Pharmaceuticals in Michigan Waters

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Sampling Protocol

- Emerging Issues Monitoring through Clean Michigan Initiative – Clean Water Fund
- January, April, July, October 2005

- Ann Arbor and Grand Rapids
  - Source water, finished drinking water
  - WWTP influent/effluent
- Monroe
  - Source water, finished drinking water

Target Analytes

- Antibiotics
  - Sulfamethoxazole
  - Lincomycin
  - Tylosin
  - Trimethoprim

- Beta-blockers
  - Atenolol
  - Metoprolol
  - Propranolol
- Analgesics
  - Acetaminophen
  - Codeine
  - Ibuprofen
- Lipid Regulators
  - Clofibric acid
  - Gemfibrozil

Target Analytes (cont'd)

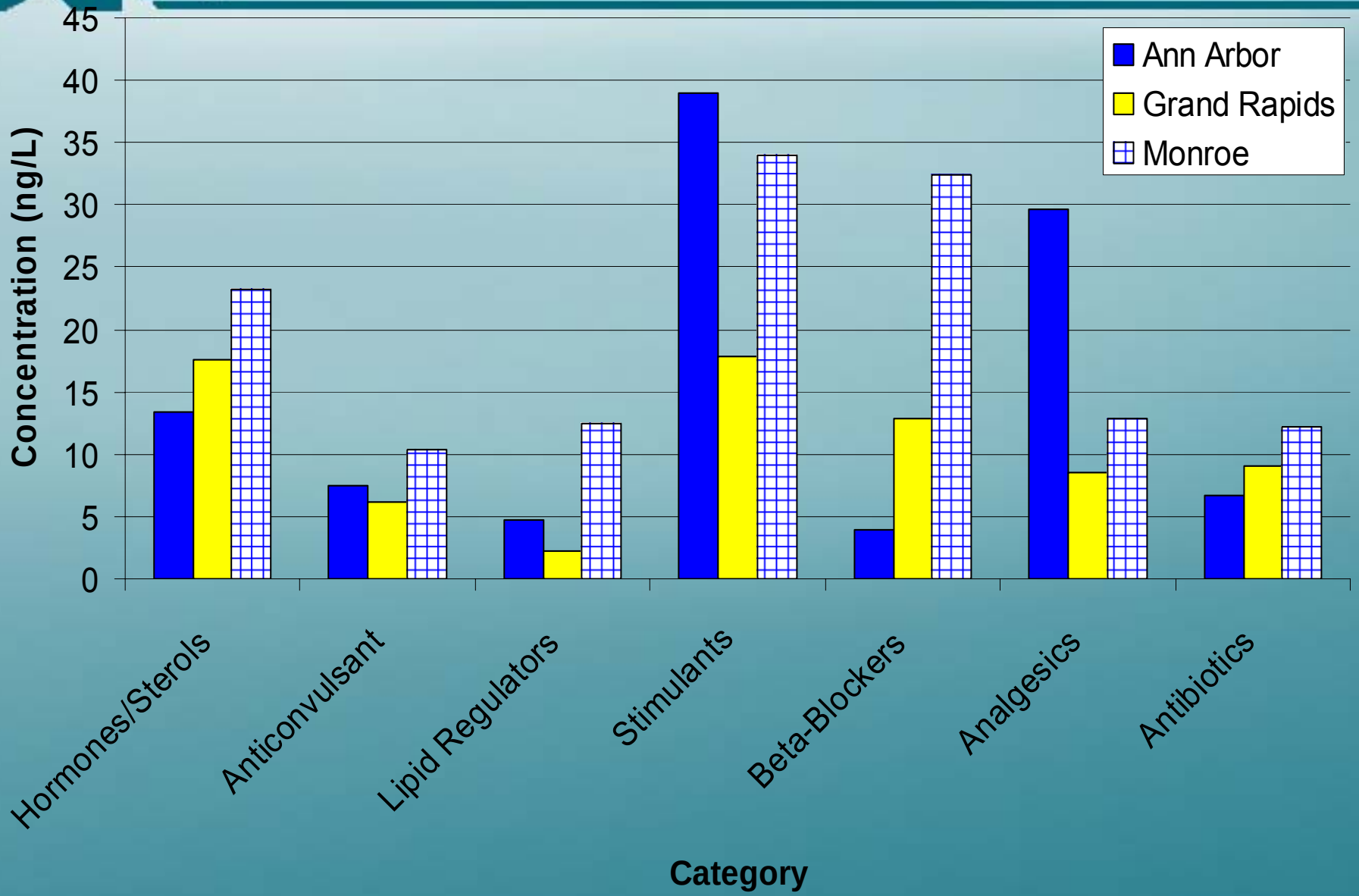
- Hormones and Sterols
  - 17-β-estradiol
  - 17-α-ethinylestradiol
  - Estrone
  - Estriol
  - Cholesterol
  - Coprostanol

- Miscellaneous
  - Carbamazepine
  - Fluoxetine
  - Norfluoxetine
  - Caffeine

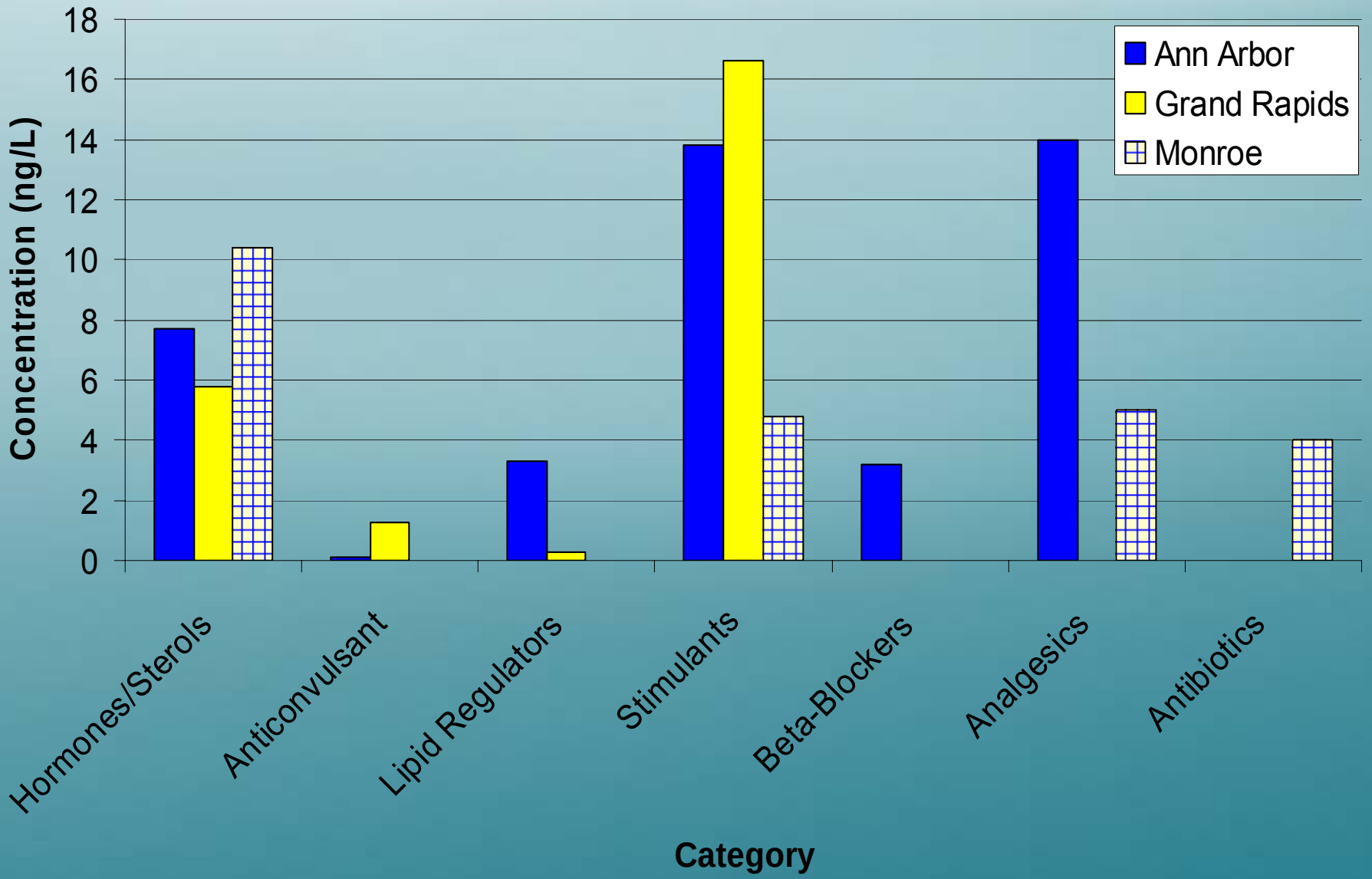
- Extras
  - Cimetidine
  - Diltiazem
  - 1,7-Dimethylxanthine
  - Diphenylhydramine
  - Erythromycin
  - Miconazole
  - Sertraline
  - Thiobendazole
  - Warfarin

- GC/MS for hormones/sterols
- LC/MS/MS for remainder

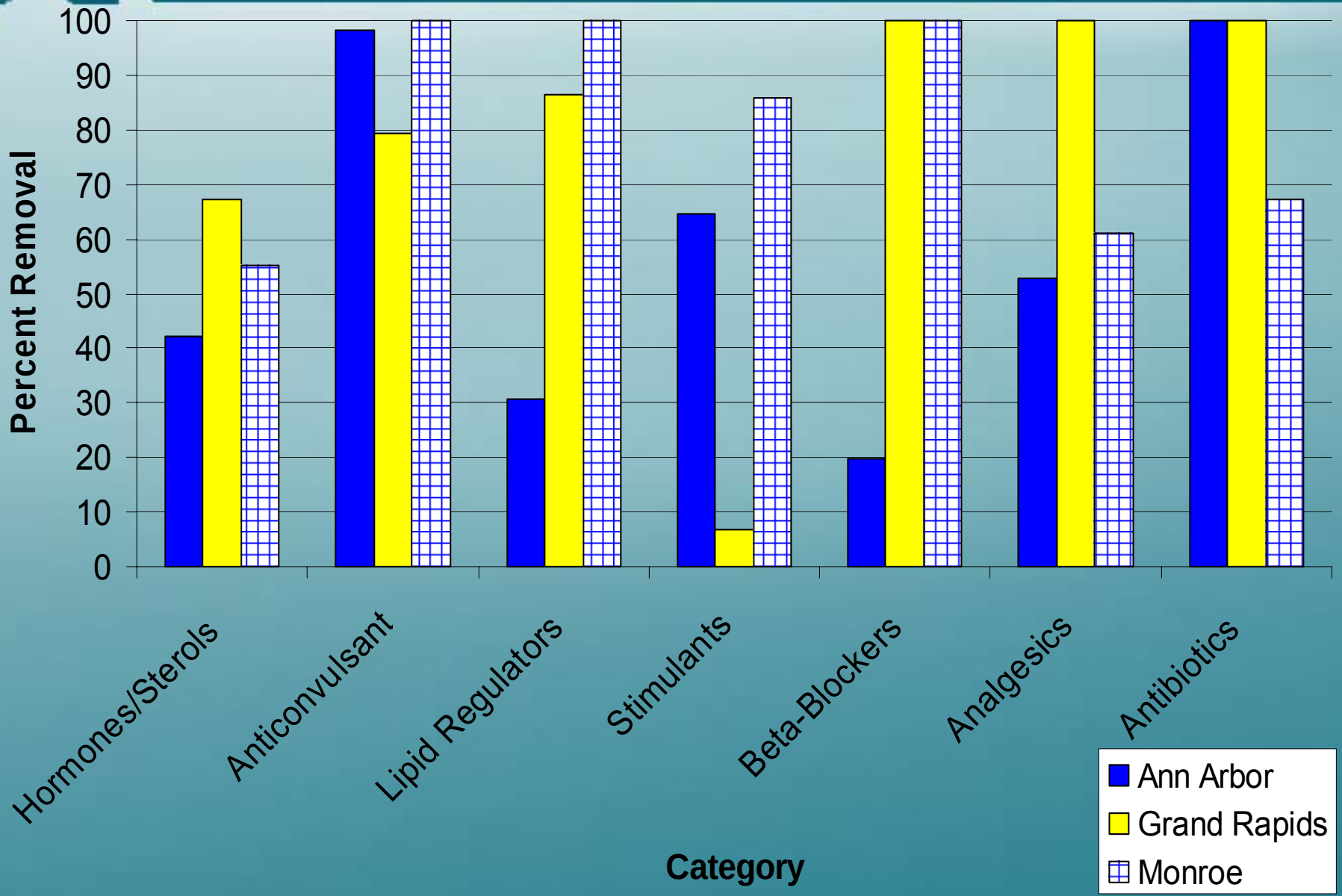
Compounds Detected in Source Water



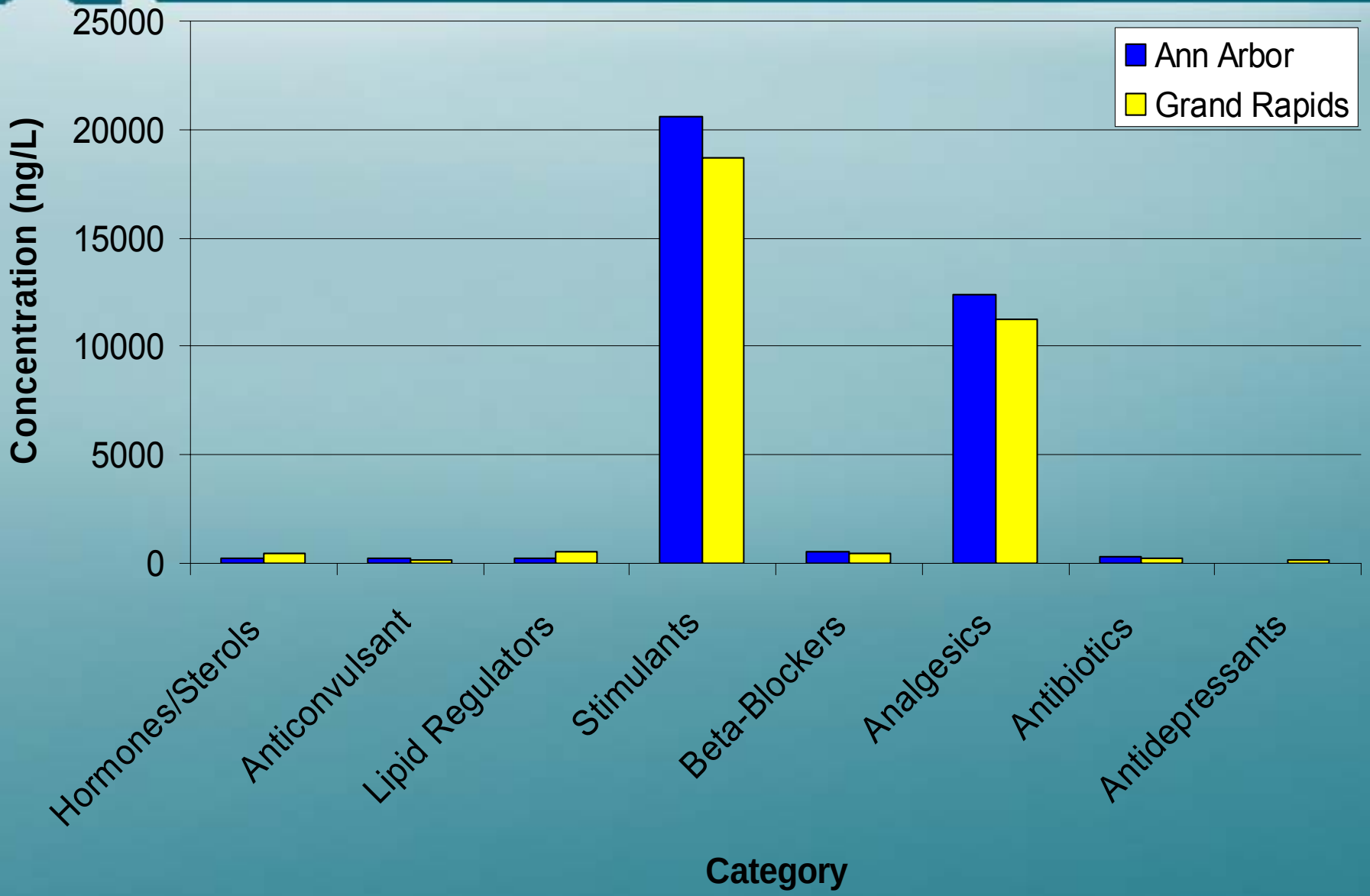
Compounds Detected in Drinking Water



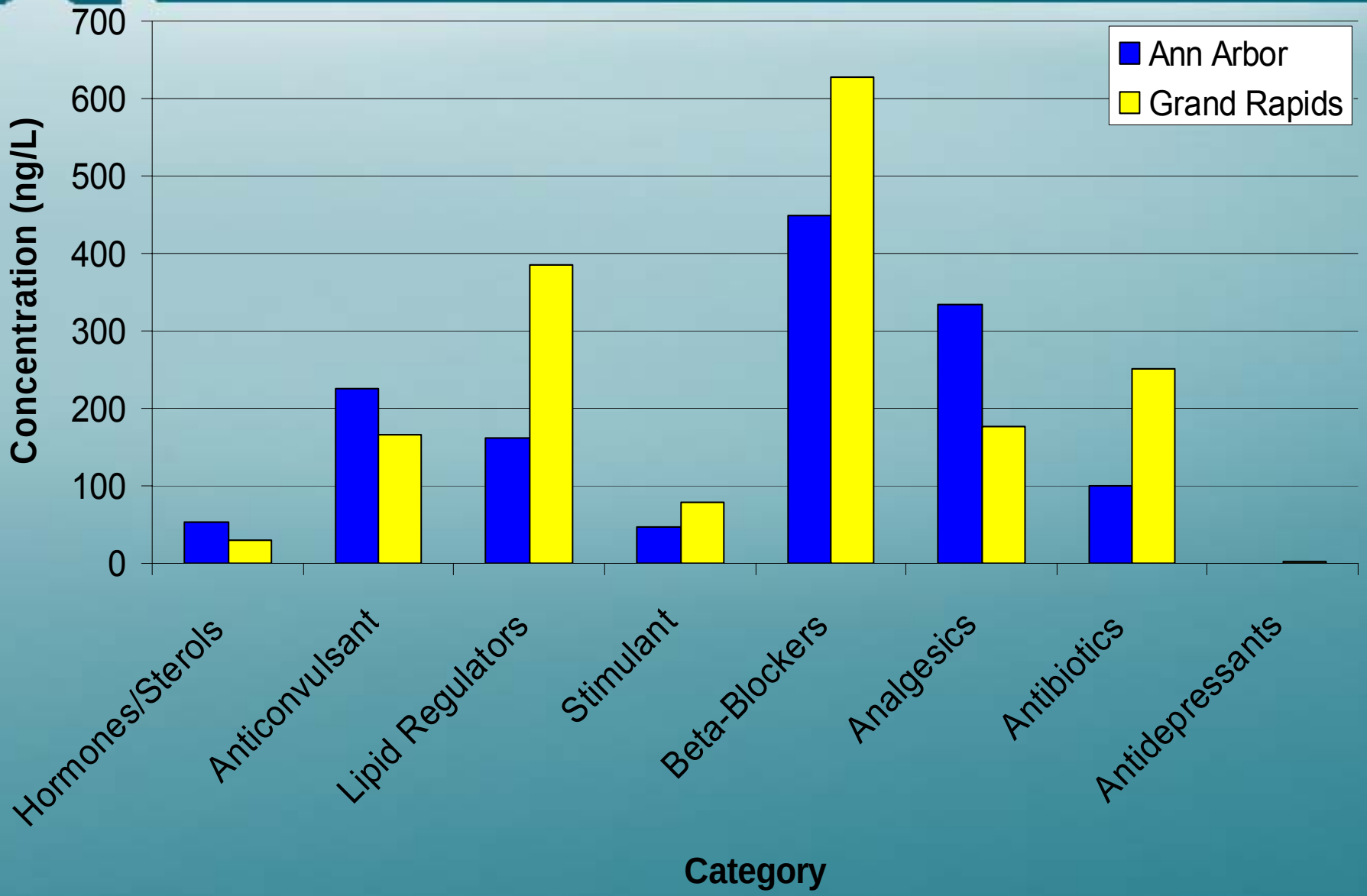
Effect of Water Treatment

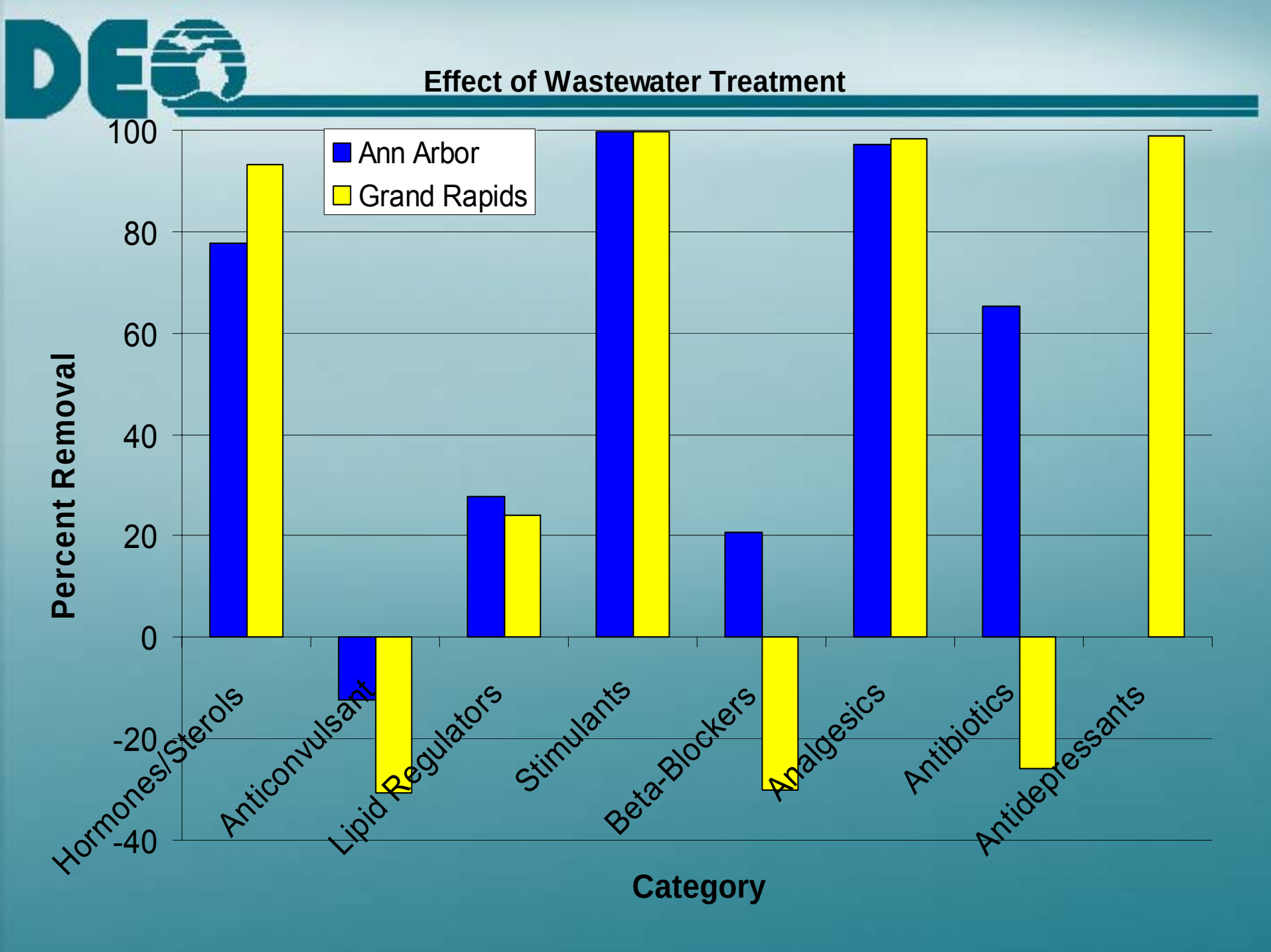


Compounds Detected in Wastewater Influent

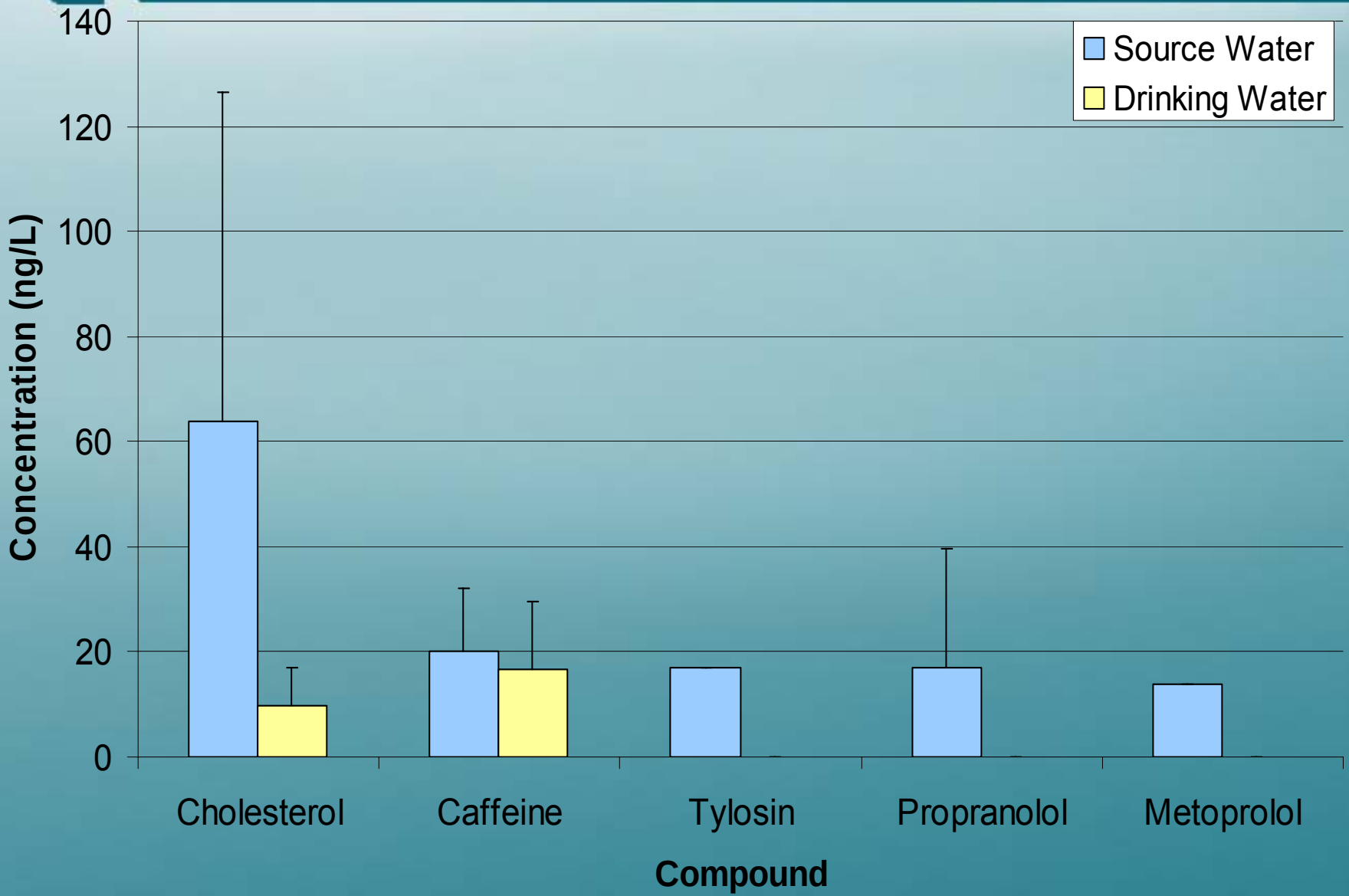


Compounds Detected in Wastewater Effluent

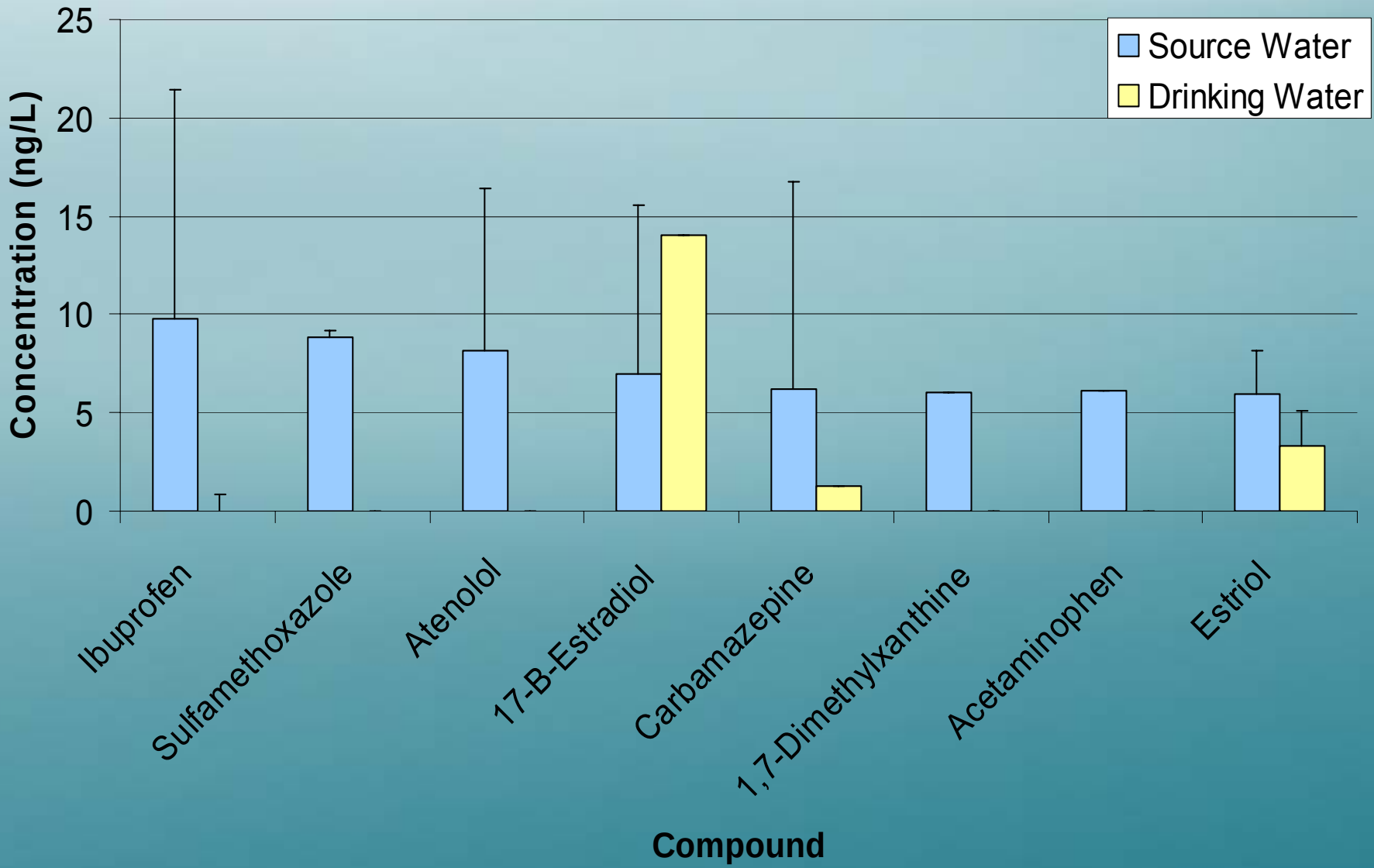



Effect of Wastewater Treatment
Ann Arbor
Grand Rapids
Percent Removal
100
80
60
40
20
0
-20
-40
Hormones/Sterols
Anticonvulsant
Lipid Regulators
Stimulants
Beta-Blockers
Analgesics
Antibiotics
Antidepressants
Category

Grand Rapids Source Water vs. Drinking Water



Grand Rapids Source Water vs. Drinking Water



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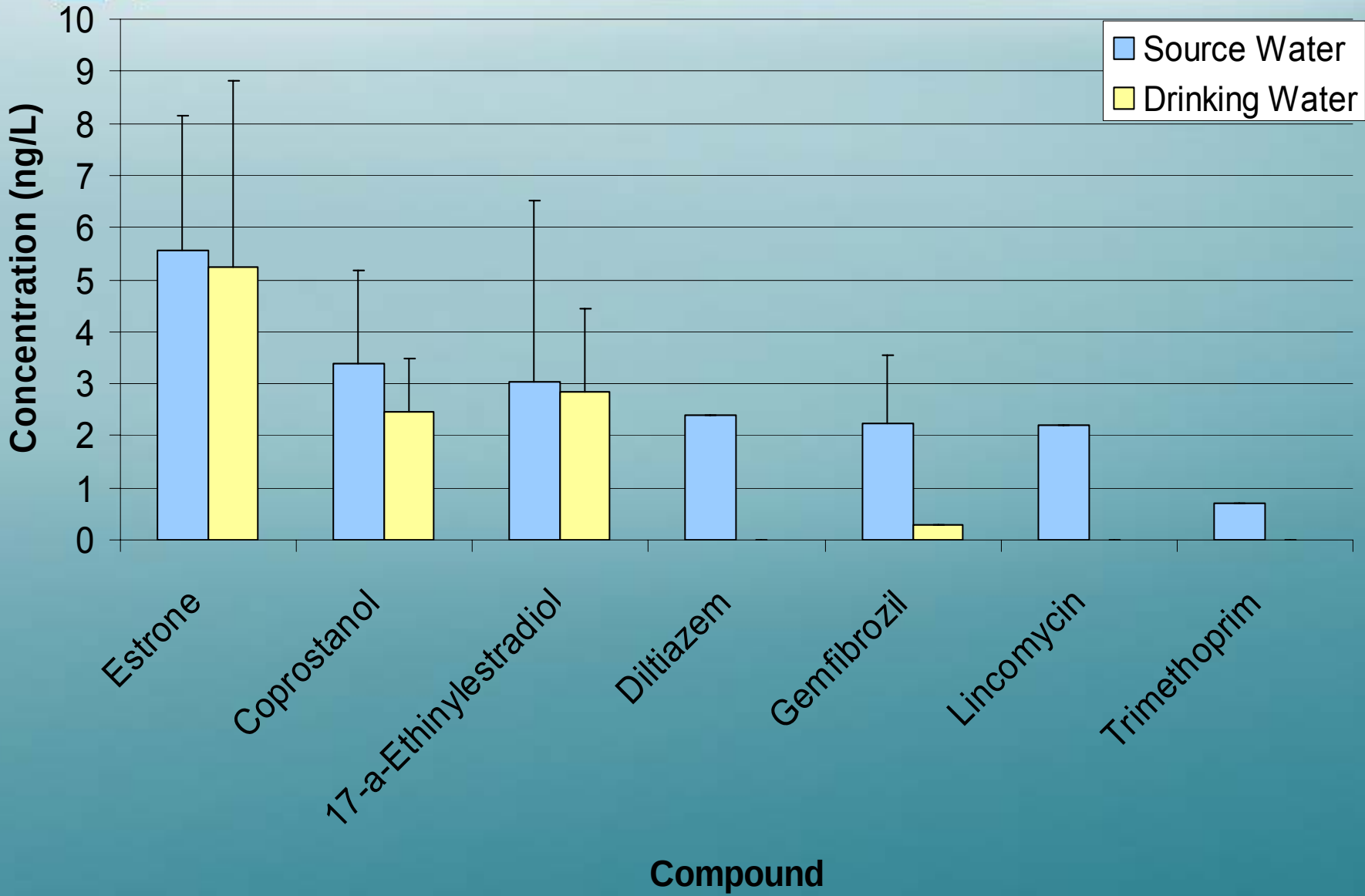
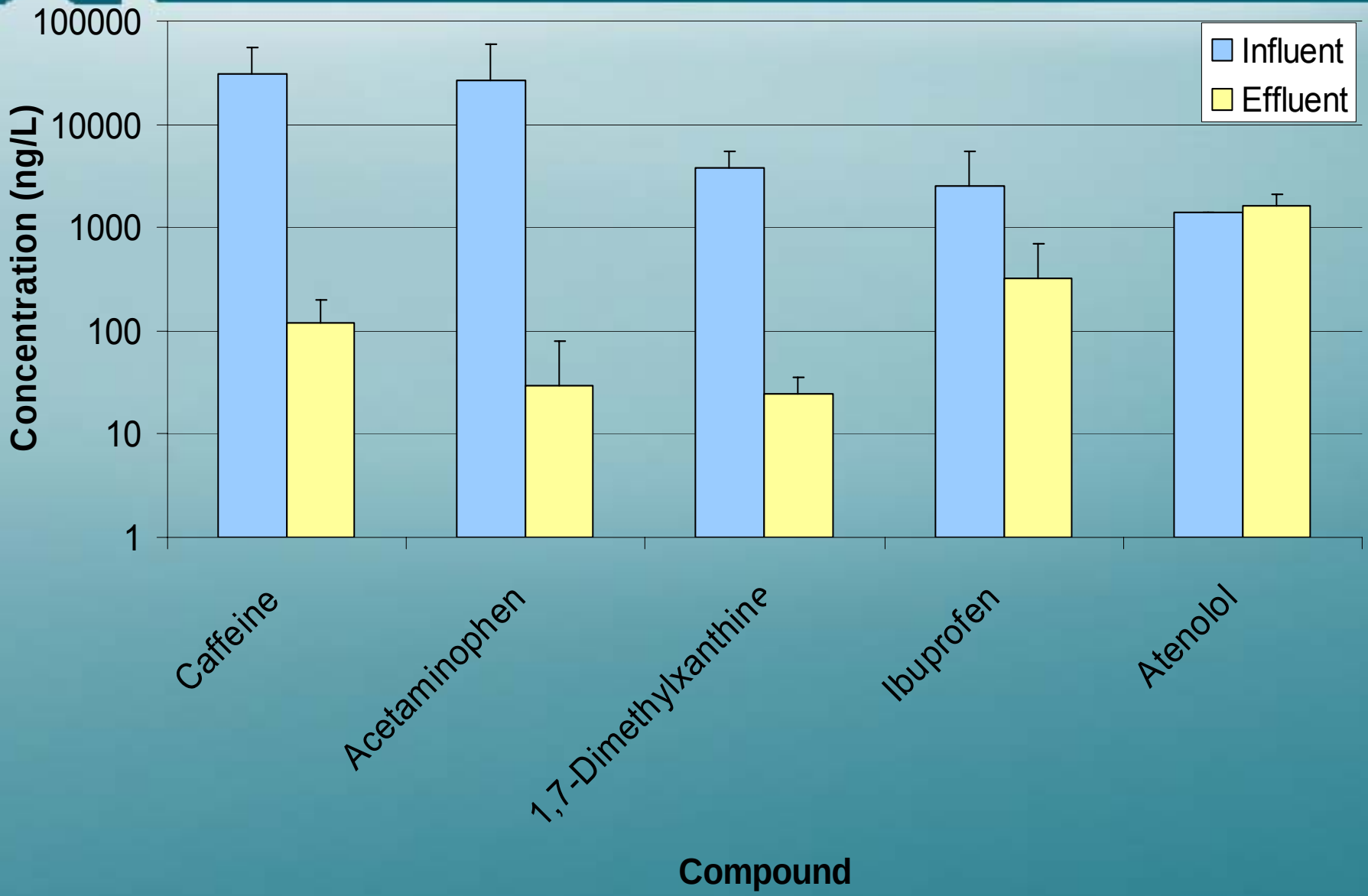


Grand Rapids Wastewater Influent vs. Effluent



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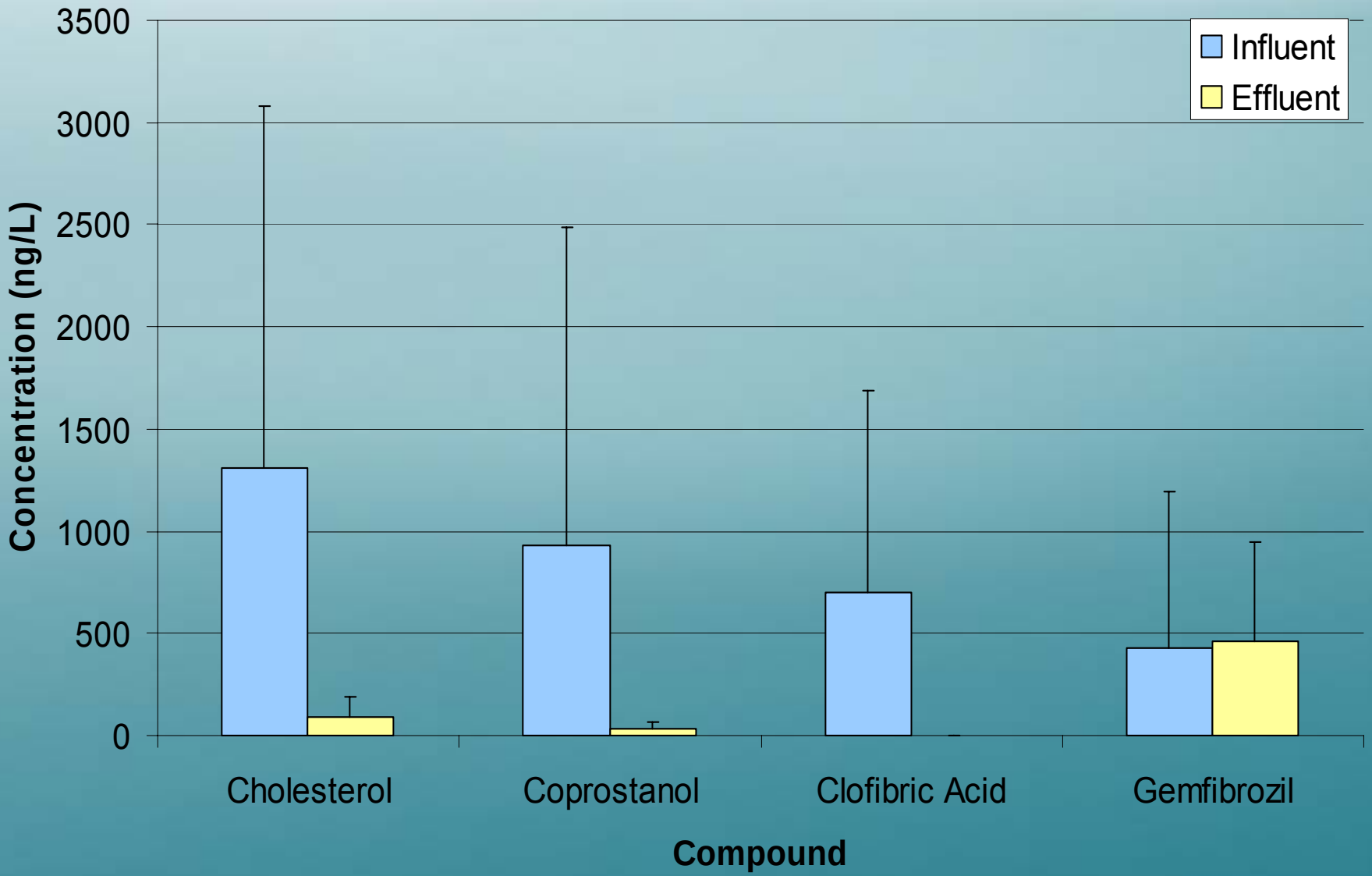

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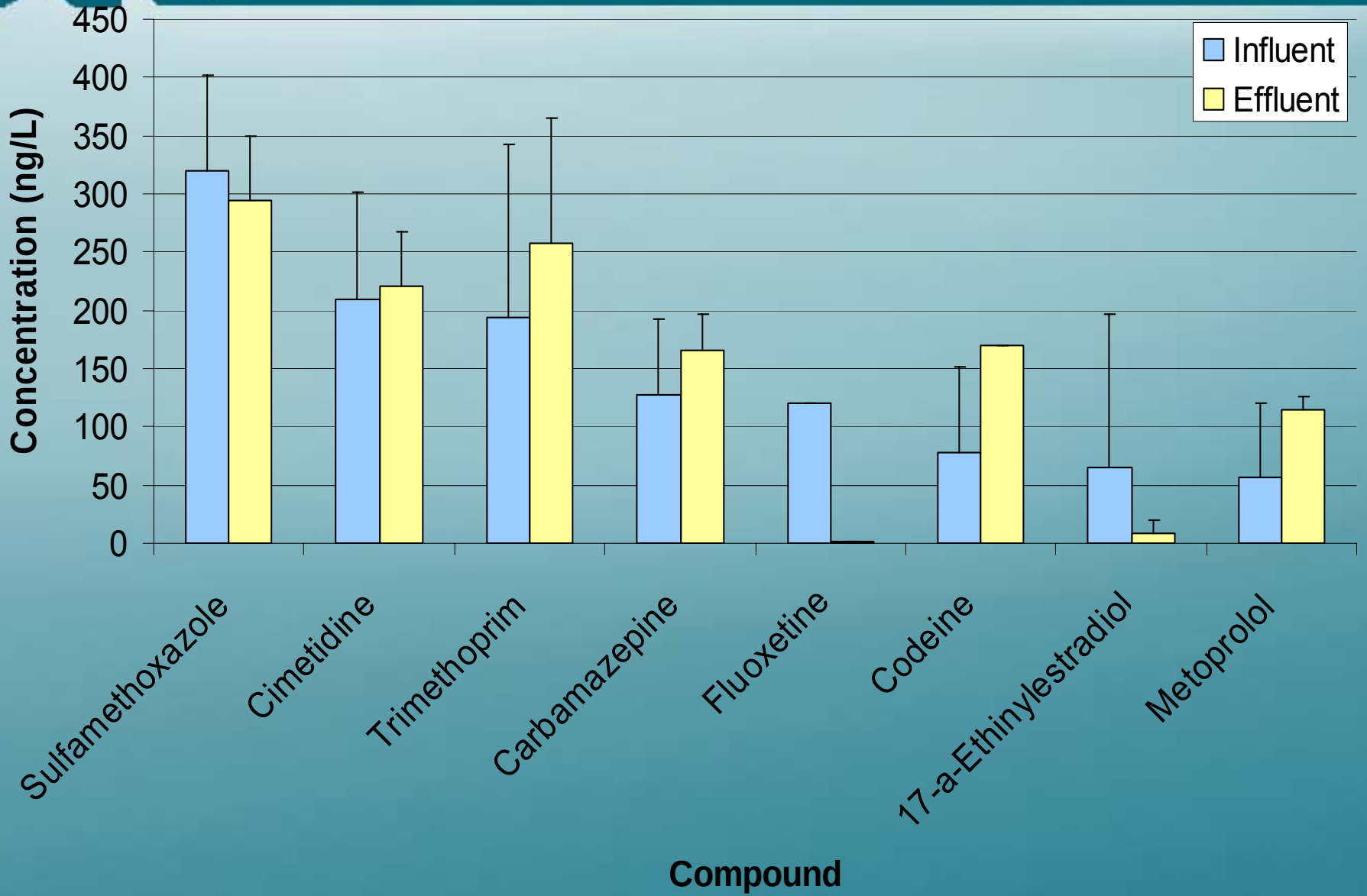

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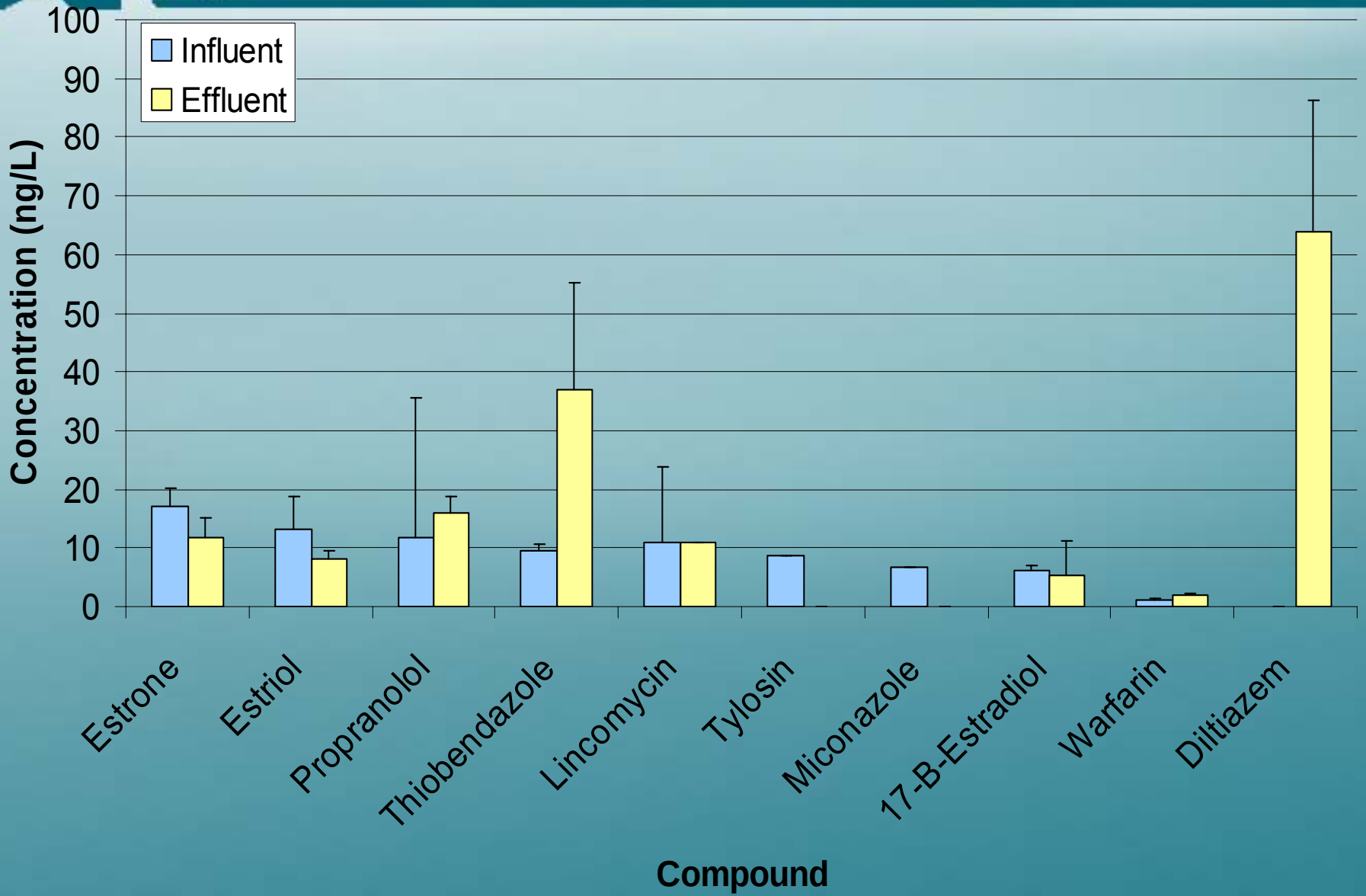
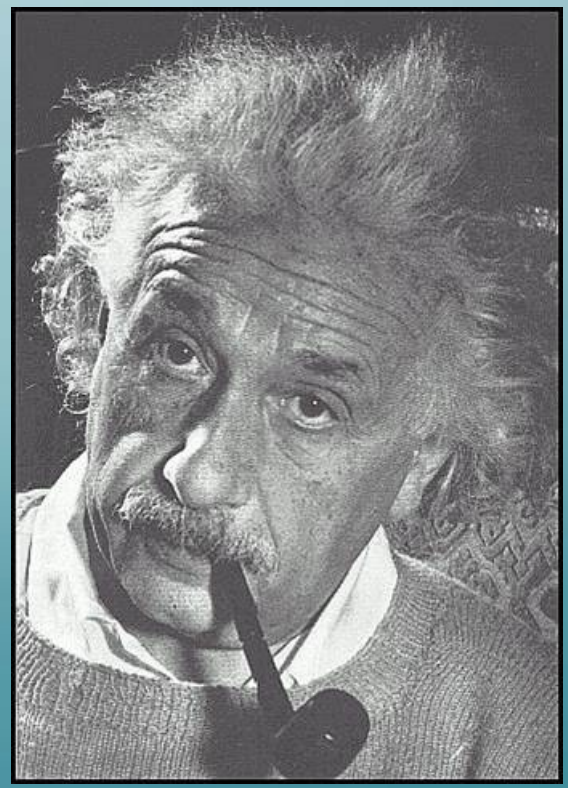


Should We Regulate PPCPs?

- "Not everything that counts can be counted, and not everything that can be counted counts."
  – often attributed to Albert Einstein



Unanswered Questions

- Is any of this a problem?
  - Antibiotic resistance
  - Endocrine disruption
  - Aquatic life
    - Persistence and bioaccumulation?
  - Wildlife
  - Human health
    - Allergic reactions?
- How can these compounds be removed?
  - Cost, technical feasibility

Points to Ponder

- Extremely low concentrations
  - Detected only because of improved technology
- Input is essentially constant
  - As is exposure of aquatic organisms
- Complex mixtures of compounds designed to be biologically active
  - Potential additive/synergistic effects
- “Pass-through” suggests resistance to biodegradation
  - Stable throughout manufacture/storage
- Need better fate and transport data to accurately assess impact

Acknowledgments

- Bryan Brooks and Kevin Chambliss, Baylor University Center for Reservoir and Aquatic Systems Research
- Janice Skadsen, City of Ann Arbor Water Utilities
- John Wierenga, City of Grand Rapids Lake Michigan Filtration Plant
- Scott Allen, City of Monroe
- Daniel Meyering and Brian Rice, Fleis and VandenBrink Engineering

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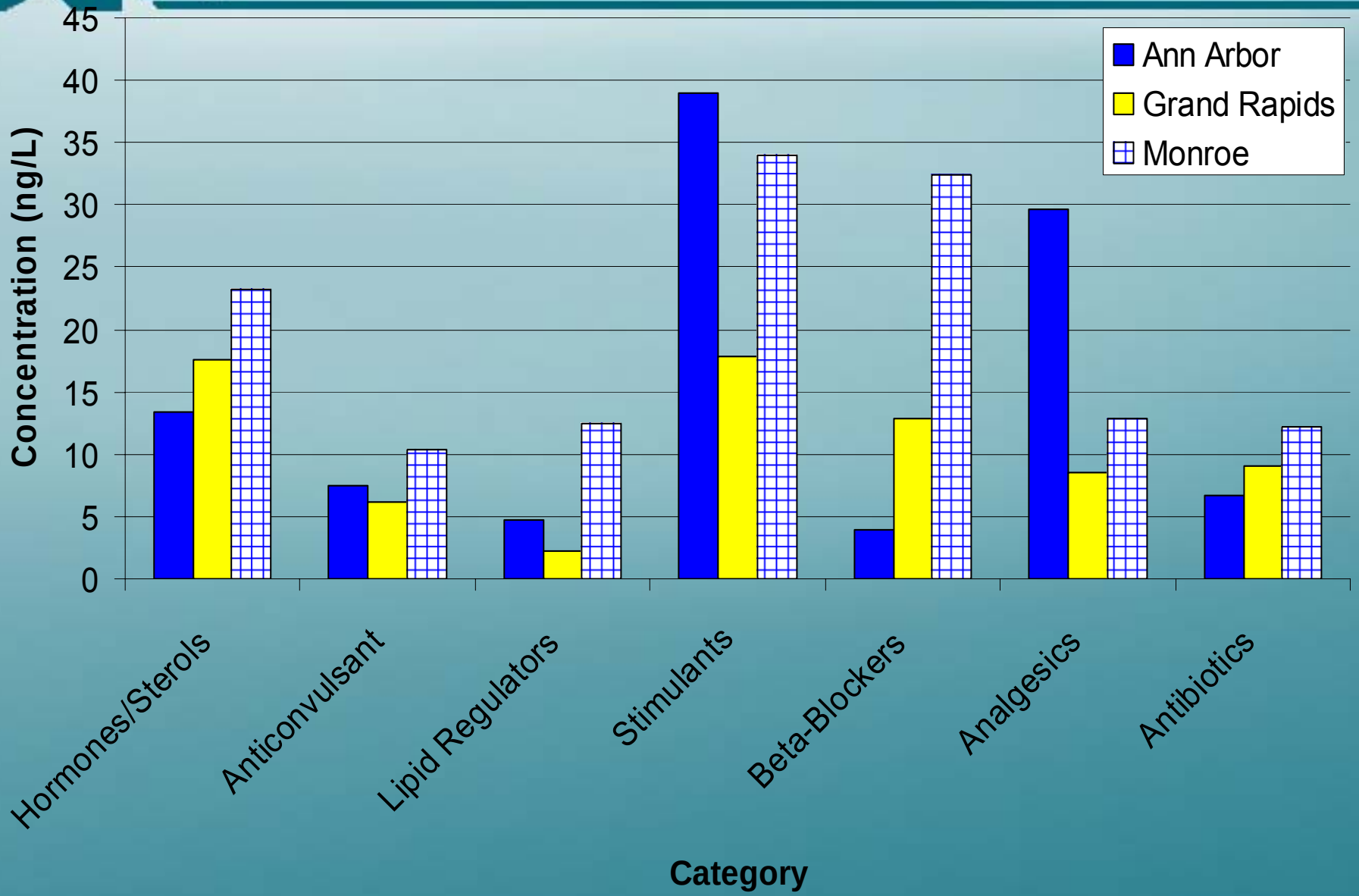

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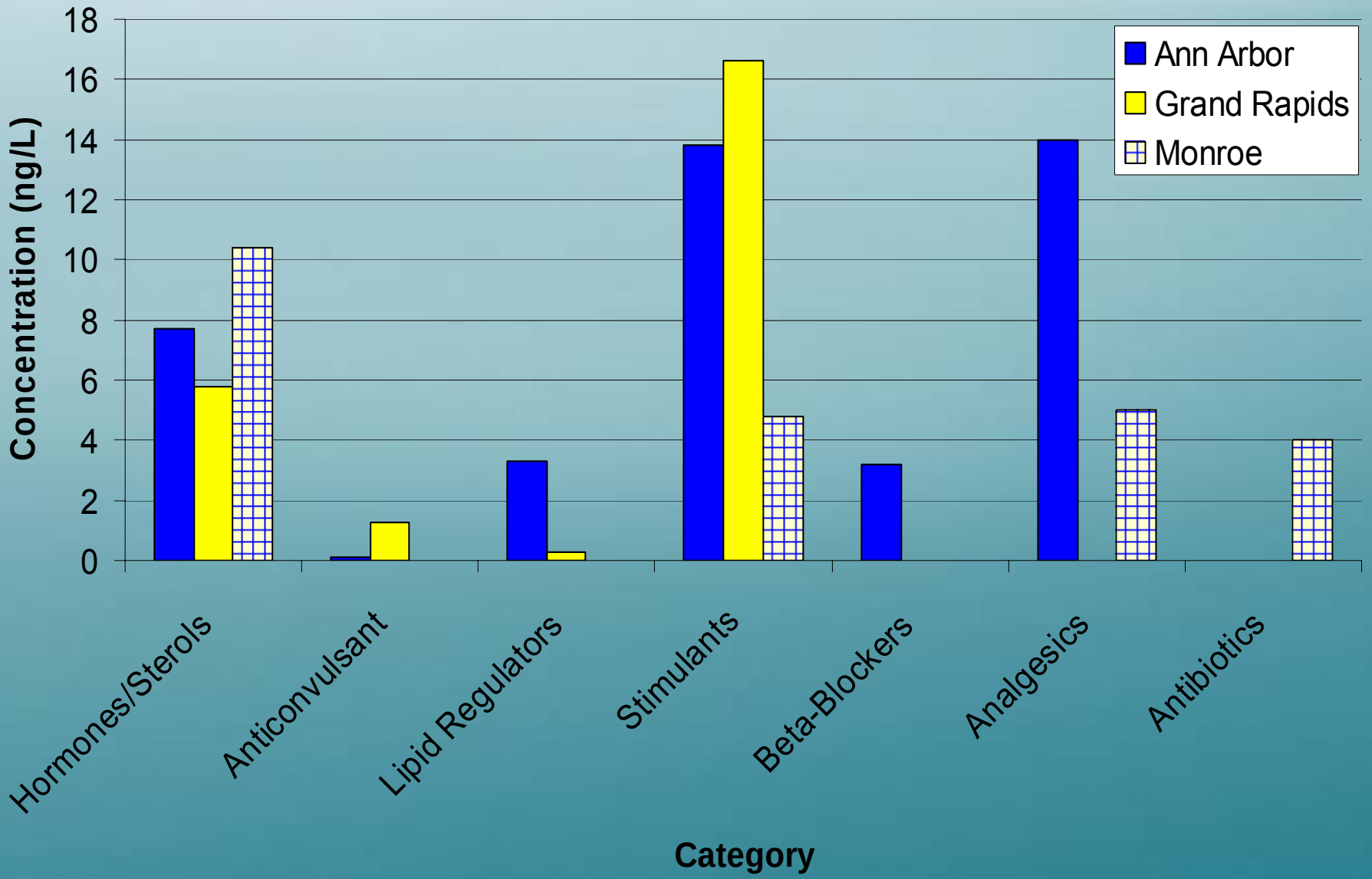

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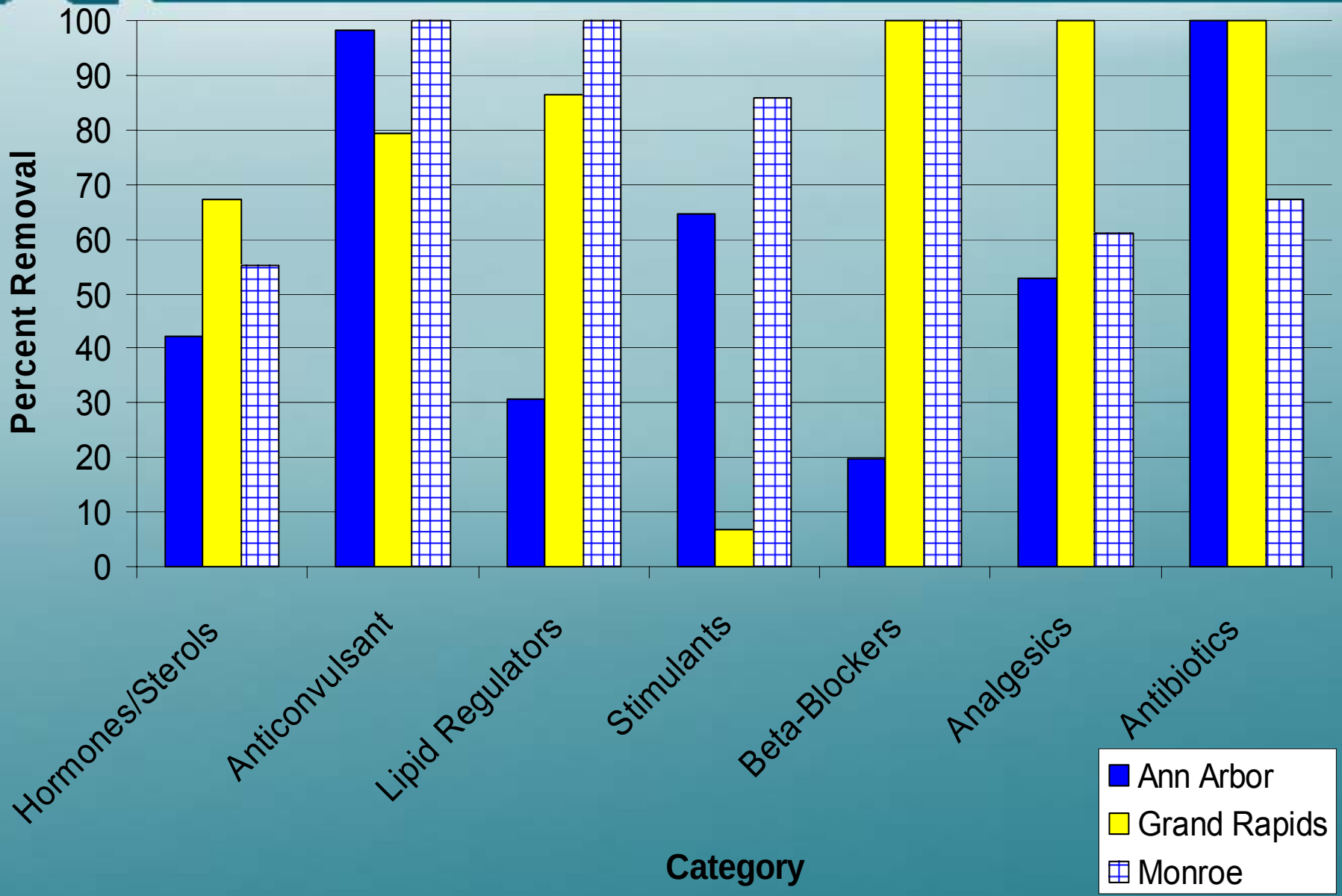

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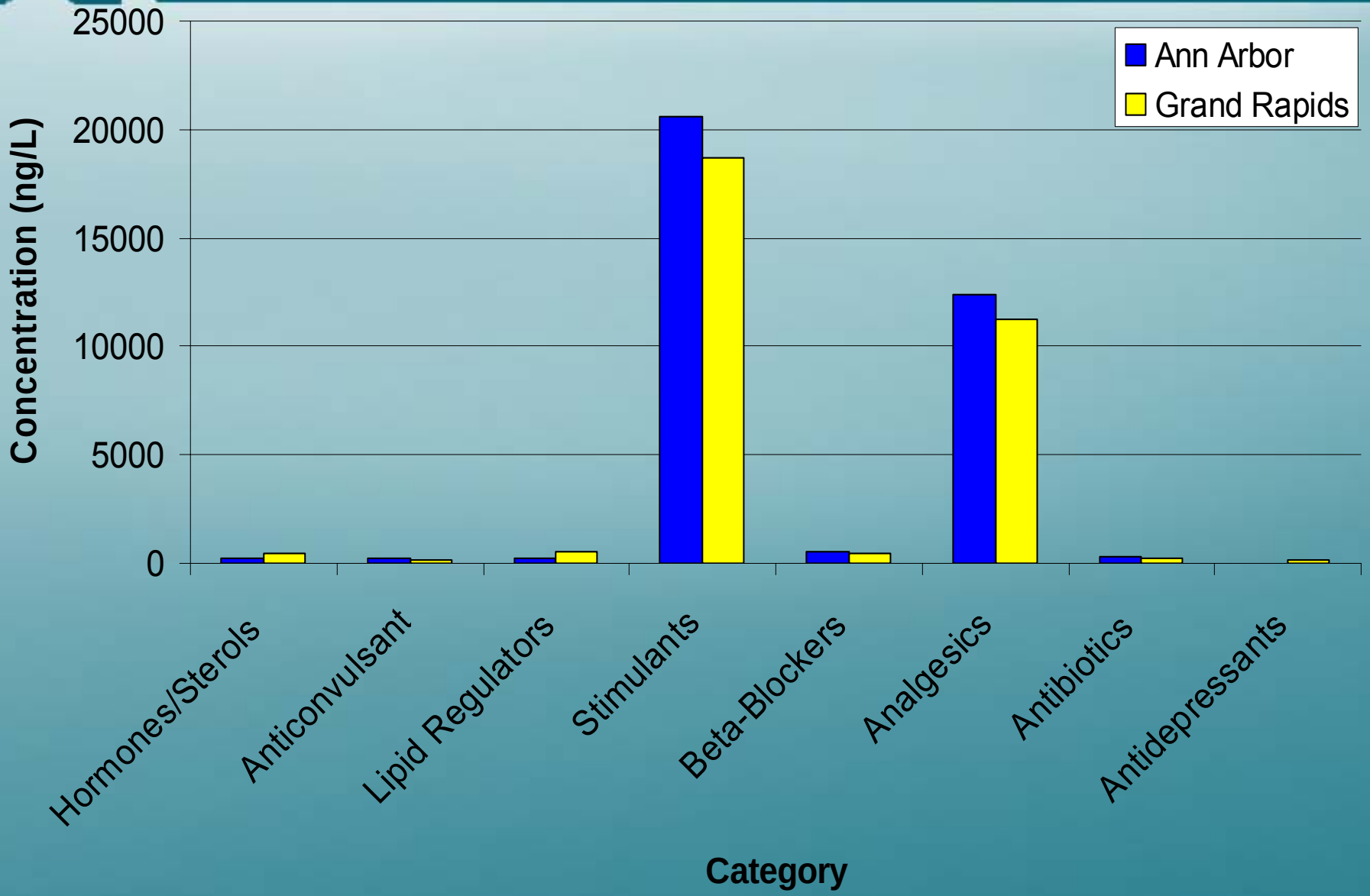

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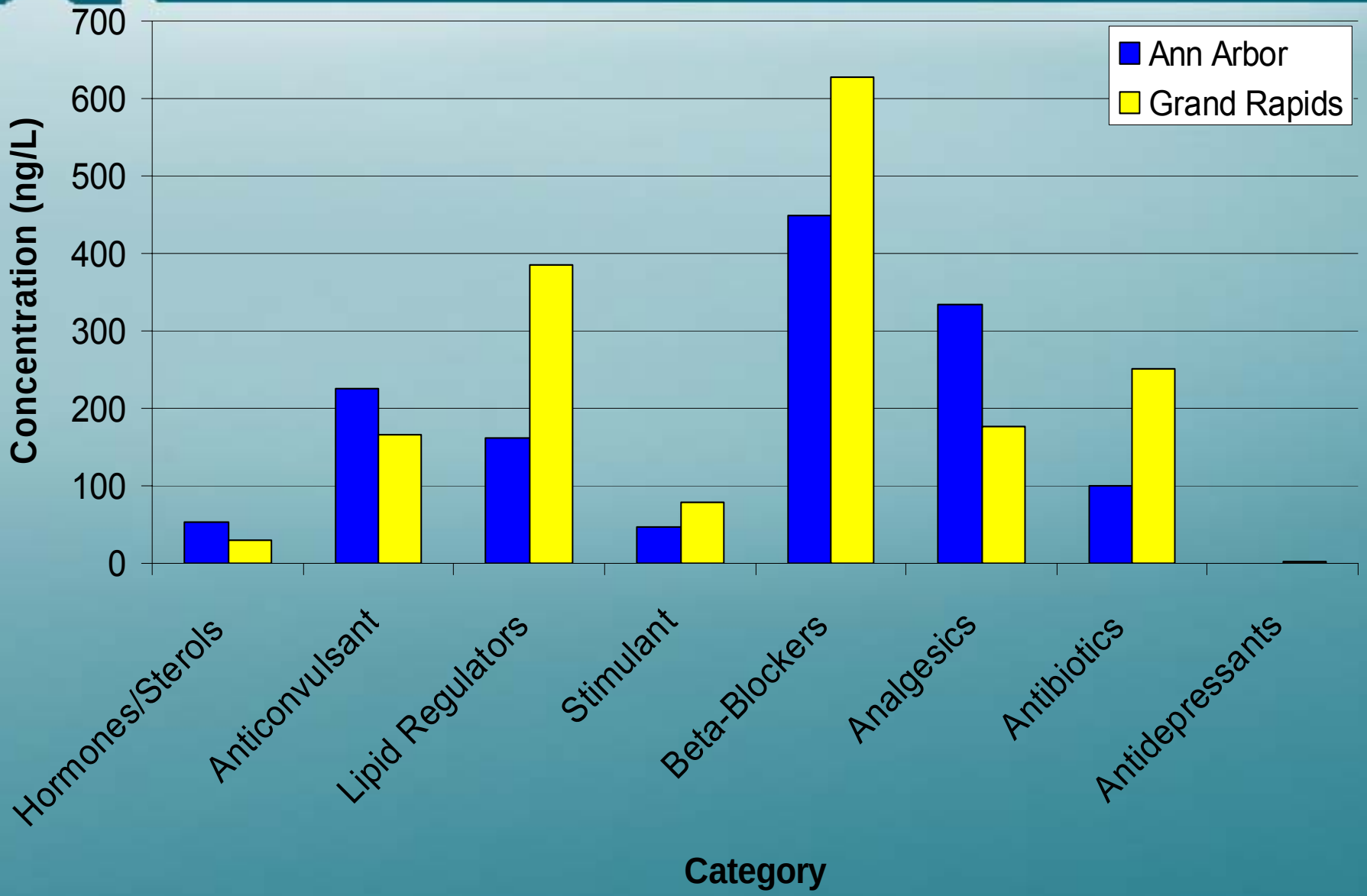

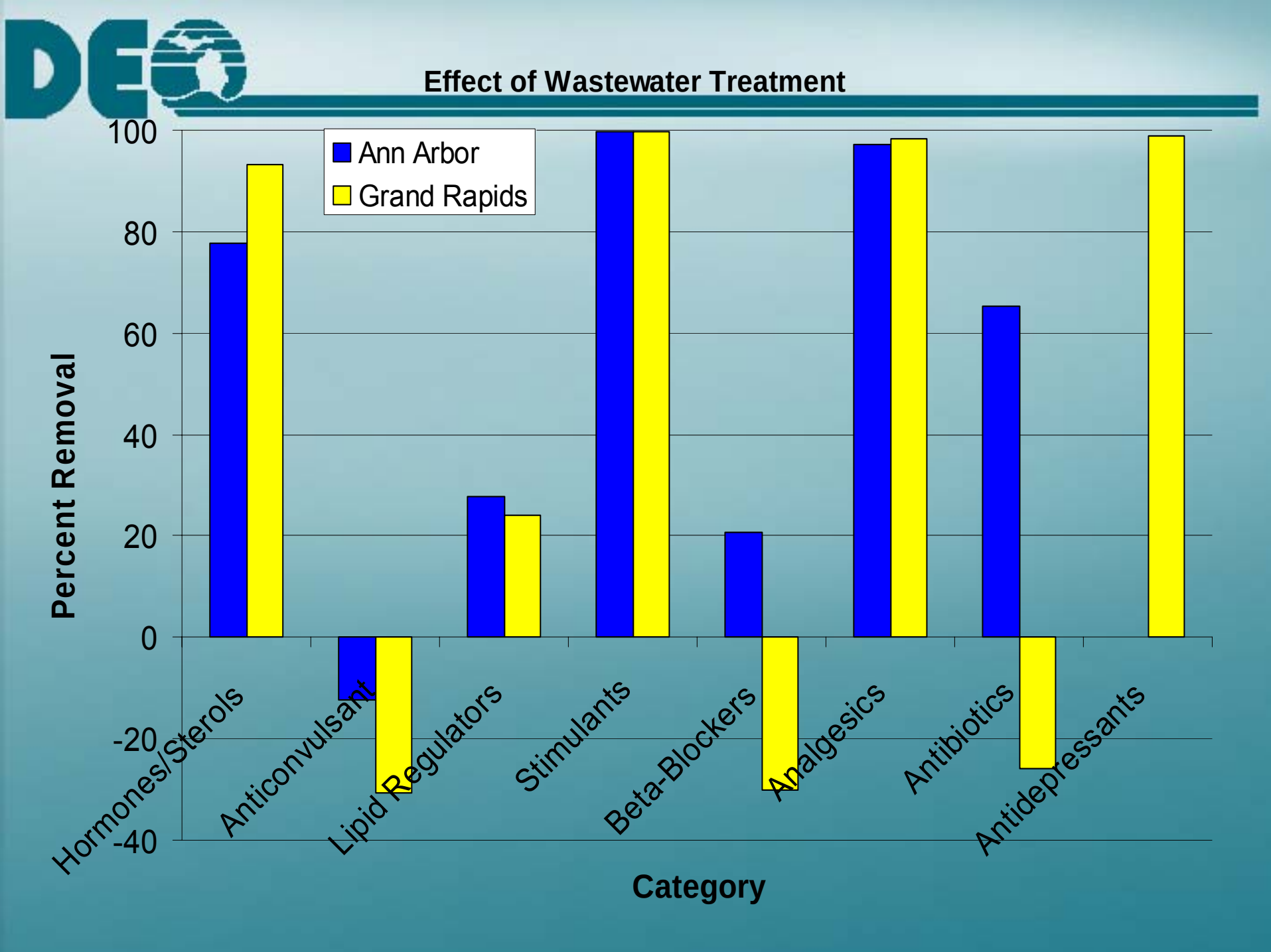
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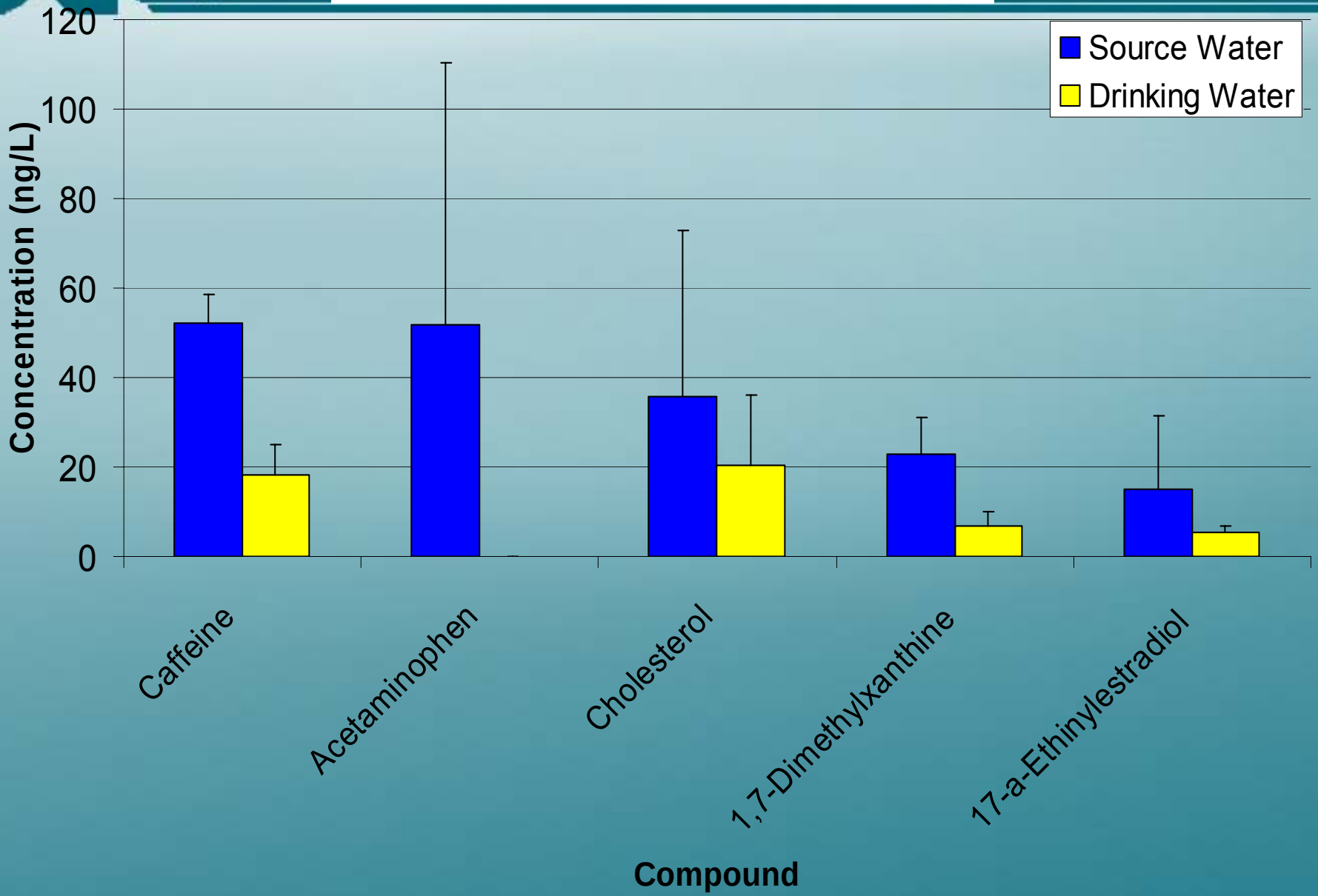

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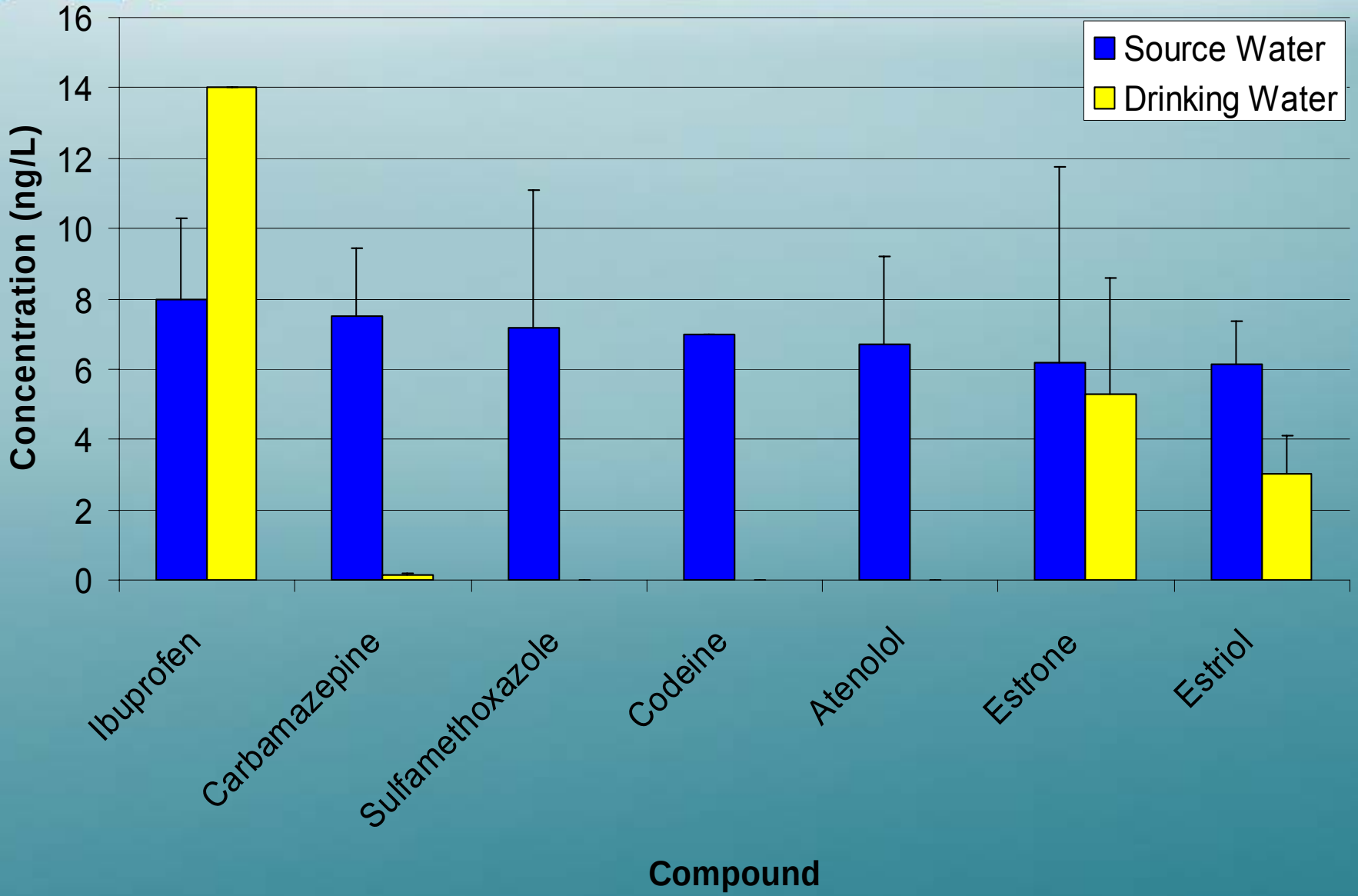

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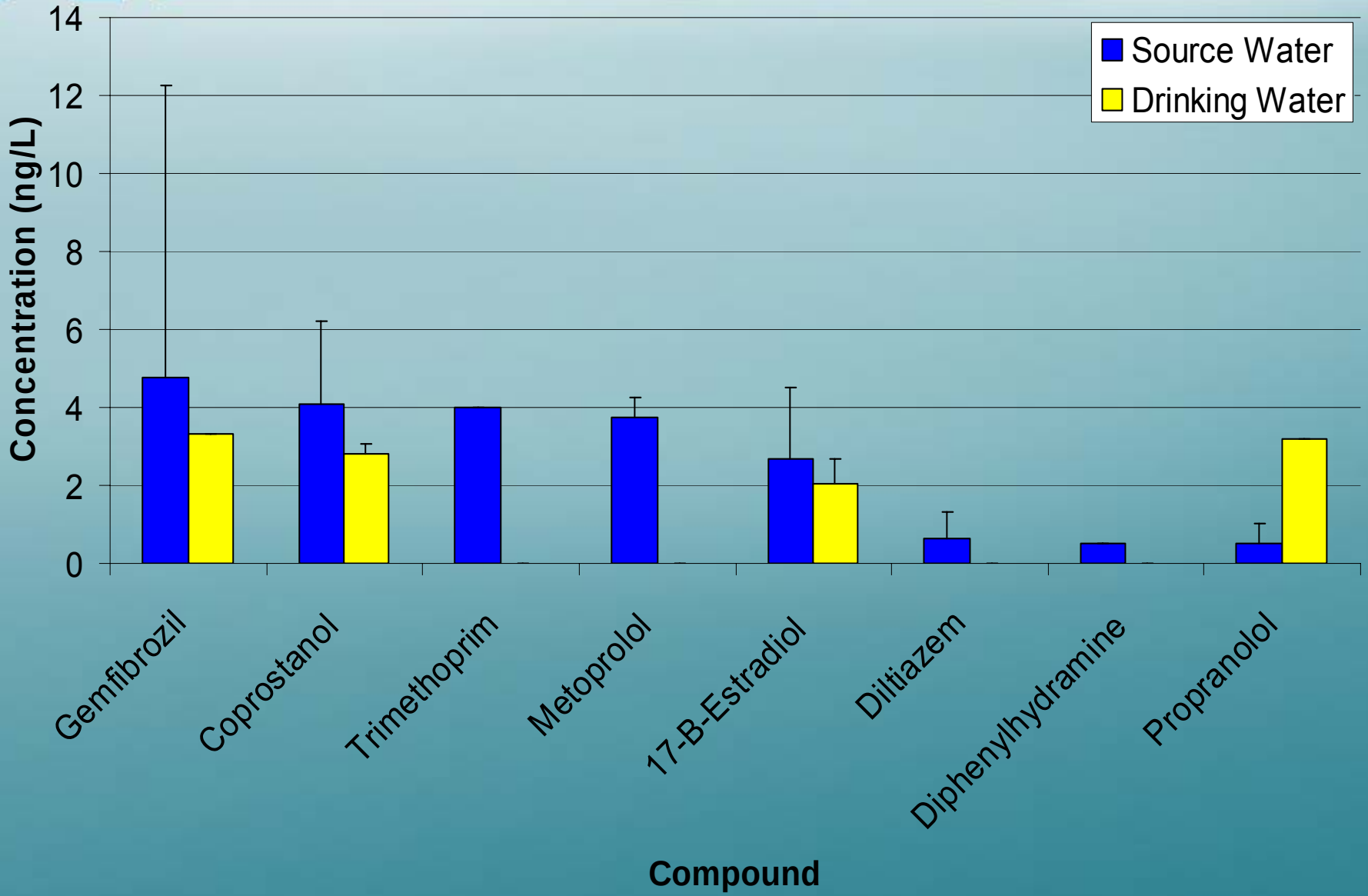
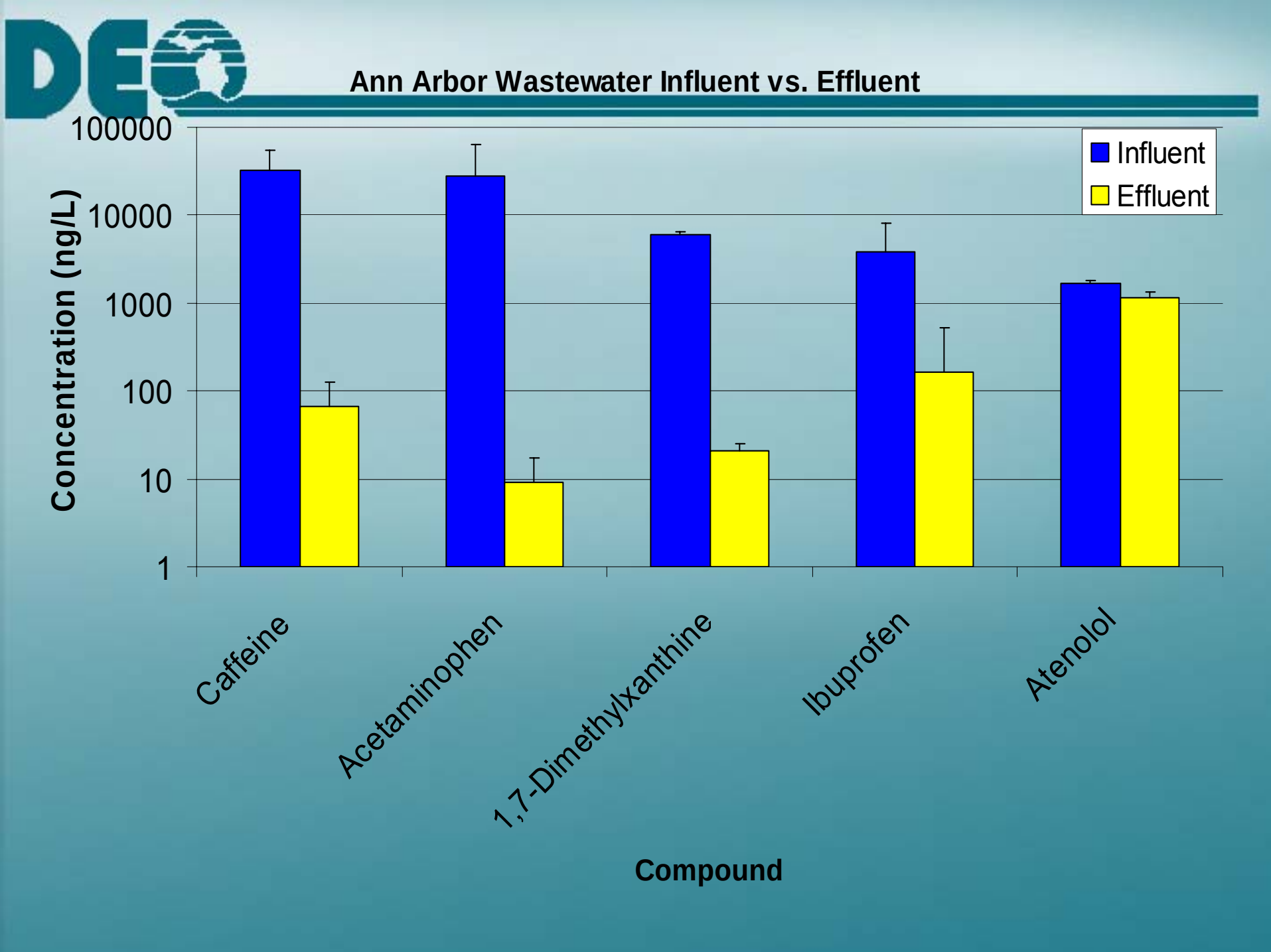
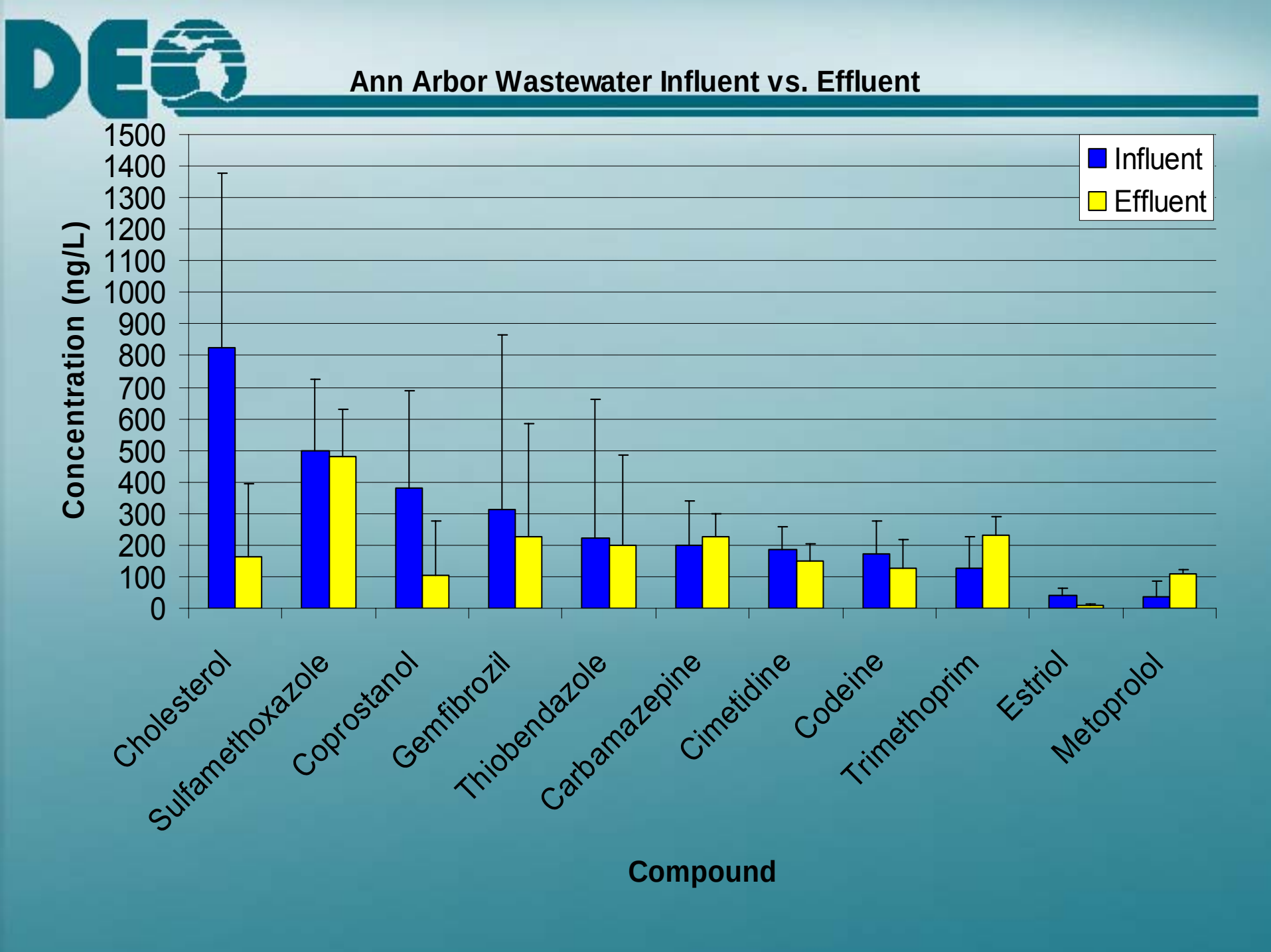
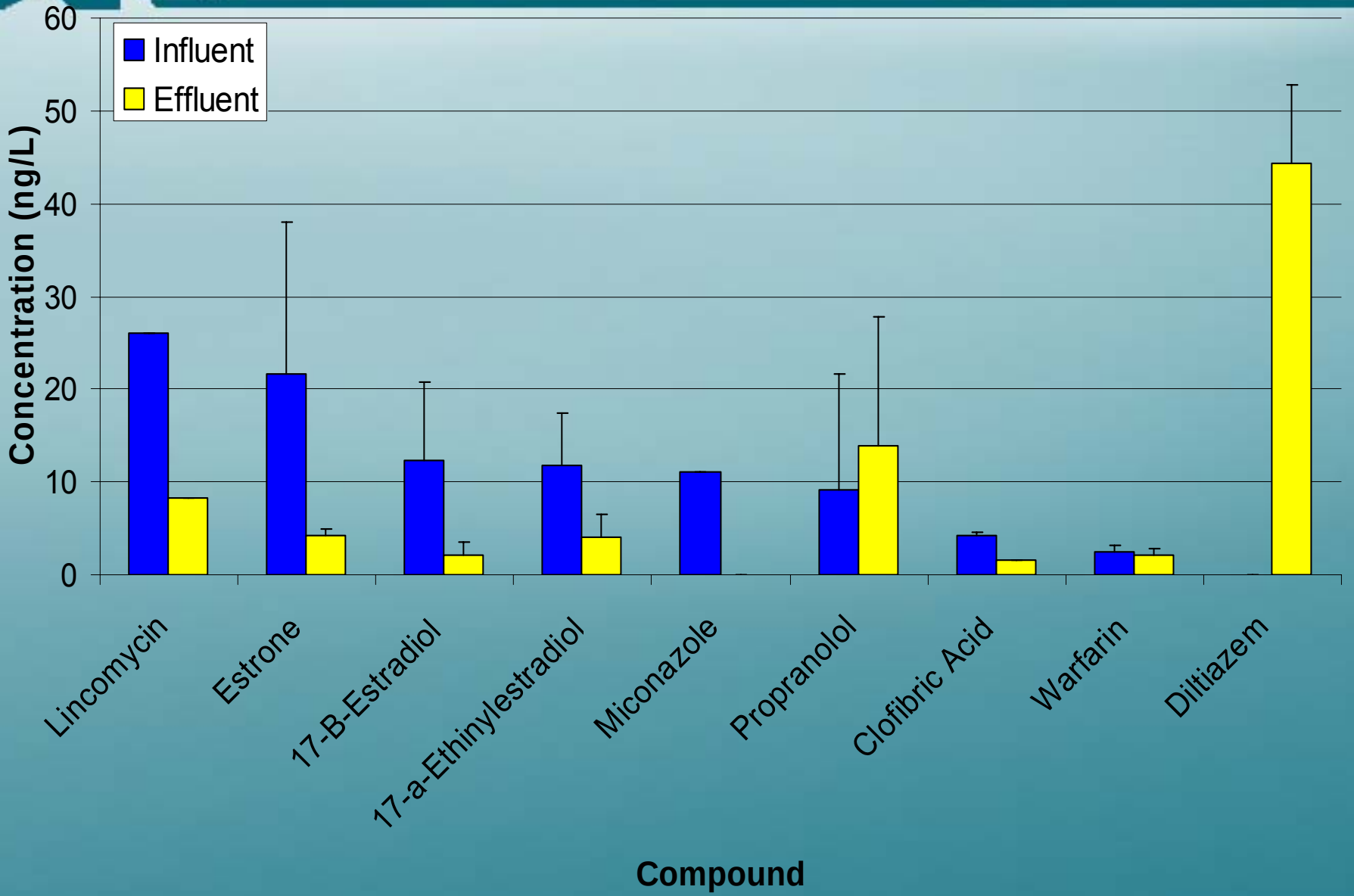


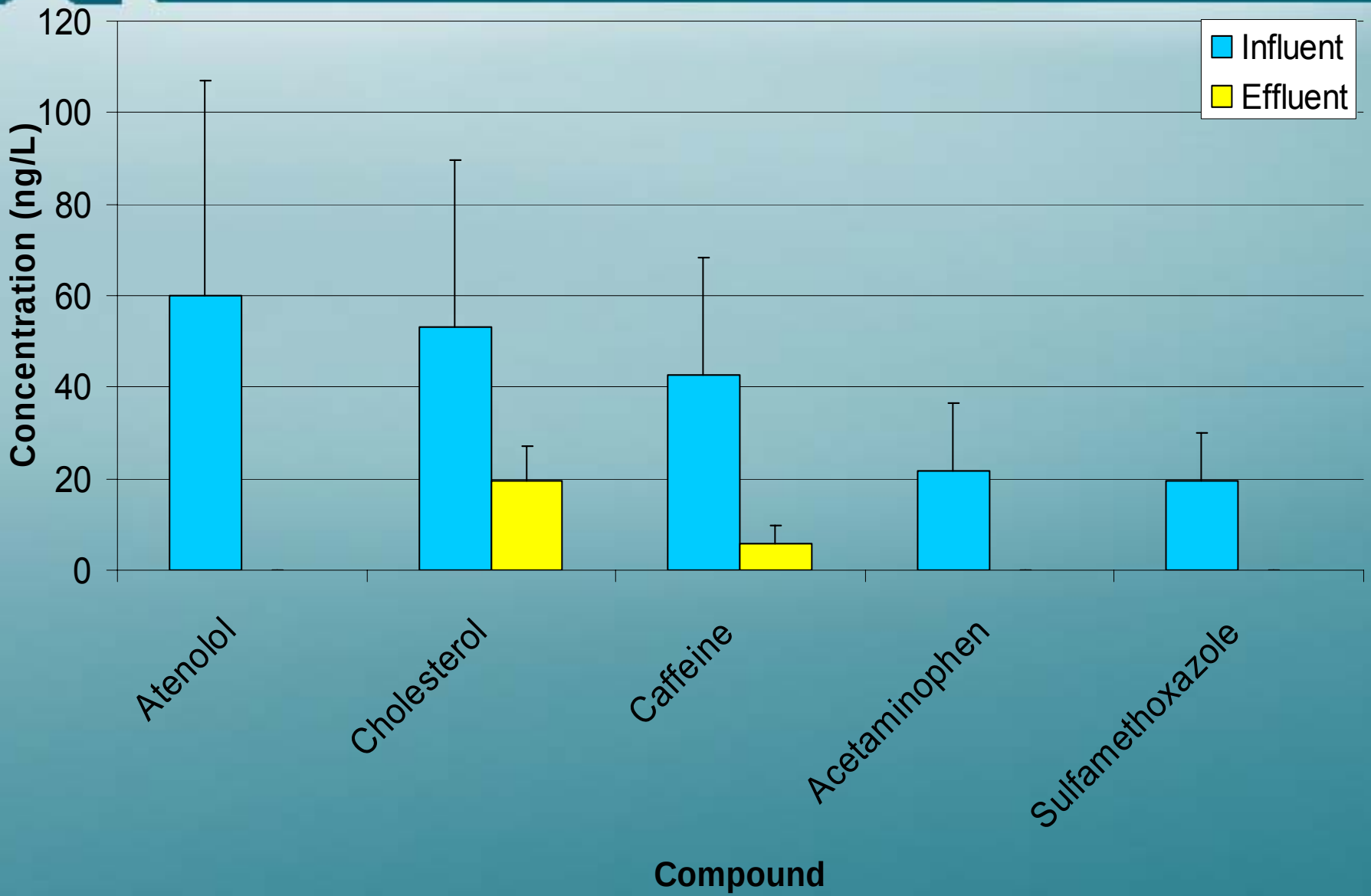

Ann Arbor Wastewater Influent vs. Effluent
100000
10000
1000
100
10
1
Concentration (ng/L)
Influent
Effluent
Caffeine
Acetaminophen
1,7-Dimethylxanthine
Ibuprofen
Atenolol
Compound


Ann Arbor Wastewater Influent vs. Effluent
Concentration (ng/L)
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
Influent
Effluent
Cholesterol
Sulfamethoxazole
Coprostanol
Gemfibrozil
Thiobendazole
Carbamazepine
Cimetidine
Codeine
Trimethoprim
Estriol
Metoprolol
Compound

Ann Arbor Wastewater Influent vs. Effluent



Monroe Source Water vs. Drinking Water



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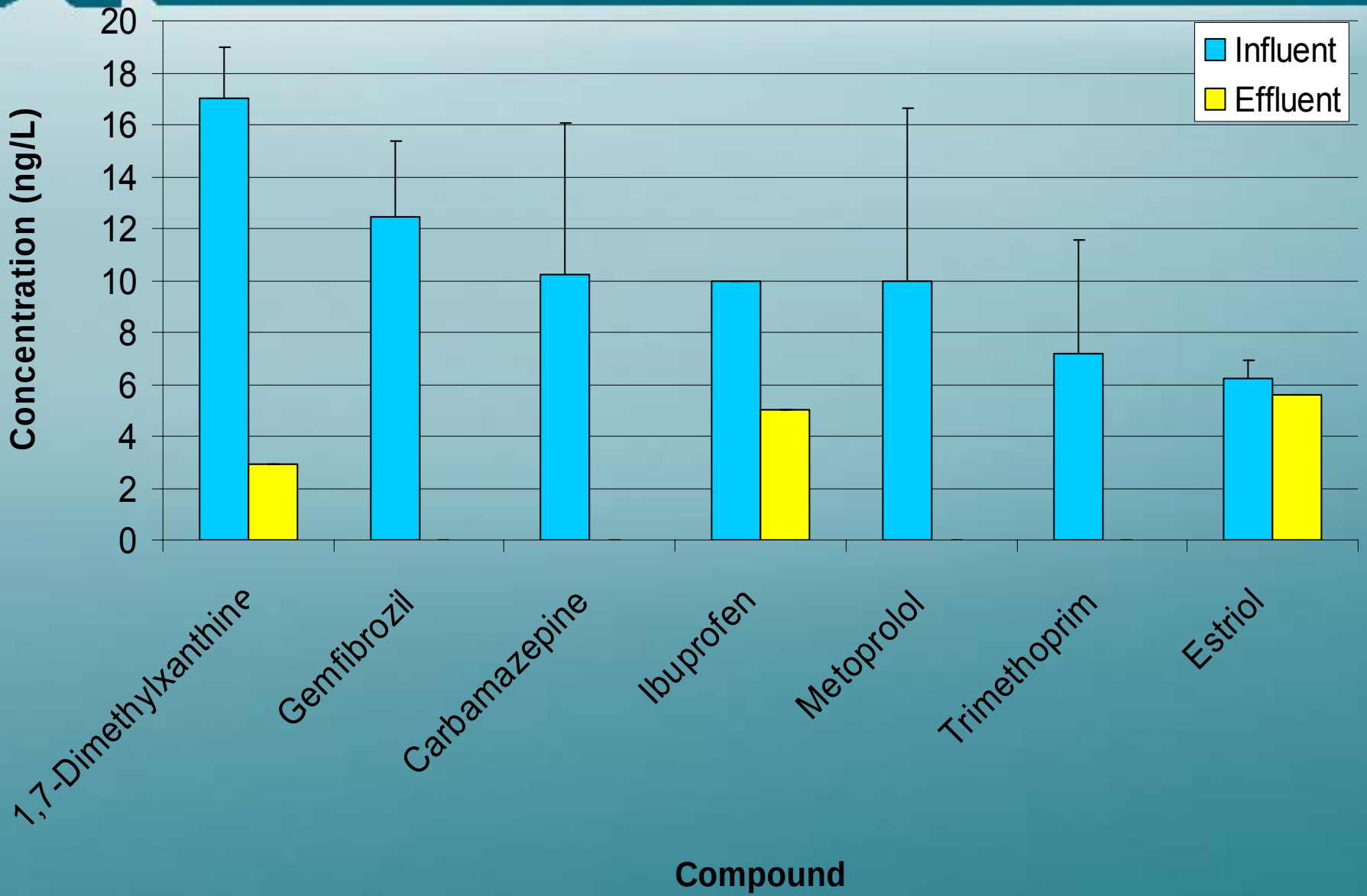

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