

Pharmaceuticals and Personal Care Products (PPCPs) in the Streams and Aquifers of the Great Miami River Basin



MIAMI
CONSERVANCY
DISTRICT

SINCE THE PHARMACY
IS CLOSED, THE DOCTOR
SAID YOU SHOULD TAKE
THREE GLASSES OF WATER...



El Gráfico

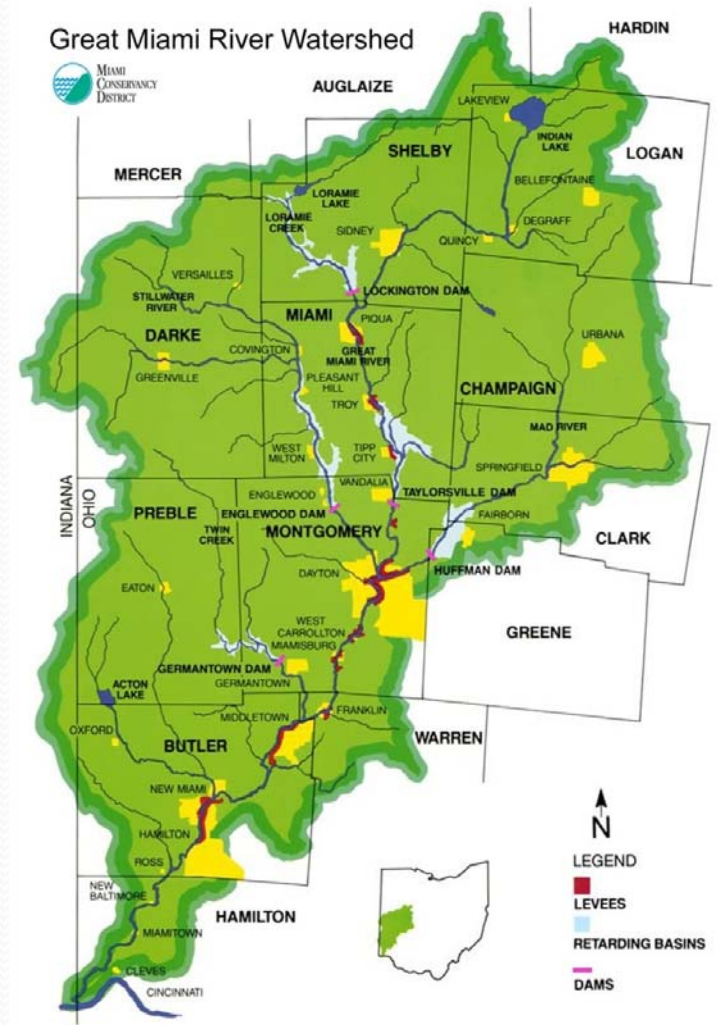
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FRAGILE KEEP FROZEN
BELOW 0°F

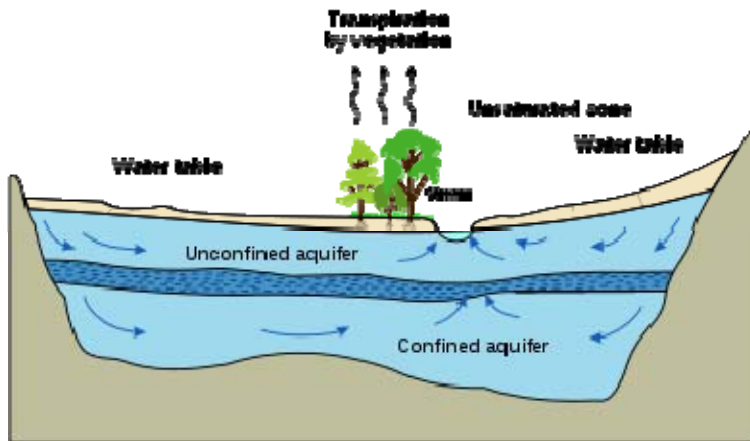


Great Miami River Basin

- 4,000 mi²
- Major tributaries:
 - Great Miami River
 - Stillwater River
 - Mad River
 - Wolf and Twin Creeks
- 1.7 million residents
- Dayton is largest city



Buried Valley Aquifers

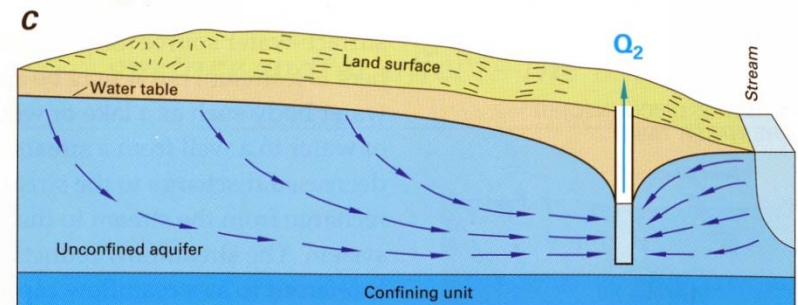
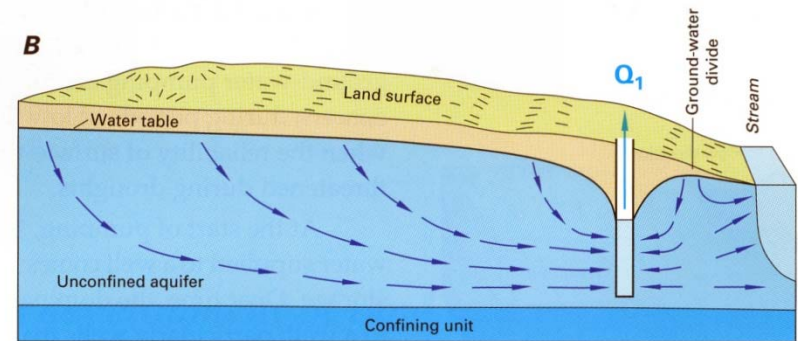
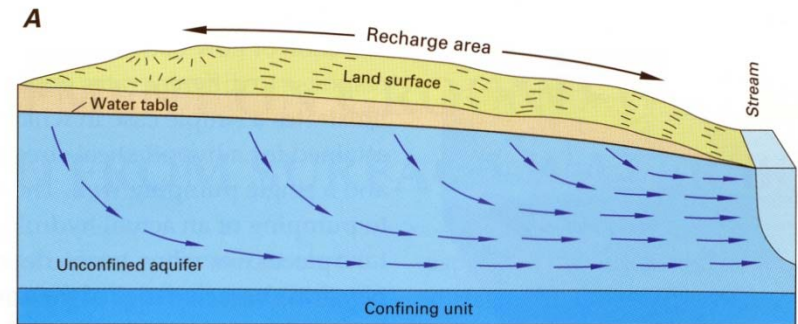


-  High hydraulic conductivity aquifer
-  Low hydraulic conductivity confining unit
-  Very low hydraulic conductivity bedrock
-  Direction of ground-water flow



Pathways for exposure to PPCPs in drinking water

1. Wastewater discharge to river
 - a) Induced infiltration from river to aquifer to well
 - b) Flood event to aquifer to well
2. Septic Systems to aquifer to river or well



Goals



1. Compare concentrations of PPCPs between high flows and low flows
2. Compare concentrations of PPCPs in effluent, surface water and groundwater
3. Construct upstream to downstream profiles of PPCP concentrations
4. Evaluate risk of exposure to PPCPs in drinking water

Target Analytes

MWH Method	Compounds Analyzed	MRL (ng/L)
EDC2SCR	Acetaminophen	1
	Atenolol	5
	BisPhenol A (BPA)	10
	Butalbital	5
	Caffeine	3
	Carbamazepine	5
	Cotinine	1
	Diazepam	1
	Estradiol	1
	Estrone	1
	Ethinyl Estradiol-17 alpha	5
	Fluoxetine	5
	Gemfibrozil	1
	Ibuprofen	1
	Iopromide	10
	Perfluorooctane sulfonate-PFOS	0.2
	Progesterone	1
	Sulfamethoxazole	1
	Testosterone	1
	Triclosan	5
	Trimethoprim	1

Compound	General Use
Acetaminophen	antipyretic and pain reliever, nonprescription drug
Atenolol	beta blocker, prescription drug
BisPhenol A (BPA)	used in polycarbonate plastics and epoxy resins
Butalbital	barbiturate, pain reliever, prescription drug
Caffeine	stimulant
Carbamazepine	anticonvulsant, prescription drug
Cotinine	nicotine metabolite
Diazepam	antianxiety/insomnia, prescription drug
Fluoxetine	antidepressant, prescription drug
Gemfibrozil	treatment of elevated blood lipids, prescription drug
Ibuprofen	anti-inflammatory, nonprescription drug
Iopromide	contrast agent for medical scans
Perfluorooctane sulfonate-PFOS	key ingredient in Scotchgard and fire-fighting foams
Sulfamethoxazole	antibiotic
Testosterone	reproductive hormone
Triclosan	antibacterial agent
Trimethoprim	antibiotic

Sampling Sites

WWTP Outfalls (3)

Headwater Streams (5)

Large River (15)

Monitoring Wells (7)

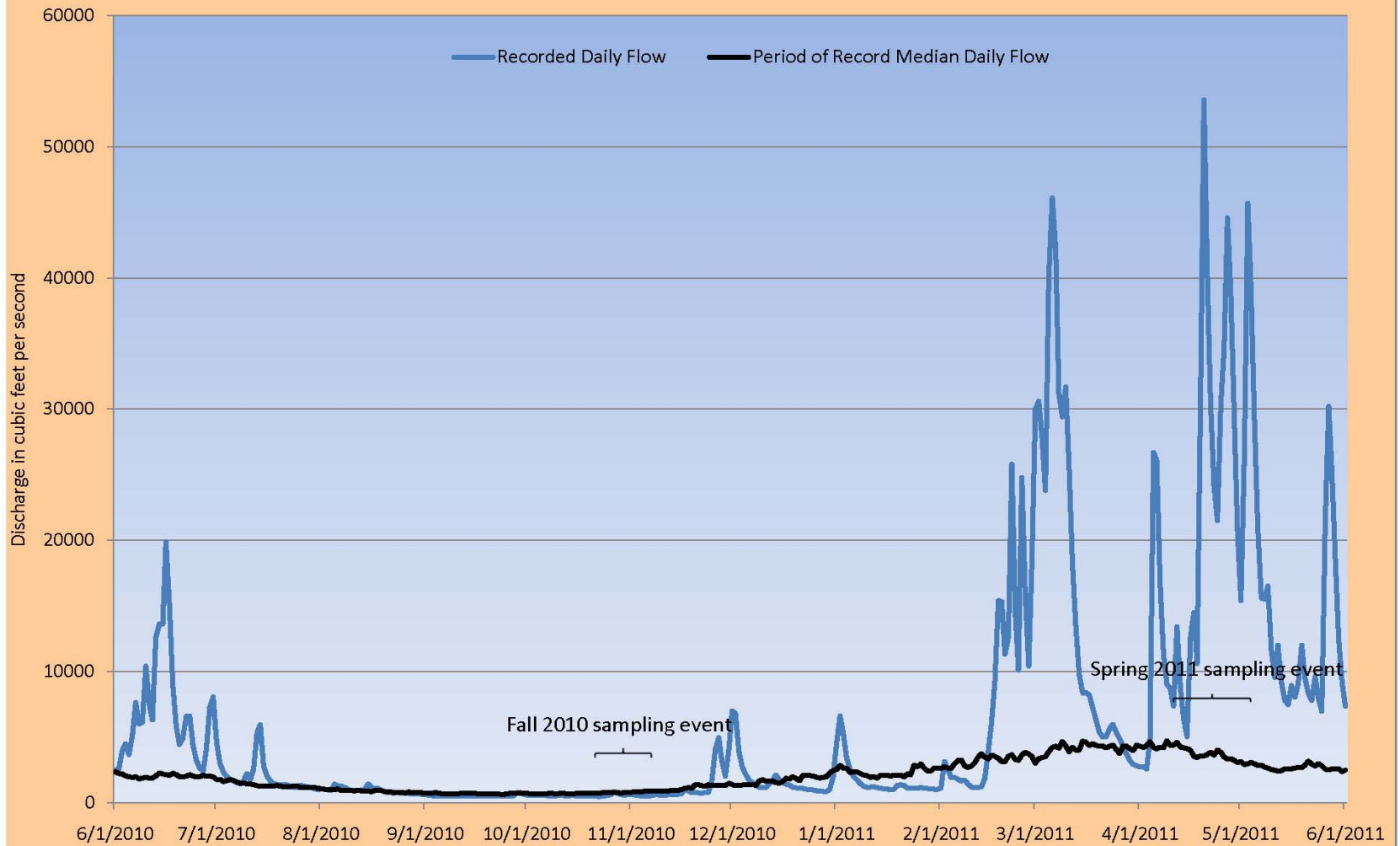
Production Wells (3)



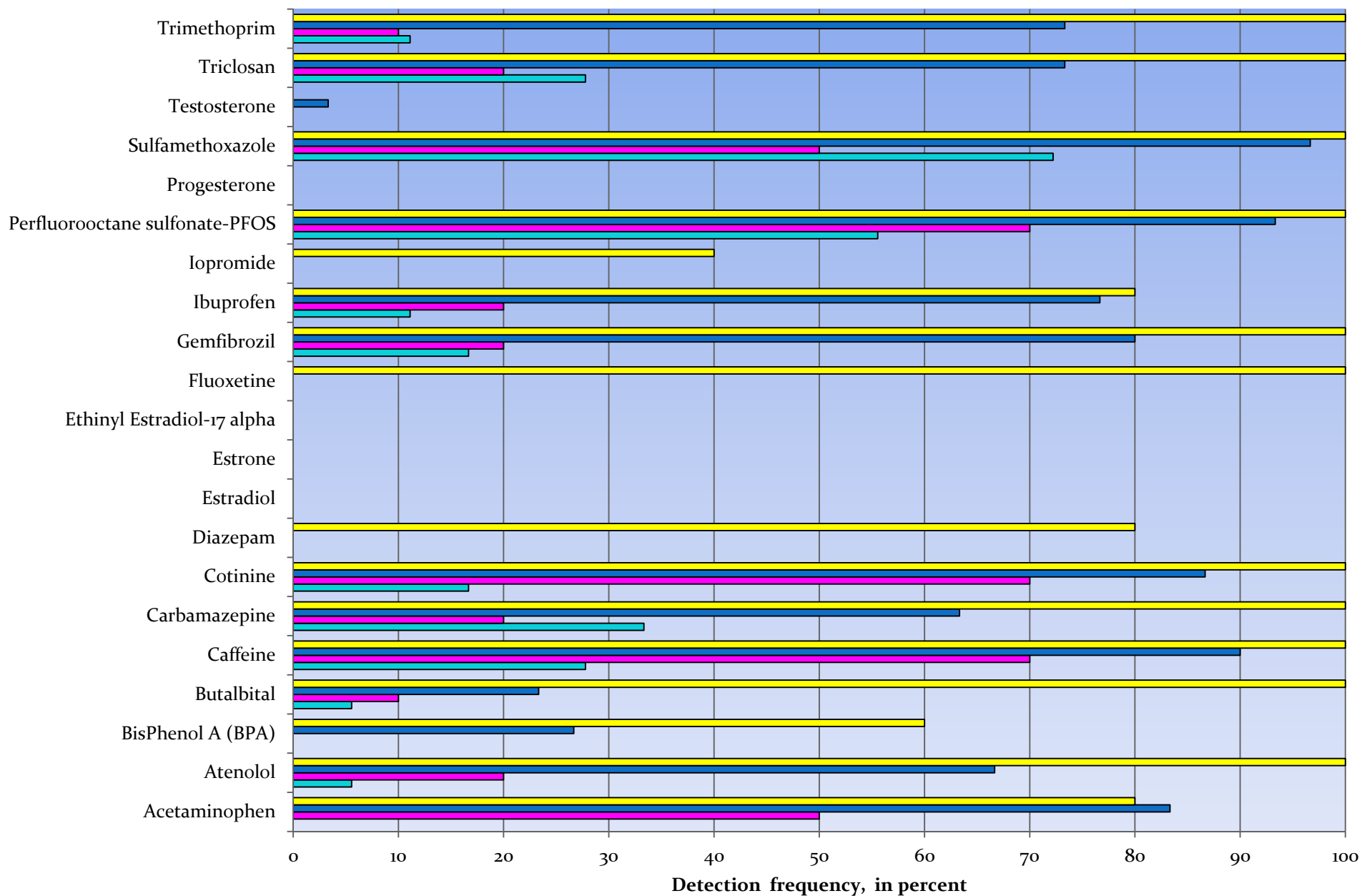




Great Miami River flow at Hamilton during sampling events



Detection frequency of PPCP compounds for all samples collected in this survey.

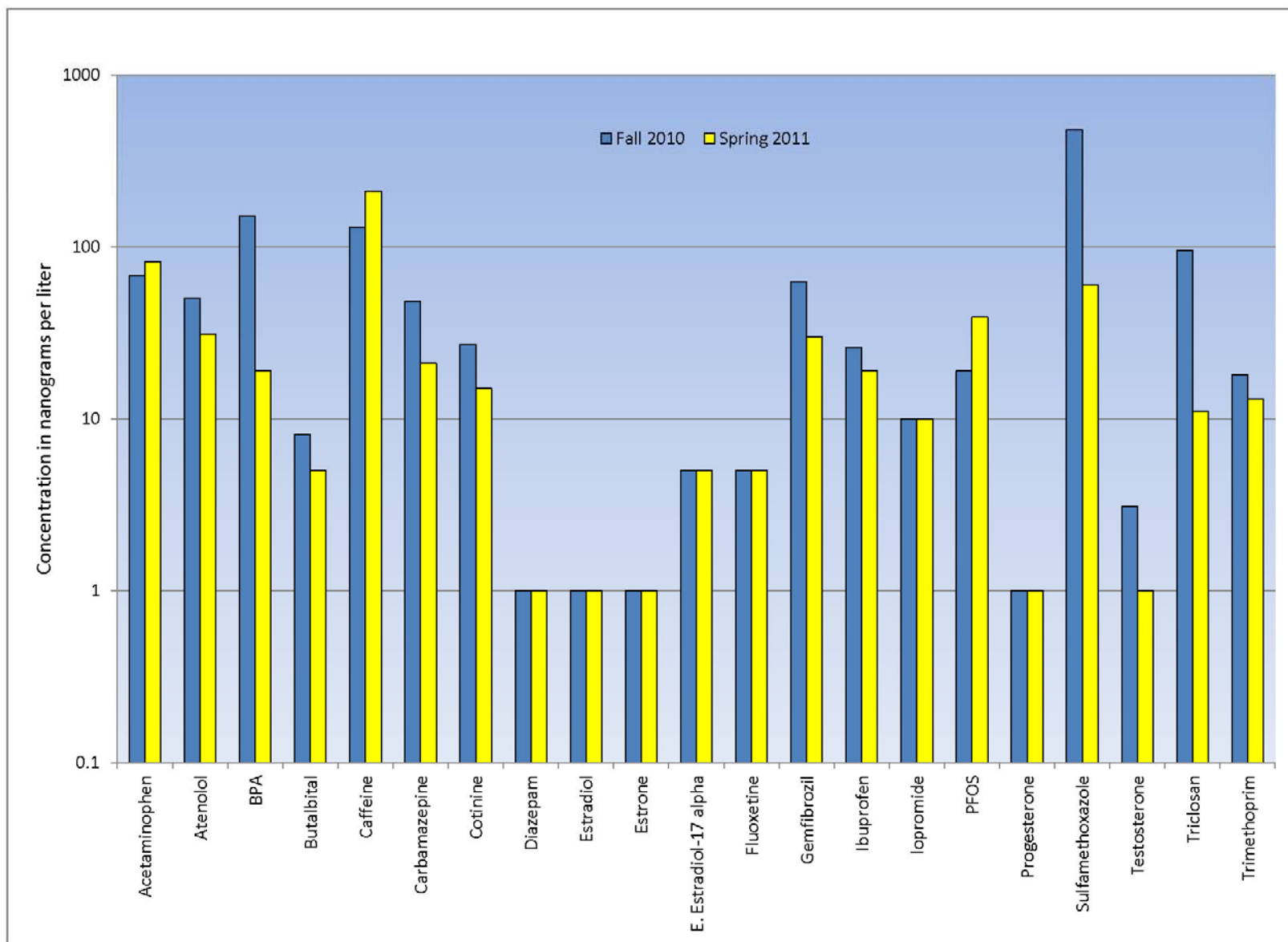


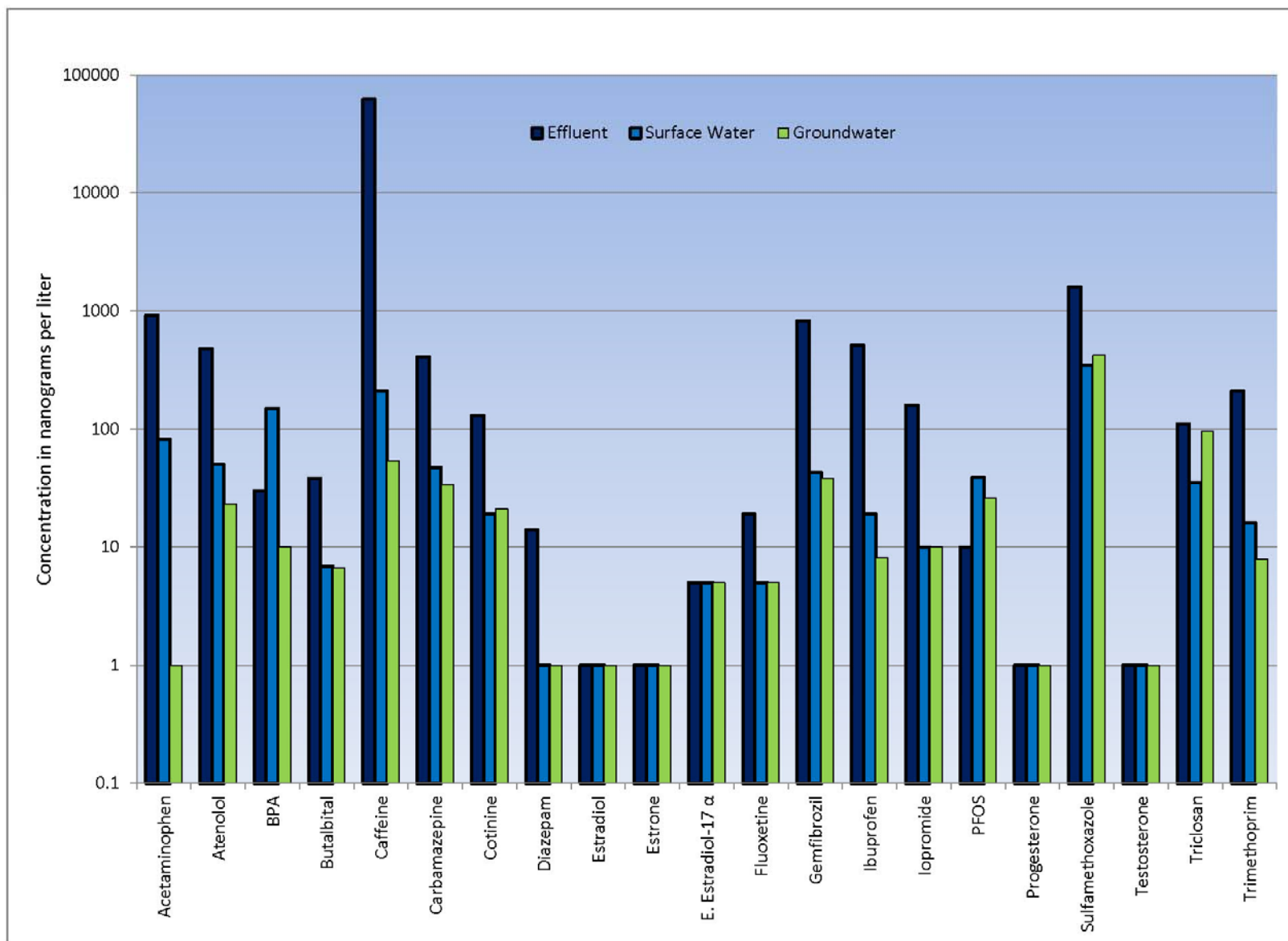
Effluent Detections

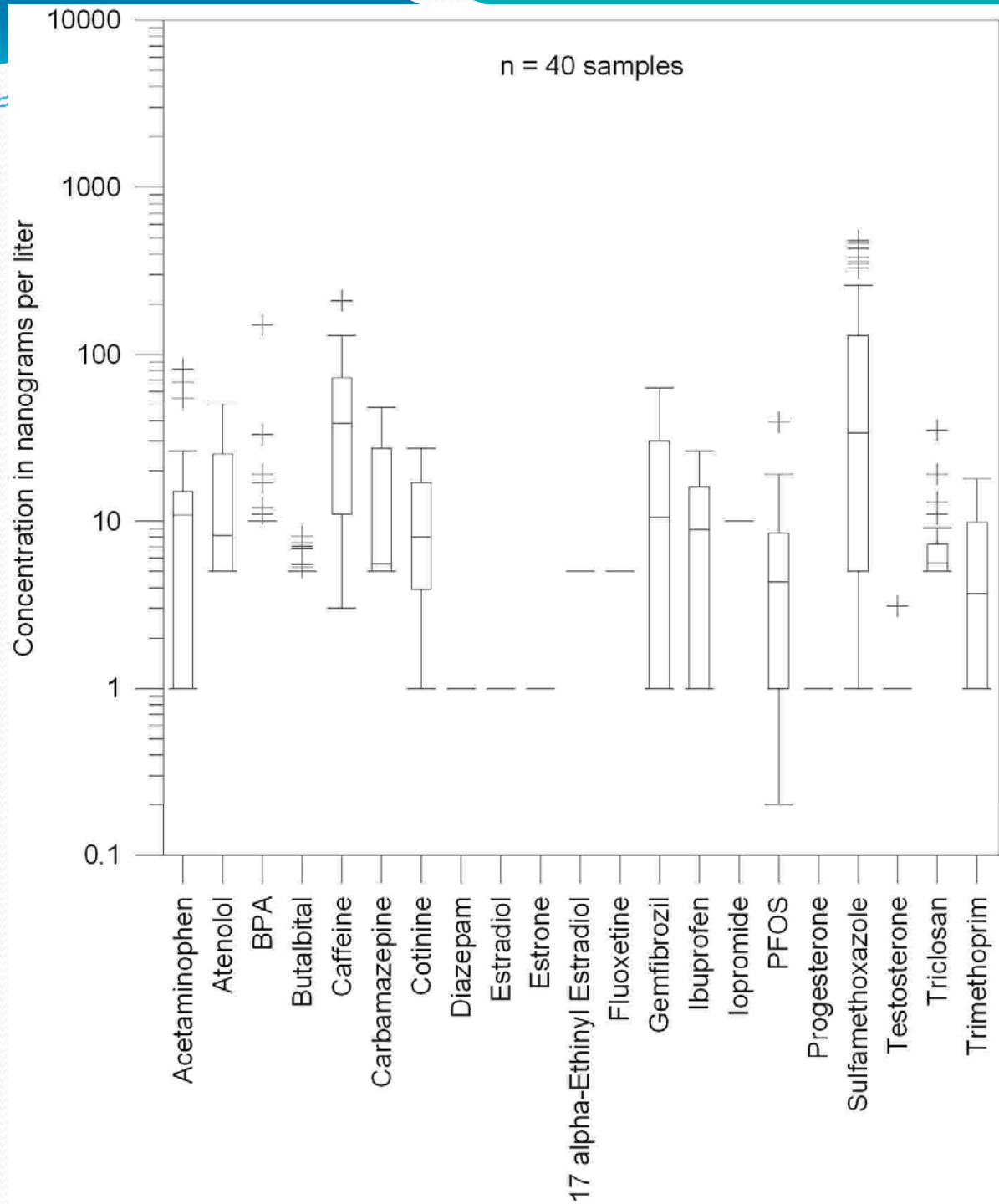
River Detections

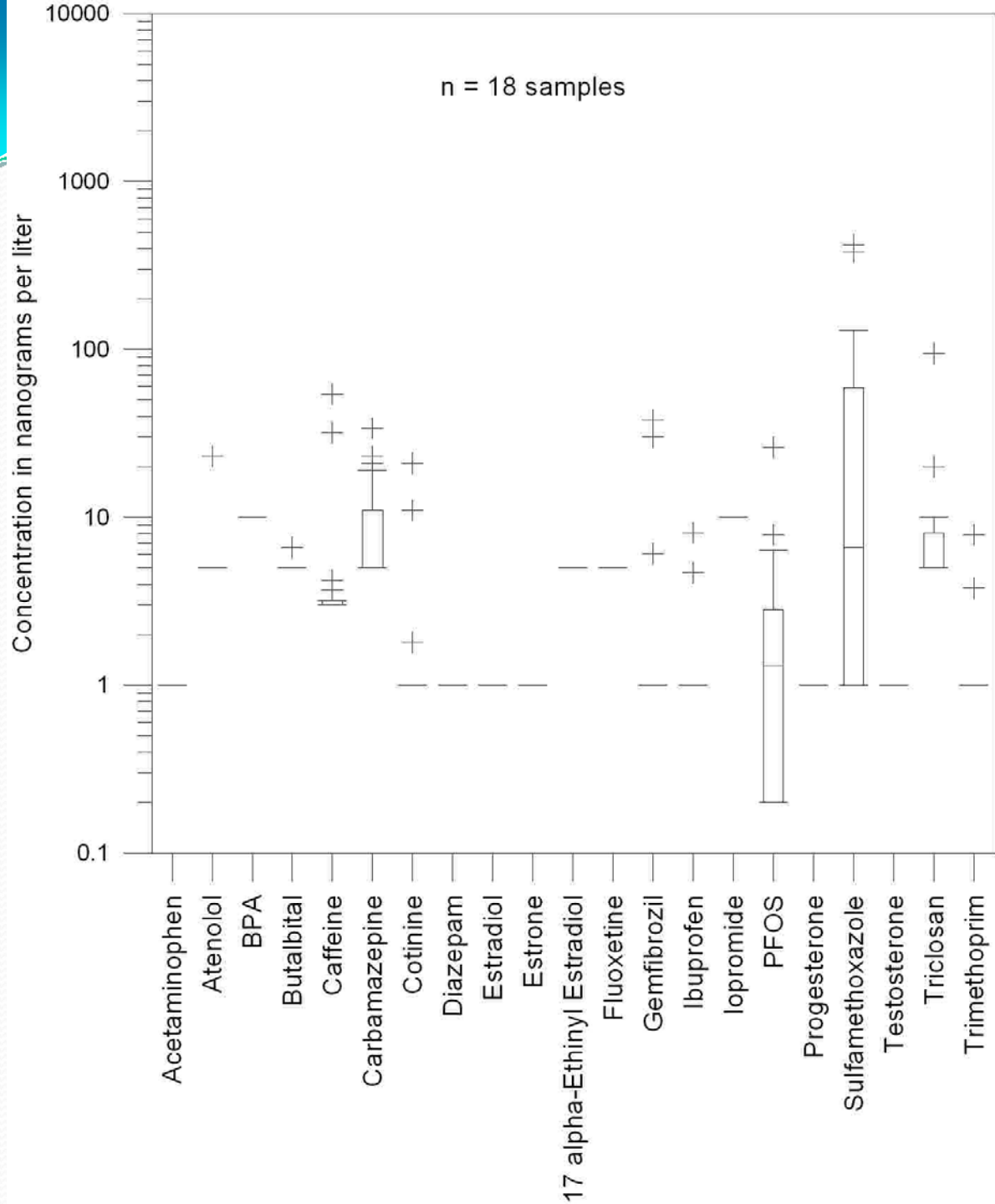
Headwater Stream Detections

Groundwater Detections



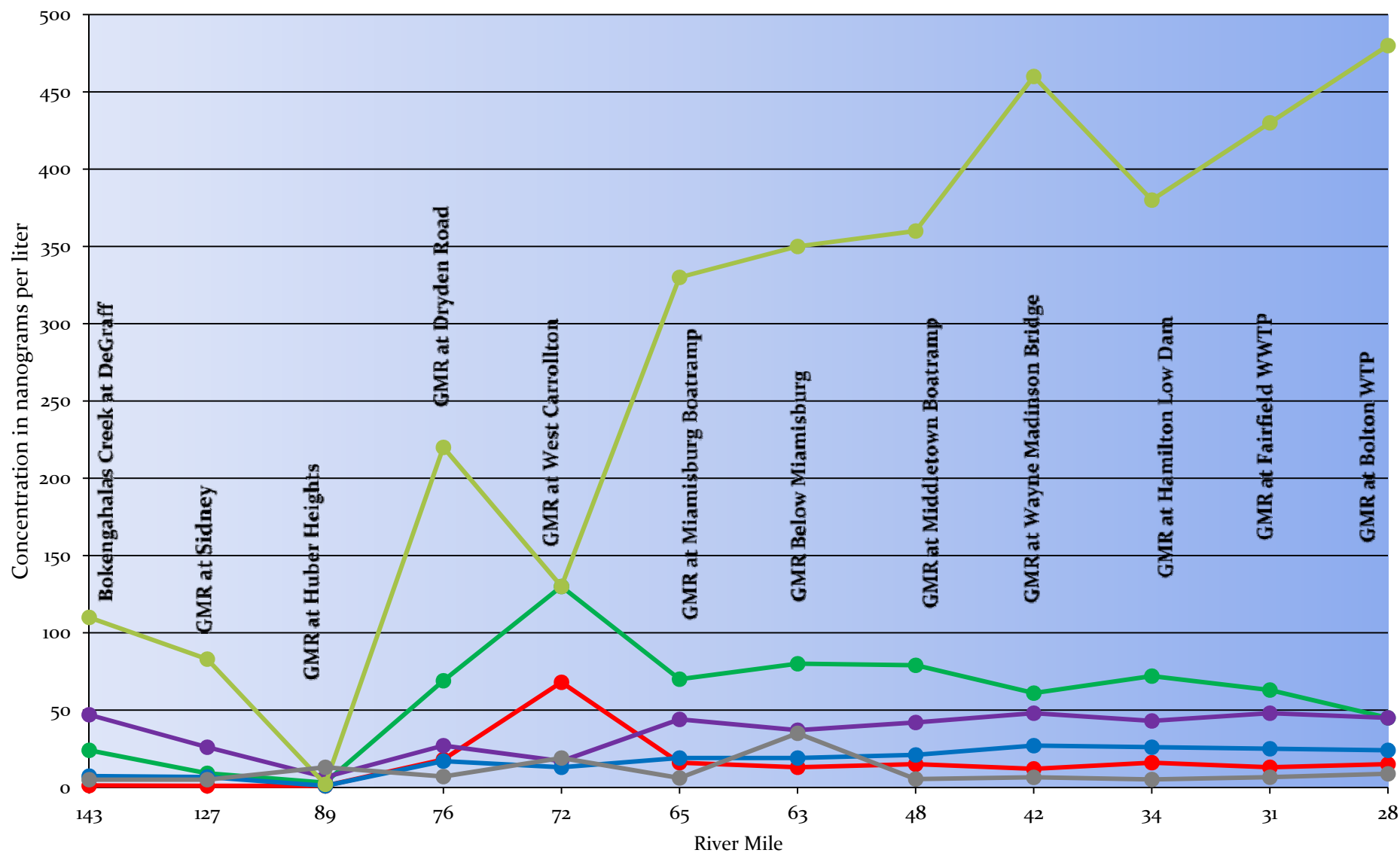






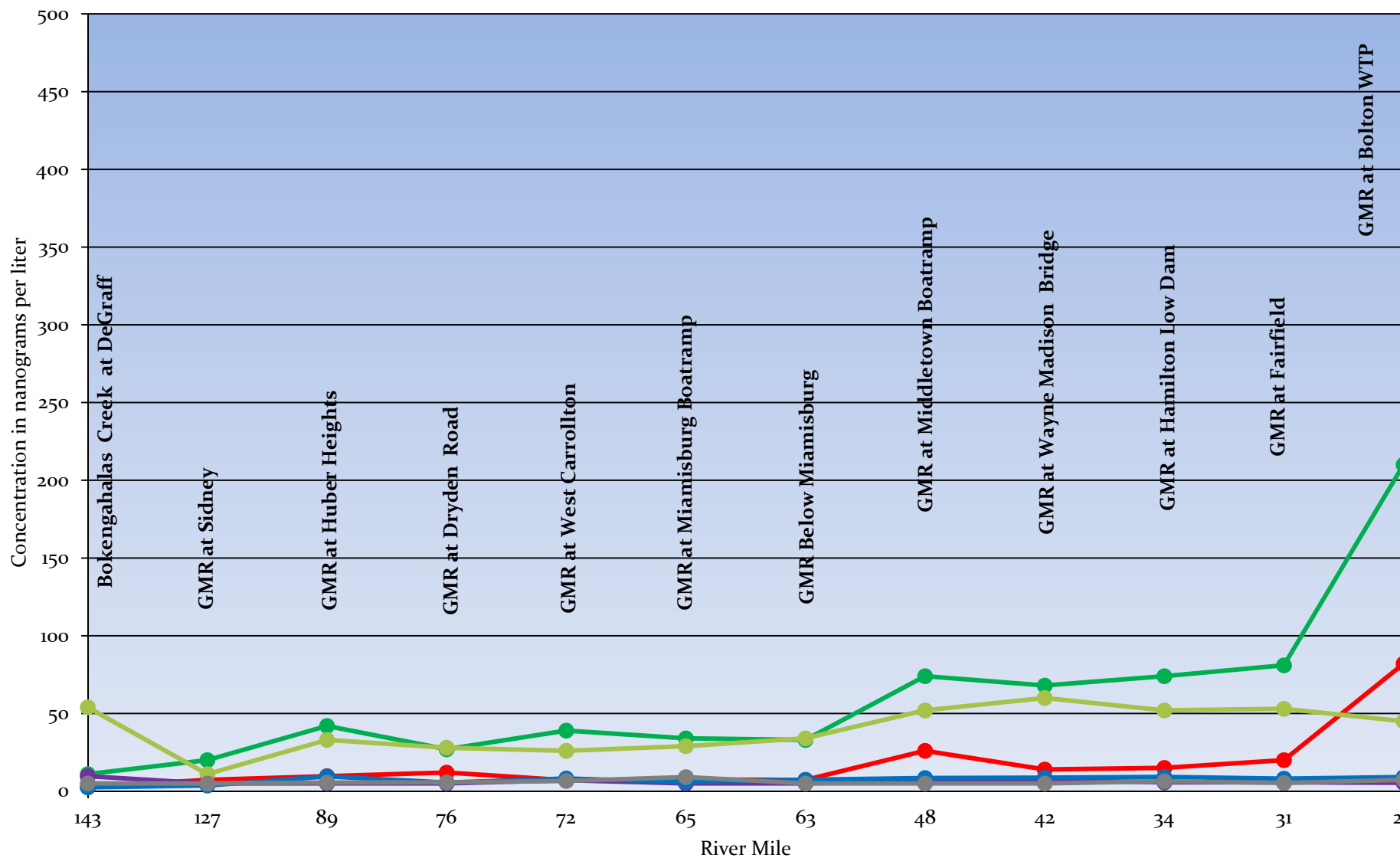
Downstream profile of six PPCP compounds in the Great Miami River in 2010.

● Acetaminophen
 ● Caffeine
 ● Carbamazepine
 ● Cotinine
 ● Sulfamethoxazole
 ● Triclosan



Downstream Profile of six PPCP compounds in the Great Miami River in 2011.

● Acetaminophen
 ● Caffeine
 ● Carbamazepine
 ● Cotinine
 ● Sulfamethoxazole
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Screening Level Risk Assessment

- New York City Department of Environmental Protection (NYCDEP), 2010, *Occurrence of pharmaceuticals and personal care products (PPCPs) in source water of the New York City water supply: Report*, 22 p.
- http://www.nyc.gov/html/dep/html/drinking_water/ws_ppcp.shtml

Detected Compound	Max Conc. In Groundwater (ng/L)	Toxicity Threshold	Basis	DWG (ng/L)	MOE based on # of 8 oz glasses of water/day to exceed DWG	Reference
Atenolol*	23	3,330 µg/kg/day	MRTD	116,550,000	42,870,130	2
Butalbital*	6.6	5,000 µg/kg/day	MRTD	175,000,000	224,318,182	2, 4
Caffeine*	54	100 mg/(8 -oz-cup)		423,000,000	66,270,000	3, 4
Carbamazepine*	34	200 mg/day	LTD	100,000	24,882	1, 4
Cotinine*	21	20 mg/day	LTD	10,000	4,029	1, 4
Gemfibrozil*	38	1,200 mg/day	LTD	600,000	133,579	1, 4
Ibuprofen*	8.1	800 mg/day	LTD	400,000	417,778	1, 4
PFOS	26	30 µg/kg/day	ADI	200	65	5
Sulfamethoxazole	420	10 µg/kg/day	ADI	35,000	705	1, 4
Triclosan*	95	1.5 µg/kg/day	ADI	350	31	1
Trimethoprim*	7.9	20 µg/kg/day	ADI	70,000	74,962	1

* Found in fewer than 40% of groundwater samples.

#8 oz glasses/day = $[DWG \times 2(L/d) \times 4.23 \text{ 8 oz/L}] / (\text{max water conc. (ng/L)})$

ADI —Acceptable Daily Intake. Maximum amount of a substance to which an individual can be exposed on a daily basis over his or her life span, without causing any harmful effects.

DWG —Drinking Water Guideline obtained from *Australian Guidelines for Water Recycling*, Augmentation of Drinking Water Supplies, May 2008, Environment Protection and Heritage Council, National Health and Medical Research Council, Natural Resource Management Ministerial Council

LTD — Lowest Therapeutic Dose. The lowest dose which produces the desired clinical effect.

MRTD — Maximum Recommended Therapeutic Dose. The recommended maximum amount of drug to be given to a patient without causing adverse health effects.

What our analysis does not consider ...

- possible additive, synergistic, or antagonistic effects of PPCPs
- potential impacts of PPCPs on aquatic life
- lack of data on effects of PPCPs at sub-therapeutic doses
- antibiotic resistant microbes





Conclusions

- PPCPs ubiquitous in surface waters of the Great Miami River Basin
- Most common PPCPs detected in groundwater caffeine, carbamazepine, cotinine, gemfibrozil, ibuprofen, PFOS, sulfamethoxazole, triclosan, trimethoprim
- Highest concentrations in wastewater effluent
- Margins of Exposure (MOEs) for PPCPs in groundwater ranged from 31 to over 224 million

Access Report

- http://www.miamiconservancy.org/water/groundwater_evalu.asp



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