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U.S. Environmental Protection Agency and Emerging Contaminants

Susan T. Glassmeyer, Ph.D.
United States Environmental Protection Agency, Cincinnati, OH

Office of Research and Development
National Exposure Research Laboratory

United States Environmental Protection Agency

Outline of Presentation

- USEPA Background
- Water Regulation 101
- How Emerging Contaminants *may* be regulated in the future
- Research on Emerging Contaminants in Drinking Water

Regulatory History

1914
Treasury Department
Public Health Service

1948
Federal Security Agency
Public Health Service
Division of Water Supply and Pollution Control

1953
Dept of Health, Education and Welfare
Public Health Service
Division of Water Supply and Pollution Control

1965
Dept of Health, Education and Welfare
Federal Water Pollution Control Administration

1970
Department of Interior
Federal Water Quality Administration

USEPA Organizational Chart

Office of Administration and Resource Management	Office of International Affairs	Region 1
Office of Air and Radiation	Office of Environmental Information	Region 2
Office of Enforcement and Compliance Assurance	Office of Prevention, Pesticides, and Toxic Substances	Region 3
Office of Chief Financial Officer	Office of Research and Development	Region 4
Office of General Council	Office of Solid Waste and Emergency Response	Region 5
Office of Inspector General	Office of Water	Region 6
		Region 7
		Region 8
		Region 9
		Region 10

Office of Research and Development (ORD)

National Exposure Research Laboratory

National Health and Environmental Effects Research Laboratory

National Risk Management Research Laboratory

National Center for Computational Toxicology

National Center for Environmental Assessment

National Center for Environmental Research

National Homeland Security Research Center

Office of Science Policy

Office of Resources Management Administration

United States Environmental Protection Agency

Mission of ORD

- **Perform research and development** to identify, understand, and solve current and future environmental problems.
- **Provide responsive technical support** to EPA's mission.
- **Integrate the work of ORD's scientific partners** (other agencies, nations, private sector organizations, and academia).
- **Provide leadership** in addressing emerging environmental issues and in advancing the science and technology of risk assessment and risk management.

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Water Regulation 101

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- ORD (and Susan) does not monitor compliance.
- ORD (and Susan) does not levy fines.
- Although this work was reviewed by USEPA and approved for publication, it may not necessarily reflect official Agency policy.
- The conclusions and opinions drawn are solely those of the author (Susan) and should not be construed to reflect the views of the Agency.

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History of US Water Pollution Law

- Refuse Act of 1899
- Public Health Service Standards beginning in 1914
- Water Pollution Control Act 1948
- Water Quality Act of 1965
- Water Quality Improvement Act of 1970
- Clean Water Act 1972 (Amended 1977)
- Safe Drinking Water Act 1974 (Amended 1996)

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Safe Drinking Water Act (SDWA)

- Protect the public's health by regulating the drinking water supply
- Rivers, lakes, streams, reservoirs, springs, and ground waters– any potential source of drinking water– are covered.
- Applies to all public water systems that have at least 15 service connections or serve at least 25 people per day for 60 days of the year. Over 160,000!

How are chemicals regulated under SDWA?

- USEPA identifies contaminants that occur, or may occur, in drinking water with a frequency and at levels that pose a threat to public health.
  - Contaminant Candidate List (CCL)
    - CCL3 released February 2008, listing 104 contaminants (11 microbial and 93 chemical)
    - Every five years, must decide to regulate (or not) at least five contaminants
  - Unregulated Contaminant Monitoring Regulation (UCMR)
    - Limited to 30 contaminants in any five year cycle
    - UCMR2 was finalized December 2006- sampling 2008

What is the drinking water regulation decision making process?

When making a “determination” to regulate, the law requires that three areas are considered:

- projected adverse health effects from the contaminant,
- the extent of occurrence of the contaminant in drinking water, and
- whether regulation of the contaminant would present a “meaningful opportunity” for reducing risks to health.

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Chemical X met the regulation criteria, now what?

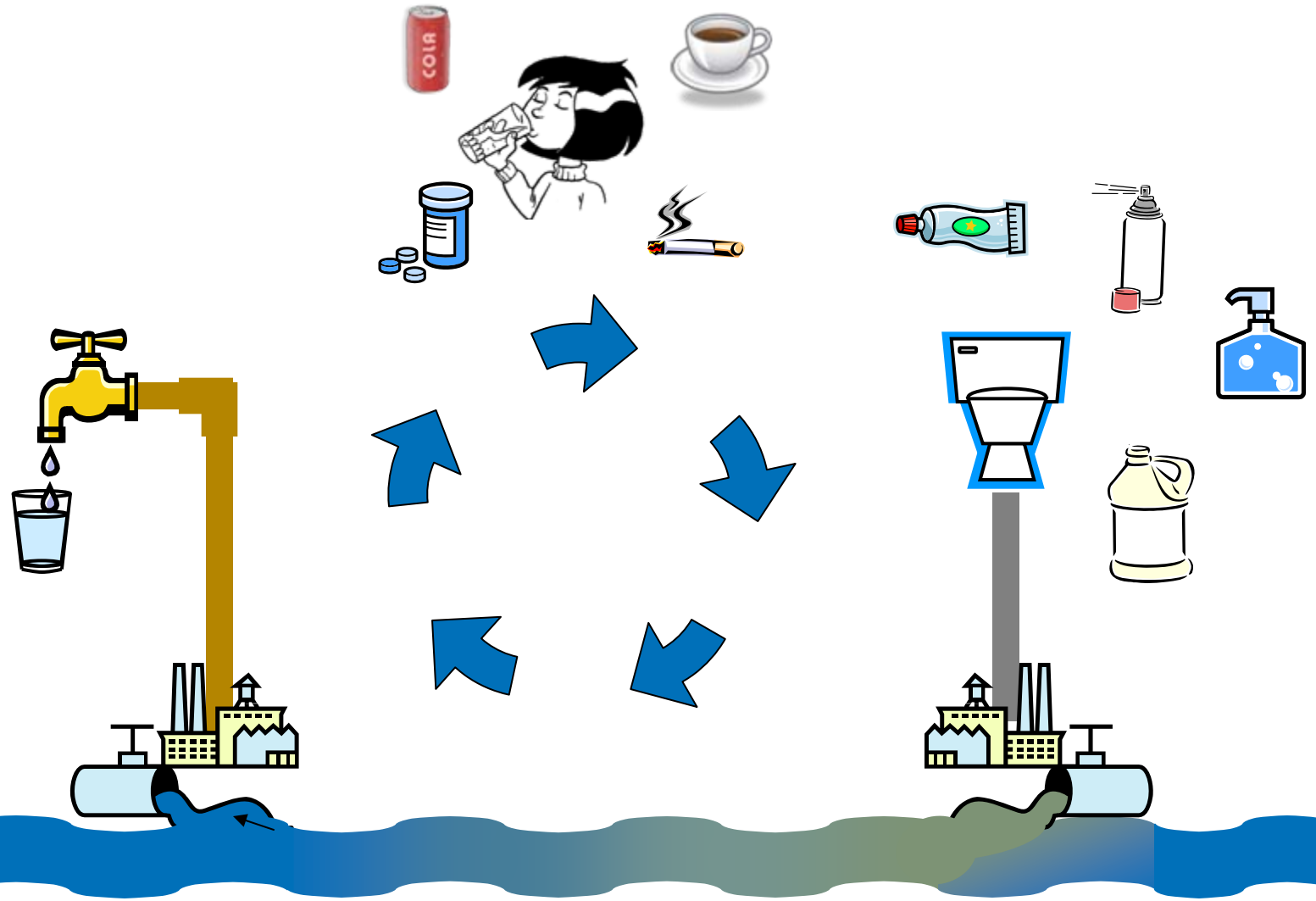
- Must determine the Maximum Contaminant Level Goal (MCLG) for each chemical
  - Concentration below which there is no known or expected risk to health
  - For many carcinogens and microorganisms, the MCLG is zero
- Next, set the Maximum Contaminant Level (MCL)
  - National Primary Drinking Water Regulations (NPDWRs)
  - Maximum concentration permitted in drinking water
  - If too difficult to measure, may impose a treatment technique (TT) requirement
- Every six years, the NPDWRs are revisited to make sure the public's health is still being protected

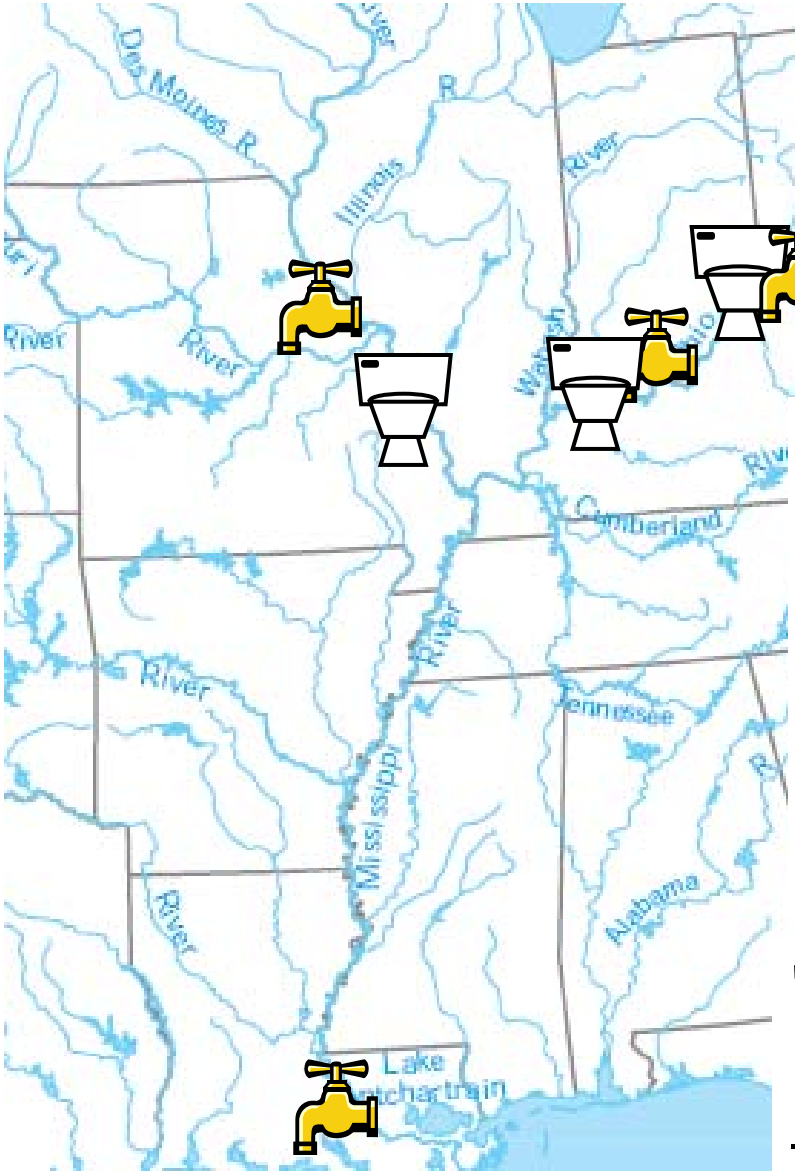
Advisories

- In addition to Regulations, USEPA issues advisories as guidance to Federal, State and local officials
- SDWA Health Advisories (HA)
  - One-Day HA: Designed to protect a 10 kg child consuming 1 L/ day from noncarcinogenic adverse effects from 1 day of exposure
  - Ten-Day HA: Designed to protect a 10 kg child consuming 1 L/ day from noncarcinogenic adverse effects from 10 days of exposure
  - Lifetime HA: Designed to protect a 70 kg adult consuming 2 L/ day from noncarcinogenic adverse effects from a lifetime of exposure
- CWA Fish Advisories: Consumption advisories to limit or avoid eating fish caught in specific water bodies

Emerging Contaminants in the Drinking Water Cycle

Water Cycle



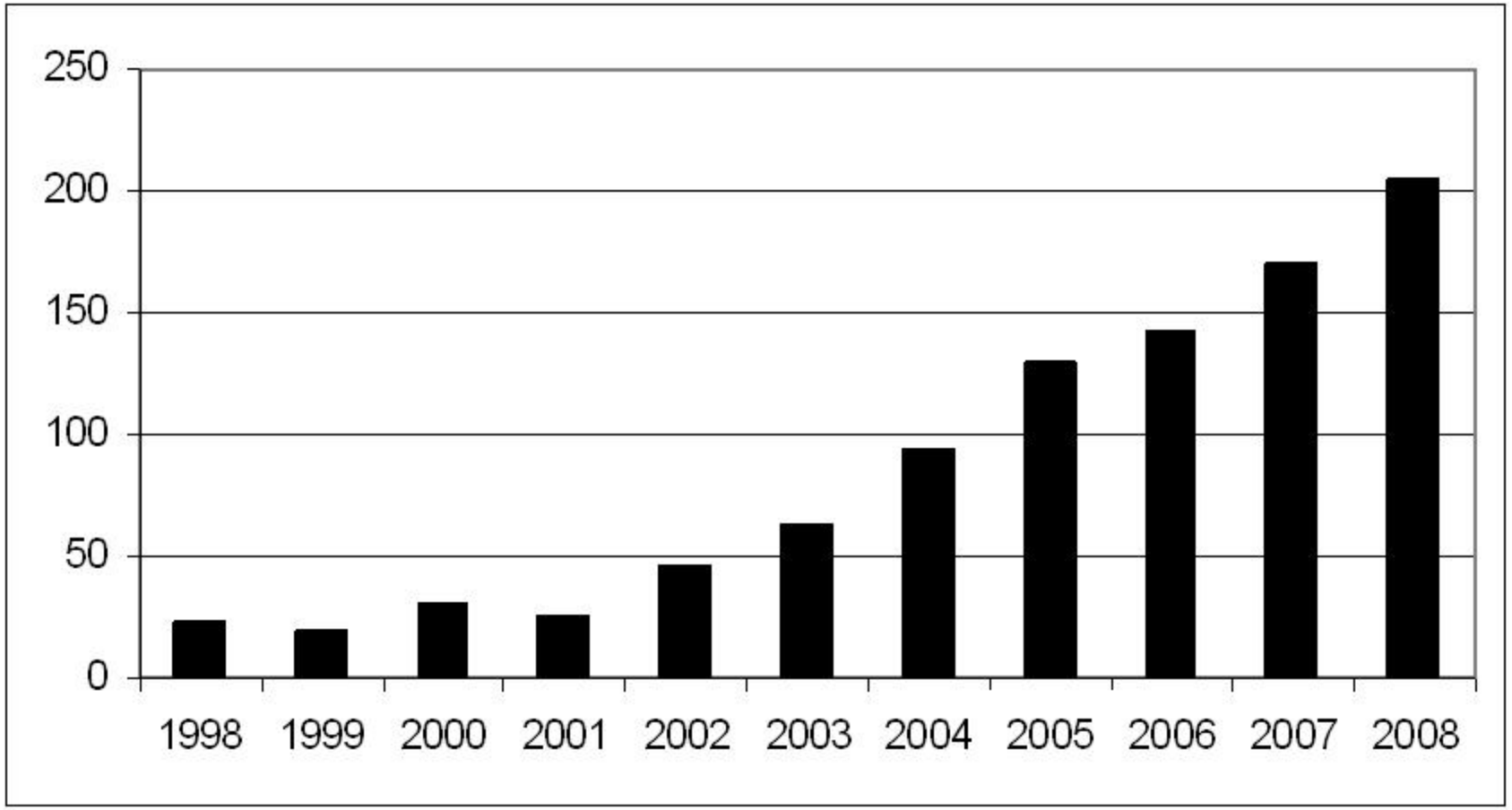


1980 USEPA survey found 20 communities (>7 million people) with drinking water source water containing 2.3-16% wastewater during average flow

(EPA-600/2-80-044)

"The best wine is the oldest, the best water the newest."
—William Blake (1757-1827)

Pharmaceutical Literature Citations

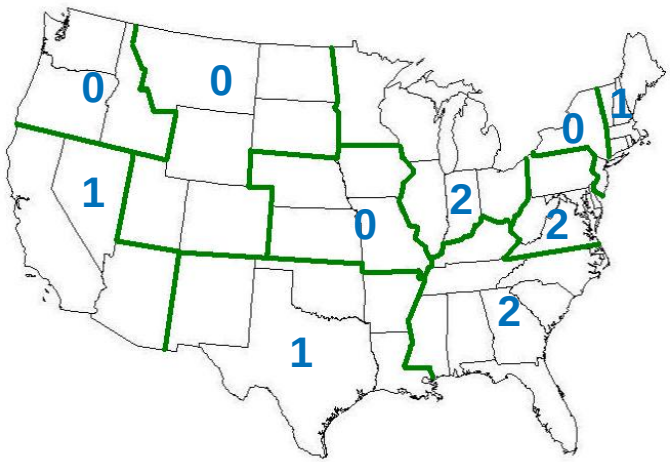


Currently, public interest on emerging contaminants in drinking water is high…

…but the drinking water regulation process is only equipped to evaluate a finite number of chemicals every 5 years

- Literally 1,000s of chemicals are considered ECs.
- Very little data on the presence of these chemicals in finished drinking water.
- There is a need to triage which ECs are frequently found and therefore *may* need to be more fully investigated under the SDWA.

Drinking Water Phase I - 2007

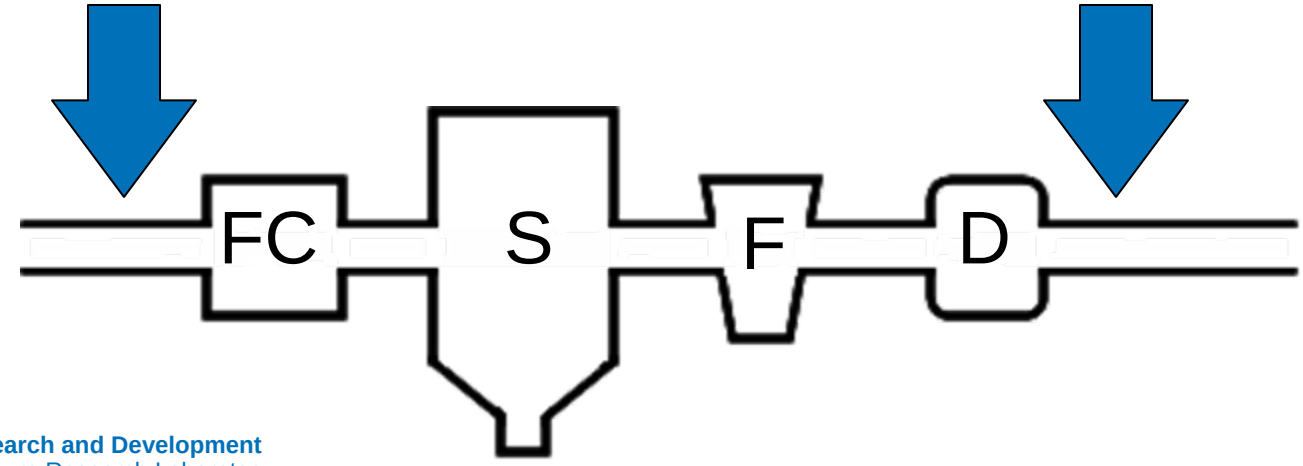


Number of Phase I sampling sites in each USEPA Region

- Nine DWTPs (one site sampled twice, n = 10)
- Source water had known or suspected wastewater contributions
- One groundwater
- Five used conventional treatment (coagulation, clarification, filtration, and chlorination)
- Three used advanced treatments (ozone, UV, carbon filtration)

Sampling Design

- Paired source and finished water samples, collected taking the residence time of the plant into account.
- Locations sampled only once.
- Included high percentage of QA/QC samples (25% spike, 25% duplicate, field blank from every location)



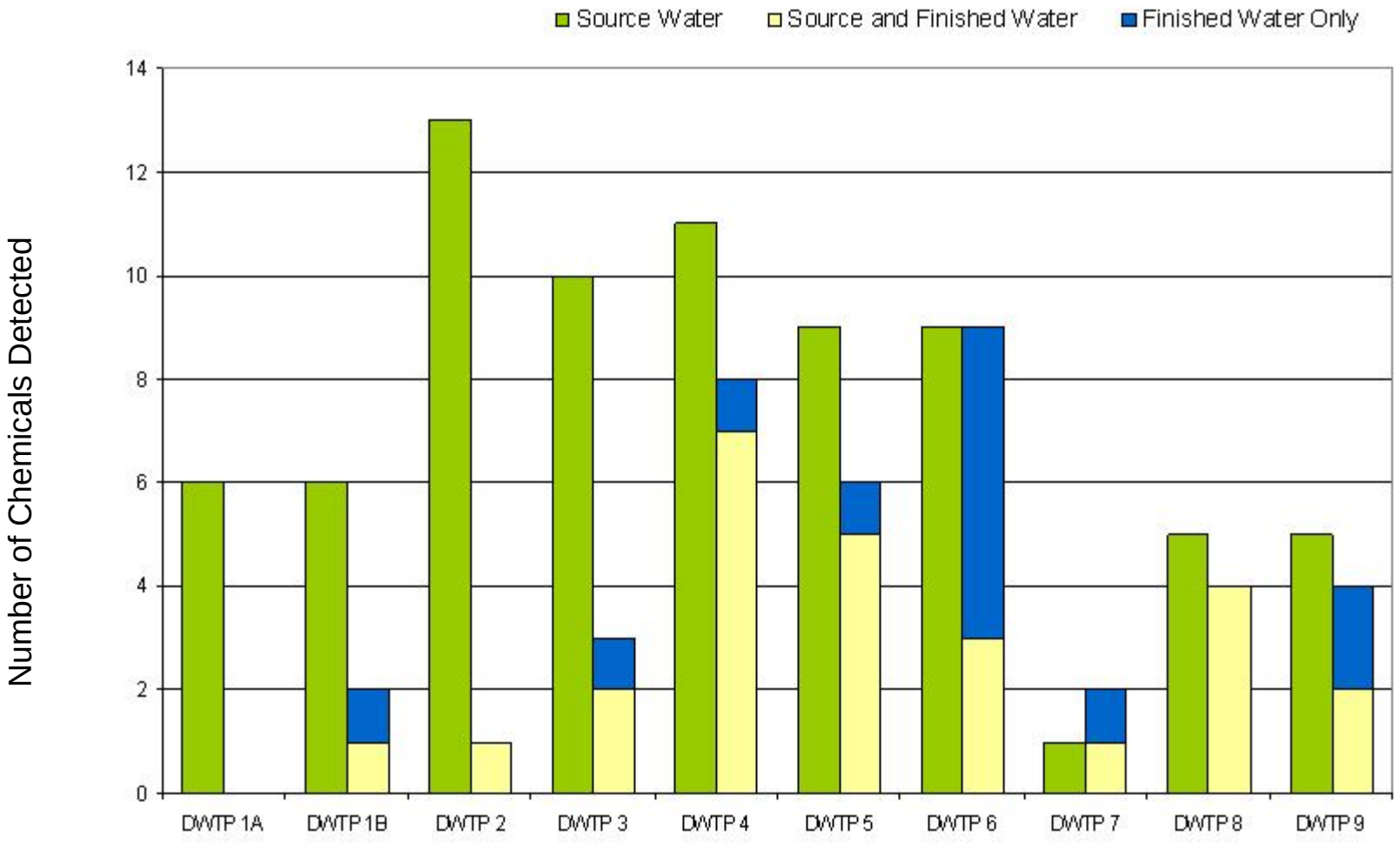
USGS Methods Used

- Pharmaceutical Method (SH 2080)
  - LC/MS
  - 13 Chemicals
- Wastewater Method (SH 1433)
  - GC/MS
  - 60 Chemicals
- New Antidepressant Method
  - LC/MS/MS
  - 10 Chemicals

83 Chemicals

- 18 prescription pharmaceuticals
- 6 nonprescription pharmaceuticals
- 14 industrial chemicals
- 10 fragrances
- 9 polycyclic aromatic hydrocarbons
- 7 pesticides
- 7 detergent metabolites
- 5 household chemicals
- 4 sterols
- 3 flame retardants

Site Specific Detections



Source/ Finished Water Comparisons

	S (n)	F (n)	Wilcoxon *p*-values (based on paired conc)
bupropion	**8**	**4**	**0.148**
venlafaxine	**8**	**nd**	***0.008***
caffeine	**6**	**2**	**0.078**
tri(2-chloroethyl)phosphate	**6**	**2**	***0.031***
carbamazepine	**7**	**6**	**0.406**
sulfamethoxazole	**5**	**1**	**0.436**
tributylphosphate	**4**	**1**	**0.625**
citalopram	**3**	**nd**	**0.250**
sertraline	**3**	**nd**	**0.250**

Comparison of Detections to Dose

- Carbamazepine
- WHO Defined Daily Dose: 1000 mg
- Maximum detected concentration in finished water 18 ng/L (Benotti et al *ES&T* 2009)

- To calculate the number of liters to consume single dose
  - 1000 mg X (1L/ 18 ng) X (10^6 ng/mg) = 55,555,556 L

- Assuming 2 L drinking water consumption per day
  - 55,555,556 L X (1 day/2 L) X (1 year/ 365 days) = 76,104 years

Margin of Exposure

- What is safe?
- Pomati (*ES&T* 2007) has provided the most conservative guideline.
- Divide lowest recommended therapeutic dose (LRTD) by
  - 10 for intrahuman viability
  - 10 for LRTD not being a no effect level
  - 10 for endocrine active and cytotoxic compounds
  - 10 for extrapolation of animal data to humans
  - 10 for the presence of mixtures in the environment
- MOE > 100,000 (or an environmental concentration < 10^{-5} of LRTD) should be protective of human health

For carbamazepine:

MOE = (1000 mg X 10^6 ng/mg)/ (2 L X 18 ng/ L) = 27,777,778

Pharmaceutical Detections in Perspective

Compound	Finished Water Maximum Conc (ng/ L)	Defined Daily Dose (mg)	Volume to Consume Single Dose (L)	Time to Consume Single Dose (years)	Margin of Exposure (MOE)
atenolol	18	75	4,166,667	5,708	2,083,333
carbamazepine	18	1000	55,555,556	76,104	27,777,778
diazepam	0.33	10	30,303,030	41,511	15,151,515
fluoxetine	0.82	20	24,390,244	33,411	12,195,122
gemfibrozil	2.1	1200	571,428,571	782,779	285,714,286
sulfamethoxazole	3	2000	666,666,667	913,242	333,333,333

Benotti et al *ES&T* 2009

Future Work

Drinking Water Phase II

- 20 to 30 Utilities
- Paired source and finished water samples
- > 200 chemical and microbiological analytes
- ~ 50 chemicals analyzed by more than one method
- Even more QA/QC than Phase I (duplicate and spike at every location, ~ 70% QC)
- Awaiting Information Collection Rule approval; sampling should begin Fall 2009

Take Home Messages

- Emerging contaminants are present in household wastewater, and are not entirely removed during wastewater treatment.
- Treatment “removal” may just be transformation.
- The chemicals present in treated wastewater can persist and travel through surface and ground waters, which can potentially be the source water for another communities drinking water.
- Concentrations of pharmaceuticals present in finished drinking water are much lower than the typical daily dose.

Collaborators and Contact Information

- Co-PIs: Edward Furlong and Dana Kolpin, USGS

- glassmeyer.susan@epa.gov
- 513-569-7526