Spokane County Toxics Management Summary of April 2014 Annual Report

Spokane River Regional Toxics Task Force September 24, 2014

Presentation

- Background
- Sampling methods and location
- Sampling results
- Source identification

Background

Brown AND Caldwell

Spokane County Regional Water Reclamation Facility (SCRWRF)

- Completed in 2011
- NPDES permit Nov. 2011-Nov. 2016
- Permit includes toxics management requirements
  - Influent and effluent monitoring for PCBs, PBDEs, dioxin
  - Source identification
  - Annual toxics management report

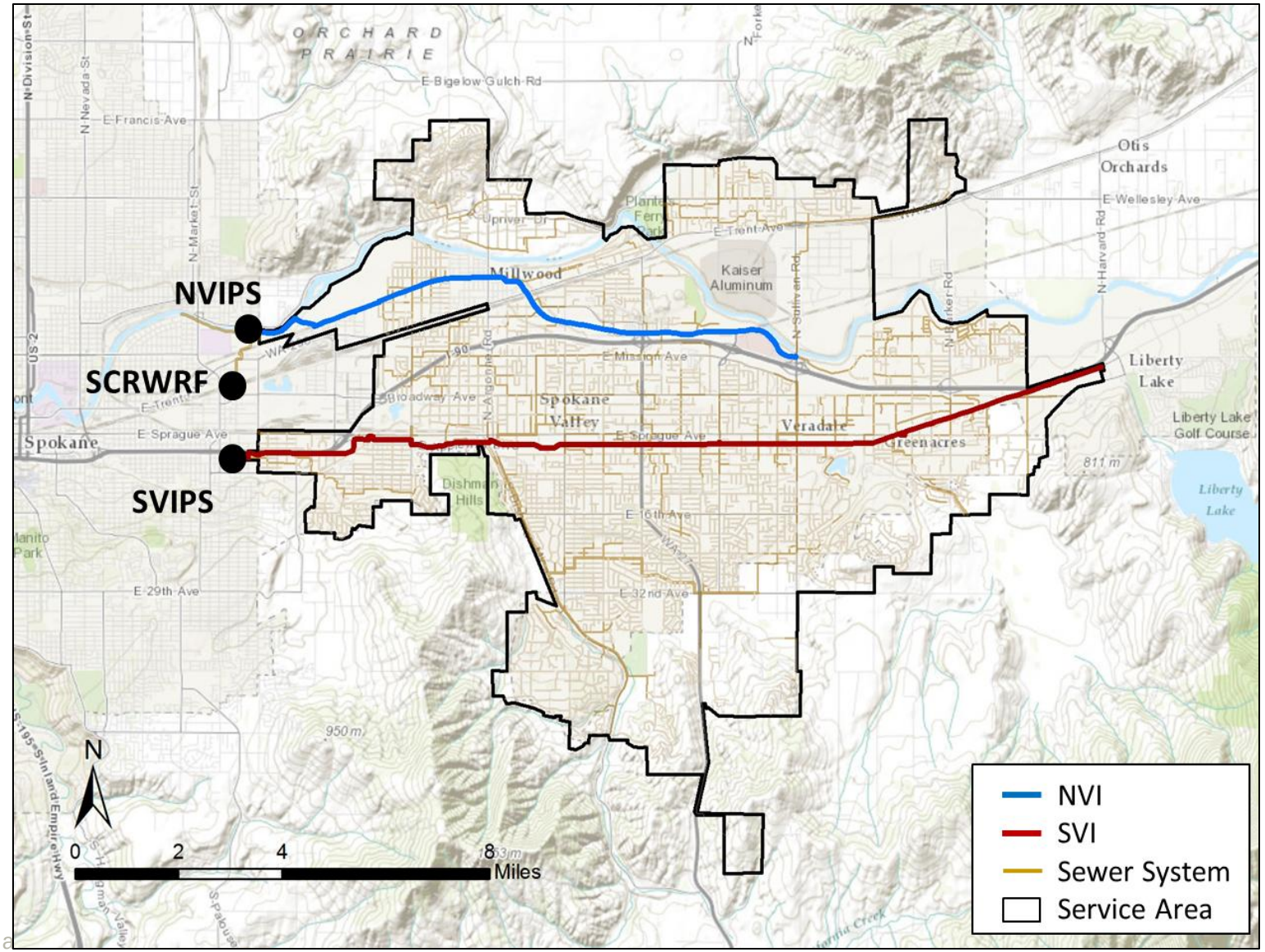
Toxics Monitoring Locations and Methods

Brown AND Caldwell

Influent and effluent sampling

- PCBs (209 congeners) - bimonthly at both influent trunk lines
- PBDEs (46 congeners) - bimonthly at both influent trunk lines
- Dioxin (2,3,7,8 TCDD) - bimonthly at both influent trunk lines
- All three sampled quarterly from effluent

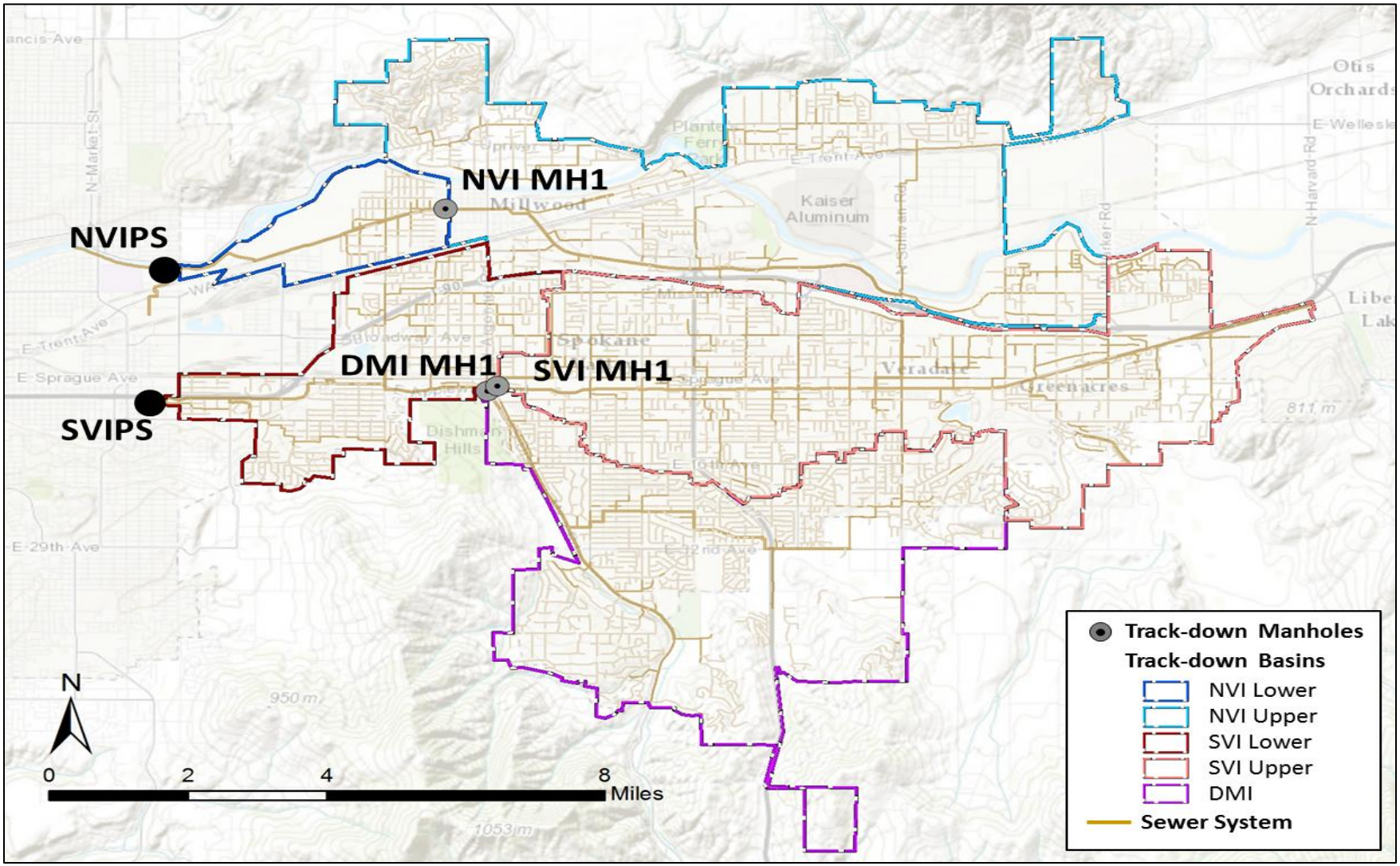
Influent and effluent monitoring locations



Track-down sampling for source identification

- Selected locations and parameters based on first three rounds of influent sampling
- Sampled three locations in collection system upstream of influent pump stations
- Four sampling events
- Analyzed for PCBs and PBDEs
  - Dioxin excluded because Rounds 1-3 were all non-detects

Track-down monitoring locations (2013)

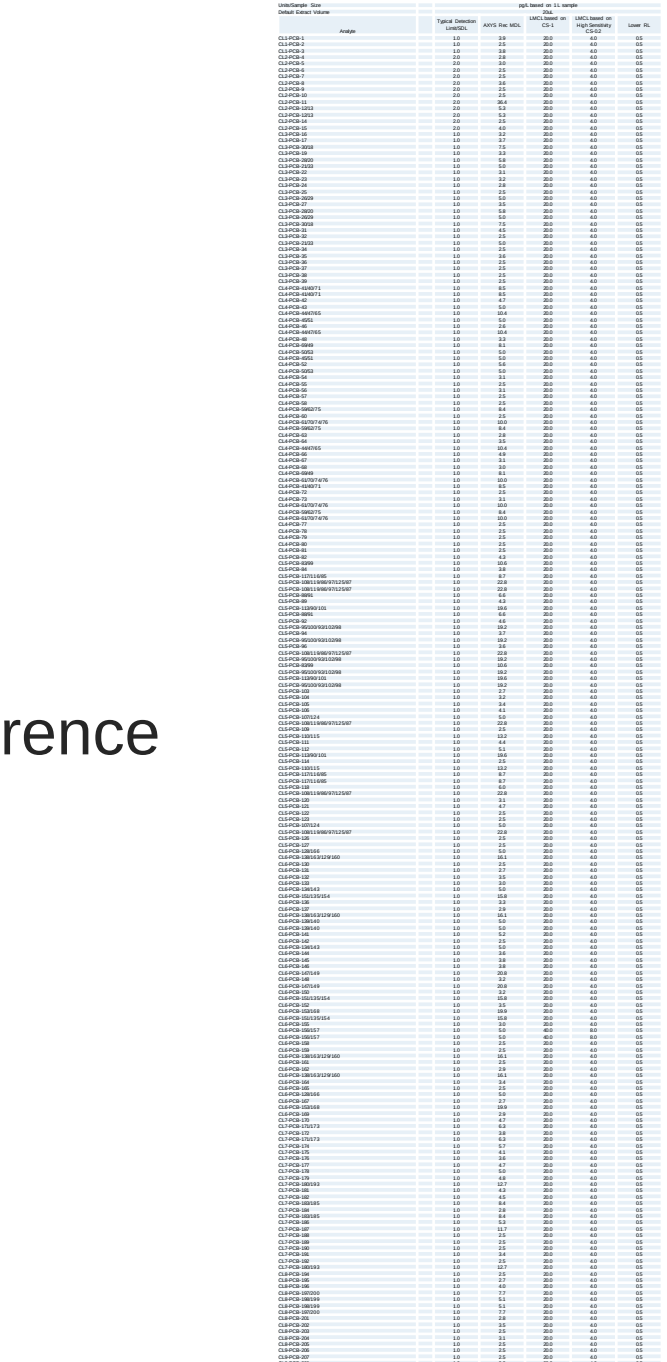


Sampling techniques

- Influent/effluent
  - Composite samplers – 24 hrs
  - Teflon tubing
  - Everything is pre-cleaned by lab
- Collection System Track-down Sampling
  - Mini-composites – 40 minutes
- Rinsate blanks
- Travel blanks
- Method blanks (lab blank)

Data quality review

- QAPP
- Examining
  - COC
  - Surrogate recovery
  - Reporting limits
  - Duplicate relative percent difference
  - Identify outliers
  - Blank factors
  - Travel and rinsate blanks
  - Homolog patterns
  - Comparing totals



Units/Sample Size	ng/L based on 1 L sample				
Default Extract Volume	20 uL				
Analyte	Typical Detection Limit/EDL	AXYS Rec MDL	LMCL based on CS-1	LMCL based on High Sensitivity CS-0.2	Lower RL
CL1-PCB-1	1.0	3.9	20.0	4.0	0.5
CL1-PCB-2	1.0	2.5	20.0	4.0	0.5
CL1-PCB-3	1.0	3.8	20.0	4.0	0.5
CL1-PCB-4	2.0	2.8	20.0	4.0	0.5
CL1-PCB-5	2.0	3.0	20.0	4.0	0.5
CL1-PCB-6	2.0	2.5	20.0	4.0	0.5
CL1-PCB-7	2.0	2.5	20.0	4.0	0.5
CL1-PCB-8	2.0	2.5	20.0	4.0	0.5
CL1-PCB-9	2.0	2.5	20.0	4.0	0.5
CL1-PCB-10	2.0	2.5	20.0	4.0	0.5
CL1-PCB-11	2.0	36.4	20.0	4.0	0.5
CL1-PCB-12/13	2.0	5.3	20.0	4.0	0.5
CL1-PCB-12/13	2.0	5.3	20.0	4.0	0.5
CL1-PCB-14	2.0	2.5	20.0	4.0	0.5
CL1-PCB-15	2.0	4.0	20.0	4.0	0.5
CL1-PCB-16	1.0	3.2	20.0	4.0	0.5
CL1-PCB-17	1.0	3.7	20.0	4.0	0.5
CL1-PCB-20/28	1.0	7.5	20.0	4.0	0.5
CL1-PCB-21	1.0	5.3	20.0	4.0	0.5
CL1-PCB-20/28	1.0	5.8	20.0	4.0	0.5
CL1-PCB-20/33	1.0	5.8	20.0	4.0	0.5
CL1-PCB-22	1.0	3.1	20.0	4.0	0.5
CL1-PCB-23	1.0	3.2	20.0	4.0	0.5
CL1-PCB-24	1.0	2.8	20.0	4.0	0.5
CL1-PCB-25	1.0	2.5	20.0	4.0	0.5
CL1-PCB-26/29	1.0	5.0	20.0	4.0	0.5
CL1-PCB-27	1.0	3.5	20.0	4.0	0.5
CL1-PCB-26/29	1.0	5.8	20.0	4.0	0.5
CL1-PCB-26/29	1.0	5.0	20.0	4.0	0.5
CL1-PCB-30/18	1.0	7.5	20.0	4.0	0.5
CL1-PCB-31	1.0	4.5	20.0	4.0	0.5
CL1-PCB-32	1.0	3.5	20.0	4.0	0.5
CL1-PCB-31/33	1.0	5.0	20.0	4.0	0.5
CL1-PCB-34	1.0	2.5	20.0	4.0	0.5
CL1-PCB-35	1.0	3.6	20.0	4.0	0.5
CL1-PCB-36	1.0	2.5	20.0	4.0	0.5
CL1-PCB-37	1.0	2.5	20.0	4.0	0.5
CL1-PCB-38	1.0	2.5	20.0	4.0	0.5
CL1-PCB-39	1.0	2.5	20.0	4.0	0.5
CL1-PCB-41/40/71	1.0	8.5	20.0	4.0	0.5
CL1-PCB-41/40/71	1.0	8.5	20.0	4.0	0.5
CL1-PCB-42	1.0	4.7	20.0	4.0	0.5
CL1-PCB-43	1.0	4.0	20.0	4.0	0.5
CL1-PCB-44/47/65	1.0	10.4	20.0	4.0	0.5
CL1-PCB-45/51	1.0	5.0	20.0	4.0	0.5
CL1-PCB-46	1.0	2.6	20.0	4.0	0.5
CL1-PCB-44/47/65	1.0	10.4	20.0	4.0	0.5
CL1-PCB-48	1.0	3.3	20.0	4.0	0.5
CL1-PCB-49/69	1.0	8.1	20.0	4.0	0.5
CL1-PCB-50/53	1.0	5.0	20.0	4.0	0.5
CL1-PCB-45/51	1.0	5.0	20.0	4.0	0.5
CL1-PCB-52	1.0	5.6	20.0	4.0	0.5
CL1-PCB-50/53	1.0	5.0	20.0	4.0	0.5
CL1-PCB-54	1.0	3.1	20.0	4.0	0.5
CL1-PCB-55	1.0	2.5	20.0	4.0	0.5
CL1-PCB-56	1.0	2.5	20.0	4.0	0.5
CL1-PCB-57	1.0	2.5	20.0	4.0	0.5
CL1-PCB-58	1.0	2.5	20.0	4.0	0.5
CL1-PCB-59/62/75	1.0	8.4	20.0	4.0	0.5
CL1-PCB-60	1.0	2.5	20.0	4.0	0.5
CL1-PCB-61/70/74/76	1.0	10.0	20.0	4.0	0.5
CL1-PCB-59/62/75	1.0	8.4	20.0	4.0	0.5
CL1-PCB-63	1.0	2.9	20.0	4.0	0.5
CL1-PCB-64	1.0	3.5	20.0	4.0	0.5
CL1-PCB-44/47/65	1.0	10.4	20.0	4.0	0.5
CL1-PCB-66	1.0	4.9	20.0	4.0	0.5
CL1-PCB-67	1.0	3.3	20.0	4.0	0.5
CL1-PCB-68	1.0	3.0	20.0	4.0	0.5
CL1-PCB-49/69	1.0	8.1	20.0	4.0	0.5
CL1-PCB-61/70/74/76	1.0	10.0	20.0	4.0	0.5
CL1-PCB-41/40/71	1.0	8.5	20.0	4.0	0.5
CL1-PCB-72	1.0	2.5	20.0	4.0	0.5
CL1-PCB-73	1.0	3.1	20.0	4.0	0.5
CL1-PCB-61/70/74/76	1.0	10.0	20.0	4.0	0.5
CL1-PCB-59/62/75	1.0	8.4	20.0	4.0	0.5
CL1-PCB-61/70/74/76	1.0	10.0	20.0	4.0	0.5
CL1-PCB-77	1.0	2.5	20.0	4.0	0.5
CL1-PCB-78	1.0	2.5	20.0	4.0	0.5
CL1-PCB-79	1.0	2.5	20.0	4.0	0.5
CL1-PCB-80	1.0	2.5	20.0	4.0	0.5
CL1-PCB-81	1.0	2.5	20.0	4.0	0.5
CL1-PCB-82	1.0	4.3	20.0	4.0	0.5
CL1-PCB-83/99	1.0	10.6	20.0	4.0	0.5
CL1-PCB-84	1.0	3.8	20.0	4.0	0.5
CL1-PCB-117/116/85	1.0	8.7	20.0	4.0	0.5
CL1-PCB-108/119/86/97/125/87	1.0	22.8	20.0	4.0	0.5
CL1-PCB-108/119/86/97/125/87	1.0	22.8	20.0	4.0	0.5
CL1-PCB-88/91	1.0	6.6	20.0	4.0	0.5
CL1-PCB-89	1.0	4.3	20.0	4.0	0.5
CL1-PCB-113/90/101	1.0	19.6	20.0	4.0	0.5
CL1-PCB-92	1.0	4.4	20.0	4.0	0.5
CL1-PCB-93	1.0	4.6	20.0	4.0	0.5
CL1-PCB-95/100/98/102/268	1.0	19.2	20.0	4.0	0.5
CL1-PCB-94	1.0	3.7	20.0	4.0	0.5
CL1-PCB-95/100/98/102/268	1.0	19.2	20.0	4.0	0.5
CL1-PCB-96	1.0	3.6	20.0	4.0	0.5
CL1-PCB-108/119/86/97/125/87	1.0	22.8	20.0	4.0	0.5
CL1-PCB-95/100/98/102/268	1.0	19.2	20.0	4.0	0.5
CL1-PCB-83/99	1.0	10.6	20.0	4.0	0.5
CL1-PCB-95/100/98/102/268	1.0	19.2	20.0	4.0	0.5
CL1-PCB-113/90/101	1.0	19.6	20.0	4.0	0.5
CL1-PCB-95/100/98/102/268	1.0	19.2	20.0	4.0	0.5
CL1-PCB-103	1.0	2.7	20.0	4.0	0.5
CL1-PCB-104	1.0	3.2	20.0	4.0	0.5
CL1-PCB-105	1.0	3.4	20.0	4.0	0.5
CL1-PCB-106	1.0	4.1	20.0	4.0	0.5
CL1-PCB-107/124	1.0	5.0	20.0	4.0	0.5
CL1-PCB-108/119/86/97/125/87	1.0	22.8	20.0	4.0	0.5
CL1-PCB-109	1.0	2.5	20.0	4.0	0.5
CL1-PCB-110/115	1.0	13.2	20.0	4.0	0.5
CL1-PCB-111	1.0	4.4	20.0	4.0	0.5
CL1-PCB-112	1.0	5.1	20.0	4.0	0.5
CL1-PCB-113/90/101	1.0	19.6	20.0	4.0	0.5
CL1-PCB-114	1.0	2.5	20.0	4.0	0.5
CL1-PCB-110/115	1.0	13.2	20.0	4.0	0.5
CL1-PCB-117/116/85	1.0	8.7	20.0	4.0	0.5
CL1-PCB-117/116/85	1.0	8.7	20.0	4.0	0.5
CL1-PCB-118	1.0	6.0	20.0	4.0	0.5
CL1-PCB-108/119/86/97/125/87	1.0	22.8	20.0	4.0	0.5
CL1-PCB-120	1.0	3.1	20.0	4.0	0.5
CL1-PCB-121	1.0	4.7	20.0	4.0	0.5
CL1-PCB-122	1.0	2.5	20.0	4.0	0.5
CL1-PCB-123	1.0	2.5	20.0	4.0	0.5
CL1-PCB-107/124	1.0	5.0	20.0	4.0	0.5
CL1-PCB-108/119/86/97/125/87	1.0	22.8	20.0	4.0	0.5
CL1-PCB-126	1.0	2.5	20.0	4.0	0.5
CL1-PCB-127	1.0	2.5	20.0	4.0	0.5
CL1-PCB-128/166	1.0	5.0	20.0	4.0	0.5
CL1-PCB-128/162/129/160	1.0	16.1	20.0	4.0	0.5
CL1-PCB-130	1.0	2.5	20.0	4.0	0.5
CL1-PCB-131	1.0	2.7	20.0	4.0	0.5
CL1-PCB-132	1.0	3.5	20.0	4.0	0.5
CL1-PCB-133	1.0	3.0	20.0	4.0	0.5
CL1-PCB-134/143	1.0	5.0	20.0	4.0	0.5
CL1-PCB-131/133/154	1.0	10.8	20.0	4.0	0.5
CL1-PCB-135	1.0	2.9	20.0	4.0	0.5
CL1-PCB-136	1.0	3.3	20.0	4.0	0.5
CL1-PCB-128/162/129/160	1.0	16.1	20.0	4.0	0.5
CL1-PCB-134/140	1.0	5.0	20.0	4.0	0.5
CL1-PCB-137	1.0	5.0	20.0	4.0	0.5
CL1-PCB-141	1.0	5.3	20.0	4.0	0.5
CL1-PCB-142	1.0	2.5	20.0	4.0	0.5
CL1-PCB-134/143	1.0	5.0	20.0	4.0	0.5
CL1-PCB-144	1.0	3.6	20.0	4.0	0.5
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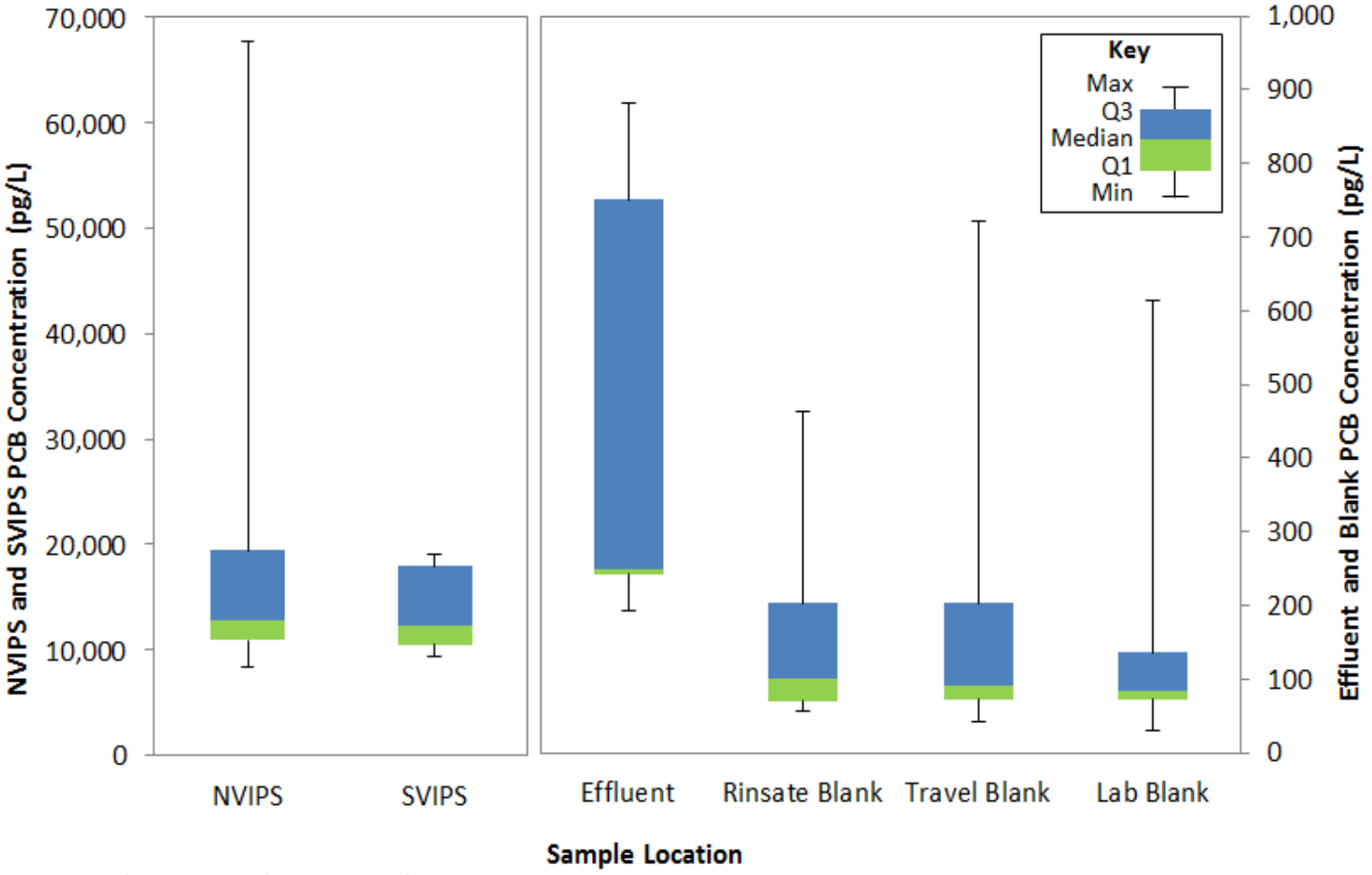
CL1-PCB-146	1.0	3.8	20.0	4.0	0.5
CL1-PCB-147/149	1.0	20.8	20.0	4.0	0.5
CL1-PCB-148	1.0	3.3	20.0	4.0	0.5
CL1-PCB-147/149	1.0	20.8	20.0	4.0	0.5
CL1-PCB-150	1.0	3.3	20.0	4.0	0.5
CL1-PCB-131/133/154	1.0	10.8	20.0	4.0	0.5
CL1-PCB-152	1.0	3.5	20.0	4.0	0.5
CL1-PCB-153/168	1.0	19.9	20.0	4.0	0.5
CL1-PCB-151/135/154	1.0	10.8	20.0	4.0	0.5
CL1-PCB-155	1.0	3.0	20.0	4.0	0.5
CL1-PCB-156/157	1.0	5.0	40.0	8.0	0.5
CL1-PCB-156/157	1.0	5.0	40.0	8.0	0.5
CL1-PCB-158	1.0	2.5	20.0	4.0	0.5
CL1-PCB-159	1.0	2.5	20.0	4.0	0.5
CL1-PCB-128/162/129/160	1.0	16.1	20.0	4.0	0.5
CL1-PCB-161	1.0	2.5	20.0	4.0	0.5
CL1-PCB-162	1.0	2.8	20.0	4.0	0.5
CL1-PCB-128/162/129/160	1.0	16.1	20.0	4.0	0.5
CL1-PCB-163	1.0	3.4	20.0	4.0	0.5
CL1-PCB-165	1.0	2.5	20.0	4.0	0.5
CL1-PCB-128/166	1.0	5.0	20.0	4.0	0.5
CL1-PCB-167	1.0	2.7	20.0	4.0	0.5
CL1-PCB-153/168	1.0	19.9	20.0	4.0	0.5
CL1-PCB-169	1.0	2.9	20.0	4.0	0.5
CL1-PCB-170	1.0	4.7	20.0	4.0	0.5
CL1-PCB-171/173	1.0	6.3	20.0	4.0	0.5
CL1-PCB-172	1.0	4.7	20.0	4.0	0.5
CL1-PCB-171/173	1.0	6.3	20.0	4.0	0.5
CL1-PCB-174	1.0	5.7	20.0	4.0	0.5
CL1-PCB-175	1.0	4.1	20.0	4.0	0.5
CL1-PCB-176	1.0	3.6	20.0	4.0	0.5
CL1-PCB-177	1.0	4.7	20.0	4.0	0.5
CL1-PCB-178	1.0	5.0	20.0	4.0	0.5
CL1-PCB-179	1.0	4.8	20.0	4.0	0.5
CL1-PCB-180/193	1.0	12.7	20.0	4.0	0.5
CL1-PCB-181	1.0	4.3	20.0	4.0	0.5
CL1-PCB-182	1.0	4.5	20.0	4.0	0.5
CL1-PCB-182/185	1.0	8.4	20.0	4.0	0.5
CL1-PCB-183	1.0	4.4	20.0	4.0	0.5
CL1-PCB-182/185	1.0	8.4	20.0	4.0	0.5
CL1-PCB-184	1.0	5.3	20.0	4.0	0.5
CL1-PCB-187	1.0	11.7	20.0	4.0	0.5
CL1-PCB-188	1.0	2.5	20.0	4.0	0.5
CL1-PCB-189	1.0	2.5	20.0	4.0	0.5
CL1-PCB-190	1.0	2.5	20.0	4.0	0.5
CL1-PCB-191	1.0	3.4	20.0	4.0	0.5
CL1-PCB-180/193	1.0	12.7	20.0	4.0	0.5
CL1-PCB-194	1.0	2.5	20.0	4.0	0.5
CL1-PCB-195	1.0	4.0	20.0	4.0	0.5
CL1-PCB-196	1.0	3.7	20.0	4.0	0.5
CL1-PCB-197/200	1.0	7.7	20.0	4.0	0.5
CL1-PCB-198/199	1.0	5.1	20.0	4.0	0.5
CL1-PCB-198/199	1.0	5.1	20.0	4.0	0.5
CL1-PCB-197/200	1.0	7.7	20.0	4.0	0.5
CL1-PCB-201	1.0	2.8	20.0	4.0	0.5
CL1-PCB-202	1.0	3.5	20.0	4.0	0.5
CL1-PCB-203	1.0	2.5	20.0	4.0	0.5
CL1-PCB-204	1.0	3.1	20.0	4.0	0.5
CL1-PCB-205	1.0	2.5	20.0	4.0	0.5
CL1-PCB-206	1.0	2.5	20.0	4.0	0.5
CL1-PCB-207	1.0	2.5	20.0	4.0	0.5

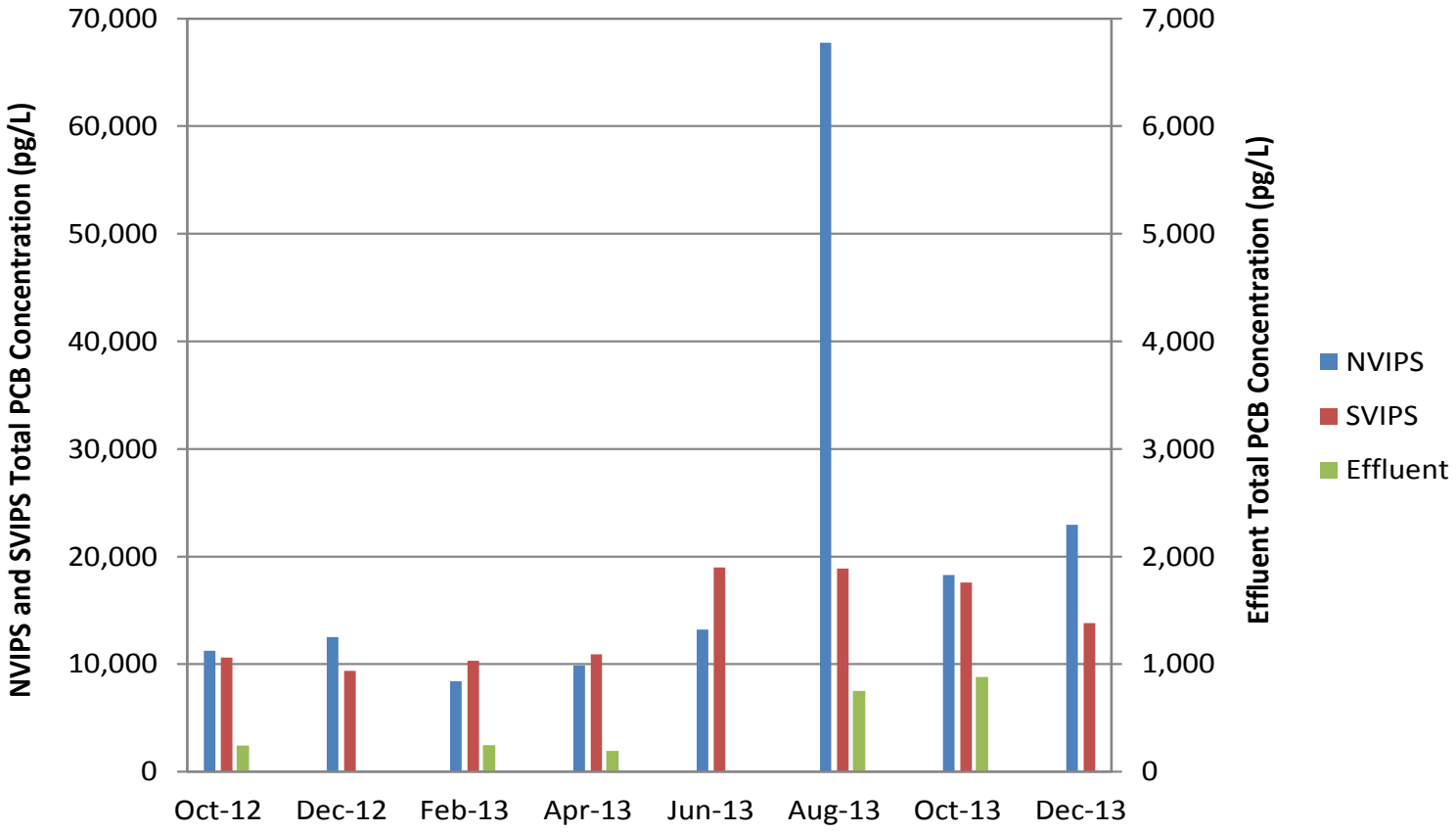
Sampling Results – Influent/Effluent

Brown AND Caldwell

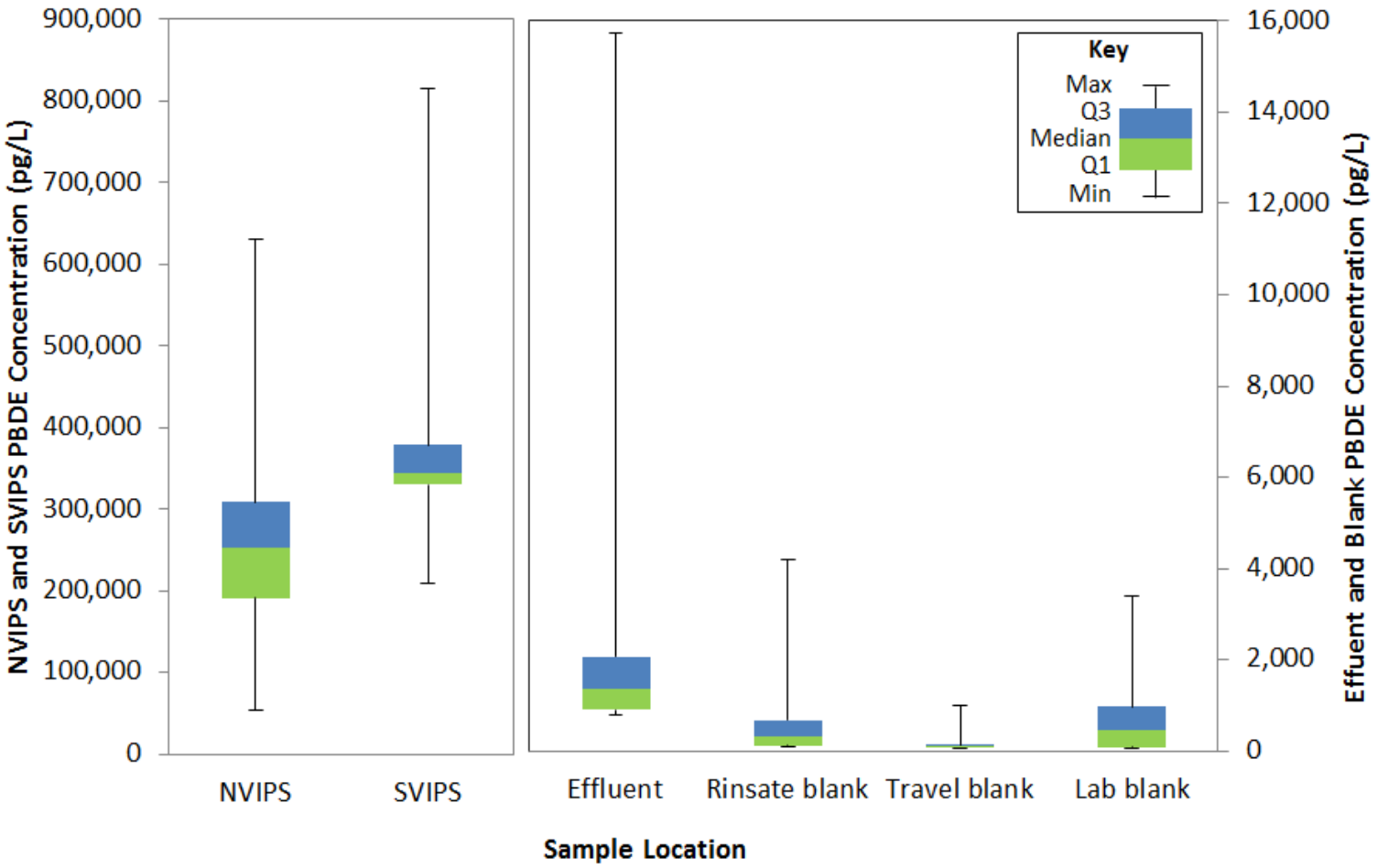
Box-whisker plot of total PCBs



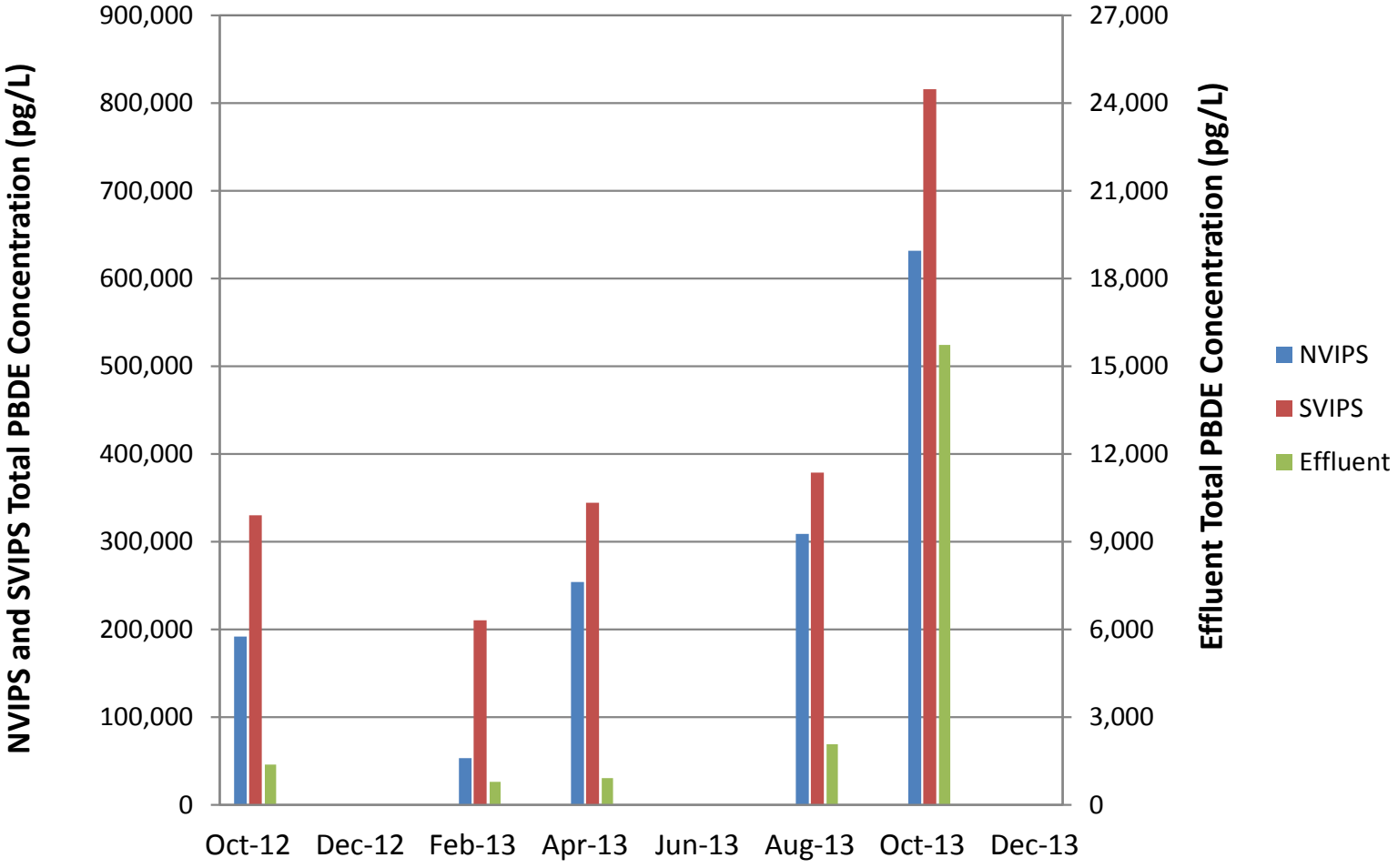
SCRWRF removed ~97% of total PCBs



Box-whisker plot of total PBDEs



WWTP removed 99% of PBDEs



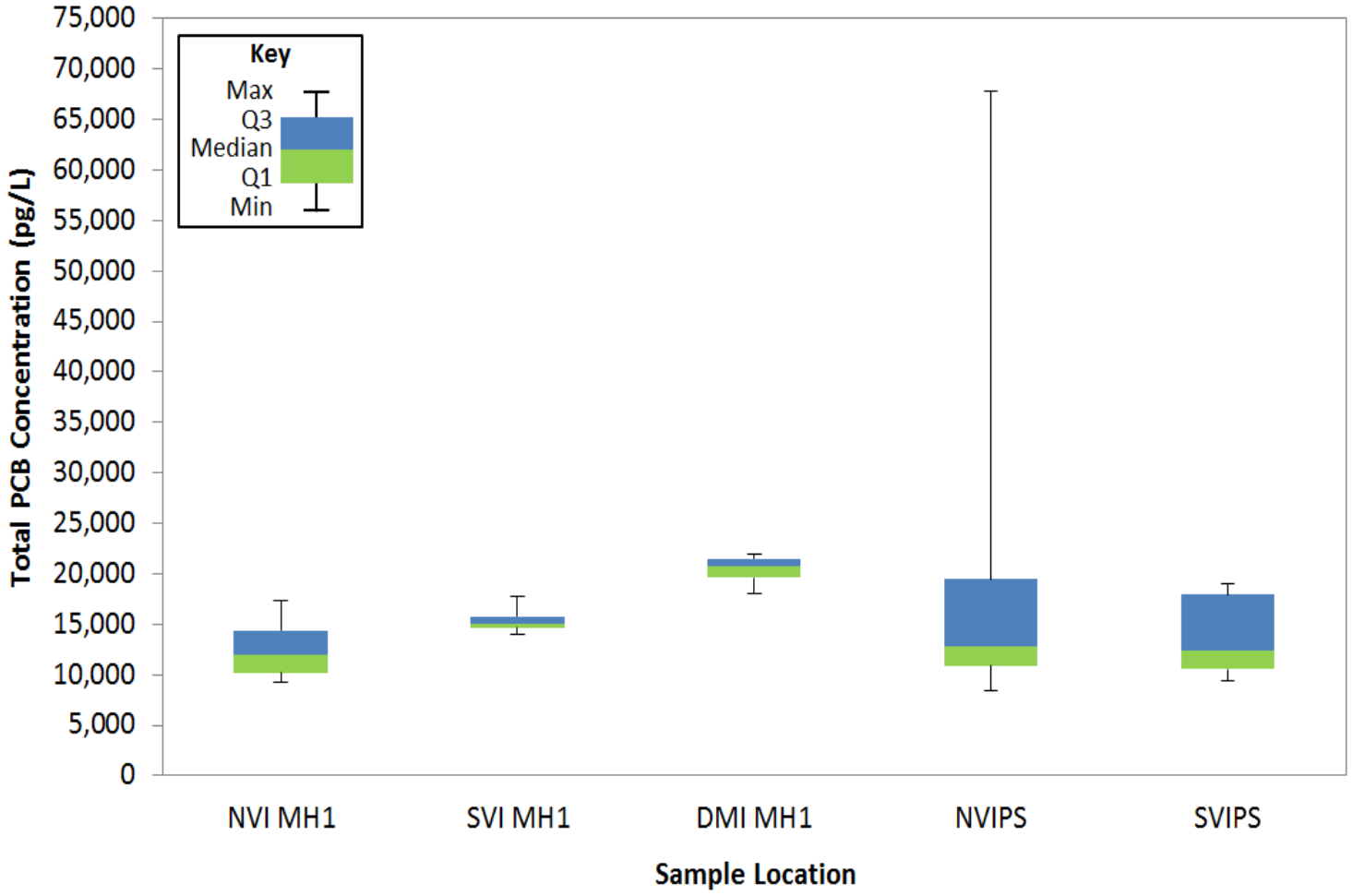
Dioxin – only 1 detect

Statistical Summary of Dioxin Data (pg/L)							
Year	Statistics	NVIPS	SVIPS	Effluent	Rinsate blank	Travel blank	Lab blank
2012	Total number of samples	2	2	1	3	2	2
	Number of detected samples	0	0	0	0	0	0
	Range of concentration detected	--	--	--	--	--	--
	Range of detection limit	0.515–0.522	0.516–0.827	0.517	0.504–0.530	0.534–0.581	0.500
2013	Total number of samples	6	6	4	6	6	6
	Number of detected samples	1	0	0	0	0	0
	Range of concentration detected	1.03	--	--	--	--	--
	Range of detection limit	0.498–0.523	0.498–0.530	0.499–0.543	0.498–0.533	0.549–0.580	0.500–1.84

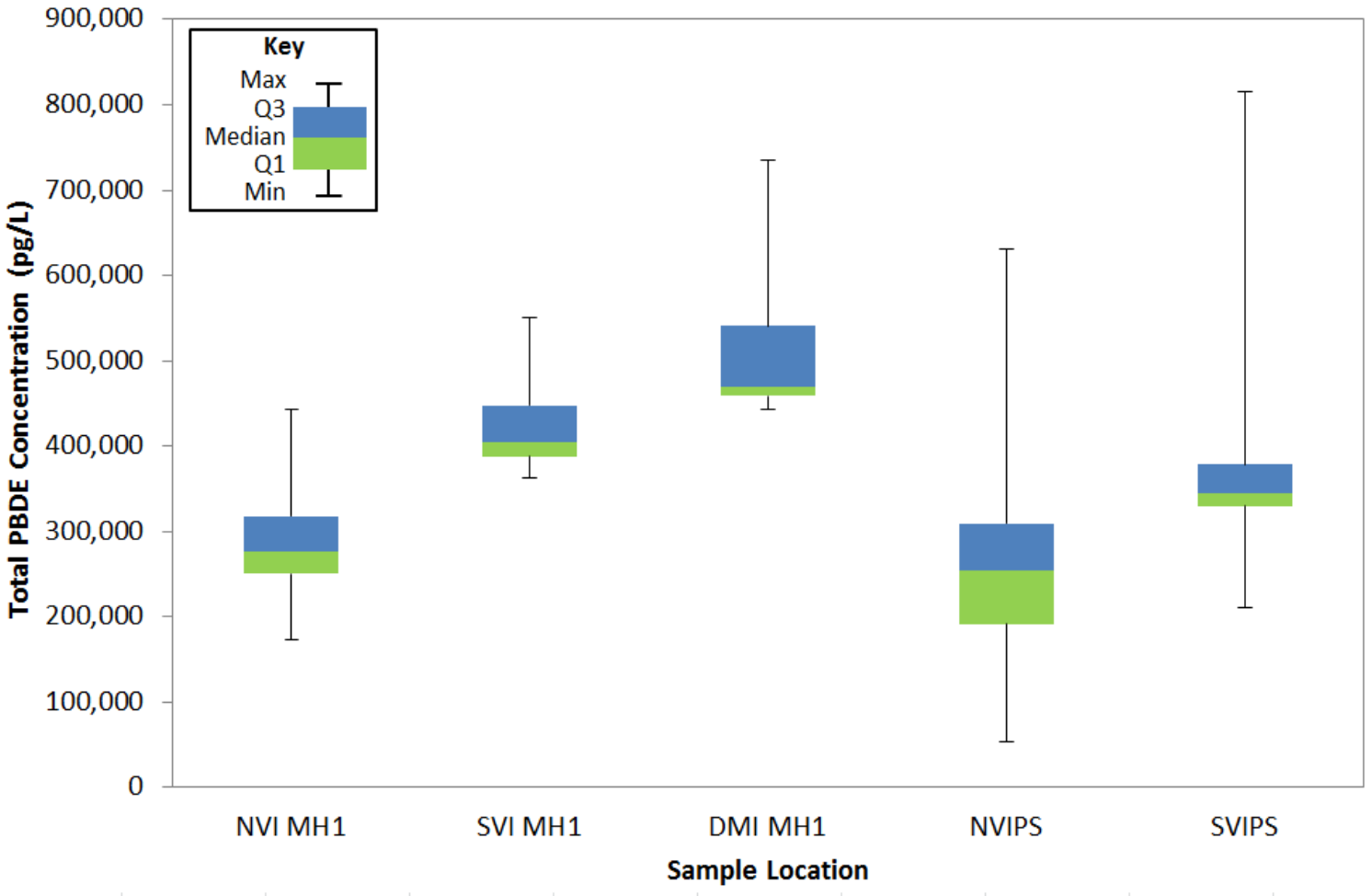
Sampling Results – Collection System Track-down

Brown AND Caldwell

PCBs in influent and track-down samples



PBDEs in influent and track-down samples



PCB and PBDE Source Identification

Dr. Lisa Rodenburg,
Rutgers University

Brown AND Caldwell

Outline

- PCB raw data trends
- PMF
  - Background – what is PMF?
  - PMF results for PCBs
  - PMF results for PBDEs

PCB raw data

- PCB concentrations in influent are similar to other urban systems such as Delaware River and NYC area.
- Effluent PCB (and PBDE) concentrations are very low – such that blank correction is required.
- Correlations among various congeners reveal several trends=>

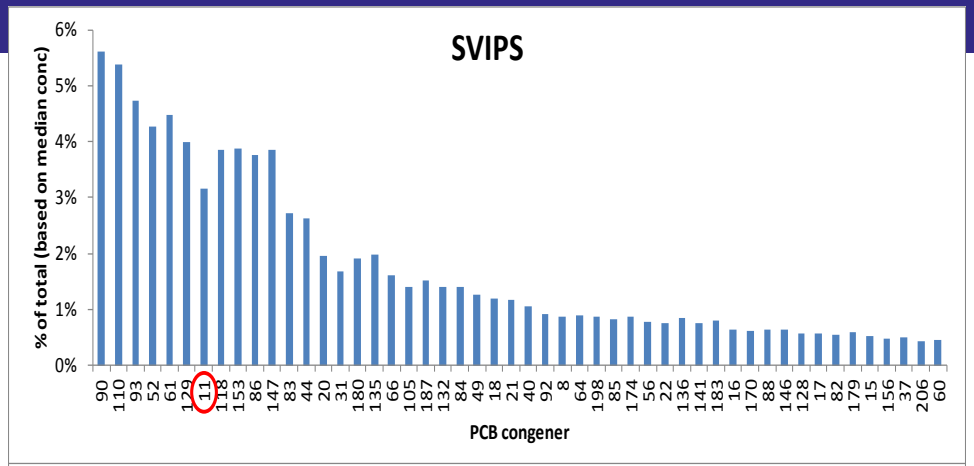
PCB 11 is most abundant congener in effluent

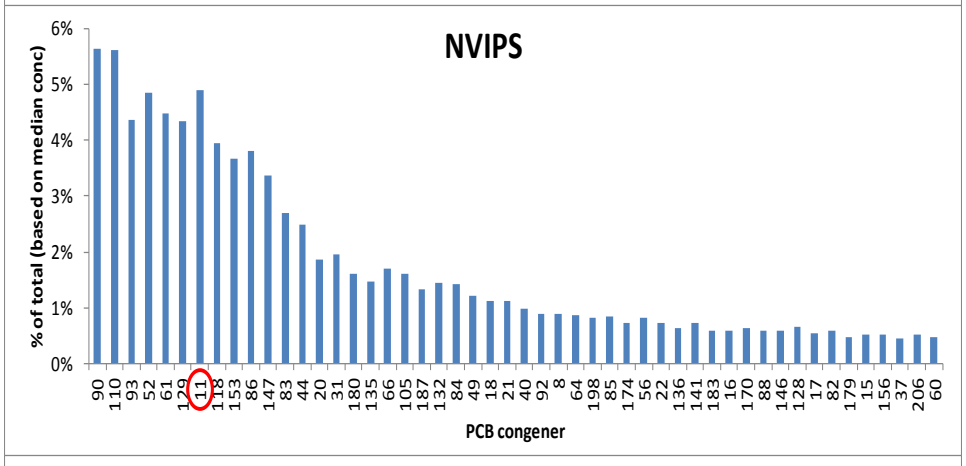
PCB 11 (3,3') strongly correlated with PCBs 35 (3,3',4) and 77 (3,3',4,4'). (see also Litten et al. 2002)

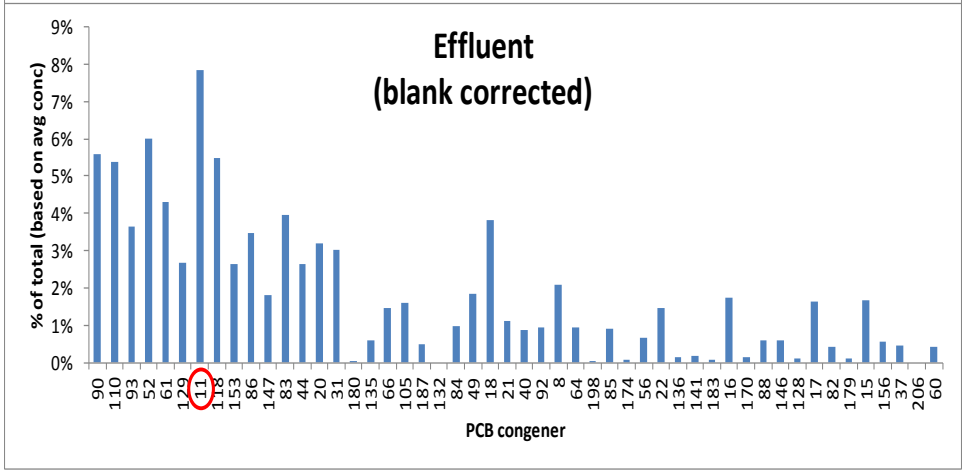
These congeners probably come from **pigment use**.

PCB 77 is dioxin-like and accounts for 0-25% (median 1.8%) of total TEQ in these samples.

Reducing legacy PCB sources will not fix this problem.







Legacy Sources of PCBs

- Aroclors were used in wide range of products
- Production banned in 1977
- Equipment containing Aroclors still in use, however

	1016	1221	1232	1242	1248	1254	1260	1262	1268
Capacitors	■	■		■					
Transformers				■		■	■		
Heat transfer				■					
Hydraulic fluids			■	■	■	■	■		
Vacuum pumps					■	■			
Gas-transmission turbines		■		■					
Rubbers		■	■	■	■	■			■
Synthetic resins					■	■	■	■	■
Carbonless copy paper				■					
Adhesives		■	■	■	■	■			
Wax extenders				■		■			■
Dedusting agents						■	■		
Inks						■			
Cutting oils						■			
Pesticide extenders						■			
Sealants and caulking compounds						■			

Source: Litten, S. 2007. Contaminant Trackdown in Urban Settings.

Factor analysis

- Leveraging “Big Data” to do:
  - Forensics – to identify the number and fingerprints of sources
  - Loading estimate – to quantify the amount of each source in each sample (can help identify source locations)
- THE MORE DATA THE BETTER!
  - In the April 2014 results, we are have about the minimum amount of data that can give useful results.
  - Next year will be better—more data.

Factor Analysis Equation

Applies to Principle Components Analysis, PMF, PVA etc.

Use this equation to predict concentrations, then minimize the sum of squared residuals between measured and predicted concentrations (E) until a stable solution is found.

You do NOT need any information about the sources, such as their fingerprints, or even how many there are!

$$X = G\,F + E$$

$(m \times n)$ $(m \times p)$ $(p \times n)$

X = input data matrix
G = matrix of conc of each factor in each sample generated by model
F = matrix of fingerprint of each factor (p) generated by model
n = number of analytes
m = number of samples
p = number of factors (sources)
E = leftover or residual

Note: in all forms of factor analysis, the user has to decide what is the 'correct' number of sources based on model output.

Advantages of Positive Matrix Factorization (PMF)

over other models, for example Principle Components Analysis

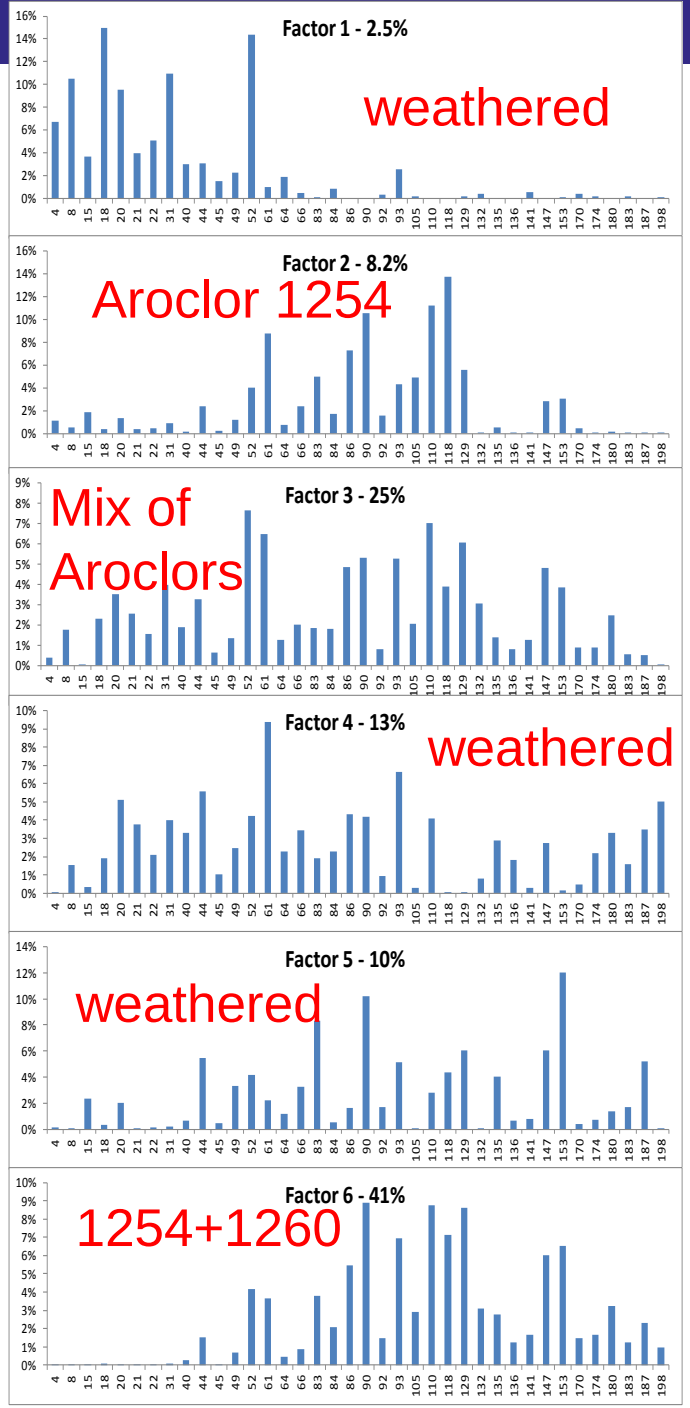
- Positive correlations only
- Uncertainty incorporated into the model
- Missing and below detection limit values can be included by assigning them a high uncertainty
- “Robust” mode can be used so that outlier values will not skew the factor profiles
- PMF reveals the importance or weighting of each factor in each sample

PCB data matrix

- All 209 congeners measured in ~150 peaks in 38 samples.
- With 38 samples, can only include 38 congeners in PMF model. (38 top congeners = ~60% of total mass)
- PCB 11 left out, since we already know where it comes from.
- As more data becomes available, more congeners can be included.

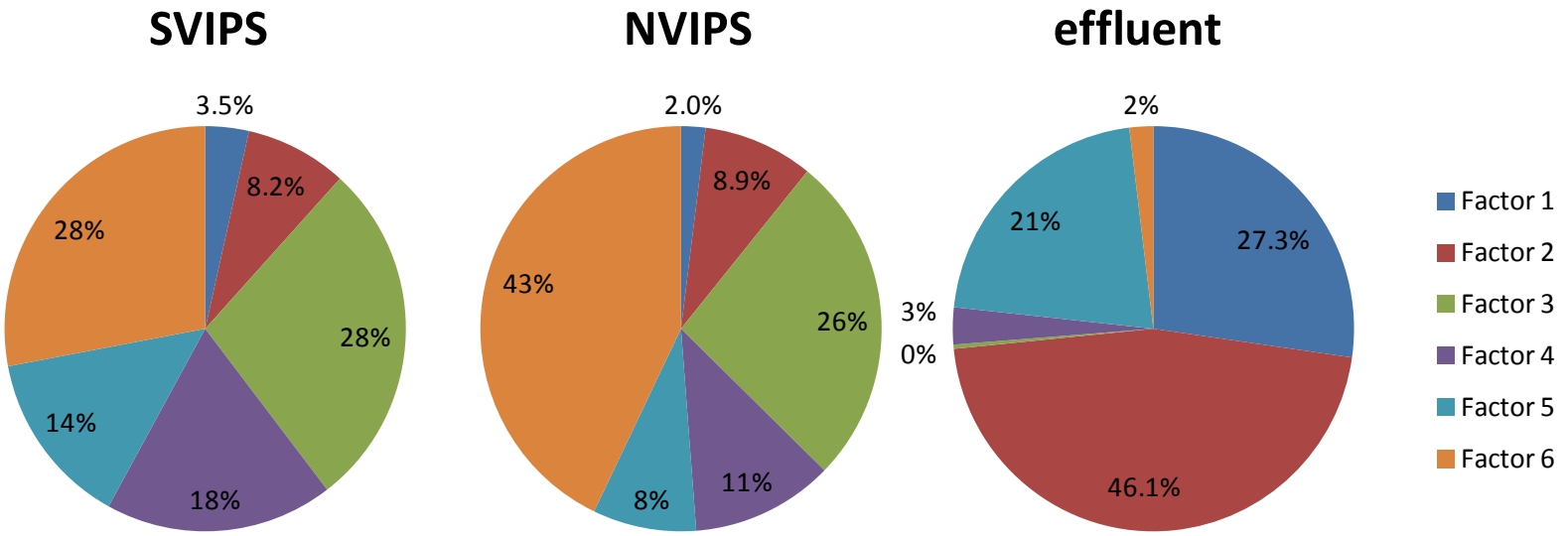
PMF results - PCBs

- Six factors (i.e. sources) =>
- Three look like Aroclors (75-85% of Σ_{38}PCBs).
- Three other sources are more weathered and probably older (15-25% of Σ_{38}PCBs).
- Results are typical of urban wastewater.
- No evidence of microbial degradation (i.e. dechlorination).



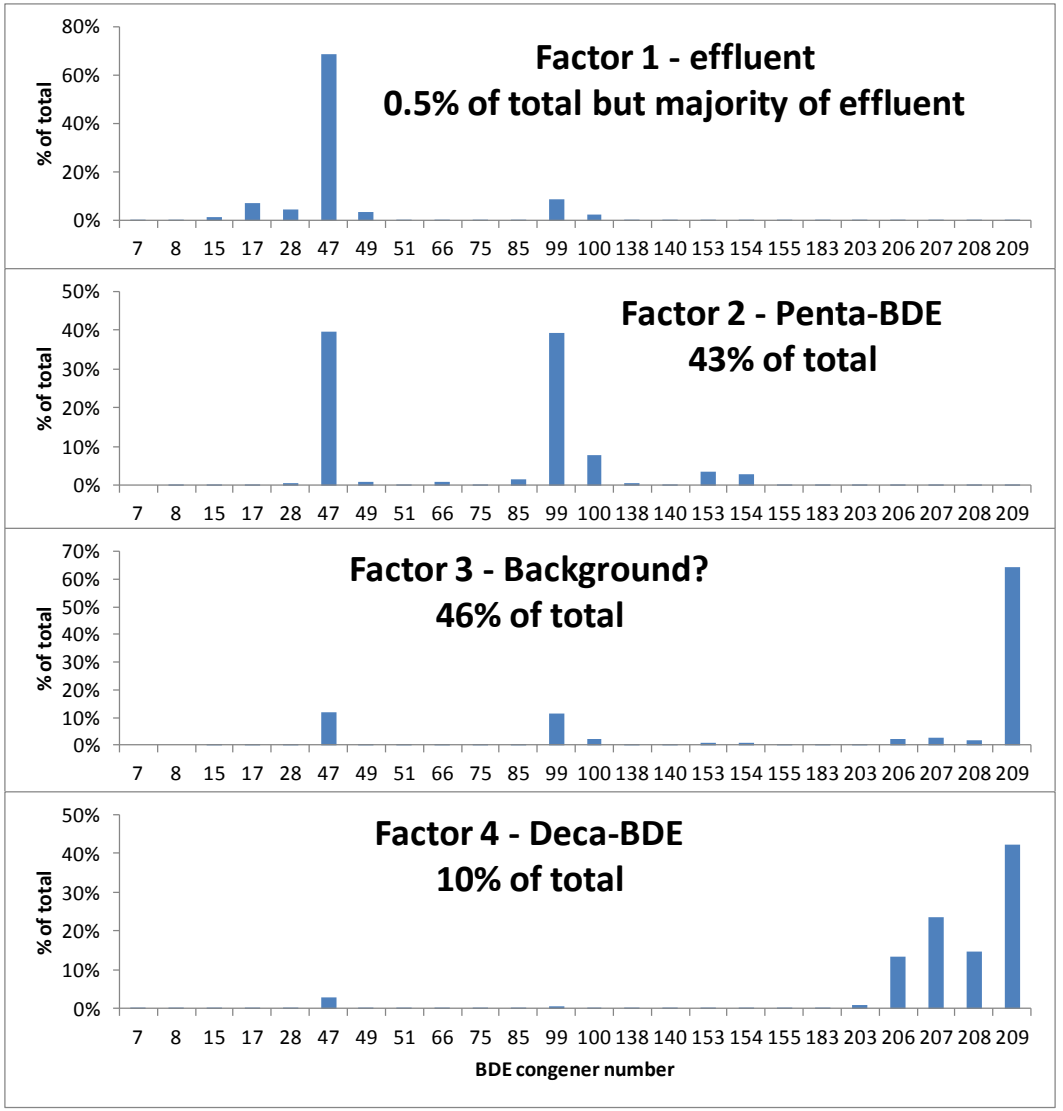
Location trends

- No obvious differences between sample locations (i.e. SVIPS vs NVIPS)
- Effluent dominated by low MW PCB congeners/factors



Factor analysis - BDEs

- 46 congeners measured
- 24 congeners included in data matrix (~100% of total mass).
- Four factors =>
- Two are related to commercial BDE formulations.
- Factor 1 is dominant in effluent and shows evidence of microbial debromination in the collection system.
- No factor resembles octa-BDE formulation.



Summary - PCBs

- High quality data sets were used.
- Raw data shows that the Spokane County system is similar to many other urban areas in the concentrations of PCBs in the influent and the mix of Aroclor-type sources.
- Spokane county has more PCB 11 than other urban systems I have investigated, and PCB 11 is strongly correlated with PCB 35 and 77 (77 is dioxin-like).
- No evidence of PCB degradation.
- Relatively unweathered Aroclors are 75-85% of Σ_{38}PCBs, but Σ_{38}PCBs = ~60% of the total.
- As more data becomes available, a greater proportion of the total PCBs can be modeled.

Summary – BDEs

- Very high quality data set
- BDEs mostly come from BDE formulations
- Some evidence of microbial degradation in the collection system.
  - This would seem to be a good thing, but…
  - These debrominated products are the dominant source of BDEs to the effluent.

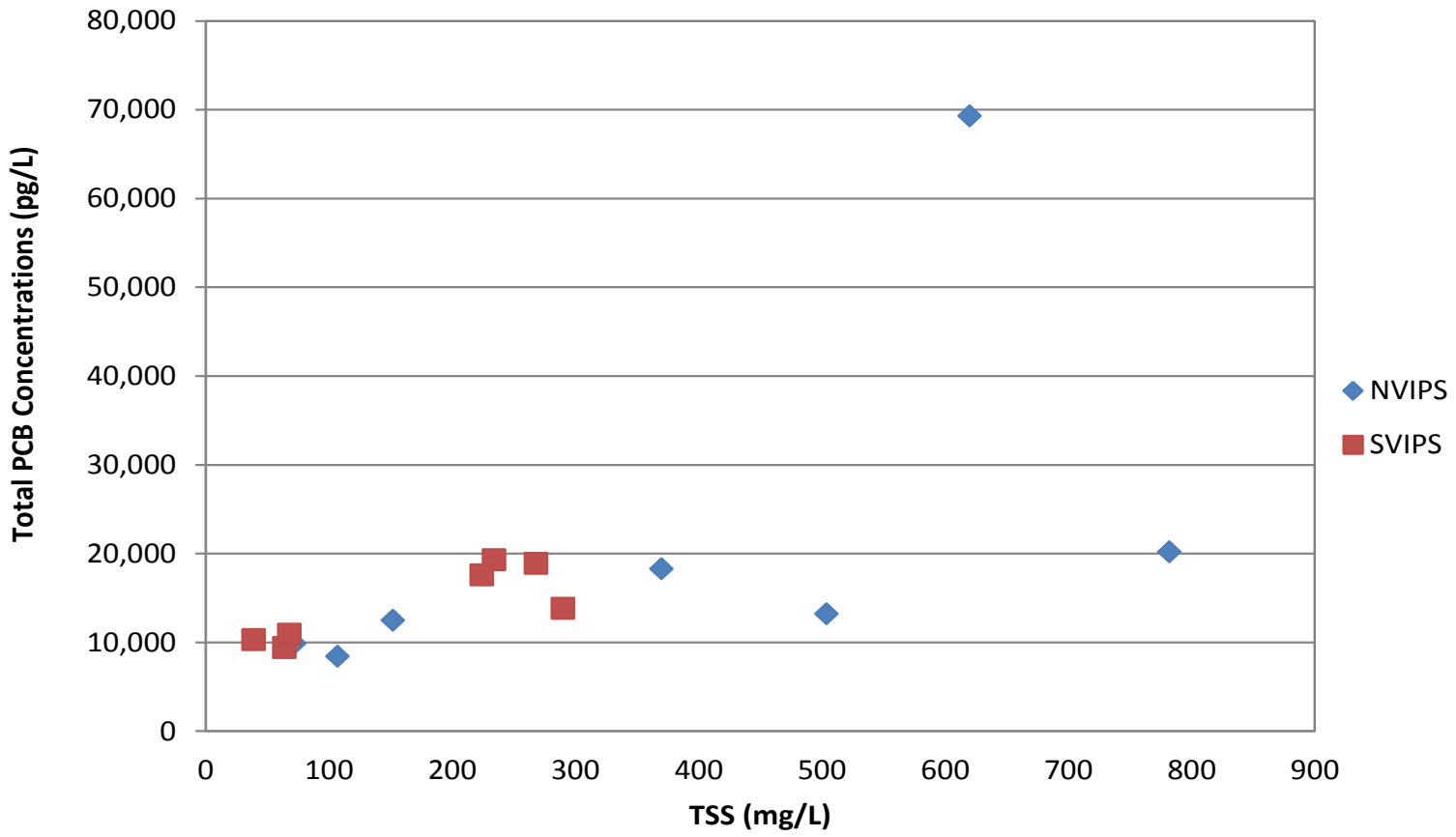
Questions and Discussion

Brown AND Caldwell

Reserve Slides

Brown AND Caldwell

Comparison of total PCB and TSS

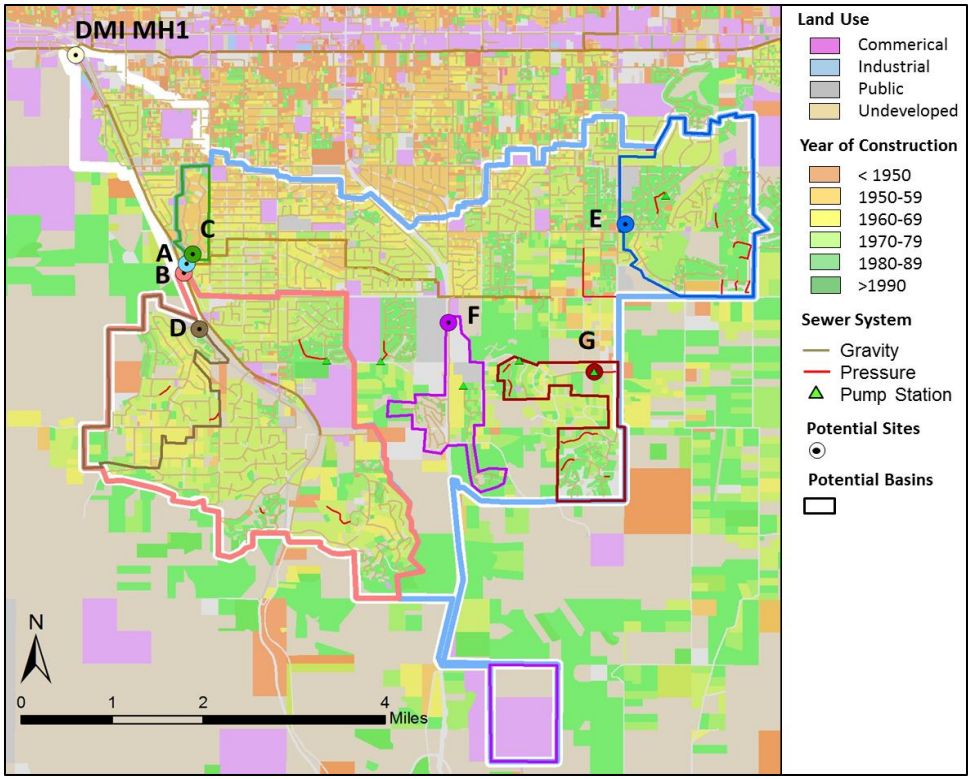


Future Years

- Next year examine NVI sewershed
- Continue producing annual reports
- Goal of modifying permit
- Collaborate with Spokane River Task Force

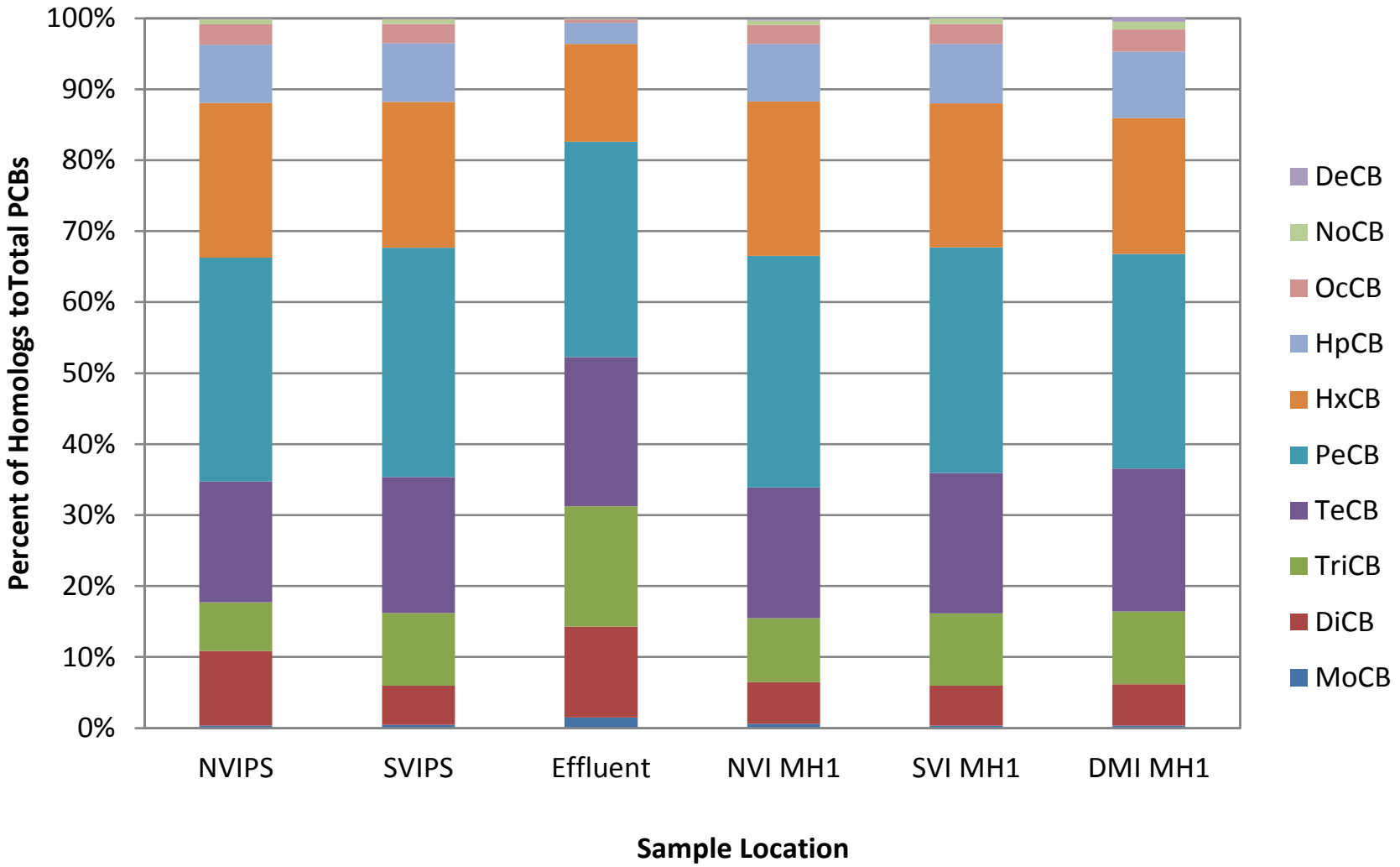
Year 2 of Track-down Sampling

- Continue track-down
- Evaluate year of construction
- Eliminate PBDEs

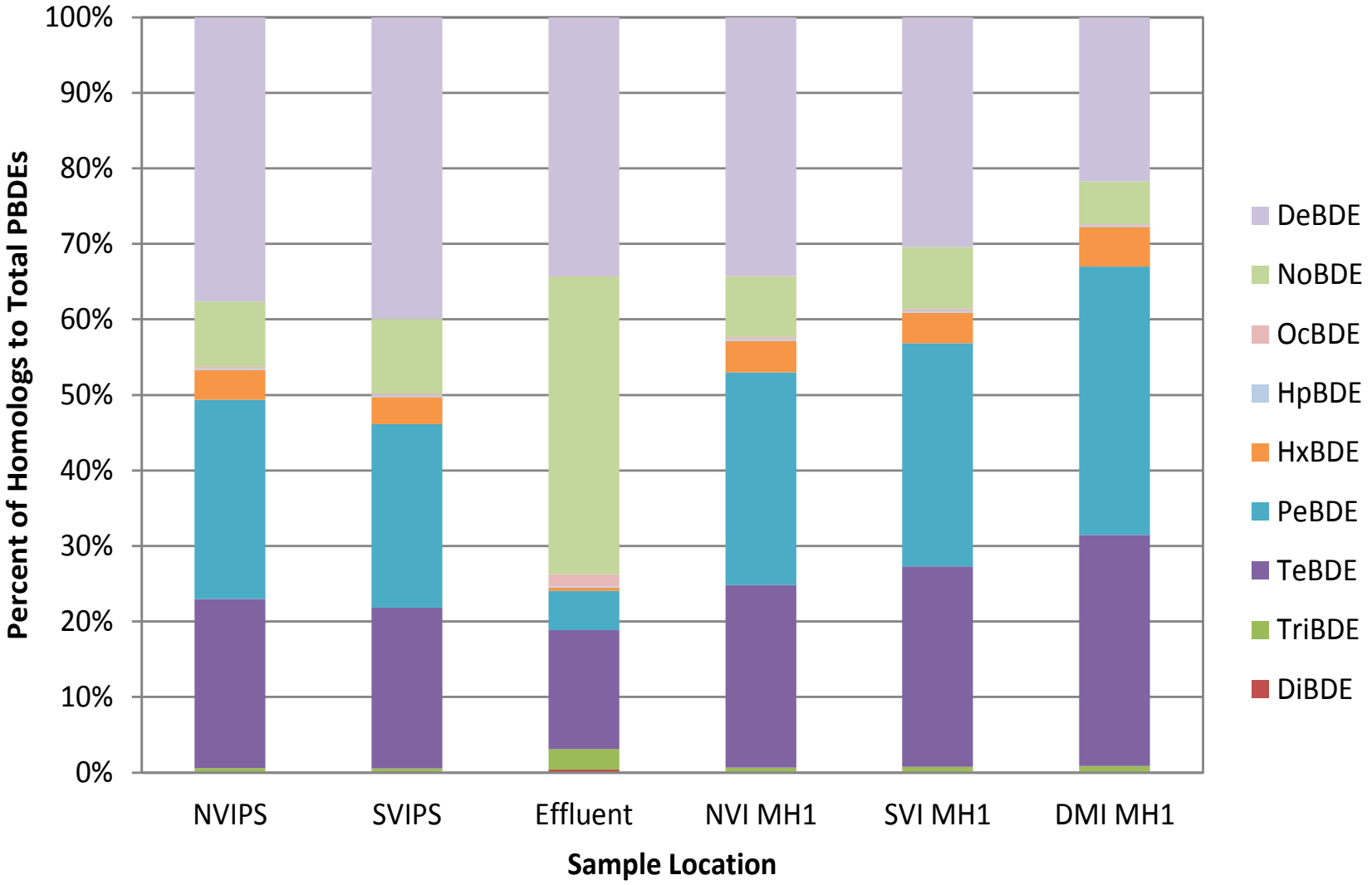


Summary of 2014 Track-Down Sampling Locations									
Site	Parcels	Land use [a]				Year of construction [a,b]			
		Resid.	Comm.	Ind.	Other [c]	<1960	1960–79	1980–99	2000+
A	6,315	98%	1%	0%	2%	11%	49%	27%	13%
B	2,498	73%	6%	0%	21%	1%	57%	33%	9%
C	148	94%	4%	0%	2%	73%	15%	11%	1%
D	509	76%	1%	0%	23%	1%	63%	26%	10%
E	936	75%	2%	0%	24%	1%	27%	37%	35%
F	229	33%	33%	0%	34%	0%	4%	60%	36%
G	348	85%	0%	0%	15%	0%	17%	69%	13%

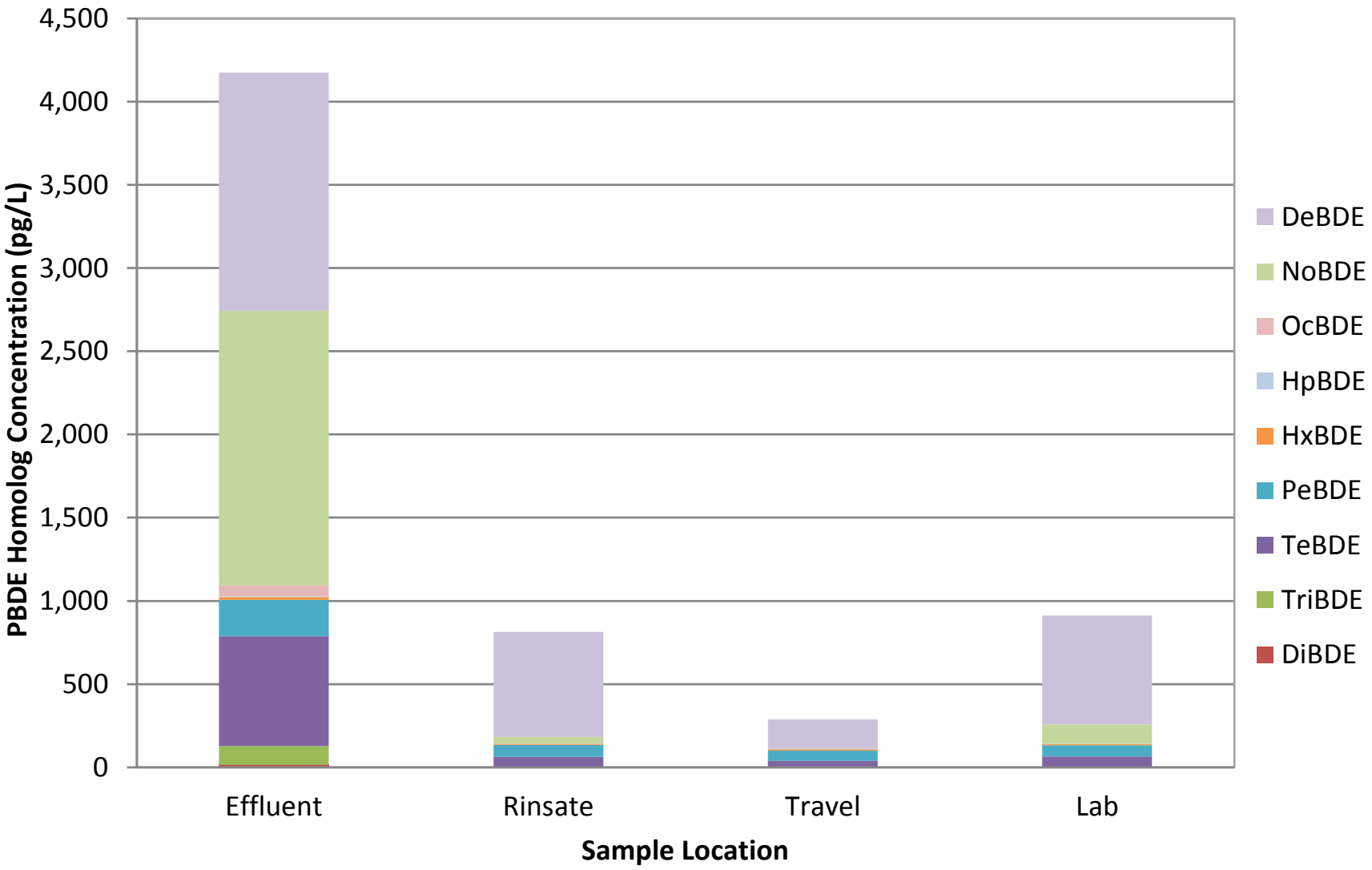
PCB Homologs



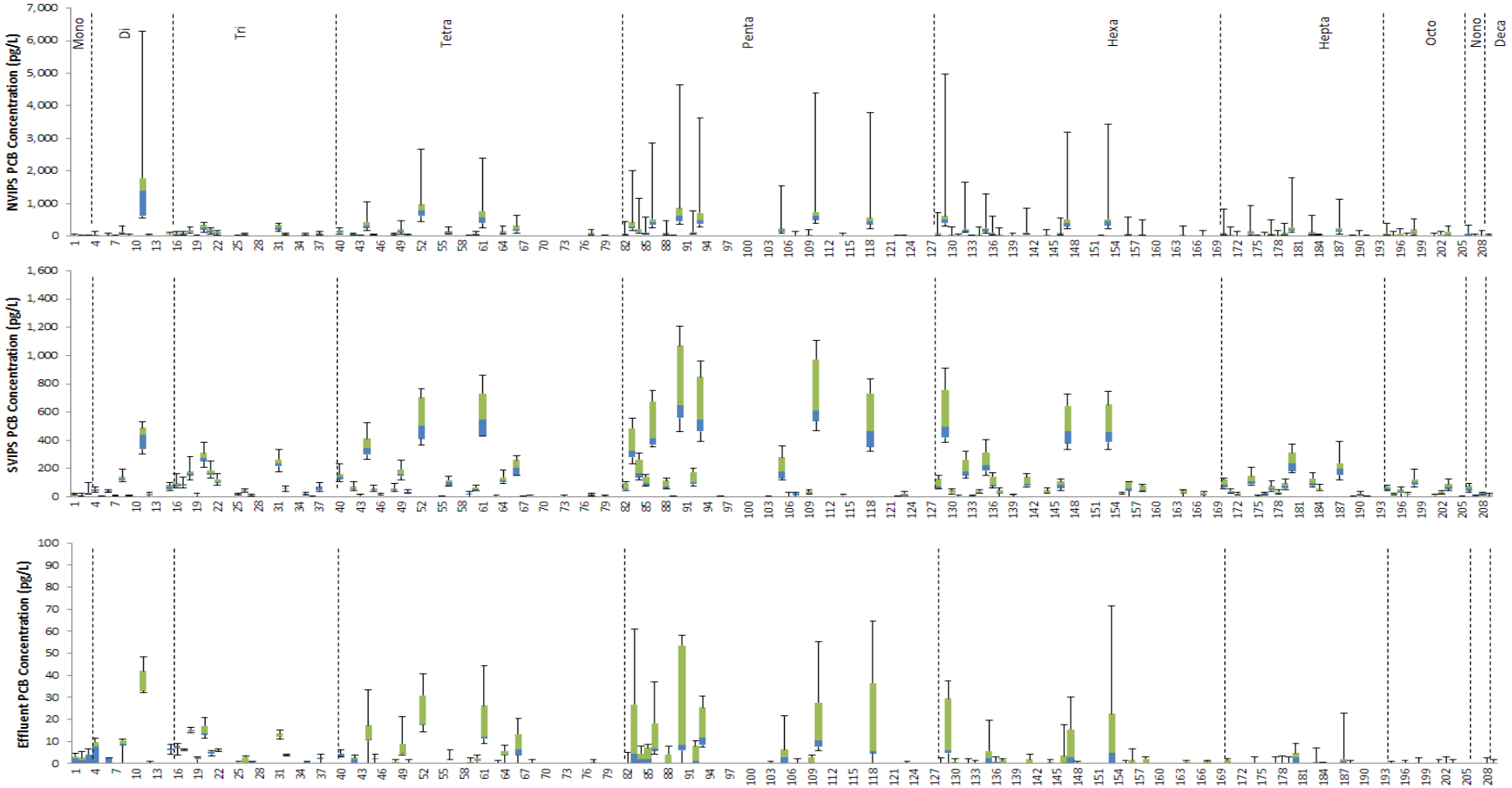
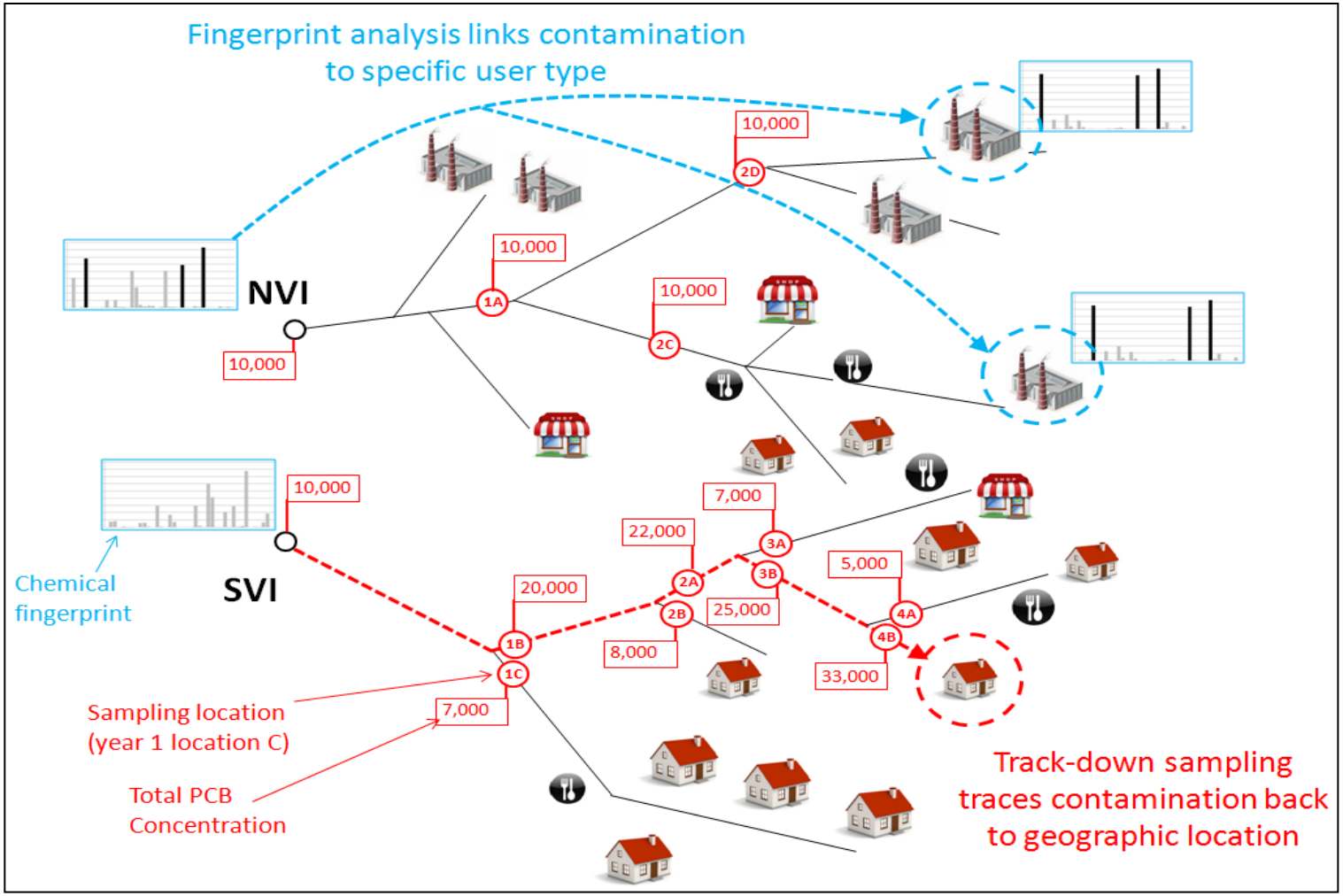
PBDE Homologs



Pattern Analysis – Effluent and Blanks



Congener Analysis – PCBs



Source Investigation