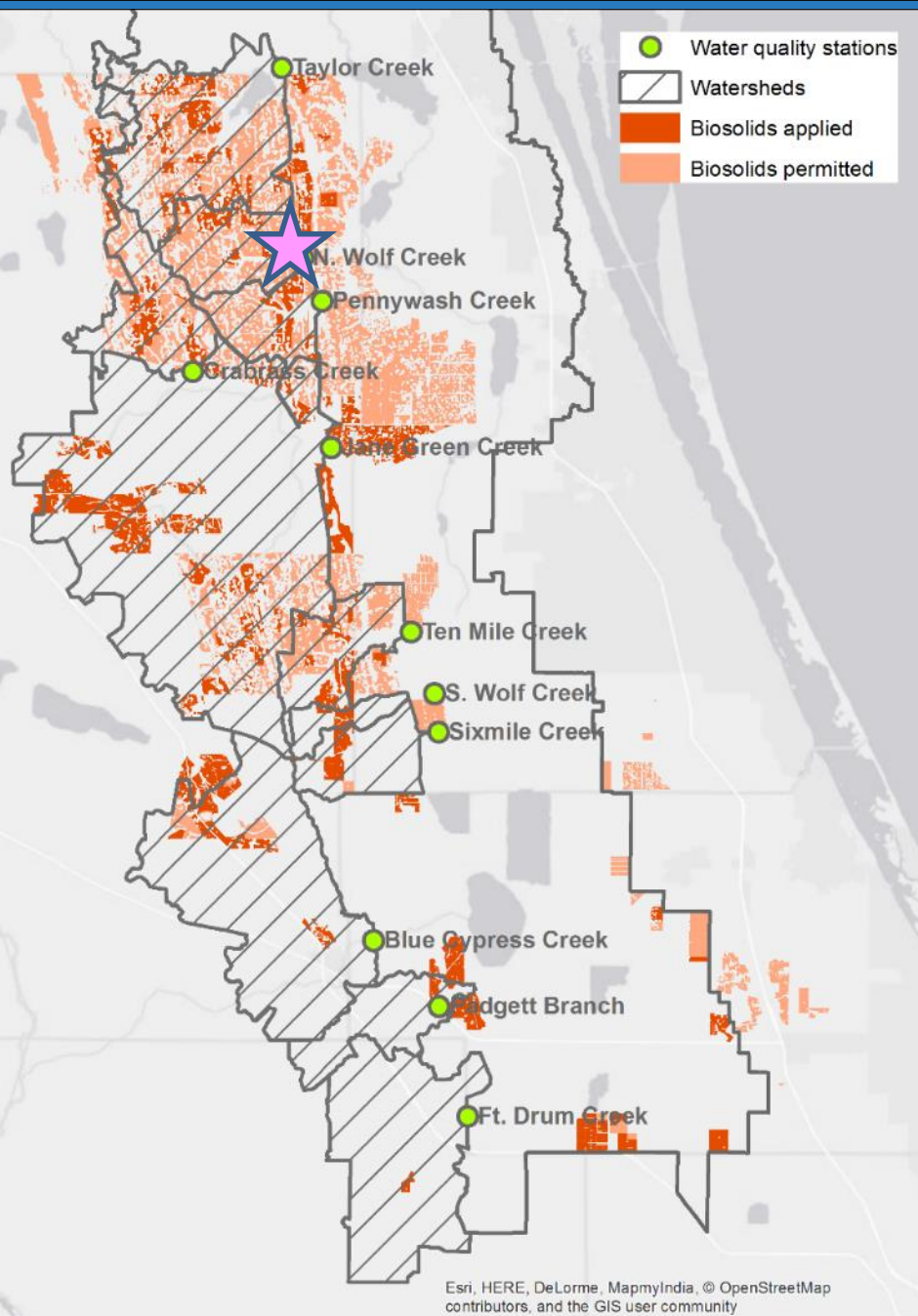
Blue Cypress Creek is the only tributary with decreasing TP and PO₄. Potassium is also exhibiting a significant decline in this watershed, suggesting a relationship to inorganic fertilizer decline.

Patterns of P Export

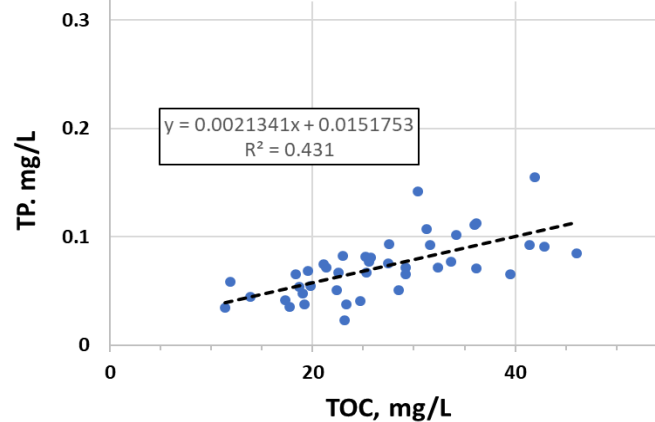
In undisturbed watersheds, phosphorus export is closely coupled to organic carbon because naturally derived biological production is the only source

USJ Watershed With High Biosolids Application Totals North Wolf

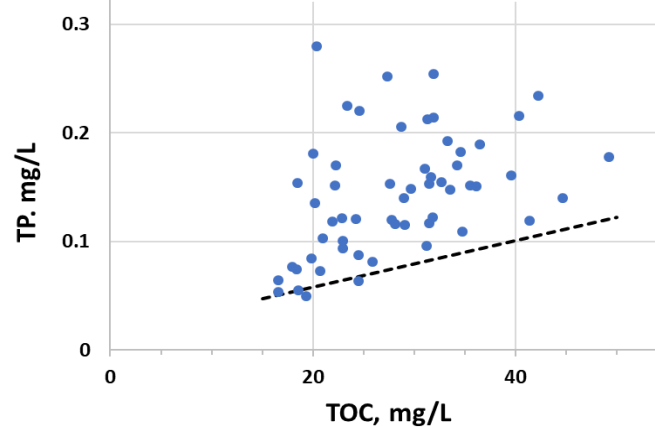
Total Biosolids P 2007 – 2017 = 47.5 kg/ha



Pre-Biosolids, 1998 - 2006

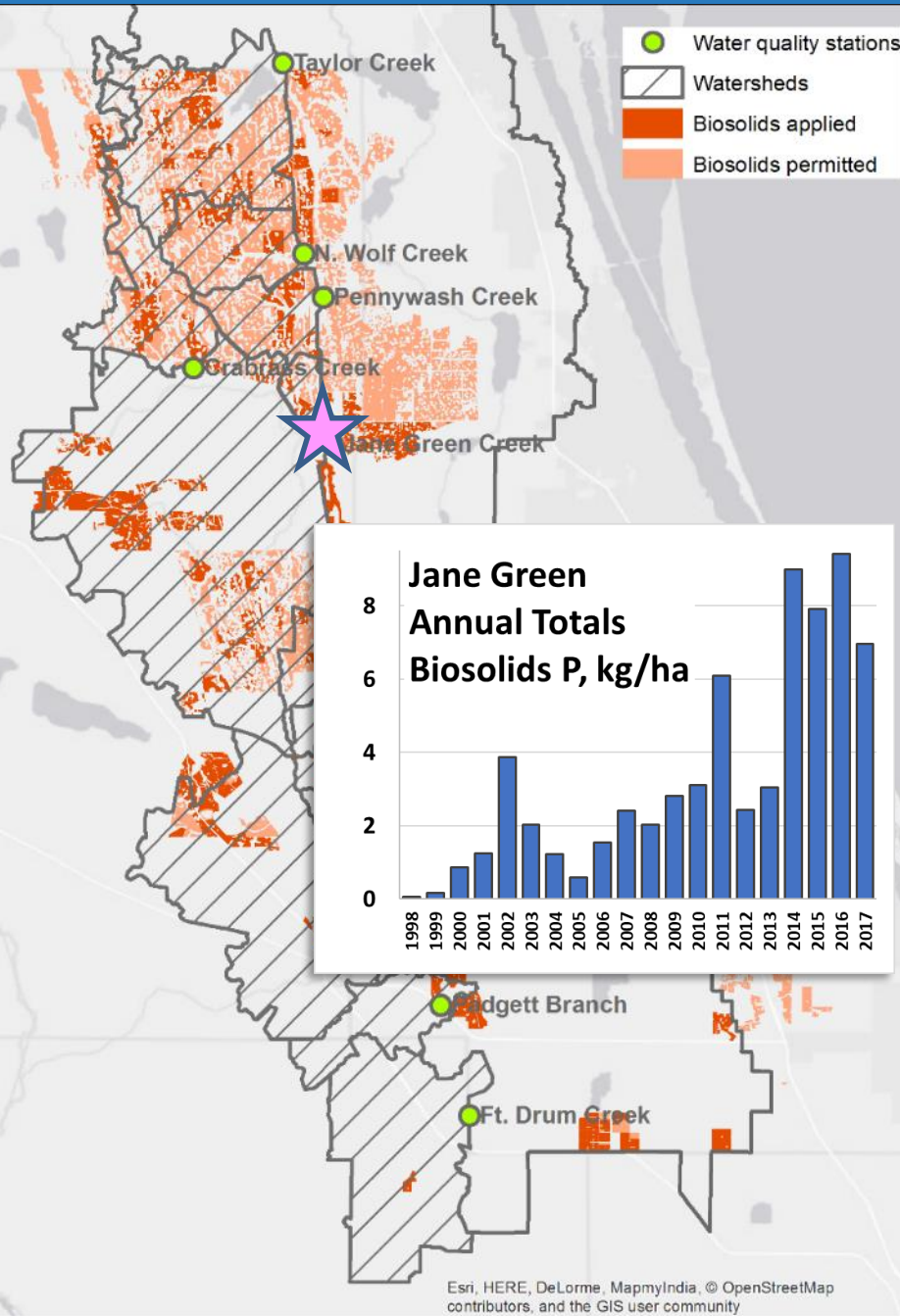


Post-Biosolids, 2008 - 2018

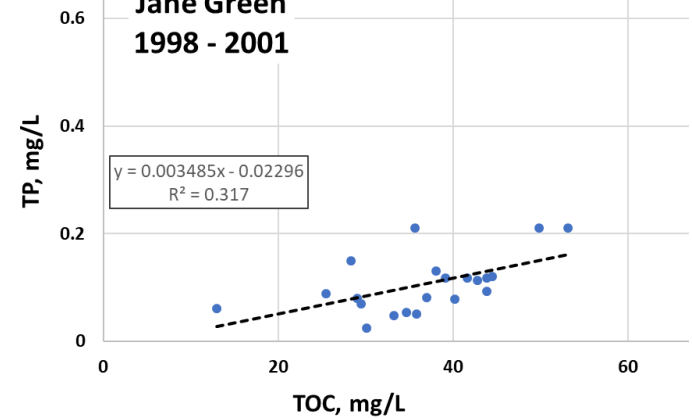


USJ Watershed With High Biosolids Application Totals Jane Green

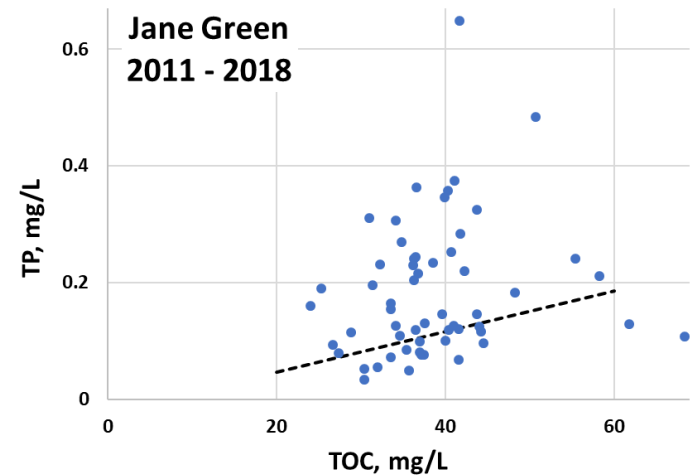
Total Biosolids P 1998 – 2017 = 66.7 kg/ha



**Jane Green
1998 - 2001**

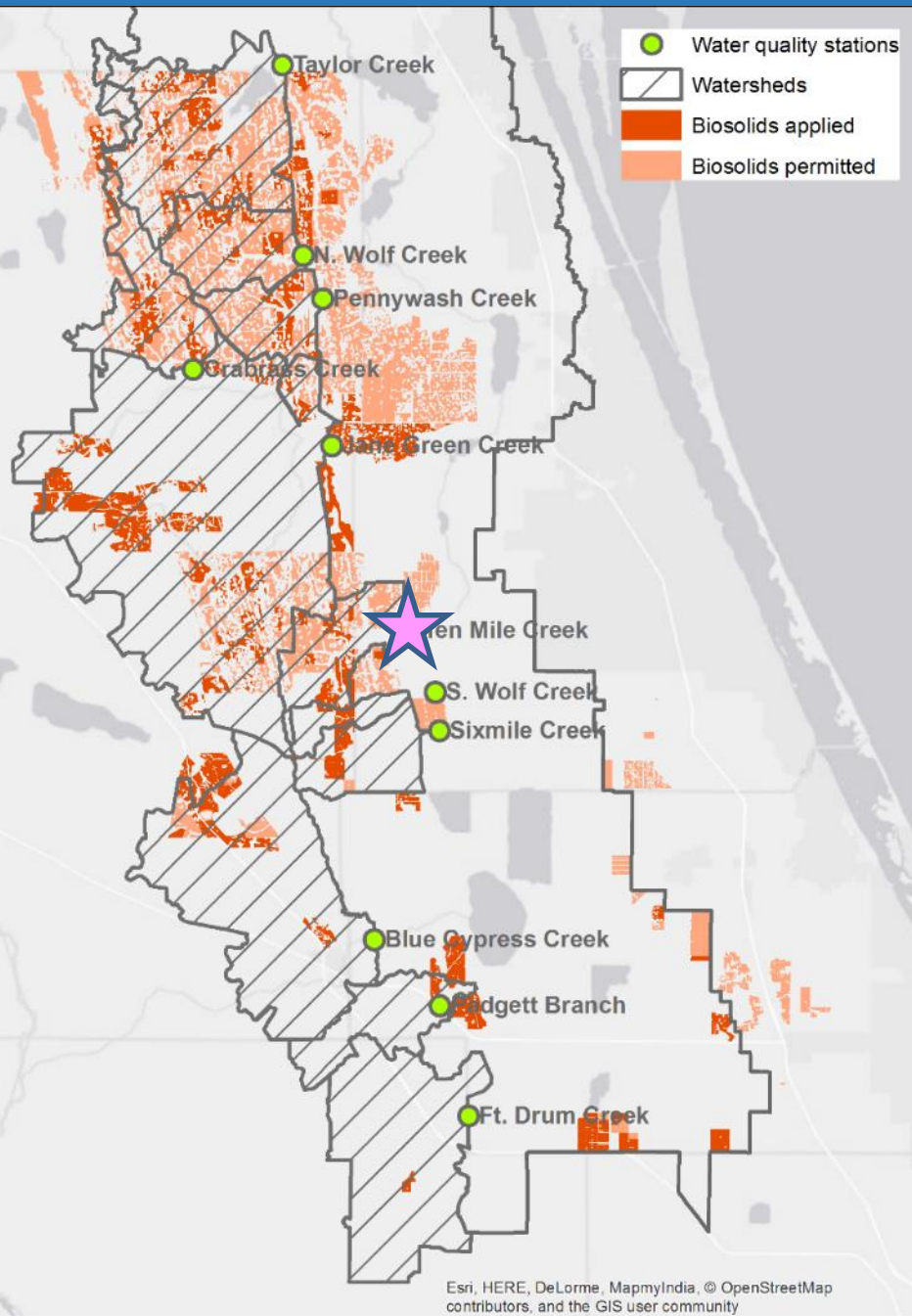


**Jane Green
2011 - 2018**

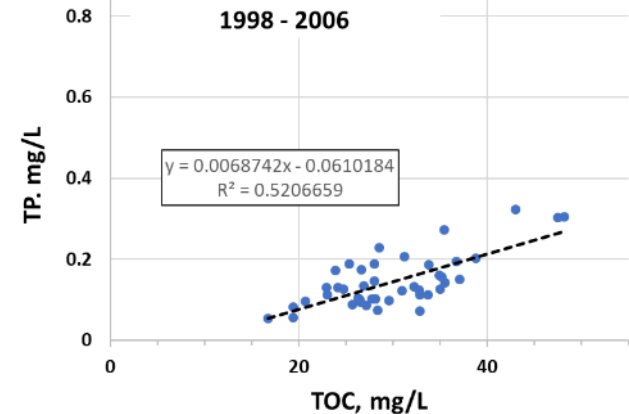


USJ Watershed With High Biosolids Application Totals Tenmile

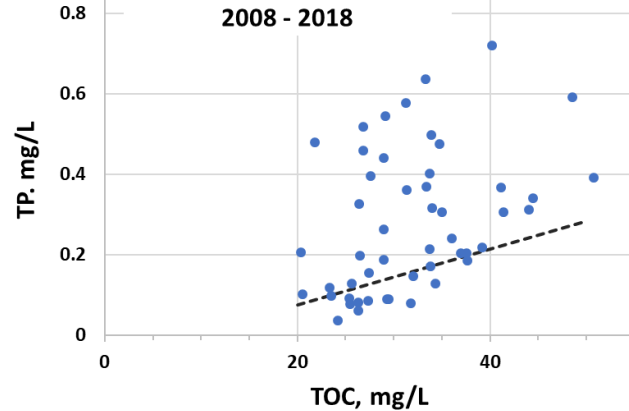
Total Biosolids P 2007 – 2017 = 56.2 kg/ha

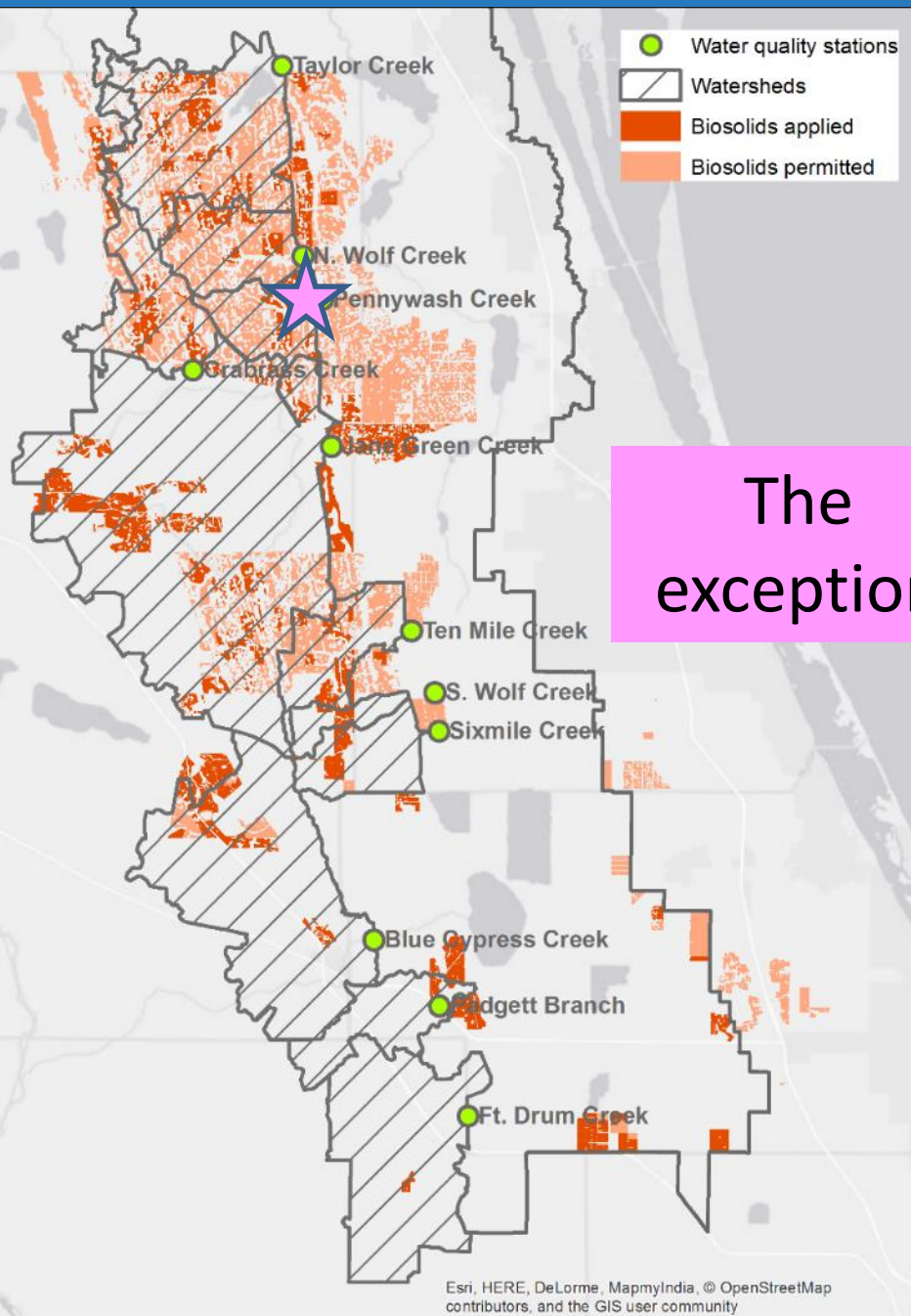


Tenmile Pre-Biosolids
1998 - 2006



Tenmile Post-Biosolids
2008 - 2018

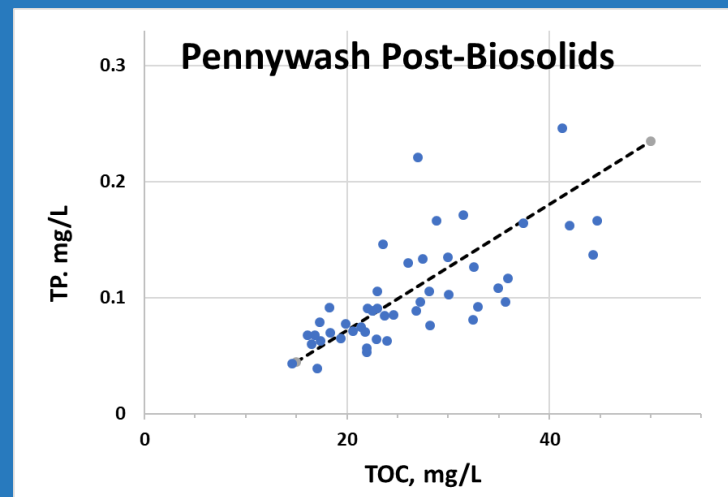
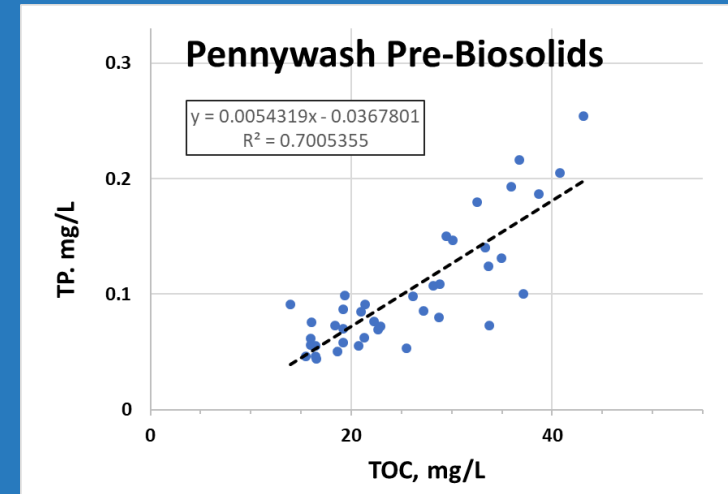




The
exception

USJ Watershed With High Biosolids Application Totals Pennywash

Total Biosolids P 2007 – 2017 = 60.8 kg/ha



Summary

- The majority of P in watersheds receiving biosolids is PO_4 with a positive relationship between cumulative application and PO_4 :TP
- Watersheds with biosolids and increasing P do not show increasing turbidity or TSS indicating erosion has not changed
- Potassium has not increased in watersheds with increasing P indicating trends are not caused by commercial fertilizers
- P and TOC have become decoupled in most biosolids watersheds indicating a departure from background export processes—P is higher than expected

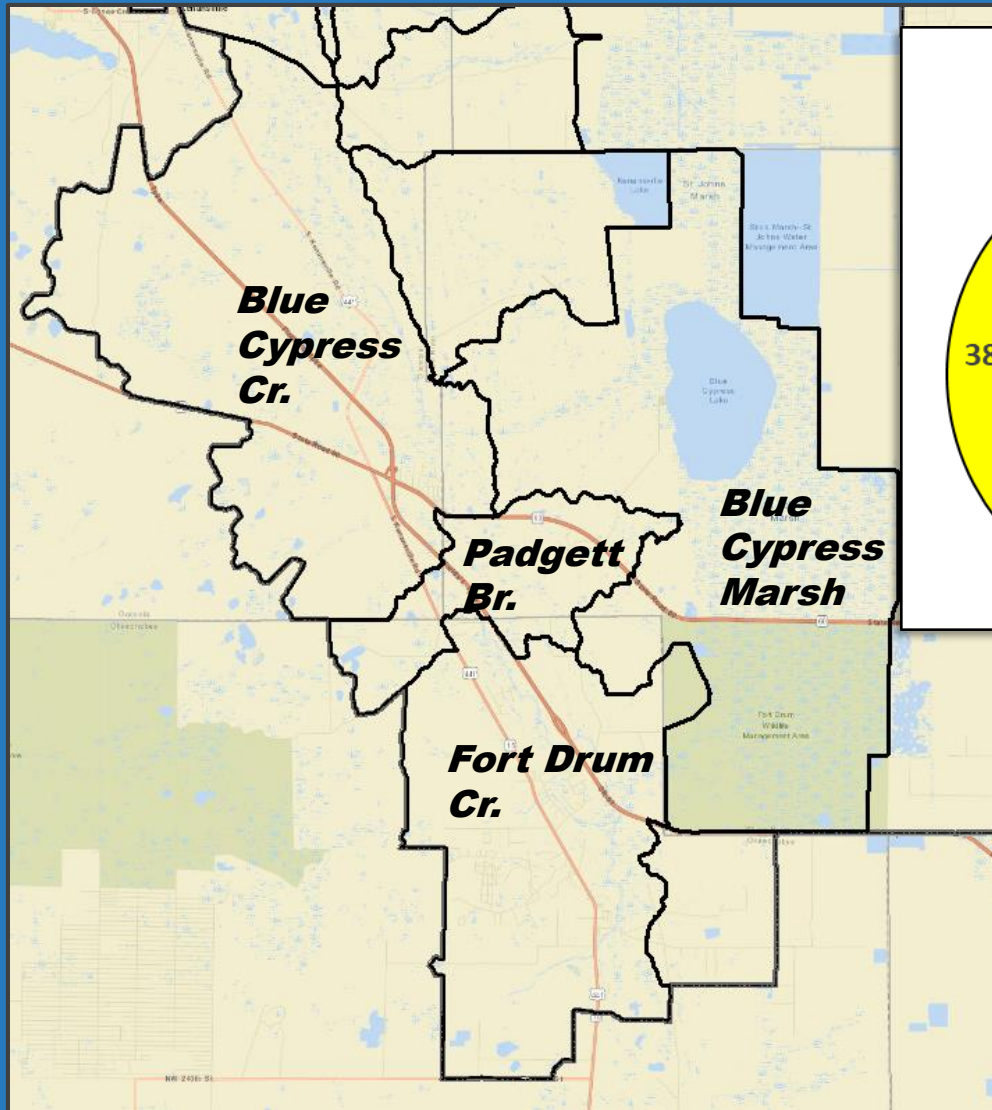
New Data

Soil and Tissue Phosphorus

Pressley Ranch permitted fields

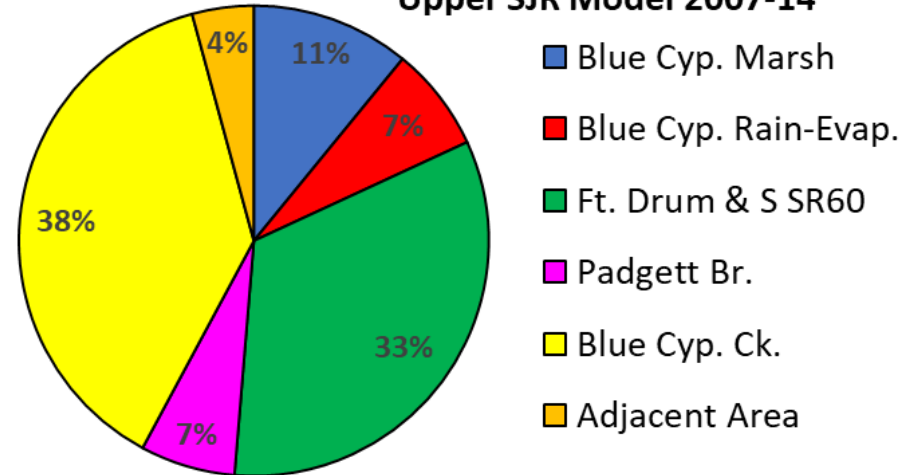
	Soil P (mg/kg)	Tissue %P
Low	10	0.14
	18	0.69
	20	0.39
	22	0.32
	24	0.28
Medium	25	0.49
	27	0.30
	27	0.38
	31	0.43
	34	0.37
	34	0.44
	35	0.43
High	43	0.40
	44	0.33
	47	0.31
	54	0.55
	55	0.37
	68	0.29
	77	0.37
	82	0.38
	84	0.35
	96	0.60

New Data: Blue Cypress Lake Revised Water Budget



Blue Cypress Lake Mean Water Budget

Upper SJR Model 2007-14



- Revised estimate directs more Fort Drum flow east