Occurrence of Pharmaceuticals, Personal Care Products and Other Organic Wastewater Compounds In Shallow Groundwater

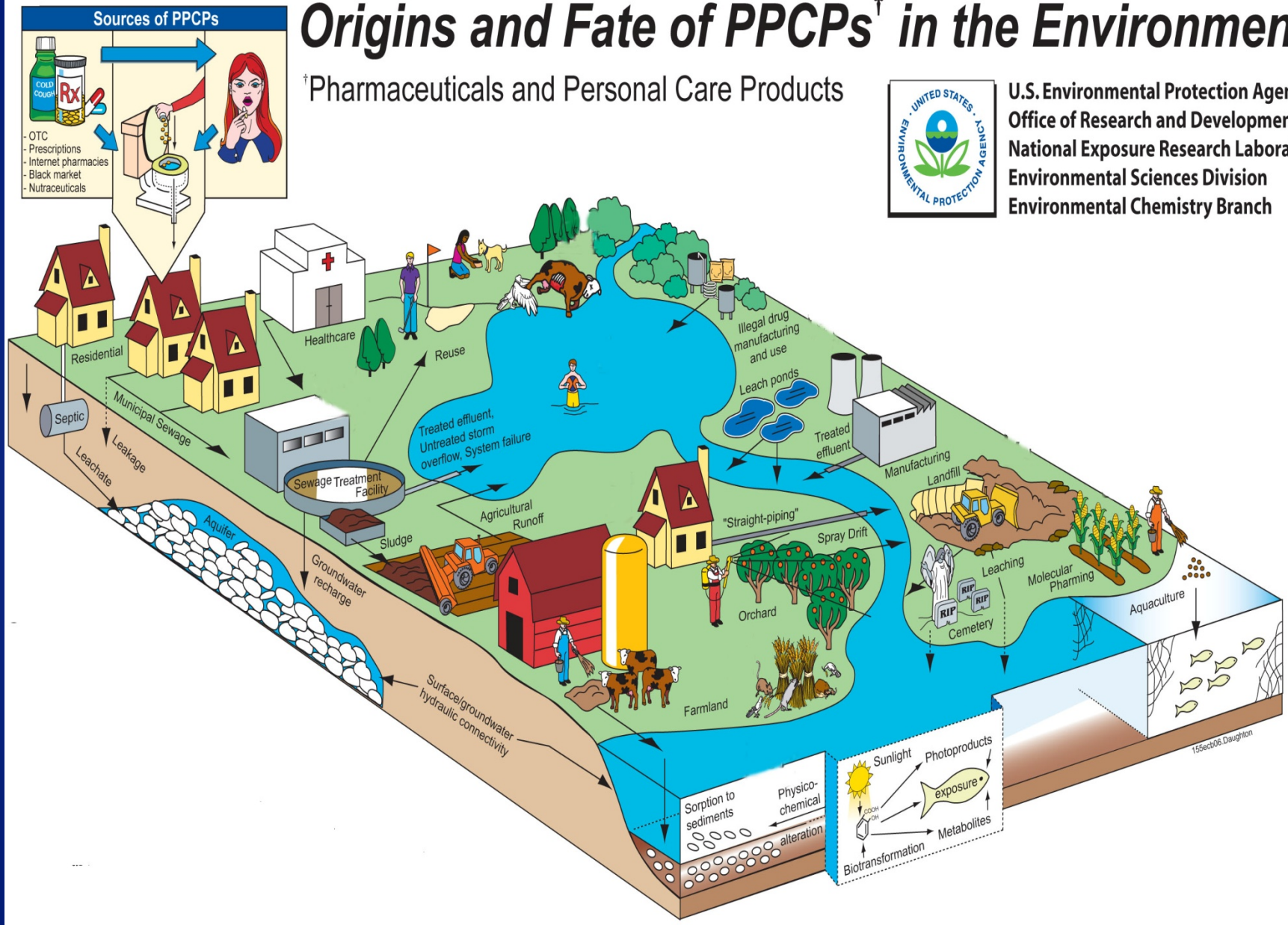
A NJG&WS Research Project

In Cooperation With The USGS

Origins and Fate of PPCPs† in the Environment

†Pharmaceuticals and Personal Care Products

U.S. Environmental Protection Agency
Office of Research and Development
National Exposure Research Laboratory
Environmental Sciences Division
Environmental Chemistry Branch



Potential Concerns

- Abnormal physiological processes and reproductive impairment
- Increased incidences of cancer
- Development of antibiotic-resistant bacteria
- Potential increased toxicity of chemical mixtures

Study Goals

Phase I:

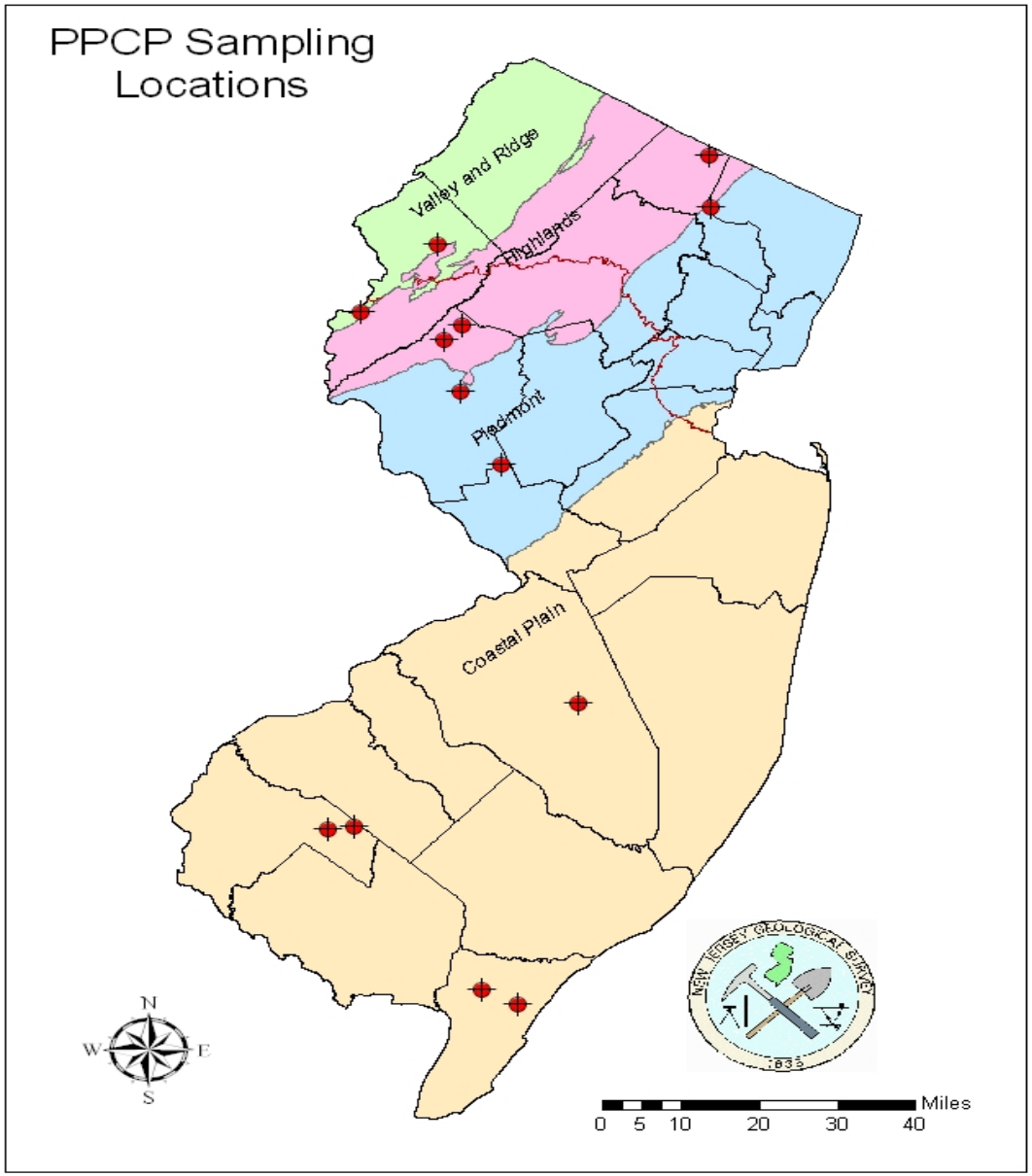
- Occurrence of PPCPs and OWCs in shallow groundwater downgradient from septic leach fields
- Concentration of PPCPs and OWCs in shallow groundwater
- Spatial distribution by Physiographic Provinces

Sampling Schedules

- Antibiotics – 33 compounds
- Wastewater – 62 compounds
- Pharmaceuticals – 13 compounds
- Hormones/Sterols – USGS – 7 compounds; AXYS – 27 compounds (EPA Method 1698 HRMS)
- Nutrients and organic carbon
- Major cations/anions and boron

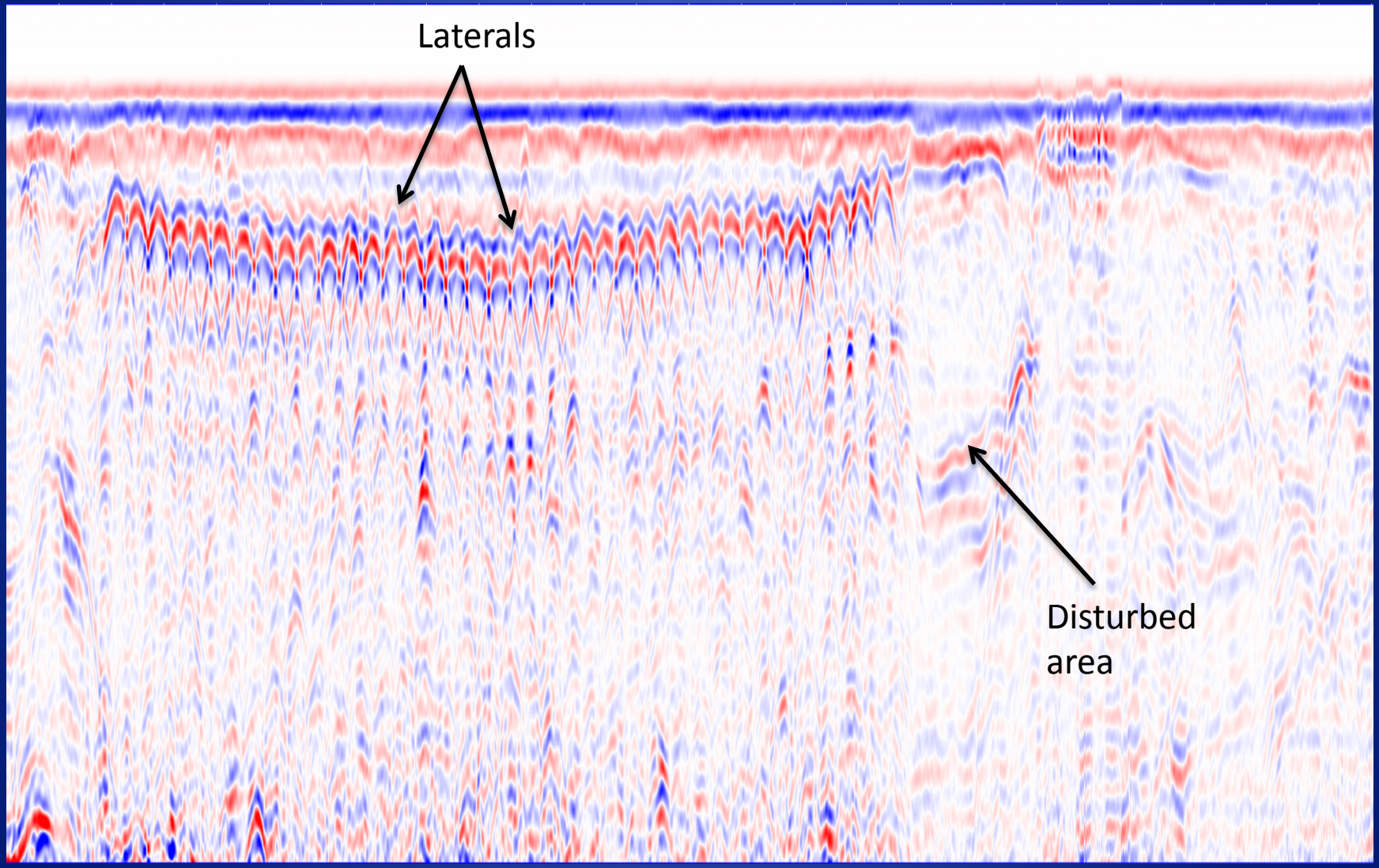
Selection of Facilities

- Permitted by the State of NJ to discharge wastewater to the groundwater
- Type of facility: focus on nursing homes and hospitals with >20 beds for their higher use of pharmaceuticals
- Geology: ability to install a temporary point to sample ground water
- Spatial distribution by Physiographic Province


PPCP Sampling Locations
Valley and Ridge
Highlands
Piedmont
Coastal Plain
N
W
E
S
NEW JERSEY GEOLOGICAL SURVEY
1835
Miles
0 5 10 20 30 40

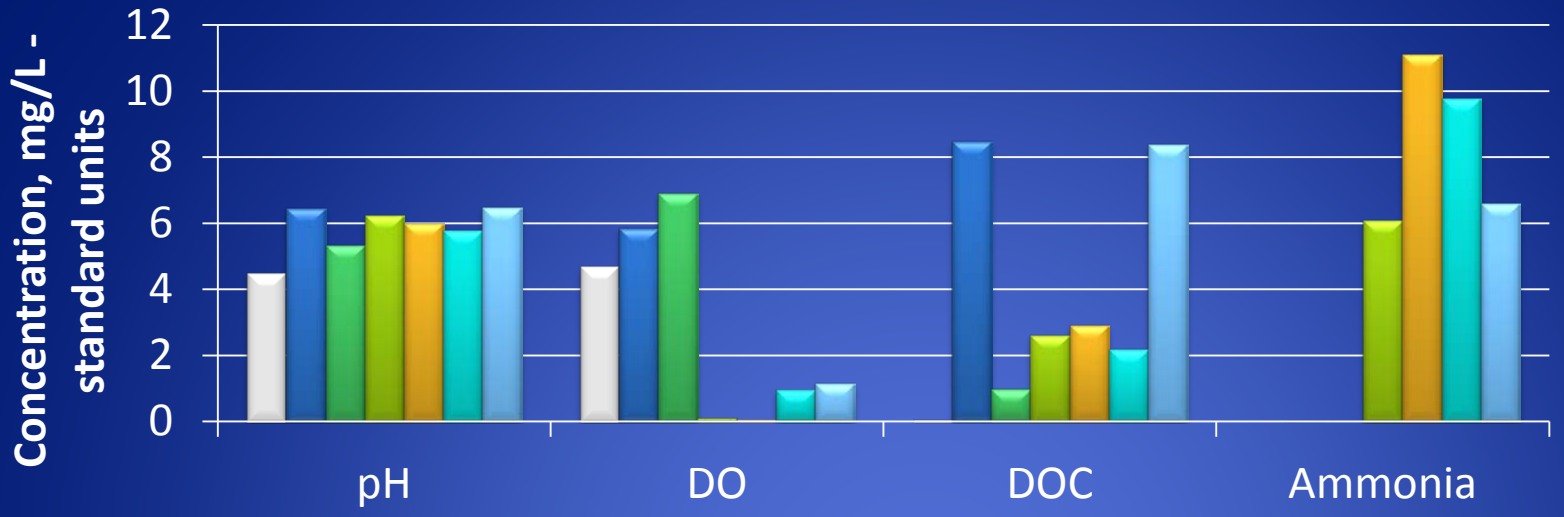
Locating Laterals

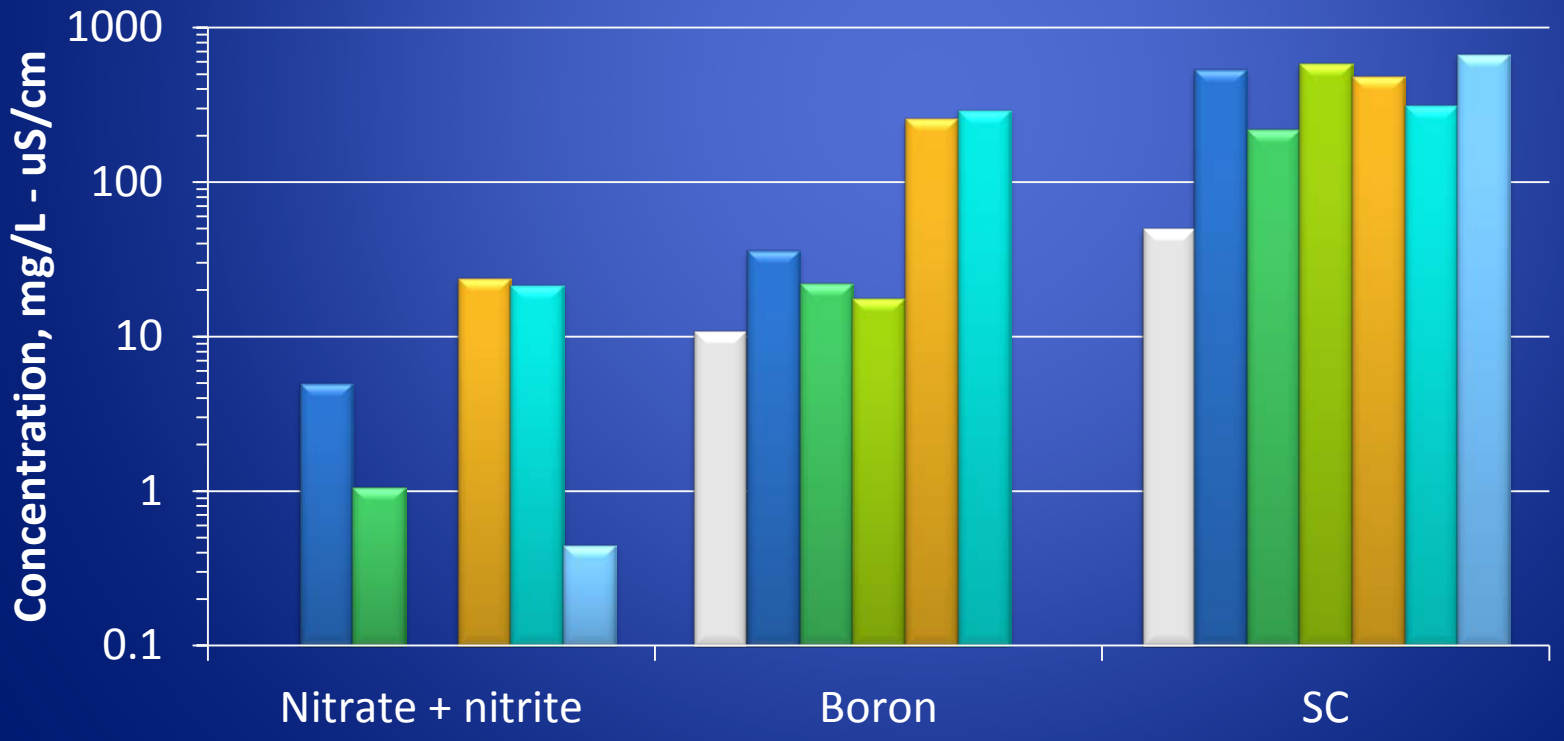
GPR Data



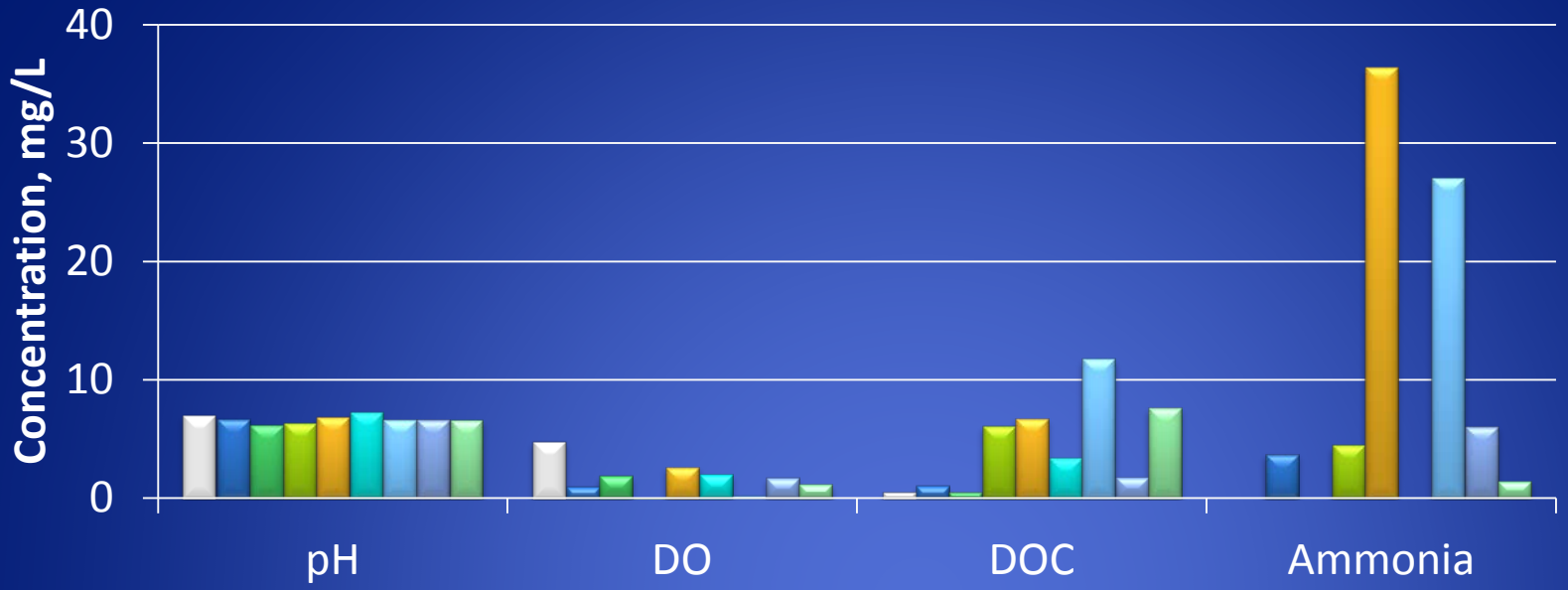

pH 4.95
SC 204 uS/cm
WL 11 ft blgs
pH 6.48
SC 540.4 uS/cm
pH 6.62
SC 473 uS/cm
WL 6 ft blgs
pH 5.94
SC 70 u/Scm
WL 12.3 ft blgs

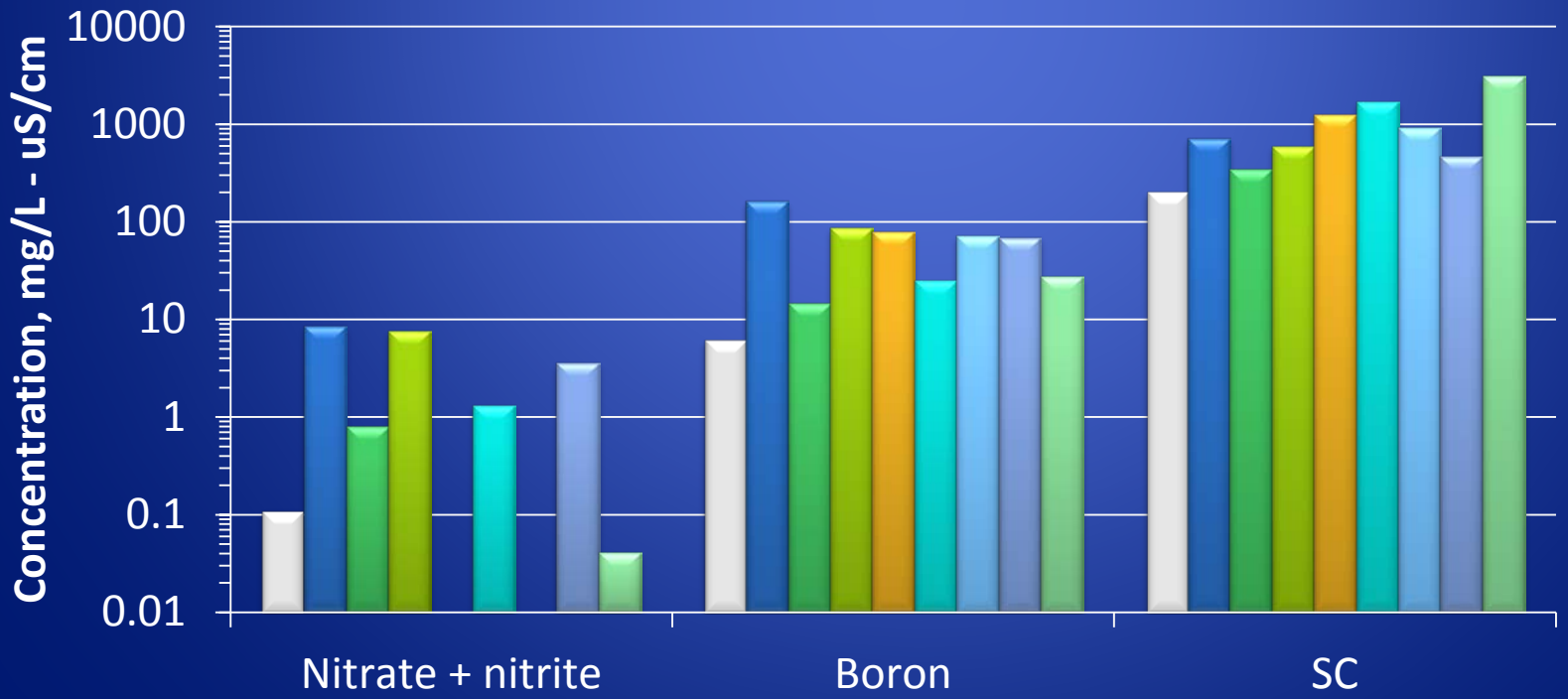
Coastal Plain



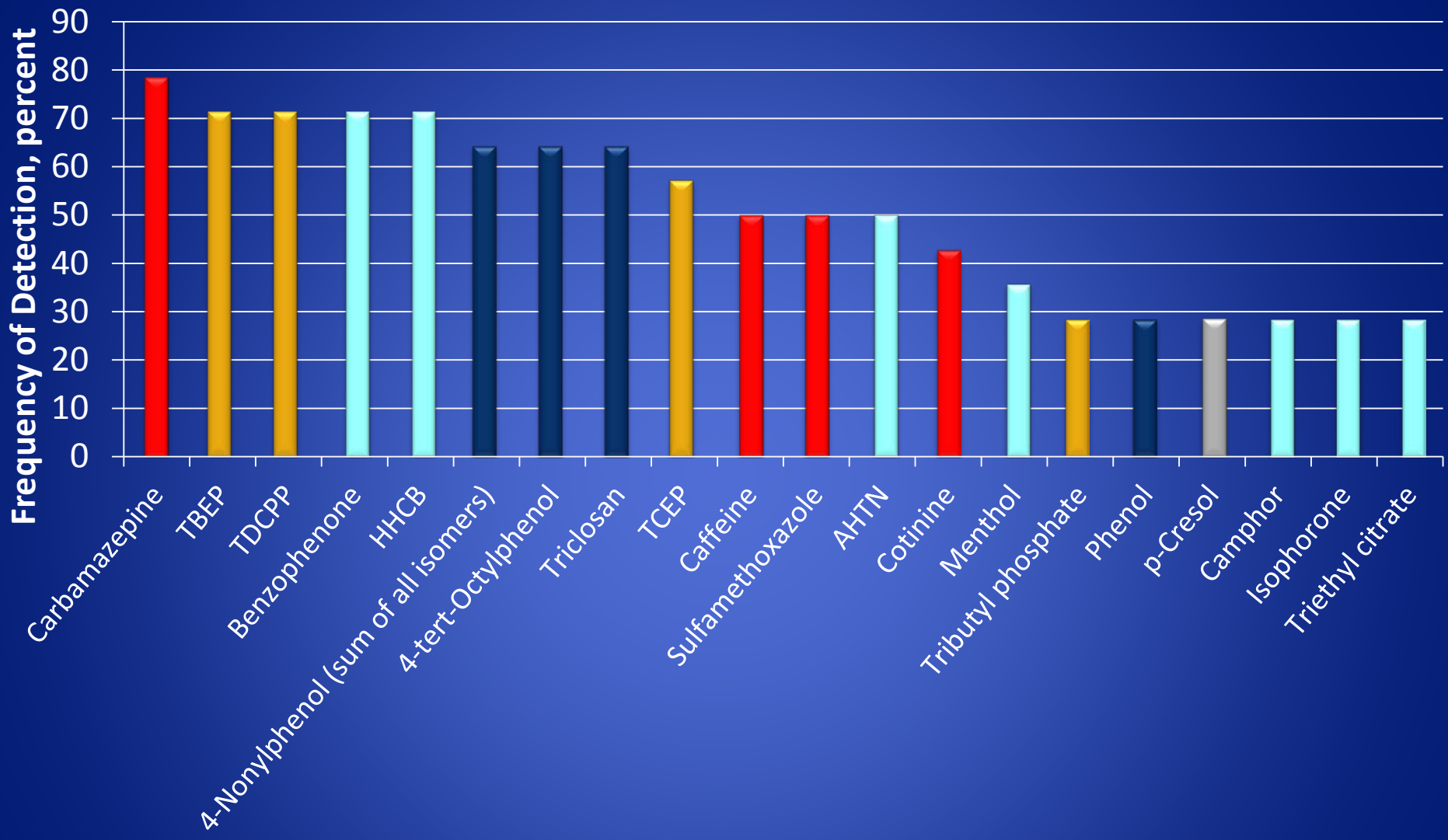


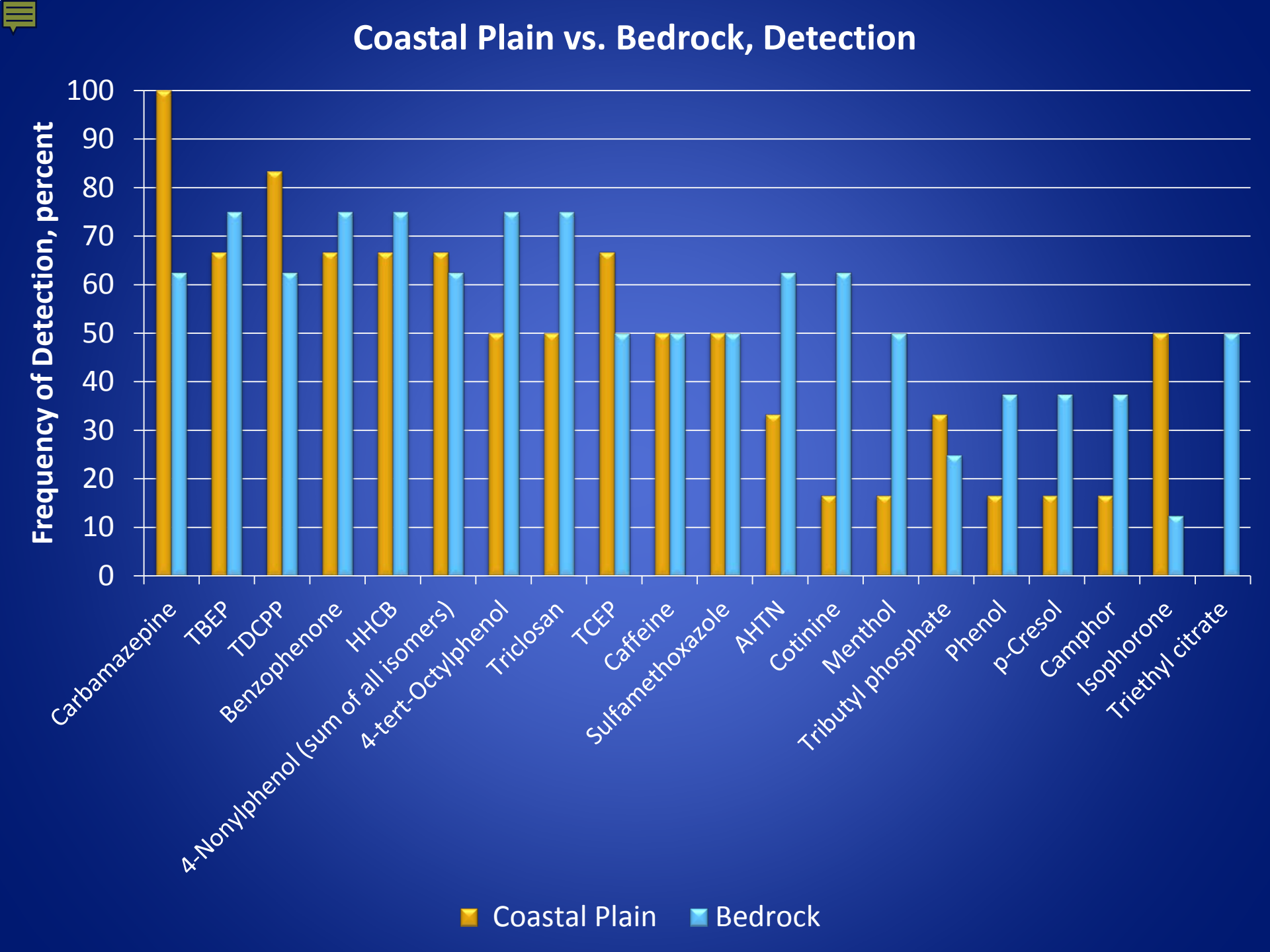
Bedrock

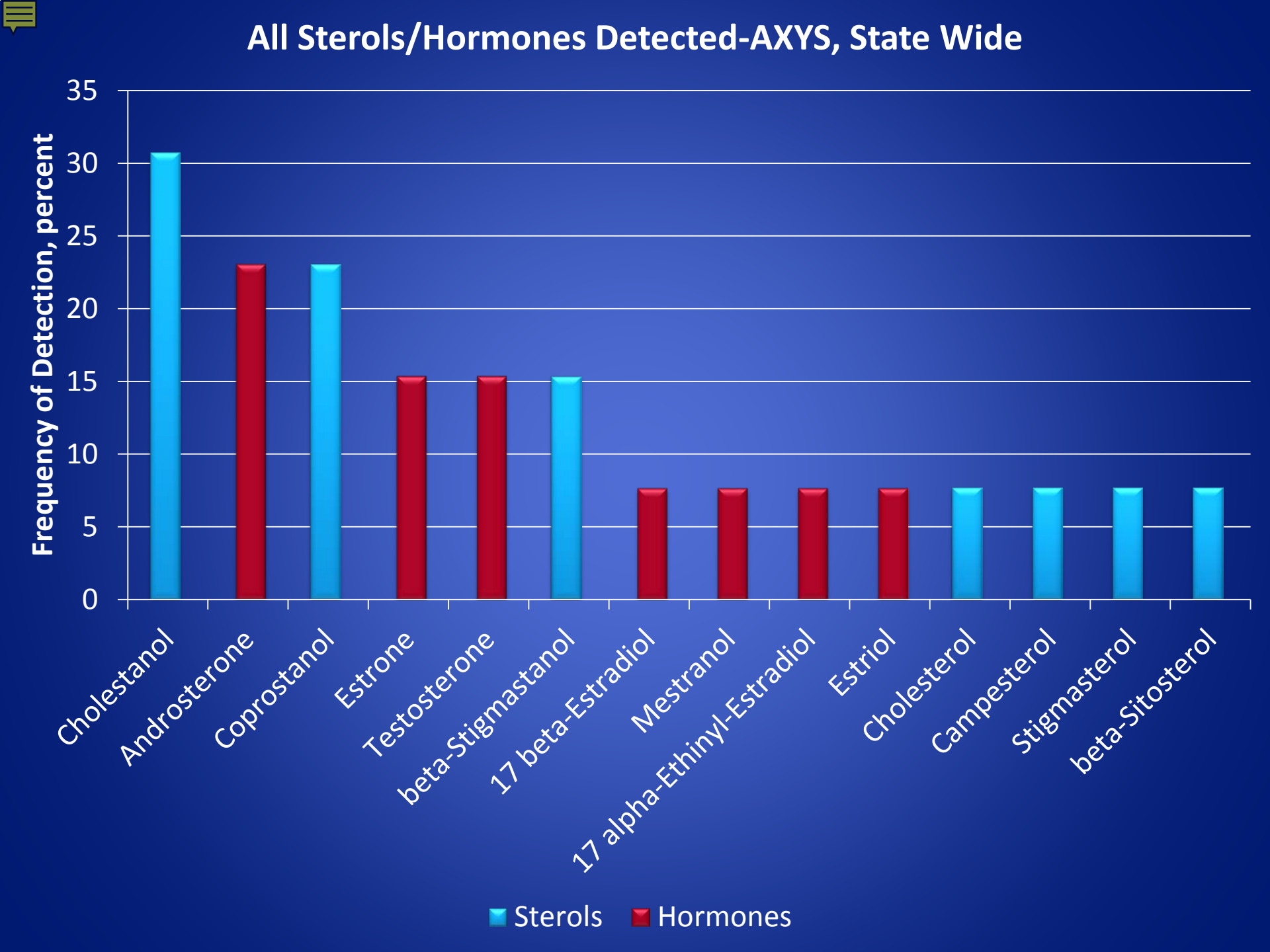

Concentration, mg/L
40
30
20
10
0
pH
DO
DOC
Ammonia
AGWQMN
FA03001
FA31001
FA19001
FA41001
FA41002
FA19002
FA19003
FA19004

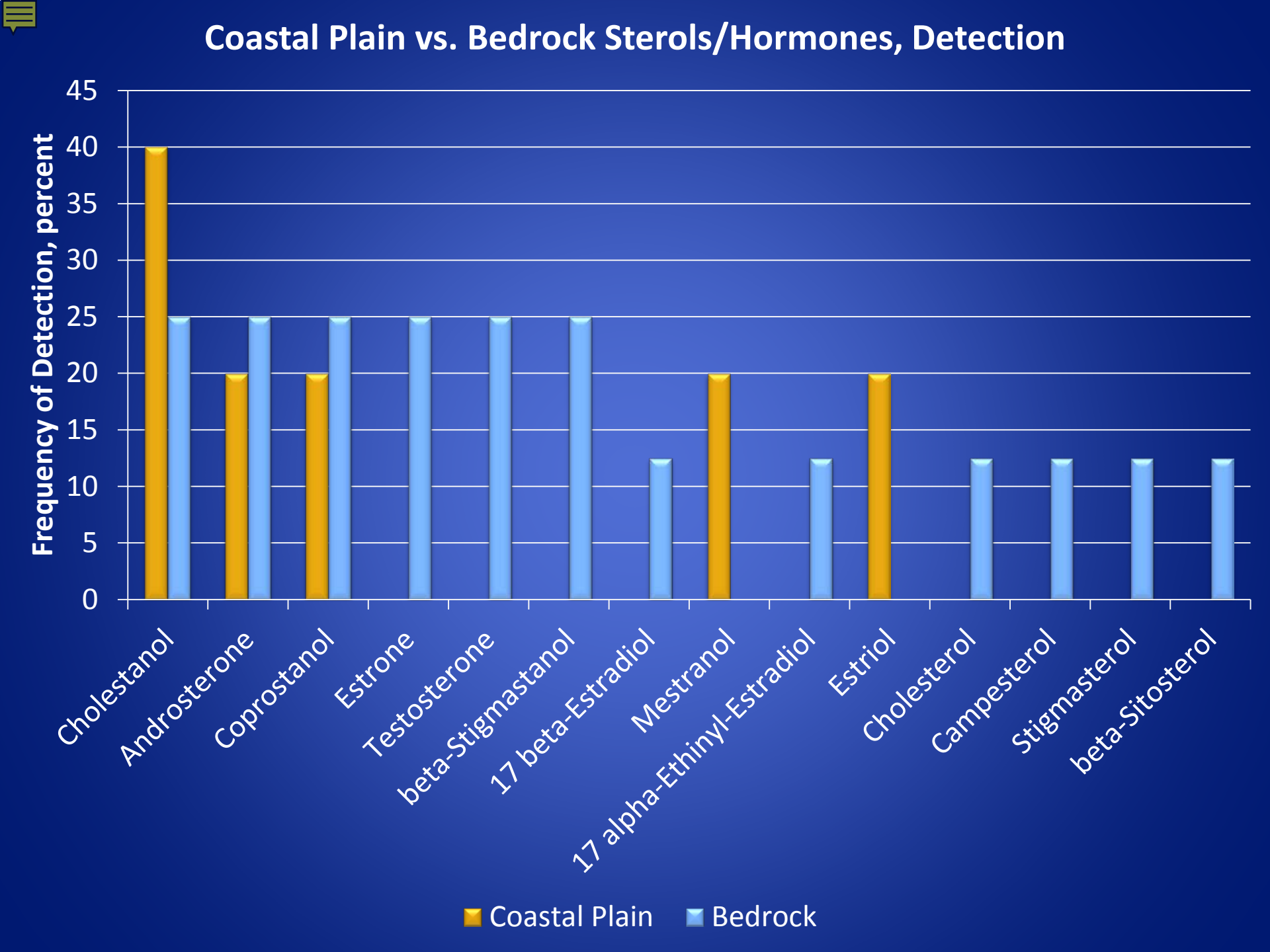

Concentration, mg/L - uS/cm
10000
1000
100
10
1
0.1
0.01
Nitrate + nitrite
Boron
SC
AGWQMN
FA03001
FA31001
FA19001
FA41001
FA41002
FA19002
FA19003
FA19004

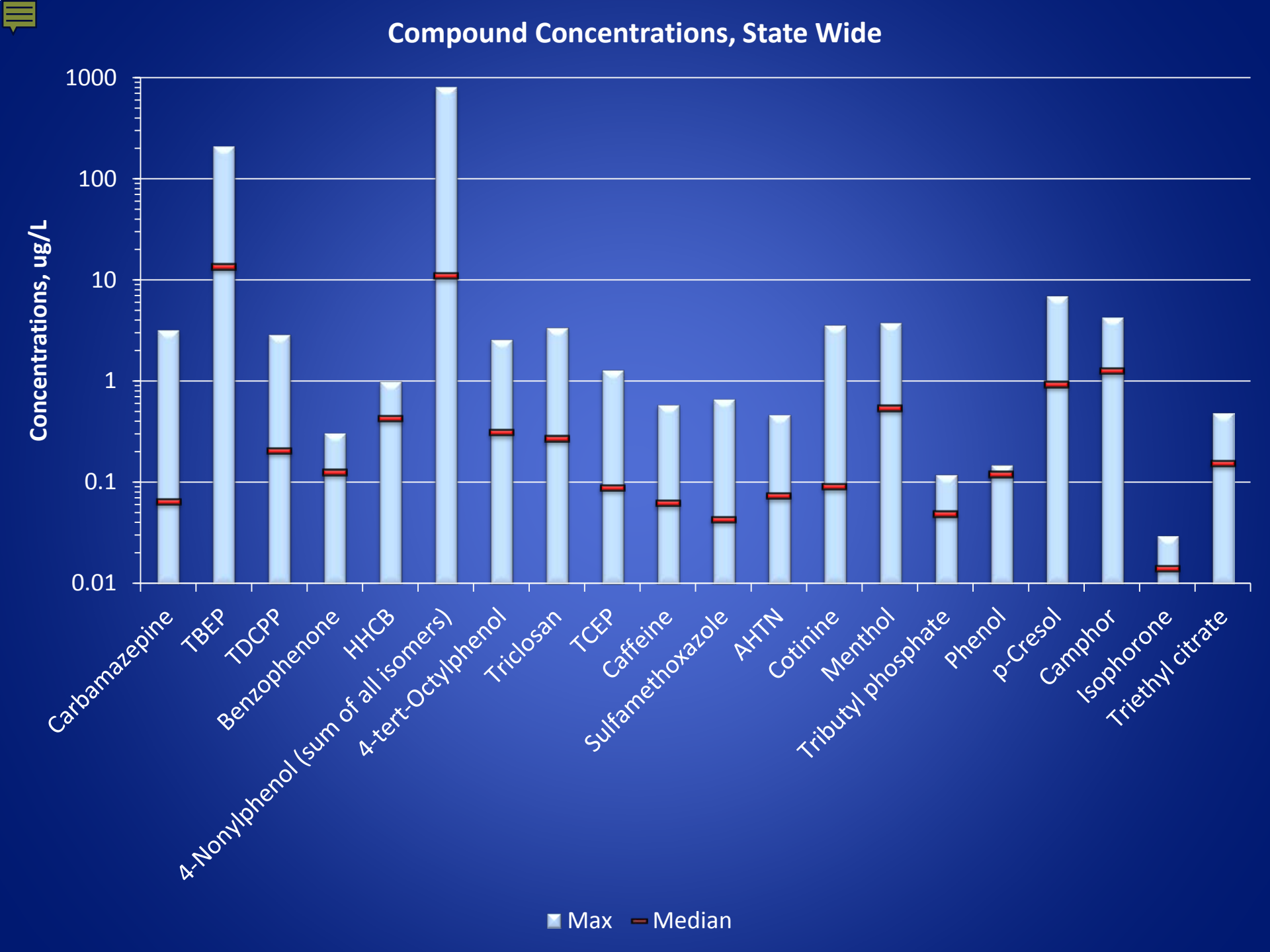
Compounds Detected >25%, State Wide



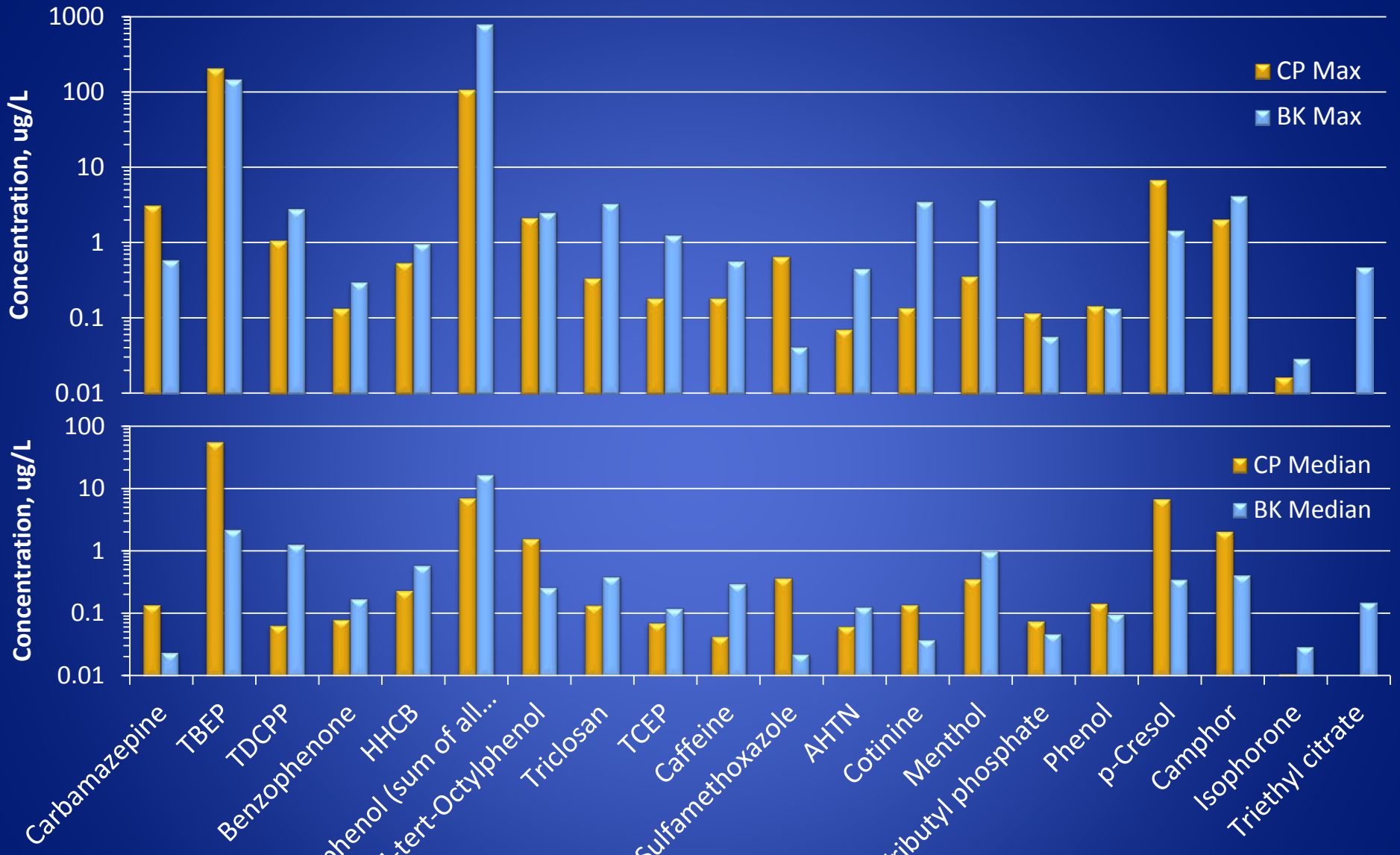

Coastal Plain vs. Bedrock, Detection
Frequency of Detection, percent
100
90
80
70
60
50
40
30
20
10
0
Carbamazepine
TBEP
TDCPP
Benzophenone
HHCB
4-Nonylphenol (sum of all isomers)
4-tert-Octylphenol
Triclosan
TCEP
Caffeine
Sulfamethoxazole
AHTN
Cotinine
Menthol
Tributyl phosphate
Phenol
p-Cresol
Camphor
Isophorone
Triethyl citrate
Coastal Plain
Bedrock

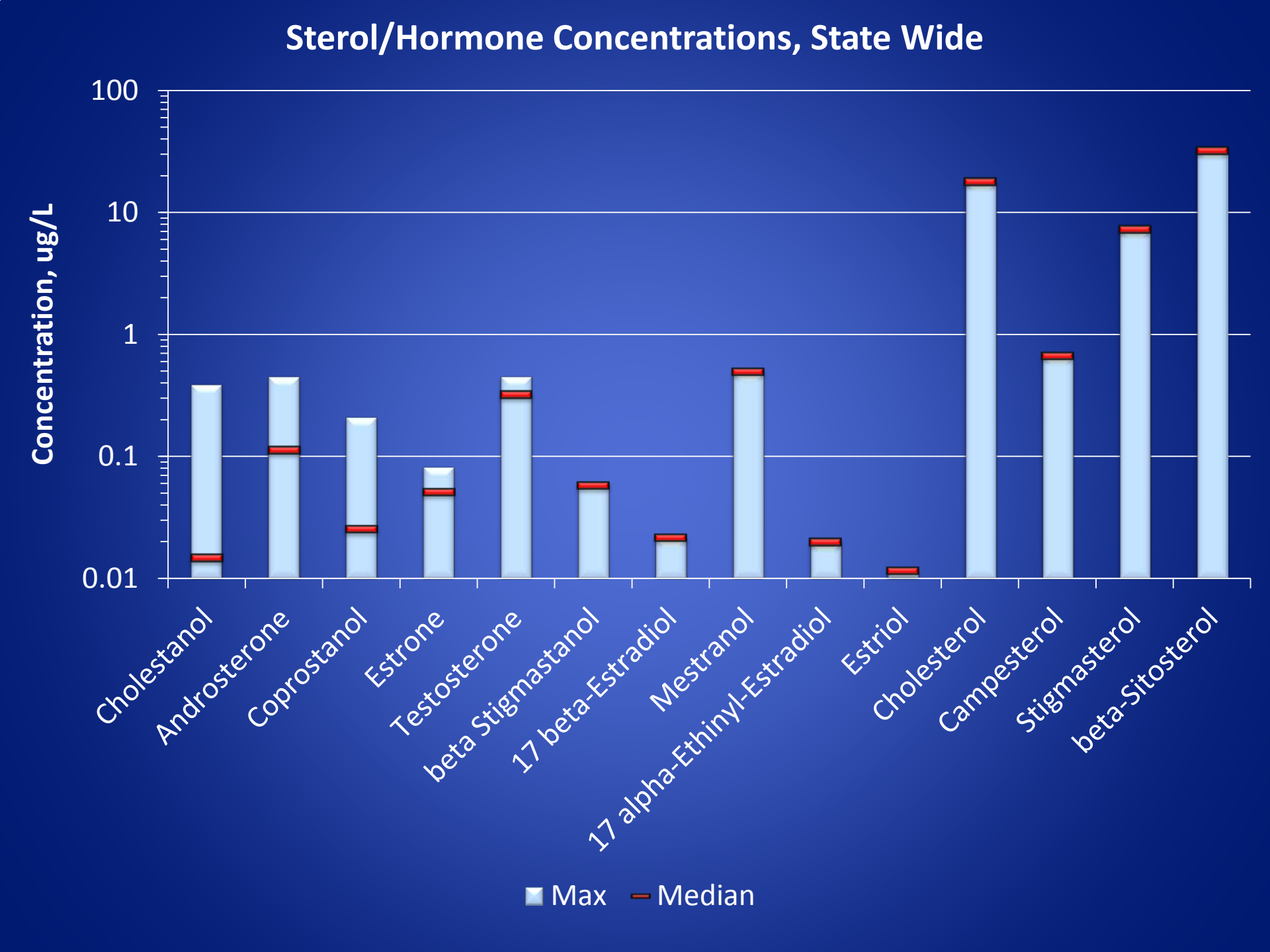

All Sterols/Hormones Detected-AXYS, State Wide
Frequency of Detection, percent
35
30
25
20
15
10
5
0
Cholestanol
Androsterone
Coprostanol
Estrone
Testosterone
beta-Stigmastanol
17 beta-Estradiol
Mestranol
17 alpha-Ethinyl-Estradiol
Estriol
Cholesterol
Campesterol
Stigmasterol
beta-Sitosterol
Sterols
Hormones


Coastal Plain vs. Bedrock Sterols/Hormones, Detection
Frequency of Detection, percent
45
40
35
30
25
20
15
10
5
0
Cholestanol
Androsterone
Coprostanol
Estrone
Testosterone
beta-Stigmastanol
17 beta-Estradiol
Mestranol
17 alpha-Ethinyl-Estradiol
Estriol
Cholesterol
Campesterol
Stigmasterol
beta-Sitosterol
Coastal Plain
Bedrock

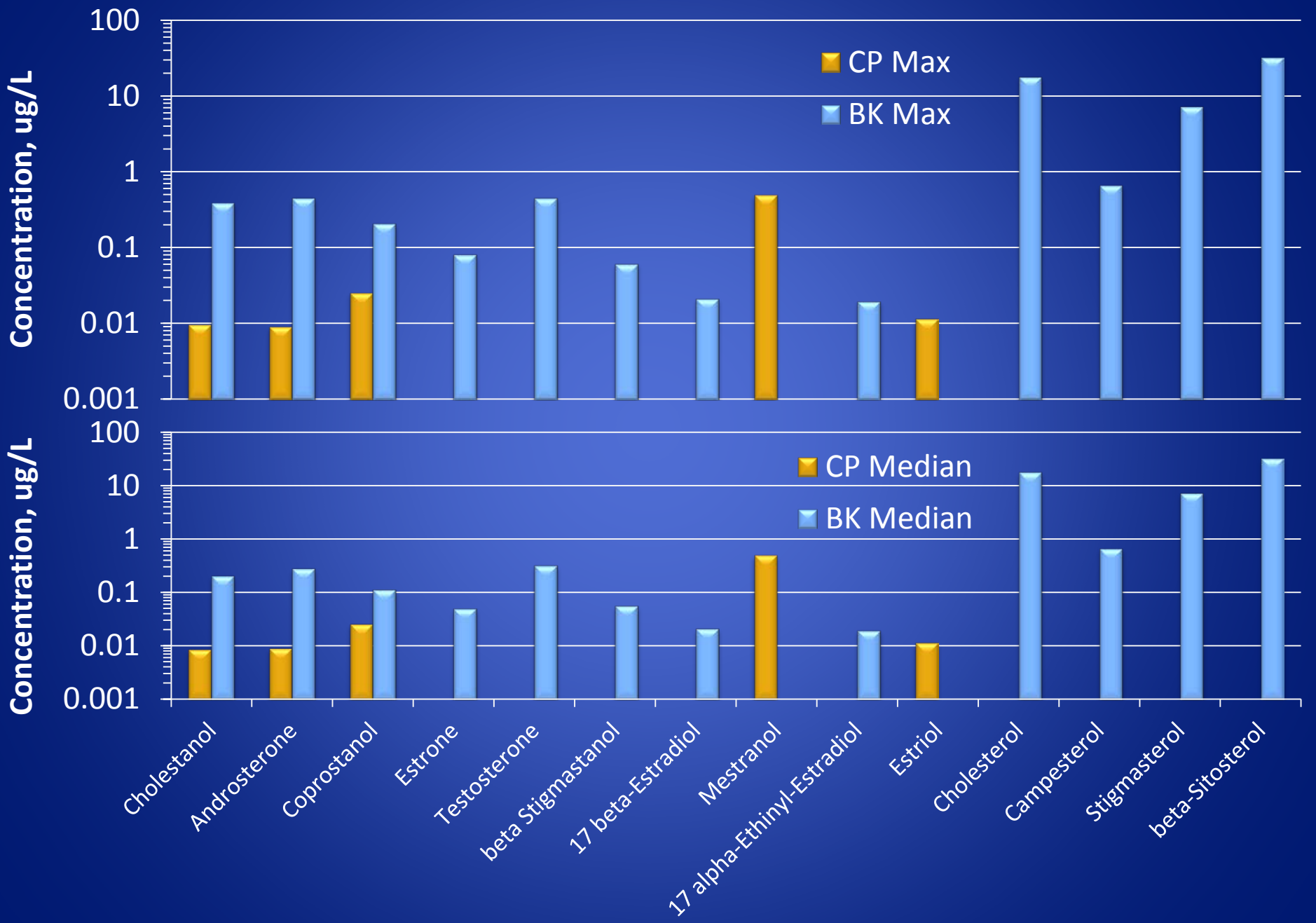

Compound Concentrations, State Wide
Concentrations, ug/L
1000
100
10
1
0.1
0.01
Carbamazepine
TBEP
TDCPP
Benzophenone
HHCB
4-Nonylphenol (sum of all isomers)
4-tert-Octylphenol
Triclosan
TCEP
Caffeine
Sulfamethoxazole
AHTN
Cotinine
Menthol
Tributyl phosphate
Phenol
p-Cresol
Camphor
Isophorone
Triethyl citrate
Max
Median

Coastal Plain vs. Bedrock, Concentrations

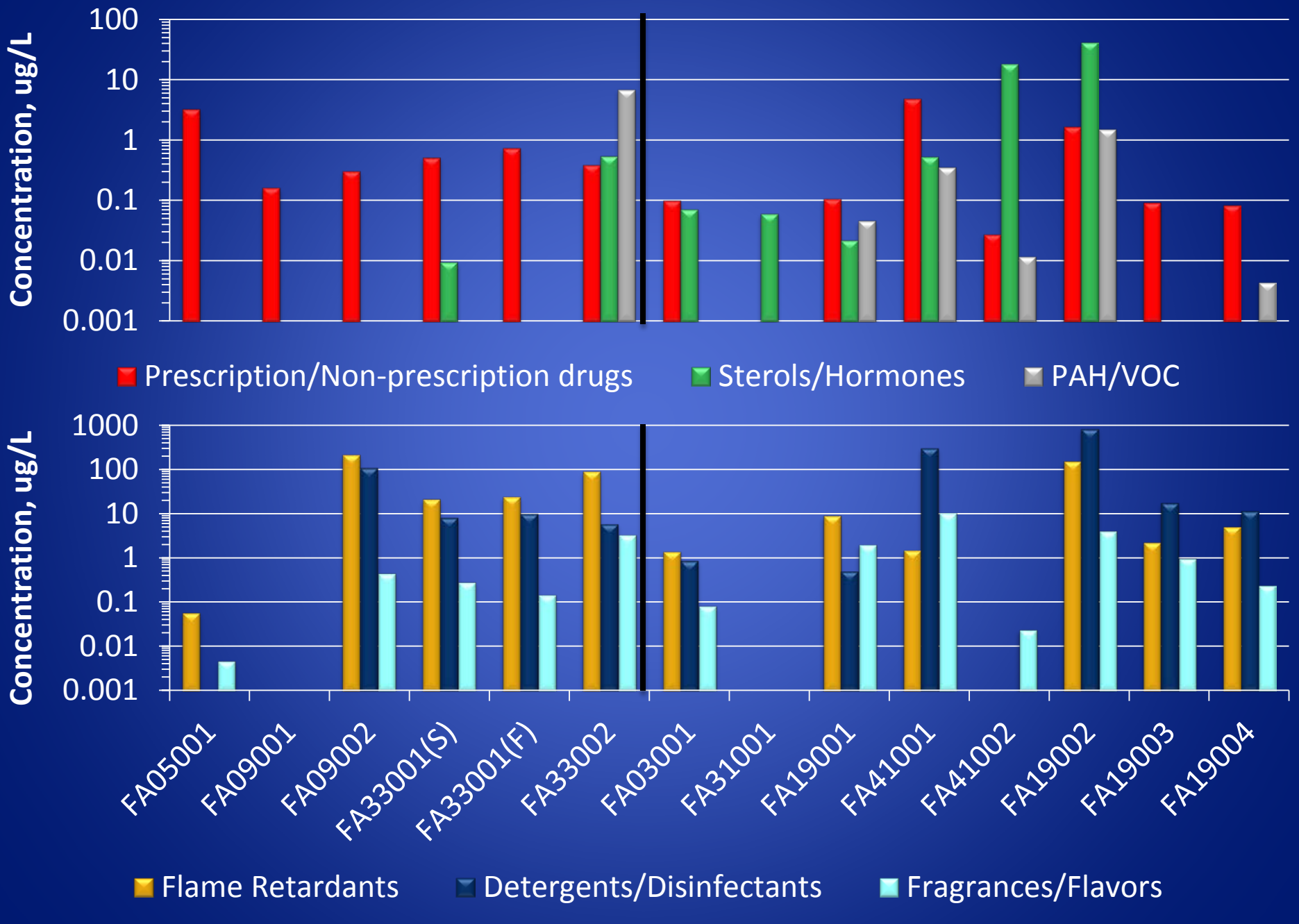


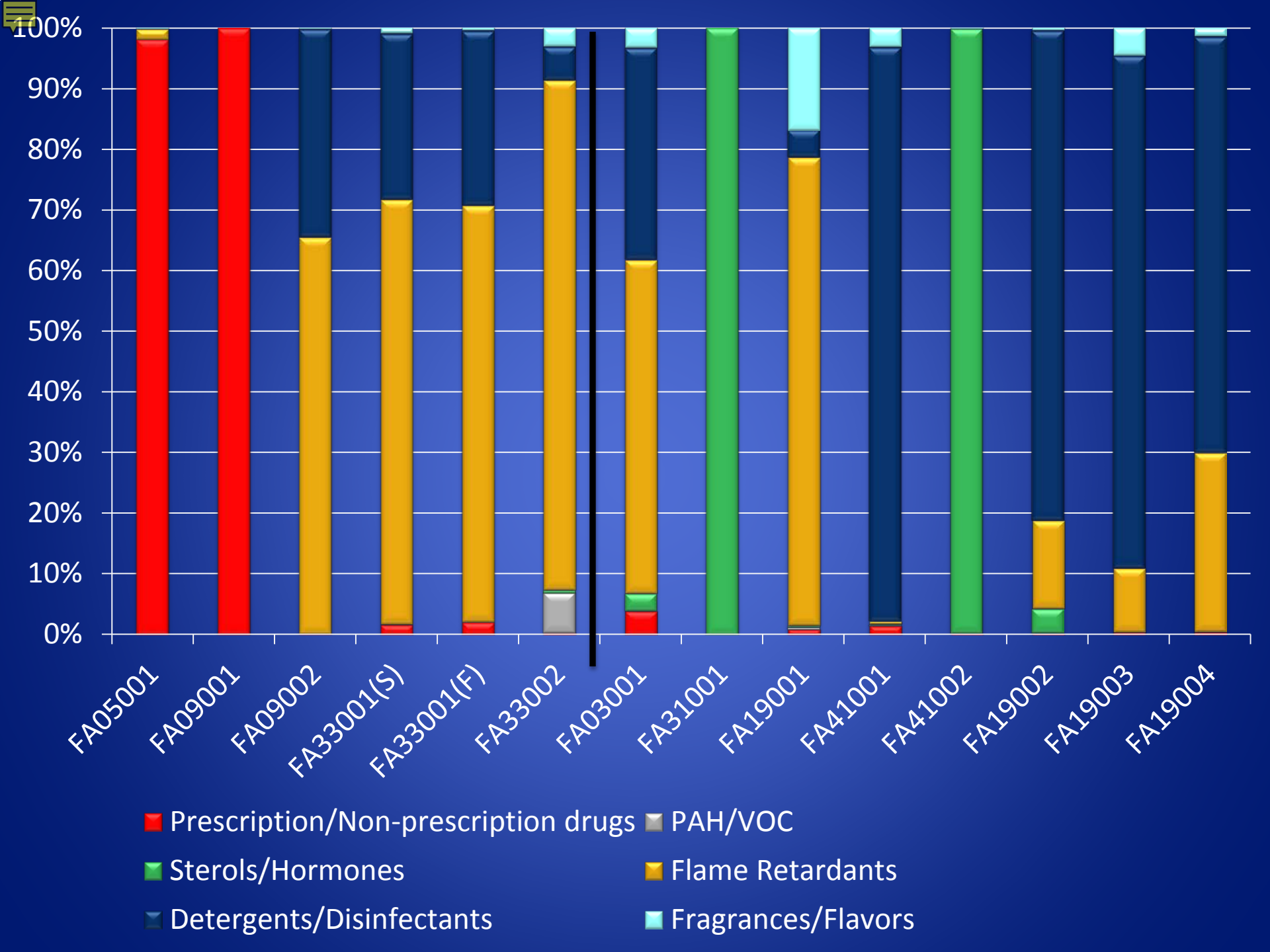

Sterol/Hormone Concentrations, State Wide
Concentration, ug/L
100
10
1
0.1
0.01
Cholestanol
Androsterone
Coprostanol
Estrone
Testosterone
beta Stigmastanol
17 beta-Estradiol
Mestranol
17 alpha-Ethinyl-Estradiol
Estriol
Cholesterol
Campesterol
Stigmasterol
beta-Sitosterol
Max
Median

Coastal Plain vs. Bedrock, Sterol/Hormone Concentrations

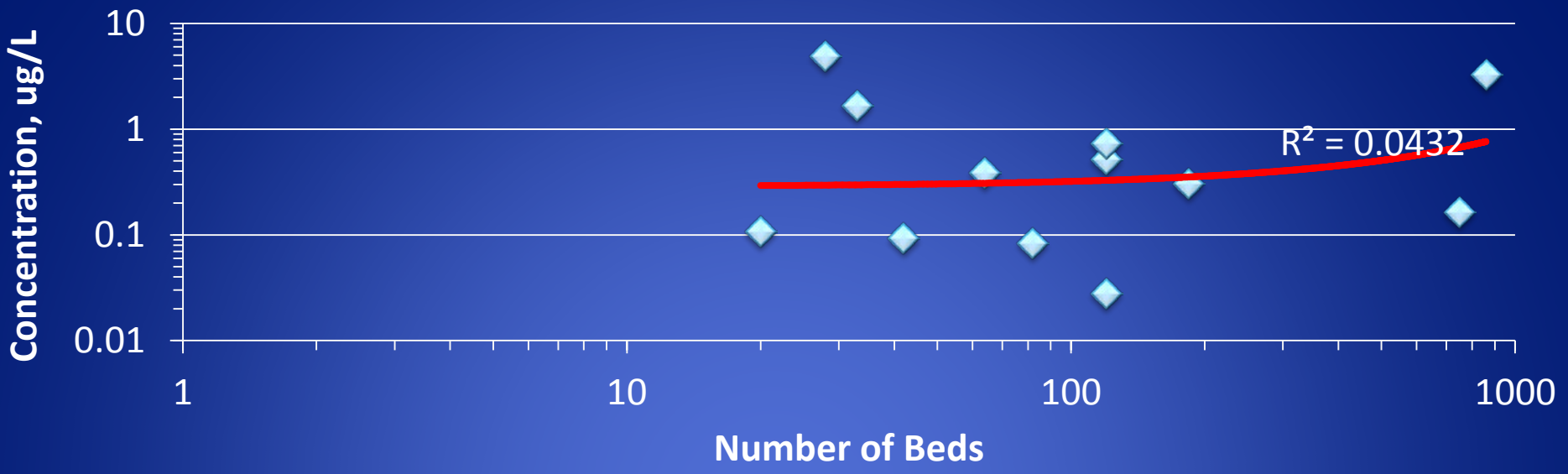


Facility Concentration, Sum

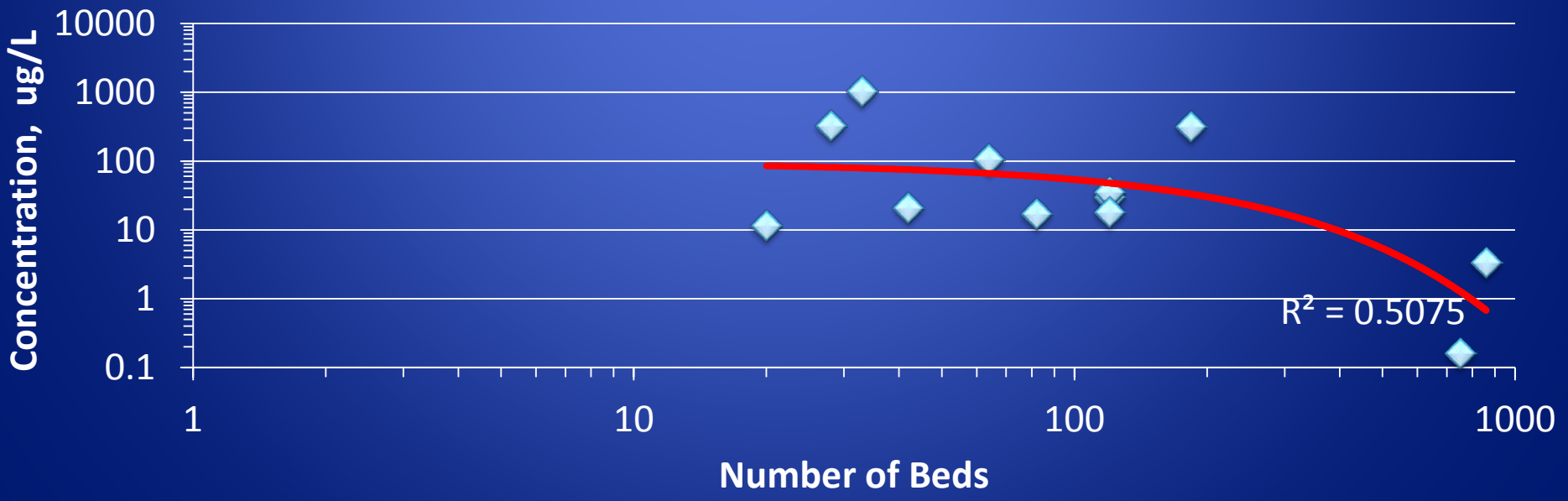



100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
FA05001
FA09001
FA09002
FA33001(S)
FA33001(F)
FA33002
FA03001
FA31001
FA19001
FA41001
FA41002
FA19002
FA19003
FA19004
Prescription/Non-prescription drugs
PAH/VOC
Sterols/Hormones
Flame Retardants
Detergents/Disinfectants
Fragrances/Flavors

Prescription/Non-prescription Drugs



Total Concentration, Sum of all Compounds



Summary

- In bedrock, monitoring wells are needed to ensure we are sampling groundwater.
- Pharmaceuticals, sterols/hormones are making their way into the shallow groundwater.
- Flame retardants and detergents/disinfectants are the wastewater compounds having the greatest concentration impact on shallow groundwater quality.
- We are unable to state at this time on geological impacts on these compounds.
- While some compounds show possible signs of adsorption or degradation, these compounds are persistent in the environment. The levels are low, but as a soup of compounds, or standing alone are a cause of concern for their impact on wildlife and embryotic development.

What Will Come Of This Data

- The NJ Geological and Water Survey in cooperation with USGS will publish an NJGWS Informational Circular
- It is hoped to get this study published in a peer reviewed journal.

Phase II

- Was preformed on two facilities in the coastal plain.
- Was designed to track the concentration and fate of these compounds from septic tank to groundwater.
- A second groundwater sample was taken farther downgradient, but from preliminary data, further groundwater flow mapping would need to be done and the second sample would need to be farther away.