# *Safe Drinking Water Act - Federal Regulations*

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**Safe Drinking Water Act - Federal Regulations**

7 contact hours

9 CC10 hours

The Safe Drinking Water Act (SDWA) was established to protect public health by regulating the nation's public drinking water supply. The SDWA authorizes the United States Environmental Protection Agency (U.S. EPA) to set national health-based standards for drinking water to protect against both naturally-occurring and man-made contaminants that may be found in drinking water. Working together, Federal agencies, state agencies and water system personnel make sure that these standards are met. This course will introduce water supply system personnel to the most recent SDWA revisions, including Maryland regulations, the National Primary Drinking Water Regulations, and review of the 1996 amendments which greatly enhanced the existing law by recognizing source water protection, operator training, funding for water system improvements, and public information as important components of safe drinking water. Information about updated monitoring requirements, recordkeeping, emergency planning and response, and certification will be covered. **Please register early; this class is limited to 15 participants.**

1. Describe in general terms the regulatory and environmental intent of the Safe Drinking Water Act;
2. Discuss the most recent revisions in the Federal drinking water regulations, including how treatment and operations requirements have been increased;
3. State the potable water monitoring requirements for which water supply personnel are accountable, and how to apply this information in order to maintain compliance; and
4. Understand future treatment changes to consider for surface water systems.

Agenda

8:00 – 9:00 Introductions, pre-test
9:00 – 10:00 Definitions and Terminology
10:00 – 11:00 SDWA History and Overview
11:00 – 12:00 Current Regulations and Rules
12:00 – 1:00 Lunch
1:00 – 2:00 Drinking Water Contaminants & MCLs
2:00 – 3:00 Sampling, Monitoring, and Record Keeping
3:00 – 3:30 Summary and Closing
3:30 – 4:00 Post Test and Evaluations


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## Process Training Sessions

Before class starts, please:
- **Sign in** on Attendance Sheet
- **Fill out** Registration Form, if appropriate

During class, please:
- **Asks questions**
- Feel free to get up and leave the classroom at any time (i.e., rest rooms, phone calls, etc.)
- **Answer questions** on post test

After class, please:
- **Fill out** a Class Evaluation
- **Pick up** Attendance Card, if appropriate

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## Housekeeping

- 1–day class
- Start class – 8:00 am
- 10-minute Breaks – every hour
- Lunch ~ 11:30 am – 12:30 pm
- End class ~ 3:30 to 4:00 pm

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## Instructor Expectations

- Begin and end class on time
- Be interactive – participate at your own comfort level
- Share experiences and needs
- Less lecture, more discussions
- Keep it simple
- ***Make this an enjoyable and informative experience!***

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## The Guiding Expectation

**"Things should be made as simple as possible -- but no simpler."**

**Albert Einstein**

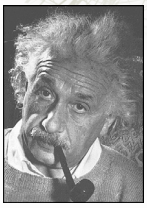


image source: www.physik.uni-frankfurt.de/~jr/physpiceinstein.html



## Ground Rules

- Discussion is encouraged; share experiences
- Use terms we all can understand
- Everyone is different, so please show respect for others in the room
- Express opinions - of things, not people
- Maintain confidences



## Ice Breaker

- Before we start, let's introduce ourselves.
  - Name,
  - What do you do, and
  - What are your learning needs?

# Introduction

Objectives, Focus, and Agenda



## SDWA Class Outline

- **Introductions and Class Objectives**
- Definitions and Acronyms
- SDWA History and Overview
- Drinking Water Contaminants & MCLs
- Current Regulations and Rules
- Sampling, Monitoring, and Record Keeping
- Summary and Closing



## Expected Learning Objectives

- Objective 1 - to associate SDWA Rules to:
  - Types of Contaminants
  - Primary Drinking Water Standards
  - Secondary Drinking Water Standards
- Objective 2 - to describe monitoring needs for:
  - Inorganic contaminants
  - Bacterial contaminants: Total Coliform and E. Coli
  - Disinfection by-products
- Objective 3 - to explain need for:
  - Water filtration
  - Disinfection with UV and chlorine

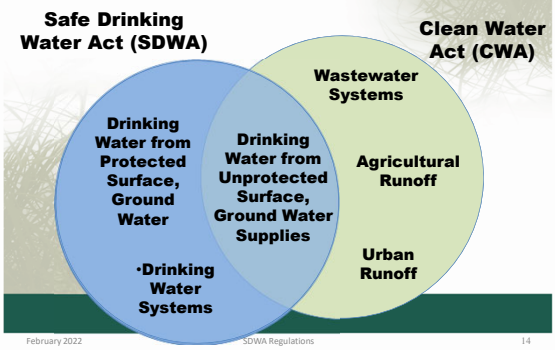
## Participant Focus

- What information can you use at your work location?
  - SDWA regulations
  - Current **filtration and disinfection technologies**
  - Filtration, UV, and chlorination:
    - **Practical process limits**
    - **Operating and trouble shooting guidelines**
- What information can you contribute to the discussion?
  - Problems with **gravity filters and disinfection**



## Regulations

**Flagship U.S. Water Quality Regulations**






## Highlights of SDWA

- Sets enforceable health standards for contaminants in drinking water
  - Currently 94 regulated contaminants
- Requires public notification of public water system violations and annual reports
- Includes provisions to protect underground sources of drinking water

## Safe Drinking Water Act of 1974

- Safe Drinking Water Act (SDWA) was established to protect the quality of drinking water in the U.S.
- Focus is on all waters actually or potentially designed for drinking use, above ground and underground sources
- EPA is authorized to establish minimum standards to protect tap water
- Owners or operators of public water systems are required to comply with primary (health-related) standards



## Safe Drinking Water Act of 1974

- 1996 amendments to SDWA required that EPA consider a detailed risk and cost assessment, and best available peer-reviewed science, when developing primary (health-related) standards
- State governments, which can be approved to implement rules for EPA, are also encouraged attainment of secondary standards (nuisance-related).



## SDWA History

- Federal SDWA introduced in 1974
- Resulted from increased concern and awareness of contaminated drinking water
- Amended: 1986, 1996
- Establishes MCL levels (or TTs in lieu of MCLs), monitoring, and reporting requirements
- Regulates 94 contaminants
  - Microbial
  - Chemical/Radiological

## SDWA Contaminants

Microbial Risks
- Turbidity (Water quality indicator)
- Coliform Bacteria (Total, Fecal & E. coli)
- Enteroviruses
- Protozoa (Giardia, Cryptosporidium)

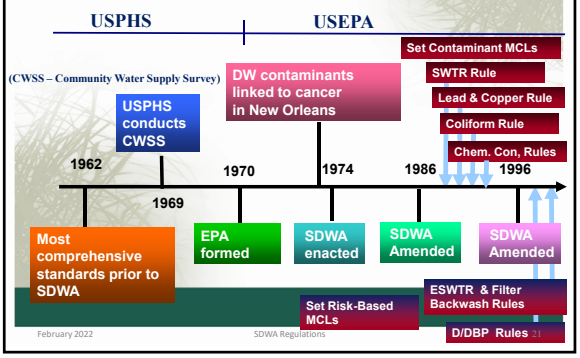
Chemical & Radiological Risks
- Inorganic chemicals (IOCs)
- Volatile organic chemicals (VOCs)
- Synthetic organic compounds (SOCs)
- Disinfectants & Disinfection by products (DBPs)
- Radionuclides (Radium 226/228, Uranium, Radon)



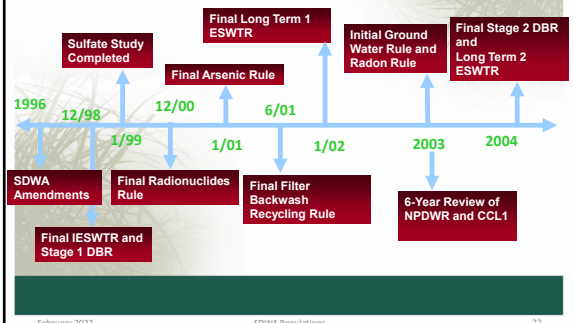
## Increased chemical monitoring following the 1986 SDWA amendments



## Federal Drinking Water Program



## Rule Schedule






## SDWA Individual Rules

- Chemical Contaminants (Phase I/II/IIB/V) Rules
  - Protects consumers from chemical contaminants by establishing MCLs
  - Establishes monitoring and reporting requirements



## Chemical Contaminants

- Volatile organic chemicals (VOCs)
- Synthetic organic chemicals (SOCs)
- Inorganic chemicals (IOCs)
- Radionuclides
- Disinfection byproducts (DBPs)


## The Water-Consuming Public is Aware (and Wary)

- Well-publicized "events"
- Bottled water sales increase dramatically



## What's in Your Water?



## Introduction

- Definitions and Acronyms

## Acronyms

- PWS – Public Water System
- MCLG - Maximum Contaminant Level Goal
- MCL - Maximum Contaminant Level
- TT – Treatment Technique
- DS – Distribution System
- IDSE – Initial Distribution System Evaluation
- DBPs – Disinfection Byproducts
  - ✓ THMs – Trihalomethanes
  - ✓ HAA – Haloacetic Acids
- NOM – Natural Organic Matter
- TOC/DOC – Total/Dissolved Organic Carbon
- UV – Ultraviolet Light
  - ✓ UV254 – Ultraviolet Absorbance at 254nm
  - ✓ SUVA – Specific UV Absorbance



## History of Drinking Water Regulations

- 1962 – U.S. Public Health Service
- 1974 – Safe Drinking Water Act (SDWA)
- 1975 – Interim Primary Drinking Water Regs.
- 1986 – Amendments to SDWA
- 1996 – New Amendments to SDWA



## Public Water Supply Regulations

- The Safe Drinking Water Act of 1974

  Directs the EPA to establish standards and requirements necessary to protect the public from all known harmful contaminants in drinking water

## Raw Water Contaminants

- Raw water source
  - Lake
  - Reservoir
  - River
  - aquifer

Concerns:

- Pathogens
- Turbidity
- Color
- Taste and odors
- Fe, Mn
- NOM
- Toxic metals, Pb
- Synthetic organics
  - Pesticides
  - Herbicides
  - Solvents
  - PPCPs/EDCs
- Radioactivity (radon)
- $H_2S$, $CO_2$
- $F^-$, $NO_3^-$, Arsenic
- $Br^-$



## Source Water Characteristics

**Surface Water**
**(and GWUDISW)**

- **Low to high turbidity and NOM**
- **Little to high biological pathogens**

**Ground water**

- **Low to no turbidity and NOM**
- **Little to no biological pathogens**

Both can:

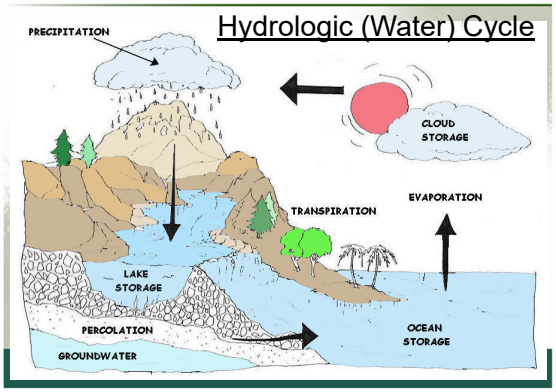
1. Be corrosive
2. Contain calcium/magnesium hardness
3. Contain iron/manganese
4. Have taste and odors



## Source Water Quality

- Proximity to contamination
- Substances that alter quality:
  1. Organic
  2. Inorganic
  3. Biological
  4. Radiological
- Sources of impurities

## Hydrologic (Water) Cycle

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## Safe Drinking Water Act (SDWA)

- SDWA is the key federal law that authorizes EPA to regulate contaminants in public water supplies
- Since enactment of the act in 1974, EPA has issued drinking water regulations for 94 contaminants
- Congress twice revised the act's process for evaluating contaminants and developing drinking water regulations (in 1986 and 1996)

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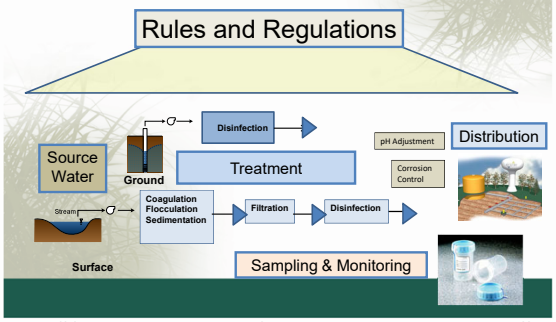
## Public Drinking Water Systems

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## Public Drinking Water Systems


National Primary Drinking Water Regulations



## Regulation Terminology

- **National Primary Drinking Water Regulation (NPDWR)**
  - Sets legal levels (MCLs) of specific contaminants that can adversely affect public health
  - Recommends Maximum Contaminant Level Goals (MCLG)
  - Treatment Technique (TT) in lieu of MCLs
- **National Secondary Drinking Water Regulation (NSDWR)**
  - Non-enforceable guidelines
  - Covers contaminants that may cause cosmetic or aesthetic effects



## Enforcement of SDWA Regulations

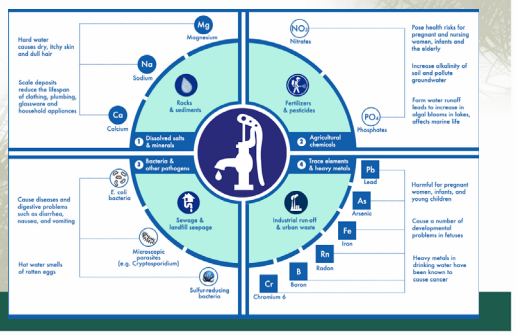
- EPA delegates primary enforcement responsibility (also called primacy) for public water systems to states if they meet certain requirements
- Exceptions: Wyoming, District of Columbia

## Safe Drinking Water Act (SDWA)

- 1974 Act requires all owners or operators of public water systems to comply with primary (health-related) standards
- State governments can be approved to implement rules for EPA and are encouraged attainment of secondary standards (nuisance-related)



## Common Contaminants in Water






**USEPA Priority Pollutants**

| Semivolatile Organics | Volatile Organics | Pesticides & PCBS | Metals & Inorganics |
|---|---|---|---|
| 2,4,6-trichlorophenol | 1,1,1-trichloroethane | 4,4-DDD | Cyanide, Total |
| 2,4-dichlorophenol | 1,1,2,2-tetrachloroethane | 4,4-DDE | Antimony |
| 2,4-dimethylphenol | 1,1,2-trichloroethane | 4,4-DDT | Arsenic |
| 2,4-dinitrophenol | 1,1-dichloroethane | Aldrin | Beryllium |
| 2-chlorophenol | 1,1-dichloroethylene | Alpha-BHC | Cadmium |
| 2-nitrophenol | 1,2-dichlorobenzene | Alpha-endosulfan | Chromium |
| 4,6-dinitro-o-cresol | 1,2-dichloroethane | Beta-BHC | Copper |
| 4-nitrophenol | 1,2-dichloropropane | Beta-endosulfan | Lead |
| Para-chloro-meta-cresol | 1,2-dichloropropylene | Chlordane | Mercury |
| Pentachlorophenol | 1,3-trans-dichloroethylene | Delta-BHC | Nickel |
| Phenol | 1,3-dichlorobenzene | Dieldrin | Selenium |
| 1,2,4-trichlorobenzene | 1,4-dichlorobenzene | Endosulfan sulfate | Silver |
| 1,2-diphenylhydrazine | 2-chloroethyl vinyl ethers | Endrin | Thallium |
| 2,4-dinitrotoluene | Acrolein | Gamma-BHC | Zinc |
| 2,6-dinitrotoluene | Acrylonitrile | Heptachlor | |
| 2-chloronaphthalene | Benzene | Heptachlor epoxide | |
| 3,3-dichlorobenzidine | Bromoform | Toxaphene | |
| 4-bromophenyl phenyl ether | Carbon tetrachloride | Endrin aldehyde | |
| 4-chlorophenyl phenyl ether | Chlorobenzene | PCB–1242 (Arochlor 1242) | |
| Acenaphthene | Chlorodibromomethane | PCB–1254 (Arochlor 1254) | |
| Acenaphthylene | Chloroethane | PCB–1221 (Arochlor 1221) | |
| Anthracene | Chloroform | PCB–1232 (Arochlor 1232) | |
| Benzidine | Dichlorobromomethane | PCB–1248 (Arochlor 1248) | |
| benzo(a) anthracene | Ethylbenzene | PCB–1260 (Arochlor 1260) | |
| Benzo(a)pyrene | Methyl bromide | PCB–1016 (Arochlor 1016) | |
| Benzo(b) fluoranthene | Methyl chloride | | |
| Benzo(b) fluoranthene | Methylene chloride | | |

## Review of Current MCLs and TTs

- National Primary Drinking Water Regulations:
  - Microorganisms
  - Disinfection Byproducts
  - Disinfectants
  - Inorganic Chemicals
  - Organic Chemicals
  - Radionuclides



## National Primary Drinking Water Regulations

EPA

| Contaminant | MCL or TT[1] (mg/L)[2] | Potential health effects from long-term[3] exposure above the MCL | Common sources of contaminant in drinking water | Public Health Goal (mg/L)[2] |
|---|---|---|---|---|
| Acrylamide | TT[4] | Nervous system or blood problems; increased risk of cancer | Added to water during sewage/ wastewater treatment | zero |
| Alachlor | 0.002 | Eye, liver, kidney, or spleen problems; anemia; increased risk of cancer | Runoff from herbicide used on row crops | zero |
| Alpha/photon emitters | 15 picocuries per Liter (pCi/L) | Increased risk of cancer | Erosion of natural deposits of certain minerals that are radioactive and may emit a form of radiation known as alpha radiation | zero |
| Antimony | 0.006 | Increase in blood cholesterol; decrease in blood sugar | Discharge from petroleum refineries; fire retardants; ceramics; electronics; solder | 0.006 |
| Arsenic | 0.010 | Skin damage or problems with circulatory systems, and may have increased risk of getting cancer | Erosion of natural deposits; runoff from orchards; runoff from glass & electronics production wastes | 0 |
| Asbestos (fibers >10 micrometers) | 7 million fibers per Liter (MFL) | Increased risk of developing benign intestinal polyps | Decay of asbestos cement in water mains; erosion of natural deposits | 7 MFL |
| Atrazine | 0.003 | Cardiovascular system or reproductive problems | Runoff from herbicide used on row crops | 0.003 |

npwdr_complete_table.pdf (epa.gov)



## Safe Drinking Water Act (SDWA)

- Law focuses on all waters designed for drinking use, whether from above ground (surface) or underground (well) sources
- With EPA's approval, states can select contaminants to monitor in drinking waters
- Both Maryland and Virginia have been approved to monitor ≅ 50 - 60 contaminants

## Consumer Confidence Report

- Customers served by a public water system can contact their local water supplier and ask for information on contaminants in their drinking water




## Consumer Confidence Report

- The CCR:
  - Lists the levels of contaminants that have been detected in the water
  - Whether the water system meets state and EPA drinking water standards


ANNUAL CONSUMER CONFIDENCE REPORT

Results of Water Quality Testing for 2020



## Consumer Disclosure

Public water systems must produce an annual consumer confidence report identifying the water source along with levels of regulated contaminants.

- A regulated chemical or pathogen
- Maximum contaminant level goal at which there is no known or expected health risk
- Maximum contaminant level, the standard for the highest level allowed in drinking water
- The average result used for judging compliance, along with the range of test results

| Contaminant | MCLG (Goal) | MCL | 2014 Results System Wide |
|---|---|---|---|
| Inorganics | | | |
| Arsenic (ppb) | 0 ppb | 10 ppb | ND |
| Barium (ppm) | 2 ppm | 2 ppm | 0.10 (0.029 – 0.28) |
| Chromium (ppb) | 100 ppb | 100 ppb | BDL (ND – 2.2) |
| Flouride (ppm) | 4 ppm | 4 ppm | 0.78 (0.071 – 1.1) |
| Nitrate (ppm) | 10 ppm | 10 ppm | 0.89 (ND – 5.9) |

Note: ppb = parts per billion; ppm = parts per million; ND = non-detect; BDL = below detection level

## Local Consumer Confidence Reports

- 0150005-Washington-Suburban-Sanitary-Commission.pdf (maryland.gov)
- ccr_2021.pdf (fairfaxwater.org)
- 2020 Baltimore City Water Quality Report Web.pdf.pdf
- 2020 DC Annual Drinking Water Compliance Report (pdf)



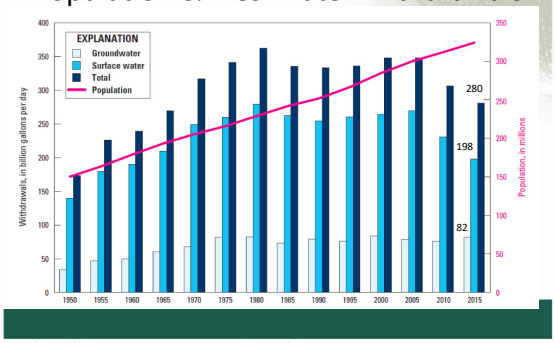
## Freshwater Sources

Three water sources:

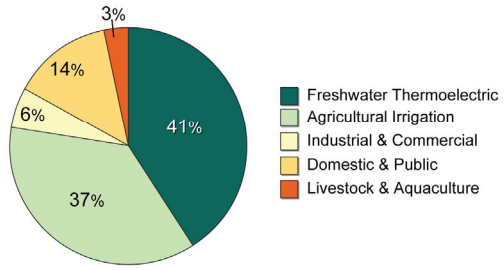
1. Surface Water
2. Ground Water
3. Ground Water Under the Direct Influence of Surface Water (GWUDISW)



## Population & Freshwater Withdrawals



## Freshwater Withdrawals by Sector






## Public Water Supply Use, BGD

| USA (Community and Noncommunity) | | | | | |
|---|---|---|---|---|---|
| Source | 1995 | 2000 | 2005 | 2010 | 2015 |
| Surface water, BGD | 25,100 | 27,300 | 29,600 | 26,200 | 24,000 |
| Ground water, BGD | 15,100 | 16,000 | 14,600 | 15,900 | 15,200 |
| Total, BGD | 40,200 | 43,300 | 44,200 | 42,100 | 39,200 |
| Community Water Systems | | | | | |
| Consumption, BGD | 22,700 | 24,200 | 25,600 | 23,700 | 23,300 |
| Population Served, 000 | 225,000 | 242,000 | 258,000 | 269,000 | 283,000 |
| gpd/capita | 101 | 100 | 99 | 89 | 83 |

Source: USGS - "Estimates of Public Water Supply Use in USA"



## Public Water Supply Sources, MGD

| Maryland (Community and Noncommunity) | | | | | |
|---|---|---|---|---|---|
| Source | 1995 | 2000 | 2005 | 2010 | 2015 |
| Surface water, MGD | 750 | 740 | 693 | 703 | 656 |
| Ground water, MGD | 83 | 84 | 96 | 89 | 94 |
| Total, MGD | 833 | 824 | 759 | 792 | 750 |
| Community Water Systems | | | | | |
| Consumption, MGD | 433 | 428 | 405 | 412 | 390 |
| Population Served, 000 | 4,167 | 4,364 | 4,383 | 4.412 | 4,582 |
| gpd/capita | 104 | 98 | 92 | 93 | 85 |

Source: USGS - "Estimates of Public Water Supply Use in USA"

## Public Water Supply Sources, MGD

| Virginia (Community and Noncommunity) | | | | | |
|---|---|---|---|---|---|
| Source | 1995 | 2000 | 2005 | 2010 | 2015 |
| Surface water, MGD | 704 | 650 | 721 | 594 | 605 |
| Ground water, MGD | 82 | 71 | 84 | 71 | 75 |
| Total, MGD | 786 | 721 | 805 | 665 | 680 |
| Community Water Systems | | | | | |
| Consumption, MGD | 424 | 412 | 442 | 476 | 503 |
| Population Served, 000 | 4,960 | 4,900 | 5,890 | 6,350 | 6,825 |
| gpd/capita | 85 | 84 | 75 | 75 | 74 |

Source: USGS - "Estimates of Public Water Supply Use in USA"



## Public Water System Withdrawals

- **Public Water System** withdrawals in 2015 were 39.2 Bgal/d, 7 percent less than in 2010
- Declines in water withdrawal observed
- Population served by public water systems increased 5 percent from 269 million in 2010 to 283 million in 2015



## Per Capita Water Consumption

- Average gpd/capita water usage is declining also
- Gallons gpd/capita decreased 6 gallons from 89 in 2010 to 83 in 2015
- GPD/capita represents the daily water usage for the population supplied by public water systems

## Public Water Systems (2015)

- Approximately 151,600 public water systems in the United States in 2015
- 50,500 (33.3%) were community systems
- 101,100 (66.7%) were noncommunity systems;
  - 83,100 transient systems
  - 18,000 nontransient systems



## Public Water Systems (2015)

**Public drinking water systems by type (2015)**

| System type | Number of systems |
|---|---|
| Community water systems | 50,496 |
| Non-transient non-community water systems | 18,034 |
| Transient non-community water systems | 83,124 |
| United States total | 151,654† |

† **Note**: Includes U.S. territories and American Indian tribal areas
**Source**: *U.S. Environmental Protection Agency*, "National Drinking Water Activity Dashboard"



## Public Water Systems (2011)

| | | Water System Population Size Category | | | | | |
|---|---|---|---|---|---|---|---|
| | | Very Small 500 or less | Small 501-3,300 | Medium 3,301-10,000 | Large 10,001-100,000 | Very Large >100,000 | Totals |
| CWS | # Systems | 28,346 | 13,737 | 4,936 | 3,802 | 419 | 51,356 |
| | Pop. Served | 4,763,672 | 19,661,787 | 28,737,564 | 108,770,014 | 137,283,104 | 299,216,141 |
| | % of Systems | 55% | 27% | 10% | 7% | 1% | 100% |
| | % Of Pop. | 2% | 7% | 10% | 36% | 46% | 100% |
| NTNCWS | # Systems | 15,461 | 2,566 | 132 | 18 | 1 | 18,178 |
| | Pop. Served | 2,164,594 | 2,674,694 | 705,320 | 441,827 | 203,000 | 6,189,435 |
| | % of Systems | 85% | 14% | 1% | 0% | 0% | 100% |
| | % Of Pop. | 35% | 43% | 11% | 7% | 3% | 100% |
| TNCWS | # Systems | 80,347 | 2,726 | 92 | 13 | 1 | 83,179 |
| | Pop. Served | 7,171,054 | 2,630,931 | 514,925 | 334,715 | 2,000,000 | 12,651,625 |
| | % of Systems | 97% | 3% | 0% | 0% | 0% | 100% |
| | % Of Pop. | 57% | 21% | 4% | 3% | 16% | 100% |
| | Total # of Systems | 124,270 | 19,029 | 5,160 | 3,833 | 421 | 152,713 |

**Source:** EPA, *Fiscal Year 2011 Drinking Water and Ground Water Statistics*, EPA 816-R-13-003, March 2013, p. 8, http://water.epa.gov/scitech/datait/databases/drink/sdwisfed/upload/epa816r13003.pdf.

## Public Drinking Water Use

- Water consumption has steadily declined since 2000
- Water conservation devices/efforts is the very likely explanation
- Decline is possibly due to increasing water (and sewer) service rates



## Safe Drinking Water Act (SDWA)

- EPA assesses future supplies and demands
- EPA addresses chlorine concerns
- 1996 amendment put emphasis on:
  - Emerging contaminants, such as *Cryptosporidium,* perchlorate, and perfluorinated compounds (PFCs)
  - Public involvement
  - Public right-to-know (i.e., annual reports)



## Safe Drinking Water Act (SDWA)

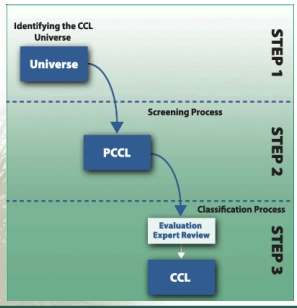
- SDWA requires EPA to review, and revise if necessary, existing national primary drinking water regulations every six years
- SDWA also requires that any revisions to drinking water regulations maintain or provide greater health protection

## Safe Drinking Water Act (SDWA)

- Since 1996, EPA has screened over 7,500 contaminants for potential regulation, revised existing regulations, and established new regulations and standards for several contaminants



## Contaminant Selection Process



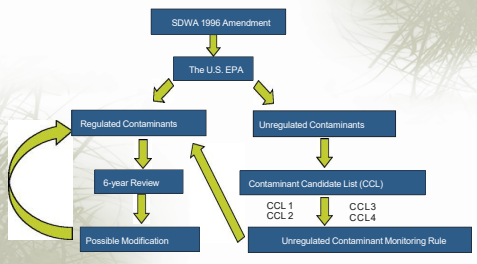

7,500 Contaminants

561 Contaminants

CCL4 includes 97 chemicals and chemical groups and 12 microbial contaminants



## Regulatory Development Process



## Safe Drinking Water Act (SDWA)

- EPA uses three criteria to decide or make a preliminary decision whether to regulate a particular contaminant:
  1) Health effect data
  2) Frequency and levels of the occurrence
  3) Meaningful opportunity to reduce any health risk if regulated



## SDWA Contaminant Regulation Timeline

| Date | Regulatory Action | Number | Cumulative |
|---|---|---|---|
| Dec. 1975 - July 1976 | Interim NPDWRs | New (22) | 22 |
| November 1979 | Total Trihalomethanes Rule | New (1) | 23 |
| April 1986 | Fluoride Rule | Revised (1) | 23 |
| July 1987 | Phase I NPDWRs | New (8) | 31 |
| June 1989 | Total Coliform Rule | Revised (1) | 31 |
| June 1989 | SWTR | New (4) and Revised (1) | 35 |
| Jan. & July 1991 | Phase II NPDWRs | New (27), Rev. (11), Deleted (1) | 61 |
| June 1991 | Lead and Copper Rule | New (1) and Revised (1) | 62 |
| July 1992 | Phase V NPDWRs | New (22) and Revised (1) | 84 |
| June 1995 | Nickel NPDWR | Remanded (1) | 83 |
| December 1998 | Stage I D/DBP Rule | New (6) and Revised (1) | 89 |
| December 1998 | Enhanced SWTR | New (1) and Revised (2) | 90 |



## SDWA Contaminant Regulation Timeline

| Date | Regulatory Action | Number | Cumulative |
|---|---|---|---|
| January 2000 | Lead and Copper Rule | Revised (2) | 90 |
| December 2000 | Radionuclides Rule | New (1) and Revised (4) | 91 |
| January 2001 | Arsenic Rule | Revised (1) | 91 |
| June 2001 | Filter Backwash Recycling Rule | Revised (1) | 91 |
| January 2002 | Long Term I Enhanced SWTR | Revised (2) | 91 |
| January 2006 | Long Term II Enhanced SWTR | Revised (1) | 91 |
| November 2006 | Groundwater Rule | New (3) | 94 |
| October 2007 | Lead and Copper Rule | Revised (2) | 94 |
| October 2009 | Aircraft Drinking Water Rule | New | 94 |
| February 2013 | Revised Total Coliform Rule | Revised (1) | 94 |
| December 2021 | Lead and Copper Rule | Revised (1) | 94 |

## What will the Future Bring?

Regulatory Challenges
- Federal Rules
- State Ordinances
- Local Ordinances

Contaminants to watch:
- Strontium
- Perchlorate
- Chrome VI
- Perfluorinated Compounds



## Strontium

- Strontium is easily taken from water and food and deposited in bones
- Natural strontium citrate is both safe and extremely beneficial for your bones
- Excessive absorption of strontium negatively affects skeletal development and leads to thickened bones prone to fracture



## Strontium

- Natural forms of strontium have been safely used in medicine for over 100 years
- Natural strontium is confused with strontium ranelate — a synthetic version with many potential adverse side effects
- The safety of natural strontium is also confused with radioactive strontium

## Strontium

- Infants, children, and adolescents are especially sensitive to strontium
- Since strontium is excreted primarily in the urine, strontium also adds burden to patients with kidney disease



## Strontium

- In October 2014, EPA made a preliminary determination to regulate strontium in drinking water based on data generated from UCMR 3
- In 2016, EPA delayed making a final decision on whether to regulate strontium



## Perchlorate
(EPA Notice - January 2012 )

- EPA Will Regulate Perchlorate
  - EPA has 24 months to propose an MCL
  - ~ 24 additional months for promulgation
  - CA MCL = 6 µg/L; MA MCL = 2 µg/L; NV Action Level = 18 µg/L
  - EPA's Federal Register notification from 2010: MCL as low as 1 µg/L
- Sources of Perchlorate
  - Munitions (Ground sources at Aberdeen, Indian Head)
  - Rocket fuel
  - Industrial sites
  - Fireworks, flares
  - **Hypochlorite (drinking water treatment)!!!**

## Perchlorate

| Common name | Stock name | Oxidation state | Formula |
|---|---|---|---|
| Hypochlorite | Chlorate(I) | +1 | $ClO^-$ |
| Chlorite | Chlorate(III) | +3 | $ClO_2^-$ |
| Chlorate | Chlorate(V) | +5 | $ClO_3^-$ |
| **Perchlorate** | **Chlorate(VII)** | +7 | $ClO_4^-$ |

**Perchlorate** adversely affects human health by interfering with iodine uptake into the thyroid gland.



## Perchlorate

- May 2019 - EPA published proposed perchlorate drinking water regulations
  - EPA requested comments on a Maximum Contaminant Level (MCL) and a health-based Maximum Contaminant Level Goal (MCLG) at 56 micrograms per liter
  - Three alternative regulatory options:
    - 18 micrograms per liter.
    - 90 micrograms per liter.
    - Withdrawal of perchlorate regulations



## Perchlorate – Final Action

- On July 21, 2020 – Final Action
- EPA determined that perchlorate **does not** meet the criteria for regulation as a drinking water contaminant under the SDWA
- EPA withdrew the 2011 regulatory determination and made a final determination not to issue a national regulation for perchlorate

## Chromium

- Chromium is an odorless and tasteless metallic element
- Chromium is found naturally in rocks, plants, soil and volcanic dust, and animals.
- The most common forms of chromium that occur in natural waters in the environment are:
  - Trivalent chromium (chromium III)
  - Hexavalent chromium (chromium VI)



## Chromium

- Chromium (III) is an essential human dietary element
- It is found in many vegetables, fruits, meats, grains, and yeast
- Chromium (VI) occurs naturally in the environment from the erosion of natural chromium deposits
- It can also be produced by industrial processes (i.e., metal plating)



## Chromium

- The national primary drinking water regulation that established the MCL for Total Chromium of 0.1 mg/L was promulgated in 1991
- In September 2010, EPA released a draft assessment of the Toxicological Effects of Hexavalent Chromium for public comment and external peer review

## Chromium

- To assess the levels of chromium VI in drinking water, EPA is requiring a selected number of systems to perform chromium VI monitoring under UCMR 3
- The UCMR 3 requires many but not all public water systems to monitor chromium VI for a one-year period



## Chromium VI ("Hexavalent" Chromium)

- CA regulates total chromium at 50 ppb
- CA's draft $Cr^{+6}$ Public Health Goal = 0.02 ppb
  - Note that current detection limits are 1 ppb!!
- Environmental Working Group December 2011 report sparked renewed interest from EPA
- EPA is considering moving $Cr^{+6}$ to UCMR4
  - But one additional contaminant must be removed from UCMR4



## Perfluorinated Chemicals

- In the 1980s and 1990s, a few laboratory toxicity studies reported liver toxicity and induction of tumors when animals were exposed to perfluorinated chemicals (PFCs)

## Perfluorinated Chemicals

- Perfluorooctanoic Acid (PFOA) and Perfluorooctane Sulfonate (PFOS) are two of the most widely used and studied chemicals in the PFAS group
- PFOA and PFAS have been replaced in the United States with other PFAS in recent years



## Perfluorinated Chemicals

- One common characteristic of concern of PFAS is that many break down very slowly and can build up in people, animals, and the environment over time



## Perfluorinated Chemicals

- Humans can be exposed to PFAS by:
  a. Working in occupations such as firefighting or chemicals manufacturing and processing
  b. Drinking water contaminated with PFAS
  c. Eating certain foods that may contain PFAS, including fish
  d. Swallowing contaminated soil or dust
  e. Breathing air containing PFAS
  f. Using products made with PFAS or that are packaged in materials containing PFAS

## Perfluorinated Chemicals

- Exposure to certain levels of PFAS may lead to:
  a. Reproductive effects such as decreased fertility or increased high blood pressure in pregnant women
  b. Developmental effects or delays in children, including low birth weight, accelerated puberty, bone variations, or behavioral changes
  c. Increased risk of some cancers, including prostate, kidney, and testicular cancers
  d. Reduced ability of the body's immune system to fight infections, including reduced vaccine response
  e. Interference with the body's natural hormones
  f. Increased cholesterol levels and/or risk of obesity



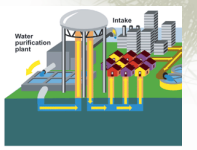
## SDWA Definitions

- PWS: Public Water System
  - 15 or more connections
  - 25 or more people per day
  - At least 60 days per year
  - Three subcategories
    - Community Water System
    - Transient Non-Community Water System
    - Non-Transient Non-Community Water System

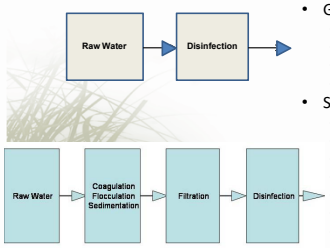


## Public Water Systems

- Public water systems deliver adequate quantities of water at pressures enough to:
  - Provide clean drinking water to:
    - Residential units
    - Businesses
    - Industrial complexes
  - Support fire-fighting equipment




## COMMON TREATMENT TECHNIQUES




- GROUNDWATER
  - pH adjustment
  - Disinfection
  - Fluoridation
  - Corrosion Control
- SURFACE WATER (& GWUDISW)
  - **Screening**
  - **Coagulation**
  - **Flocculation**
  - **Sedimentation**
  - **Filtration**
  - Disinfection
  - Fluoridation
  - Corrosion control



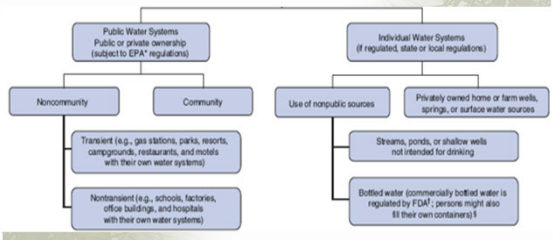
## Drinking Water Systems

**Public Water Systems**
**Public or Private Ownerships**
**(subject to EPA* regulations)**

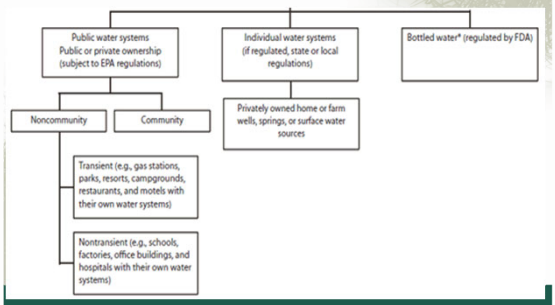
- **Noncommunity**
  - **Transient (e.g., gas stations, parks, resorts, campgrounds, restaurants, and motels with their own water systems)**
  - **Nontransient (e.g. schools, factories, office buildings, and hospitals with their own water systems)**
- **Community**



## Drinking Water Systems



## Drinking Water Systems






## SDWA Definitions

- Community Water System (CWS)
  - A PWS that supplies water to the same residential population year-round.
  - Examples:
    - Cities
    - Towns
    - Rural Water Systems
    - Trailer Parks (not seasonal)



## Community Water Systems

- Over 283 million Americans get their drinking water from community water systems (2015)
- 8% of U.S. community water systems provide water to 82% of the U.S. population through large municipal water systems


## SDWA Definitions

- Transient Non-Community Water Systems
  - Provides water in a place where people do not stay for long periods of time
  - Examples include:
    - Restaurants
    - Rest stops
    - Campgrounds



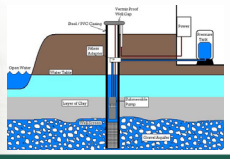

## SDWA Definitions

- Nontransient Non-Community Water Systems (NTNSWS)
  - Regularly supplies water to at least 25 people at least 6 months per year but not to their residences
  - Examples include:
    - Schools
    - Factories



## Private Well Systems

- About 10 percent of people in the United States rely on water from private wells
- Private wells are not regulated under the SDWA



## Regulation Terminology

- Contaminant - Any physical, chemical, biological, or radiological substance or matter in water
- MCLG – Maximum Contaminant Level Goal; a health goal which allows an adequate margin of safety
- MCL – Maximum Contaminant Level; highest level of contaminant allowed in water; set close to MCLG



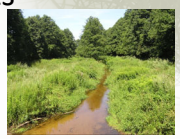
## Types of Contaminants

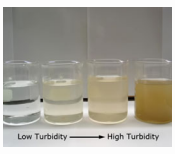
- Chemicals (organic and inorganic)
  - Naturally occurring
  - Man-made
- Microbiological
- Disinfectants and disinfection by-products
- Radiological




## Contaminants

- **Physical** contaminants primarily impact the physical appearance of water
- Examples of physical contaminants are turbidity and natural organic material (NOM) suspended in lakes, rivers, and streams from soil erosion





## Contaminants

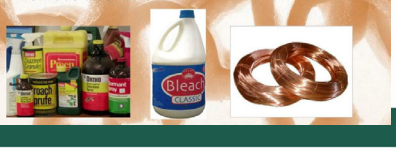
- **Chemical** contaminants are elements or compounds
- May be naturally occurring or man-made
- Examples of chemical contaminants include nitrates, bleach, salts, pesticides, metals, toxins produced by bacteria, and human or animal drugs



## Contaminants

### Chemical Contaminants

- Any cleaning chemical accidently used in a food would cause immediate and severe illness
- Chemical contaminants can cause cancer and nervous disorders






## Contaminants

- **Biological** contaminants – microorganisms
- Examples of biological or microbial contaminants include bacteria, viruses, and parasites (Protozoans and Metazoans)

## Classes of Microorganisms: The Microbial World

**Viruses:** smallest (0.02-0.3 µm diameter); simplest: nucleic acid + protein coat (+ lipoprotein envelope)

**Bacteria:** 0.5-2.0 µm diameter; prokaryotes; cellular; simple internal org.; binary fission.

**Protozoa:** most >2 µm - 2 mm; eucaryotic; single cell; non-photosynthetic; flexible cell membrane.; wide range sizes and shapes; hardy cysts and oocysts; flagellates amoebae, ciliates, sporozoans (*Cryptosporidium* sp.) and microsporidia.

***Cryptosporidium parvum* oocyst**

**~5 um**



## Waterborne Diseases

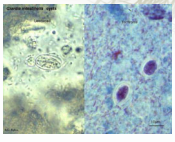
| | |
|---|---|
| Viruses | Norovirus (gastroenteritis)<br>Rotavirus (gastroenteritis)<br>Hepatitis A virus (infectious hepatitis)<br>Adenovirus (respiratory, gastroenteritis) |
| Bacteria | *Escherichia coli* (gastroenteritis)<br>*Salmonella typhi* (typhoid fever)<br>*Vibrio cholerae* (cholera)<br>*Shigella* (dysentery) |
| Protozoa | *Giardia lamblia* (gastroenteritis)<br>*Cryptosporidium parvum* (cryptosporidiosis) |



## Waterborne Pathogens

- Disease symptoms usually are explosive emissions from either end of the digestive tract

*Escherichia coli*



*Giardia* sp.*

## Protozoa

Giardia

Cryptosporidium



## Contaminants

- **Radiological** contaminants are chemical elements with an unbalanced number of protons and neutrons
  - Result: Unstable atoms that can emit ionizing radiation
- Examples of radiological contaminants include radium, radon, cesium, plutonium, and uranium



## Regulation Terminology

- **Treatment Technique**
  - § 141.2(b)(7): "…in lieu of establishing a maximum contaminant level (MCL), if…it is not economically or technologically feasible to ascertain the level of the contaminant."
  - Examples: Filtration and disinfection techniques for inactivating viruses and Giardia to avoidance levels

## Treatment Technique (TT)

- Alternative to an MCL when it is not economically and technologically feasible to ascertain the level of the contaminant
- A TT is also an enforceable standard involving a measurable procedure or level of technological performance (e.g., "Action Level")



## Steps for Developing Drinking Water Standards

- Setting the MCLG
  - Health effects information
  - Exposure information
  - Relevant information and procedures developed by EPA for risk assessment and characterization



## Safe Drinking Water Act (SDWA)

- 1996 amendments to SDWA require that EPA consider a detailed risk and cost assessment, and best available peer-reviewed science, when developing standards
- Risk-based process – prioritizes contaminants for regulation based on the contaminant's health effects and occurrence

## First Objective

- Provide an understanding of the **risk** reduction goals of SDWA and the chemical monitoring under the drinking water regulations

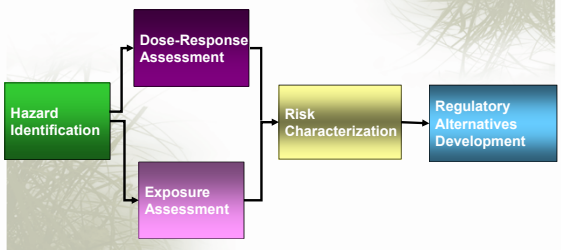


## What is Risk?

- EPA definition (from Integrated Risk Information System)
  - **Probability** of injury, disease or death from exposure to a chemical agent or a mixture of chemicals



## Components of Risk Assessment in Rulemaking



## What is an Adverse Health Effect?

- **EPA definition (from Integrated Risk Information System):**

"… any biological, physiological, anatomical, pathological, and/or behavioral change that may affect the performance of the whole organism or reduce the ability of the organism to respond to additional challenges."



## Identifying Adverse Health Effects

- Different adverse effects can occur with different magnitude, frequency and durations of exposure
- Typically, two broad categories of adverse health effects are considered:
  - Cancer
  - Non-cancer



## Maximum Contaminant Level Goals (MCLG)

- Considerations in setting an MCLG:
  - End-point – cancer or noncancer
  - Acute or chronic exposure concerns
  - Sensitive populations
- Data obtained from epidemiological and toxicological studies

## Contaminant Candidate Lists (CCLs)

- Process for creation of CCLs:
  - Consider broad universe of contaminants and collect into unified database (CCL database)
  - Develop screening criteria to cull universe to several thousand (PCCL)
  - Develop classification algorithm to narrow list to ~100 contaminants
  - Regulatory determination: 5 to 10 contaminants every five to six years



## Regulatory Development Process


| | First | Second | Third | Fourth |
|---|---|---|---|---|
| CCL | 1998 | 2005 | 2009 | 2016 |
| | 60 | 51 | 119 | 109 |
| UCMR | 1999 | 2007 | 2012 | 2016 |
| | 26 | 25 | 30 | 30 |
| RegDet | 2003 | 2008 | 2016 | 2021 |
| | 9 NR | 11 NR | 4 NR<br>1 Delayed | 6 NR<br>2 Reg |
| | | | (Strontium) | (PFOA & PFOS) |



## Unregulated Contaminants

- Under the Unregulated Contaminant Monitoring Rule(UCMR), EPA collects data for contaminants suspected to be present in drinking water, but that do not have health-based standards set under the SDWA

## Current and Previous UCMRs

- UCMR 5 (2022-2026)
- UCMR 4 (2017-2021)
- UCMR 3 (2012-2016)
- UCMR 2 (2007-2011)
- UCMR 1 (2001-2005)
- UCM-State Rounds 1&2 (1988-1997)



## Contaminant Candidate List

- Every five years EPA reviews the list of contaminants, largely based on the Contaminant Candidate List



## Current and Previous CCLs

- Draft CCL 5
- CCL 4 (2016)
- CCL 3 (2009)
- CCL 2 (2005)
- CCL 1 (1998)

## Regulatory Determination

- The SDWA requires EPA to periodically decide whether to regulate at least five contaminants on the CCL
- This action is called regulatory determination
- A regulatory determination is a formal decision on whether EPA should develop a national primary drinking water regulation for a specific contaminant



## Regulatory Determination

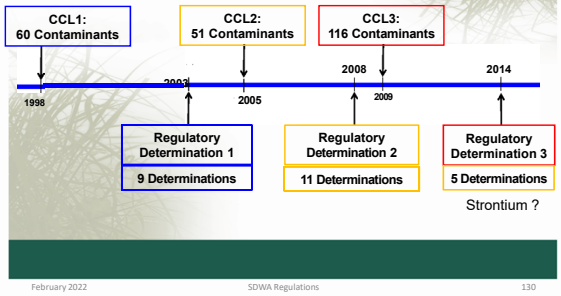
- EPA is required to make regulatory determinations for at least five contaminants from the most recent CCL
- Determinations must be decided within five years after the completion of the previous round of regulatory determinations



## Regulatory Determination

- Regulatory Determination 4
- Regulatory Determination 3
- Regulatory Determination 2
- Regulatory Determination 1

## Timeline of CCL and Regulatory Determinations






## Background on CCL and Regulatory Determinations

- CCL 1 and Regulatory Determinations
  - March 1998 - Published CCL1 and listed 60 contaminants
  - July 2003 - Published final determination "not to regulate" 9 of the 60 contaminants
- CCL 2 and Regulatory Determinations
  - February 2005 - Published CCL2 and carried forward 51 remaining CCL1 contaminants
  - July 2008 - Published final determination "not to regulate" 11 of the 51 contaminants



## Background on CCL and Regulatory Determinations

- CCL 3 and Regulatory Determinations
  - September 2009 - Published CCL 3 and listed 116 contaminants
  - October 2014 – Published final determination to regulate strontium and "not to regulate" 4 of the 116 contaminants
- CCL 4 – Final
  - November 2016 – EPA Published CCL 4 and listed 109 contaminants
  - 97 chemicals or chemical groups and 12 microbial contaminants

## Drinking Water Rule Groups

| Contaminant Type | Regulation |
|---|---|
| **Chemical contaminants** | •Arsenic rule<br>•Chemical contaminant rules<br>•Lead and copper rule<br>•Radionuclides rule<br>•Variance and exemptions rule |
| **Microbial contaminants** | •Aircraft drinking water rule<br>•Ground water rule<br>•Stage 1 and stage 2 disinfectant/disinfection byproducts rule<br>•Surface water treatment rules<br>•Total coliform rule and revised total coliform rule |
| **Right-to-know rules** | •Consumer confidence report rule<br>•Public notification rule |



## Contaminants of Concern

- Turbidity (in surface waters)
- Chlorine & Disinfection Byproducts
- Total/Fecal/e. Coli Coliforms
- Lead and Copper
- Inorganic Chemicals (Arsenic and others)
- Volatile Organic Chemicals (THMs, HAAs)
- Radioactive materials (Radium)



## Contaminants

Turbidity in Surface Waters

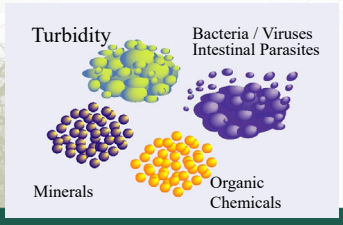
## SDWA Individual Rules

- SWTR
  - Surface Water Treatment Rule
  - Protects against exposure to harmful viruses, bacteria, Giardia and other pathogens by requiring certain types of treatment for surface water sources



## SURFACE WATER TREATMENT

"The water treatment plant is the primary barrier against unsafe water…any malfunction in the treatment process could result in water quality problems."





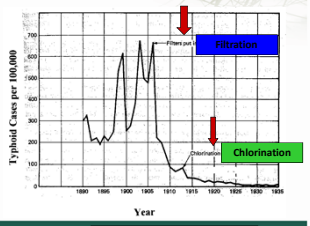

## Early USA Water Treatment Milestones

| | |
|---|---|
| 1871: | First slow sand filter in USA |
| 1896: | First rapid sand filter in USA |
| 1908: | First use of chlorine as a primary disinfectant |
| 1920s: | Filtration and chlorination used widely in large cities |

## Filtration and Chlorination

- In 1908, a water treatment plant in Jersey City, New Jersey, used chlorine as primary disinfectant
- USA typhoid cases began to drop dramatically
- In early 1900s most U.S. water treatment systems were using filtration and chlorine disinfection to remove microbial contaminants.

Figure 1 Typhoid Cases 1890-1935 Philadelphia

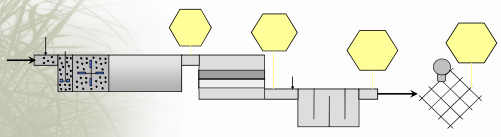



From McGhee, 6th Ed., 1991



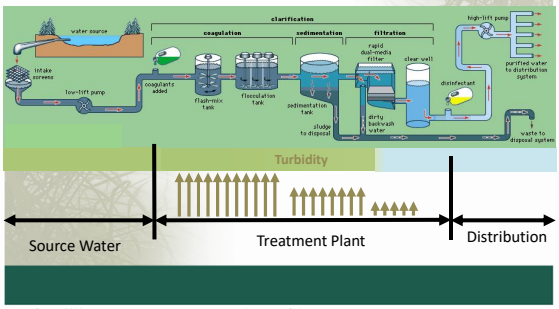
## Water Treatment Goals

- Turbidity removal often requires treatment beyond regulatory levels
- Water treatment strategies focus on multiple barrier approaches to assure safe drinking water
  - Turbidity removal
    - Coagulation/flocculation + sedimentation + **filtration**
  - Disinfection



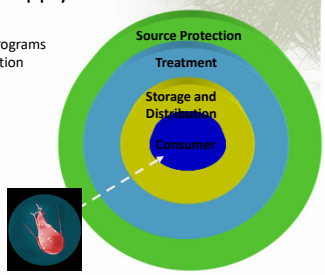


## Surface Water Treatment Plant and Distribution System



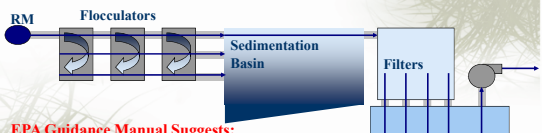
## Multiple Barriers In Water Supply Protection

- Sources
  - Watershed management programs
  - Intake and wellhead protection
- Treatment
  - Coagulation, flocculation, sedimentation
  - Filtration
  - Disinfection
- Storage
  - Disinfectant contact time
  - Screens
- Distribution
  - Pressure
  - Disinfection






## Filtration: Conventional



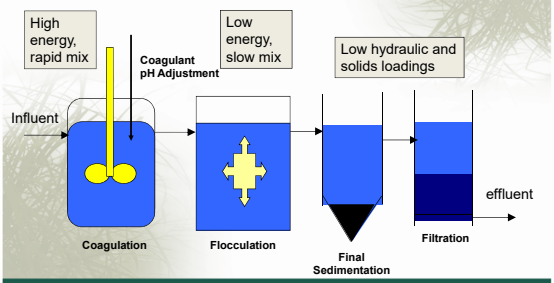

**EPA Guidance Manual Suggests:**

**Removals:**
- 2.5 Log Removal *Giardia*
- 2.0 Log Removal Viruses

**Inactivation:**
- 0.5 Log Inactivation *Giardia*
- 2.0 Log Inactivation Viruses



## Enhanced Solids Removal System



## Percentage vs. Log Reductions

| Percentage Reductions | Log Reductions |
|---|---|
| 90 | 1-log |
| 99 | 2-log |
| 99.9 | 3-log |
| 99.99 | 4-log |



## Filtration: Direct


**EPA Guidance Manual Suggests:**

**Removals:**
- 2.0 Log Removal *Giardia*
- 1.0 Log Removal Viruses

**Inactivation:**
- 1.0 Log Inactivation *Giardia*
- 3.0 Log Inactivation Viruses



## Filtration: Conventional or Direct

- At Least 95 Percent of the Combined Filter Effluent (CFE)[1] Turbidity Samples Must Be < 0.5 NTU Each Month Except That:
  - The State Can Determine That Some Level Higher Than 0.5 NTU but <1 NTU Will Inactivate And/or Remove 99.9 Percent of *Giardia lamblia* Cysts
- The CFE Turbidity Must at No Time Exceed 5 NTU

[1]**The Rule Says "Representative Samples of a System's Filtered Water." EPA considers this to be CFE; some states apply the limit to individual filters.**

## Surface Water Treatment Options

Surface Water Treatment Rule (SWTR - 1989)

- Objectives: To ensure adequate treatment of raw water

  To filter and disinfect surface water sources
- Finished water **turbidity standard of ≤ 0.5 NTU; cannot exceed 5 NTU**
- Concentration and time (C x T) requirements for disinfection; detectable residual chlorine cannot be less than 0.2 mg/L for more than 4 hours
- Maintain Total Coliforms < 100MPN/100 ml and fecal coliforms < 20 MPN/ml in 90% of water samples
- Annual watershed inspection and report; system Sanitary Surveys periodically



## Surface Water Treatment Options

Enhanced Surface Water Treatment Rules (ESWTR – 1998 - 2006)

- Objectives: To treat raw water for **Cryptosporidium**
- To cover or treat remaining finished water reservoirs
- Finished water turbidity standard of ≤ 0.3 NTU
- Benchmark/**profile for Cryptosporidium** removal



## Long Term 1 Enhanced Surface Water Treatment Rule (LT1ESWTR)

January 14, 2002

## SDWA Individual Rules

- LT1ESWTR
  - Long Term 1 Enhanced Surface Water Treatment Rule
  - Applies to systems serving <10,000 people.
  - Sets Cryptospiridium removal and turbidity requirements
  - Requires disinfection benchmarking and covers on new finished water reservoirs



## Long Term 1 Enhanced Surface Water Treatment Rule

- Goals
  - Improve control of microbial pathogens, including Cryptosporidium, in drinking water
  - Address risk trade-offs with disinfection byproducts



## Summary of the LT1 Rule

- MCLG of zero for *Cryptosporidium*
- Requirements for SW/GWUDI systems serving 10,000 or fewer people
  - 2 log removal of *Cryptosporidium* for systems required to filter under the SWTR
  - Strengthened turbidity performance standards for combined filter effluent
  - Individual filter turbidity monitoring and reporting provisions for systems
  - Disinfection profile and benchmark provisions to assure continued levels of microbial protection where facilities take steps to comply with new DBP standards

## Summary of the LT1 Rule

- Compliance Dates
  - January 2002(last revised)
    - IESWTR: Surface water systems and Subpart H systems serving 10,000 or more persons
  - January 2005
    - LT1SWTR:Small surface water and ground water under the influence systems serving fewer than 10,000 persons must comply with strengthened turbidity performance standards and individual filter monitoring and reporting requirements
    - States begin first round of sanitary surveys



## Public Health Concerns Addressed

- *Cryptosporidium* is common in source waters and is highly resistant to chlorination disinfection practices
- *Cryptosporidium* causes gastro-intestinal illness lasting a few days in healthy, adult individuals
- Symptoms can be much more severe in sensitive populations (including death for those with weakened immune systems)
- Milwaukee outbreak
  - 400,000 illnesses
  - 4,000 hospitalizations
  - 50 deaths



## Waterborne Disease Outbreaks Cause Irreparable Damage to Public and PWSs

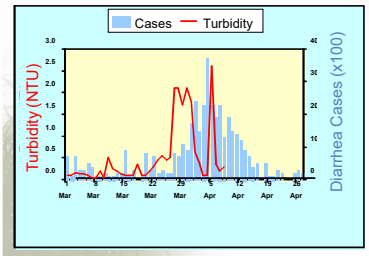
| Year | State/Territory | Cause of Disease | No. of People Affected |
|---|---|---|---|
| 1985 | Massachusetts | *Giardia lamblia* (protozoan) | 703 illnesses |
| 1987 | Georgia | *Cryptosporidium parvum* (protozoan) | 13,000 illnesses |
| 1987 | Puerto Rico | *Shigella sonnei* (bacterium) | 1,800 illnesses |
| 1989 | Missouri | *E. coli* 0157 (bacterium) | 243 illnesses / 4 deaths |
| 1991 | Puerto Rico | *Unknown* | 9,847 illnesses |
| 1993 | Missouri | *Salmonella typhimurium* (bacterium) | 650 illnesses / 7 deaths |
| 1993 | Wisconsin | *Cryptosporidium parvum* (protozoan) | 400,000 illnesses 50+ deaths |
| 1998 | Texas | *Cryptosporidium parvum* (protozoan) | 1,400 illnesses |
| 1999 | New York | *E. coli* 0157 (bacterium) | 150 illnesses / 1 death |
| 2000 | Ontario | *E. coli* 0157 (bacterium) | 1,000 illnesses / 7 deaths |

***Source: HDR's Handbook of Public Water Systems***

## Milwaukee Disease Outbreak - 1993

403,000 illnesses (out of 1.6 million population)

Ineffective coagulation, flocculation, and filtration






## Benefits of the LT1ESWTR

- Improve public health by increasing level of protection from exposure to *Cryptosporidium* and other pathogens through improvements in filtration
- Decrease the likelihood of endemic illness from *Cryptosporidium* by 110,000 to 463,000 cases annually and related health costs
- Reduce likelihood of occurrence of out-breaks by providing a larger margin of safety



## LT1 Treatment Techniques

- Treatment techniques in lieu of MCLs for *Giardia lamblia*, viruses, heterotrophic plate count bacteria, *Legionella*, and *Cryptosporidium*
- These requirements are in addition to the requirements in the existing Surface Water Treatment Rules

## LT1 Treatment Techniques

- Treatment technique requirements consist of installing and properly operating water treatment processes that reliably achieve a number of conditions
- Filtered systems
  - At least 99% (2 log) removal of *Cryptosporidium* between point where source water is not subject to recontamination by surface water runoff and point downstream before or at first customer
  - Unfiltered systems:
  - Must include *Cryptosporidium* control under watershed control program
  - Compliance with disinfection profiling and benchmarking provisions



## Surface Water Treatment Techniques

- System is in compliance with treatment technique requirements if it meets SWTR and LT1ESWTR requirements
  - Disinfection (including profiling/benchmarking); and
  - Filtration avoidance or applicable turbidity performance standards



## Turbidity Standards

- Systems using conventional filtration or direct filtration
  - Turbidity level of representative samples of filtered water must be less than or equal to 0.3 NTU in at least 95% of the measurements taken each month
  - Turbidity level of representative samples of filtered water must at no time exceed 1 NTU
  - Framework for these requirements is identical to SWTR—only specific standards have changed

## Monitoring Requirements for Individual Filters

- Rule establishes new requirements to continuously monitor individual filter performance
- Individual filter monitoring requirements are not part of the treatment technique
- Exceedance of the performance requirement triggers other actions—it is not a violation
- Designed to raise awareness of individual filter performance (informational)



## Individual Filter Provisions

- Monitoring Requirements
- For systems using conventional or direct filtration
  - Systems must conduct continuous turbidity monitoring for each individual filter
    - If a system has 1 or 2 filters, continuous monitoring of the combined filter effluent may be substituted.
  - Systems must record results of individual filter monitoring every 15 minutes
  - Must calibrate turbidimeters using procedure specified by manufacturer
  - If there is a failure in the continuous turbidity monitoring equipment, system must conduct grab sampling every 4 hours in lieu of continuous monitoring but for no more than 5 working days following failure of the equipment



## Individual Filter Provisions

- Trigger (A)
  - Individual filter turbidity level greater than 1.0 NTU in 2 consecutive measurements taken 15 minutes apart
- Action (A)
  - Record filter number, turbidity measurement, date(s) exceedance occurred
  - Produce filter profile within 7 days of exceedance (if no obvious reason for exceedance)
  - Report that profile has been produced or report obvious reason for exceedance within 10 days after then end of each month system serves water to the public

## Individual Filter Provisions

- Trigger (B)
  - Individual filter turbidity level greater than 1.0 NTU in 2 consecutive measurements taken 15 minutes apart in each of 3 consecutive months
- Action (B)
  - Record filter number, turbidity measurement, date(s) exceedance occurred
  - Self-assessment of filter within 14 days of exceedance
    - Assessment of filter performance
    - Development of filter profile
    - Identification/prioritization of factors limiting performance
    - Assessment of applicability of corrections
    - Filter self-assessment report



## Long Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR)

January 24, 2005



## LT2ESWTR Requirements

- Purpose: to limit exposure by requiring microbial disinfection based on source water quality
- Required disinfection levels –
  - *Cryptosporidium* 3.0 log - 5.5 log (99.9% - 99.9997%)
  - viruses (IESWTR) 4.0 log (99.99%)
  - *Giardia* (IESWTR) 3.0 log (99.9%)

## Rule Background

- Builds on existing Surface Water Treatment Rules
- Flexible, risk-based Rule based on new *Cryptosporidium* (*Crypto*) data
- Accounts for
  - Current level of treatment
  - Source water quality
  - System size
- Offers range of compliance options
- Improves public health protection



## Rule Summary

- Source water monitoring requirements
- Profiling and benchmarking requirements
- Treatment technique requirements
- Microbial toolbox components
- Uncovered finished water storage facilities
- Sanitary surveys



## Sanitary Survey - Definition

"..an onsite review of the water source, facilities, equipment, operation and maintenance of a public water system for the purpose of evaluating the adequacy of such source, facilities, equipment, operation, and maintenance for producing and distributing safe drinking water."

## Why Conduct Sanitary Surveys?

- Helps to ensure:
  - Public health protection
  - Compliance with regulations
- Proactive and preventive in nature



## 8 Elements of A Sanitary Survey as Defined by EPA

1. Source
2. Treatment
3. Distribution System
4. Finished Water Storage
5. Pumps, Pumping Facilities, and Controls
6. Monitoring, Reporting, and Data Verification
7. System Management and Operation
8. Operator Compliance with State Requirements



## Crypto Monitoring

- Applies to system ≥ 10,000
- Sample at least monthly for 2 years for crypto, turbidity and *E. coli*
- **Initial Distribution System Evaluation (IDSE)** and Compliance Monitoring
- Monthly reporting of results to State or EPA HQ

## *E. coli* Monitoring

- Applies to systems < 10,000
- Sample at least once every two weeks for 1 year
- Crypto monitoring initiated if annual mean *E. coli* concentration is greater than…
  - 10 *E. coli* /100 mL for lake/reservoir sources
  - 50 *E. coli* /100 mL for flowing stream sources
- Crypto monitoring at least twice per month for 1 year or monthly for 2 years
- Monthly reporting to state



## Population Based Monitoring

- Required for **Initial Distribution System Evaluation (IDSE)** and Compliance Monitoring
- Monitoring based on population and source water type
- Targets problem areas based on better understanding of DBP, Crypto, E. coli occurrence and formation
- Greater equity of public health protection



## The IDSE

- Purpose: to select new monitoring sites that more accurately reflect sites representing high TTHM and HAA5 levels
- Approach: standard monitoring program or system-specific study

## IDSE General Requirements

- Purposes of IDSEs
  - Determine locations of high TTHMs and HAAs throughout the distribution system
  - Results are used in conjunction with the Stage 1 DBPR monitoring in order to identify locations for Stage 2 DBPR monitoring



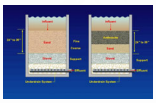
## IDSE – Very Small System Waivers

- For systems serving under 500, the State will review the current data to determine whether existing monitoring locations are sufficient. The status of an IDSE waiver will be documented in the system's monitoring schedule, if applicable.



## SDWA Individual Rules

- **Filter Backwash Recycling Rule (FBRR)**
  - Reduces risks from recycling contaminants removed during filtration
  - Affects systems that recycle spent filter backwash water, thickener supernatant, or liquids from dewatering



## Background

- Filter backwash recycle reintroduces contaminants back into the treatment process
- 1996 SDWA Amendments require EPA to promulgate a regulation that "governs" recycle of filter backwash water within a treatment plant



## Purpose of FBRR

- Recycle streams are source of high concentration of microbial pathogens and chemical contaminants
  - Contribute to the contaminant load
  - Coagulant chemistry imbalance
  - Hydraulic surge--overwhelms plant's unit processes
- Waste flows may adversely affect plant performance and, subsequently, pathogen removal



## Purpose of FBRR

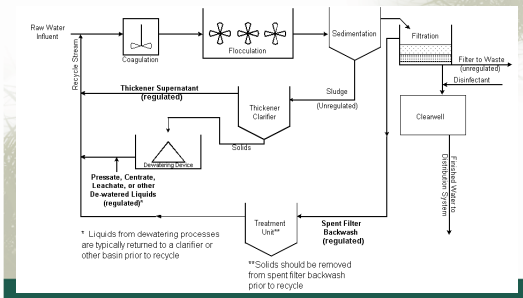
- FBRR reduces potential for *Cryptosporidium* oocysts to pass through filters into finished water by ensuring proper management of residual streams
- FBRR also allows States to evaluate recycle practices and identify any potential problems.

## Systems Covered by FBRR §141.76(a)

- SW and GWUDI (Subpart H) systems that employ conventional or direct filtration and
- Recycles one or more of the following:
  - Spent Filter Backwash Water
  - Thickener Supernatant
  - Liquids from Dewatering Processes

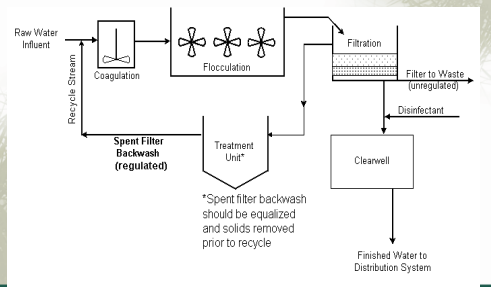


## Conventional Treatment Plant






## Direct Filtration



## *What is Filter Backwash Water?*

- Resulting water pushed back through the filter in the cleaning process
- Filter backwashing is an integral part of treatment plant operation



## *What is Thickener Supernatant? What are Liquids from Dewatering Processes?*

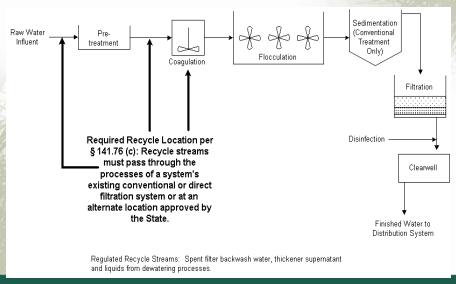
- Thickener Supernatant
  - The "clear water" that exits sedimentation basins and clarifiers after particles have been allowed to settle out
- Liquids from Dewatering Processes
  - Dewatering processes remove water from waste solids "sludge" in order to reduce the solids volume to be disposed



## Key Components

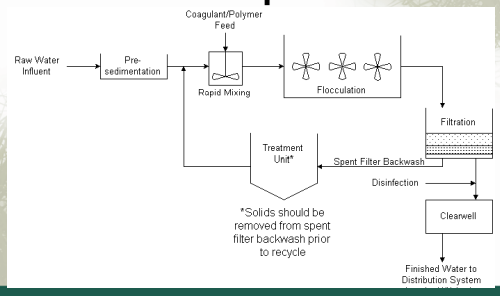
- Submit Data to State
  - Plant schematic
  - Plant and recycle flow rates
  - State-approved operating capacity of plant
- Appropriate Recycle Return Location
  - Through all processes of a system's conventional and direct filtration treatment
  - State-approved alternate location
- Maintain Specific Records

# Recycle Return Location



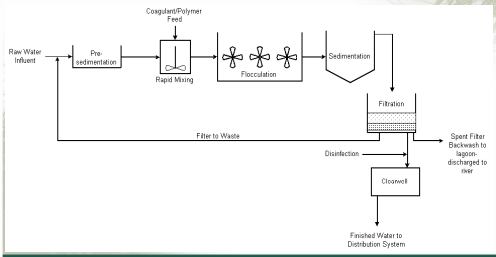



# Example 1

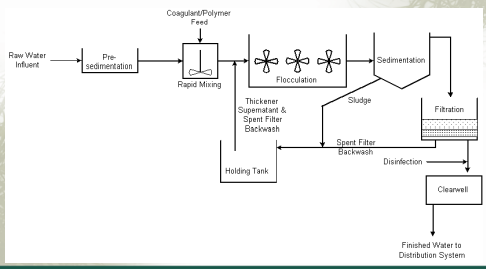





# Example 2



## Example 3





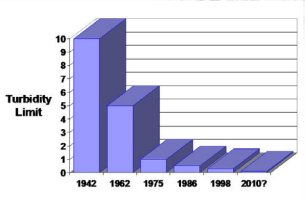

## Stage 1 and 2 Disinfection/Disinfection Rules (Stage 1 DBPR & Stage 2 DBPR)

January 24, 2005



## Treatment Goals

- Stage 2 D/DBP Rule
  - Remove natural organic matter
- Long Term 2 ESWTR
  - Remove particles/turbidity
  - Turbidity goal: 0.1 NTU



## Monitoring Requirements

*Monitoring Frequency and Number of Sites*

Stage 1 DBPR:
- *Plant-based*
- *Dependent on number of treatment plants or wells*

Stage 2 DBPR:
- *Population-based*
- *Dependent on population served*



## Disinfectants and Disinfection Byproducts (D/DBP) Rules

- Applies to any CWS/NTNC system that adds a disinfectant
- Effective dates:
  - Stage 1 D/DBP Rule - January 2002 (>10,000 SW)
  - Stage 1 D/DBP Rule - January 2004 (SW<10,000 and GW)
  - Stage 2 D/DBP Rule – January 2006 – October 2013 (all populations; SW and GW)
- Balance benefits of acute microbial protection against risks of chronic exposure to disinfection byproducts



## Disinfectant and Disinfection Byproducts (DBPs)

- **Disinfectants**
  - **Chlorine**
  - **Chloramines**
  - **Chlorine Dioxide**
- **Maximum Residual Disinfectant Level (MRDL)**
  - Level of a disinfectant added for water treatment that may not be exceeded at the consumer's tap without an unacceptable possibility of adverse health effects

## Disinfectants and Disinfection Byproducts (DBP)

| Regulated DBP Contaminants | MCL (mg/L) | MCLG (mg/L) | Regulated Disinfectants | MRDL* (mg/L) | MRDLG* (mg/L) |
|---|---|---|---|---|---|
| **Total Trihalomethanes (TTHMs)** | 0.080 | | Chlorine | 4.0 as $Cl_2$ | 4 |
| Chloroform | | - | | | |
| Bromodichloromethane | | Zero | | | |
| Dibromochloromethane | | 0.06 | | | |
| Bromoform | | zero | | | |
| **Five Haloacetic Acids (HAA5)** | 0.060 | | Chloramines | 4.0 as $Cl_2$ | 4 |
| Monochloroacetic acid | | - | | | |
| Dichloroacetic acid | | Zero | Chlorine dioxide | 0.8 | 0.8 |
| Trichloroacetic acid | | 0.3 | | | |
| Bromoacetic acid | | - | | | |
| Dibromoacetic acid | | - | | | |



## Disinfectants and Disinfection Byproducts (DBP)

| Regulated DBP Contaminants | MCL (mg/L) | MCLG (mg/L) | | MRDL* (mg/L) | MRDLG* (mg/L) |
|---|---|---|---|---|---|
| **Bromate** (plants using ozone) | 0.010 | Zero | *Stage 1 DBPR includes maximum residual disinfectant levels (MRDLs) and goals (MRDLGs) which are similar to MCLs and MCLGs but for disinfectants | | |
| **Chlorite** (plants using chlorine dioxide) | 1.0 | 0.8 | | | |
| **Treatment Technique** | | | | | |
| Enhanced coagulation/enhanced softening to improve removal of DBP precursors (See Step 1 TOC Table for systems using conventional filtration treatment) | | | | | |



## IDSE – 40/30 Certification

- For systems with consistently low DBP levels, the IDSE requirements may be waived. The State will identify the waiver status in the system's monitoring schedule.

## 40/30 Certification

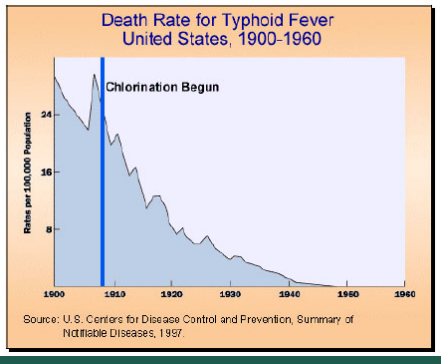
- Eligibility
  - All required Stage 1 DBPR (Subpart L) compliance samples have been taken
  - No individual sample exceeded 0.040 mg/L for TTHM.
  - No individual sample exceeded 0.030 mg/L for HAA5
  - No TTHM or HAA5 monitoring violations.
- MDE will review data & Determine 40/30 waivers, if applicable
  - Refer to monitoring schedules each year for changes.



## Disinfection

- Goal
  - To destroy or inactivate pathogenic microorganisms including bacteria, cysts, algae, spores and viruses.
- Problem
  - Forms disinfection byproducts





## Methods of Disinfection

| Chemical Oxidation | Physical Means |
|---|---|
| **Chlorine** | **Ultraviolet light** |
| Ozone | Heat |
| Peracetic Acid (new) | Membranes |



## Comparative Effectiveness of Disinfectants

| | Crypto | Giardia | Viruses | Residual |
|---|---|---|---|---|
| Chlorine | **NE** | **G** | **E** | **G** |
| Chlorine dioxide | **P/F** | **G** | **G** | **F** |
| Ozone | **P/F/G** | **E** | **G/E** | **P** |
| Chloramines | **NE** | **P** | **P** | **G** |
| UV | **E** | **E** | **F** | **none** |

NE – not effective; P – poor; F – fair; G – good; E - excellent



## Comparative Effectiveness of Disinfectants

| Treatment Process | Microorganisms | | |
|---|---|---|---|
| | Viruses | Bacteria | Protozoans |
| Free chlorine | Very effective | Very effective | Less effective |
| Chlorine dioxide | Effective | Very effective | Effective |
| Iodine | Effective | Effective | Not effective |
| UV light | Effective | Very effective | Very effective |
| Natural sunlight | Effective | Effective | Less effective |
| Boiling | Very effective | Very effective | Very effective |
| Membrane Filtration | Variably effective | Very effective | Very effective |

## Chlorine

- Most widely used disinfectant
- Saved millions of lives and eliminated waterborne diseases such as cholera and typhoid
- Relatively easy to use
- Safety concerns for liquid chlorine cylinders or tank cars (chlorine gas)
- Relatively inexpensive
- Major disadvantages:
  - production of THMs, HAAs, other chlorinated disinfection byproducts
  - must dechlorinate wastewater



## Disinfection Performance Goal

**Disinfection Goal:**

Maintain ≥ 0.20 mg/L free chlorine
At all monitoring sites in the distribution system, at all times.

- Regulatory Requirements:
  - Minimum of 0.20 mg/L free chlorine
  - Maximum of 4.0 mg/L free chlorine



## Site Specific Conditions

- Chlorine Disinfection
  - Disinfectant Residual Cannot Be < 0.2 mg/l for More Than 4 Hours (or > 4.0 mg/l)
    - Unless Caused by "Unusual and Unpredictable Circumstances"
  - Disinfectant Residual in the Distribution System Cannot Be Undetectable in More Than 5 Percent of Monthly Samples for Any Two Consecutive Months

## Disinfection – Regulatory Goals

- EPA's regulatory framework requires systems using surface water (or groundwater "under the direct influence" of surface water) to:
  - **Disinfect** their water **and/or**
  - **Filter** their water or meet criteria for avoiding filtration so that the following contaminants are controlled at the following levels
    - † Cryptosporidium - 99 percent (2-$\log_{10}$) removal
    - † Giardia lamblia - 99.9 percent (3-$\log_{10}$) removal/inactivation
    - † Viruses - 99.99 percent (4-$\log_{10}$) removal/inactivation



## General Requirements

- Establishes **Treatment Techniques** That Must Achieve:
  - At Least 99.9 Percent Removal And/or Inactivation of *Giardia lamblia* Cysts
  - At Least 99.99 Percent Removal And/Or Inactivation of Viruses
    - Between a Point Where the Water Is Not Subject to Contamination by Surface Water Runoff and a Point Before the First Customer



## Removal Efficiency is Dependent on Microbial Type

- *Giardia* and *Cryptosporidium*
  - Filtration is best
    - Large size
    - Resistant cyst and oocyst
- Bacteria and Enteric Viruses
  - Disinfection is ultimate barrier
  - Filtration and coagulation also help via adsorption to particles
    - Dependent on surface charge of virus

## Disinfection Basics

- The chlorine dose required depends on two considerations: the chlorine demand and the desired chlorine residual.
- Dose = Demand, mg/L + Residual, mg/L
- The chlorine demand is the amount used up reacting with various components of the water such as harmful organisms and other organic and inorganic substances
- When the chlorine demand has been satisfied, demand reactions stop



## CHLORINE CHEMISTRY

- $Cl_2$ + $H_2O$ -> HOCl + HCl
- Which one is the bacteria killer ?

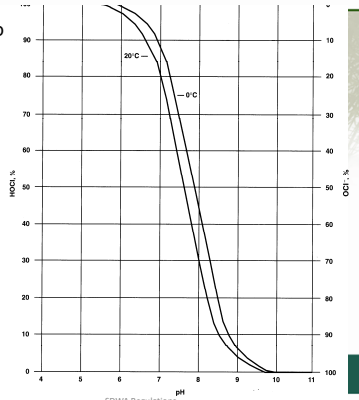
  hypochlorous acid = HOCL "Killer"
- HOCl -> H+ + OCl-

  0……7……14

  pH
- How does pH effect the disinfection process ?

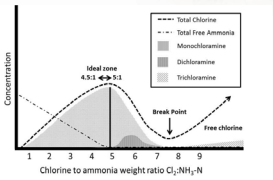


As pH goes up the amount of HOCl drops off.

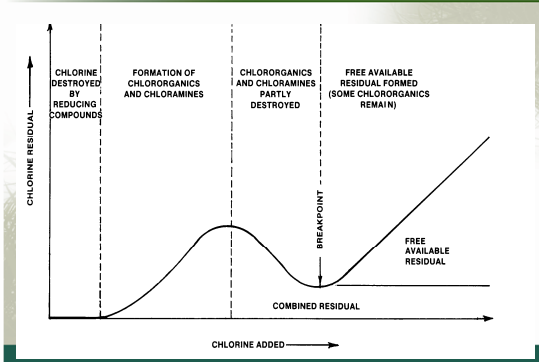


## Breakpoint Chlorination Curve

- Understanding breakpoint chlorination and chlorine interactions with ammonia are critical for understanding chlorine demand:
  - Total Chlorine
  - Total Free Ammonia
  - Free Chlorine
  - Monochloramines
  - Dichloramines
  - Trichloramines








## Chlorine Dosages

| | Min. Cl Dosage* Mg/L-min | Min. Contact Time, minutes | Min. Cl Residual mg/L | Max. Cl Residual mg/L |
|---|---|---|---|---|
| Typical | > 20 | > 30 | > 0.2 | < 4.0 |
| Virus inactivation | > 4 | 3-log reduction | | |
| Giardia inactivation | > 100 | | | |

* Dosage to comply with EPA Filtration and Disinfection requirements

## Waterborne Diseases

| | |
|---|---|
| Bacteria | *Escherichia coli* (gastroenteritis)<br>*Salmonella typhi* (typhoid fever)<br>*Vibrio cholerae* (cholera)<br>*Shigella* (dysentery) |
| Viruses | Norovirus (gastroenteritis)<br>Rotavirus (gastroenteritis)<br>Hepatitis A virus (infectious hepatitis)<br>Adenovirus (respiratory, gastroenteritis) |
| Protozoa | *Giardia lamblia* (gastroenteritis)<br>*Cryptosporidium parvum* (cryptosporidiosis) |



## Types of Disinfectant Systems

- Chemical agents
  - chlorine ($Cl_2$)
  - chlorine dioxide ($ClO_2$)
  - ozone ($O_3$)
  - chloramines
- Physical agents
  - UV radiation
  - membranes



## CHLORINE CHEMICALS

- Chlorine, $Cl_2$ 100%
  Gas compressed to liquid
- Sodium Hypochlorite, NaOCl 12% -15%
  Household bleach, 1% – 8 %
- Calcium Hypochlorite, $Ca(OCl)_2$ 65%
  HTH is used primarily in swimming pools
  Tablets available for residential wells

## Chlorine Disinfection

- Advantages:
  - Low cost
  - Easy to obtain??
  - Effective at low doses
- Disadvantages:
  - Residual harmful to environment
  - Toxic and hazardous to handle




## Disinfection

- Effectiveness is based on "Dosage":

**Dosage = "Dose" X "Time"**

Where: **Dosage =** **rate of application of a dose**

Dose = Quantity:
- Chlorine residual concentration
- UV light Intensity

Time = Detention, contact, or exposure



## Chlorine versus UV

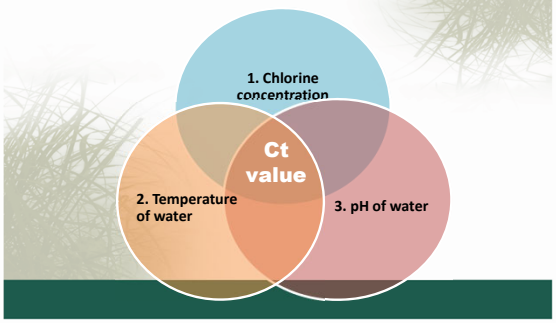
- ***Chlorine dosage (CT) = C x t***

Where, CT = Chlorine dosage, mg/L-min
C = Residual Chlorine concentration, mg/L
t = Contact time, minutes

- ***UV dosage (D) = I x t***

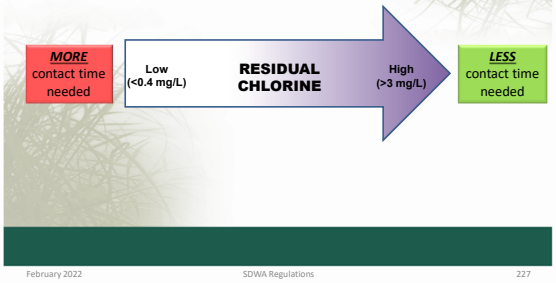
Where, D = UV dosage, mW-sec/cm$^2$ or mJ/cm$^2$
I = UV intensity, mW/cm$^2$
t = exposure time, seconds

## Factors Affecting Ct Value



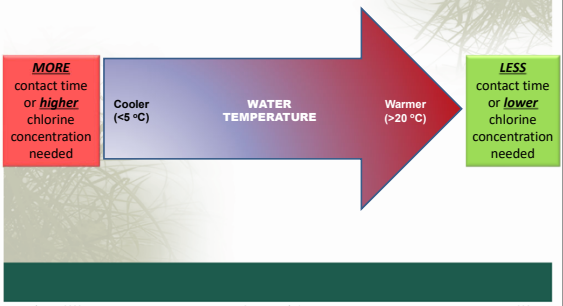



## Factors Affecting Ct, Chlorine Dose



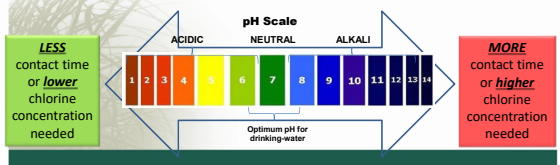



## Factors Affecting Ct, Temperature



## Factors Affecting Ct, pH

- pH measures acid or alkaline (or basic) conditions in water
  - pH 7 considered neutral, pH <7 considered acidic and pH >7 considered alkali





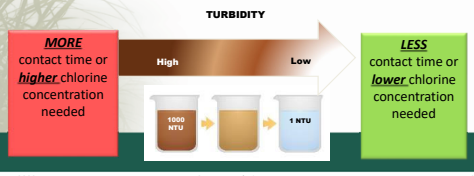

## Factors Affecting Ct, pH

- **For effective chlorination, the pH of the water should be < pH 8.0**
- To balance water quality considerations, including chlorination, the optimum pH of drinking-water is generally between pH 6.5 and pH 8.5
- Where water is >pH 8.0, higher chlorine concentrations or more contact time will be required!



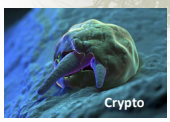
## Factors Affecting Ct, Turbidity

- Chlorine reactive substances may consume chlorine and increase chorine demand
- May also 'shield' microorganisms from inactivating chlorine effects



## Factors Affecting Ct, Microorganism






BACTERIA VIRUSES PROTOZOA

***LESS*** contact time or ***lower*** chlorine concentration needed

MOST EFFECTIVE LEAST EFFECTIVE

***MORE*** contact time or ***higher*** chlorine concentration needed

SEWAGE



## Potential Health Issues?

- Microbial Health Concerns
  - Cryptosporidiosis and Giardiasis
    - Vomiting and diarrhea, potentially life threatening for immune compromised, elderly and young
- Disinfection By-Product Health Concerns
  - Cancer
    - Bladder, colon and rectal
  - Reproductive
    - Neural tube defects and miscarriages
  - Brominated compounds are thought to pose a greater health risk than chlorinated compounds
  - Nitrogenated compounds may be even worse???



## How we know the disinfection process is working

- Coliform testing
  - State and Federal law requires testing
  - Number of tests is based of population served
- Federal Surface Water Treatment Rule
  - Requires all surface water systems to use a "treatment technique" to remove or inactivate disease causing organisms

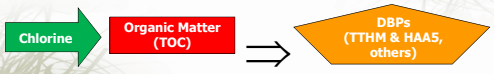
## The Disinfection Barrier:
### What's not working…

- Distribution system evaluations indicate:
  - — Water systems aren't monitoring throughout their systems
  - — At critical sites, free chlorine residual is not maintained ≥ 0.2 mg/L.



## The Flip Side:
### Disinfection Byproduct (DBP) Formation

- DBPs are formed when chlorine (or other disinfectant) reacts with organics (total organic carbon) in the water



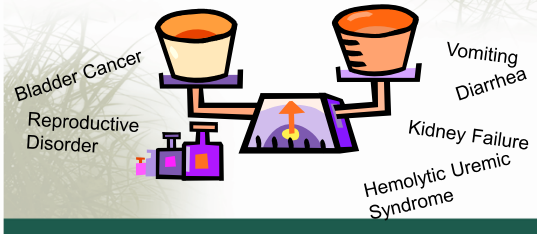

- Formation is impacted by:
  - Reactions within the bulk water (due to increased chlorine, temperature, organics, etc.)
  - Reactions within the distribution system infrastructure (e.g., biofilm, etc.)
  - Water age (time)



## Risks Must be Balanced

**Increase Chlorine = Increase DBPs**

**Decrease Chlorine = Increase Microbial Risk**



## Disinfection By-products (DBPs)

- By-products of reactions between disinfectant (chlorine, ozone, etc.) and natural organic matter present in source water



## All disinfectants form DBPs

- Chlorine – TTHMs, HAA5, other chlorinated DBPs (haloacetonitriles, haloketones, etc)
- Chloramines – N-nitrosodimethylamine (NDMA), other nitrogenous DBPs
- Chlorine dioxide – chlorite, chlorate
- Ozone – bromate, aldehydes, keytones, etc.



## DBP Formation

NOM = natural organic matter

NOM + $Cl_2$ --------> THMs, HAAs, other chlorinated DBPs

NOM + $Cl_2$ + $Br^-$ --------> brominated THMs, HAAs, other DBPs

**{Depends on chlorine dose, NOM concentration (and type), temperature, pH, time}**

## Natural Organic Matter (NOM)

- Present in all natural waters
- Consists of living organisms:
  - algae, protozoa, bacteria, viruses
- Consists of non-living material:
  - decayed vegetation, humic substances
- Usually measured as TOC or DOC
- Largest fraction of DOC is usually humic substances
- Can only identify about 20 % of the DOC



## Stormwater Runoff – Major Source of Organic Matter

**Forests and wetlands help control runoff and nutrients but ...**

**contribute color and organic compounds**



## Sources of Organic Matter



## NOM Removal

Why Do We Care?

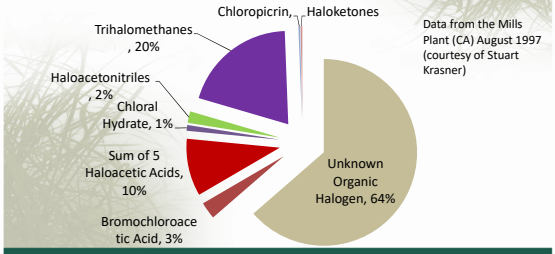
- NOM is present in all surface waters
- Exerts a disinfectant demand
- **Precursor to THMs and HAAs and other DBPs**
- Coagulant demand – NOM controls the optimum coagulant dose for most waters, *not turbidity*
- Source of color
- Fouling of membranes and GAC adsorbers
- Increases solubility of pollutants and heavy metals
- Carbon source for biofilm growth
- Can affect corrosion
- Source of tastes and odors

*In most cases, we want to maximize NOM removal*



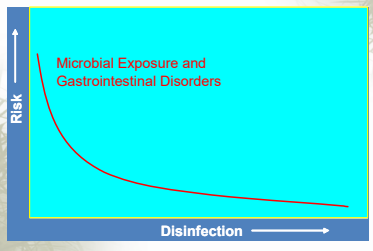
## Emerging Disinfection Byproducts

- What do we really know??

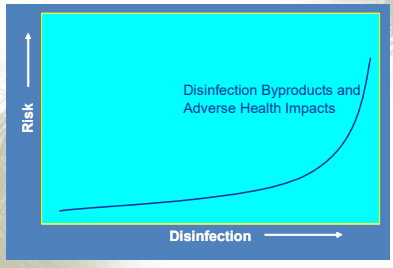





## Microbial Risks

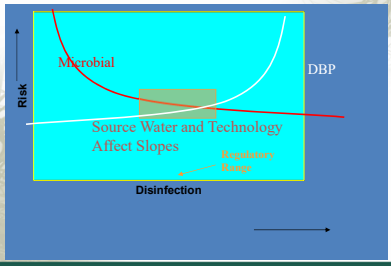


## Disinfection Byproduct Risks



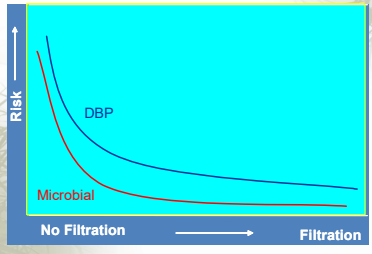



## Microbial vs. DBP Risk Trade-Offs






## Filtration Reduces both Microbial and DBP Risks



## SDWA Individual Rules

- Stage 1 Disinfectants/Disinfection Byproducts Rule (DBP)
  - Increases requirements for some regulated DBPs
  - Sets new requirements for haloacetic acids, chlorite, and bromate



## Specific Requirements MCLs and MRDLs

| Compound(s) | Stage 1 & 2 (mg/L) |
|---|---|
| TTHMs | 0.080 |
| HAA5 | 0.060 |
| Bromate | 0.010 |
| Chlorite | 1.0 |
| Chlorine | 4.0 |
| Chloramines | 4.0 |
| Chlorine Dioxide | 0.8 |

Stage 1: System-wide Running Annual Avg. (RAA)

Stage 2: Locational Running Annual Avg. (LRAA)

MRDLs for Chlorine and Chloramines may be exceeded in response to public health problems

### Stage 1 Sampling Frequency

| Surface | Sampling Frequency | Ground |
|---|---|---|
| ≥10,000 | 4/plant/quarter (1 max, 3 rep. RT) | |
| 500 - <10,000 | 1/plant/quarter (max RT) | ≥10,000 |
| < 500 | 1/plant/year (warmest month) | < 10,000 |



## Stage 1 D/DBP Monitoring Requirements

- Chlorine dioxide
  - Chlorine dioxide plants
  - Daily at entrance to distribution system
  - Compliance - Daily/follow up monitoring
- Chlorine/Chloramines
  - All systems
  - Same location and frequency as TCR monitoring
  - Compliance - Running annual average

## Stage 1 D/DBP Monitoring Requirements

- **TTHM/HAA5 - Routine Monitoring**
  - Surface Water Systems >10,000 = 4/plant/Q
  - Surface Water Systems 500 – 9,999 = 1/plant/Q
  - Surface Water Systems <500 = 1/plant/Y* (warmest)
  - Ground Water Systems >10,000 = 1/plant/Q
  - Ground Water Systems <10,000 = 1/plant/Y* (warmest)
- Single sample represents the maximum residence time
- Multiple samples - 25% samples represent the maximum residence time
- Compliance - Running Annual Average
- *Increase to 1/Q if MCL is exceeded



## Stage 1 D/DBP Monitoring Requirements

- DBP precursors – Total Organic Carbon
  - Conventional filtration systems
  - Monthly for total organic carbon and alkalinity
  - Compliance - Running Annual Average (RAA)
  - Systems that cannot achieve TOC removal requirements due to water quality parameters or operational constraints must apply to State for minimum TOC removal requirements within 3 months of not meeting requirements
  - If State does not approve, systems must meet TOC removal requirements



## Stage 2 D/DBP Rule

- Provides greater public health and protection through:
  - Identifying locations with highest Disinfection Byproducts (DBPs)
  - Basing Compliance on Locational Running Annual Average (LRAA)
  - Requiring tests for connected and consecutive water systems
- Population Based Monitoring for all systems with disinfection

## Stage 2 DBPR Requirements

- Purpose: to ensure that all locations in the distribution system comply with the MCLs – "environmental justice"
- Phase 2A
  - LRAA of 120/100 µg/L at Stage 1 locations
  - Continue to meet system-wide RAA of 80/60
- Phase 2B
  - LRAA of 80/60 at new "representative" high locations
- Initial Distribution System Evaluation (IDSE)
- Significant Excursions



## D/DBP Rule: Stage 2

- Compliance Monitoring
  - Locational Running Annual Average (LRAA)
    - MCLs: 80/60
  - Monitoring for Large SW systems (> 10,000)
    - Quarterly sampling
    - At least one quarterly sample at peak month
    - 4-20 DS locations determined by IDSE *and* stage 1 locations
      - 2-8 at high THM sites, and 1-7 at high HAA sites
  - Monitoring for small SW systems (< 10,000)
    - 2 locations as determined by IDSE

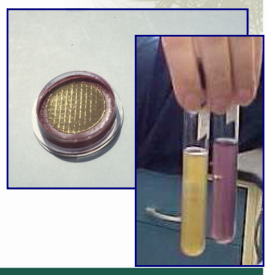


## SDWA Individual Rules

- Total Coliform Rule (TCR)
  - Objective: to monitor microbial contamination in the water distribution system
  - Establishes monitoring requirements and MCLs for indicator bacteria
  - TCR revision: final rule went into effect in 2016

## Total Coliforms—Traditional Definition

- Aerobic and Facultatively Anaerobic
- Gram-Negative
- Non-Sporeforming
- Rod-Shaped
- Ferment Lactose With Gas and Acid Production
  - Within 48+/- 4 Hours at 35 +/- 0.5 C.





## Fecal Coliform Bacteria—Traditional Definition

- Total Coliform Bacteria That:
  - Ferment Lactose at an Elevated Temperature When Using Standard (FC) Media
    - 44.5 +/- 0.2 C (Body Temperature)
- Short-Lived but Fecal Indicator
- *E. Coli* Is a Fecal Coliform

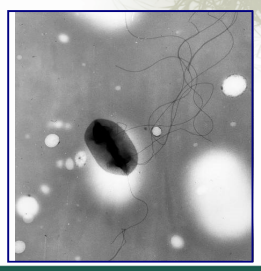


## New Approach: Enzyme - Based Methods

- Lactose Fermentation Determined, In Part, By The Presence of $\beta$–galactosidase.
- Total Coliform's $\beta$–galactosidase Metabolizes ONPG or CNPG -- color reaction.
- E. coli's B-glucuronidase Metabolizes MUG – UV Fluorescence.

## Escherichia coli

- Hundreds of Strains Known
- Most Strains Are Harmless and Live in the Intestines of Healthy Humans and Animals
- Strain O157:H7
  - Produces a Powerful Toxin
  - Causes Bloody Diarrhea and Occasionally Leads to Kidney Failure





## E. coli 0157:H7

- Sources of Outbreaks
  - Undercooked Beef, Dairy Products, Raw Vegetables, Drinking Water
- Symptoms
  - Occur in 1-9 Days (3 Average); Recover in ~ 8 Days
  - Watery Diarrhea With Abdominal Pain/ Bloody Diarrhea; Little or No Fever
  - Some Develop Haemolytic Uremic Syndrome (HUS)
    - Kidney Failure May Occur, Some Cases are Fatal



## E. coli 0157:H7 - Analytical Methods

- Detected Using Typical Total Coliform Methods
- Does Not Grow Well at 44.5 Degrees C
  - Fecal Coliform Incubation Temperature
- Does Not Cause A Positive Reaction With MUG
  - Does Not Cause UV Fluorescence
- Can Be Identified Using Specific Methods Followed by Serotyping.

## Revised Total Coliform Rule (RTCR)

- Final February 2013
- Applies to all PWSs
  - Maximum Contaminant Level (MCL)
  - Treatment Technique Triggers (TTT)
    - Level 1 – Total Coliform MCL violations
    - Level 2 – E. coli MCL violations
- Effective April 1, 2016
- **Sampling siting plan NLT March 31, 2016**
- Beginning CY 2017, annual site visits



## Arsenic Rule

USPHS, 1942

EPA, 2002



## Arsenic Rule

- Establishes monitoring requirements
- Establishes MCL of 0.010 mg/L

## Arsenic

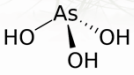
- Number 1 deadliest poison known to humans

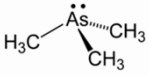

- Chlorine gas, aka mustard gas, is number 2…!




## Inorganic and Organic Arsenic

- Humans are exposed to arsenic in two forms:
  - Inorganic:
    - Arsenic compounds that contain no carbon
    - Highly toxic
    - Carcinogenic
  - Organic:
    - Arsenic compounds that contain carbon and hydrogen
    - Low to no toxic effects

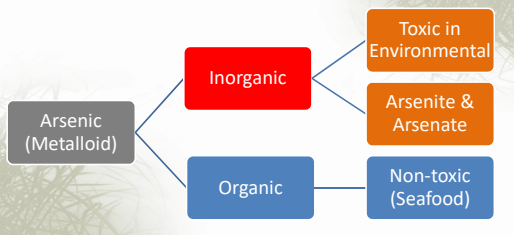



Trimethylarsine: low toxicity



## What is Arsenic?



## Arsenic Standard – USPHS

- In 1942, an arsenic drinking water standard of 0.05 mg/L (equal to 50 µg/L) was initially adopted by the United States Public Health Service (USPHS)
- The standard remained in effect well after EPA was form in 1970
- In the 1980s and 1990s, EPA studied lowering the standard

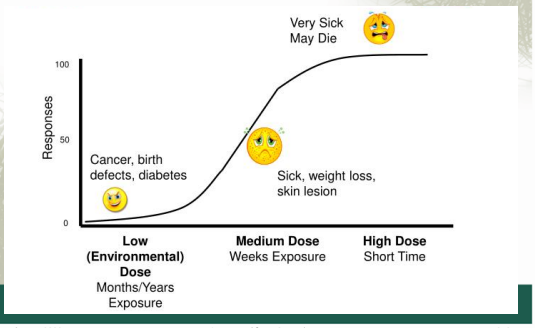


## Health Effects of Arsenic

- Cancer
  - Bladder cancer
  - Lung cancer
- Non-Cancer
  - Heart disease
  - High blood pressure



## Body's Response to Arsenic



## Arsenic Rule – EPA

- In the 1996 amendments to the SDWA, Congress directed EPA to propose a new arsenic standard by January 2000
- In June 2000, EPA proposed lowering the maximum contaminant level (MCL) for arsenic from 50 µg/L to 5 µg/L or 0.005 mg/L…!
- Before finalizing, EPA requested public comments on three standard options:
  - 3 µg/L, 10 µg/L and 20 µg/L



## Arsenic Rule – EPA

- In 2001, EPA adopted a lower standard for arsenic in drinking water that applies to both community water systems and non-transient non-community water systems
- The new arsenic standard of 10 µg/L (10 ppb) replaced the old standard of 50 µg/L (50 ppb)



## Arsenic Rule Making

**Proposed Arsenic Rule**

- June 22, 2000
- 5 µg/L standard
- EPA requested comments on three optional standards:
  - 20 µg/L
  - 10 µg/L
  - 3 µg/L

**Final Arsenic Rule**

- January 22, 2001
- 10 µg/L standard adopted
- Effective date: February 22, 2002
- Compliance date: January 23, 2006

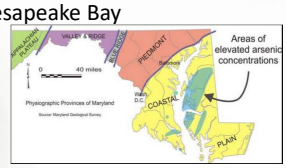
## Arsenic Regulation

- Arsenic standard set at 10 ppb
  - Some states considered alower MCL
- New standard became effective 1/23/06
  - Extensions were available for smaller systems, <3,300 (up to 9 additional years possible)
  - In MD, 19 systems in Non-compliance; 12 systems with exemption; 32 MCL violations (5 systems); 28 monitoring violations as of 10/31/08



## Arsenic in Maryland Groundwaters

- Arsenic concentrations exceeding 10 µg/L current drinking water standards have been detected in Maryland's Coastal Plain ground water on both sides of the Chesapeake Bay

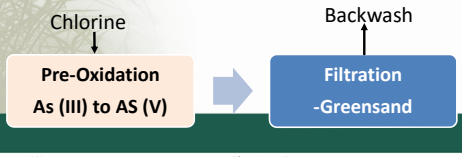



Source: Maryland Geological Survey 2008

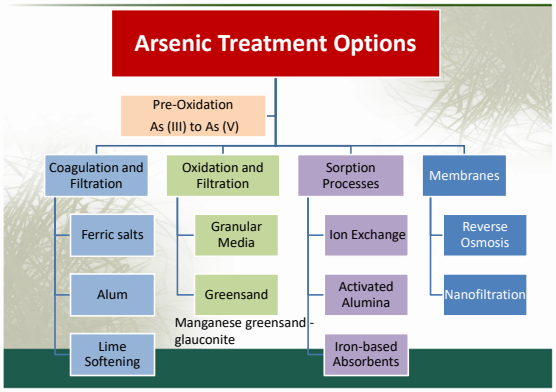


## Arsenic Removal from Groundwater

- Removal efficiency for Arsenite As(III) is poor compared to that for Arsenate As(V)
- For effective removal of arsenic from water, Arsenite As(III) forms need to be oxidized to Arsenate As(V) forms



## Arsenic Treatment Options






## Arsenic Removal Processes

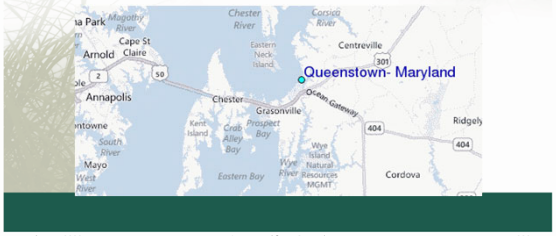
- Virtually all WTPs removing arsenic pre-oxidize first
- Most follow up with an iron-based arsenic coagulation or adsorption/filtration processes
- Approximately 80 percent use adsorptive medias, with 80 percent of the operating cost due to media replacement, e.g., throw-away media



## Case Study

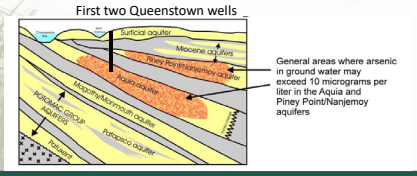
Queenstown, MD

- Historic town located on the Eastern Shore of the Chesapeake Bay



## Case Study
Queenstown, MD

- Until 2009, the Town had two operating wells drilled into the Aquia aquifer (300 feet below ground surface)






## Case Study
Queenstown, MD

- Aquia aquifer wells were:
  - Del Rhodes Avenue Well: (MDE Permit ID – QA79G010); installed in 1932; capacity: 85,000 gallons/day
  - Queenstown Outlet Mall (MDE Permit ID – QA71G007); installed in 1988; capacity: 150,000 gallons/day
- As expected, both wells had occasional problems with arsenic levels; range 10 to 20 µg/L



## Case Study
Queenstown, MD

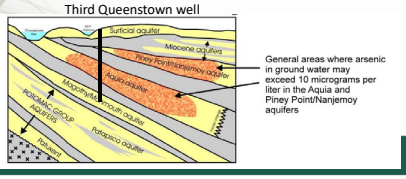
- When EPA adopted the new 10 µg/L Arsenic standard, the town had to make a choice:
  - Treat water at both wells to remove arsenic to less than 10 µg/L
  - Drill a third, but deeper well to reach the arsenic-free Magothy/Monmouth aquifer and blend it with water from the other two wells
- The Town decided to install the deeper third well to provide for future drinking water demand and fire service as well as deal with the arsenic problem

## Case Study

Queenstown, MD

- A third well was drilled into the Magothy/Monmouth aquifer (650 feet below ground surface) at the Outlet Mall (Outlet Mall Well #2, MDE Permit ID – QA2008G018-01); installed in 2009; capacity: 70,000 to 100,000 gallons/day

Third Queenstown well





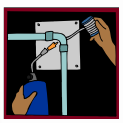

## What is the Lead and Copper Rule?

The Lead Action Level is point zero one five milligrams per liter (0.015 mg/L) Sometimes you'll hear this referred to as 15 parts per billion or 15ppb. The copper action level is one point three milligrams per liter (1.3 mg/L) Which is sometimes referred to as 1.3 parts per million or 1.3ppm



## SDWA Individual Rules

- Lead & Copper Rule
  - Sets action levels for lead and copper that prompt corrosion control measures if exceeded
  - Sets monitoring, testing, reporting requirements



## What is the Lead and Copper Rule?

- The Lead and Copper Rule was first published in the Federal Register on June 7, 1991
- It became effective on December 7, 1992
- This rule can trigger treatment requirements when lead and/or copper in drinking water exceed certain action levels.



## Lead and Copper

- Lead and copper are regulated by a treatment technique that requires systems to control the corrosiveness of their water
- If more than 10% of tap water samples exceed the action level, water systems must take additional steps
- For copper, the action level is 1.3 mg/L and for lead is 0.015 mg/L



## Lead & Copper Rule

- Objective: optimize corrosion control to limit corrosion of lead and copper pipe
- Stabilize treated water by raising water pH/alkalinity or by adding phosphates
- Sample drinking water from faucets in homes

## Washington, D.C.

- **Lead contamination in Washington, D.C., drinking water**, first discovered in 2001, left thousands of children with lifelong health risks, and led to a re-evaluation of the use of monochloramine in public drinking-water systems



## Adverse Effects of Lead

- Infants and children:
  - Delays in physical or mental development
  - Children could show slight deficits in attention span and learning abilities
- Adults:
  - Kidney problems
  - High blood pressure



## What is the Lead and Copper Rule?

**Lead enters drinking water mainly from the corrosion of lead-containing household plumbing.**

## Lead and Copper Problems

- Washington, D.C.
  - 2001 – 2010
  - Chlorine to monochloramine use
  - Pinholes in copper piping
  - Water not stabilized
  - Lead connections (from main to homes - 25,000…!)
- Flint, Michigan
  - Change in water source
  - Water not stabilized



## Ground Water Rule

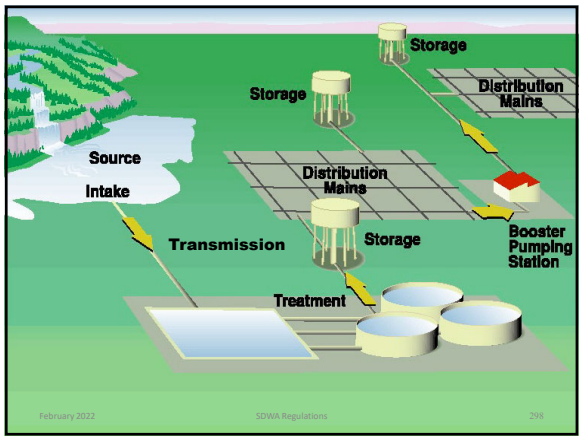
- Final October 2006
- Periodic Sanitary Surveys
- Rule applies to groundwater systems only
- Source water monitoring for E. coli
- Sets trigger and action levels
- Take corrective actions where necessary
- Compliance monitoring



*141.600*

## Combined Distribution Systems

- What is a Combined Distribution Systems (CDS)?
  - Defined as the interconnected distribution system consisting of the distribution systems of wholesale systems and consecutive systems that receive finished water from those wholesale system(s).
- What is a Consecutive system?
  - Defined as a public water system that receives some or all of its finished water from one or more wholesale systems.
    - NOTE: In addition to buying finished water, some consecutive systems also operate a treatment plant (meaning a plant that treats source water to produce finished water).




## Combined Distribution Systems (CDS)

- What is a Wholesale system?
  - Defined as a public water system that treats source water as necessary to produce finished water and then delivers some or all of that finished water to another public water system. Delivery may be made through a direct connection or through the distribution system of another consecutive system.
    - NOTE: Under this definition, a consecutive system that passes finished water from a wholesaler to another consecutive system, and that does not also treat source water, is not a wholesale system. Rather, the system that actually produces the finished water is responsible for any wholesale system requirements.



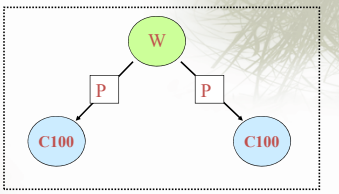
## CDS Example #1

Symbol Key

W-Wholesaler

P-permanent connections

C100-consecutive system that receives all finished water from one or more W systems




**Determination:** All 3 systems are part of same CDS
**Rationale:** The connections between systems are permanent.

## CDS Example #2

Symbol Key

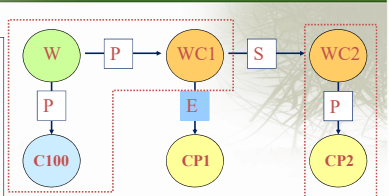
W-Wholesaler

P- Permanent connections

C100-consecutive system that receives all finished water from one or more W systems

CP- consecutive that allows produces its own finished water

E- Emergency Connections




**Determination:**
CDS-1: W,C100 and WC1
CDS-2: WC2, CP2
CP1: Independent system

**Rationale:**
WC2: Receives only 3% of total volume of water
WC2 & CP2: Part of a separate CDS
CP1: Emergency connection has never been used



## SDWA Individual Rules

- Radionuclides
  - Sets uranium MCL
  - Revises monitoring requirements for combined radium 226/228, gross alpha particle and beta particle, and photon radioactivity



## Radionuclides Rule

- Federal Rule Finalized 2000
  - Radon not included, will be a separate rule
- Standards for Radium 226, Radium 228,and Uranium
  - Combined Radium-226/Radium-228 5 pCi/L
  - Gross Alpha Particle activity 15 pCi/L
  - Uranium 30 ug/L
- Compliance deadline December 8, 2003

## Two More Rules

- Public Notification Rule
  - Requires customer notification of violations
  - Specifies time frames based on seriousness of violation
- Consumer Confidence Report Rule
  - Required of all CWS
  - Yearly water quality report to customers



## 141.32 General Public Notification

- **Purpose:**
  - To Protect Public Health by Requiring Timely Public Notification When Contamination or Other Risks Occur
- **Requirements Available From EPA's Website**
  - www.epa.gov/safewater/pn.html



## Public Notification Rule

- Objective: to notify the public of any acute or chronic health risks related to drinking water
  - Tier 1 notification – within 24 hours using appropriate communication methods
  - Tier 2 notification – within 30 days
  - Tier 3 notification – within 1 year

## Subpart Q—Public Notification

- Initial Requirements Published May 4, 2000
- Effective Dates:
  - October 31, 2000 in Direct Implementation Arenas
  - May 6, 2002 in Primacy States
- Major Changes:
  - Tier 1 - Potential for Serious Short-Term Health Effects
  - Tier 2 Serious but Not Immediate
  - Tier 3 All Other Violations



## Subpart Q—Public Notification: Public Notification Rule Major Changes

- Tier 1 Violations
  - Fecal Coli MCL
  - Response Time Reduced From 72 Hours to 24 Hours
- Tier 2 Violations (Other MCLs,TTs)
  - Serious but Not Immediate
  - Response Time Extended to 30 Days From 14 Days



## Subpart Q—Public Notification: New PN Rule Major Changes (cont.)

- Tier 3 Violations (All Other Violations)
  - Less Serious and Long-Term Effects
  - Response Time and Repeats Extended to 12 Months From 3 Months
- Mandatory Health Effects Language Is Simplified

## Consumer Confidence Report (CCR)

- Objective: to educate the public about contaminants found in their drinking water
- Annually send CCR to all customers (small pamphlet with website identified)



Part 141.31—Reporting Requirements

- 141.31 Reporting Requirements
  - Supplier of the Water Must Report to the State Within 48 Hours Failure to Comply With Any NPDWR, Including Monitoring Requirements.



## SAFE DRINKING WATER ACT REGULATIONS

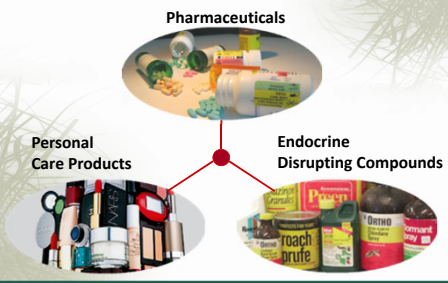
Future Regulation Activity

## "Emerging Contaminants"

- Pharmaceuticals and Personal Care Products (PPCPs)
- Pharmaceutically Active Compounds (PhACs)
- Trace Organic Contaminants (TOrCs)
- Endocrine Disrupting Compounds (EDCs) – Chemicals that interfere with the function of the endocrine system
- Contaminants of Emerging Concern (CECs)



## Emerging Contaminants - Micro-constituents






## Emerging Disinfection Byproducts

- Scientific community debating the toxicity and public health relevance of emerging DBPs
  - Concern about chloramine-related DBPs vs. chlorine-related DBPs
- Ideas have been floated at conferences:
  - Find and apply a better surrogate than THMs and HAAs?
  - Total Organic Halide (TOX) instead of THMs and HAAs?
  - Regulate more toxic DBPs (iodo- and bromo-compounds)?
  - Force GAC across all treatment plants as a TT?

## Emerging Disinfection Byproducts

- Lots of potential techniques (a few are listed here)
  - Point of Chlorination, Chloramination
  - Enhanced Coagulation
  - UV or Ozone disinfection
  - GAC
  - Ion Exchange
  - High Pressure Membranes (RO or NF)



## Manganese

- Under review at EPA—regulatory changes uncertain
- Potential Treatment:
  - Potassium permanganate
  - Chlorine Dioxide
  - Ozone
  - Free Chlorine
  - Oxide-Coated Filter Media (Greensand Filtration)
  - Lime-Soda Ash Water Softening
  - Biological Mn Removal



## Microbial Contaminants

- Enteroviruses and Noroviruses are on UCMR3
  - Known outbreaks related to water
  - Mostly concerned with groundwater systems
  - Potential for concern with surface water systems
- Pathogens in biofilms
  - Premise plumbing in hospitals, hotels, schools, etc.
  - Examples: *Legionella, Naegleria fowleri*
- Controls??
  - Change in filtration or disinfection practices?
  - Distribution system residual disinfectant?
  - Private management of premise plumbing systems

## Summary

- 94 chemicals and microbial contaminants are regulated under the SDWA
- Chlorine disinfection and final filtration are the two most important water treatment processes regulated by the SDWA
- EPA will be slow to promulgate any future drinking water standards
- D/DBPs and Perfluorinated chemicals likely to be regulated



## The End



## Questions?

Evaluation Survey – to be given prior to the final quiz:
https://form.jotform.com/211263553828154

# Thank You

Final Quiz – to be timed (one submission per student):
https://form.jotform.com/211263353181144

**Maryland Center for Environmental Training**
**College of Southern Maryland**
**La Plata, MD**