

# Total and Dissolved Phosphorus Monitoring Study



THE CITY OF  
**COLUMBUS**  
ANDREW J. GINTHER, MAYOR

DEPARTMENT OF  
PUBLIC UTILITIES

**Melodi Clark**, Surveillance Lab Manager

# Presentation Outline

- Phosphorus forms and analytical methods
- New NPDES monitoring requirements
- TP / DRP study at City of Columbus WWTPs
- Results
- Observations and conclusions

# Phosphorus



Jackson Pike WWTP

# Phosphorus

- Nutrient required by all organisms for the basic process of life
- Natural element found in rocks, soils and organic material. It clings tightly to soil particles and is used by plants.
- Phosphorus exists in water in either particulate phase or dissolved phase.
- Total phosphorus is a measure of all the forms of phosphorus, dissolved or particulate, that are found in a sample
- Phosphorus is one of two macro-nutrients (nitrogen is the other) that when present in high concentrations may contribute to excessive growth of algae, also called eutrophication

# Phosphorus Forms

## Particulate Phosphorus –

- Particulate P may be organic (part of solid-phase biomass) or inorganic (e.g., orthophosphate precipitate, or ortho-P adsorbed to other solids)
- Particulate P may be suspended in flowing streams, or may settle in slowly flowing streams, lakes or impoundments
- Settled particulate P may be re-suspended from stream beds

## Dissolved Phosphorus –

- Dissolved P is the filterable (soluble, inorganic) fraction of phosphorus, the form directly take up by plant cells. It is the phosphorus that remains in the water after a sample has been filtered.
- Dissolved Phosphorus is highly bioavailable to algae, and remains in the water unless converted to particulate (solid phase)



# Phosphorus Analytical Methods

- **Total Phosphorus** –
  - Includes both particulate and dissolved forms of phosphorus
  - Sample is digested to convert all particulate to dissolved; then sample is analyzed colorimetrically to determine the total phosphorus
- **Dissolved Phosphorus** –
  - Several names – essentially equivalent:
    - *Dissolved Reactive Phosphorus (DRP)*
    - *Dissolved Phosphorus (DP)*
    - *Dissolved Orthophosphate*
    - *Soluble Phosphorus*
    - *Soluble Orthophosphate*
    - *Orthophosphate*
  - Sample is filtered to remove particulate P; then sample is analyzed colorimetrically to determine the dissolved phosphorus
  - Sample must be analyzed within 48 hours

## New TP and DRP Monitoring in NPDES Permits

- Most Publicly Owned Treatment Works (POTWs) across Ohio will have new phosphorus monitoring requirements added to their NPDES permits as a result of a new state law – Ohio Senate Bill 1, enacted in April of 2015.
- Excerpt from SB 1, now part of ORC 6111.03 :

“Not later than December 1, 2016, a publicly owned treatment works with a design flow of one million gallons per day or more, or designated as a major discharger by the director, shall be required to begin **monthly monitoring of total and dissolved reactive phosphorus** pursuant to a new NPDES permit, an NPDES permit renewal, or a director-initiated modification. The director shall include in each applicable new NPDES permit, NPDES permit renewal, or director-initiated modification a requirement that such monitoring be conducted.”

- If you haven't already received a new or modified permit, you will soon!

## New Phosphorus Monitoring '*Complication*'

- TP samples must be collected as composites as they have been, ***BUT***... DRP samples must be collected as grabs
- In accordance with federally approved analytical methods (40 CFR 136), the samples for dissolved analysis must be filtered within 15 minutes of sample collection, which doesn't allow the use of 24-hour composite samples
- Hence TP and DRP samples collected on the same date will not correspond with each other as representative of the same sampling period



# Study Overview & Objectives



## Study Overview

- The City of Columbus Surveillance Lab and WWTP laboratories performed a study to evaluate analytical results from various sample types:
  - grab vs. composite samples,
  - grab samples collected at 8-hour intervals during the day,
  - immediate filtration vs. filtration after sample transport from plant to central surveillance lab, and
  - filtration of composite samples vs. filtration of grab samples
- While not all of these sampling and filtration alternatives strictly comply with approved methods, it was believed useful to understand potential differences in measured values based on the differences in sampling type, timing and handling.

## Study Objectives

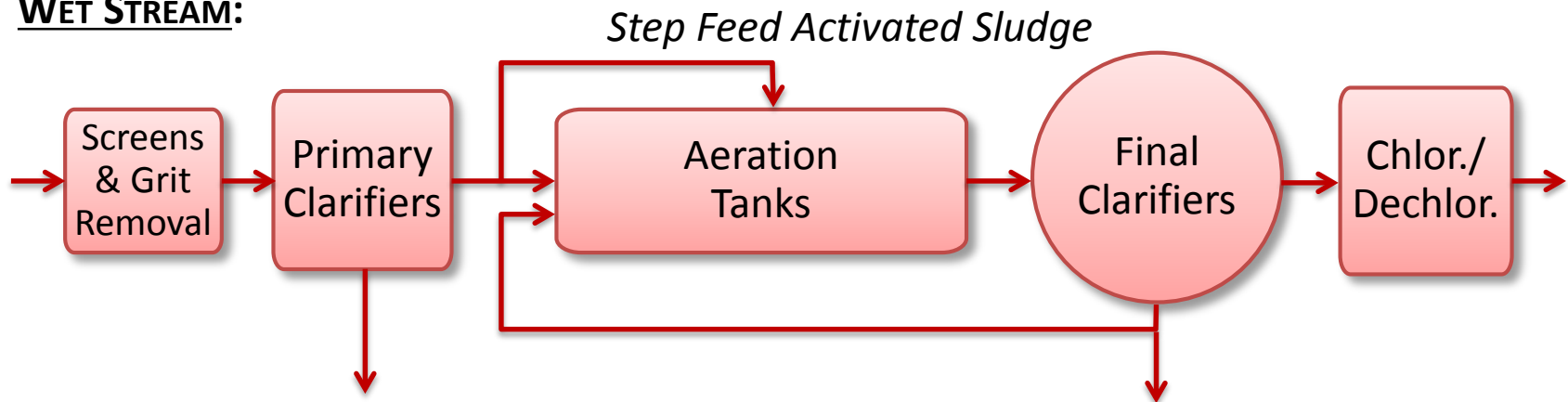
- The objective of this study was to determine the relative difference in reported TP and DRP values depending upon when and how samples are collected and filtered.
- Understand the difference in measured values of DP between more representative (*but not approved*) composite samples and less representative (*although approved*) grab samples collected at three different times during the day.
- Sampling for all of these analyses was performed in September and October of 2015, at the City's two major wastewater treatment plants: Southerly and Jackson Pike.

## Columbus' WWTPs

	Jackson Pike WWTP	Southerly WWTP
Average Design Capacity (permit)	68 MGD	114 MGD
Peak Wet Weather Capacity (full secondary treatment)	150 MGD	330 MGD
Collection System	Combined & Separate	Separate <i>(mostly)</i>
2015 Average Flow	78.7 MGD	100.7 MGD
2015 Average Influent TP	3.9 mg/l	5.7 mg/l
2015 Average Effluent TP	3.4 mg/l	2.3 mg/l

# Southerly & Jackson Pike Have Similar Treatment Processes

## WET STREAM:



## SOLIDS STREAM:

- Primary sludge thickening
- Waste activated sludge centrifuge thickening
- Anaerobic digestion
- Centrifuge dewatering
- Thickening overflow & centrate recycles to plant infl.

**\*\* No phosphorus removal treatment processes \*\***

## Study Sampling Program

Collection Type	Grab	Grab	Grab	24-hr Composite
Collection Time	8:00	16:00	23:59	23:59
Analyses	TP, DRP	TP, DRP	TP, DRP	TP, DRP
Filtration (DRP)	at Plant, w/in 15 mins	at Plant, w/in 15 mins	at Plant w/in 15 mins <hr/> at Lab w/in 10 hrs	at Plant w/in 15 mins <hr/> at Lab w/in 10 hrs
Daily Analyses per Sample	2	2	3	3

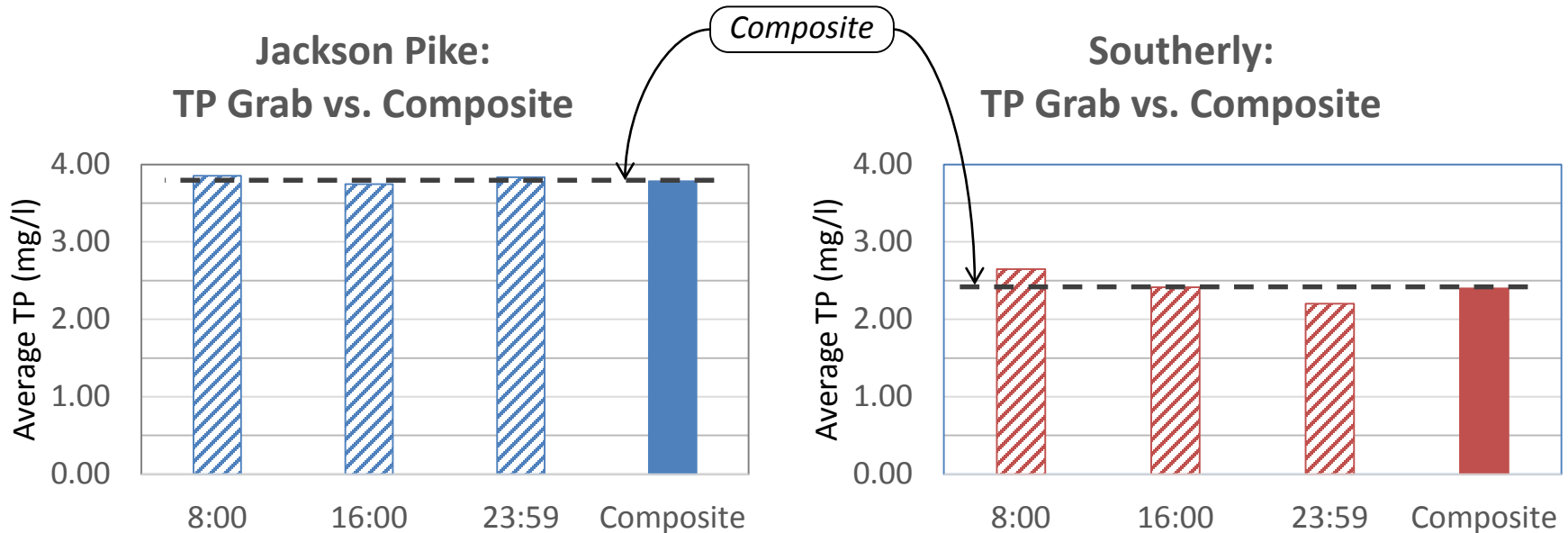
- Composites are flow-proportional 24-hour samples
- Sampling at each plant performed over 3-week period; 12 days at each plant
- Daily analyses at each plant: TP - 4/day, and DRP - 6/day
- Total phosphorus analyses performed for study: TP – 96 samples  
DRP – 144 samples



# Results



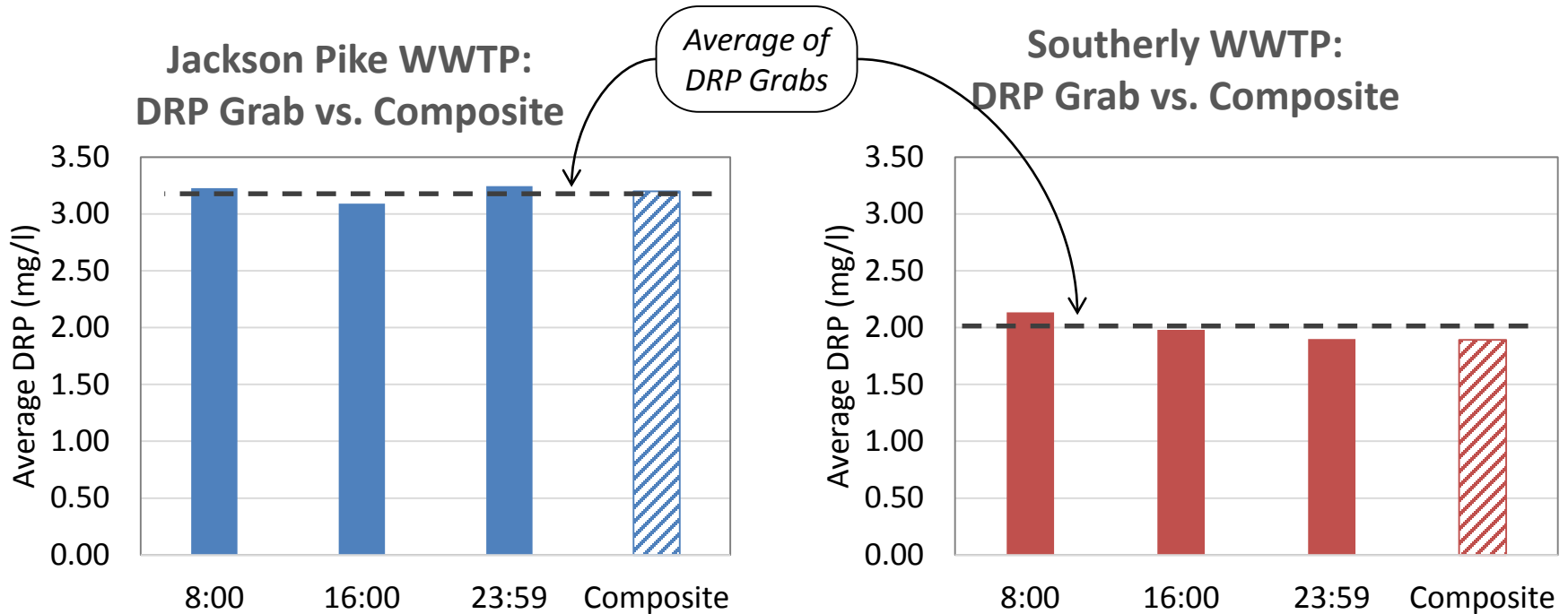
## TP: Grab Times vs. Composite



- Jackson Pike TP grabs range from 99% to 102% of composite TP
- Southerly TP grabs range from 90% to 110% of composite TP
- Acceptable variability (40 CFR 136) for TP is +/- 10%
- **OBSERVATION:** Grab samples at various times from this study are within the acceptable variability for TP analysis

## DRP

### Grab Times vs. Composite



- Jackson Pike composite DRP is 100% of the average of DRP grabs
- Southerly composite DRP is 94% of the average of DRP grabs
- Acceptable variability (40 CFR 136) for DRP is +/- 10%

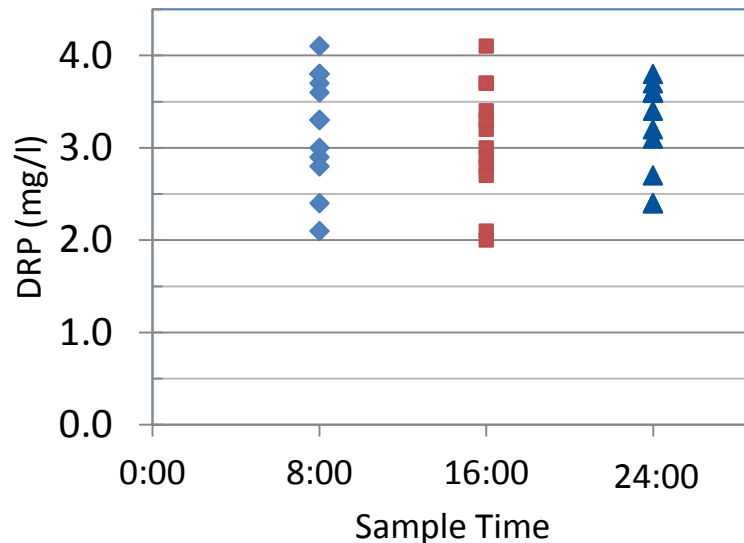
## Grab Samples vs. Composites for DRP

- A single instantaneous grab is not ideally representative for a 24-hr period
  - Much more representative would be the average of 24 grabs taken hourly for the day – *but highly impractical !!*
  - Average of 3 grabs is more representative than any 1 of the 3 grabs
- This study showed 24-hr composites are quite close to grabs collected at various times – within acceptable variability for DRP analysis
- If used for process control, treatability studies or process modeling, immediate sample filtration for DRP may not be necessary to achieve acceptable data accuracy
- This would allow for flexibility for operators and engineers to achieve cost-effective sample collection for analysis and evaluation

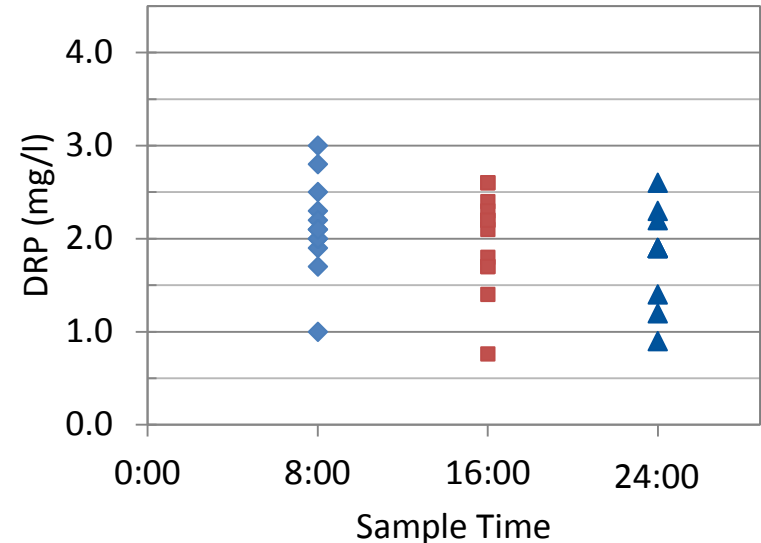
## DRP:

# Time of Grab Sample Collection

**Jackson Pike: DRP Grab Time**



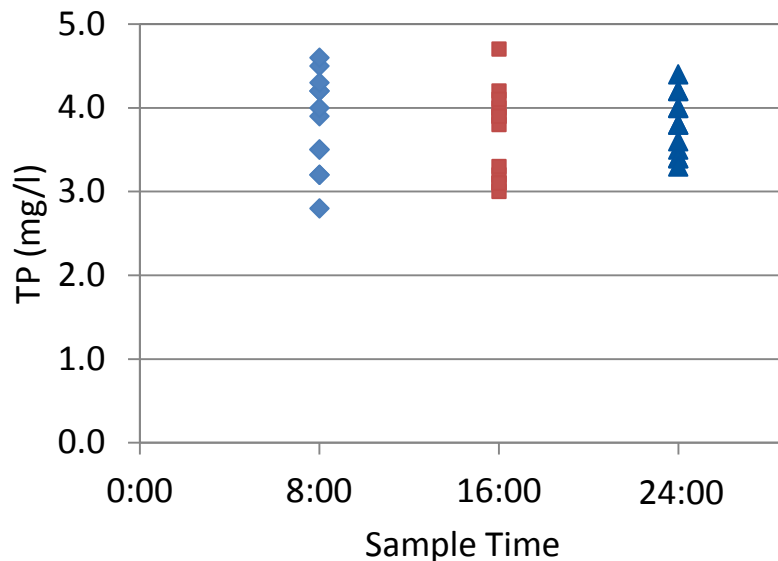
**Southerly: DRP Grab Time**



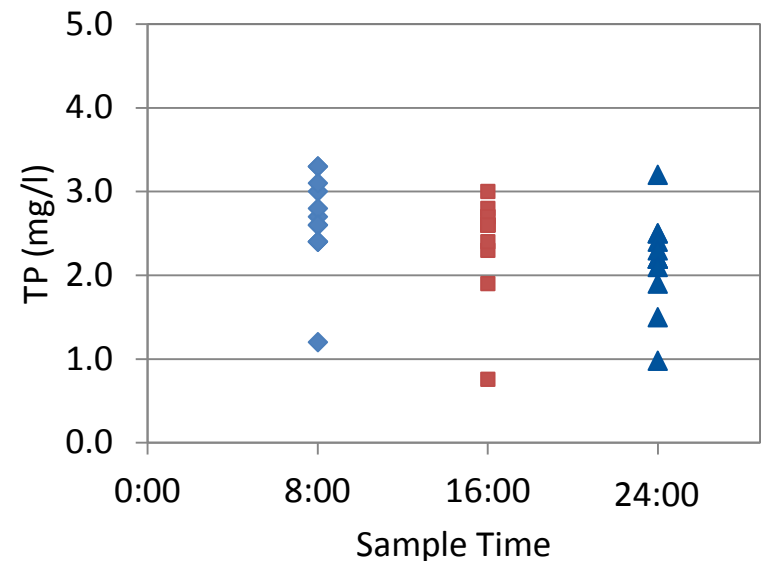
- Fairly consistent daily variation of measured values at specific times for each plant
- It may be feasible to determine a 'most representative' time of day to collect grab samples for a given plant

## TP: Time of Grab Sample Collection

**Jackson Pike: TP Grab Time**



**Southerly: TP Grab Time**



- Similar to DRP, TP has fairly consistent daily variation of measured values at specific times for each plant



## DRP:

# Immediate Filtration vs. Delayed Filtration for Grab & Composite

	Jackson Pike WWTP		Southerly WWTP	
Filtration Time (after collection)	Grab	Composite*	Grab	Composite
w/in 15 mins	3.26	2.88	1.82	1.89
after 10 hrs	3.28	2.96	1.85	1.93
<i>delayed filtration recovery percentage</i>	<i>102%</i>	<i>103%</i>	<i>102%</i>	<i>102%</i>

*\* One pair of outlier values removed*

- Both Jackson Pike and Southerly sample analyses showed effect of 10-hour filtration delay on average DRP values was very slight – about 2% higher
- While immediate filtration is required for NPDES reporting, for other purposes a delay before filtration of up to 10 hrs appears to have essentially no effect

# Summary



## Summary

- Time of filtration following sample collection appears to have a relatively small impact on DRP analytical results
  - Regardless – 40 CFR 136 **requires** filtration within 15 minutes
  - Filtration delay for convenience **may be acceptable** for process control, process treatability studies, or other similar purposes
- Time of grab collection appears to make a difference (relatively slight)
  - There may be a specific time for each plant that is most representative
  - Another study would be interesting performing multiple grabs in a day to determine the optimal (most representative) sampling time for a given plant
- Based on this study, it appears there is relatively little difference between DRP analyzed on a composite sample vs. average of multiple grab samples

# Questions?

- Melodi Clark
- City of Columbus Surveillance Lab Manager
- 614-645-1239
- [mlclark@columbus.gov](mailto:mlclark@columbus.gov)
- Special Thanks to Guy Jamesson!