One Water Conference, Regulatory Session, Columbus, OH

THE OHIO STATE UNIVERSITY

Development of Design Criteria for Low-Pressure Membrane Filtration

Zuzana Bohrerova[1], Megan Patterson[1,2], Tim Wolfe[2] and Linda Weavers[1]

[1] Ohio Water Resources Center and Department of Civil, Environmental, and Geodetic Engineering, OSU
[2]Stantec

WATER RESOURCES CENTER OHIO WRC

Presentation Overview

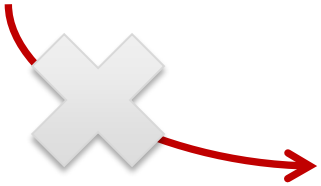
1. Project Background
   a. Lack of Innovation in Small PWSs
   b. Project Overview
   c. Plan Approval Process in Ohio
2. Selected Emerging Technology
   a. Emerging Technology Selection
   b. Overview of Microfiltration / Ultrafiltration (MF/UF)
3. Initial Thoughts in Development of Design Criteria

Technology Innovation Challenging in the Water Industry

Nationwide discussion to improve innovation b/c

Innovation:

- Improves finished water quality → better public heath outcomes
- Reduces cost



Barriers

Project Overview

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**

Potential Impacts Beyond Ohio

Ohio WRC Develops Emerging Technology Design Criteria

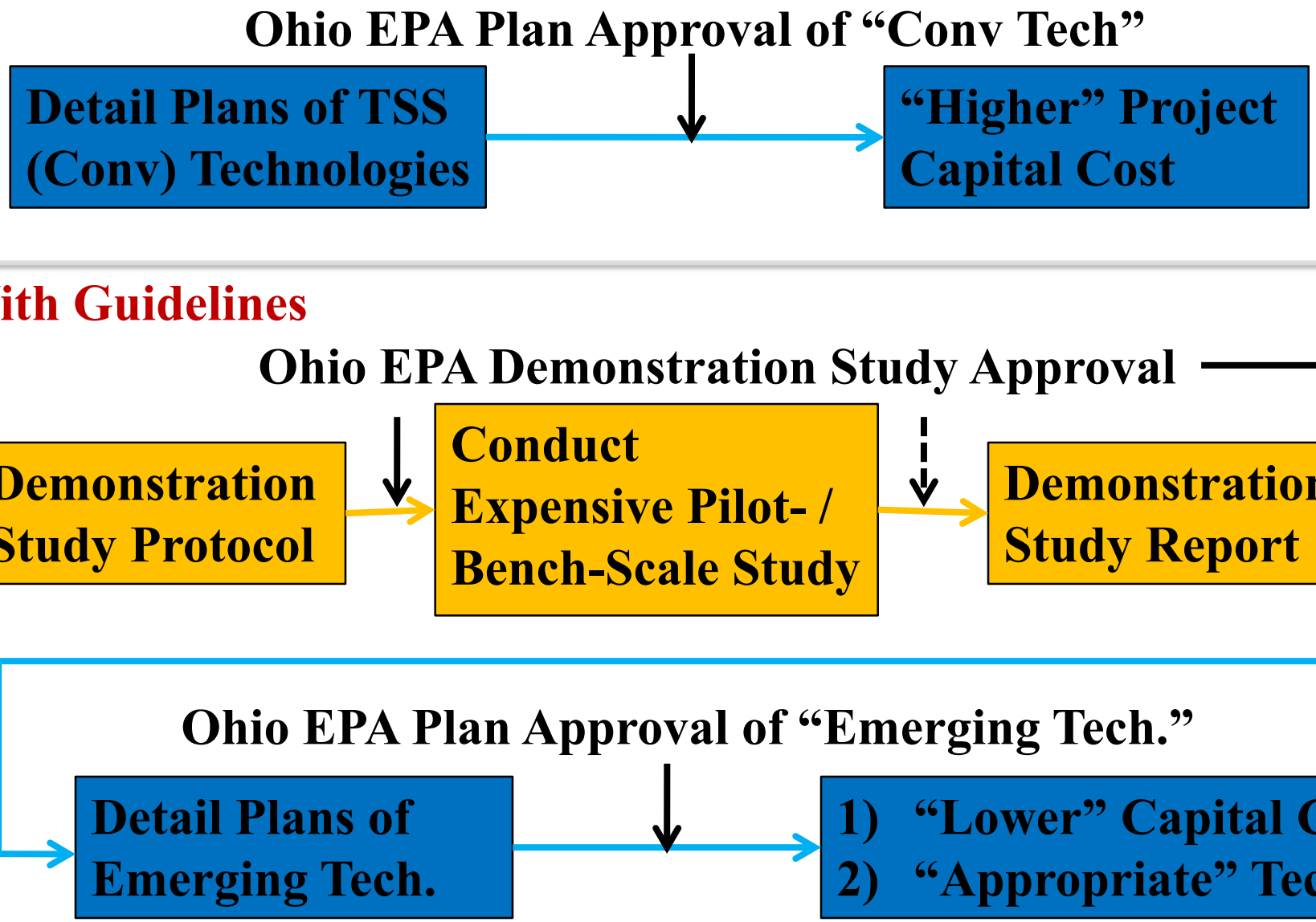
+

Ohio EPA Adopts Design Criteria as Supplement to TSS

→

Joint presentation of process to GLUMRB

Plan Approval in Ohio



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
- Catridge 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

Selected Emerging Technology

Byesville, OH

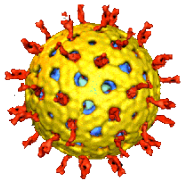
Microfiltration/Ultrafiltration (MF/UF)

- 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

Why use MF/UF?

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

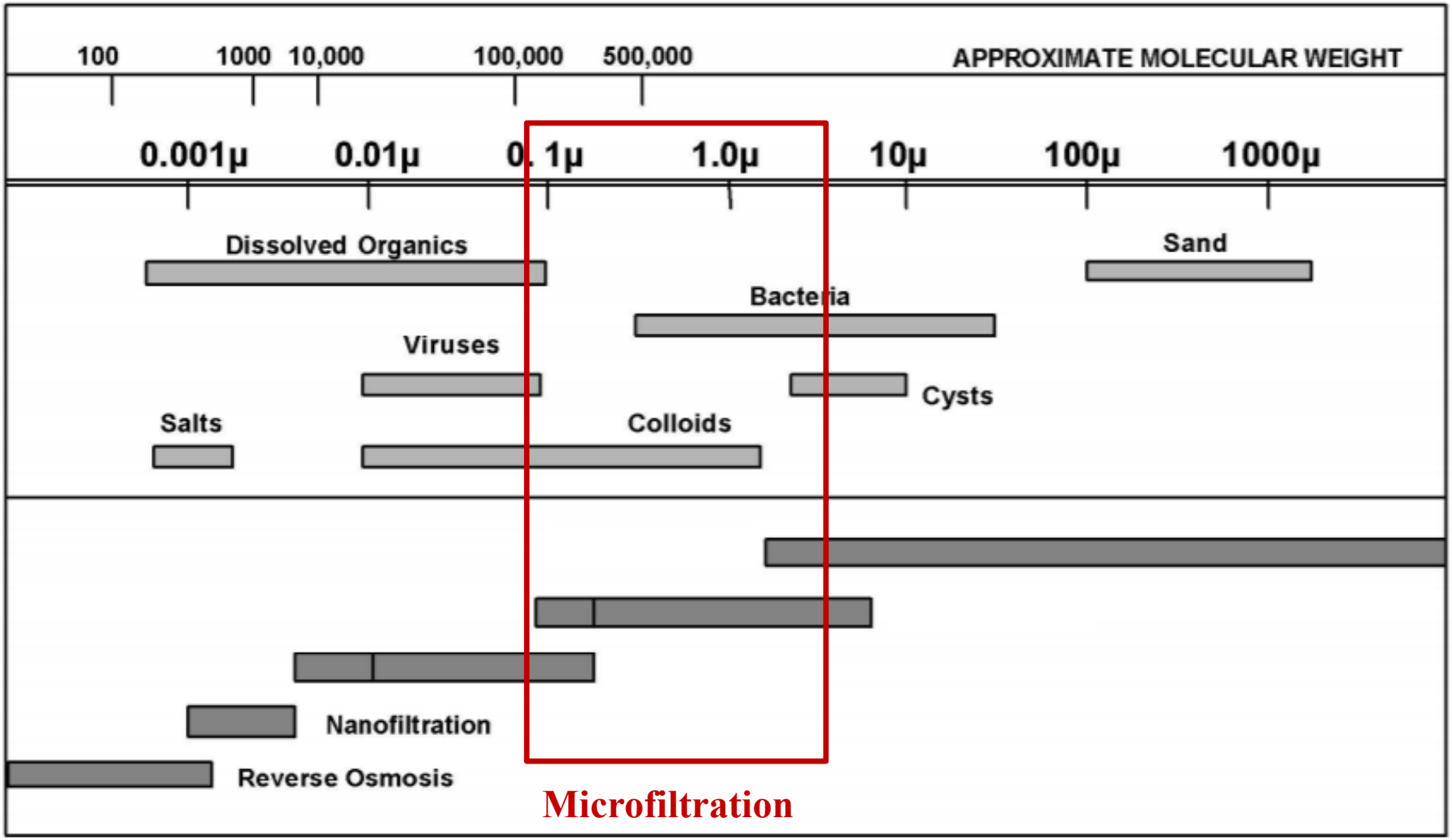
Salmonella
0.4 – 2 μm



Rotavirus
60 nm

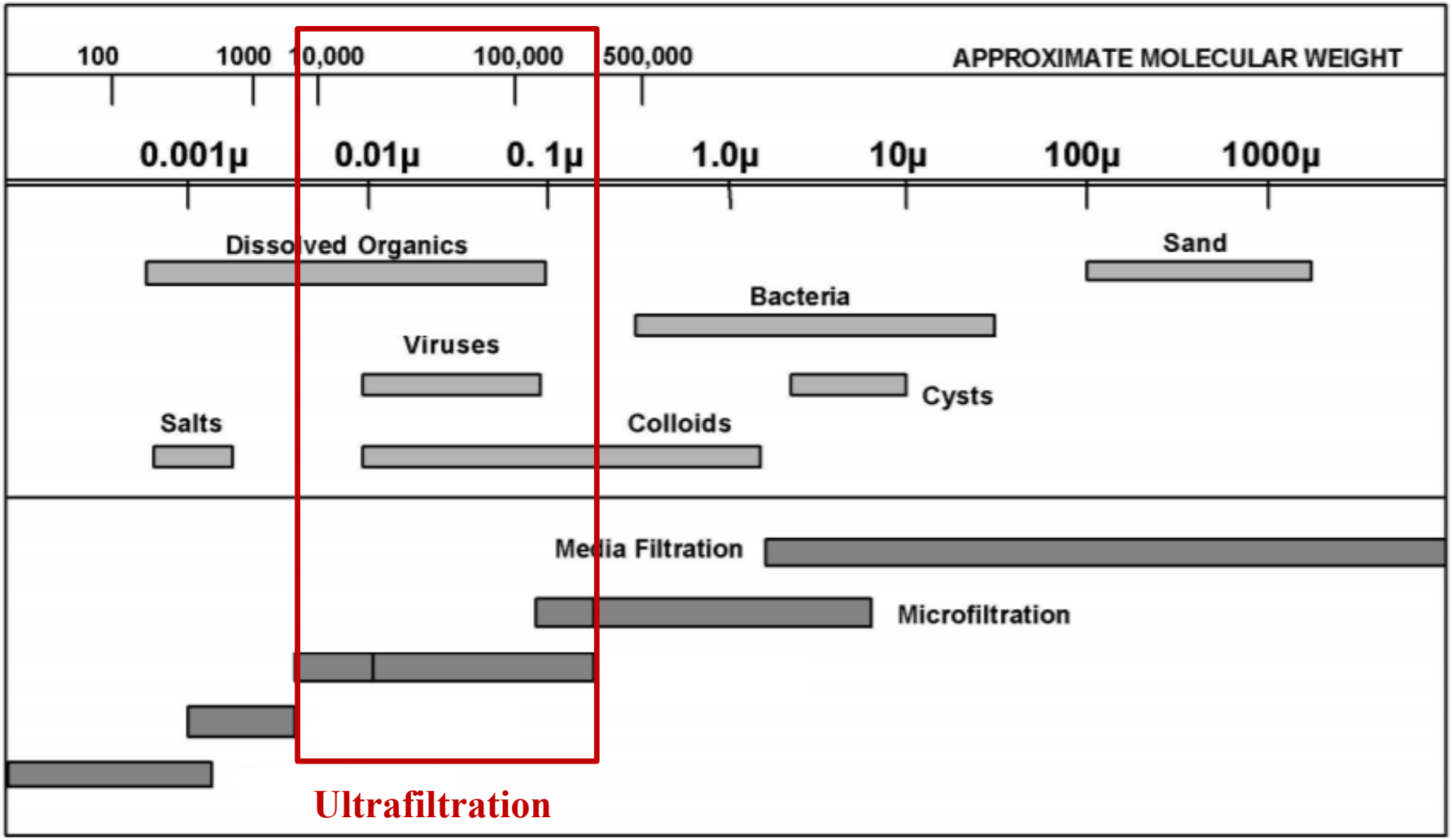
Giardia
6 – 10 mm

Principle of Filtration – **Size Exclusion**



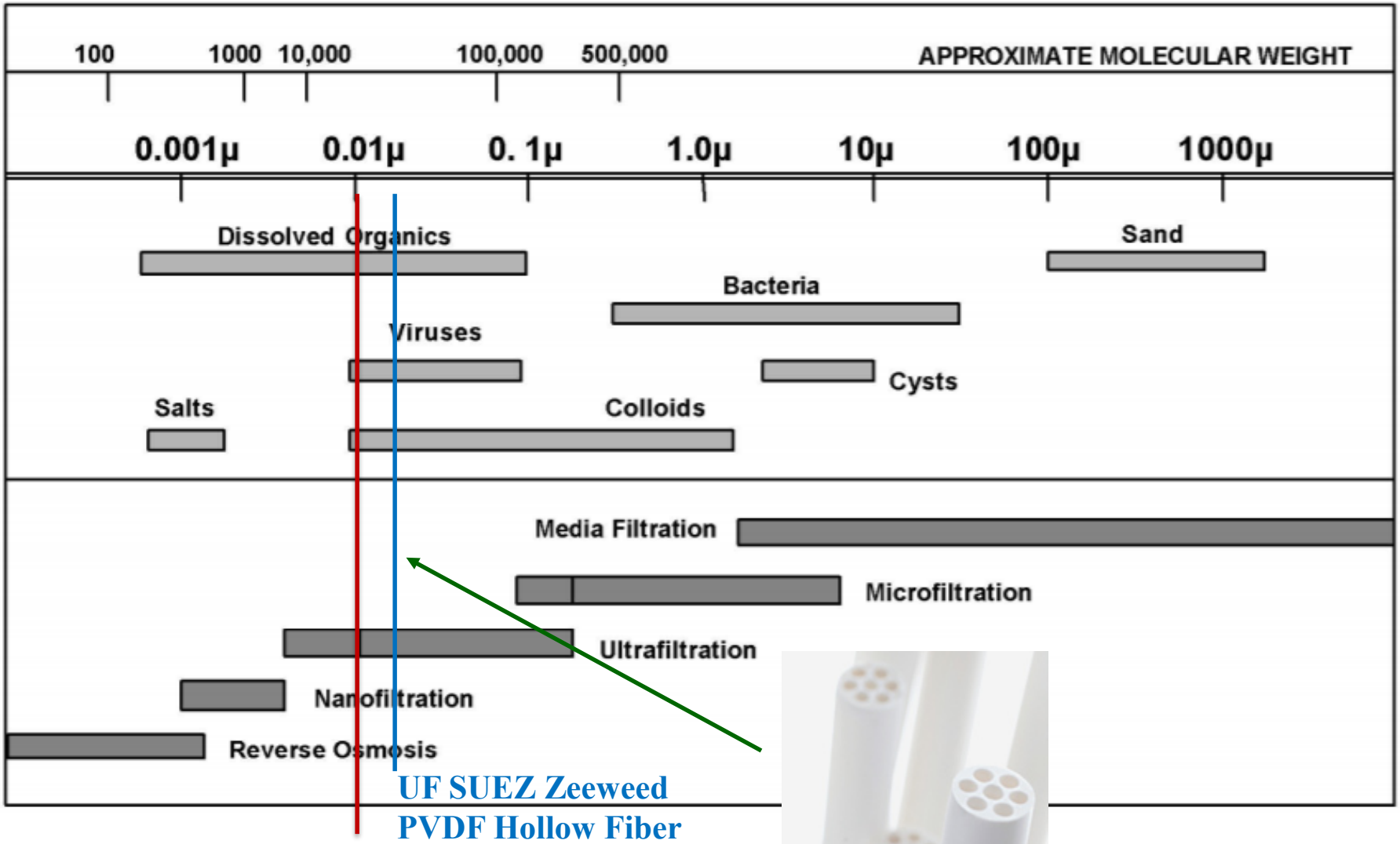
- MF classified by pore size in microns (µ)
- UF classified by molar mass (g/mol) or Dalton Molecular Weight Cut Off (MWCO)

Principle of Filtration – Size Exclusion



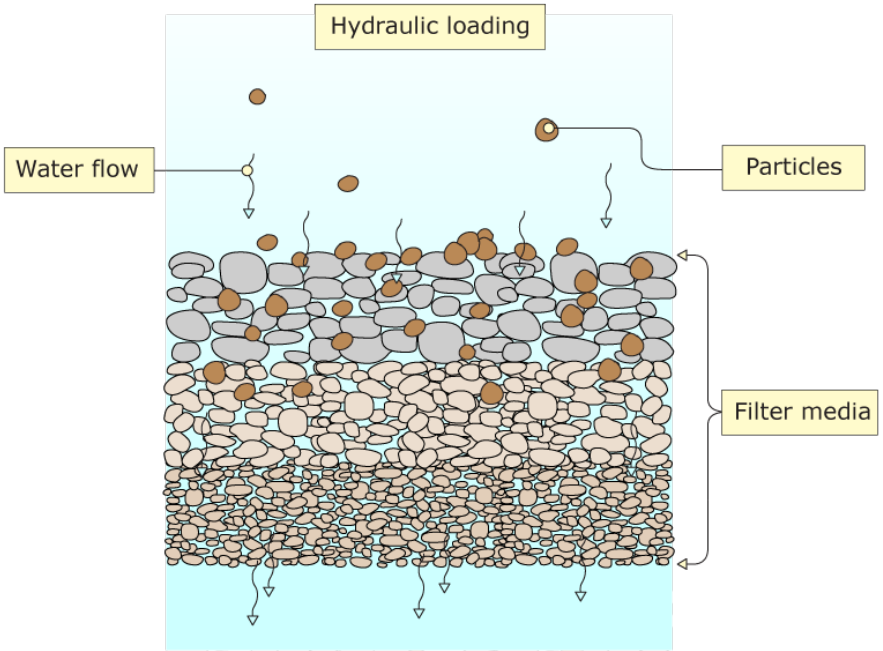
- MF classified by pore size in microns (µ)
- UF classified by molar mass (g/mol) or Dalton Molecular Weight Cut Off (MWCO)

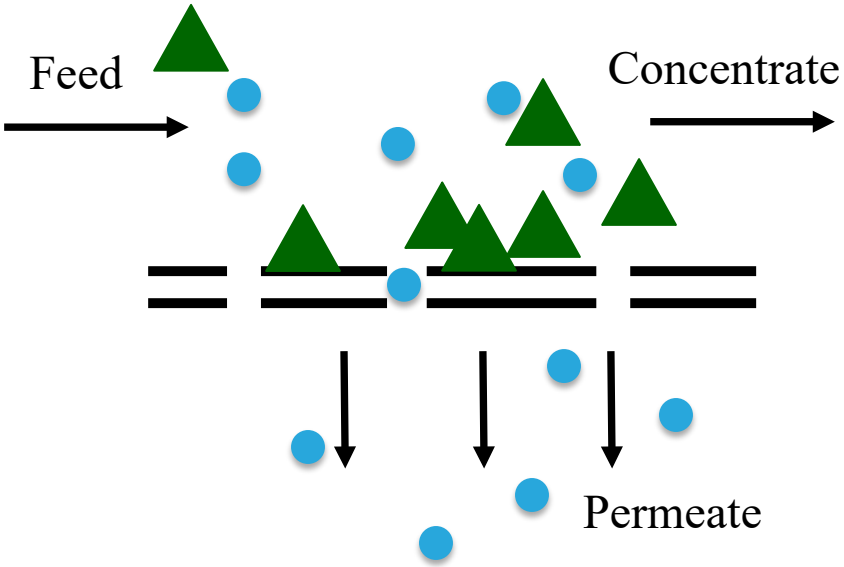
Pore Size of Example UF Membranes



Inge Multibore
PES

How Membranes Work





Rapid Sand Filter

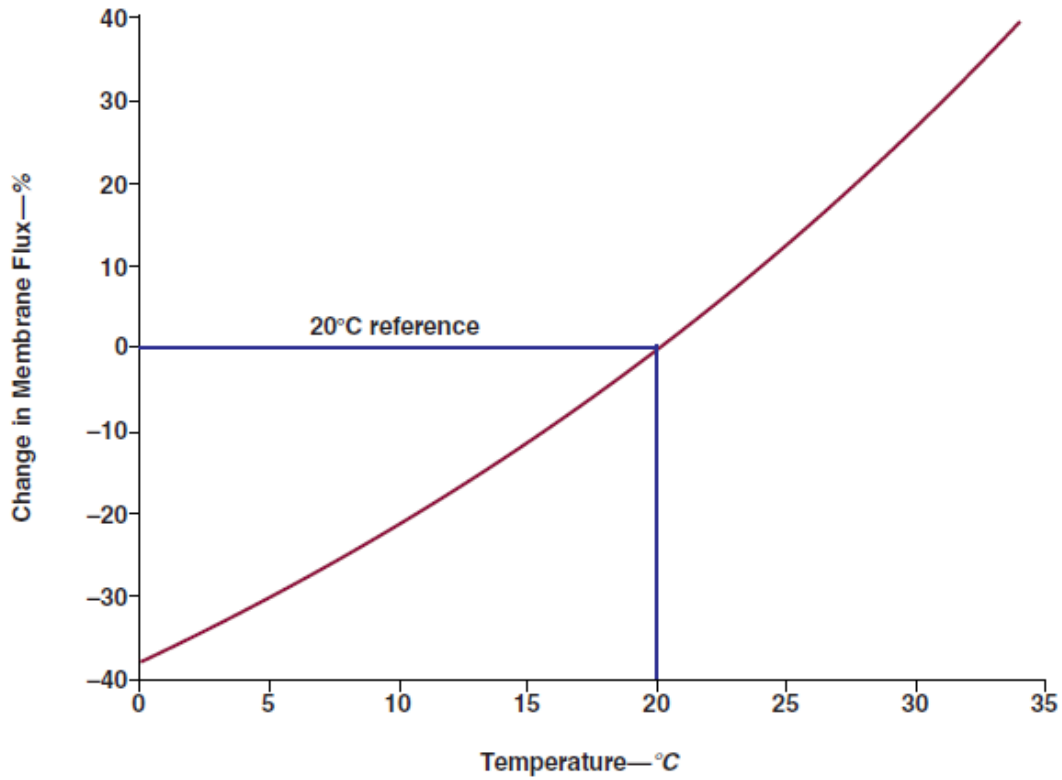
Membrane

Like granular media filtration rate, Flux is a velocity

Flux – flow of permeate, i.e., the water passing through the membrane, per unit area of membrane (g/ft^2d or l/m^2h)

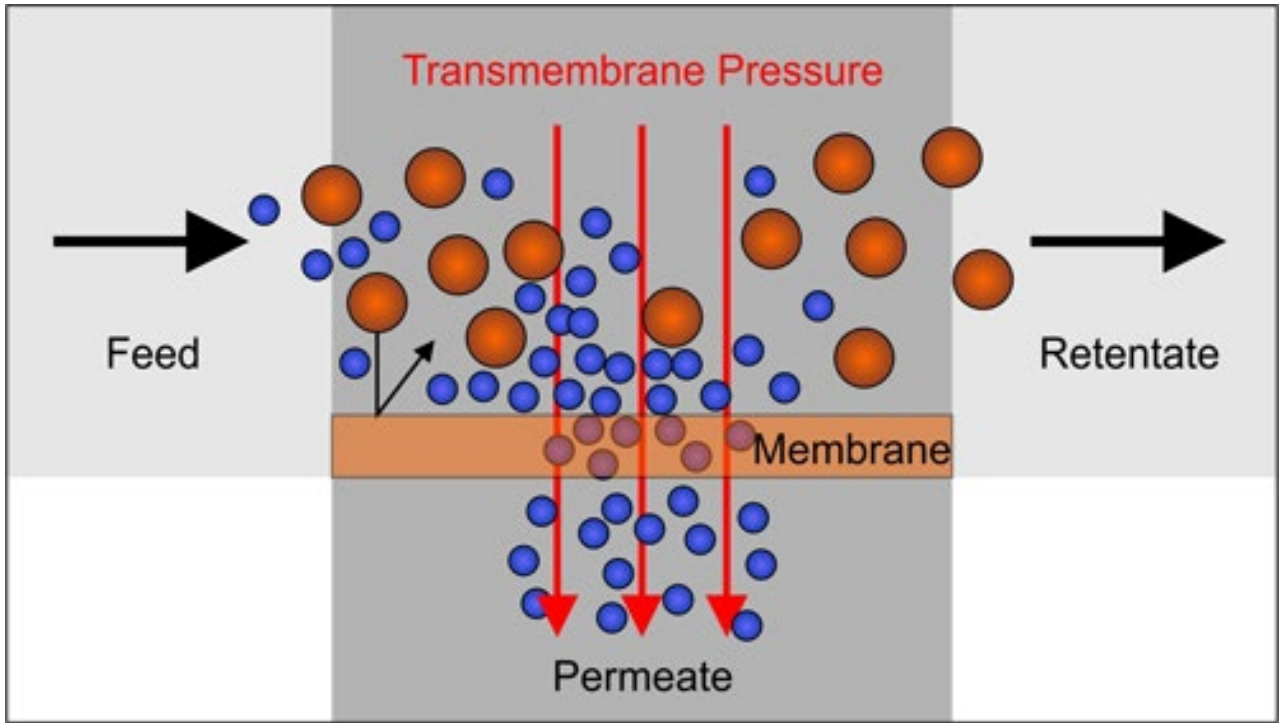
MF/UF typical flux 50-100 g/ft^2 d

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



Based on Mallevialle et al, 1996

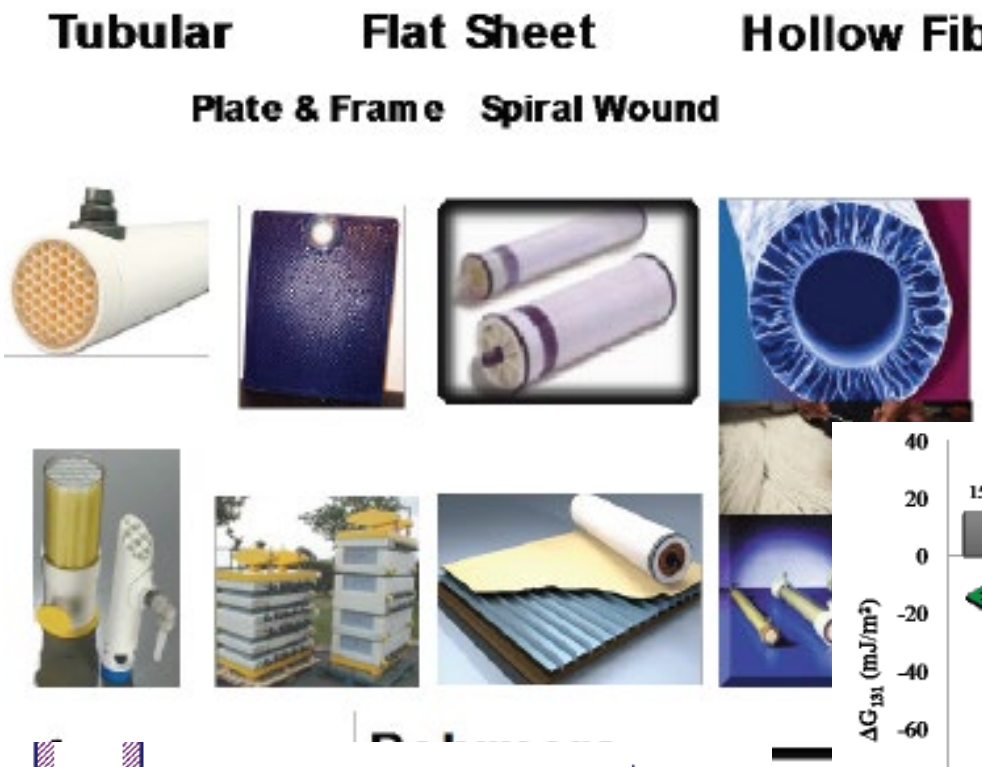
Transmembrane Pressure (TMP)



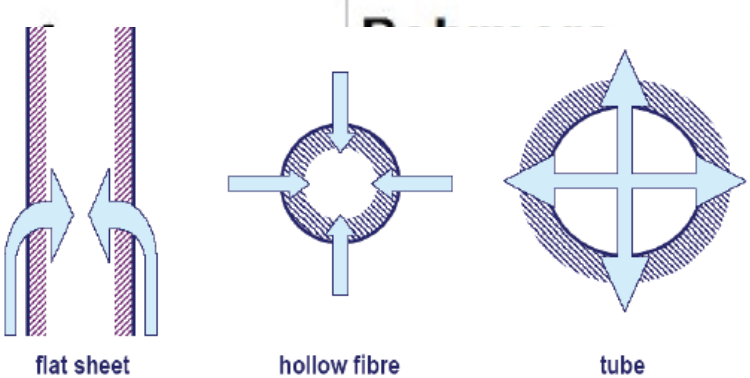
<u>TMP</u> - Difference in pressure between feed and permeate of membrane (psi)

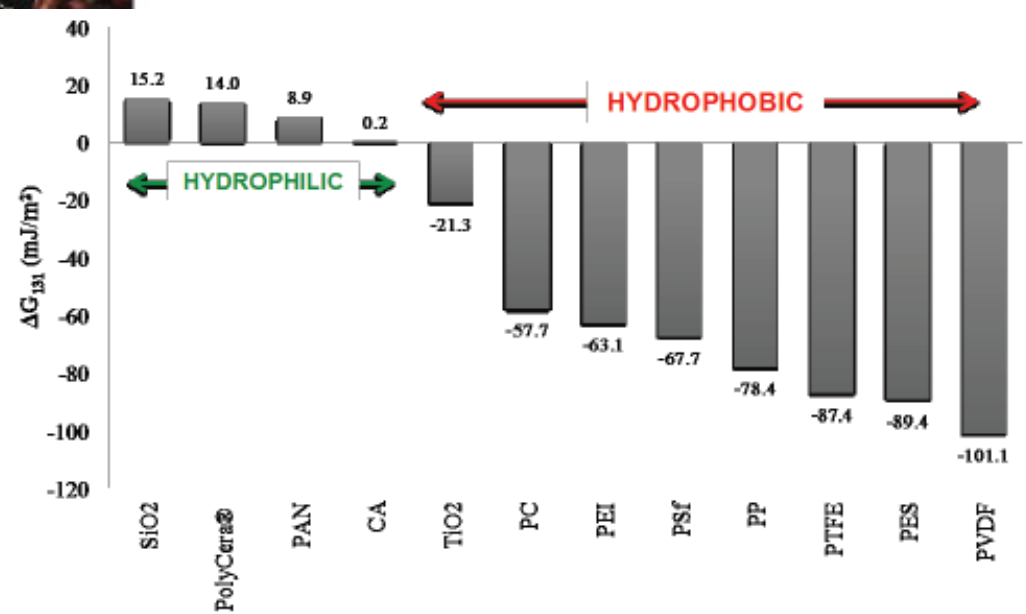
- Typically 3-15 psi
- There is no significant difference between the range of pressures at which MF and UF operate

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

Initial Focus: Design FLUX

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

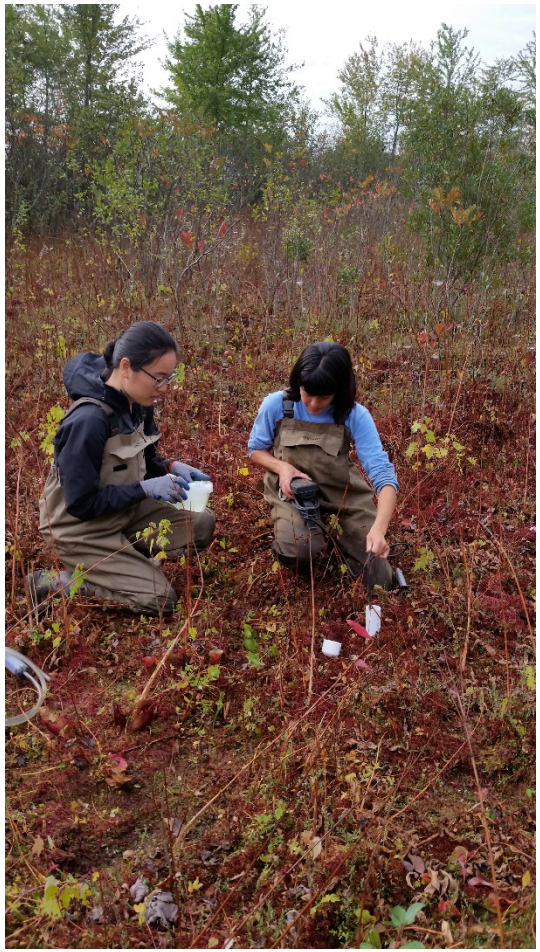
- Technical Advisors:
  Rob Shoaf, AECOM, Joe Jacangelo, Stantec

Project Funding - OWDA

Acknowledgements

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.



wrc.osu.edu
#Ohio_WRC

Questions?

Thank you!!