

**Polychlorinated Biphenyl (PCB) IN
Precipitation, Snowpack, Baseflow and
Stormwater in the Upper and Middle Rio
Grande Watershed
with
Special Emphasis on Los Alamos National
Laboratory**

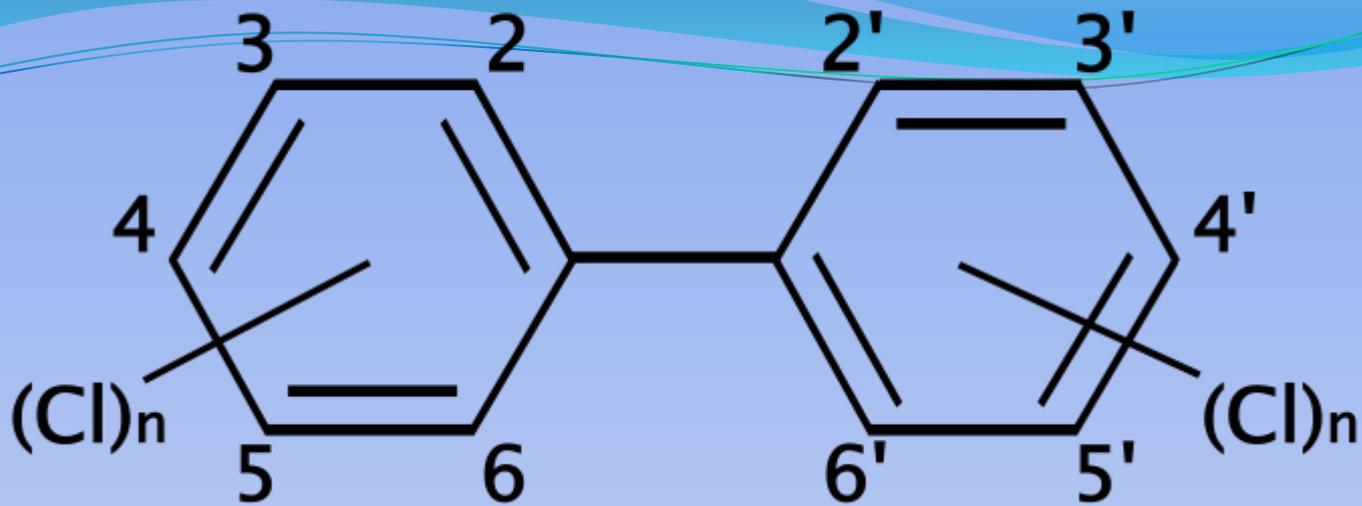
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DOE Oversight Bureau

The data presented was collected by Los Alamos National Laboratory and New Mexico Environment Department Surface Water Quality Bureau and the DOE Oversight Bureau

The samples were collected within the last 6 years (2005 – 2011)

All data analyzed using EPA Method 1668A

All data has been blank corrected



Chemical Structure of PCBs.

Polychlorinated biphenyls (PCBs) are composed of two benzene rings (12 carbon atoms) forming a biphenyl with 1 to 10 chlorine atoms attached.

209 possible congeners, based on the number and location of chlorine atoms attached to carbon atoms in the benzene rings

PCB homologues are groups of PCB congeners containing the same number of chlorine atoms (1 – 10) Homologue patterns can be used to identify unique mixtures due to different source terms

PCB Basics

•Polychlorinated Biphenyls

- Production began in 1929, banned in 1977
- Between 1930 and 1975 - 1,400 million pounds (635 million kg) produced in US
- in 1976, 95% of all capacitors were filled with PCBs representing 70% of US production
- 5% of all transformers were filled with PCBs representing 30% of US Production (IRAC1979)

•Toxicity

- PCBs have been shown to cause cancer in animals. PCBs have also been shown to cause a number of serious non-cancer health effects in animals, including effects on the immune system, reproductive system, nervous system, endocrine system and other health effects.
- probable human carcinogens
- the types of PCBs likely to be bioaccumulated in fish and bound to sediments are the most carcinogenic PCB mixtures (<http://www.epa.gov/osw/hazard/tsd/pcbs/pubs/effects.htm>).

•Aroclors

- Monsanto brand-name mixtures of PCB congeners (1930-1977)
- Numbering convention (e.g. 1254, 1260)
- First two digits = Number of carbon atoms in structure (12)
- Second two digits = Percentage of weight attributable to chlorine (54%, 60%)

Aroclor Common Uses (IARC 1979)

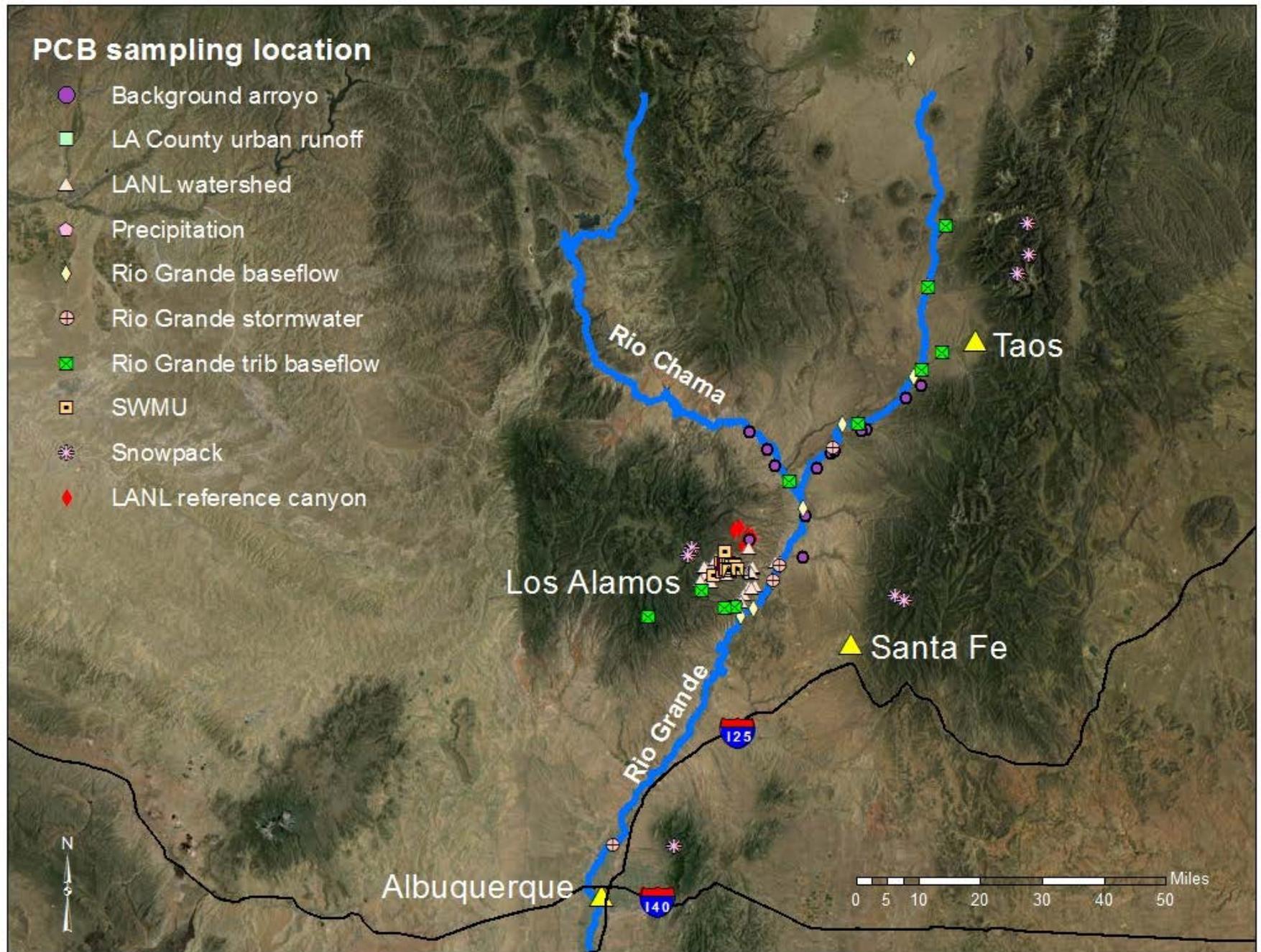
- ✿ 1016 - Capacitors
- ✿ 1221 - Capacitors, gas-transmission turbines, rubbers, adhesives
- ✿ 1232 - Hydraulic fluids, rubbers, adhesives
- ✿ 1242 - Transformers, heat transfer, hydraulic l/lubricants (hydraulic fluids, gas-transmission turbines), plasticizers (rubbers, carbonless paper), adhesives
- ✿ 1248 - Hydraulic fluids, lubricants, plasticizers, adhesives
- ✿ 1254 - Capacitors, transformers, hydraulic/lubricants (vacuum pumps, hydraulic fluids), plasticizers (rubbers and synthetic resins), adhesives, wax extenders, de-dusting agents, inks, cutting oils, pesticide extenders, sealants and caulking compounds
- ✿ 1260 - Transformers, hydraulic fluids, synthetic resins, de-dusting agents
- ✿ 1268 – Plasticizers (rubbers, synthetic resins), wax extenders

Products that may contain PCBs include:

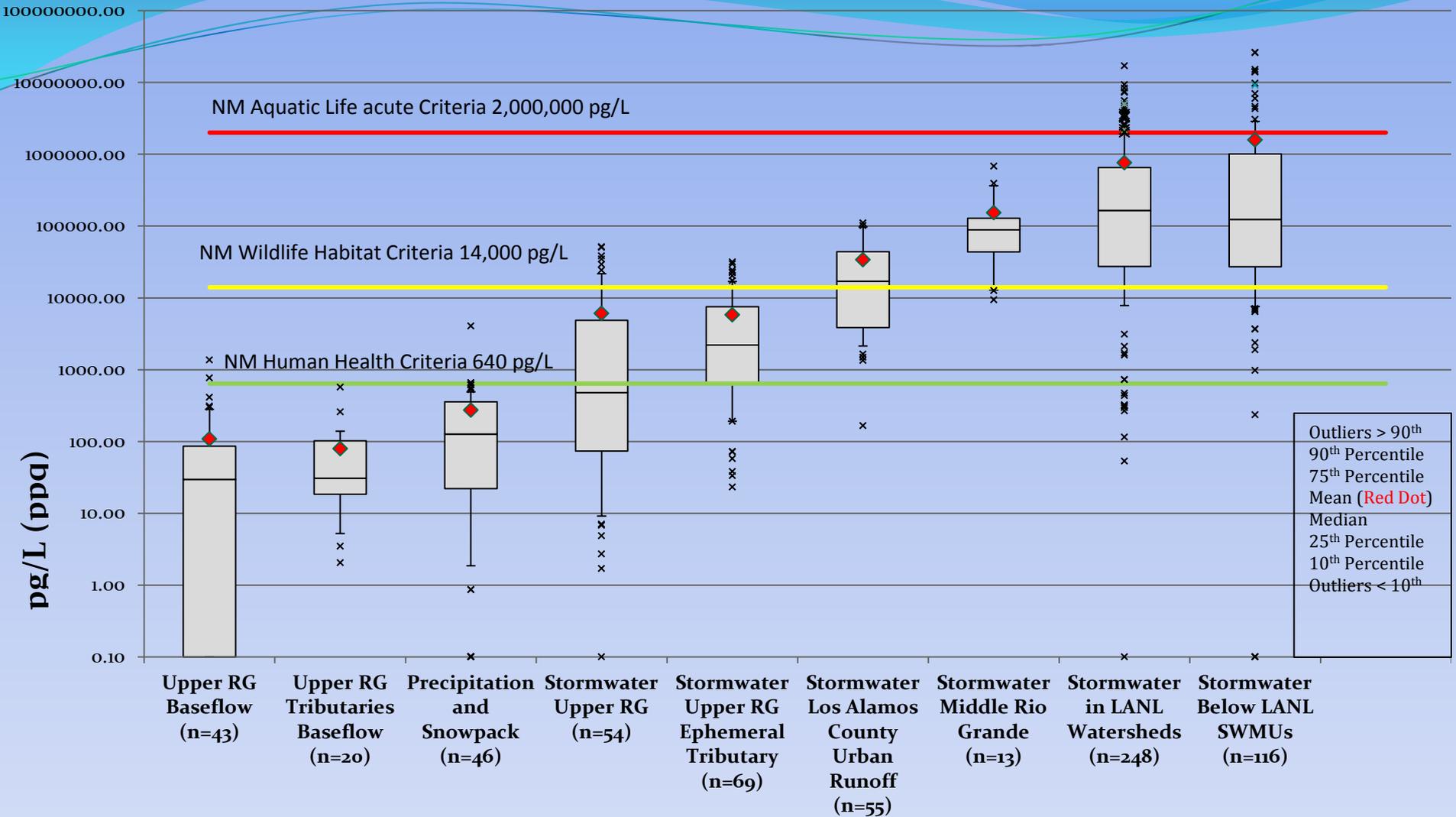
- Transformers and capacitors
- Other electrical equipment including voltage regulators, switches, reclosers, bushings, and electromagnets
- Oil used in motors and hydraulic systems
- Old electrical devices or appliances containing PCB capacitors
- Fluorescent light ballasts
- Cable insulation
- Thermal insulation material including fiberglass, felt, foam, and cork
- Adhesives and tapes
- Oil-based paint
- Caulking
- Plastics
- Carbonless copy paper
- Floor finish

PCB sampling location

- Background arroyo
- LA County urban runoff
- ▲ LANL watershed
- ◆ Precipitation
- ◇ Rio Grande baseflow
- ⊕ Rio Grande stormwater
- ⊠ Rio Grande trib baseflow
- SWMU
- ✱ Snowpack
- ◆ LANL reference canyon



Total PCB in Water



Outliers > 90th
 90th Percentile
 75th Percentile
 Mean (Red Dot)
 Median
 25th Percentile
 10th Percentile
 Outliers < 10th

Mean	107	79	792	6,023	5,780	33,763	151,836	752,416	1,563,360
Median	30	31	127	478	2,200	17,000	88,936	165,500	124,000

Normalizing Total PCB in Water as an Assessment Tool

Normalize total PCB in water by dividing by suspended sediment concentration (SSC) using the equation below:

$$\text{Total PCB in water (pg/L)} / \text{SSC (g/L)} = \text{Total PCB in suspended sediments (pg/g)}$$

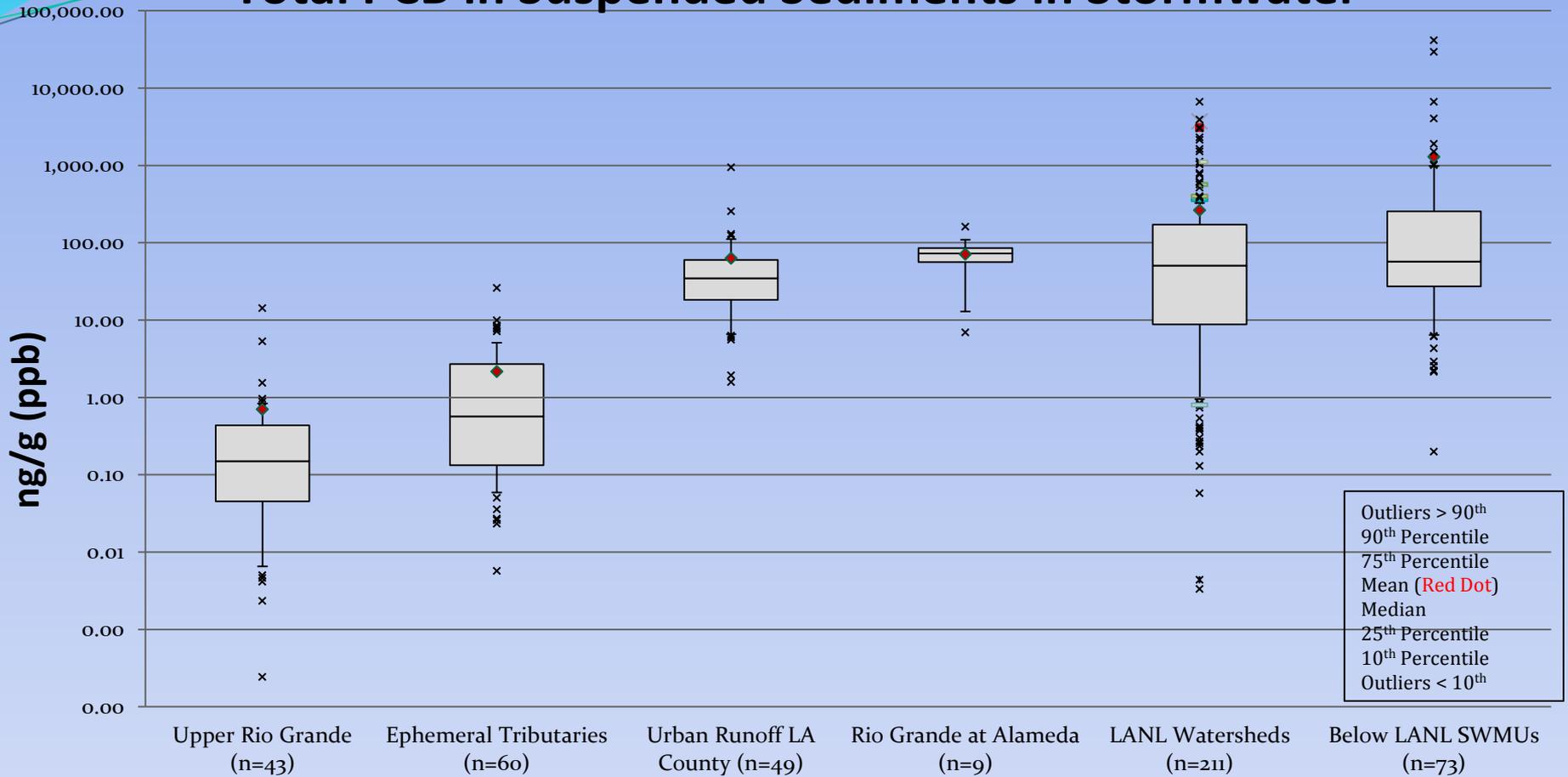
This results in a calculated value for total PCB in the suspended sediments

This value is used to evaluate if you have elevated levels of PCBs in the suspended sediments - indicating a potential source term

or

The watershed has low or baseline levels of PCB but excessive levels of suspended sediments in stormwater

Total PCB in Suspended Sediments in Stormwater



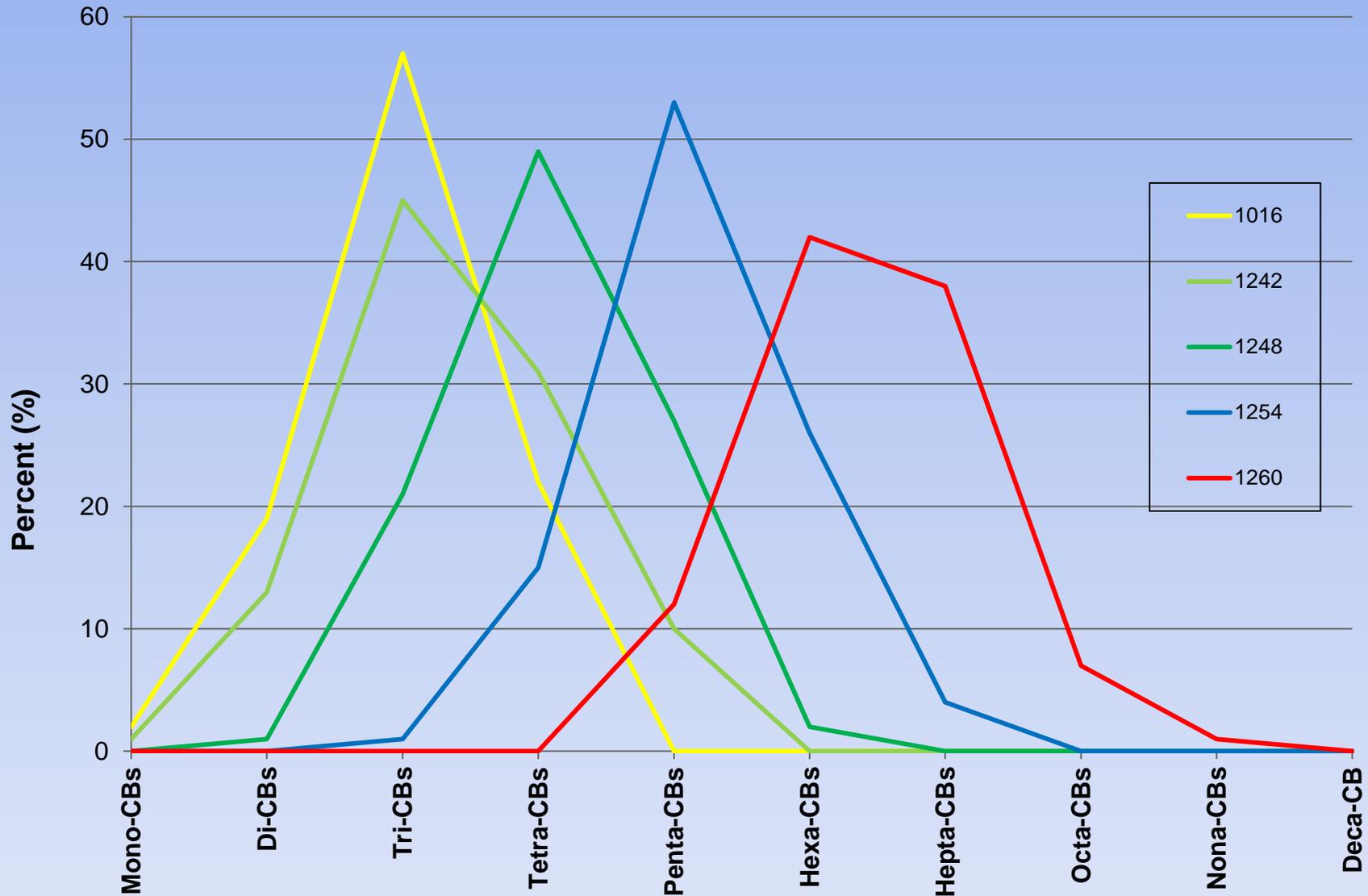
	Upper Rio Grande (n=43)	Ephemeral Tributaries (n=60)	Urban Runoff LA County (n=49)	Rio Grande at Alameda (n=9)	LANL Watersheds (n=211)	Below LANL SWMUs (n=73)
Mean	0.71	2.17	63	71	263	1,299
Median	0.15	0.6	34	73	51	57

Typical composition (%) of some commercial PCB mixtures

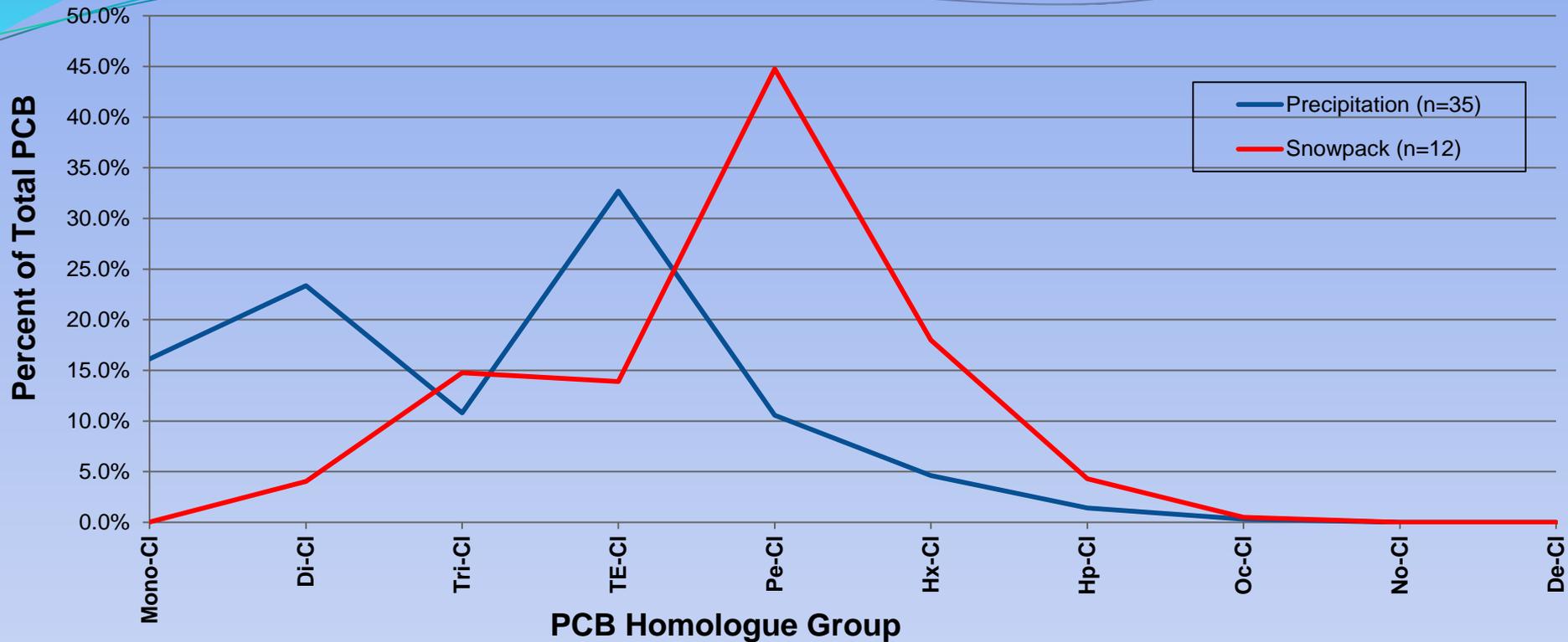
	Aroclor				
	1016	1242	1248	1254	1260
Mono-CBs	2	1	—	—	—
Di-CBs	19	13	1	—	—
Tri-CBs	57	45	21	1	—
Tetra-CBs	22	31	49	15	—
Penta-CBs	—	10	27	53	12
Hexa-CBs	—	—	2	26	42
Hepta-CBs	—	—	—	4	38
Octa-CBs	—	—	—	—	7
Nona-CBs	—	—	—	—	1
Deca-CB	—	—	—	—	—

- Columns may not total 100% due to rounding; "—" signifies less than 1%.
- Lot-to-lot variability exists but has not been quantified.
- Impurities include chlorinated dibenzofurans and naphthalenes; see World Health Organization (WHO) (1993) for sample concentrations.
- Sources: Adapted from Silberhorn et al. (1990), ATSDR (1995).

Typical Homologue Distribution for Some Aroclors



Homologue Distribution in Precipitation (rainfall) and Snowpack

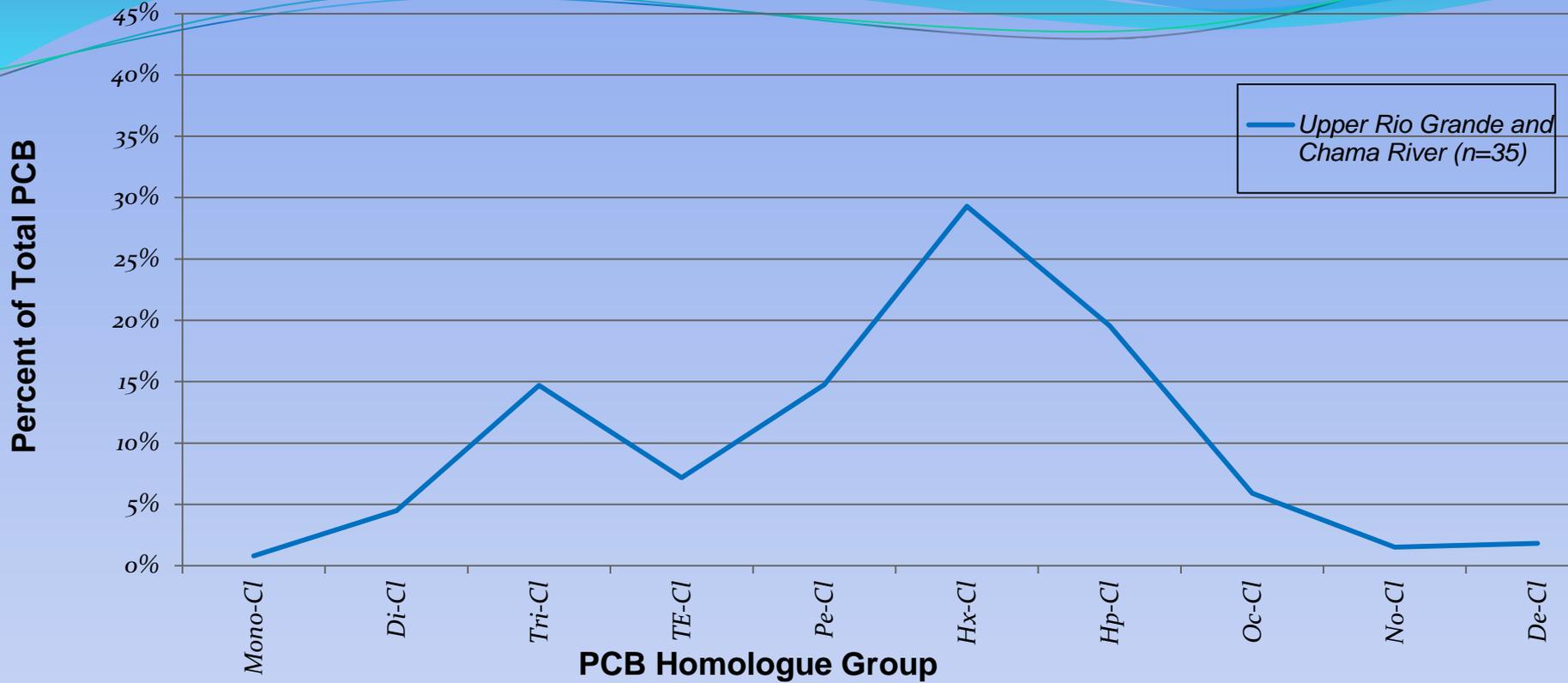


Rainfall demonstrates a bimodal distribution with peaks in the Di-CL and Te-CL homologue groups while snowpack demonstrates a shift toward higher chlorinated PCBs

Volatilization of lower chlorinated congeners in snowpack?

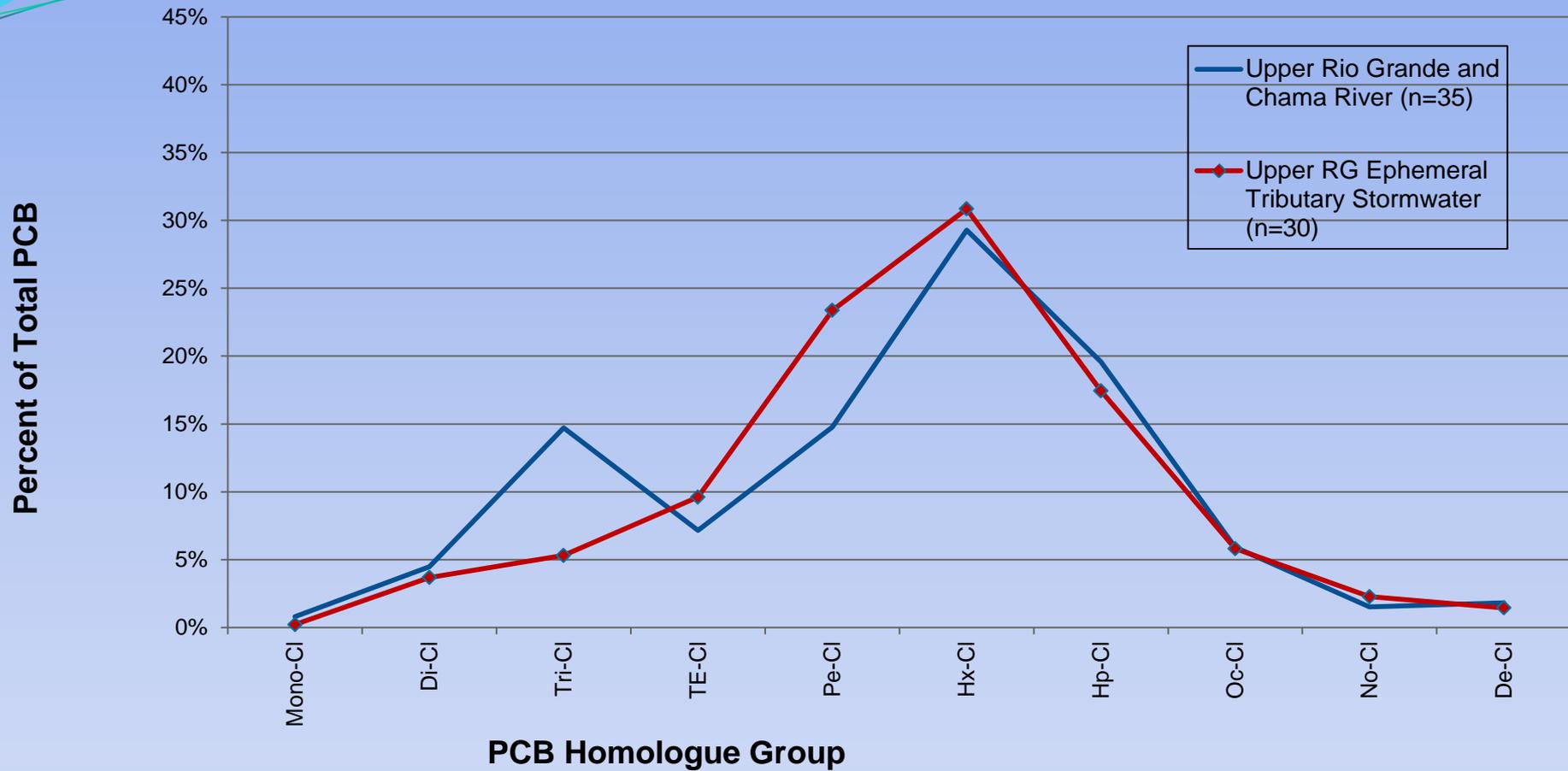
Increased dust loading on snowpack – source of higher chlorinated congeners?

Homologue Distribution in Stormwater



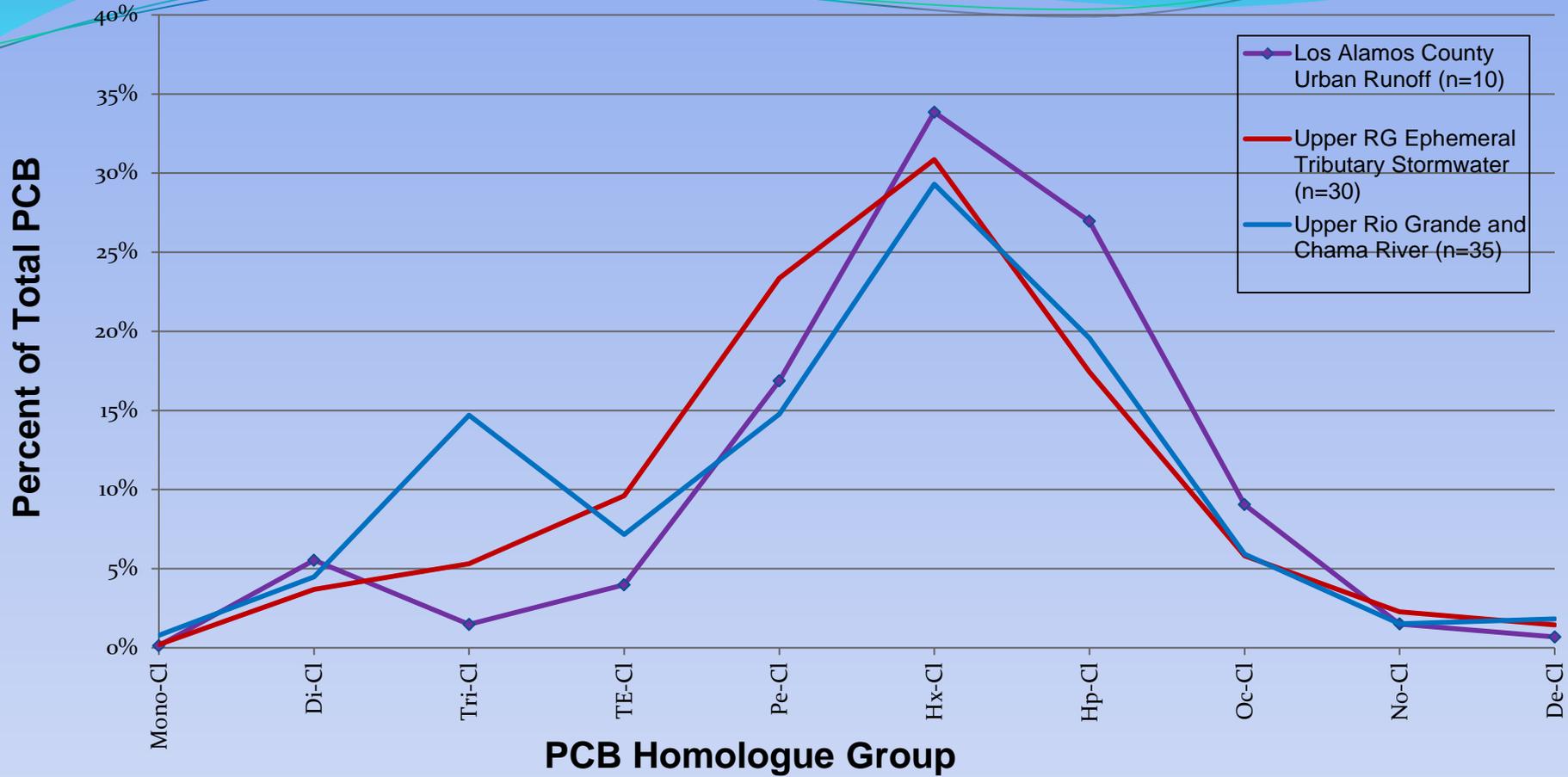
Upper Rio Grande and Chama River stormwater exhibits a bimodal homologue distribution with peaks in the Tri-CL and Hx-CL homologue groups

Homologue Distribution in Stormwater



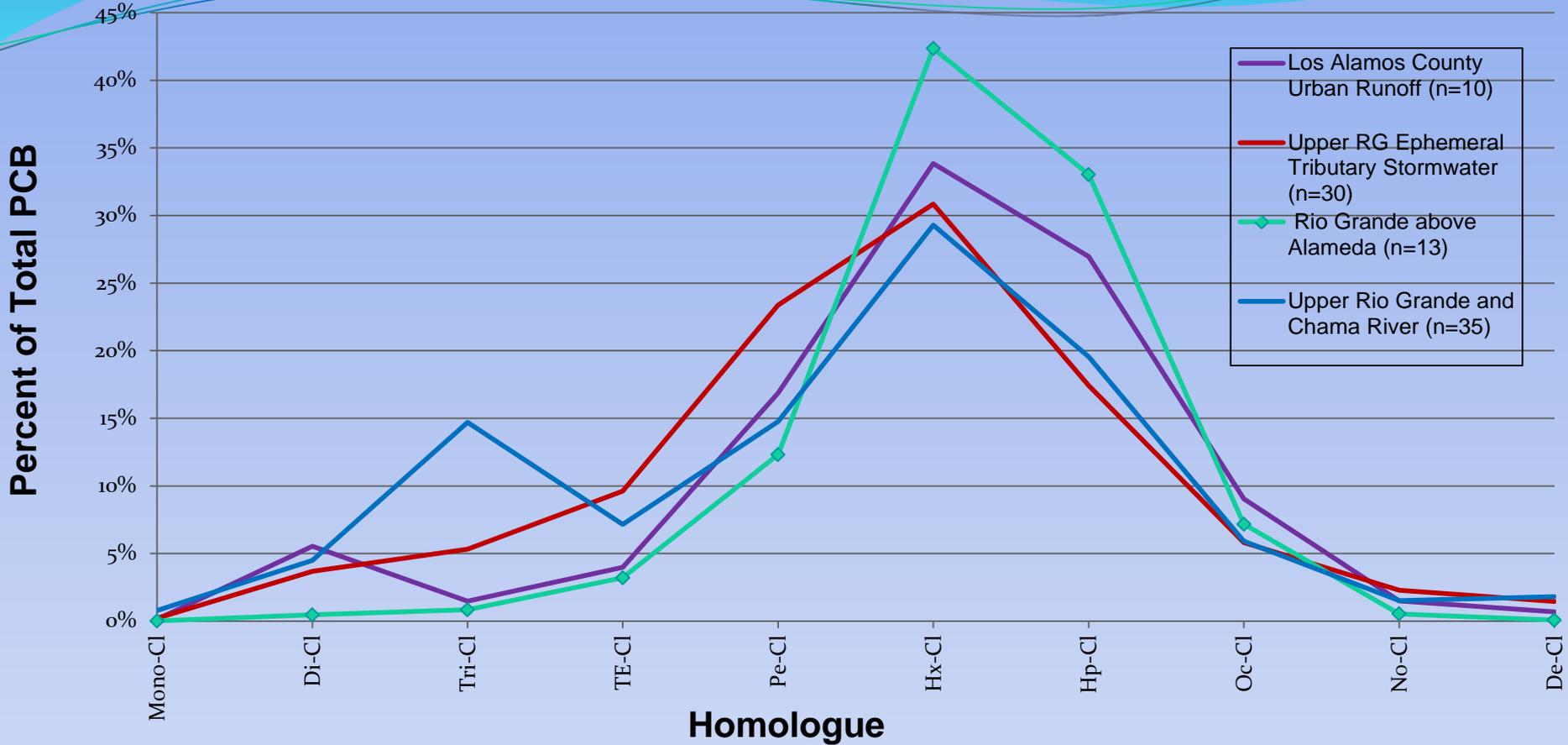
Ephemeral tributary stormwater (**red**) does not have the same bimodal pattern as Rio Grande stormwater and there is a slight shift towards larger levels of higher chlorinated congeners

Homologue Distribution in Stormwater



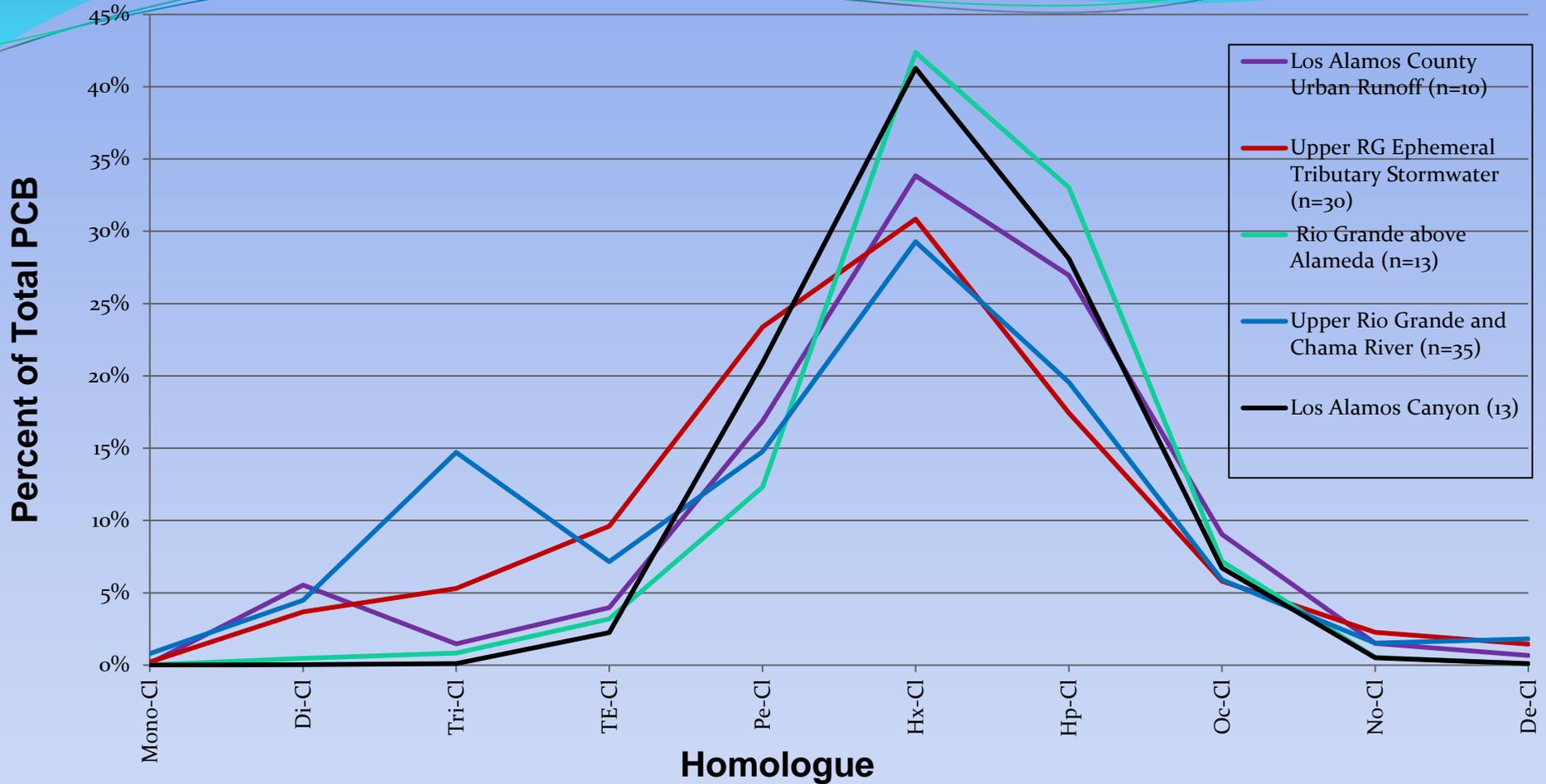
Los Alamos County urban runoff (**purple**) displays smaller levels of the lower chlorinated congeners and a shift towards higher chlorinated congeners

Homologue Distribution in Stormwater



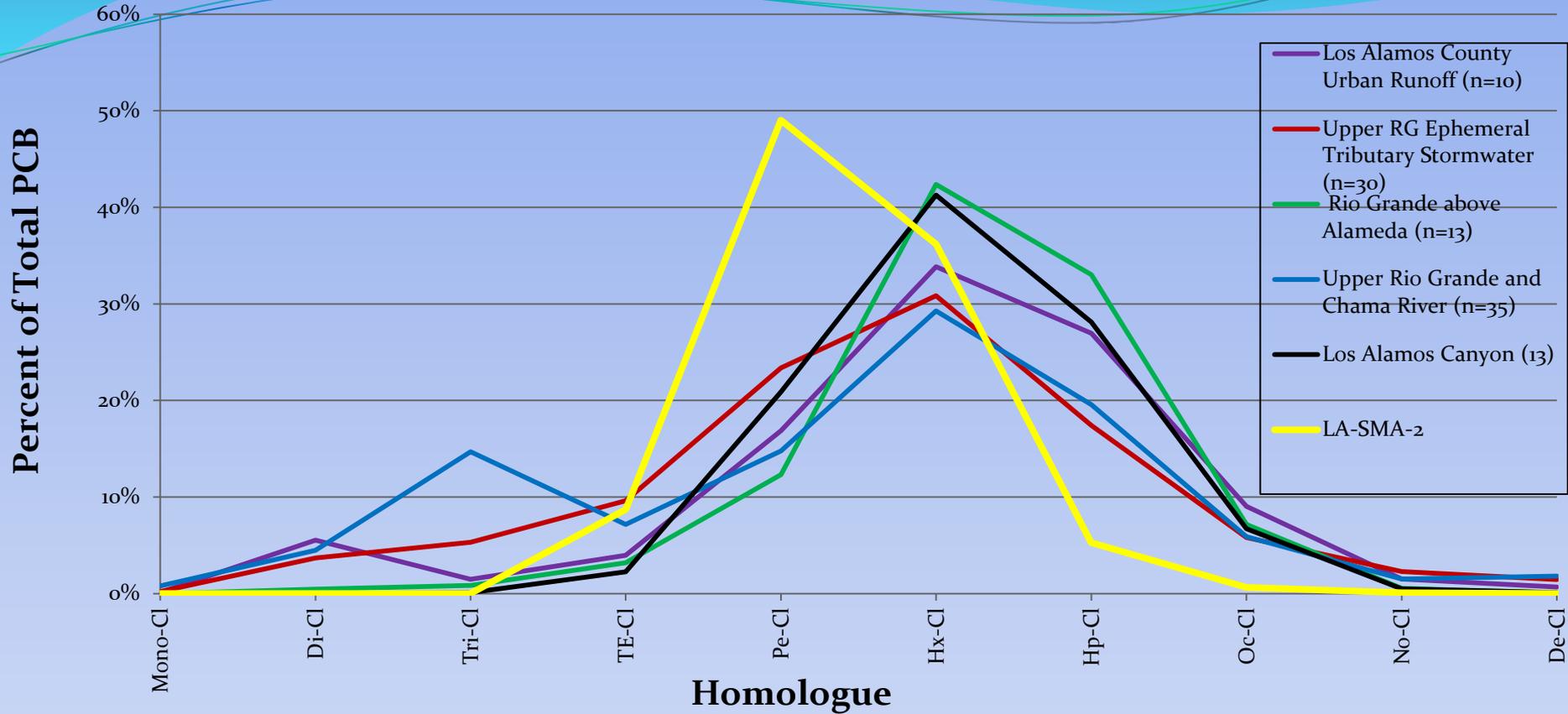
Rio Grande above Alameda stormwater (**teal**) shows a continued reduction of lower chlorinated congeners and the highest levels of Hx-CL and Hp-CL congeners

Homologue Distribution in Stormwater



Middle Los Alamos Canyon (**black**) homologue pattern is similar to what we see in the Rio Grande above Alameda

Homologue Distribution in Stormwater



Aroclor 1254 was used as a cutting oil which was discharged into a septic tank which drained into small ephemeral drainage in Los Alamos Canyon.

LA-SMA-2 is the monitoring point for that drainage and the homologue pattern is unique to that drainage

Summary

Baseline flows in the upper Rio Grande and tributaries, snowpack and precipitation are nearly always below the Human Health criteria

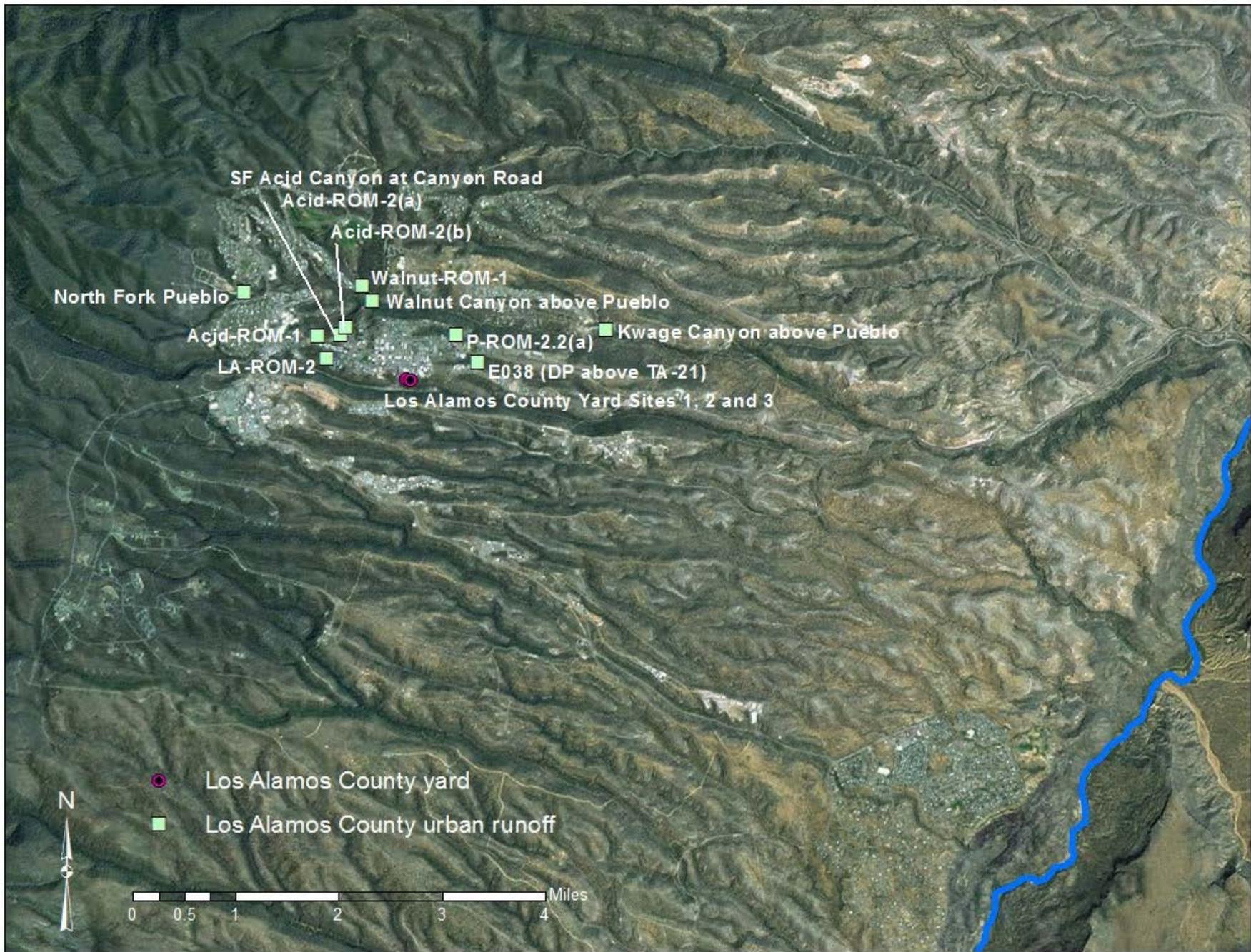
Upper Rio Grande and ephemeral tributary stormwater often exceed the Human Health criteria and occasionally exceed the Wildlife Habitat criteria

Los Alamos County urban runoff, Rio Grande above Alameda and LANL watersheds nearly always exceed the Human Health criteria and usually exceed the Wildlife Habitat criteria

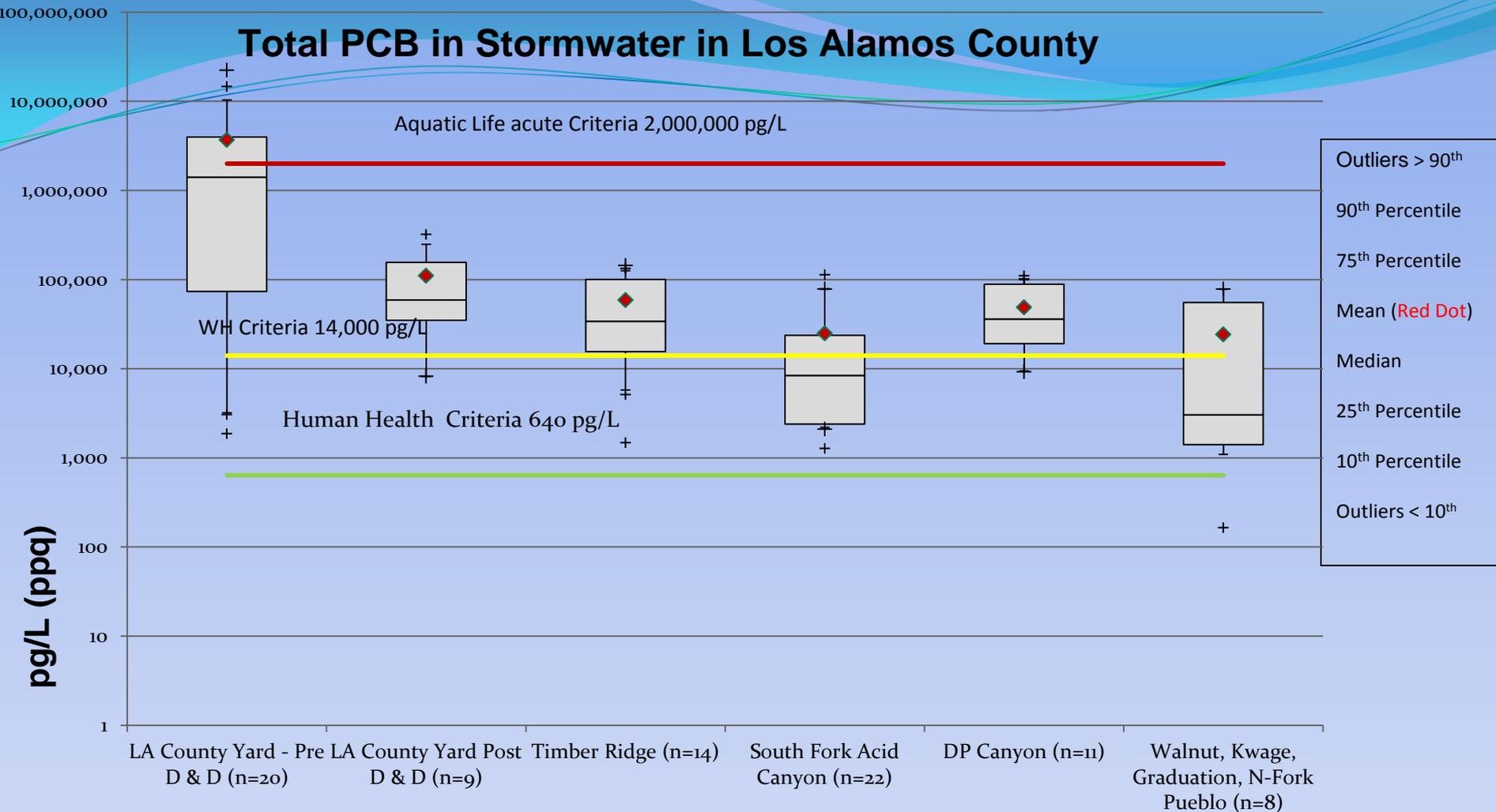
Stormwater below LANL SWMUs nearly always exceeds the Wildlife Habitat criteria and exceeds the Aquatic Life Acute criteria in twenty-five percent of the samples collected

Normalizing total PCB in water data to SSC can be used to evaluate between baseline levels of PCBs and those impacted by potentially contaminated sources

PCB homologue signatures can be used to differentiate between different source terms

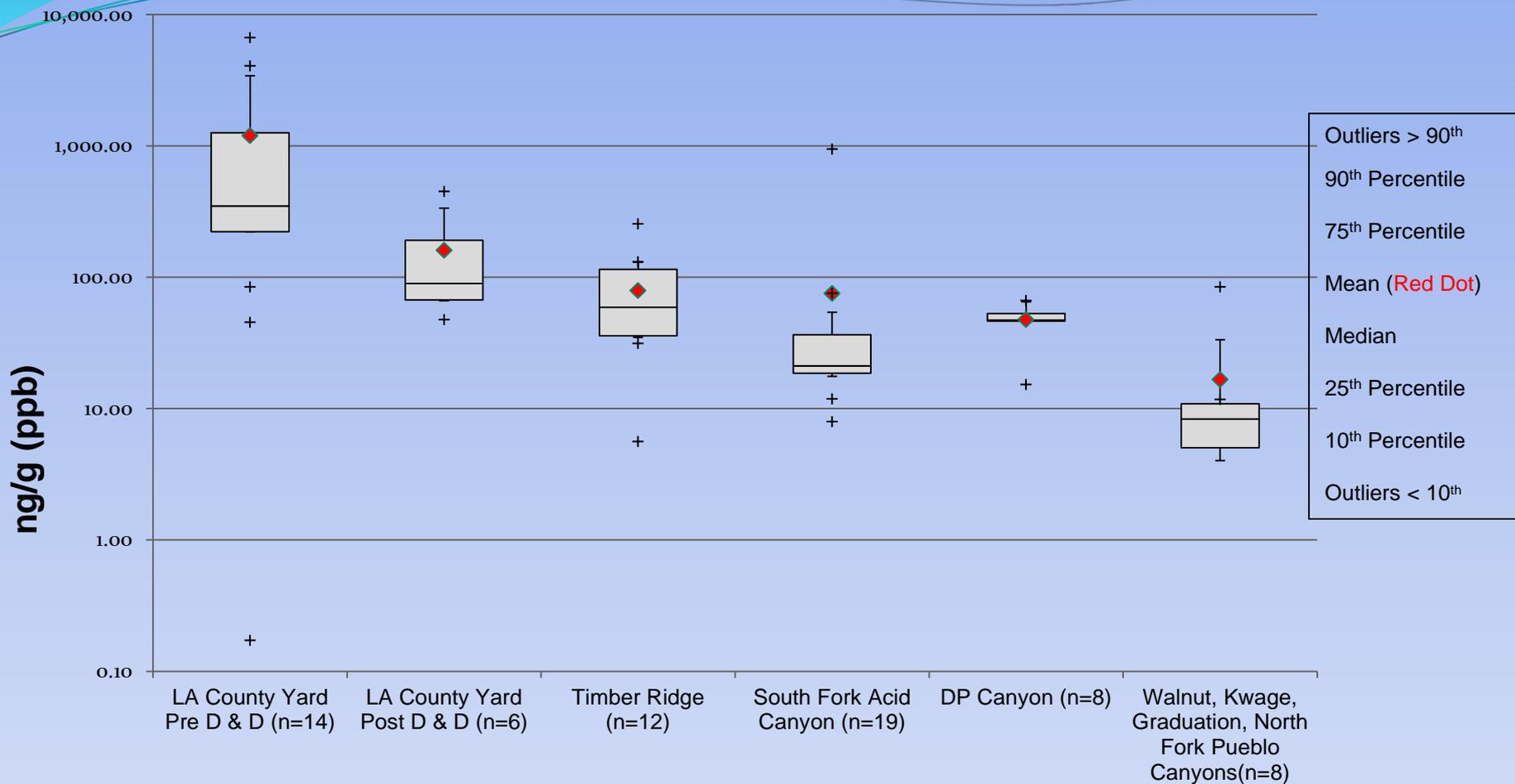


Total PCB in Stormwater in Los Alamos County



Mean	3,673,782	110,400	58,830	24,887	48,729	24,230
Median	1,410,000	59,000	34,100	8,410	36,100	3,040

Total PCB in Suspended Sediment in Los Alamos County Stormwater Runoff

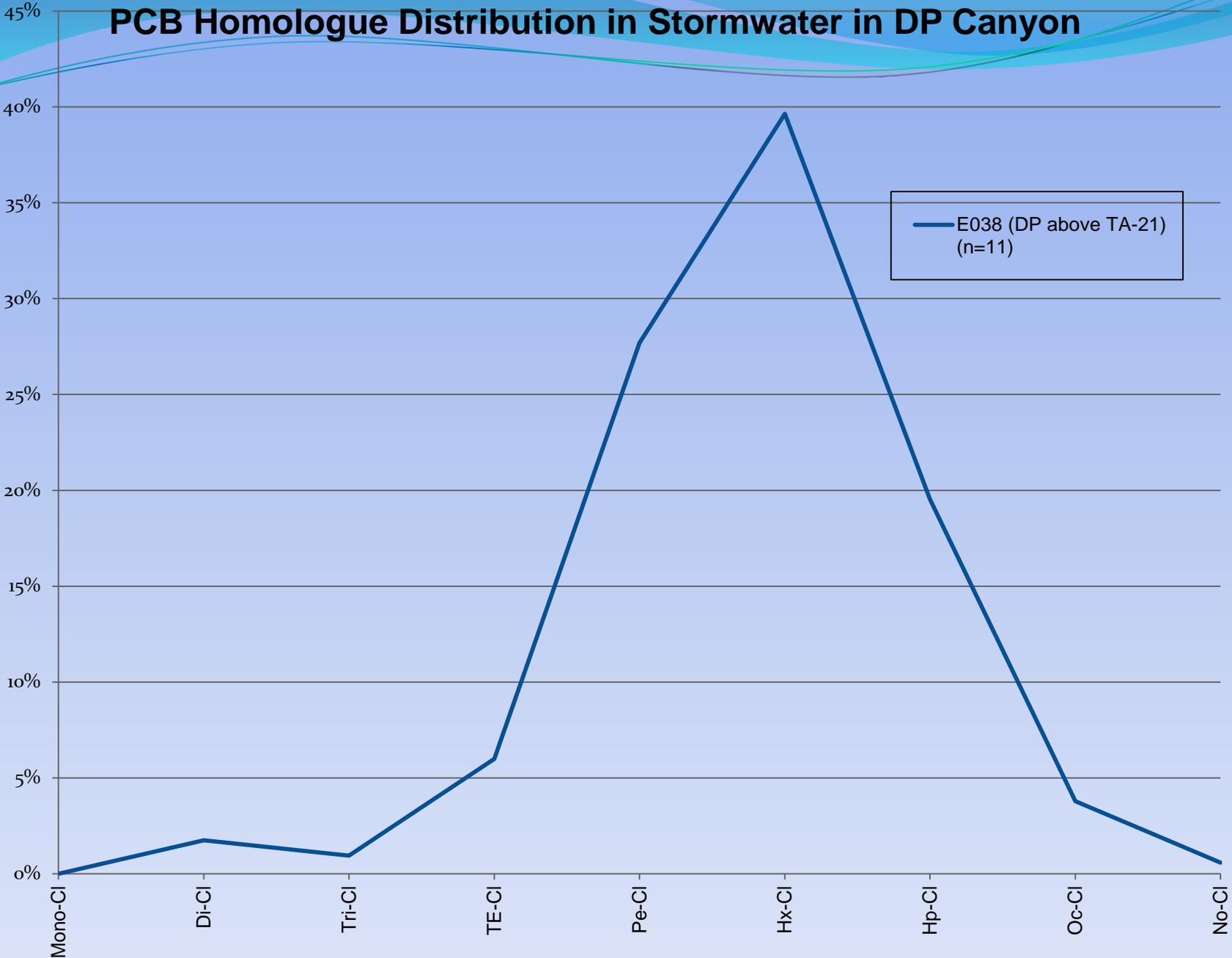


Mean	1,192	160	79	75	48	17
Median	348	90	59	21	47	8

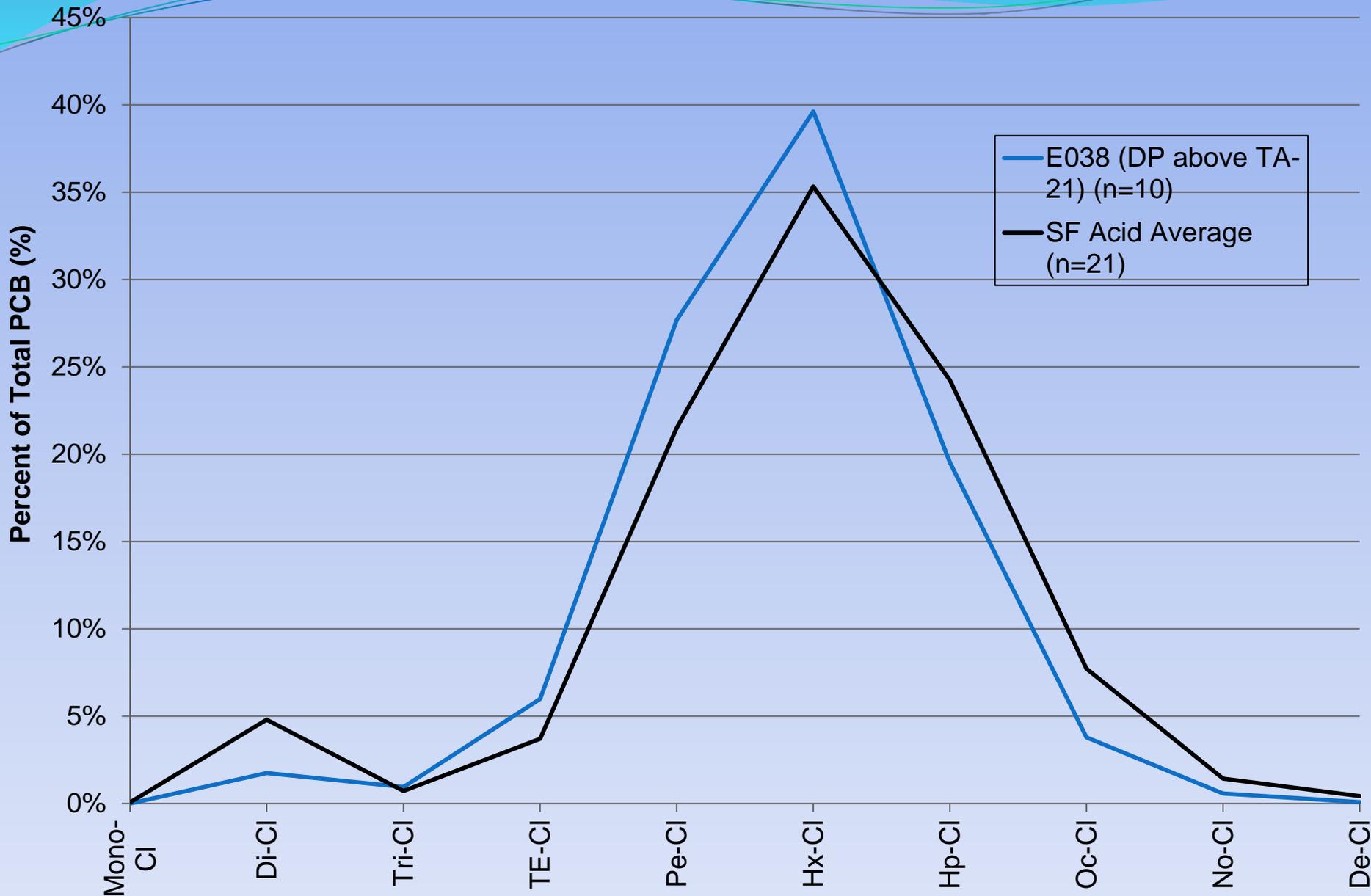
PCB Homologue Distribution in Stormwater in DP Canyon

Percent of Total PCB (%)

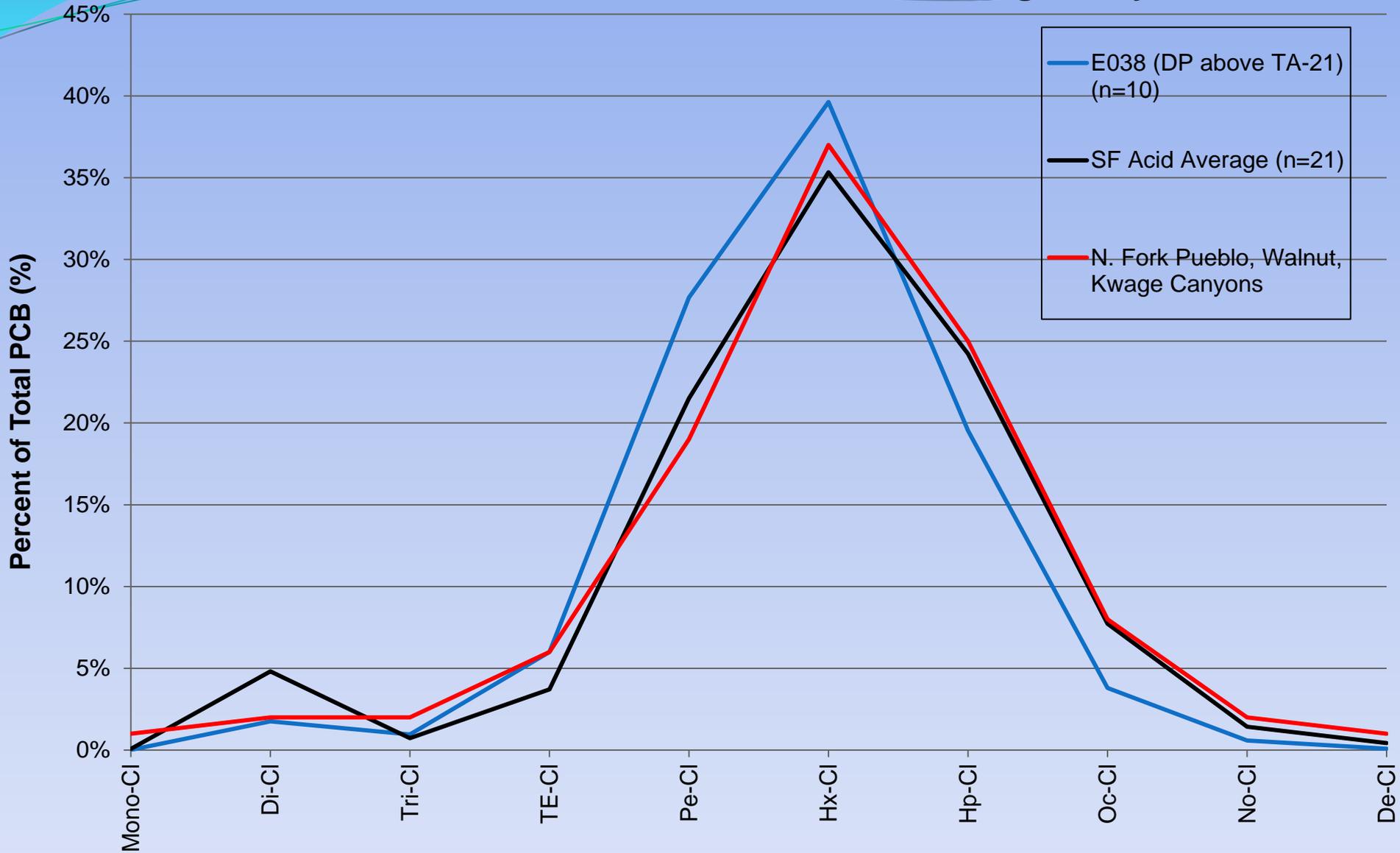
E038 (DP above TA-21)
(n=11)



PCB Homologue Distribution in Stormwater in DP and South Fork Acid Canyons

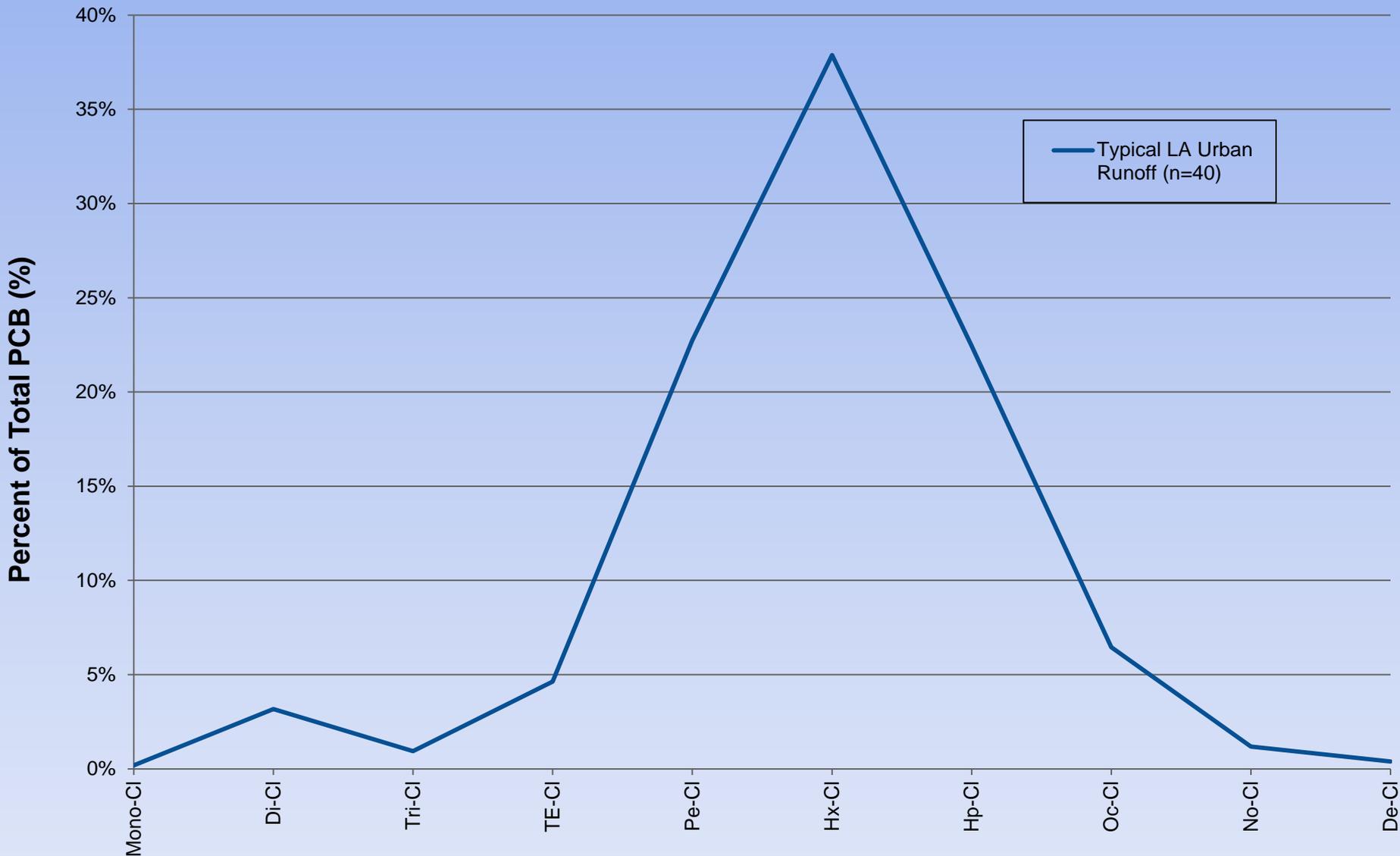


PCB Homologue Distribution in Stormwater in DP, S. Fork Acid, N. Fork Pueblo, Walnut, and Kwage Canyons

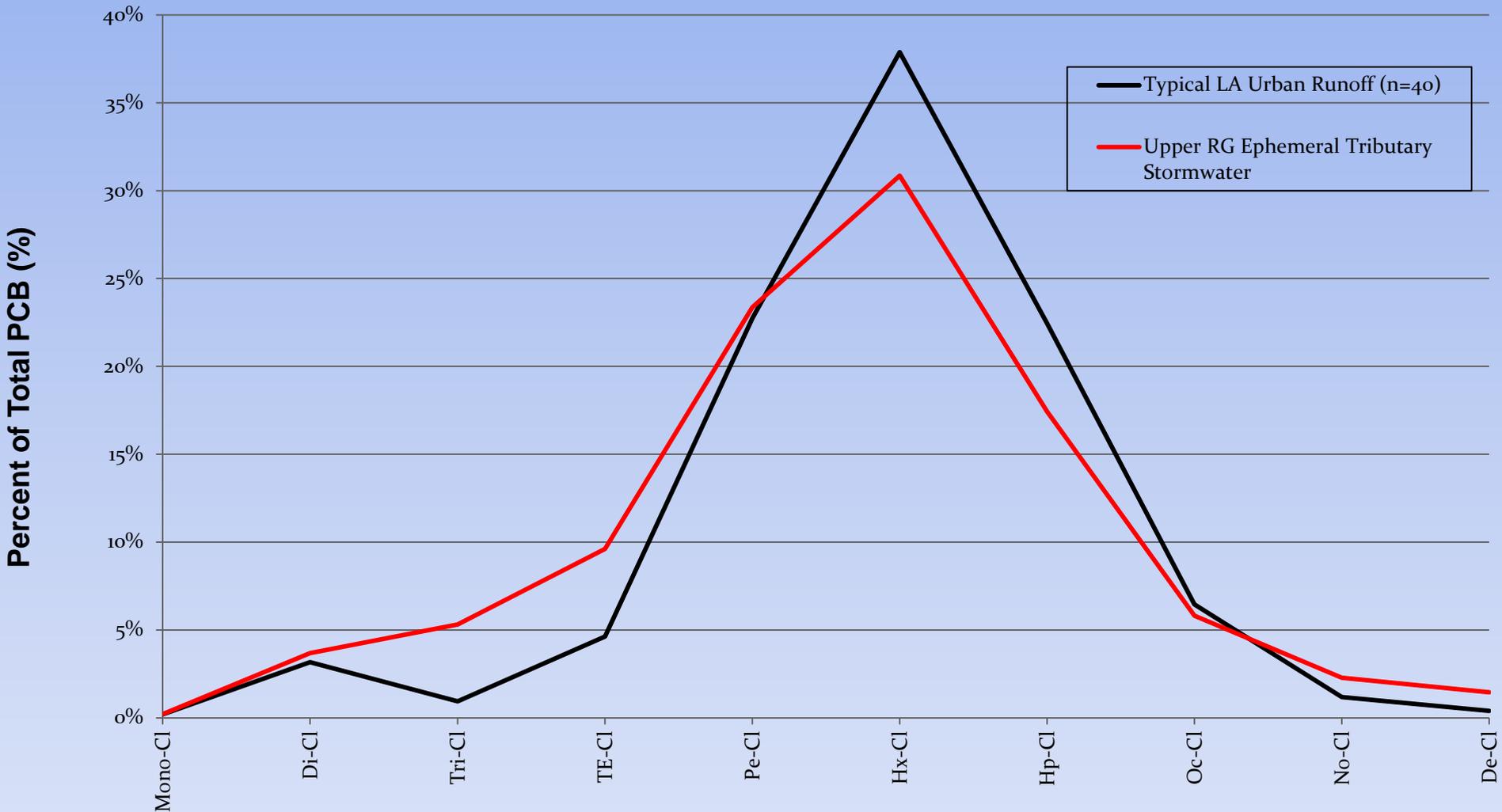


PCB Homologue Distribution in Typical LA Urban Runoff (n=40)

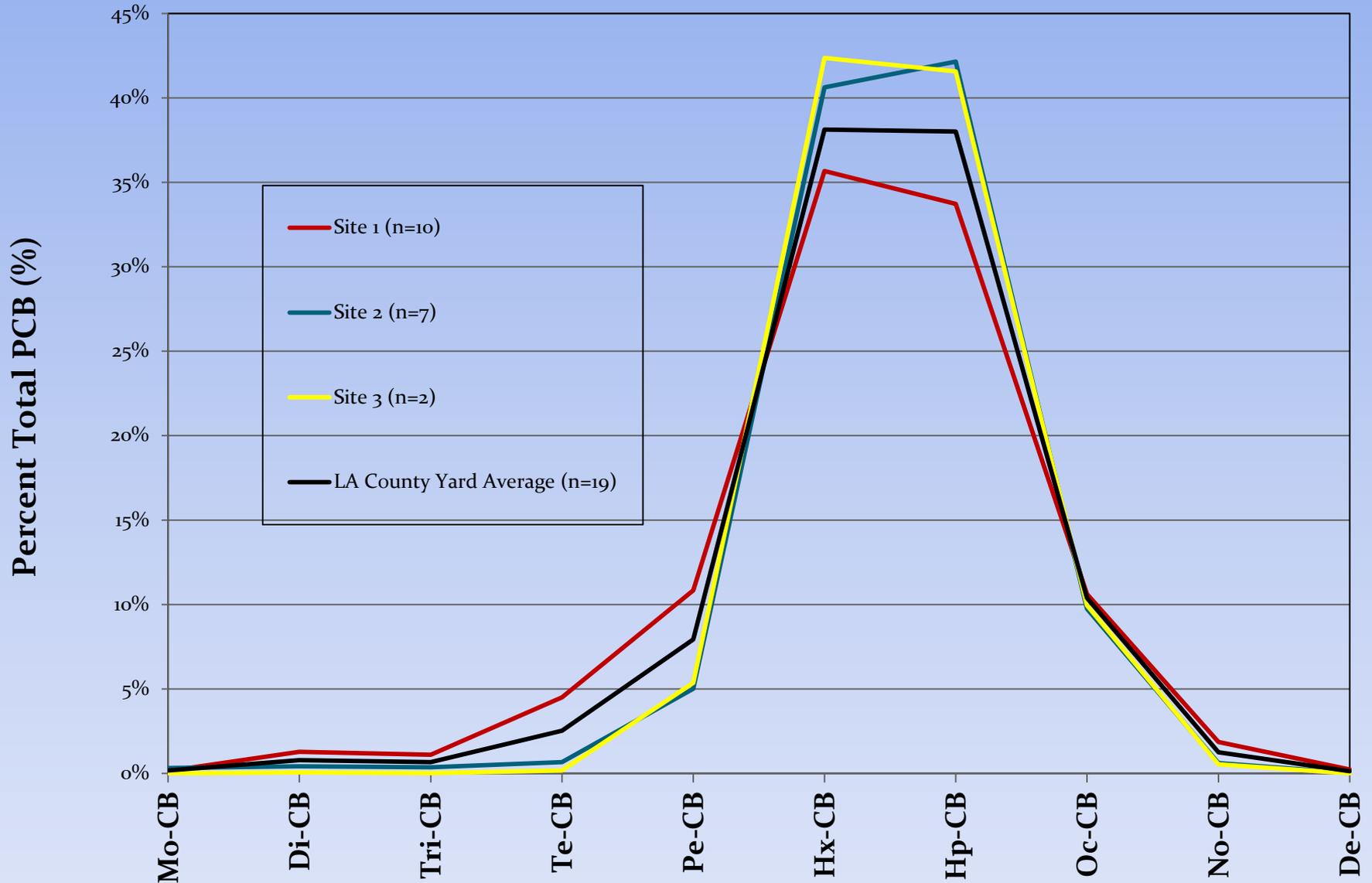
South Fork Acid, DP, Graduation, Kwage, Walnut,
North Fork Pueblo Canyons



PCB Homologue Distribution in Typical Los Alamos County Urban Runoff vs Upper Rio grande Ephemeral Tributary Stormwater

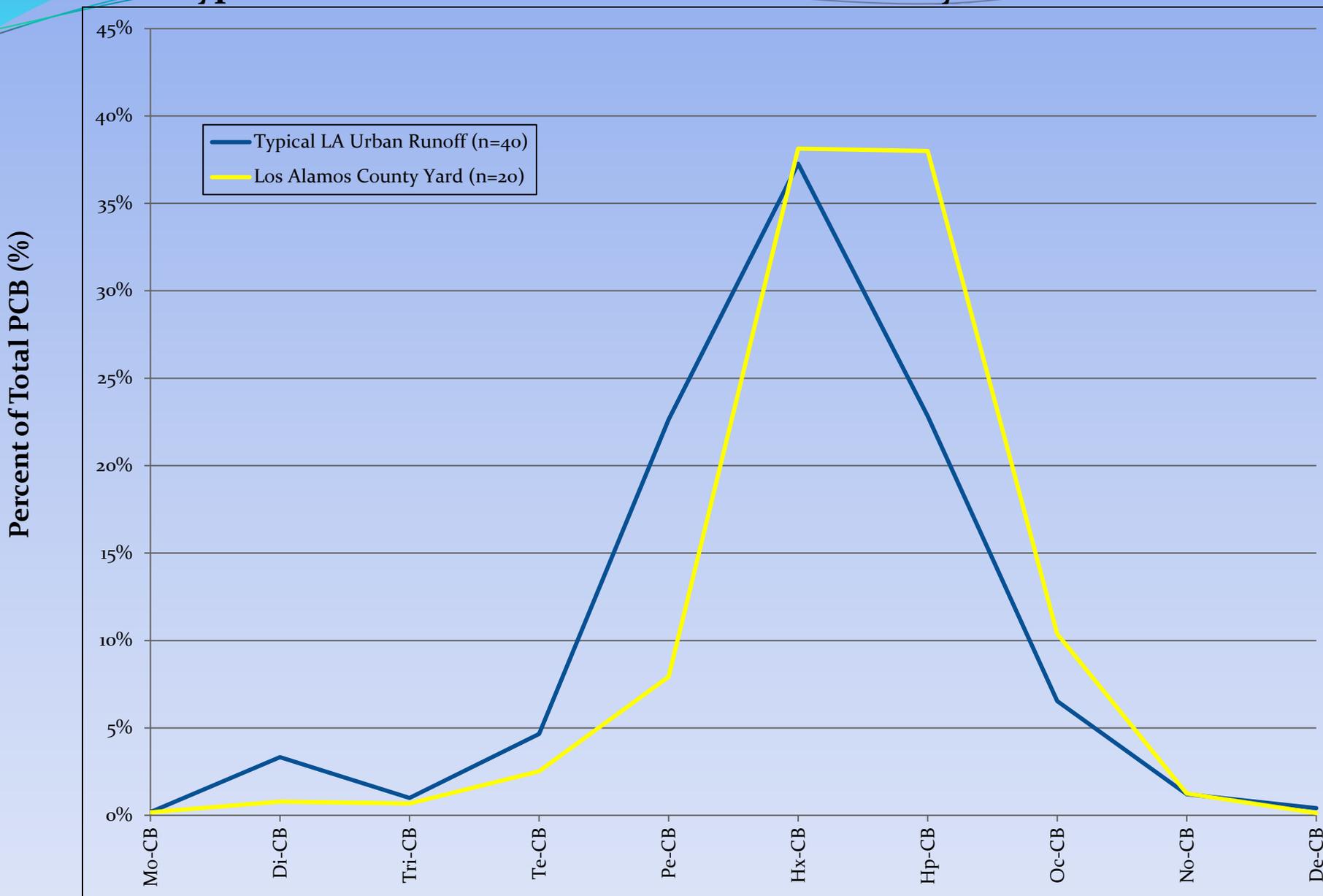


PCB Homologue Distribution Los Alamos County Yard



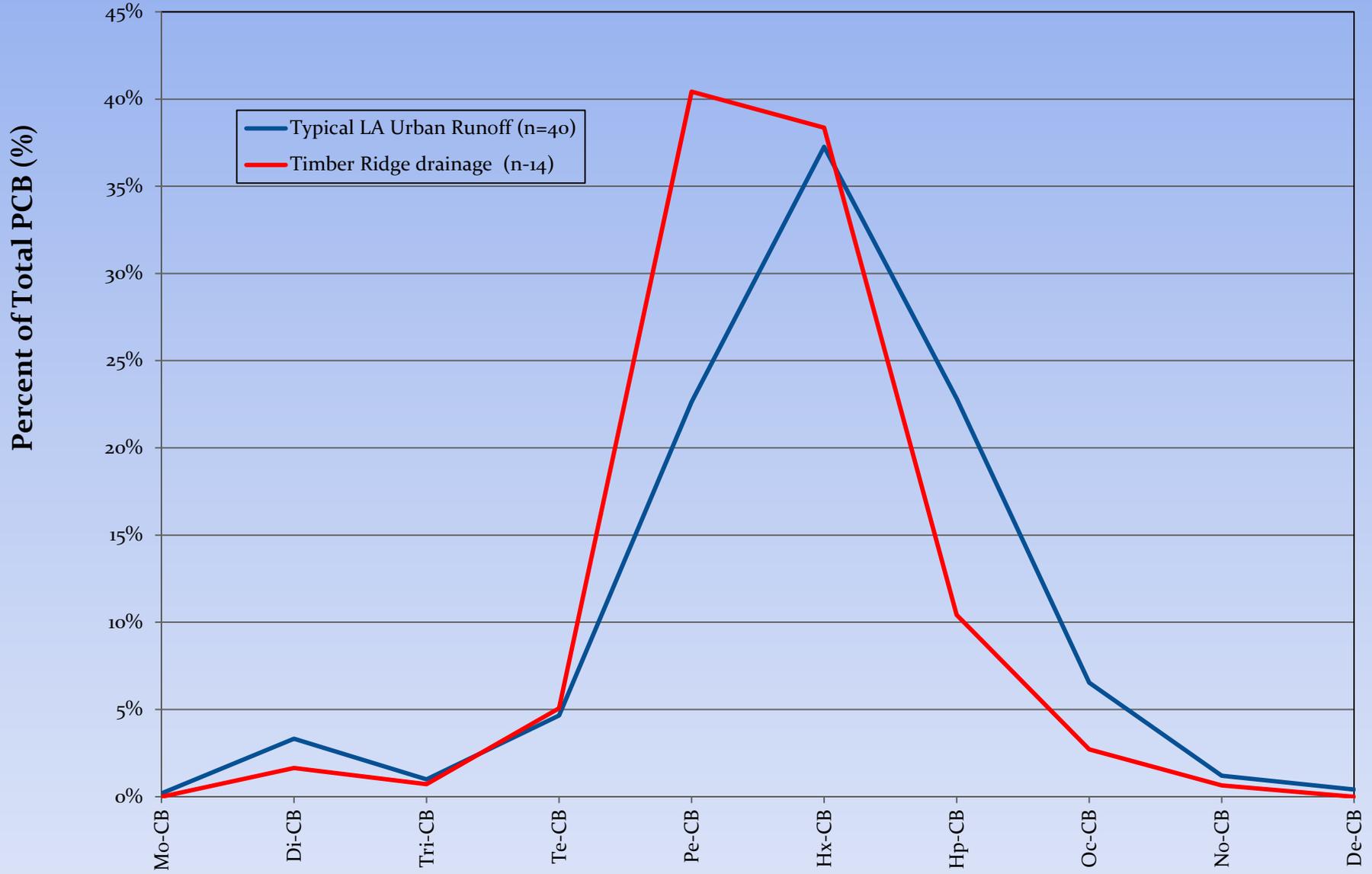
PCB Homologue Distribution

Typical LA Urban Runoff vs Las Alamos county Yard Runoff

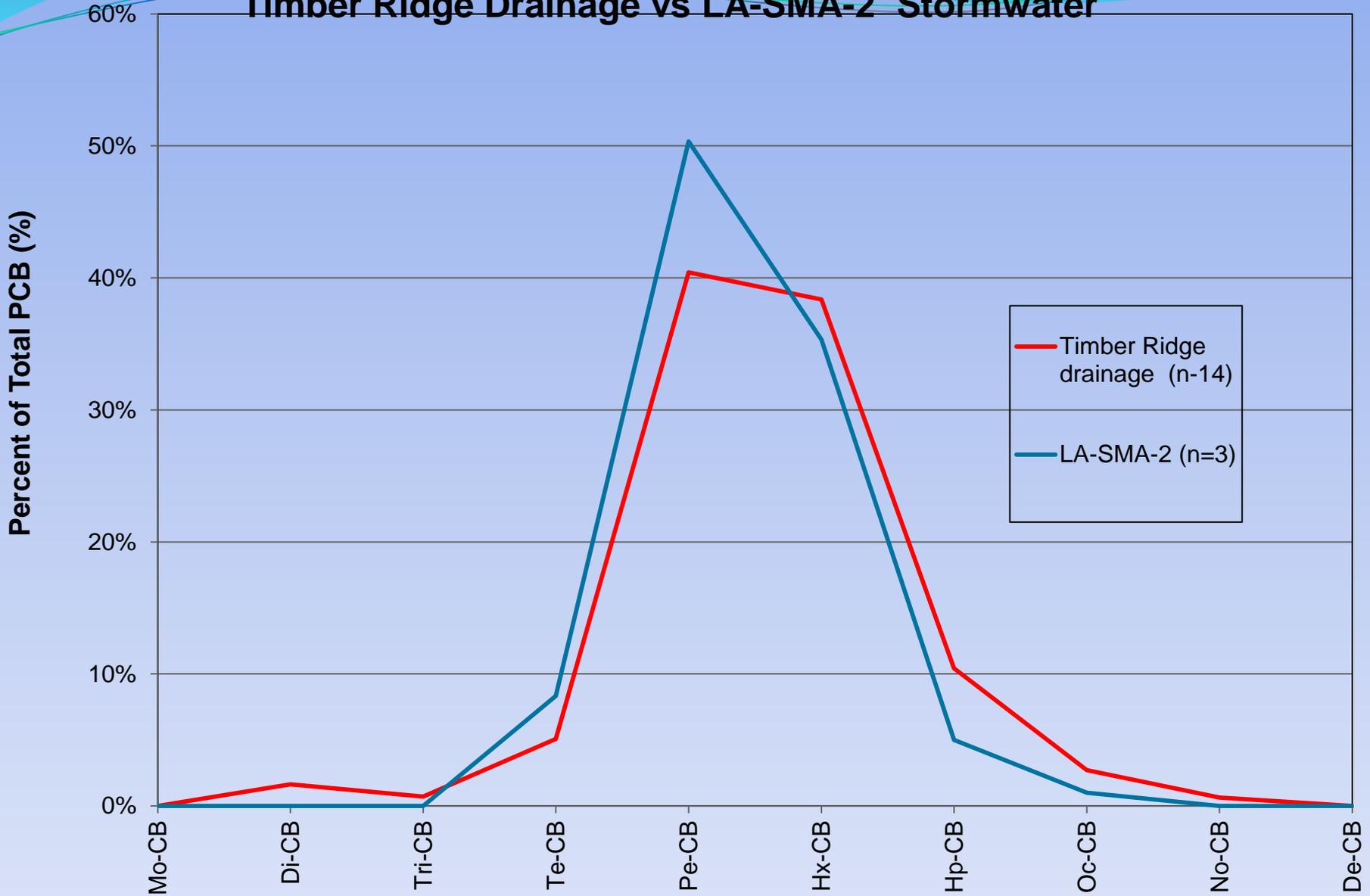


PCB Homologue Distribution

Typical LA Urban Runoff vs Timber Ridge Runoff



PCB Homologue Distribution Timber Ridge Drainage vs LA-SMA-2 Stormwater



Los Alamos County Summary

Concentrations of PCBs in stormwater runoff from Los Alamos County urban areas are nearly always greater than the New Mexico Human Health water quality criteria.

Concentrations of PCBs in stormwater runoff from Los Alamos County urban areas are usually greater than the New Mexico Wildlife Habitat water quality criteria.

Average concentrations of PCB in Los Alamos County urban runoff (0.034ug/L; n=55) are 2.4 times the New Mexico Wildlife Habitat water quality criteria (0.014 ug/L). Median value was 0.017 ug/L.

Average concentration of PCB in suspended sediments in Los Alamos County urban runoff is 61 ng/g (ppb); (n=47). Median value was 34 ng/g (ppb).

Using an average concentration of 61 ng/g in suspended sediments, the suspended sediment concentration would have to be reduced to 230 mg/L to meet the WH Habitat Criteria.

Recent work at the Los Alamos County Yard (future Trinity development site) has reduced the average PCB concentrations in stormwater by over 33 times and the average levels in suspended sediment by 7.5 times

Contact Information

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