King County PCB Pathways and Loading Studies

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January 14, 2014

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Bulk Atmospheric Deposition in the Lower Duwamish/Green River Basin – Phase I

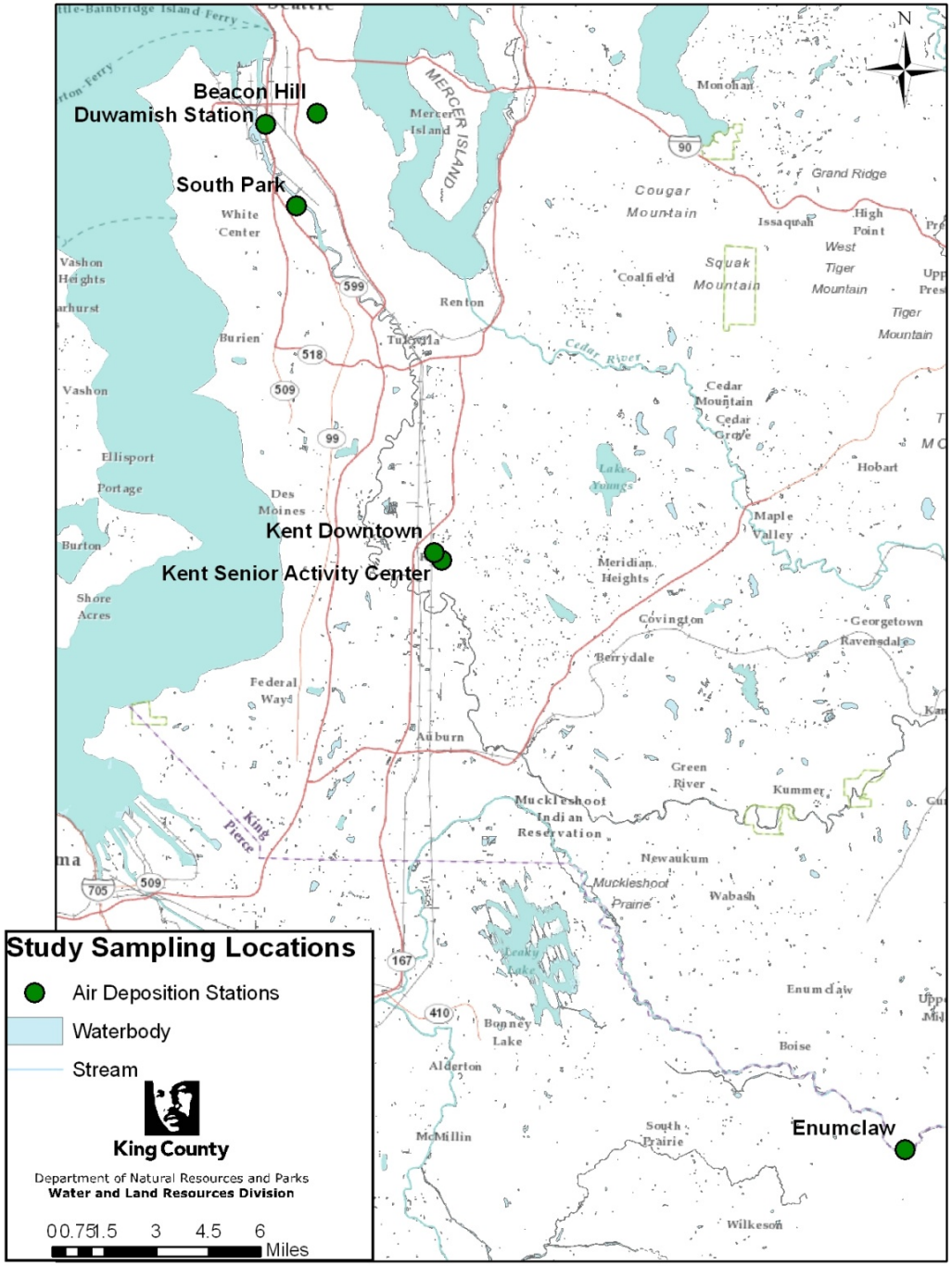
Objectives:

- compare bulk atmospheric deposition rates in areas of different land use within the Green/Duwamish River Basin

- provide information to assist in understanding atmospheric sources to the Lower Duwamish Waterway

Study Design

Site	Land use
Duwamish	Industrial & urban
Beacon Hill	Regional urban
South Park	Suburban, industrial, residential
Kent downtown	Suburban & commercial (with rail)
Kent Senior Center	Suburban & commercial (without rail)
Enumclaw	Rural



Study Design

- Passive Sampler

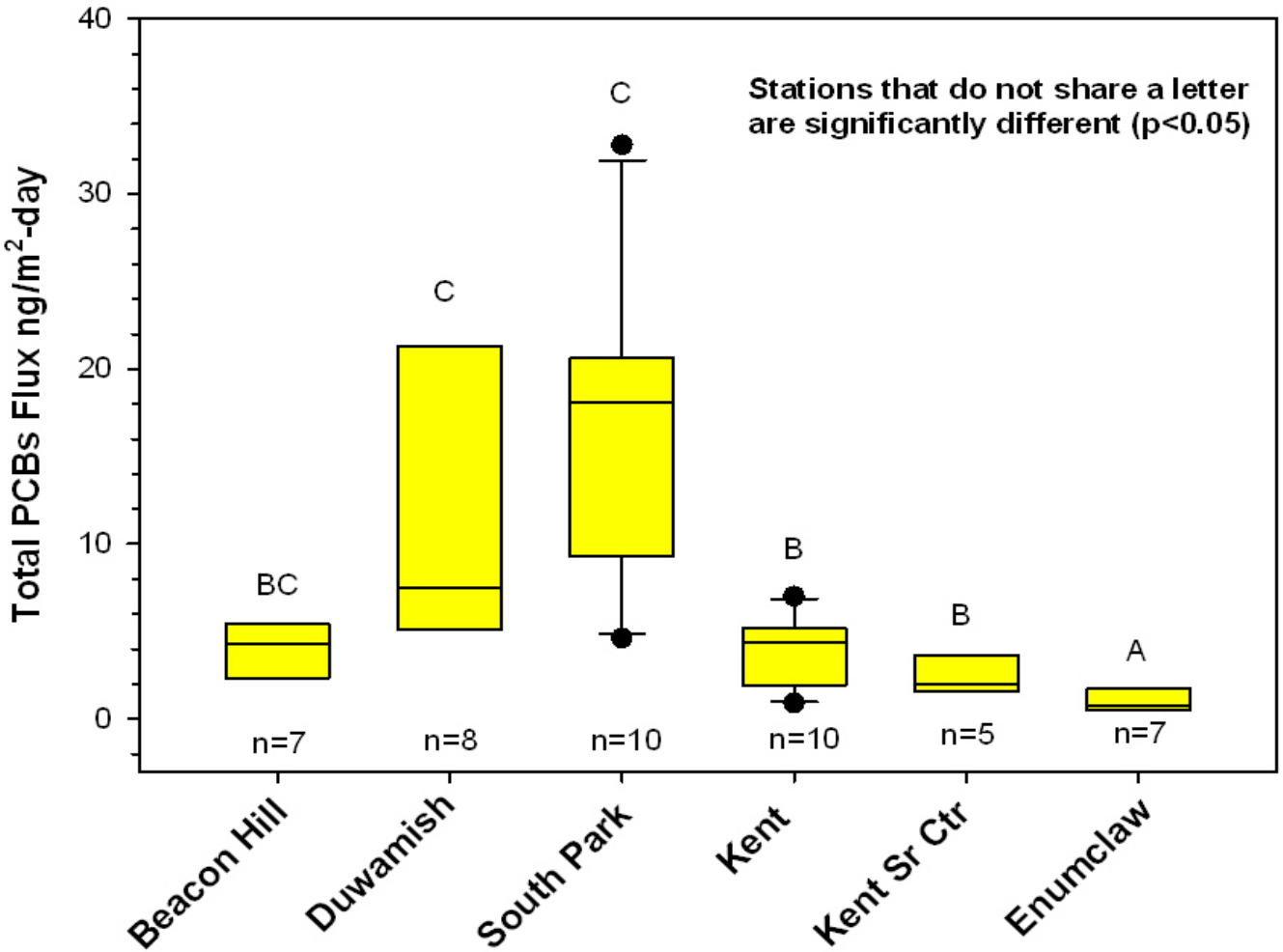
Study Design

- Analytes: metals (including Hg), PAHs, PCB congeners, dioxin/furan congeners
- Schedule
  - Metals, Hg, PAHs: continuous sampling August 2011 for approx 14 months.
  - PCBs, Dioxin/furans: intermittent due to high analytical cost; over same time period
  - Samples deployed ~2 weeks during wet season, ~4 weeks during dry season.
  - Targeted ending deployment before sample containers overflowed

Sample Totals

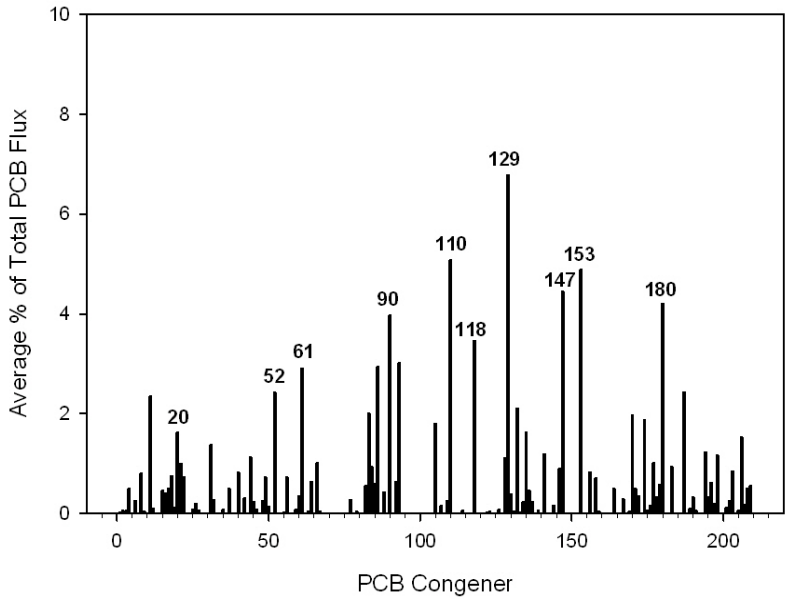
	Beacon Hill	Duwamish	South Park	Kent	Kent_SC	Enumclaw
PAHs	22	27	24	26	7	21
Metals	22	27	26	26	7	20
Mercury	22	25	25	25	7	19
PCBs	7	8	10	12	5	7
Dioxins/Furans	7	9	10	12	5	7
Totals	**80**	**96**	**95**	**101**	**31**	**74**

Spatial Trends - Total PCBs Flux



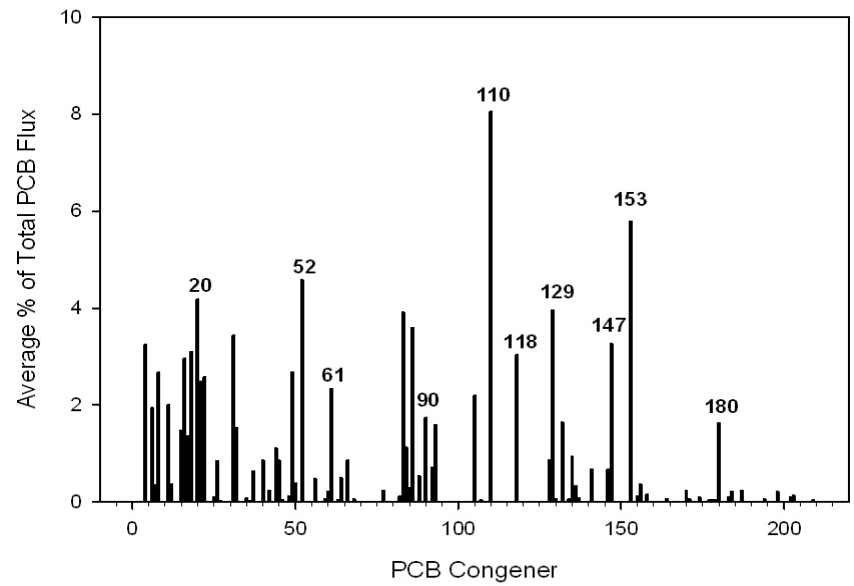
PCB Congener Profiles

Duwamish Station

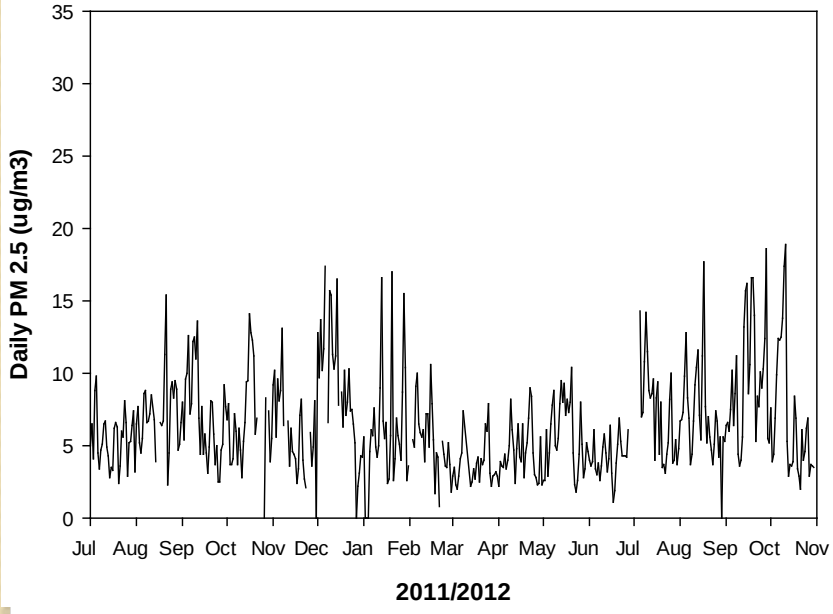


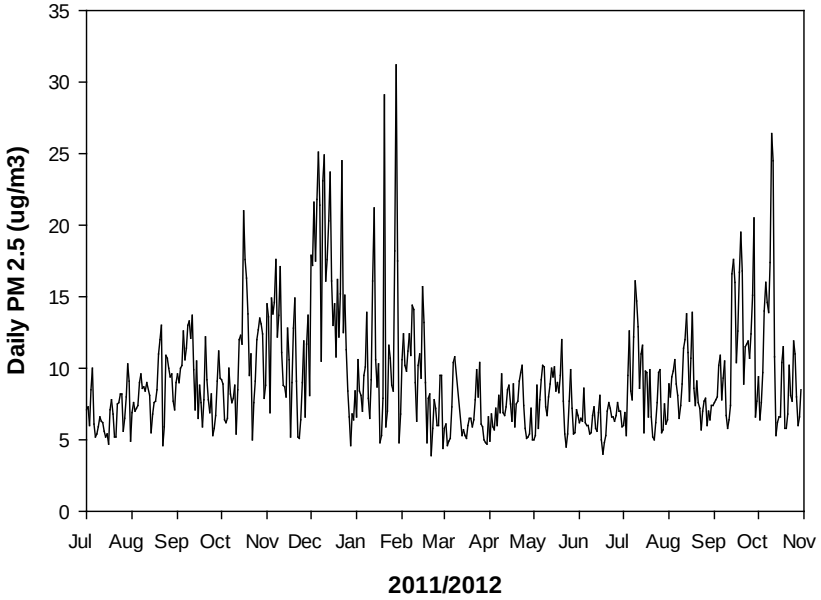
More light and fewer heavy congeners as you move from urban to rural land use. Congener pattern analysis may be completed after Phase II.

Enumclaw Station



Small Particle Concentrations

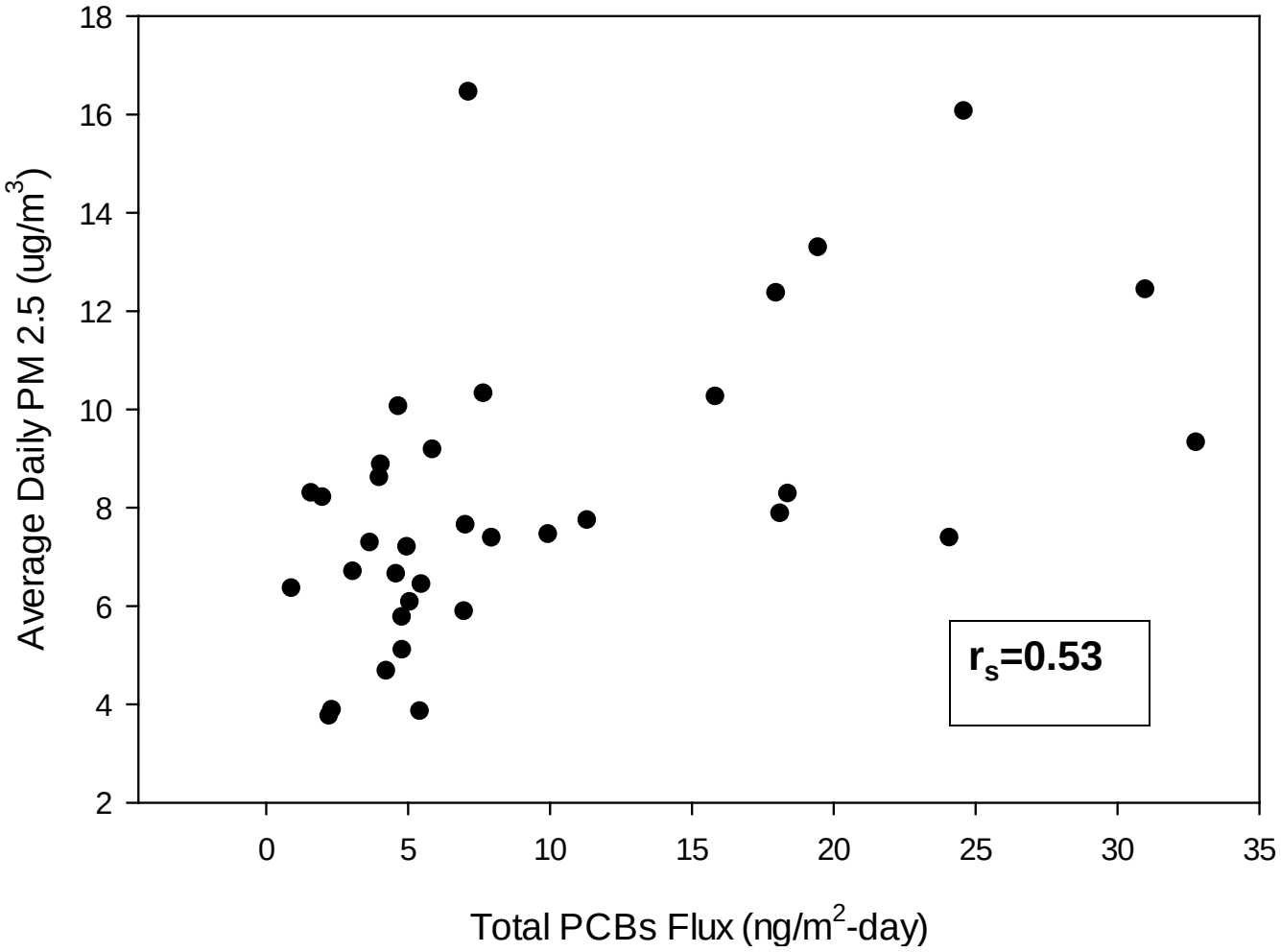




Beacon Hill

South Park

PCB Flux with PM 2.5 at South Park



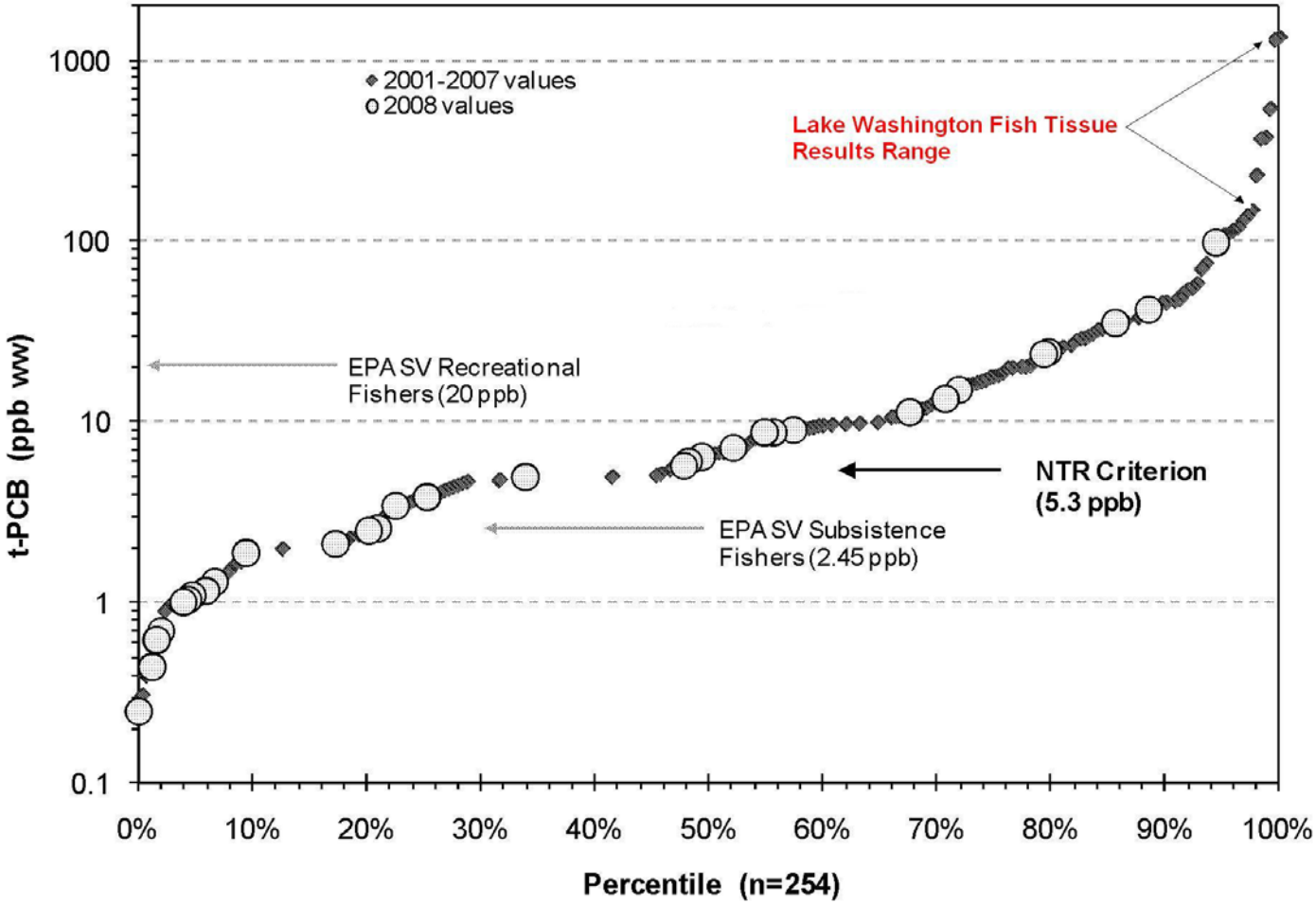
Findings

- Metals and organics deposition relate to degree of urbanization; congruent with studies in Toronto, SF, NJ, IL
- PCB deposition at South Park was more than two times higher than Duwamish. The reason(s) for this difference are unknown.
- PCB deposition was always higher at Duwamish and South Park than any other station sampled.

Phase II Bulk Air Deposition Study

- Sampled in 2012 for PCBs at Duwamish, Georgetown and South Park to acquire more data. Samples in analysis.
- Presenting all results at Salish Sea Conference in April, 2014
  - Other Duwamish source control studies included (PCBs in Green River water, sediment and suspended solids)

Lake Washington PCB/PBDE Loadings Study



Distribution of Total PCBs in Edible Fish Tissue, WSTMP 2001-2008.

Lake Washington PCB/PBDE Loadings Study

- Objectives
  - Estimate PCB and PBDE loadings to Lakes WA and Union, to Puget Sound
  - Determine key pathways (CSO, stormwater, streams, air, rivers, bridge runoff) to Lakes
  - Model response time from total PCB load reduction
  - Total PCB load reduction needed for safe levels in Lake WA fish

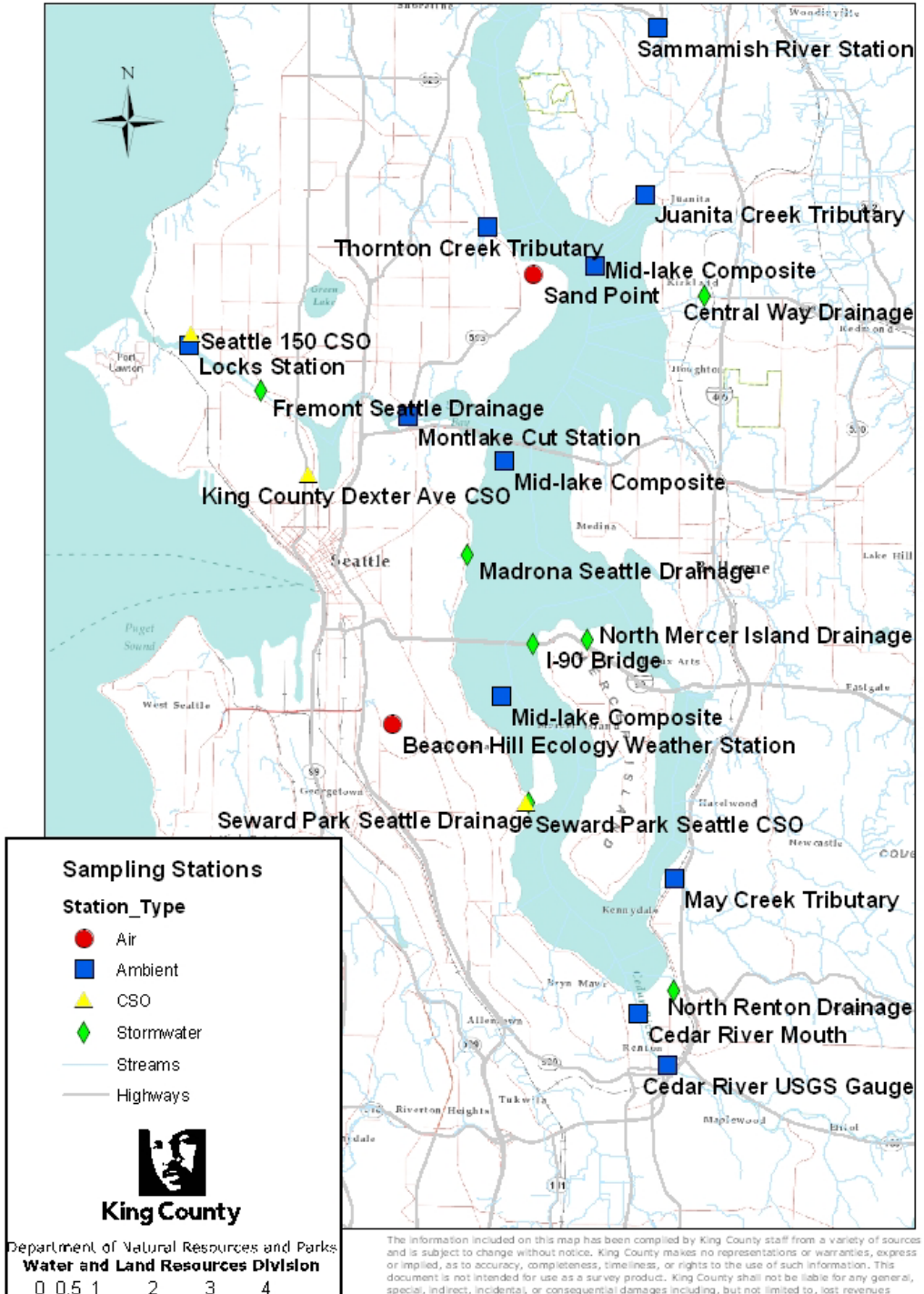
Lake WA Project Components

- Field study (Pathway sampling of PCB and PBDE congeners)
- Loadings estimates (PCBs & PBDEs)
- PCB modeling
- PCB load scenarios for Lake WA
- Findings and recommendations

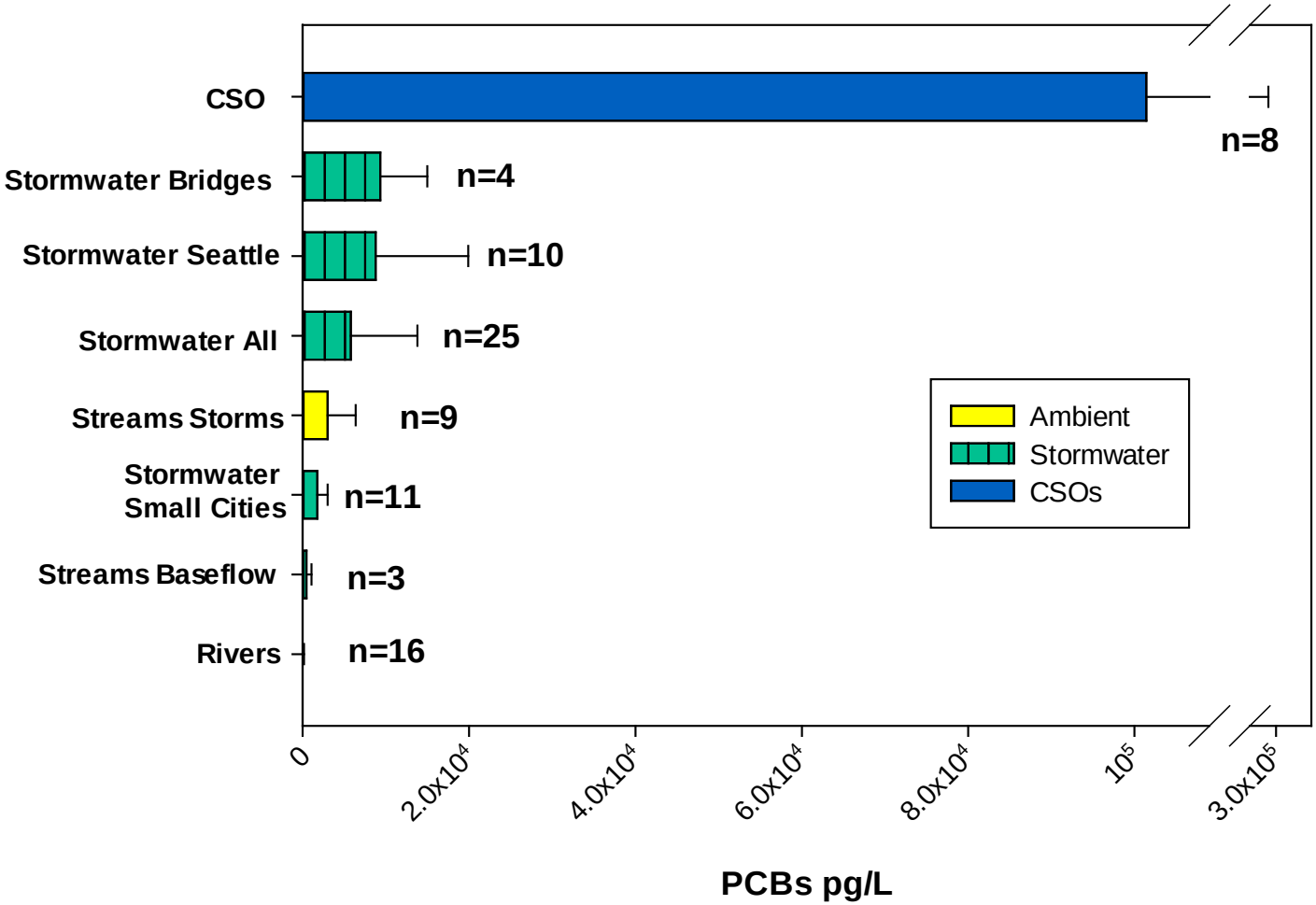
Field Study

- 209 PCB and 9 PBDE congeners in
  - CSOs (1 King County, 2 Seattle)
  - Stormwater (storm and baseflow, 6 stns)
  - Streams (3 stns)
  - Atmospheric deposition (wet and dry, 2 stns)
  - Sammamish and Cedar Rivers (3 stns)
  - I-90 Bridge runoff
  - Lake Washington and Ship Canal inlet and outlet

Sampling Stations



Measured Water Concentrations



Loadings Estimates

Concentration X Flow = Loading

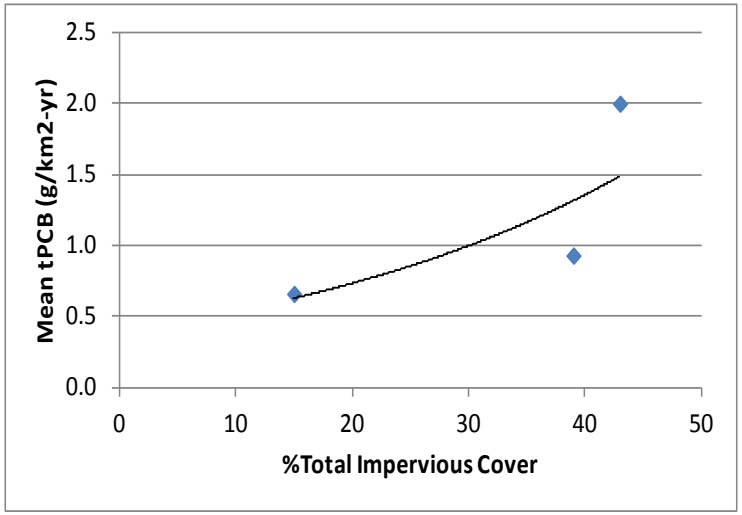
Field study mean concentration used, except

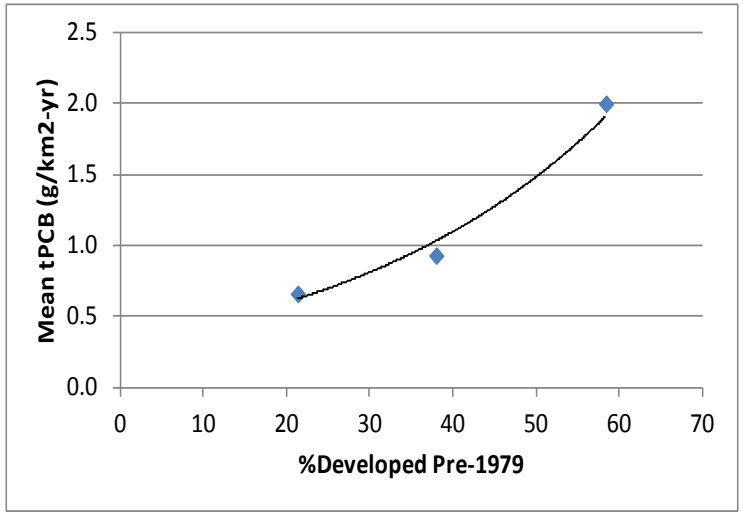
- Stormwater: extrapolated from tributary data
- CSO data combined with LDW CSO data

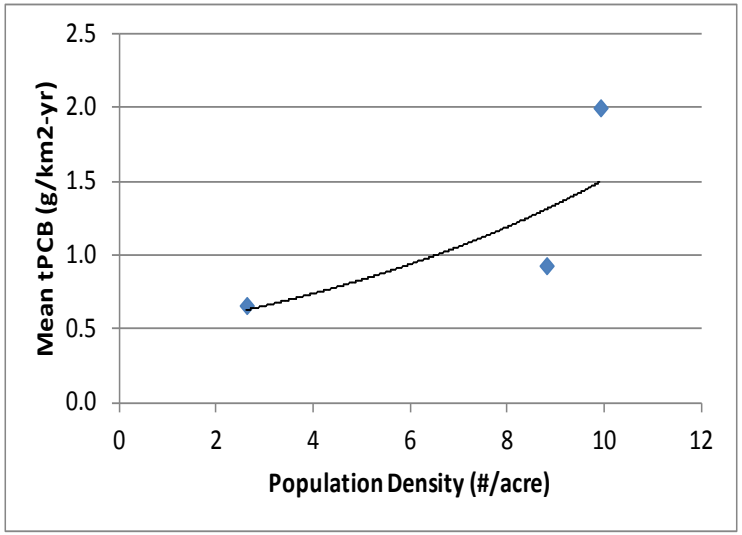
Flow

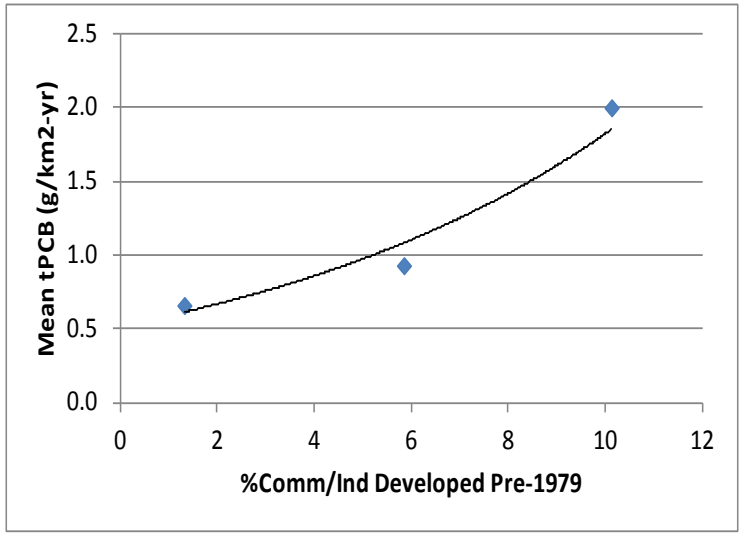
- Gauged flow data for most input pathways
- Seattle stormwater flow based on land area of partially-separated sewer and tributary flow
- Flow through Locks – water balance approach
- I-90 Bridge – average annual rainfall

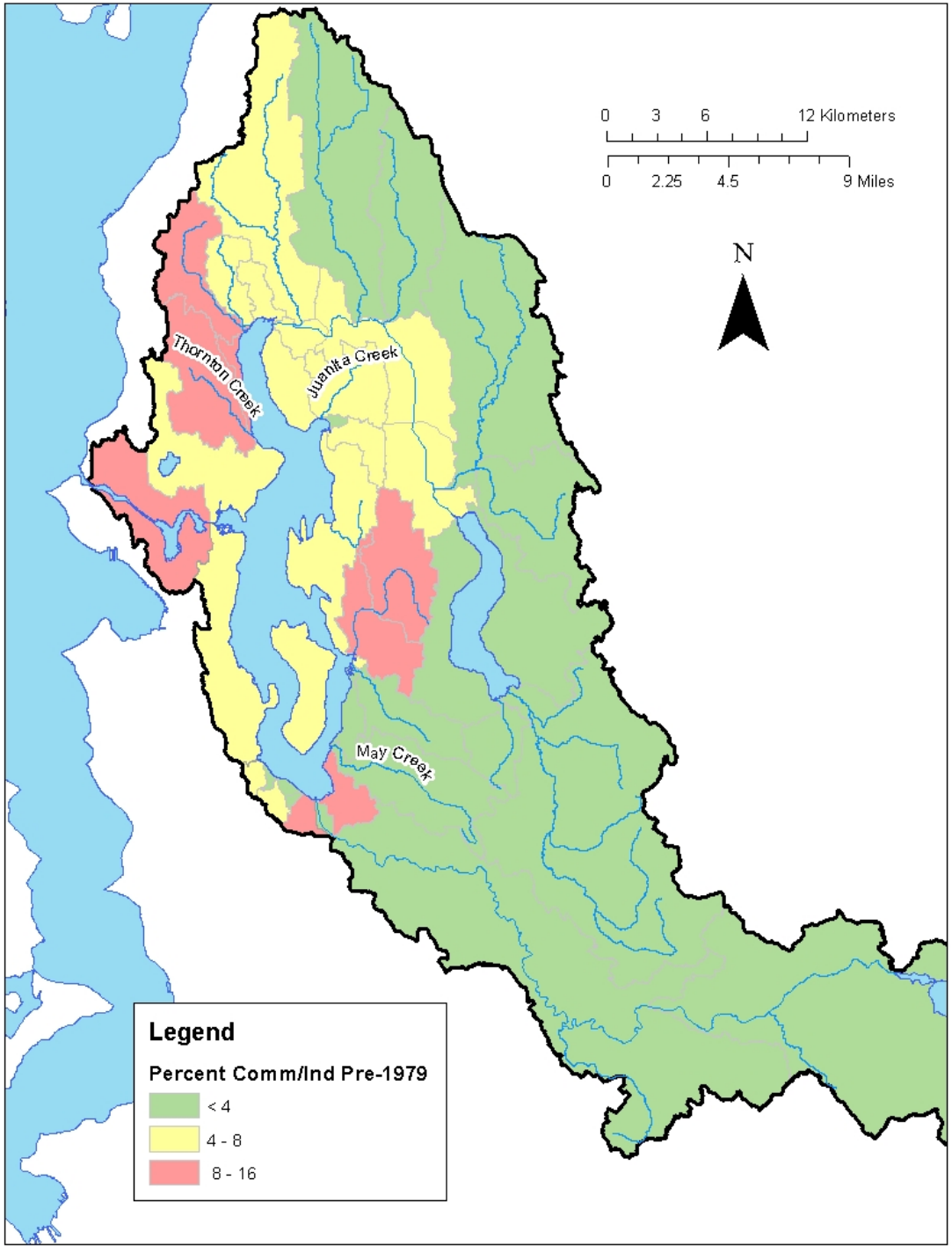
Correlations with Land Use/Population





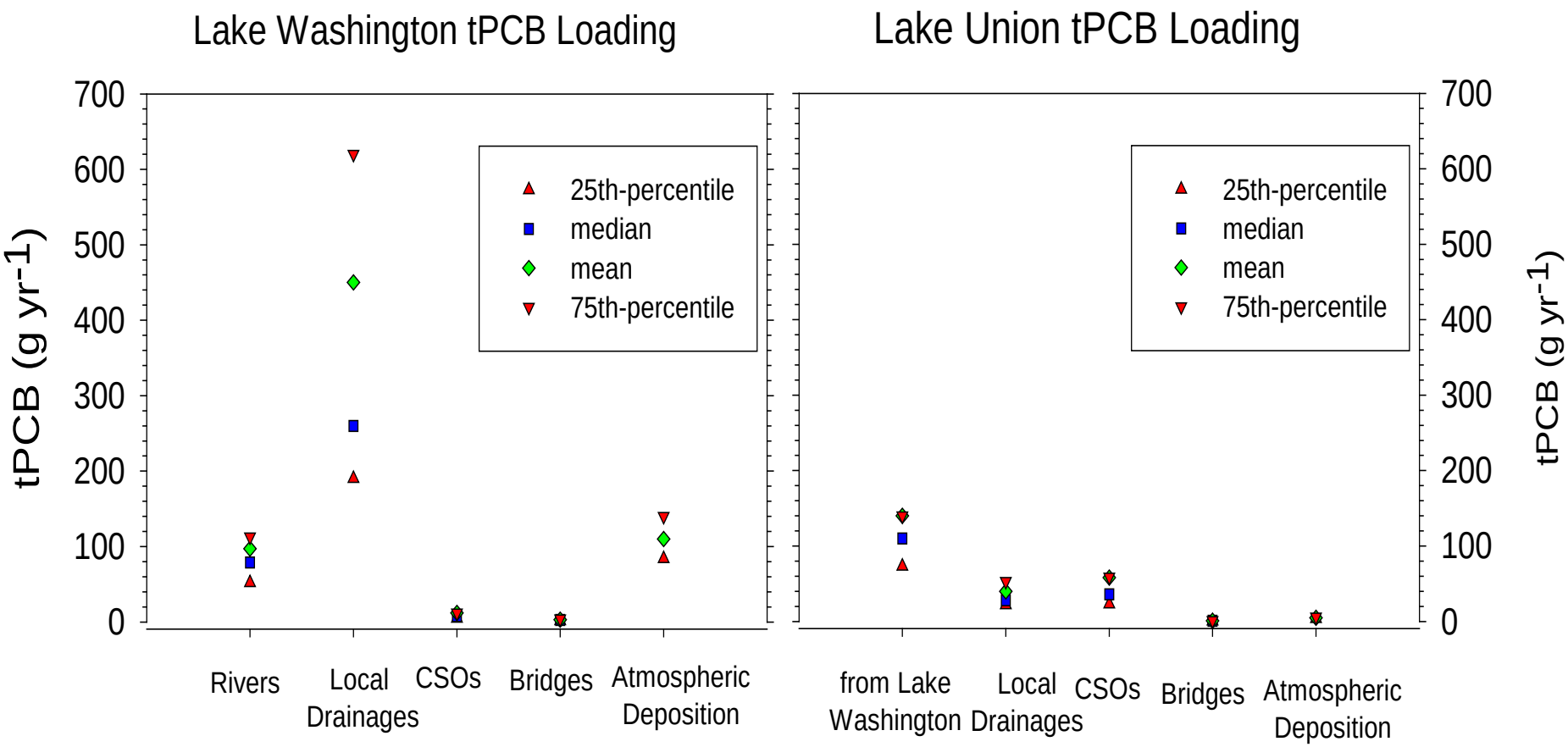






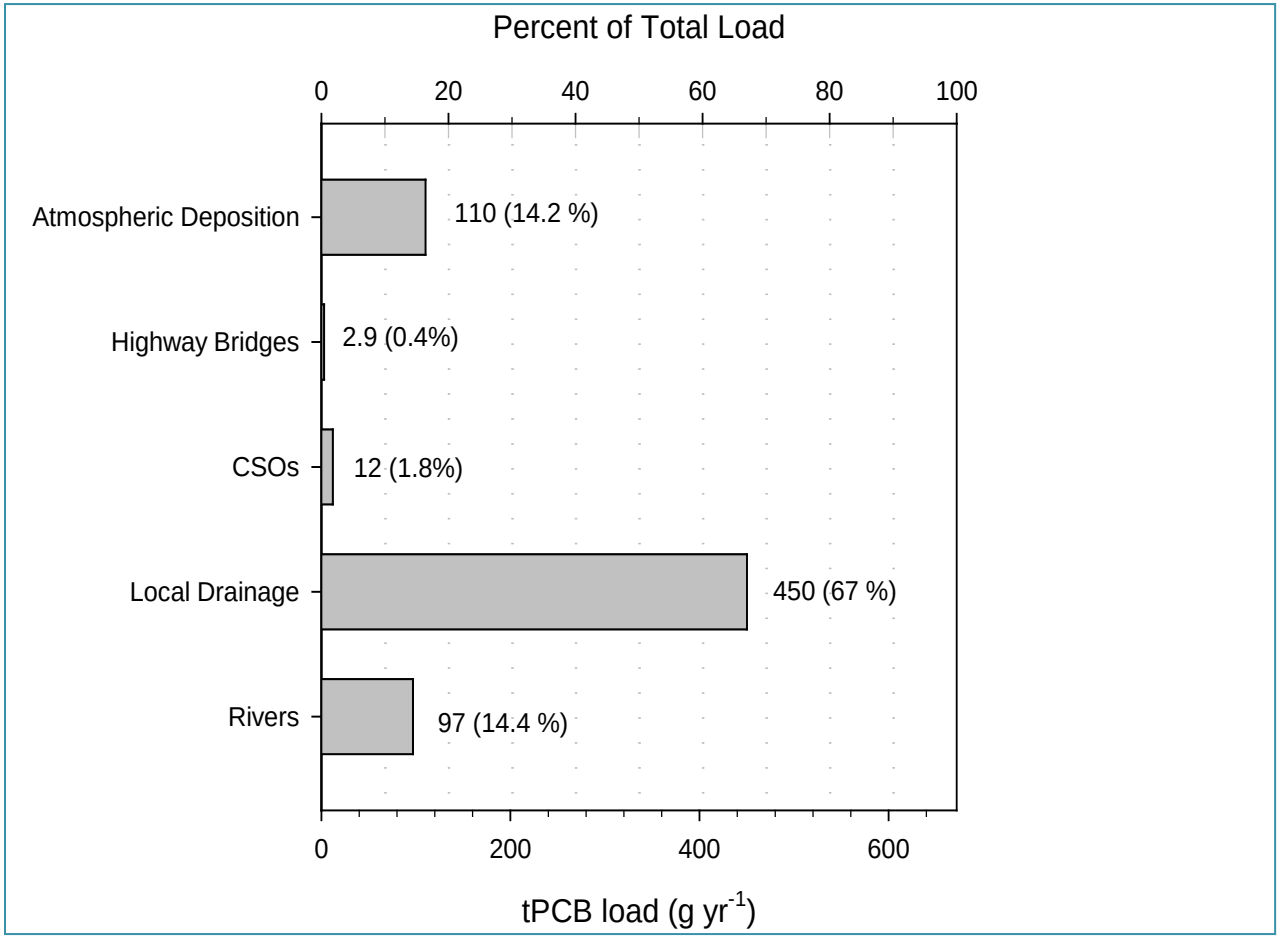
Lake WA Watershed Pre-1979 Commercial/ Industrial Land Use

PCB Loading by Pathway: Lakes WA and Union



Lake Washington Annual PCB Loadings

Total PCB Load = 672 grams/year



Load from Local Drainage Driven by Stormwater

- Stormwater is <30% of annual flow in streams BUT
- Accounts for 80-90% of annual PCB load from local drainage

Atmospheric Deposition Load Comparison

- Direct deposition:
  - Lake WA (King County 2013)
  - Puget Sound (Brandenberger et al. 2010)
- Direct and indirect deposition
  - LDW bounded (Leidos and New Fields 2014)

Waterbody	Direct Deposition $ng/m^2/d$	Indirect Deposition $ng/m^2/d$
Lake WA	2.6 - 4.3	NA
Lower Duwamish	4.3 -18	0.62 - 8.0**
Puget Sound	0.75 – 2.54	NA

**High uncertainty; low and high bounds for impervious surface

PCB Load to Puget Sound via Locks

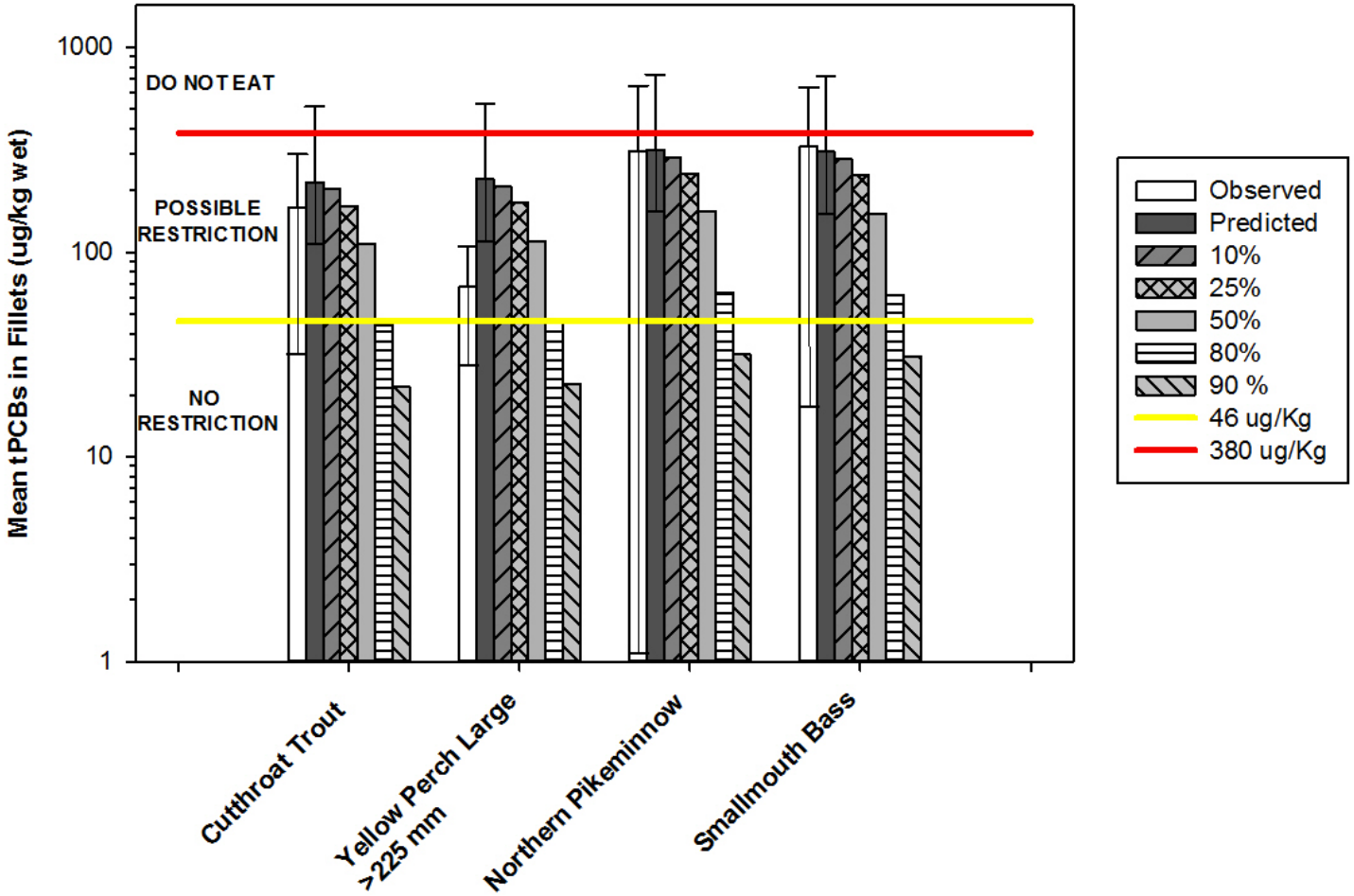
- Mean of 360 g/yr or 0.23 g/km^2/yr
- Equals 4.5% of median total load to Puget Sound
- In range of Green River into Duwamish: 0.14 to 1.99 g/km^2/yr (Gries and Sloan 2009)
- Higher than 5 rivers: 0.0053 to 0.014 g/km^2/yr (Gries and Osterberg 2011)
  - Skagit
  - Snohomish
  - Nooksack
  - Stillaguamish
  - Puyallup

Modeling and Simulations

- Two-compartment box model for predicting sediment and water concentrations in lake
- Bioaccumulation model for predicting fish tissue concentrations
- Similar approach used as Ecology work for Puget Sound
- Used models to estimate total PCB load reduction required to reach safe levels in fish tissue based on DOH 46 ppb fillet concentration

* **85% reduction in total PCB load needed**

Total PCB Load Reduction Scenarios



Error bars on Observed are standard deviations on the mean. Error bars on Predicted are tissue concentrations using low and high tPCB load estimates.

Recommendations

- Need to conduct urban inventory of PCB sources
  - Field screening kits for street dust and other solids
  - Sampling permissions difficult to get
- Treatment options
  - Test existing biotreatment for PCB removal effectiveness
  - Promote new technologies
- PCB cycling is data gap
  - Need research on volatilization from land surfaces
  - Develop indirect deposition model

Website (Loadings and Data Reports)

- http://www.kingcounty.gov/environment/watersheds/cedar-river-lake-wa/pcb-pbde-loadings.aspx (or Google "King County PCBs in Lake Washington")

Lake WA Advisory Panel

- Fred Bergdolt, WA Dept. of Transportation
- Betsy Cooper, King County Wastewater Treatment Division
- Jonathan Frodge, Seattle Public Utilities
- Jenny Gaus, City of Kirkland
- Joan Hardy, WA Dept. of Health
- Rachel McCrea, WA Dept. of Ecology
- Doug Navetski, King County Stormwater Management
- Andy Rheaume, City of Redmond
- Ronald Straka, City of Renton
- Heather Trim, People for Puget Sound/FutureWise
- Bruce Tiffany, King County Industrial Waste
- Patrick Yamashita, City of Mercer Island