The Significance of Reporting Methodologies in Stringent Phosphorus NPDES Permits

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Presentation Objectives

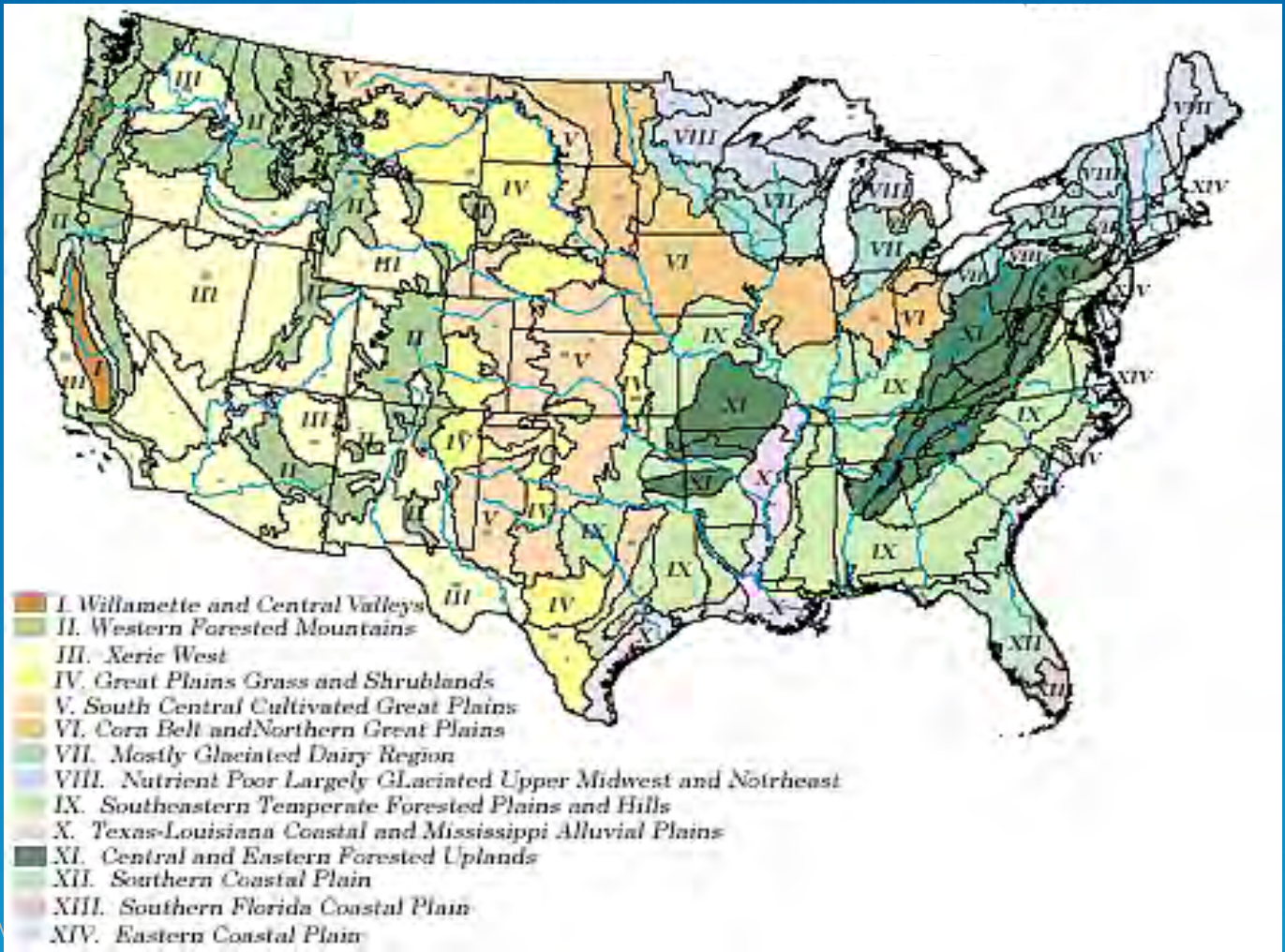
1) Review history of numeric nutrient criteria
2) Summarize reporting methodologies across US:
   - Averaging durations (weekly, monthly, seasonal, annual)
   - Averaging methods (means, medians, percentiles)
   - Concentrations vs. loads
3) Evaluate impacts of methodologies on compliance with total phosphorus limits using four MA facilities
4) Discussion and recommendations

NUMERIC NUTRIENT CRITERIA

US EPA Numeric Nutrient Criteria

- 1986 EPA "Gold Book"
  - 0.1 mg/L TP free-flowing streams
  - 0.05 mg/L TP where stream enters lake/reservoir
  - 0.025 mg/L TP in lake/reservoir
- 1998 EPA Regional Nutrient Criteria
  - US divided into 14 Ecoregions (with sub-regions)
  - Criteria for TN, TP, chlorophyll-a, and turbidity
  - Different criteria for lakes/reservoirs, rivers/streams, estuaries/coastal environments, wetlands

Numeric Nutrient Criteria – 1998 Ecoregions



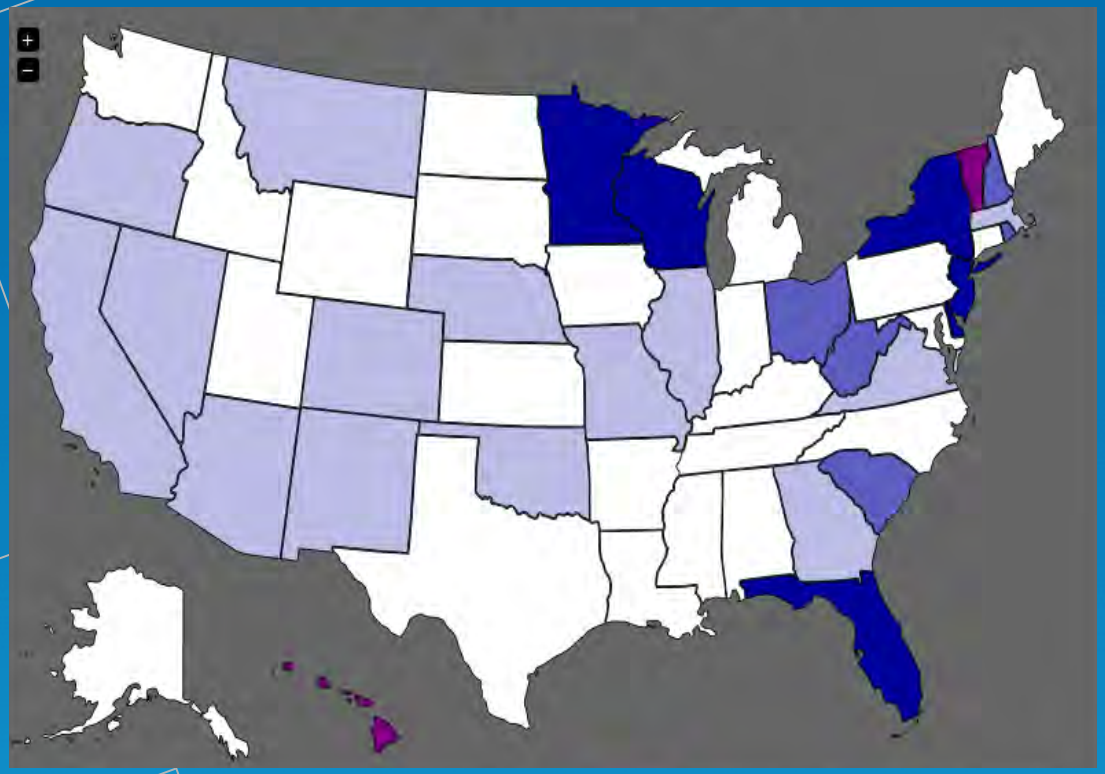
US EPA Numeric Nutrient Criteria

- Using data from unimpaired reference waters:
  - Select 75th percentile levels for each parameter from each water body type

OR…

- Using data from all regional water bodies:
  - Select 25th percentile levels for each parameter from each water body type
- Done for each season, then averaged over year

2014 Progress Toward State Nutrient Criteria



Level 5	Complete set of N and P criteria for all watertypes**
Level 4	2 or more watertypes with N and/or P criteria
Level 3	1 watertype with N and/or P criteria
Level 2	Some waters with N and/or P criteria
Level 1	No N and/or P criteria

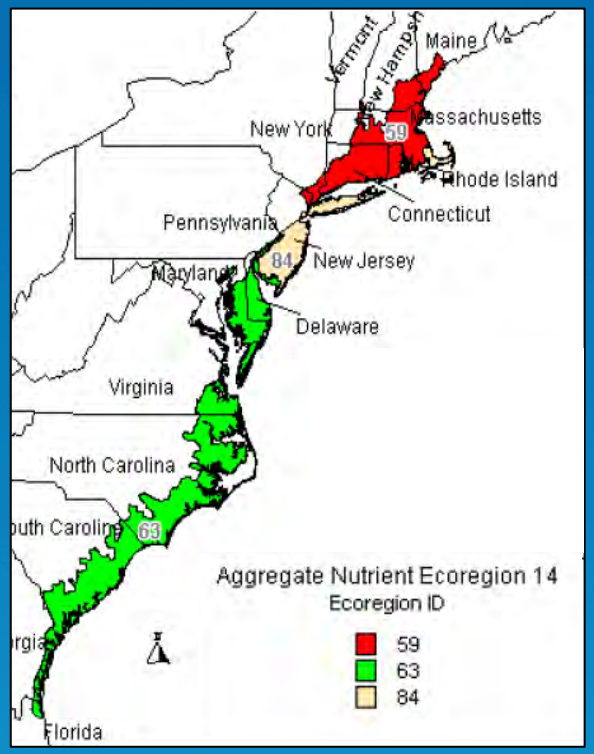
	District of Columbia
	American Samoa
	Commonwealth of Northern Marianas
	Guam
	Puerto Rico
	US Virgin Islands

Nearly half of US states have not established criteria for either N or P

Massachusetts Nutrient Criteria

- 314 CMR 4.00 Surface Water Quality Standards
  - Narrative criteria unless site-specific TMDL established
  - Protect designated uses
  - Highest and best practical treatment
- Typical NPDES Permit Limits
  - 0.1 mg/L, 0.2 mg/L, 0.75 mg/L, 1.0 mg/L
  - Report-only

Eastern Coastal Plain



0.03125 mg/L TP Region-wide
0.02375 mg/L TP - Sub-region 59 (Eastern MA except Cape Cod)

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TOTAL PHOSPHORUS REPORTING METHODOLOGIES

Phosphorus Regulation

- NPDES Permits issued by US EPA (2011 data):
  - 3,130 facilities with TP limits
  - 24,238 facilities with report-only TP

NPDES Regulations: 40 CFR 122.45(d)(2)

"For continuous discharges all permit effluent limitations, standards, and prohibitions, including those necessary to achieve water quality standards, shall ***unless impracticable*** *be stated as: (2)* ***Average weekly and average monthly discharge limitations*** *for POTWs."*

2010 Permit Writers' Manual

Nutrient criteria are *"different from most of its other recommended criteria"* in 3 ways:

1) Ecoregional, not national
2) Calculated based on reference conditions rather than lab testing
3) **Do not include specific duration or frequency components**

2000 Ecoregion XIV Rivers and Streams Report

*"Identify **appropriate periods of duration** (i.e., how long) **and frequency** (i.e., how often) of occurrence **in addition to magnitude** (i.e., how much). EPA does not recommend identifying nutrient concentrations that must be met at all times, rather **a seasonal or annual averaging period…is considered appropriate**."*

National NPDES Permits

Watershed	POTW	TP Limit	Reported As	Notes
Potomac River/ Chesapeake Bay	Blue Plains (DC Water)	0.18 mg/L	12-mo. rolling average	Less stringent mo. avg. load
Onondaga Lake	Metropolitan Syracuse WWTP	0.10 mg/L and 9,757 kg/yr	12-mo. rolling average	Expect reduction to 0.02 mg/L
Tualatin River (Oregon)	Durham WWTF	0.11 mg/L	Monthly median	May – October only
Tualatin River (Oregon)	Rock Creek WWTF	0.10 mg/L	Monthly median	May – October only
Spokane River (Washington)	Riverside Park WRF (Spokane)	8.07 kg/d	Seasonal avg. daily load	March – October
State of Colorado	Regulation #85	1.0 mg/L / 2.5 mg/L	Annual median / 95th percentile	Calculated as rolling values

MASSACHUSETTS CASE EXAMPLES

Seven Methodologies for Concentration & Load

- Monthly Average (arithmetic mean)
- Maximum of 60-day Rolling Average
- Seasonal Average (April – October)
- Annual Average
- Monthly Median
- Seasonal Median (April – October)
- Annual Median

Case Examples – Four Treatment Facility Types

- Enhanced Biological Phosphorus Removal
  - Secondary treatment; no chemical addition
- Ballasted Flocculation (tertiary)
- Cloth Disk Filtration (tertiary)
- Upflow Sand Filtration (tertiary)

4 year of data evaluated

Enhanced Biological Phosphorus Removal

Year	Month	Monthly Average	Max 60-day Rolling Avg	Seasonal Average	Annual Average	Monthly Median	Seasonal Median	Annual Median
2012 (mg/L)	January	0.37			0.42	0.26		0.30
	February	0.57			0.42	0.45		0.30
	March	0.41			0.42	0.33		0.30
	April	0.75	0.75	0.48	0.42	0.63	0.32	0.30
	May	0.59	0.66	0.48	0.42	0.37	0.32	0.30
	June	0.45	0.66	0.48	0.42	0.50	0.32	0.30
	July	0.22	0.51	0.48	0.42	0.18	0.32	0.30
	August	0.19	0.33	0.48	0.42	0.17	0.32	0.30
	September	0.76	0.47	0.48	0.42	0.63	0.32	0.30
	October	0.41	0.58	0.48	0.42	0.31	0.32	0.30
	November	0.17			0.42	0.15		0.30
	December	0.19			0.42	0.18		0.30

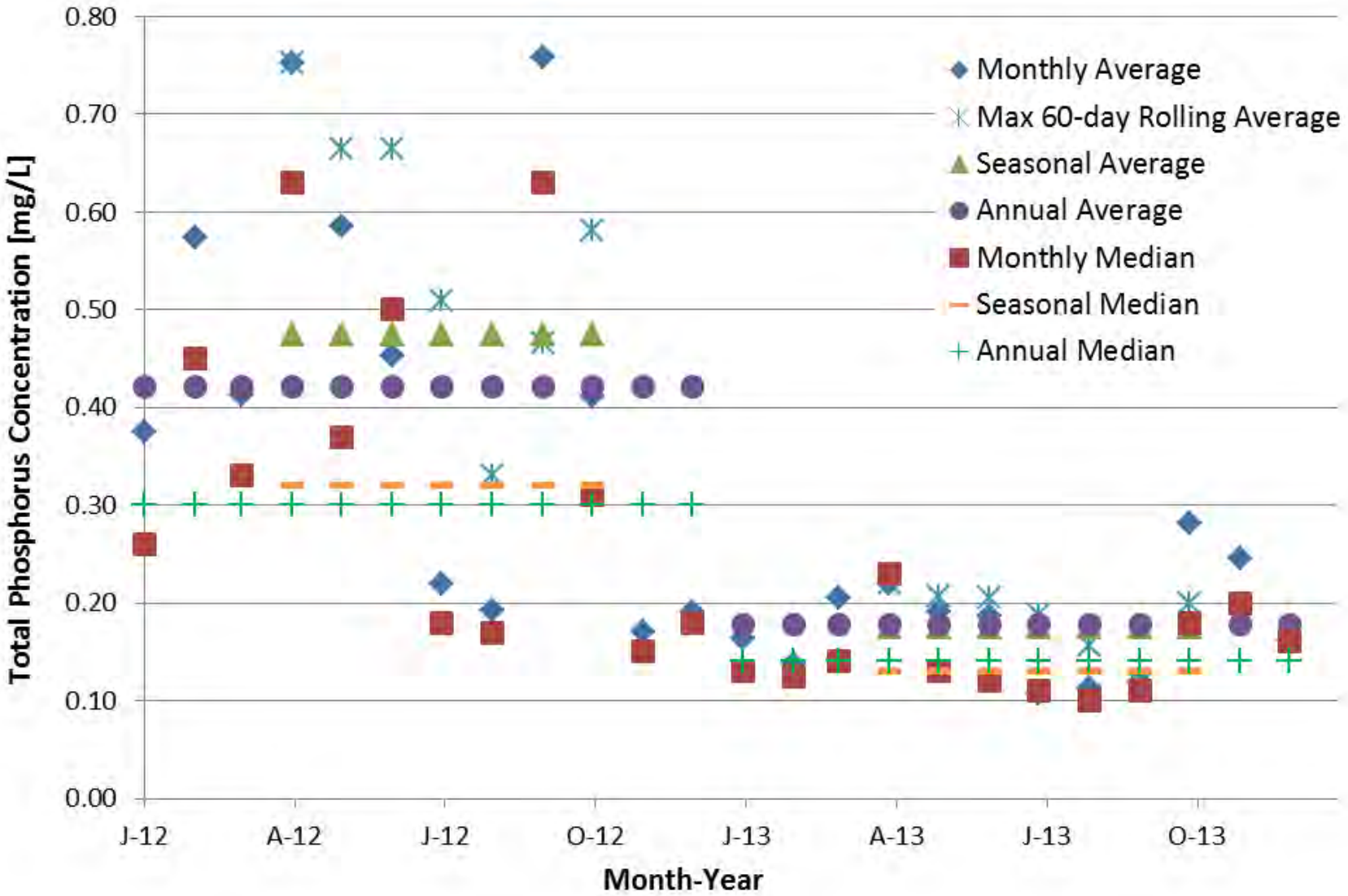
Shaded cells indicate compliance with 0.45 mg/L TP limit

Enhanced Biological Phosphorus Removal

Year	Month	Monthly Average	Max 60-day Rolling Avg	Seasonal Average	Annual Average	Monthly Median	Seasonal Median	Annual Median
2013 (kg/d)	January	18			21	11		13
	February	18			21	11		13
	March	43			21	21		13
	April	27	27	21	21	31	13	13
	May	22	25	21	21	13	13	13
	June	37	31	21	21	20	13	13
	July	11	31	21	21	11	13	13
	August	11	26	21	21	9	13	13
	September	10	11	21	21	11	13	13
	October	23	16	21	21	15	13	13
	November	18			21	15		13
	December	13			21	10		13

Shaded cells indicate compliance with 95 kg/d and future 21 kg/d limits

EBPR (0.45 mg/L TP limit)



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Ballasted Flocculation

Year	Month	Monthly Average	Max 60-day Rolling Avg	Seasonal Average	Annual Average	Monthly Median	Seasonal Median	Annual Median
2012 (mg/L)	January	0.48			0.25	0.50		0.20
	February	0.79			0.25	0.73		0.20
	March	0.82			0.25	0.79		0.20
	April	0.24	0.24	0.19	0.25	0.24	0.18	0.20
	May	0.21	0.23	0.19	0.25	0.22	0.18	0.20
	June	0.18	0.22	0.19	0.25	0.19	0.18	0.20
	July	0.20	0.21	0.19	0.25	0.19	0.18	0.20
	August	0.13	0.19	0.19	0.25	0.14	0.18	0.20
	September	0.21	0.17	0.19	0.25	0.22	0.18	0.20
	October	0.14	0.18	0.19	0.25	0.14	0.18	0.20
	November	0.20			0.25	0.16		0.20
	December	0.35			0.25	0.32		0.20

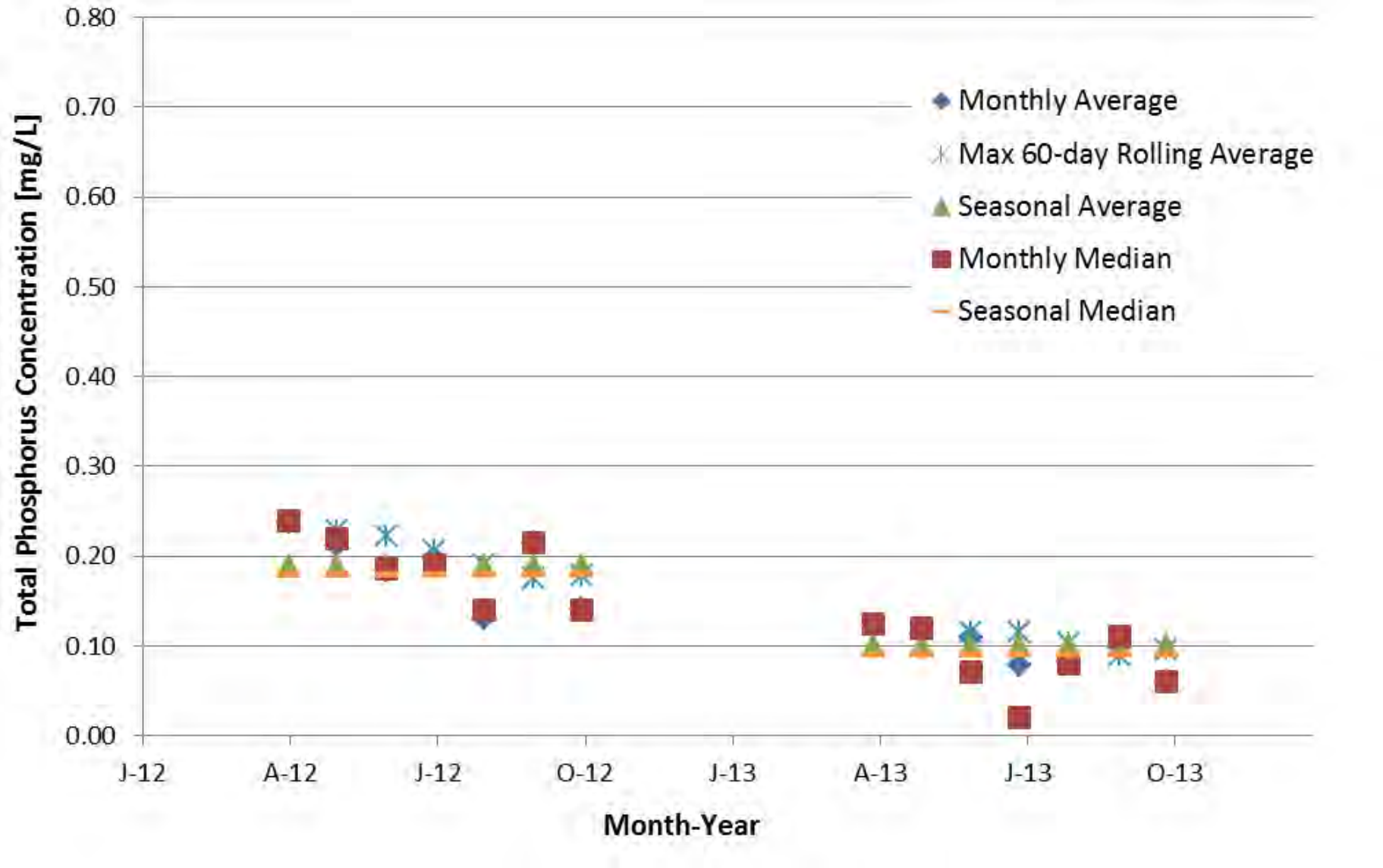
Shaded cells indicate compliance with 0.2 mg/L TP limit

Ballasted Flocculation

Year	Month	Monthly Average	Max 60-day Rolling Avg	Seasonal Average	Annual Average	Monthly Median	Seasonal Median	Annual Median
2013 (mg/L)	January	0.53			0.17	0.58		0.11
	February	0.43			0.17	0.43		0.11
	March	0.29			0.17	0.28		0.11
	April	0.12	0.12	0.10	0.17	0.13	0.09	0.11
	May	0.11	0.12	0.10	0.17	0.12	0.09	0.11
	June	0.11	0.11	0.10	0.17	0.07	0.09	0.11
	July	0.08	0.12	0.10	0.17	0.02	0.09	0.11
	August	0.08	0.10	0.10	0.17	0.08	0.09	0.11
	September	0.10	0.09	0.10	0.17	0.11	0.09	0.11
	October	0.06	0.09	0.10	0.17	0.06	0.09	0.11
	November	0.24			0.17	0.24		0.11
	December	0.83			0.17	1.07		0.11

Shaded cells indicate compliance with 0.2 mg/L TP limit

Ballasted Flocculation (0.2 mg/L TP limit)



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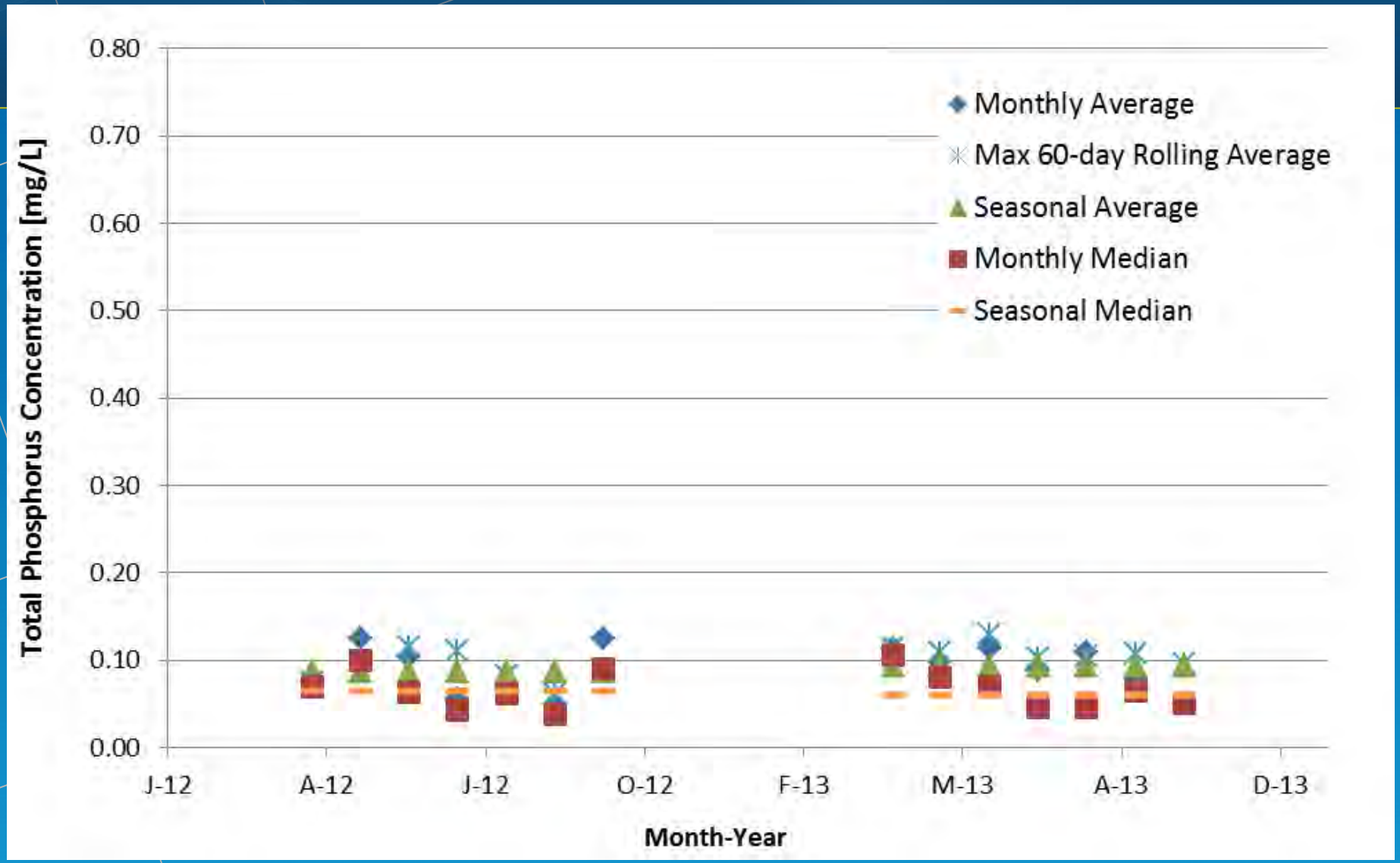
Upflow Sand Filtration (0.1 mg/L TP limit)



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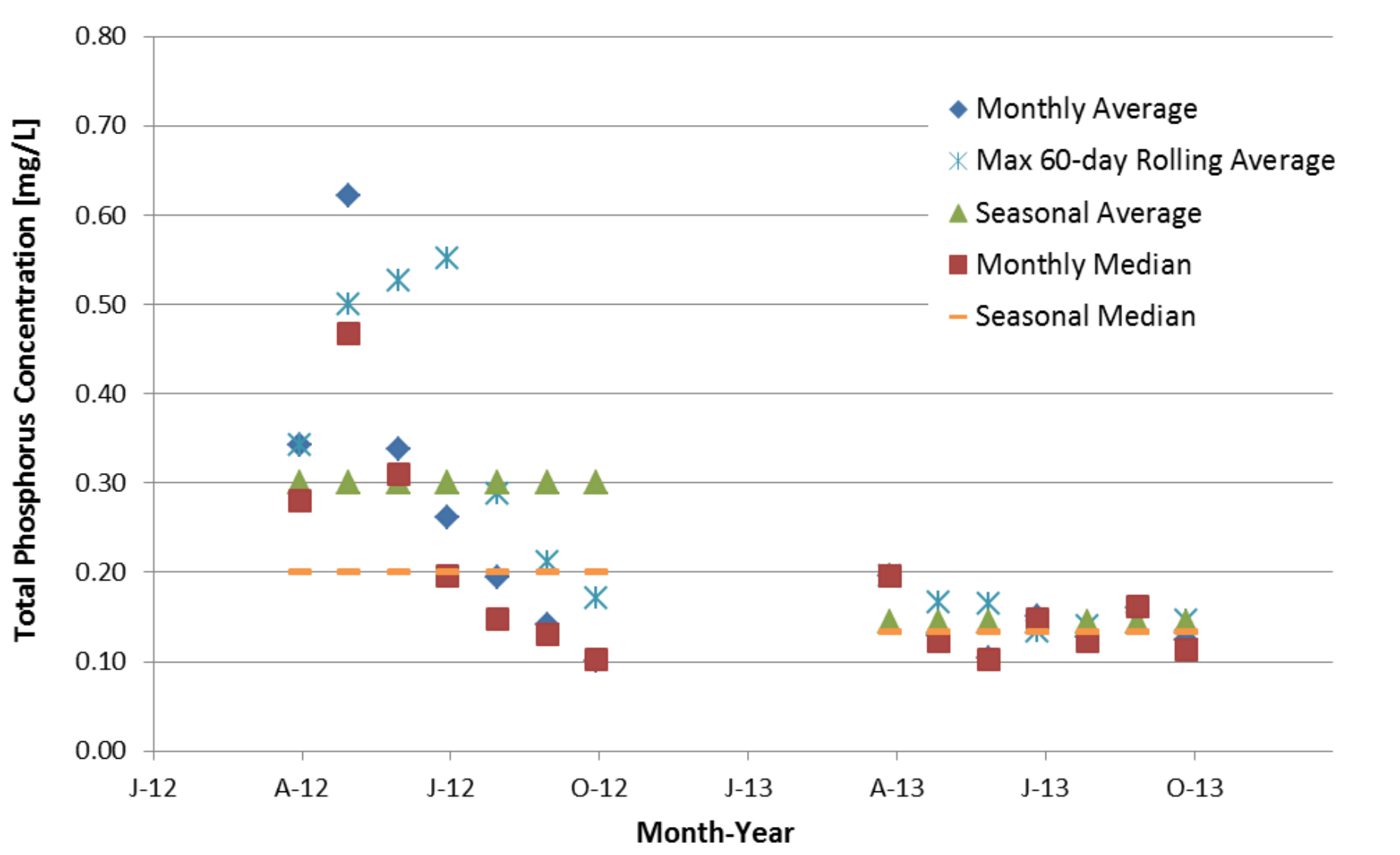
Cloth Disk Filtration (0.2 mg/L TP limit)



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Conclusions from Case Examples

- 60-day rolling average results in highest values
  (One outlier can impact 3 months of reportable values)
- Medians generally lower than means
  (Applies to monthly, seasonal, and annual values)
- Processes with more variation/outliers benefit from median limits
- Longer averaging periods increase compliance
- Compliance higher with load-based limits at facilities operating below permitted flow

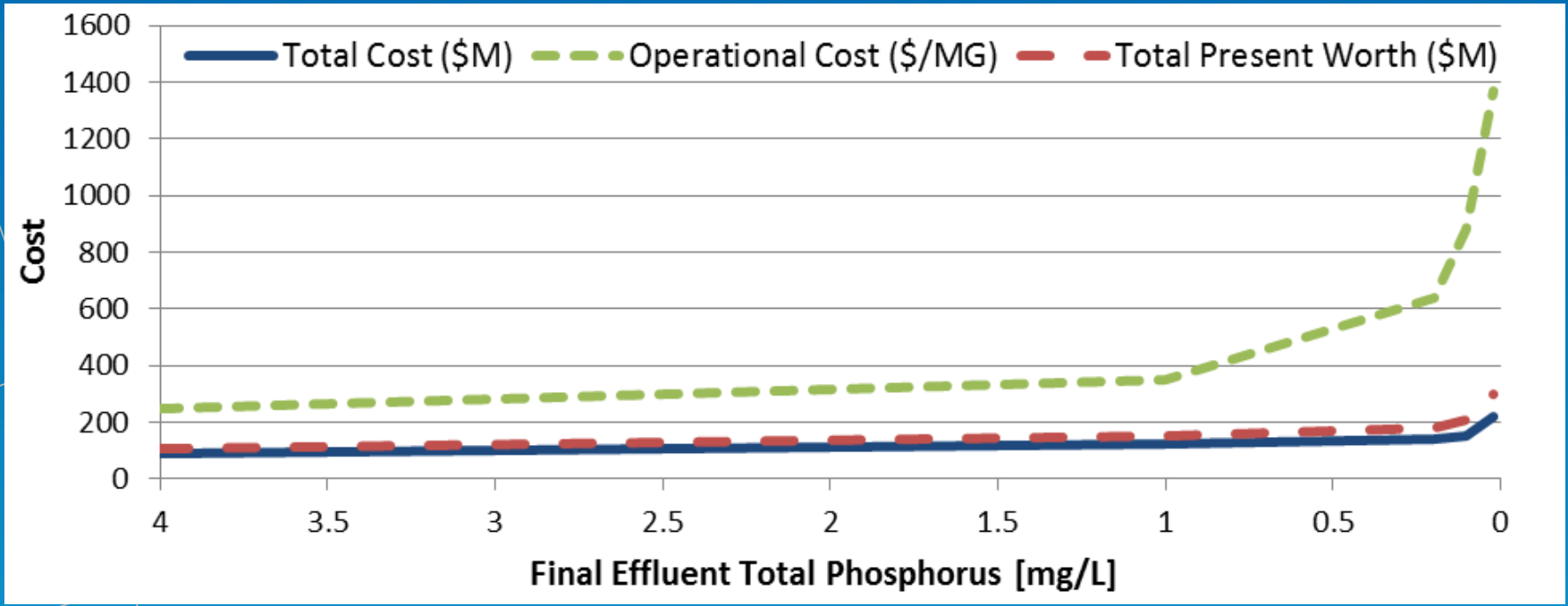
DISCUSSION & RECOMMENDATIONS

Considerations in Permit Development

- D+ Rating of US Wastewater/Stormwater Infrastructure (ASCE, 2014)
- Poor to fair condition; mostly below standard
- $298 billion needed over 20 years
- Largely related to SSOs and CSOs (raw discharge)
- Competing needs for limited funding

Permits must meet simultaneous goals of water quality protection and sound investment

Projected Costs to Treat Effluent at 10 mgd Facility



Source: WERF, 2011

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2011 WERF Study Findings

"Even exemplary plants may produce violations if regulators pick values that are inappropriate to the associated averaging period, ***no matter how much effort, cost and energy is expended****."*

(Bott and Parker, 2011)

Considerations in Permit Development (cont.)

- Uncertainties inherent in numeric criteria:
  - Regional criteria not site-specific
  - Variety of data quality used in their establishment
  - Based on 25th/75th percentile methods
  - Calculated using average of 4 seasons

Wouldn't a monthly average permit limit imply a much higher level of certainty in the criteria?

Considerations in Permit Development (cont.)

- Uncertain relationship between nutrient criteria and water quality impairment
  - Nutrients do not pose acute toxicity
  - Not adequate links between numeric criteria and impairment of beneficial uses

Too much variation in the natural world to have regional criteria accurately matched with site-specific impairments

Recommendations

- Site-specific modeling and TMDLs
- Time frames for permits reflective of impacts
- Adaptive management approach – allow flexibility initially and monitor benefits
- Allow medians when consistent with water quality goals (if outliers don't impact quality)
- Combine with 95th percentile value if needed

Recommendations (cont.)

- Allow medians to encourage EBPR
  - Lower chemical consumption
  - Lower energy use
  - Lower O&M costs
  - More sustainable
- Allow load-based TP when operating below flow limits and permit is based on TMDL
  - Encourages phased implementation
  - Allows phased expenditures

Conclusion

- Averaging types (mean, median)
- Averaging durations
- Concentration vs. load-based limits

These are expensive decisions that require forethought, scientific basis, sound reasoning, and coordination between regulators and facility managers during permit development

Questions?

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