Development of Design Criteria for Low-Pressure Membrane Filtration

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1. Project Background
   a. Lack of Innovation in Small PWSs
   b. Project Overview
   c. Plan Approval Process in Ohio

2. Selected Emerging Technology
   a. Emerging Technology Selection
   b. Overview of Microfiltration / Ultrafiltration (MF/UF)

3. Initial Thoughts in Development of Design Criteria
Technology Innovation Challenging in the Water Industry

Nationwide discussion to improve innovation b/c

Innovation:
• Improves finished water quality ➔ better public health outcomes
• Reduces cost

Barriers
High Water Quality at Reasonable Cost

Emerging Technology – OUR PROJECT

Ohio WRC + Advisory Committees → Design Criteria for an Emerging Technology → Design Criteria for Additional Technologies?

Ancillary contaminants – IN PARALLEL

Ohio AWWA Technology Committee - TOC, Microcystin, Taste & Odor, Giardia, Crypto, corrosion control, Mn, etc. → Procedures for Ancillary Contaminants → PWS Compliance

Project Overview
Potential Impacts Beyond Ohio

Ohio WRC Develops Emerging Technology Design Criteria

Ohio EPA Adopts Design Criteria as Supplement to TSS

Joint presentation of process to GLUMRB

Recommended Standards for Water Works
Plan Approval in Ohio

Ohio EPA Plan Approval of “Conv Tech”

Detail Plans of TSS (Conv) Technologies

“Higher” Project Capital Cost

Ohio EPA Demonstration Study Approval

Demonstration Study Protocol

Conduct Expensive Pilot- / Bench-Scale Study

Demonstration Study Report

Ohio EPA Plan Approval of “Emerging Tech.”

Detail Plans of Emerging Tech.

1) “Lower” Capital Cost
2) “Appropriate” Tech

With Guidelines
Plan Approval in Ohio

With Design Criteria from Our Project

Ohio EPA Plan Approval of “Emerging Tech.”

Detail Plans of Emerging Tech. → Project Construction and Commissioning

Possibly Conduct Inexpensive Full-Scale Demo Study (i.e., to Increase Component Capacity) →

1) “Lower” Demo Study and Capital Costs
2) “More Appropriate” Treatment Technology
Steps to Develop Design Criteria for Selected Emerging Technology

**Performance Criteria**
- Review approval criteria and best practices
- Determine critical operating parameter

**Pilot- and Full-Scale Data**
- Collect data from manufacturers and operating facilities
- Determine how much data for how long for statistical proof

**Design Criteria**
- Use analysis results to define design criteria
- Finalize criteria for plan approval with OEPA
Emerging Technology Subcommittee developed list of technologies that required demonstration:

- RO Membranes
- Anion Exchange
- Proprietary Media for Arsenic Removal
- Rapid Sand Filter
- Ballasted Flocculation and Sedimentation
- Superpulsators

- Dissolved Air Flotation (DAF)
- Multi-tech
- Cartridge Filters
- Microfiltration/ Ultrafiltration
- Tablet Chlorinators
- Ozone
- MIEX

Subcommittee narrowed list to 3 promising technologies (bold), based on:
- Potential benefit to small and medium Ohio PWSs
- Presence of existing full-scale systems to base design criteria
Microfiltration/Ultrafiltration (MF/UF)

- Requested for plan approval by many small and medium PWS’s
- Currently requires pilot-scale demonstration study prior to design
- Numerous installations for many years

Byesville, OH
1. Particle / TSS removal – **SIZE EXCLUSION**
   a. *Cryptosporidium / Giardia* – typical membrane removes >6.0-log
   b. Most bacteria removed
   c. Some demonstrated removal of viruses
      i. MF – 0.5-2.5-log
      ii. UF – 1.0-6.0-log
   d. Physical barrier to particle passage

- **Salmonella**
  - 0.4 – 2 μm
- **Rotavirus**
  - 60 nm
- **Giardia**
  - 6 – 10 mm
• MF classified by pore size in microns (µ)
• UF classified by molar mass (g/mol) or Dalton Molecular Weight Cut Off (MWCO)
Principle of Filtration – Size Exclusion

- MF classified by pore size in microns (µ)
- UF classified by molar mass (g/mol) or Dalton Molecular Weight Cut Off (MWCO)
Pore Size of Example UF Membranes

- UF Toray PVDF Hollow Fiber
- UF SUEZ Zeeweed PVDF Hollow Fiber
- Inge Multibore PES
How Membranes Work

Rapid Sand Filter

Membrane
Flux – flow of permeate, i.e., the water passing through the membrane, per unit area of membrane (g/ft²d or l/m²h)

MF/UF typical flux 50-100 g/ft² d

FIGURE 2 Percent change in membrane flux with respect to temperature variation, referenced to 20°C

Based on Mallevialle et al, 1996
**TMP** - Difference in pressure between feed and permeate of membrane (psi)
- Typically 3-15 psi
- There is no significant difference between the range of pressures at which MF and UF operate
Characteristics of Membranes that Can Affect Flux

- Configuration
- Flow regime
- Material

Hoek et al., 2017, Water Planet, Review
Initial Focus of Design Criteria: FLUX

- Design value based on current operational and scientific data
- Considers operational factors - irreversible fouling and cleaning
- Considers membrane characteristics
- Considers influent water quality
Acknowledgements

- **Project Lead:** Megan Patterson, Zuzana Bohrerova, Linda Weavers and Tim Wolfe

- **Core Advisory Committee:**
  - Avon Lake Regional Water
  - Greater Cincinnati Water Works
  - Cleveland Division of Water
  - Columbus Division of Water
  - Newark Water Department
  - Ohio EPA
  - Westerville Water Department
  - USEPA

- **Technical Advisors:**
  - Rob Shoaf, AECOM, Joe Jacangelo, Stantec

Project Funding - OWDA
Ohio Water Resources Center

- Enables and conducts water resources research,
- Fosters collaboration among water professionals,
- Trains the next generation of water scientists,
- Educates the public on water resources issues in the State of Ohio.

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Questions?

Thank you!!