One Water – Government & Regulatory Affairs Workshop – March 9, 2017

Ohio EPA's *first* Nutrient Mass Balance Study for Ohio's Major Rivers

THE CITY OF COLUMBUS
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DEPARTMENT OF PUBLIC UTILITIES

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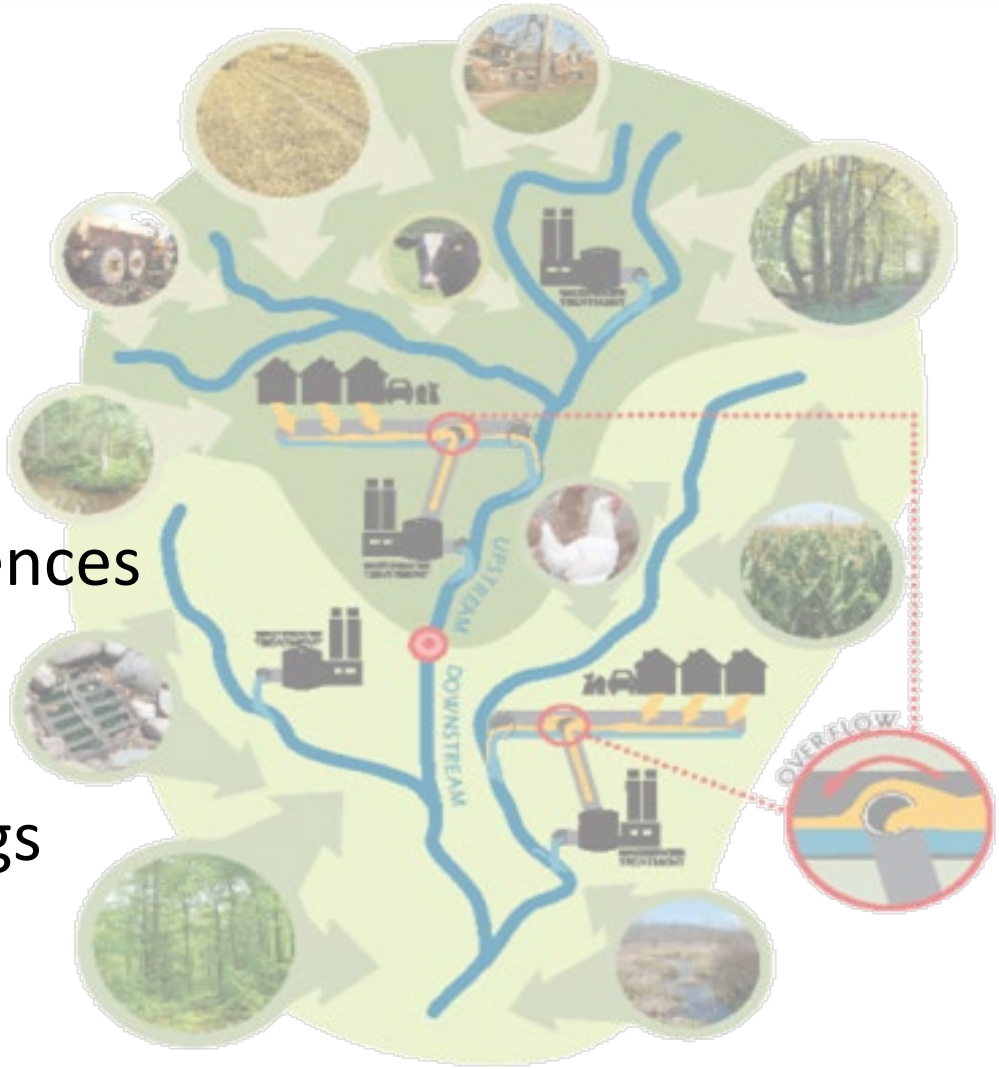
Nutrient Mass Balance Study for Ohio's Major Rivers

- Background
- Watersheds & data
- Study methodology
- Nutrient loading influences
- Study results
- Observations & findings
- Next



Background

- Need for nutrient loading mass balance by source types in Ohio watersheds recognized by *Point Source & Urban Runoff Nutrient Workgroup* (2012)
- Watersheds nutrient mass balance recommended in *Ohio Nutrient Reduction Strategy* (2013)
- Legislation: H.B.64 (2015) – requires Ohio EPA to:
  - Determine nutrient loads from point & nonpoint sources for watersheds in Lake Erie and Ohio River basins
  - Update and report every 2 years

Objectives

- Info to guide Ohio EPA policy & management:
  - Relative loads (by watershed)
  - Understand load sources (NPS *vs.* CSO *vs.* wastewater)
  - Most environmentally beneficial and cost effective means to reduce overall nutrient loadings
- Support national programs:
  - GLWQA Annex 4
  - Gulf Hypoxia Task Force
- Inform stakeholders:
  - Local governments, industry, agriculture community, non-governmental organizations, citizens

Ohio Environmental Protection Agency

Nutrient Mass Balance Study for Ohio's Major Rivers

Report available at:

http://www.epa.state.oh.us/dsw/wqs/NutrientReduction.aspx#146065085-nutrient-mass-balance

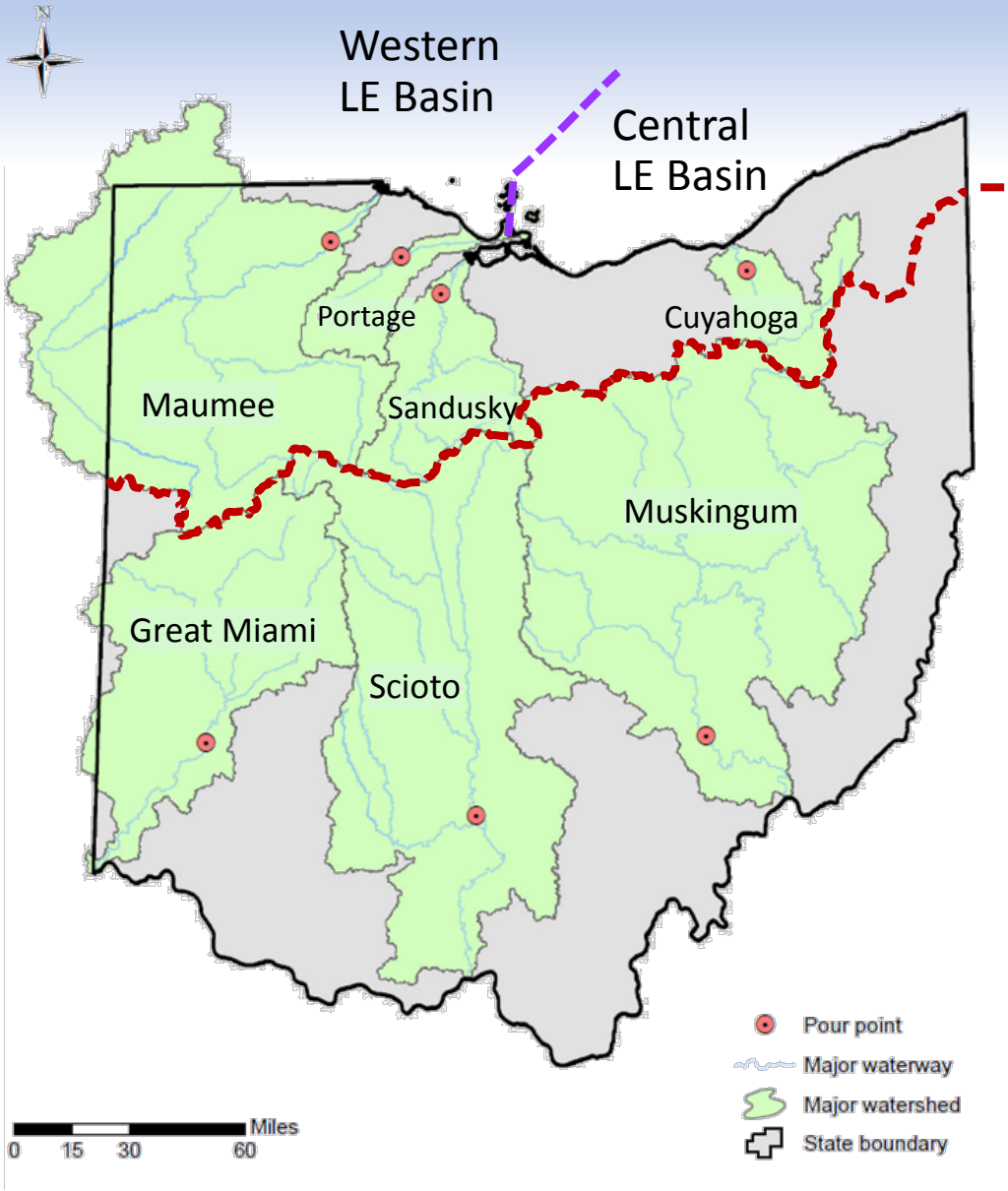
Division of Surface Water

Modeling, Assessment and TMDL Section

December 30, 2016

Study Work Plan

- Developed by Ohio EPA Modeling, Assessment & TMDL Section – Fall 2015
  - Prioritize & select watersheds to be studied
  - Develop approach for calculations
  - Identify available data
- Early technical stakeholder outreach & review:
  - AOMWA (Assoc. of Ohio Metro. Wastewater Agencies)
  - Ohio Farm Bureau
  - USGS
  - NCWQR (Heidelberg University)
  - The Nature Conservancy



Study Area Covered

- 7 major watersheds
- 26,000 sq. mi. (in Ohio)
- 63% of Ohio's land area

Available Data Used

- **Nutrient concentration data** – National Center for Water Quality Research (NCWQR), Heidelberg Univ.
  - Analysis of **daily** samples for TP and TN
- **Flow data** – USGS flow gaging stations
  - Continuous flow monitoring
- **Point source monitoring data** – Ohio EPA DMR reporting data from NPDES program
  - Flow data; variable nutrient concentration data
  - CSO and SSO reporting
- **Home sewage treatment systems** – estimates from GIS analysis of US Census data; literature data for per capita nutrient yields; Ohio Dept. of Health survey data

Data Time Period

- Loads calculated for '**water years**' (Oct 1 to Sept 30 basis)
  - Most recent complete data available for 2013 and 2014 (when study started)
  - Designated "wy13" and "wy14"
  - Matches related efforts in reporting e.g., GLWQA-Annex 4, NCWQR, USGS

Calculation Methodology

Mass balance loading calculation:

$$\boldsymbol{Total\ Load = NPDES + HSTS + NPS_{upst} + NPS_{dst}}$$

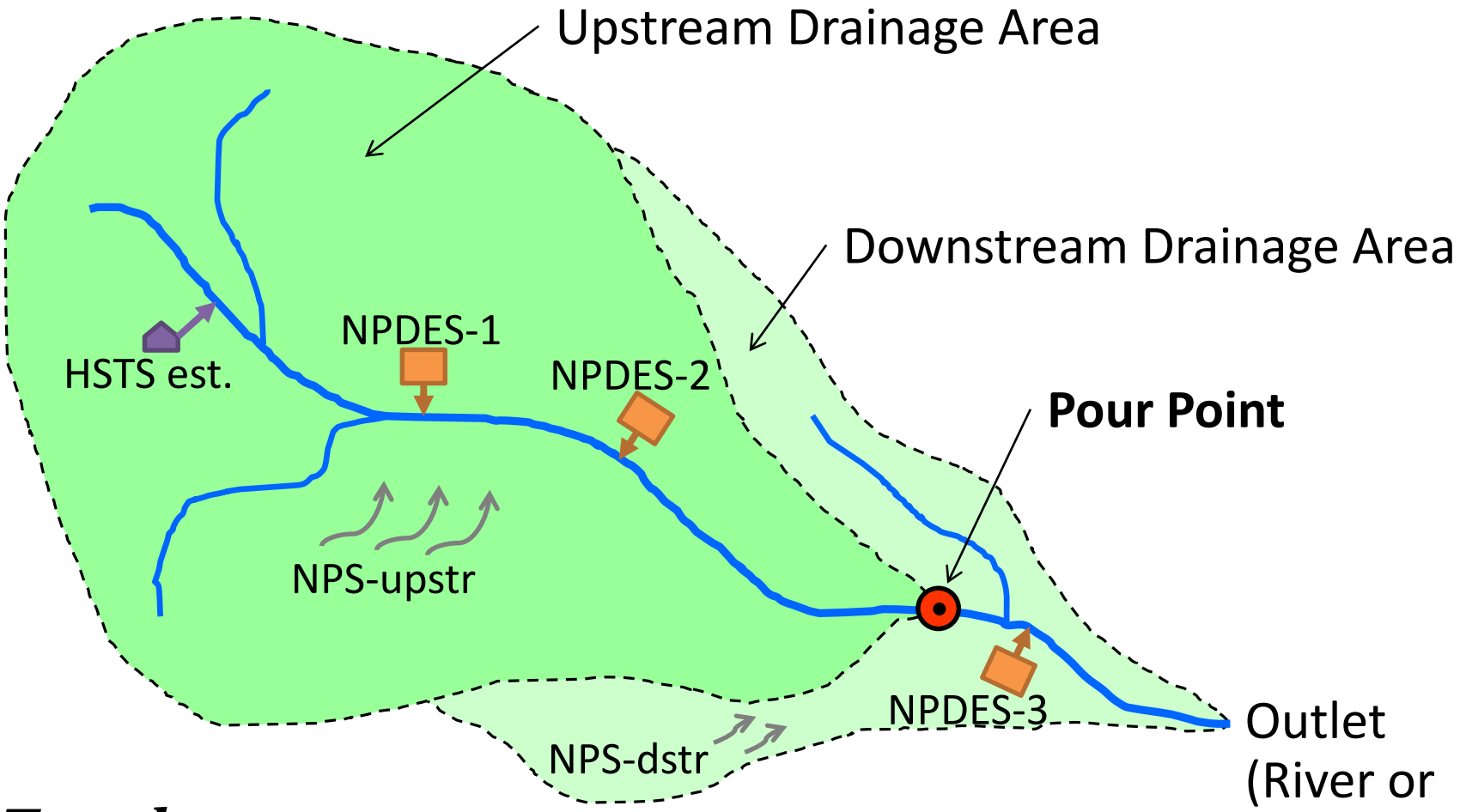
NPDES = sum of all NPDES loads

HSTS = estimate of total HSTS load

NPS_{upst} = calculated 'Pour Point' load *minus* (NPDES + HSTS)

NPS_{dst} = est. from NPS_{upst} relative to downstream area

Watershed Schematic for Calculation



$$\boldsymbol{Total\ Load = PS + HSTS + NPS_{upst} + NPS_{dst}}$$

Calculation: NPDES

- **NPDES sources**
  - Municipal NPDES
    - Total annual discharge (reported data)
    - Median of nutrient concentration, if reported
    - Nutrient concentration estimates from similar facilities, if not reported
  - CSOs (all wet weather) includes bypass flows
    - Actual reporting data or system characterization flows (LTCP) if under-represented
    - Most SSOs do not report volume (only occurrence)
    - CSO nutrient concentrations fixed (based on literature values)
  - Industrial facilities
    - Total annual discharge (reported data)
    - Nutrient concentration only if there was reported data
    - If no nutrient monitoring, assume de minimis contribution

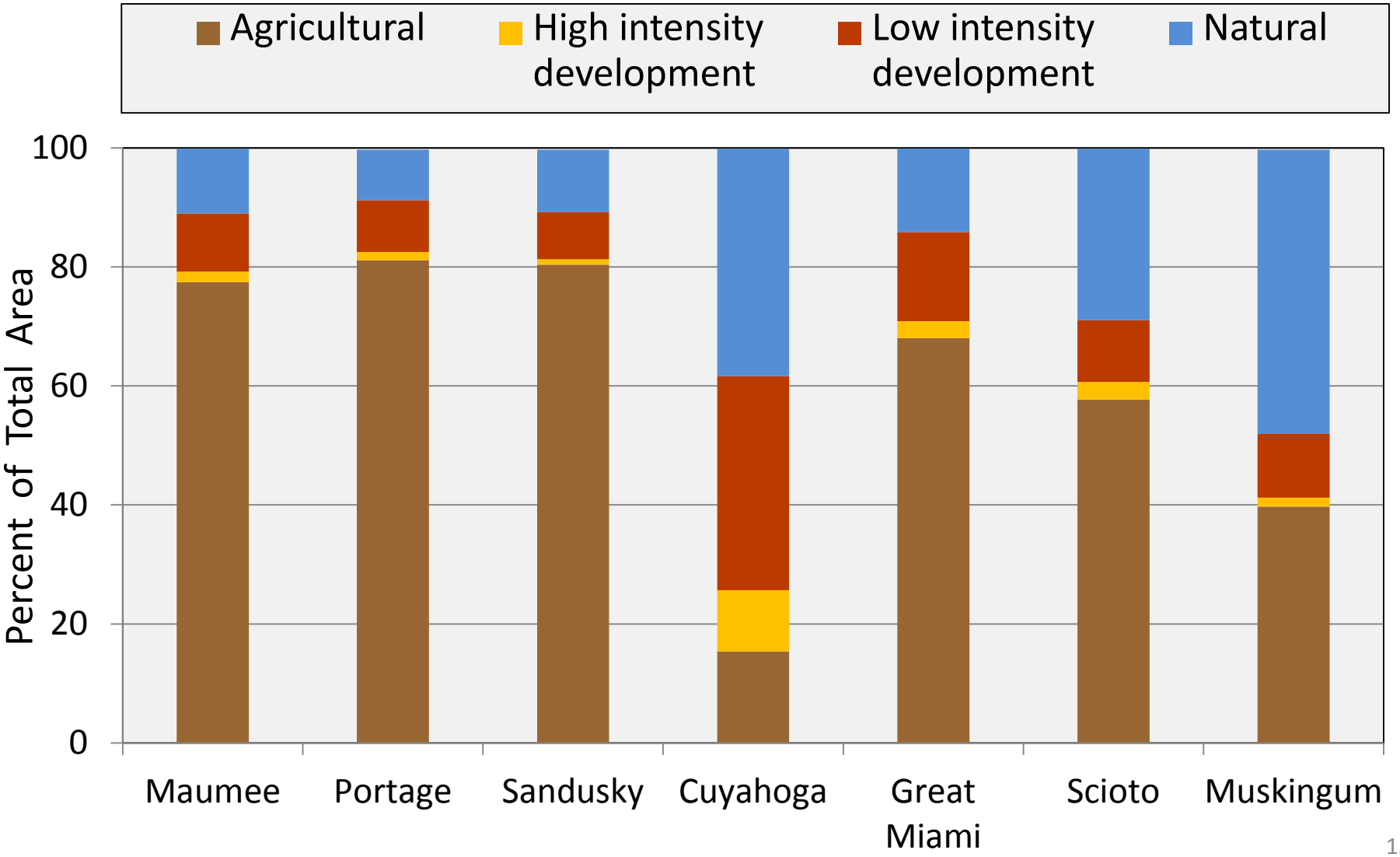
Calculation: HSTS, NPS

- **Household sewage treatment systems (HSTS)**
  - Population using HSTS (2010 US Census)
    - Estimated using GIS analysis of census information
  - Nutrient yield (lb/person/year): from literature (Lowe, 2009)
  - Differentiated by regional 2012 survey (ODH, 2013)
    - direct discharge vs. onsite
    - onsite: working vs. failed
- **Nonpoint source**
  - NPS upstream of pour point
    - Does not differentiate between types of NPS (e.g., agriculture vs. urban stormwater)
  - NPS downstream = Upstream NPS Yield x Downstream Area
    - NPS Yield = NPS Load *divided by* Watershed Area

Factors Influencing Watershed Loadings

- Land use:
  - Agricultural, Urban development, Natural
- Nonpoint source yield:
  - NPS Load *divided by* Upstream Watershed Area
- Population density
- Per capita yield:
  - Sum of PS Loads *divided by* Watershed Population
- Watershed size (area)
- Annual water yield:
  - Annual Watershed Discharge *divided by* Drainage Area

Land Use by Watershed



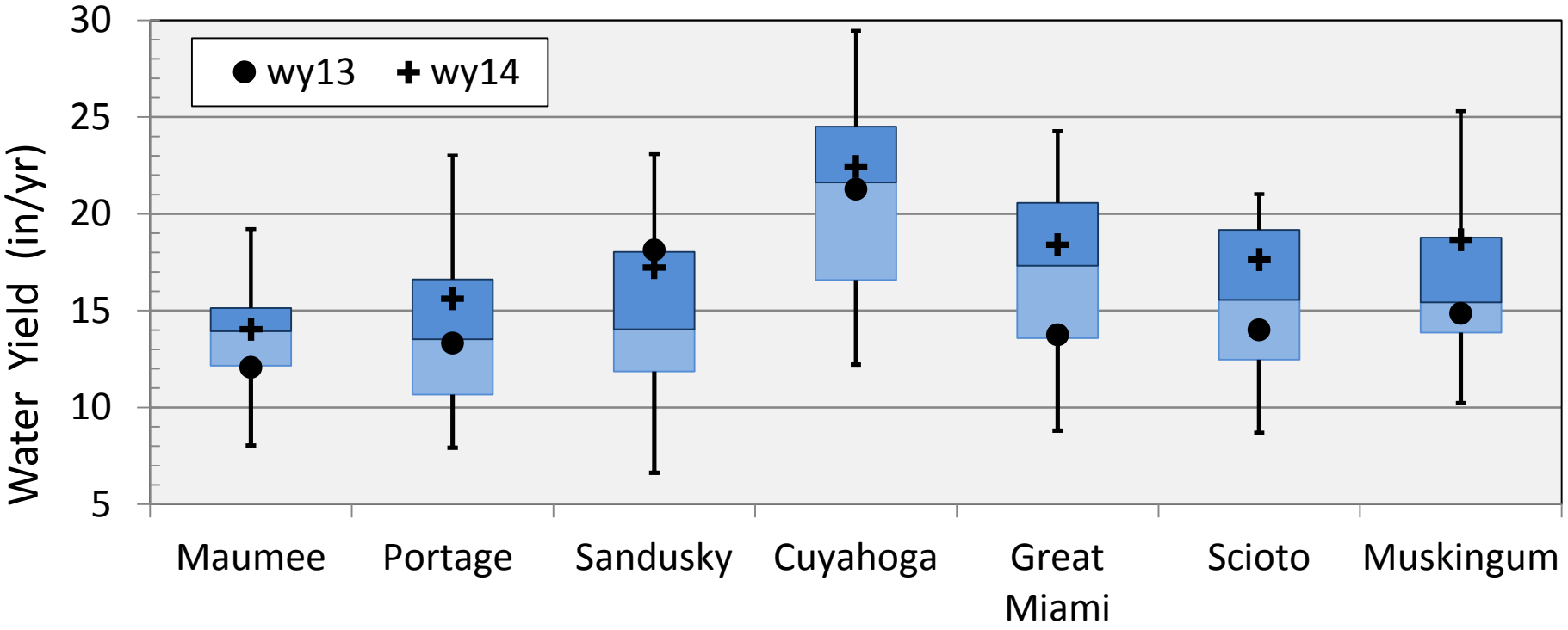
Population Density by Watershed

Watershed	Total Population	Drainage Area (sq. mi.)	Population Density (pop./sq.mi.)
Maumee	1,086,242	6,568	165
Portage	67,181	585	115
Sandusky	130,088	1,420	92
Cuyahoga	1,005,298	808	1,244
Great Miami	1,359,723	3,889	350
Scioto	1,939,124	6,509	298
Muskingum	1,462,086	8,044	182

Water Yield: Study *vs*. 20-year History

Water Yield = total discharge divided by watershed area

- Water yields for study years (wy13 & wy14) were within typical ranges during past 20 years for all watersheds

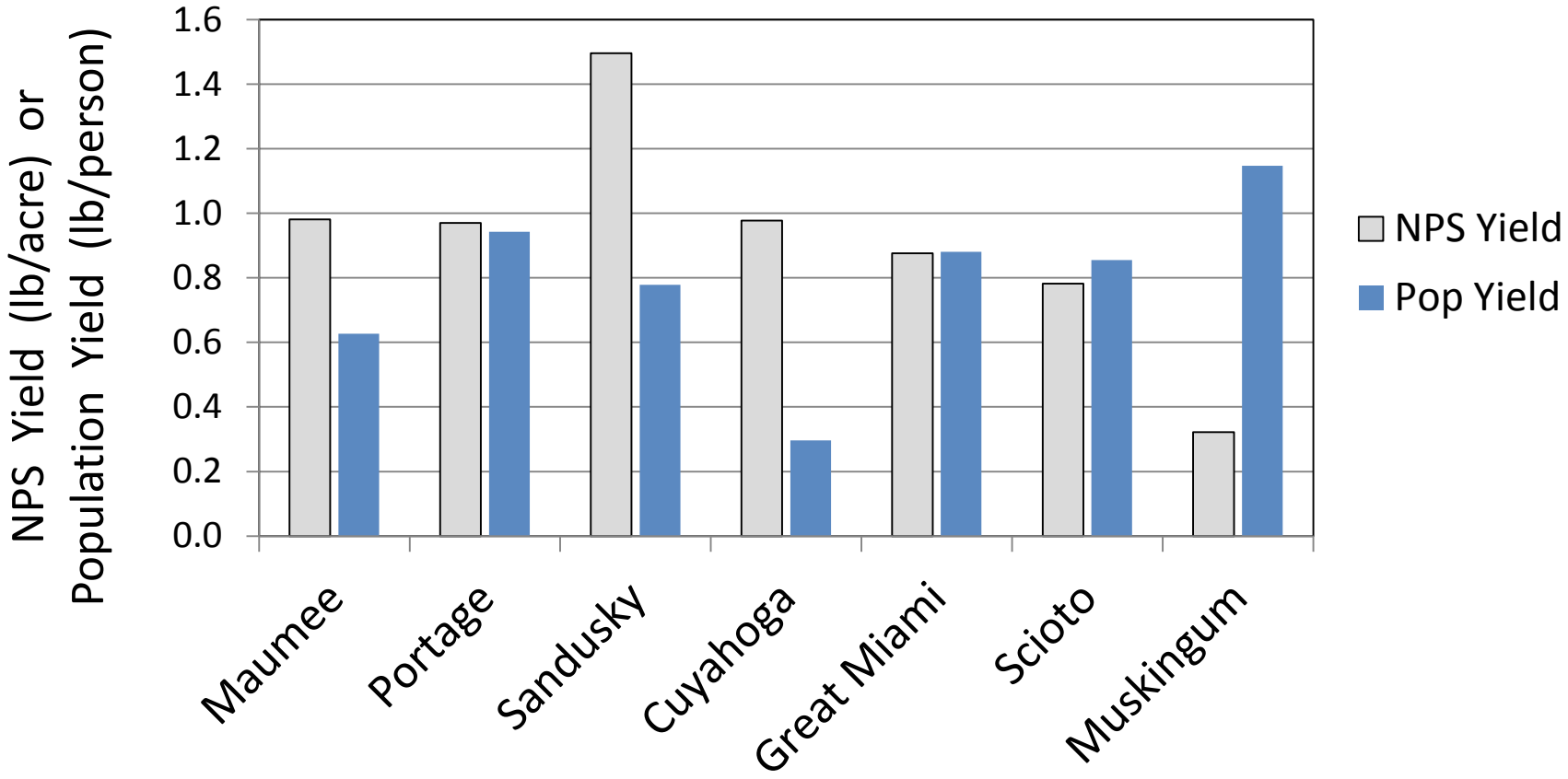


** Water Years 1996-2015; (2002-2015 for Muskingum)*

Phosphorus: NPS & Population Yields

Average: wy13 & wy14

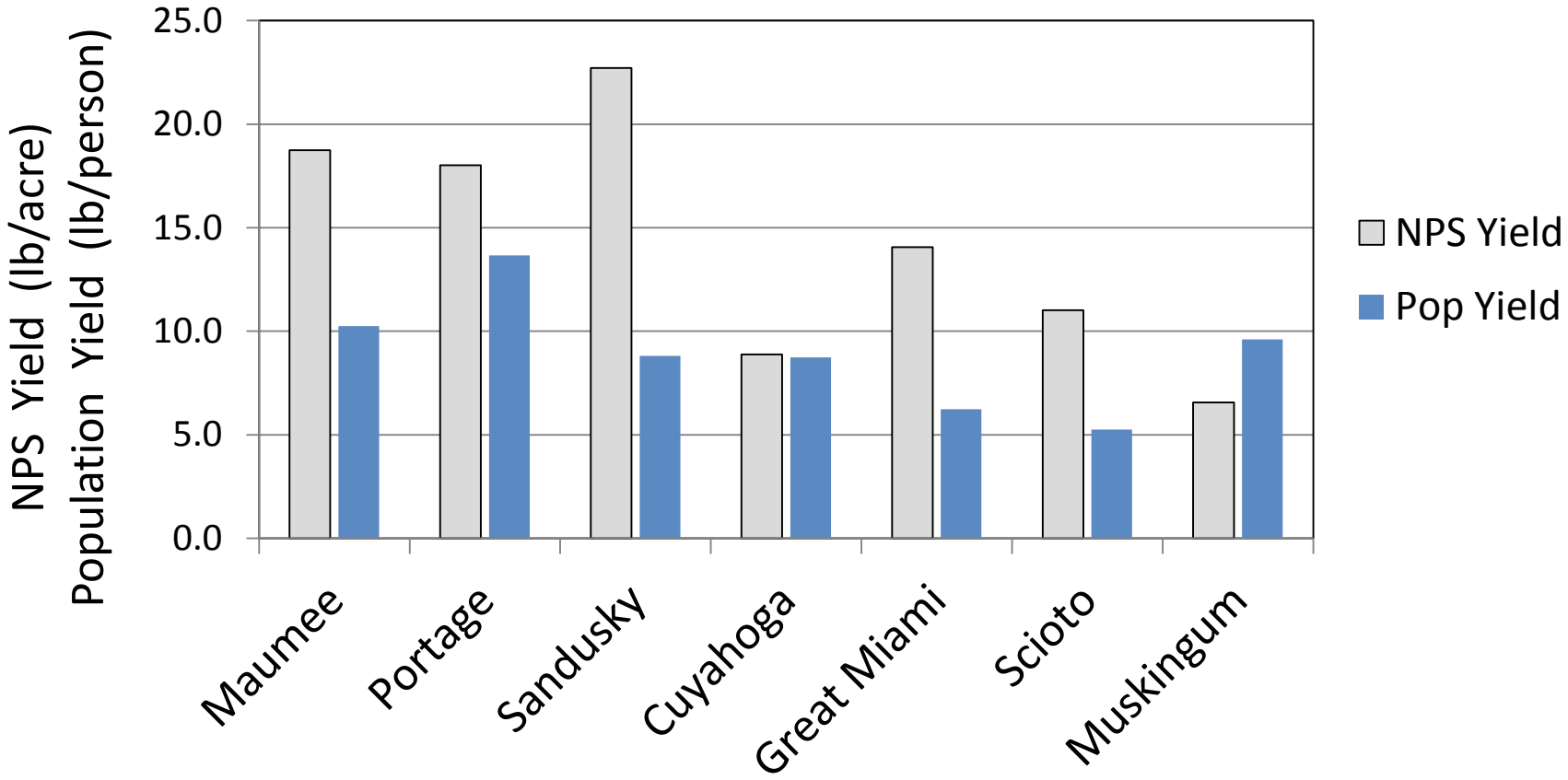
- NPS Yield = NPS Load *divided by* Watershed Area
- Population Yield = PS Load *divided by* Population in Watershed



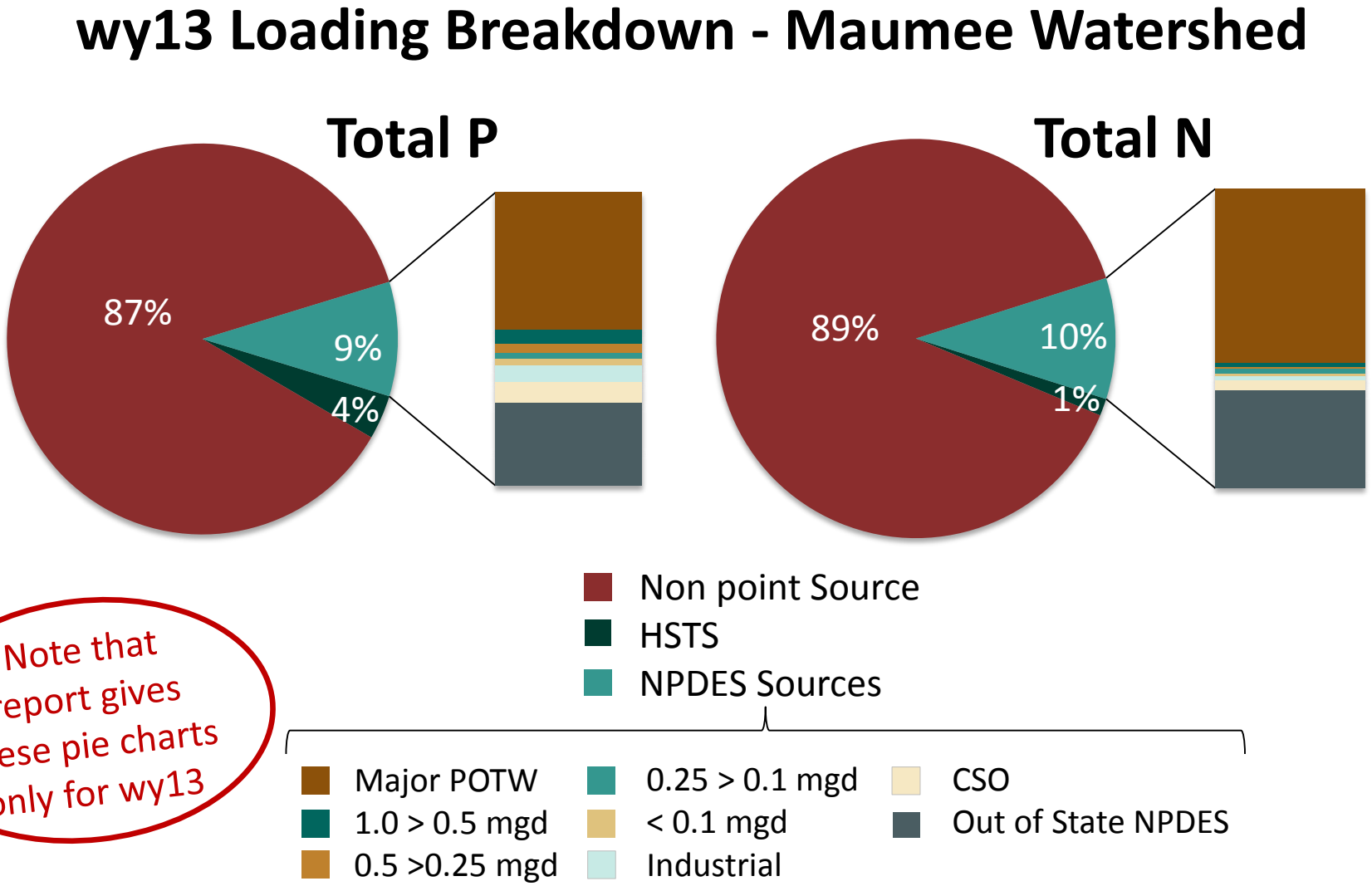
Nitrogen: NPS & Population Yields

Average: wy13 & wy14

- NPS Yield = NPS Load *divided by* Watershed Area
- Population Yield = PS Load *divided by* Population in Watershed



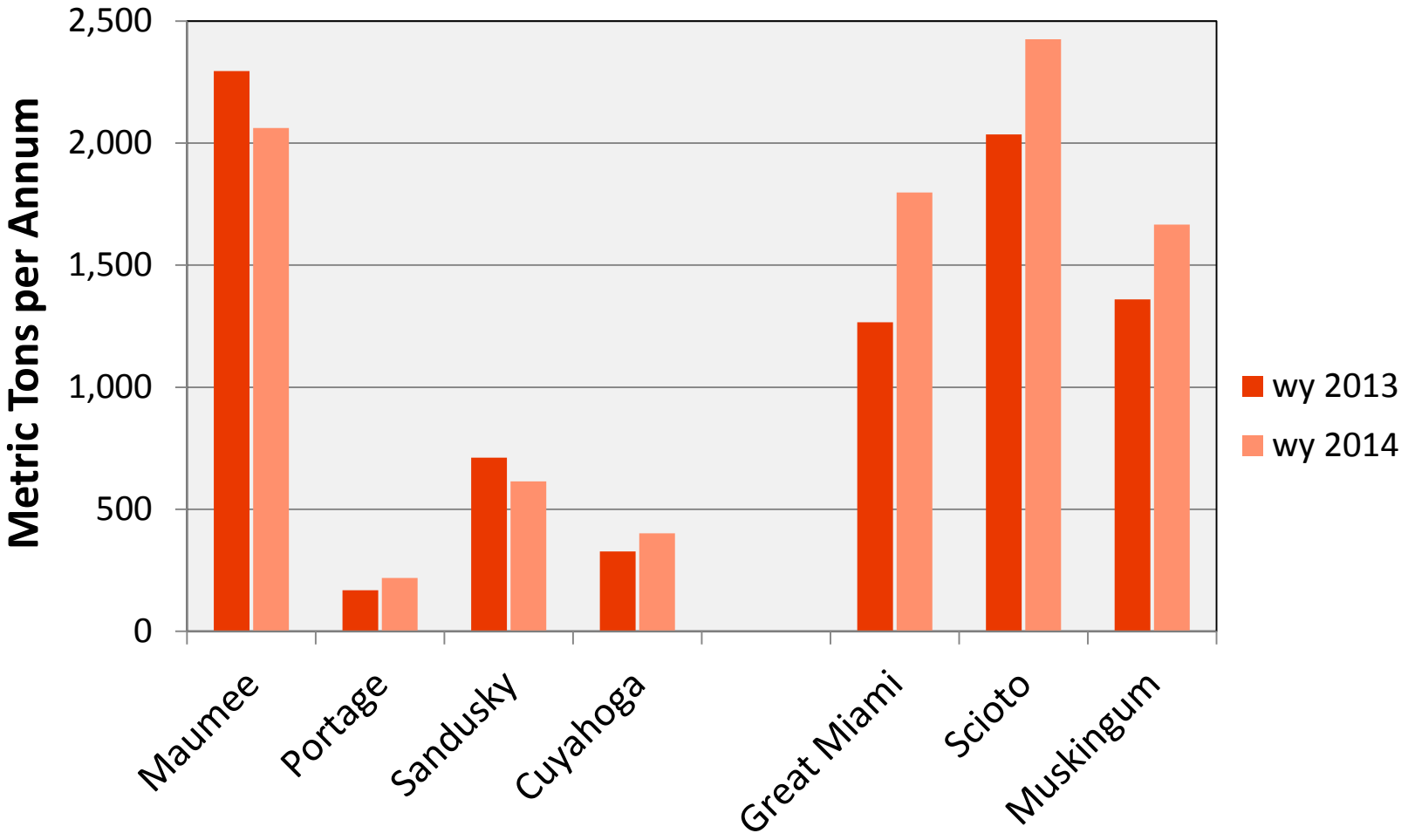
Example Watershed Information



Note that report gives these pie charts only for wy13

Total Phosphorus Loading by Watershed

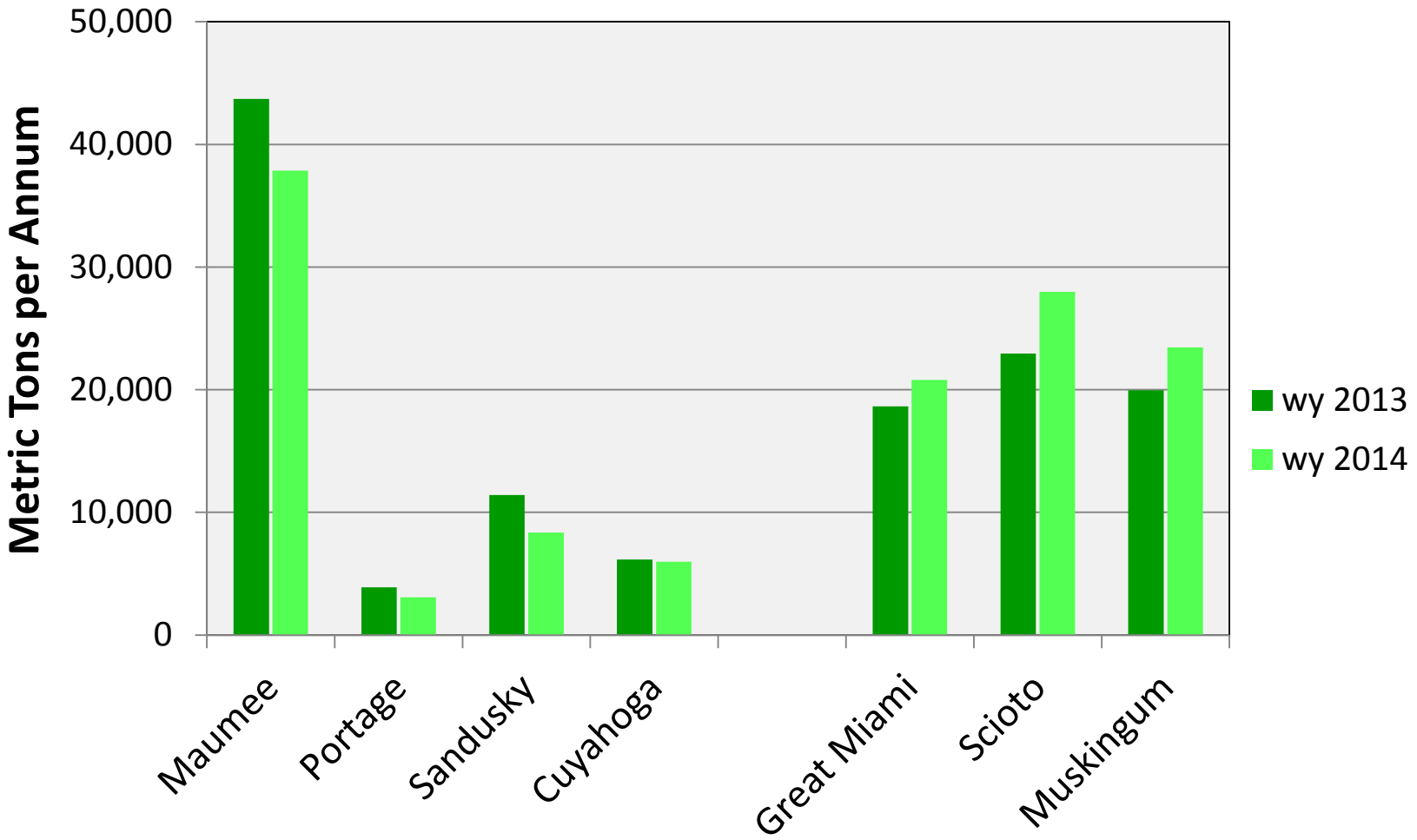
wy13 & wy14



(1 metric ton ≈ 2200 lbs)

Total Nitrogen Loading by Watershed

wy13 & wy14



(1 metric ton ≈ 2200 lbs)

Comparative Average Annual Loadings

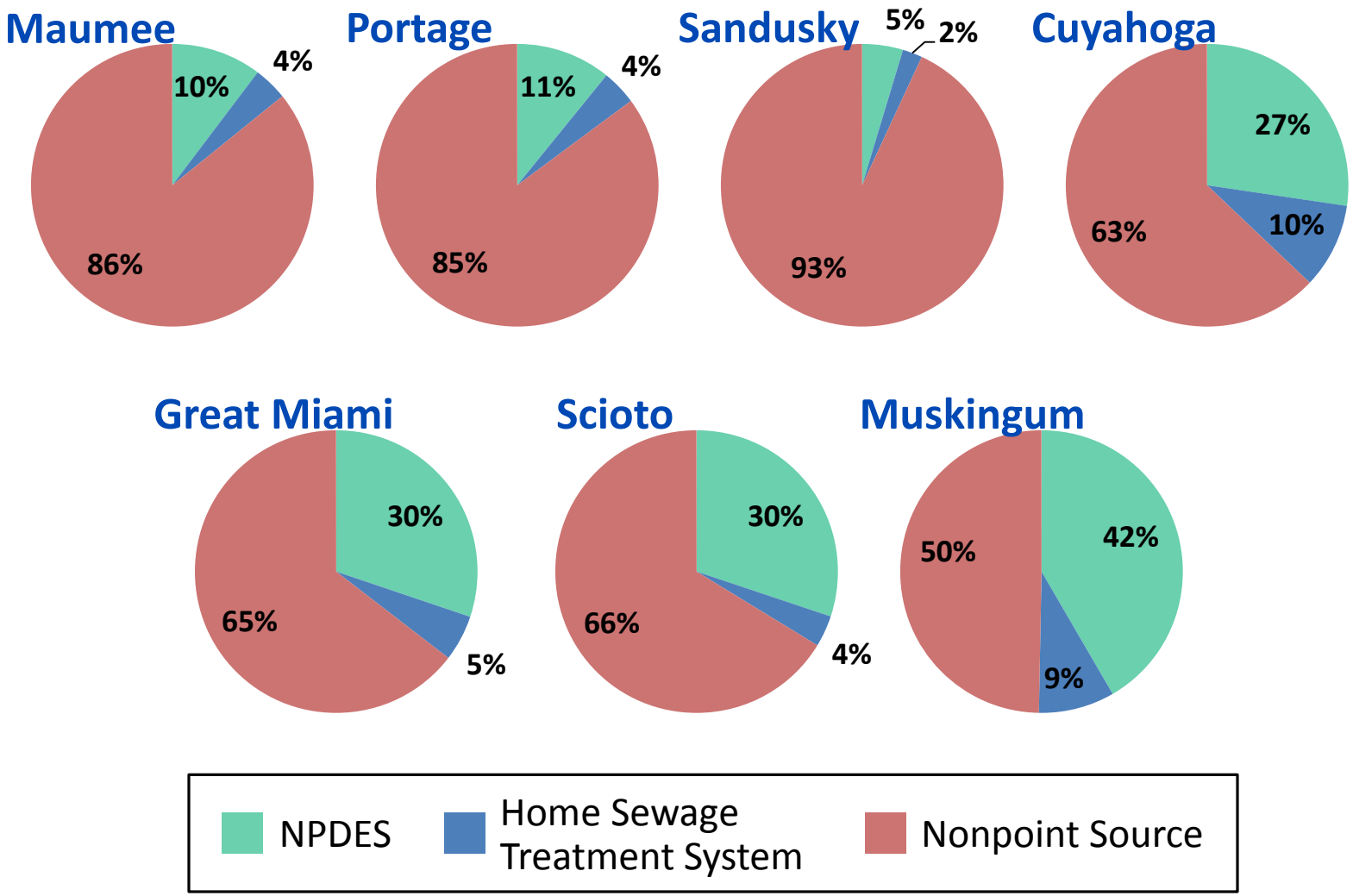
		Phosphorus		Nitrogen	
	Drainage Area (sq.mi.)	**Loading* (mta)†**	**Rank**	**Loading* (mta)†**	**Rank**
Maumee	*6,568*	2,200	1	40,800	1
Portage	*585*	200	7	3,500	7
Sandusky	*1,420*	700	5	9,900	5
Cuyahoga	*808*	400	6	6,100	6
Great Miami	*3,889*	1,500	3	19,700	4
Scioto	*6,509*	2,200	1	25,500	2
Muskingum	*8,044*	1,500	3	21,700	3

* *average wy13–14*

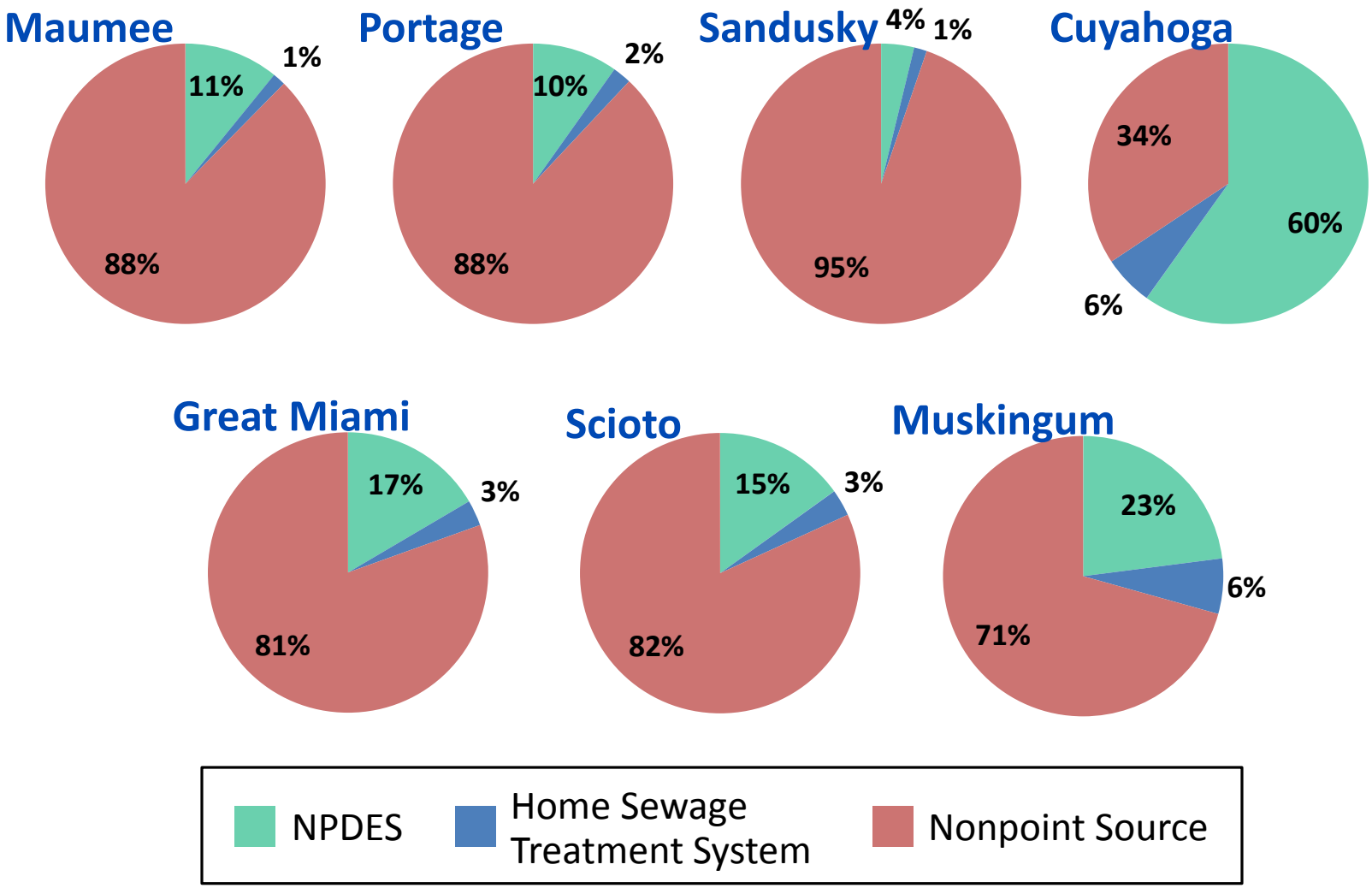
† *mta = metric tons per annum*

Total Phosphorus Loads by Source:

Major Ohio Watersheds (average wy13-14)



Total Nitrogen Loads by Source:
Major Ohio Watersheds (average wy13-14)



Observations & Findings

1. **Nonpoint Sources contribute greatest share of nutrient loadings to all watersheds – both P and N**
    - *Exception is Nitrogen in Cuyahoga*

– NPS Phosphorus loadings*
- 85% to 93% for LE Basin watersheds (Cuyahoga: 63%)
- 65-66% for Great Miami and Scioto
- 50% for Muskingum

– NPS Nitrogen loadings*
- 88% to 95% for LE Basin watersheds (Cuyahoga: 34%)
- 81-82% for Great Miami and Scioto
- 71% for Muskingum

* *Average wy13–14*

Observations & Findings

2. **Cuyahoga unique among Ohio watersheds**
   - relatively lower P and N load fractions from NPS; relatively higher load fractions from NPDES
   - Causes: high urban land use and population density

3. **Ohio R. watersheds have higher NPDES load fractions**
   - Phosphorus: most POTWs do not have P limits
   - Additional causes: relatively higher population density & natural land cover fraction; relatively lower agriculture

4. **Muskingum has lower fraction of NPS loadings**
   - Likely cause: relatively lower agricultural land use and higher natural land cover

Observations & Findings

5. **NPDES loadings dominated by major POTWs**
   - POTWs <1.0mgd contribute very small fraction of total
   - Little benefit to more stringent controls on small POTWs
6. **HSTS loadings are low fraction of overall total**
   - Phosphorus: 5% of overall
   - Nitrogen: 3% of overall
7. **CSO loadings are low fraction of overall total**
   - Phosphorus: 3% of overall (20% of NPDES)
   - Nitrogen: <2% of overall (<14% of NPDES)

Observations & Findings

8. **NPS loadings are underestimated**
   - Calculation method assumes no natural assimilation of NPDES discharge loads

9. **Watersheds vary in total loadings relative to their size** based upon relative role of their sources
   - Understanding differences will help inform future decisions for nutrient reduction efforts

2016 Report Critique

- Report should more clearly emphasize that NPS loads dominate
- Average of loading data for each watershed generally more useful than any single year's data
- 2 major watersheds have significant fraction of drainage area downstream from pour points: Scioto (41%), Great Miami (30%)
  - Consider future alternate pour points *and/or* consider downstream land use (relative to upstream land use) to estimate NPS load
- Some errors (minor) – ***but OEPA should correct online document!***
  - Appendix B total load calculations by watershed are incorrect (although values used in report text are correct)
  - Various other (relatively minor) errors in figures, tables or text

Next Study Report (2018)

- Increase the portion of the state covered by mass balance
  - Add more watersheds
  - Determine appropriate load estimator for watersheds with less frequent monitoring
- Start to establish trends with 5 years of data
- Refine HSTS estimates
  - Use county level statistics where needed
  - Improve population estimates by refining sewerage areas
- Improve nutrient concentration estimates for CSO discharges
- Refine NPS load estimates
  - Separate urban storm water component
  - Differentiate agricultural loads by nutrient source

Acknowledgements

Ohio EPA, Division of Surface Water,
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- Dale White
- Josh Griffin

Questions ???

THE CITY OF COLUMBUS
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DEPARTMENT OF PUBLIC UTILITIES

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