The Water Treatment Plant of the Future

Stig Regli
Policy Advisor
SRMD/OGWDW/USEPA

Overview

- Historical perspective on water treatment being influenced by changes in our understanding of public health risk and remedial science/engineering
- Challenges from climate change, anthropogenic contamination, defacto water reuse and infrastructure conditions
- Some options on how the drinking water industry might respond to the challenges

Major Influences on WTPs – A Historical Perspective (1)

- 50 years ago
  - Most PWS using surface water filtered and disinfected
  - Most PWS using GWs did not disinfect
  - Waterborne disease perceived by public to be mostly eradicated
- 1970s
  - EPA adopted public health service standards
  - First DBPs (THMs) discovered and regulated leading to greater precursor removal and use of alternative disinfectants to chlorine

Major Influences on WTPs – A Historical Perspective (2)

- 1980’s
  - Concerns from Giardia, viruses, and bacteria led to promulgation of SWTR and TCR in 1989 and more stringent use of filtration and disinfection technologies
- 1990’s
  - Concerns from lead and copper levels led to Rule (1991) more effective corrosion control
  - Concerns from DBPs and Cryptosporidium lead to Stage 1 D/DBPR and IESWTR, increased use of alternative disinfectants to chlorine, tighter controls for filtration as well as increased use of GAC and membrane filtration

Major Influences on WTPs – A Historical Perspective (3)

- 2000's
  - Concerns from arsenic led to rule in 2001 and variety of treatment responses
  - Additional concerns for DBPs and Cryptosporidium led to Stage 2 DBPR and LT2 and further shifts to alternative disinfectants (including UV), GAC, membrane technology

Challenges (1)

- Climate change
  - Changes in water quantity; effects on water chemistry, biology and quality; source water quality variability
- Wastewater and non-point source contamination
  - Understanding risks from multiple low level contaminants and extent to which this warrants a remedial response
  - DBP precursors from wastewater discharges
- Defacto water reuse
  - Percent contributions going up especially under low flow conditions

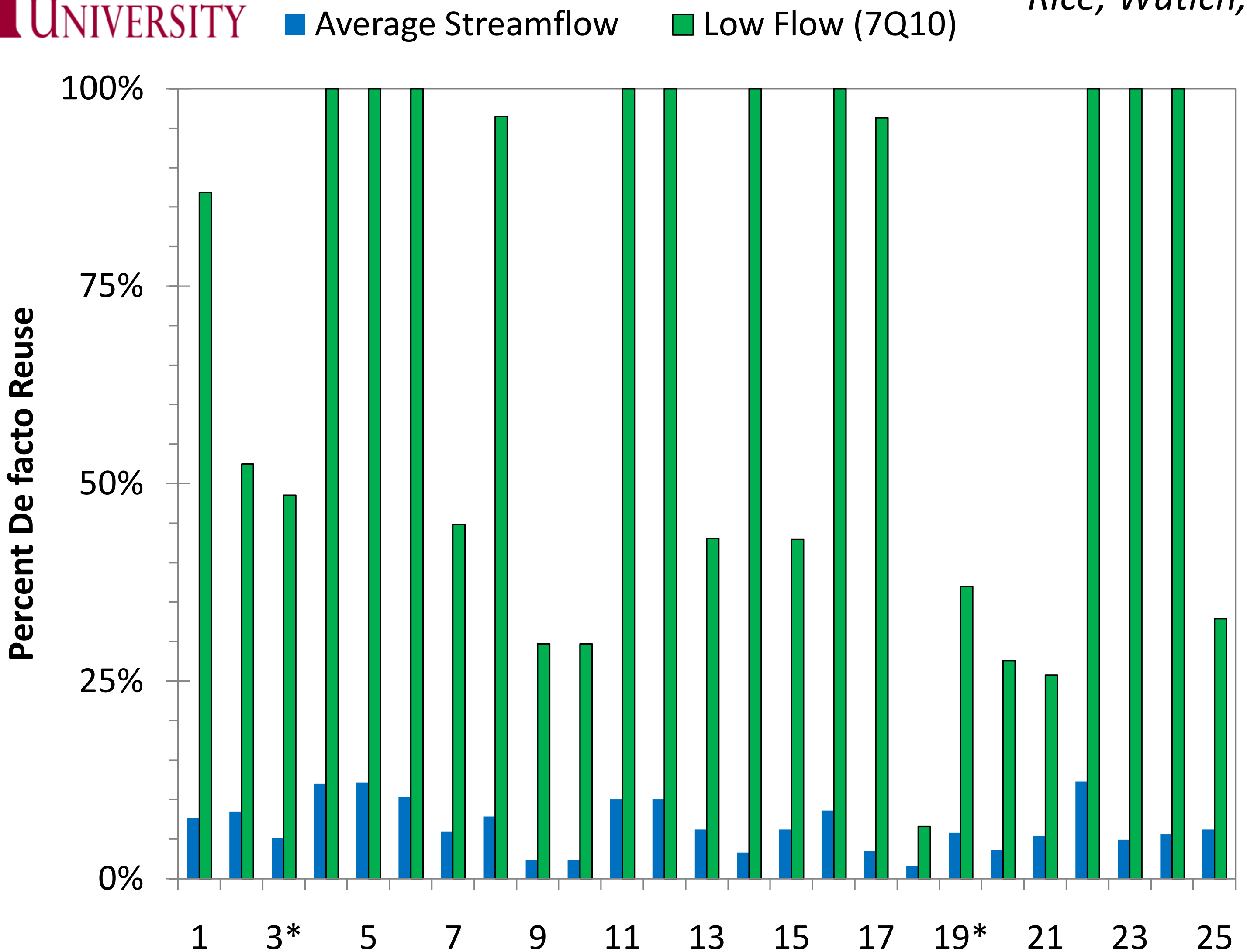
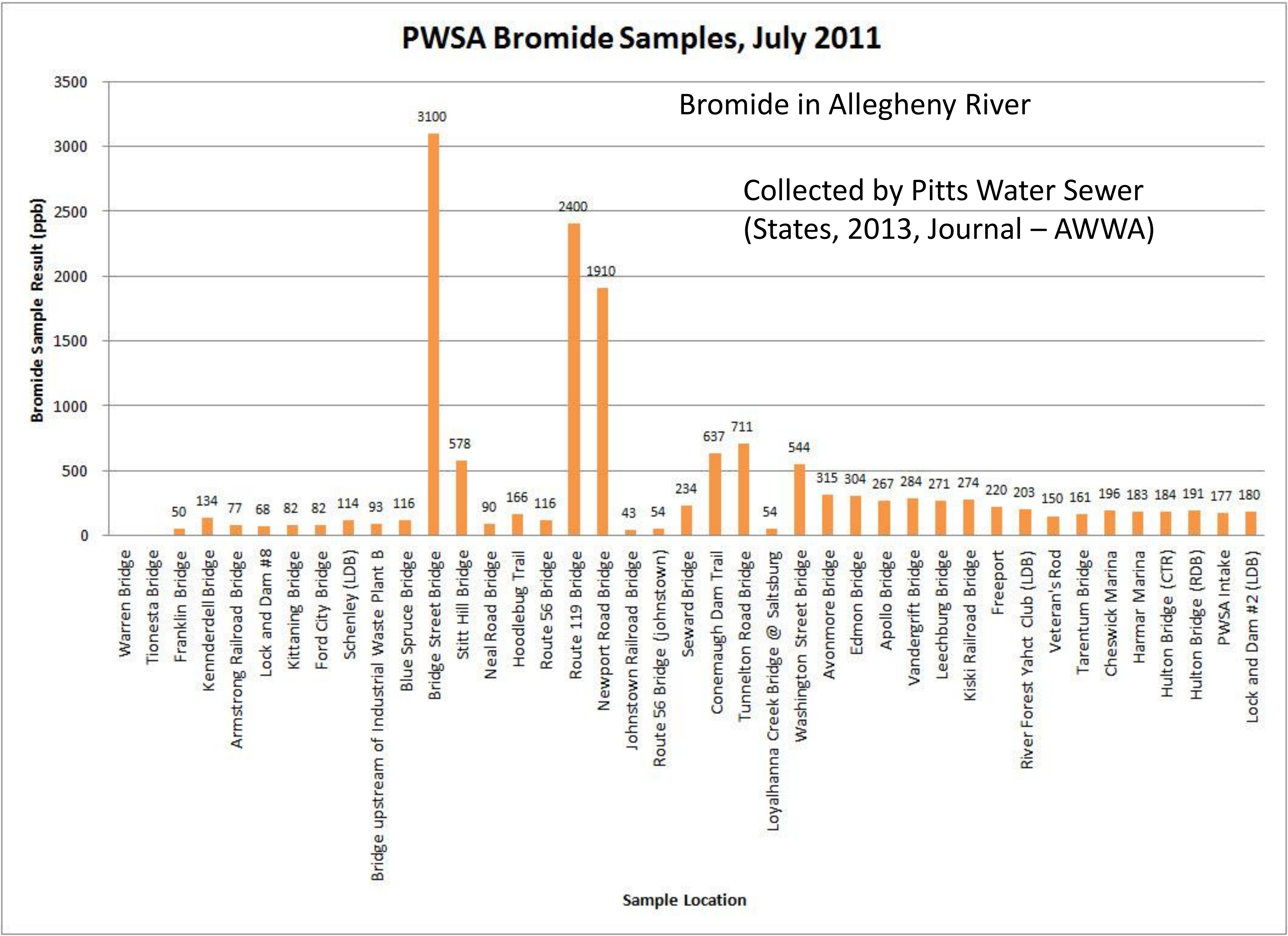


Figure 4. De facto reuse under average flow and low-flow conditions (modeled by 7Q10). Cities marked with an asterisk are calculated on the basis of 7Q10 streamflow values from the EPA 1980 study. (The x-axis gives same site IDs as in Figure 2.)


PWSA Bromide Samples, July 2011
Bromide in Allegheny River
Collected by Pitts Water Sewer
(States, 2013, Journal – AWWA)
Bromide Sample Result (ppb)
3500
3000
2500
2000
1500
1000
500
0
50
134
77
68
82
82
114
93
116
3100
578
90
166
116
2400
1910
43
54
234
637
711
54
544
315
304
267
284
271
274
220
203
150
161
196
183
184
191
177
180
Warren Bridge
Tionesta Bridge
Franklin Bridge
Kennderdell Bridge
Armstrong Railroad Bridge
Lock and Dam #8
Kittaning Bridge
Ford City Bridge
Schenley (LDB)
Bridge upstream of Industrial Waste Plant B
Blue Spruce Bridge
Bridge Street Bridge
Stitt Hill Bridge
Neal Road Bridge
Hoodlebug Trail
Route 56 Bridge
Route 119 Bridge
Newport Road Bridge
Johnstown Railroad Bridge
Route 56 Bridge (Johnstown)
Seward Bridge
Conemaugh Dam Trail
Tunnelton Road Bridge
Loyalhanna Creek Bridge @ Saltsburg
Washington Street Bridge
Avonmore Bridge
Edmon Bridge
Apollo Bridge
Vandergrift Bridge
Leechburg Bridge
Kiski Railroad Bridge
Freeport
River Forest Yahct Club (LDB)
Veteran's Rod
Tarentum Bridge
Cheswick Marina
Harmar Marina
Hulton Bridge (CTR)
Hulton Bridge (RDB)
PWSA Intake
Lock and Dam #2 (LDB)
Sample Location

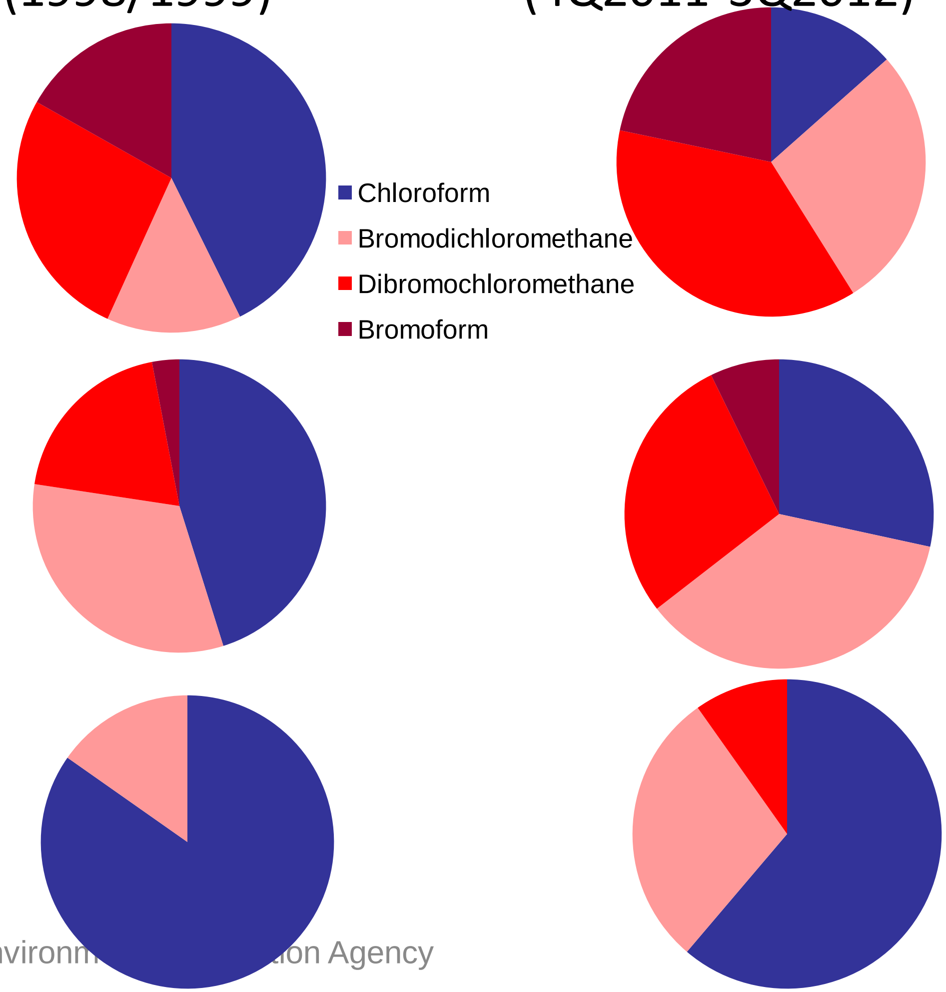
Chlorinated & Brominated THM in Drinking Water

(1998/1999) (4Q2011-3Q2012)

Pittsburgh Water & Sewer

Wilkinsburg Penn Joint

Westmd Mun – Sweeney Plt

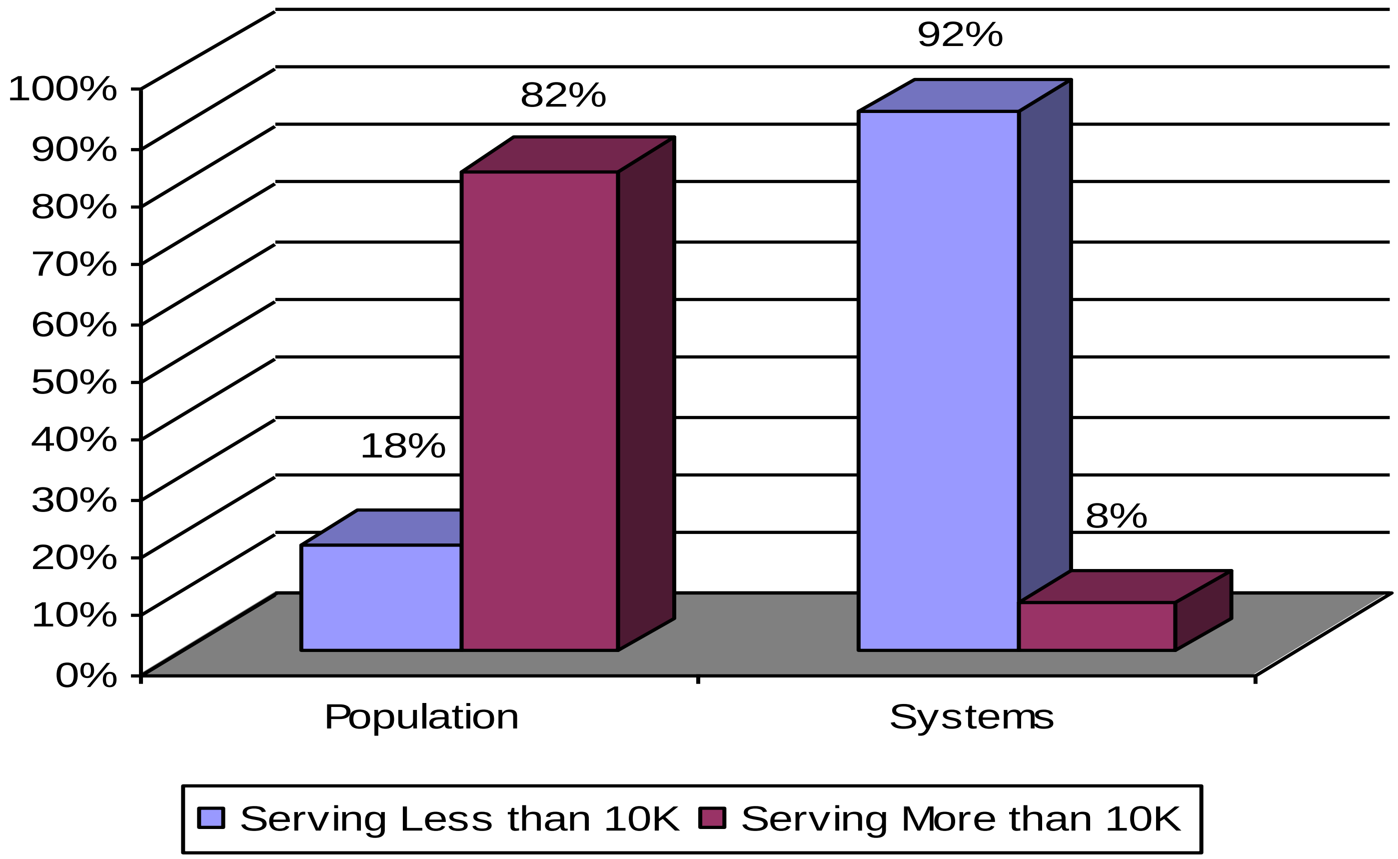


Source: 1998/1999 ICR Data
2011/2012 DBP Compliance Results

Challenges (2)

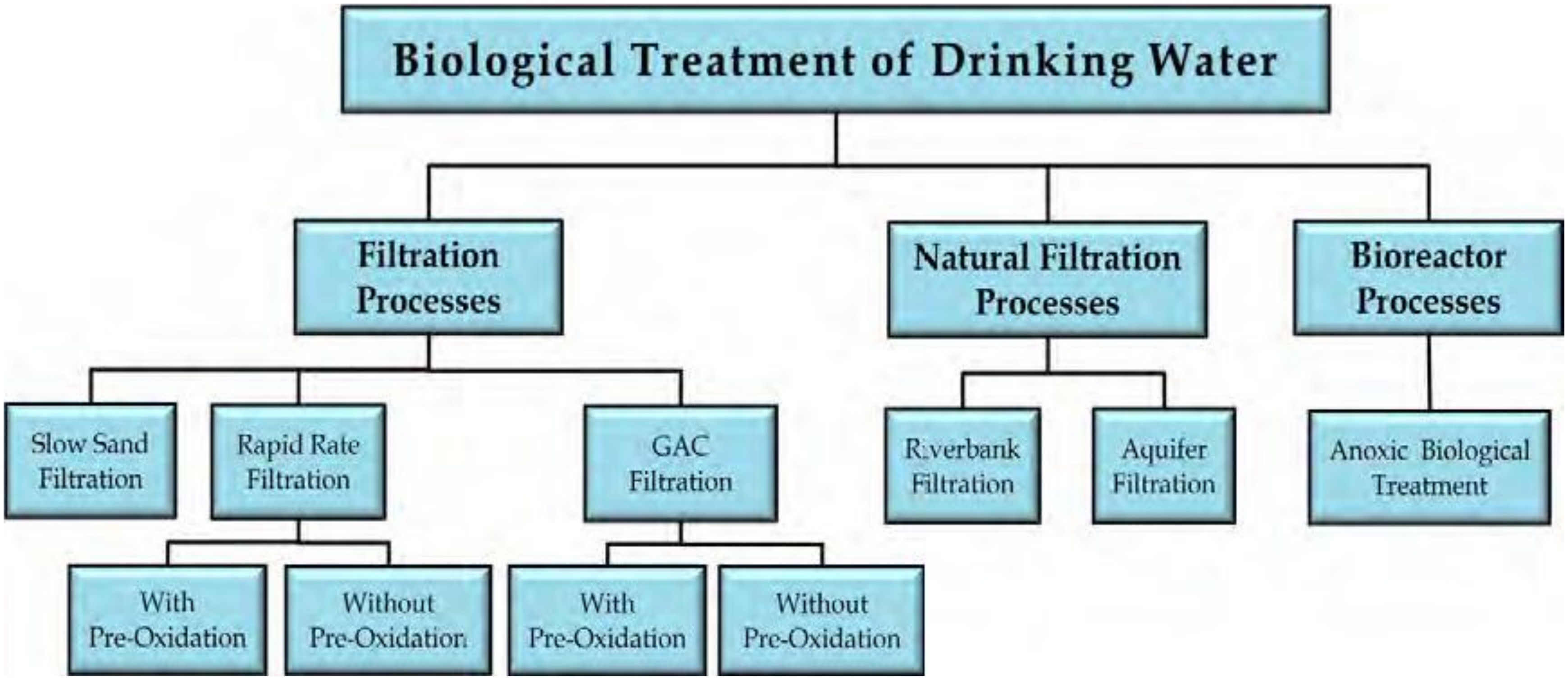
- Distribution system considerations
  - Fire flow requirement influence ~ 75% of capacity devoted to fire flow leading to long residence times
  - Intrusion events, increased main breaks, effects of pressure management, biofilm and growth and potential release of pathogens
- Environmental footprint of additional technology
- Dis -economies of scale for small systems

Small Systems Profile



Some Technology Options

- Biological treatment
- Advanced oxidation processes including UV
- GAC
- Membranes
- Enhanced distribution management control strategies
- Many are combinations of above


Biological Treatment of Drinking Water
Filtration Processes
Natural Filtration Processes
Bioreactor Processes
Slow Sand Filtration
Rapid Rate Filtration
GAC Filtration
Riverbank Filtration
Aquifer Filtration
Anoxic Biological Treatment
With Pre-Oxidation
Without Pre-Oxidation
With Pre-Oxidation
Without Pre-Oxidation

Example - River Bank Filtration in Louisville, KY (2010)

- Uses natural filter and biological processes occurring on river bank to remove sediment, pathogens, organic chemicals, DBP precursors, herbicides, pesticides, zebra mussels, and asiatic clams
- Also provides stable water temperature
  - cooler and more aesthetically pleasing
  - reduces temperature fluctuation stress contributing to main breaks

UV Opportunities? – Looking Ahead

- UV in Advanced Oxidation Processes to address multiple concerns
  - Pathogen suite including adenovirus
    - Substitutes for primary inactivation
  - Multiple chemicals such as EDCs, pesticides, etc.
- To what extent can exposure/risks from complex mixtures be better characterized?
  - Need better understanding of tradeoffs from different sequence applications of UV with conventional disinfectants and AOPs

UV Disinfection of Ground Water Systems

EPA Demonstration Project

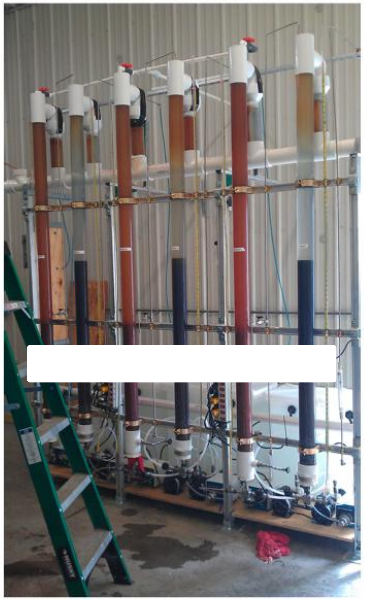
This research will provide reliable performance data for several innovative UV technologies for use as a sustainable disinfection strategy for small systems

Evaluation and Assessment Activities

- Innovative technologies, including LED devices, that can target specific wavelengths for optimal inactivation of pathogens.
- Evaluate innovative UV technologies applicable to small systems under controlled test-bed challenge studies.
- Assess dose-response & reactor performance with 4-log inactivation goal for highly resistant AD2 and bacterial/viral surrogates.
- Conduct subsequent UV demonstration studies at several IN, KY, and OH water facilities to facilitate state approval. (field performance, costs, system control strategies, ease of operations, and sustainability metrics).

Guidance on the design, operation, and cost of biological treatment systems for removal of chemicals of emerging concern

- ✓ Pilot study that evaluated the effectiveness of biological water treatment for ammonia removal from water to reduce ammonia in water, and the formation of nitrites/nitrates in the distribution system
- ➢ Full-scale demonstration in Palo, Iowa
- ➢ Aerobic and anaerobic pilot systems currently evaluating removal of multiple contaminants (perchlorate, nitrate, pesticides, DBP precursors, CECs)



Small Systems Treatment

Biological Treatment for Drinking Water: Ammonia Removal

This research will provide guidance on the design and operation of biological treatment systems for ammonia oxidation

- EPA developed technology piloted at a small Iowa community
- Collaboration with the State of Iowa's Department of Natural Resources
- Other pilot systems are being installed in other facilities in Iowa, Illinois, NC and Ohio
- Construction on a full-scale are currently in the works

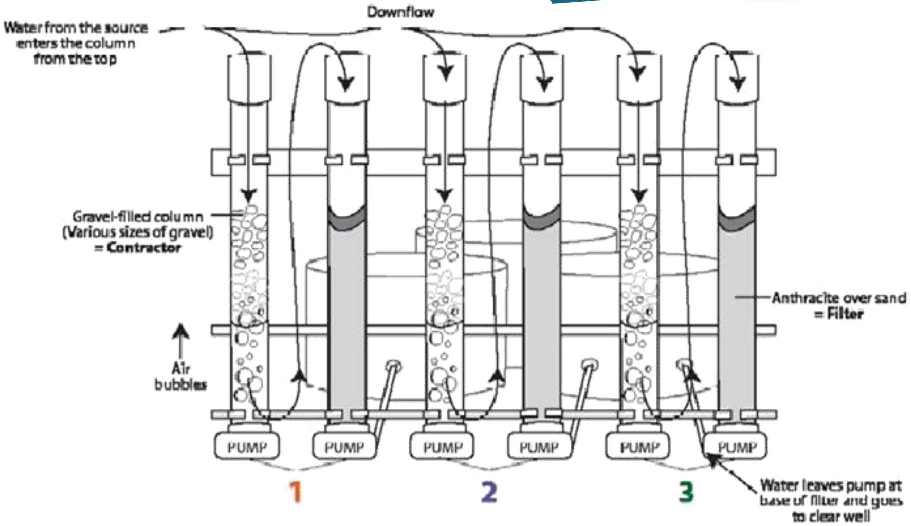


Figure 3. Schematic of pilot technology.