Membrane Treatment for Water and Wastewater Systems

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Introduction

- Why are we discussing membrane treatment?
  - Newer Federal and State regulations
  - Drought -> Poorer raw water quality
  - Increased demands -> Poorer raw water quality
  - Cost of membranes has become more competitive with conventional treatment
  - Site space availability

Introduction

- Regulatory Requirements
  - Water Treatment
    - Reviewed under §290.42(g) as innovative treatment techniques and exceptions to the Rules
    - Must meet site-specific performance requirements when used at surface and groundwater treatment facilities, in lieu of granular media filters, per §290.111(b)(1)(B)
  - Wastewater Treatment
    - Reviewed under §217.7(b)2 as innovative treatment techniques and exceptions to the Rules
    - Must meet site-specific performance requirements when used at WWTPs, in lieu of conventional WW treatment design, per §217.157

Membrane System Overview

- What do terminology is used with membranes?
- What types of membranes are available?
- What is the purpose of each membrane type?
- What is the difference between vacuum and pressure membrane systems?
- What pretreatment is required?
- Log Removal…what is it?
- Where do membrane systems fit into water treatment processes?
- Where do membrane systems fit into wastewater treatment processes?

Membrane System Overview

- What do terminology is used with membranes?
  - Membrane – Material where the lateral dimensions (length, width) are much greater than the material thickness
  - Filtrate – Filtered water that passes through the pores (openings in membrane) of an MF/UF membrane to a downstream process
  - Permeate – Treated water that diffuses through a NF/RO membrane to a downstream process
  - Flux – A measure of the rate at which the permeate passes through the membrane per unit of membrane surface area, expressed as gallons per square foot per day (gfd)
  - Recovery – Ratio of filtrate/permeate produced compared to the original feed water flow rate, expresses as a percentage

Membrane System Overview

- What do terminology is used with membranes?
  - Concentrate – The waste stream from a membrane system
  - Transmembrane Pressure (TMP) – Measurement of the force required to push/pull filtrate across an MF/UF membrane surface, physical indicator of membrane fouling
  - Fouling – Loss of performance due to suspended or dissolved material deposition on the membrane surface
  - Rejection – A measurement of the amount of suspended/dissolved material removed from the feed stream by the membrane, expressed as a percentage
  - Pressure Vessel – A cylindrical container designed to house membrane elements

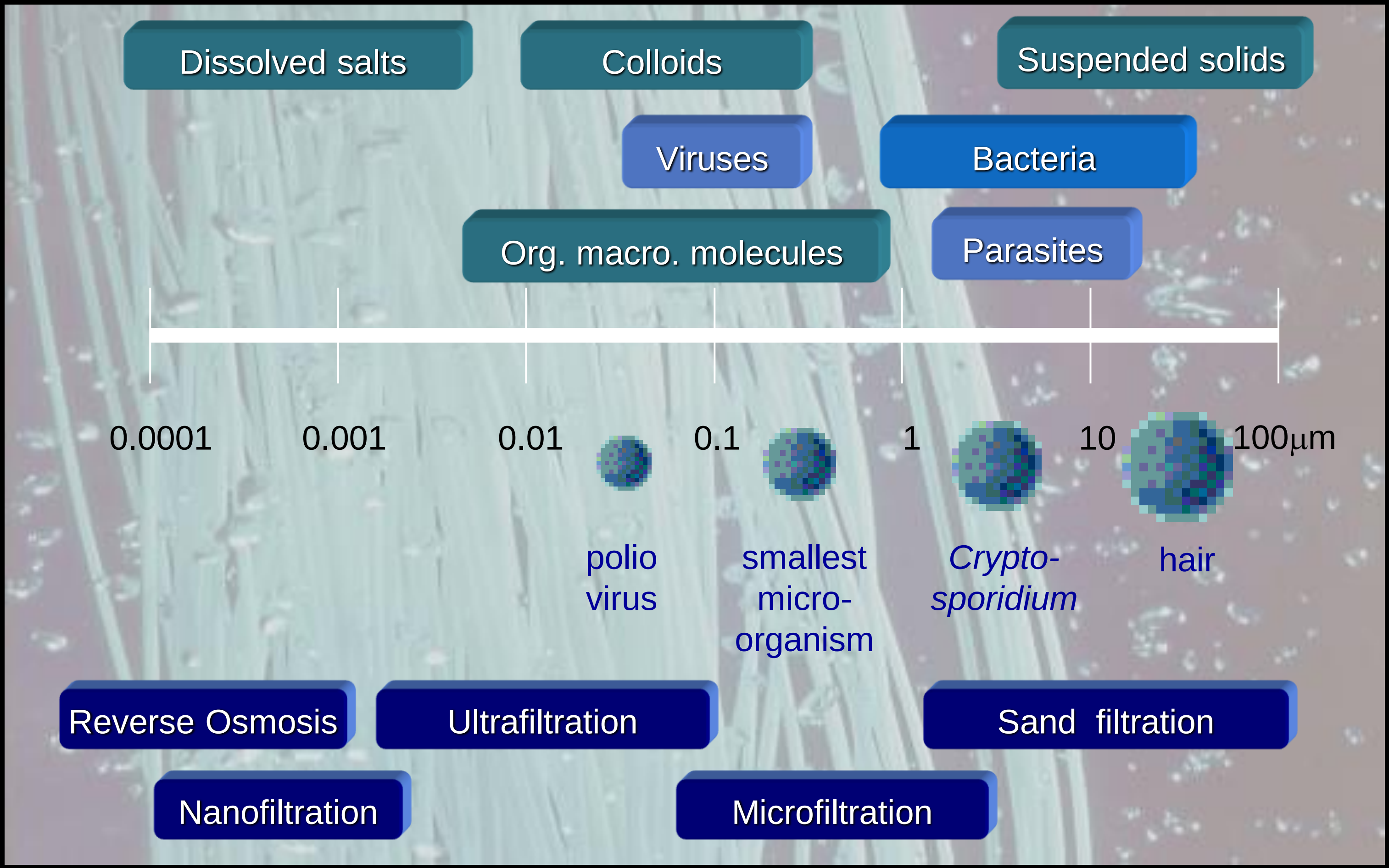
Membrane System Overview

- What do terminology is used with membranes?
  - Element – The actual membrane itself
  - Stage – The number of times concentrate is treated in series
  - Pass – The number of times permeate is treated in series
  - Backpulse – A method of cleaning membranes by forcing filtrate back through the membrane to clean off the feed side of the membrane
  - Clean-In-Place (CIP) – A method of cleaning the membranes by soaking in chemical solutions while still inside the pressure vessels
  - Membrane Biological Reactor (MBR) – A type of MF/UF system used in conjunction with WWTP processes

Membrane System Overview

- What types of membranes are available?
  - Microfiltration (MF)
  - Ultrafiltration (UF)
  - Nanofiltration (NF)
  - Reverse Osmosis (RO)
  - Membrane Biological Reactor (MBR)

Membrane System Overview



Membrane System Overview

- What is the purpose of each membrane type?

- Water
  - MF/UF – Replace conventional granular media filtration
  - NF/RO – Enhance removal attained by MF/UF, can also soften water and remove all or part of dissolved minerals

- Wastewater
  - MBR – Enhance biological process and replace secondary clarification and filtration processes (consists of MF/UF membranes)
    - MF/UF/NF/RO processes can also be utilized at the end of WWTP processes to enhance quality of effluent used for reuse

Membrane System Overview

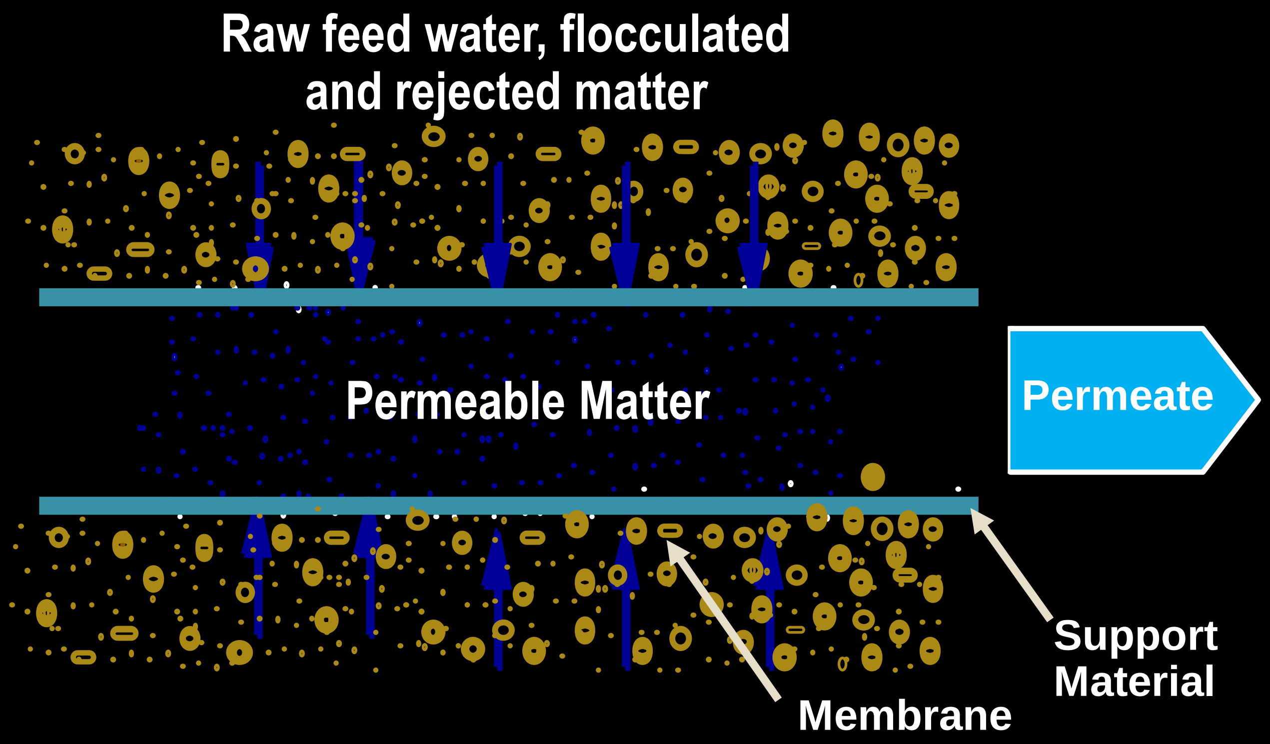
- What is the purpose of each membrane type?

- Typical Recovery Rates – Water
  - MF – 95%
  - UF – 90%
  - NF – 80–90%
  - RO – 70–80%

- Typical Recovery Rates – Wastewater
  - MBR (MF) – 85–95%
  - MBR (UF) – 80–90%

Membrane System Overview

- What is the purpose of each membrane type?



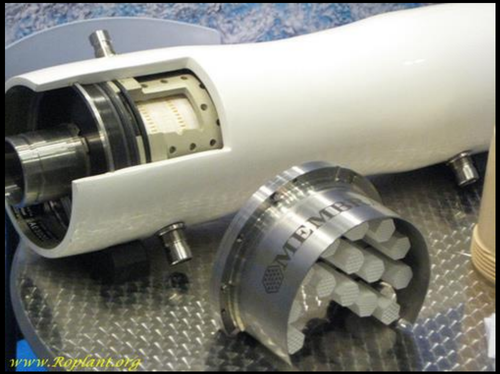
Membrane System Overview

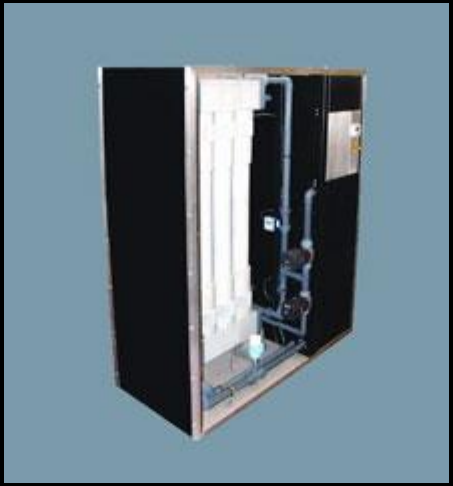
- What is the purpose of each membrane type?

- Microfiltration (MF)
  - Operates by filtration via pores in the membrane
  - Designed to remove particles 0.1 microns and larger
    - Suspended solids, Giardia, Crypto, large bacteria. Algae
    - May be able to meet 6-log removal of Giardia and Crypto
  - Can be designed to run as a pressure or vacuum system
    - Most common design is pressure
  - Pressure system – 10-30 psi, Vacuum system – -10-20 psi

Membrane System Overview

- What is the purpose of each membrane type?
- Pressure MF Examples





Membrane System Overview

- What is the purpose of each membrane type?
- Vacuum MF Examples

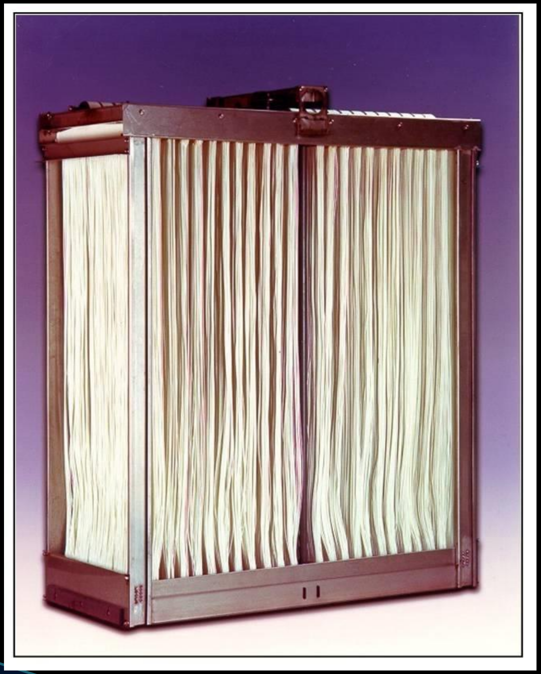
Membrane System Overview

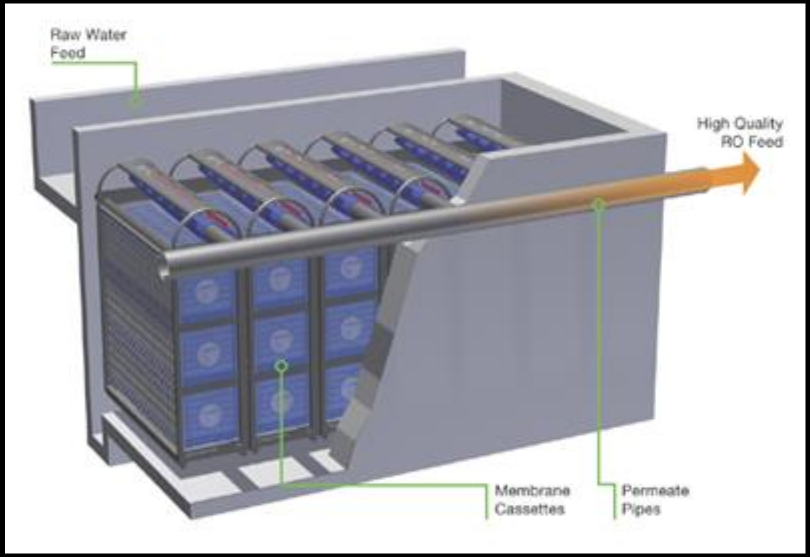
- What is the purpose of each membrane type?

- Ultrafiltration (UF)
  - Operates by filtration via pores in the membrane
  - Designed to remove particles 0.01 microns and larger
    - Suspended solids, Giardia, Crypto, large bacteria, algae
    - May be able to meet 6-log removal of Giardia and Crypto
  - Can be designed to run as a pressure or vacuum system
    - Most common design is vacuum
  - Pressure system – 20-40 psi, Vacuum system – -5-20 psi

Membrane System Overview

- What is the purpose of each membrane type?
- Vacuum UF Examples





Membrane System Overview

- What is the purpose of each membrane type?
- Pressure UF Examples

Membrane System Overview

- What is the purpose of each membrane type?

- Nanofiltration (NF)
  - Operates by diffusion across the membrane itself
  - Designed to remove particles 0.001 microns and larger
    - Giardia, Crypto, large bacteria, algae, limited amounts of monovalent ions, such as components of TDS, some radionuclides
    - Able to consistently meet 6-log removal of Giardia and Crypto
  - Because of limitations in removing large amounts of TDS (50-70% of RO), typically used for softening or for enhanced TOC removal
  - Designed to run as a pressure system
  - Pressure system – 75-150 psi, depending on TDS content

Membrane System Overview

- What is the purpose of each membrane type?
- NF Examples

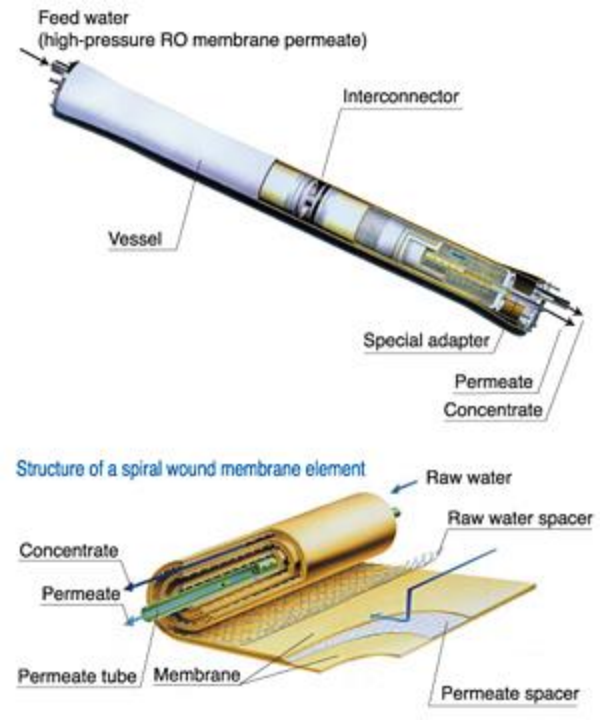
Membrane System Overview

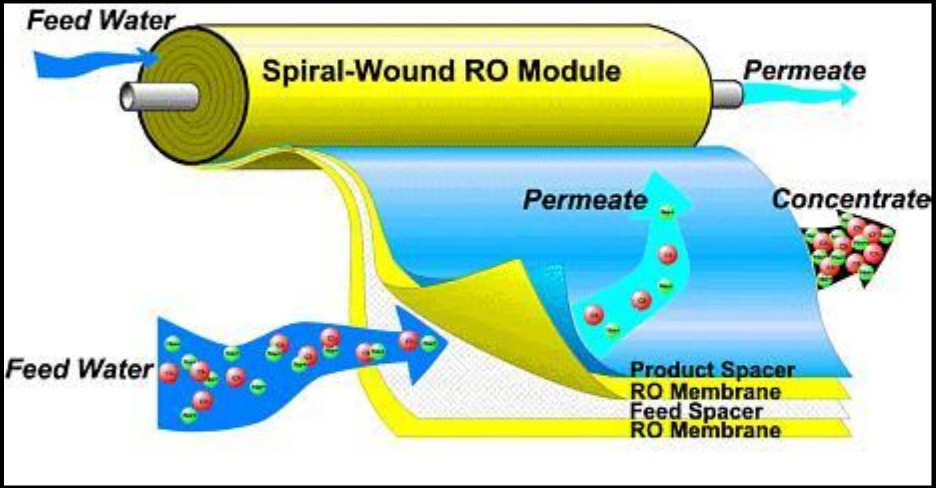
- What is the purpose of each membrane type?

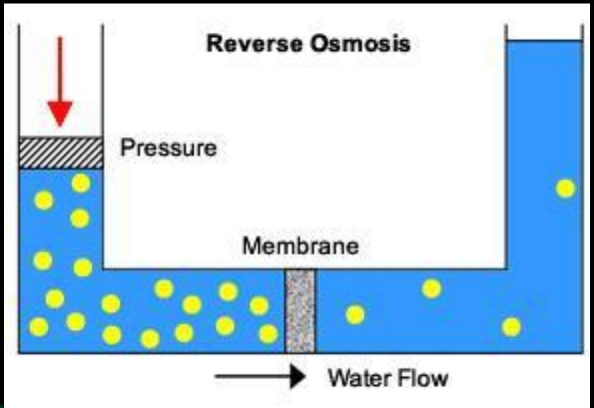
- Reverse Osmosis (RO)
  - Operates by diffusion across the membrane itself
  - Designed to remove particles 0.001 microns and larger
    - Giardia, Crypto, large bacteria, algae, 99% of monovalent ions, such as TDS, some radionuclides
    - Able to consistently meet 6-log removal of Giardia and Crypto
  - Typically used for removal or reduction of TDS (desalination)
  - Designed to run as a pressure system
  - Pressure system – 150-300 psi, depending on TDS content

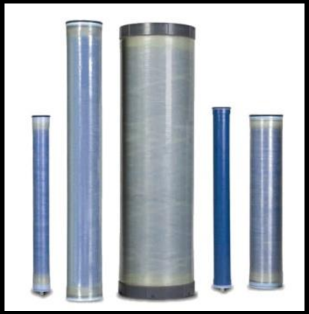
Membrane System Overview

- What is the purpose of each membrane type?
- RO Examples









Membrane System Overview

- What is the purpose of each membrane type?

- NF/RO Design Requirements
  - Site-specific
  - May submit pilot or full-scale data from a similar raw water source
  - Provide blending ratio calculations based on full- or side-stream treatment with NF/RO

Membrane System Overview

- What is the difference between vacuum and pressure membrane systems?
  - In a pressure system, feed water is forced through the membrane pores by a pressure pump.
  - In a vacuum (submerged) system, the membranes are not placed in a housing or vessel, but placed in a basin or tank that is often open to atmosphere. In this type of system, filtrate is drawn through the membrane via a vacuum pump.

Membrane System Overview

- What pretreatment is required?
  - Incorporate pretreatment in final design, matching pretreatment used in piloting, as a minimum
  - If piloted water turbidity limit is less than the raw water source's historical turbidity, TCEQ and/or Membrane Manufacturer may require pretreatment to meet performance warranty of membranes

Membrane System Overview

- Log Removal…what is it?
  - 1 log removal/inactivation = remove 90%
  - 2-log removal/inactivation = remove 99%
  - 3-log removal/inactivation = remove 99.9%
  - 4-log removal/inactivation = remove 99.99%
  - 4.5-log removal/inactivation = remove 99.9945%
    - Log rem/inact = Log (initial concentration / final concentration)
    - Log rem/inact = Log (11,245 per 100 ml / 8 per 100 ml)
    - Log rem/inact = Log (1405.625) = 3.1

Membrane System Overview

- Benefits of pretreatment with membranes?
  - Current Removal Credit – MF, UF, NF, RO
    - No pretreatment
  - 2.0-log Crypto
  - 3.0-log Giardia
  - **No virus credit**

Membrane System Overview

- Benefits of pretreatment with membranes?
  - Current Removal Credit – MF, UF, NF, RO
    - With coagulation/flocculation pretreatment
  - 2.0-log Crypto
  - 3.0-log Giardia
  - 1.0-log Virus

Membrane System Overview

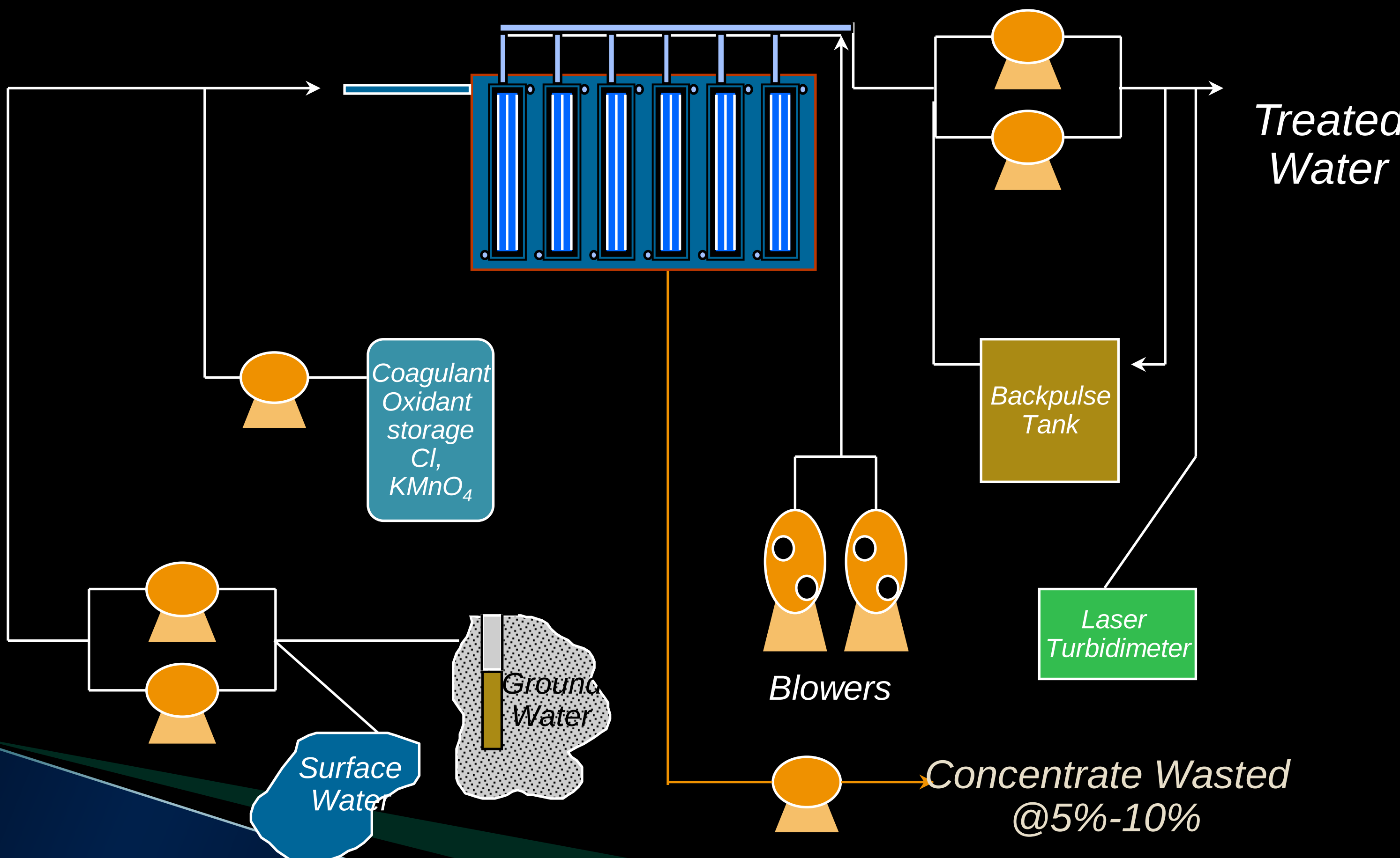
- Benefits of pretreatment with membranes?
  - Current Removal Credit – MF, UF, NF, RO
    - With coagulation/flocculation /clarification pretreatment
  - 2.0-log Crypto
  - 3.0-log Giardia
  - **2.0-log Virus**

Membrane System Overview

- Do we still need pretreatment?
  - A good rule of thumb is:
    - If you already have existing pretreatment at the plant, keep using it!
    - If the facility is completely new, pilot membrane system with and without pretreatment to determine whether pretreatment is needed.

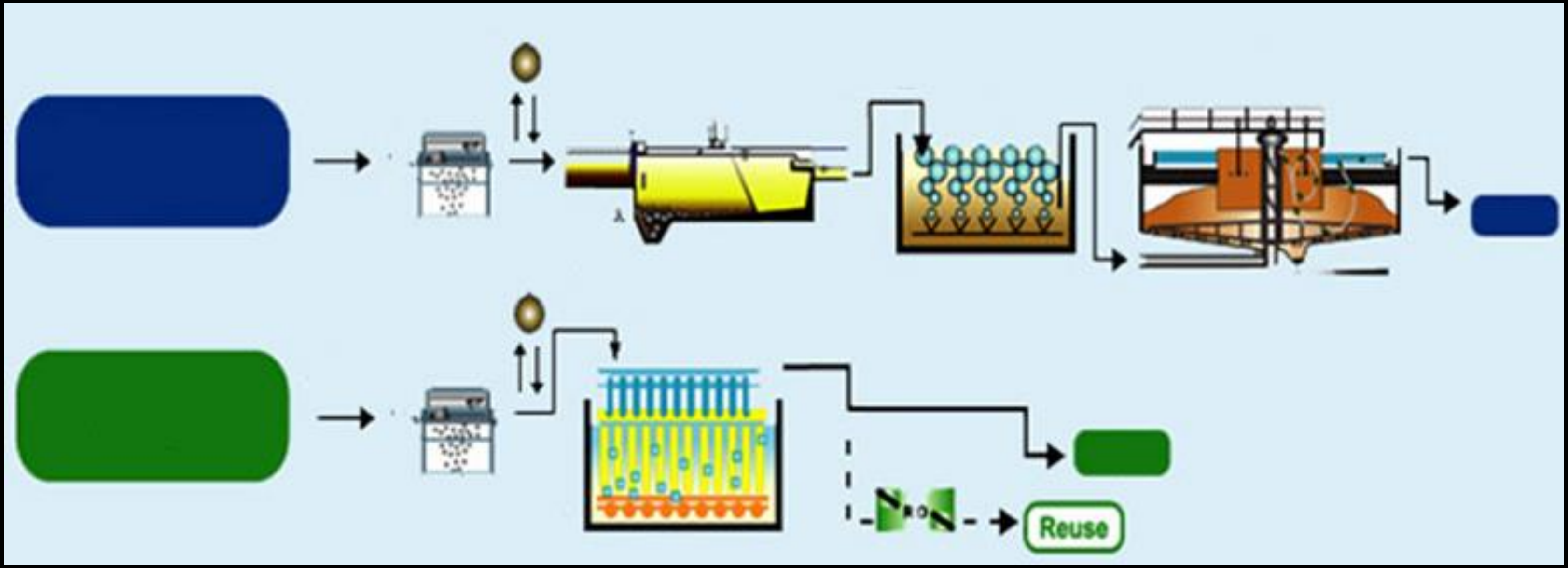
Membrane System Overview

- Where do membrane systems fit into water treatment processes?



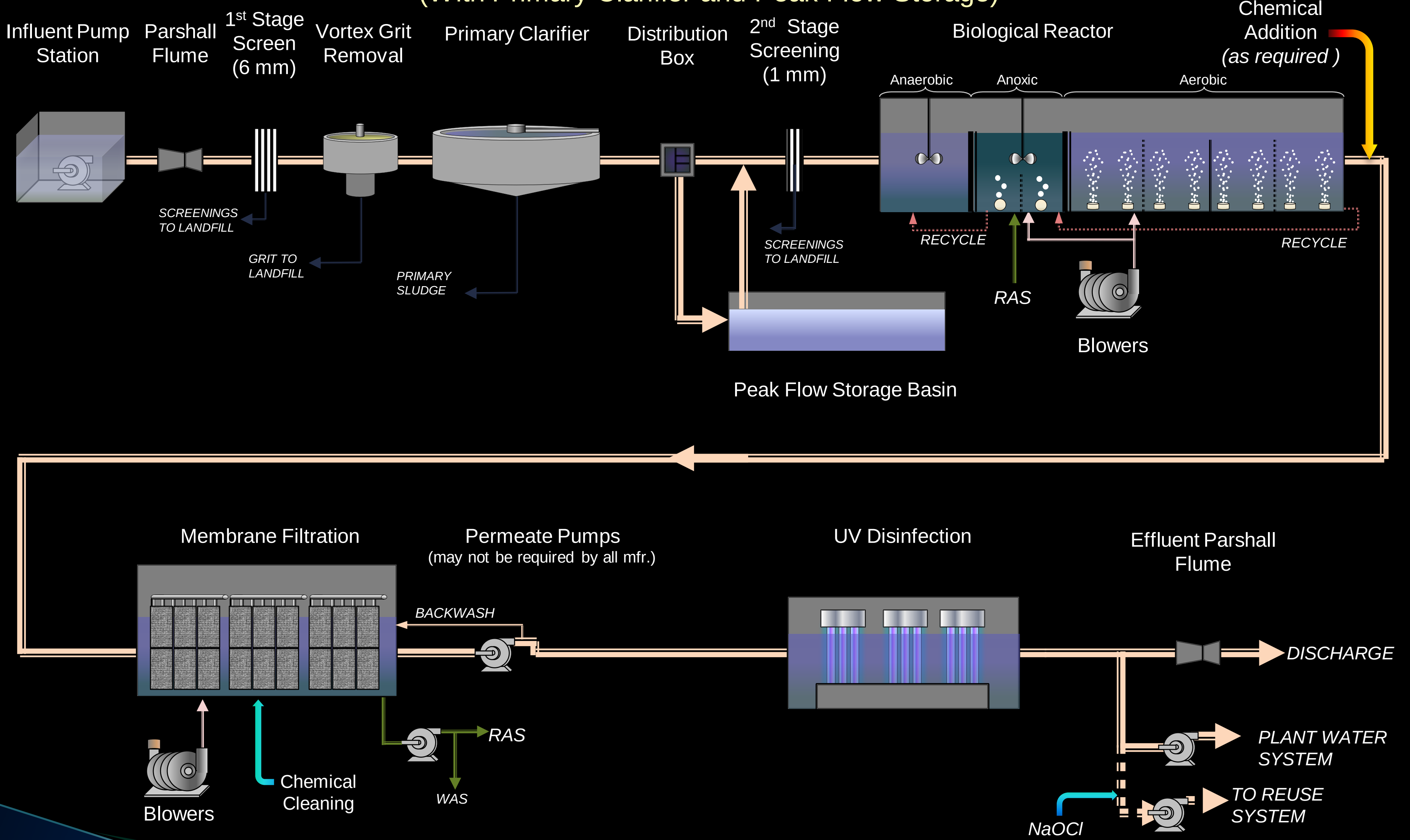
Membrane System Overview

- Where do membrane systems fit into wastewater treatment processes?



Membrane System Overview

(With Primary Clarifier and Peak Flow Storage)



Membrane Costs

- What are typical capital costs?
- What are typical operating costs?

Membrane Costs

- What are typical capital costs?
  - Typical WTP membrane equipment costs (per gallon)
    - MF – \$0.50 – \$1.00
    - UF – \$0.50 – \$1.00
    - NF – \$0.75 – \$1.50 (may require MF/UF pretreatment)
    - RO – \$0.75 – \$1.75 (may require MF/UF pretreatment)
  - Typical WWTP membrane equipment costs (per gallon)
    - MF/UF – \$1.00 – \$2.00 (installed downstream of conventional processes)
    - NF/RO – \$1.50– \$2.50 (will require MF/UF pretreatment)
    - MBR – \$1.00 – \$2.00 (installed in aeration basins)

Membrane Costs

- What are typical operating costs?
  - Typical WTP O&M costs (per 1,000 gallons)
    - MF – $0.50 – $1.00
    - UF – $0.50 – $1.00
    - NF – $0.75 – $1.00 (may require MF/UF pretreatment)
    - RO – $1.00 – $2.00 (may require MF/UF pretreatment)
  - Typical WWTP O&M costs (per 1,000 gallons)
    - MF/UF – $1.00 – $2.00 (installed downstream of conventional processes)
    - NF/RO – $2.00– $4.00 (will require MF/UF pretreatment)
    - MBR – $1.00 – $2.00 (installed in aeration basins)

Deciding to Use Membranes

- Why not continue conventional treatment?
- Are other upgrade technologies available instead of membranes?
- When is it appropriate to enhance existing processes with membranes?
- When is it appropriate to replace existing processes with membranes?

Deciding to Use Membranes

- Why not continue conventional treatment?
  - Newer Federal and State regulations
  - Cost of membranes has become more competitive with conventional treatment
  - Need for expansion / Limitations on plant space
  - Limitations on raw water supply / quality

Deciding to Use Membranes

- Are other upgrade technologies available instead of membranes?
  - WTP process alternatives
    - Multimedia filtration (sand, anthracite, garnet)
    - GAC (granular activated carbon)
    - Ion exchange
  - WWTP process alternatives
    - BNR (biological nutrient removal)
    - Chemical precipitation of nutrients
    - Cloth filtration (disc filters)

Deciding to Use Membranes

- When is it appropriate to enhance existing processes with membranes?
  - Water Treatment
    - Difficulty in consistently meeting LT2ESWTR
    - Difficulty in consistently meeting DBPR
    - Decrease in raw water quality / Increase in turbidity
  - Wastewater Treatment
    - Meet Type I reuse limits and reduce nutrients
    - Continued difficulty in handling solids / repeated clarifier upsets

Deciding to Use Membranes

- When is it appropriate to replace existing processes with membranes?
  - Water Treatment
    - Continued noncompliance with LT2ESWTR / DBPR
    - Age of existing conventional filters leads to full replacement
    - Significant decrease in raw water quality / Increase in turbidity
  - Wastewater Treatment
    - Tighter TPDES permit limits
    - Age of existing processes leads to full replacement
    - Consideration of satellite or new WWTP facility

Selecting and Designing

- How do we determine level of treatment needed?
- Do we treat full-stream or side-stream?
- What are the design requirements?
- What do we do with the waste stream now?
- How do membranes impact solids handling in wastewater processes?
- What is a pilot and how do we do it?

Selecting and Designing

- How do we determine level of treatment needed (what are the treatment drivers)?
  - Water
    - Removal of suspended solids (turbidity)?
    - Removal of organics and hardness?
    - Removal of dissolved minerals (TDS)?
  - Wastewater
    - Removal of nutrients?
    - Need to produce Type I or better quality reuse water?

Selecting and Designing

- Do we treat full-stream or side-stream?
- Full-Stream Treatment
  - Implies treating the entire flow in the plant
  - Usually required if replacing an entire existing filtration system
- Side-Stream Treatment
  - Implies treating part of the plant flow and blending with the remaining non-filtered stream
  - This approach is typically used to reduce the initial capital cost of the membrane system
    - Most membrane systems are modular in design and can be expanded easily, if designed for future expandability
  - Side-stream treatment designs must be reviewed with TCEQ to ensure that blended water quality can meet treatment requirements

Selecting and Designing

- What are the design requirements?
  - Rated capacity of membrane filtration WTP – Total filtrate/permeate per day minus in-plant water used per day
  - Approved at flux rate adjusted to 20 ºC using TCEQ generic calculation
    - Or approved vendor temperature adjustment calculation

Selecting and Designing

- What do we do with the waste stream now?

  - Membrane-specific
  - Site-specific
  - Limited by water quality

Selecting and Designing

- What do we do with the waste stream now?
  - Membrane-specific
    - MF/UF – Part of waste stream can be recycled to head of WTP or discharged to WWTP or receiving stream
    - NF/RO – Waste stream should not be recycled to head of WTP
      - Typical disposal is via evaporation pond or discharge to WWTP or receiving stream

Selecting and Designing

- What do we do with the waste stream now?
  - Site-specific
    - Close to WWTP or WW collection system – Discharge to WWTP
      - Consider corrosion protection requirements!
    - Far from WWTP or WW collection system – Consider discharge to receiving stream, use of evaporation pond, use of deep-well injection

Selecting and Designing

- What do we do with the waste stream now?
  - Limited by water quality
    - MF/UF waste – Volume of discharge to receiving stream should not be affected
    - NF/RO waste – Volume of discharge to receiving stream will be based on salinity, chemistry and pH impacts to receiving stream

Selecting and Designing

- How do membranes impact solids handling in wastewater processes?
  - Conventional Solids Handling
    - Secondary Clarification, RAS/WAS Pumping, Solids thickening, solids dewatering and disposal
    - Sludge in aeration basin – 2,000 – 4,000 mg/L MLVSS
  - Membrane System Solids Handling
    - MBR, Waste solids from MBR basin, solids dewatering and disposal
    - Sludge in aeration basin – 8,000 – 20,000 mg/L MLVSS

Selecting and Designing

- What is a pilot and why and how do we do it?
  - Why pilot?
    - Membrane systems are considered innovative treatment. 30 TAC 290.42(g) requires that where innovative treatment systems are proposed, the system must be piloted to demonstrate how the system will produce water that meets all State and Federal standards.
  - Current Requirements for the Owner
    - 90 days (typical)
    - Pilot study protocol (site specific, preapproved by TCEQ)
    - Pilot study report (site specific, data accepted by TCEQ for full-scale design)
    - Exception from piloting – may submit pilot or full-scale data from a similar or worse raw water source

Selecting and Designing

- What is a pilot and why and how do we do it?
  - Future Requirements for the Owner
    - Same as current
    - Also must provide membrane-specific data required under LT2ESWTR with each pilot study report

Selecting and Designing

- What is a pilot and why and how do we do it?
  - Future Requirements for the Membrane Vendor
    - Provide challenge study removal efficiency
    - Provide maximum log removal value (LRV), verified by a particular direct integrity test (DIT)
    - Provide non-destructive performance test (NDPT) for verification of membrane modules not challenged
    - Provide a quality control release value (QCRV) for the NDPT

Operational Differences

- Basic differences in operating principles.
- How are pretreatment requirements different for membrane treatment?
- How are instrumentation requirements different for membrane treatment?
- How are membranes different from traditional filters in cleaning?
- How do membranes change operation of solids and waste stream handling?
- How is equipment operating life different for membrane systems?

Operational Differences

- Basic differences in operating principles.
  - Potable Water Production
    - Conventional plants use coagulants ahead of coag/floc/sed process to render settled water of <2 NTU to send to conventional filters. Must regularly produce settled water of about 2 NTU or less to ensure compliance with IFE and CFE limits. Water quality to filters is key for conventional plants and meeting limits.
    - Quality of water to membranes has much less impact on finished water quality. Fixed pore size of membranes dictates finished water quality. Poorer water quality will impact frequency of membrane cleaning but not so much the quality of the finished water.

Operational Differences

- Basic differences in operating principles.

  - Wastewater Treatment

    - Conventional plants (those with final clarifiers) rely on final clarifiers to settle the solids from mixed liquor leaving clear effluent to flow from clarifier. Operators of WWTPs with final clarifiers must produce a sludge that will settle leaving behind clear effluent.

    - Membrane WWTPs do not have final clarifiers. Process control related to making sludge settle goes away. No longer care if the sludge will settle. Process control shifts to maintaining nutrient removal treatment. Also now have effluent filtration. Well suited to plants with nutrient removal in their TPDES permit or Type I reuse needs.

Operational Differences

- How are pretreatment requirements different for membrane treatment?
  - Potable Water Production
    - Membrane plants require raw water screening to protect the membranes.
    - Conventional WTPs may or may not have screening. Screening not so much of an issue in conventional WTPs.

Operational Differences

- How are pretreatment requirements different for membrane treatment?
  - Wastewater Treatment
    - Fine screens are required for MBR plants to protect the membranes.
    - MBR plants are commonly used to provide nutrient removal. Nutrient balance becomes more of an issue if biological nutrient removal is required.

Operational Differences

- How are instrumentation requirements different for membrane treatment?
  - Potable Water Production
    - Conventional WTPs utilize nephelometric turbidimeters to measure NTU in IFE and CFE.
    - Membrane WTPs in Texas <u>must</u> utilize laser turbidimeters to measure mNTU in membrane effluent.
    - Additionally, membrane WTPs must complete DITs on each membrane rack a minimum of once every 7 days. Must maintain pressure sensors and instrumentation associated with DIT.

Operational Differences

- How are instrumentation requirements different for membrane treatment?
  - Wastewater Treatment
    - Instrumentation required to operate the membrane system is more complex than for conventional WWTP.
    - Very little difference in instrumentation requirements for TPDES compliance verification.
    - Analytical procedures for permit compliance remains bench top analytical with an MBR plant as it does with a conventional WWTP with final clarifiers.

Operational Differences

- How are membranes different from traditional filters in cleaning?
  - Traditional filters are cleaned through the filter backwash procedure.
  - Treated water is flushed back up through the filter opposite the direction of normal flow.
  - Normal filter runs are 48-96 hours.
  - Additional chemicals are typically not used in traditional filter backwash procedure.

Operational Differences

- How are membranes different from traditional filters in cleaning?
  - Membranes are cleaned in several ways. Additional chemicals are used in the cleaning process:
    - Routine backpulses on regular intervals (every 15-30 minutes) using water and air pulses. (membrane remains in ~normal service)
    - Weekly mini-CIPs (maintenance cleans) using low pH (acid) and chlorine (hypochlorite). (membrane out of service for relatively short period)
    - Comprehensive CIPs using low pH (acid) and chlorine (hypochlorite). May also use neutralizing chemicals to neutralize chlorine and low pH (monthly-2/year). (membrane out of service)
    - Time required for cleaning of RO membranes can be up to twice as long as for MF/UF membranes (2 days vs. 1)

Operational Differences

- How do membranes change operation of solids and waste stream handling?
  - Potable Water Production
    - Very little change in how solids are handled. Can either be handled onsite or discharged to sewer for handling at WWTP.
  - Wastewater Treatment
    - MBR systems can be capable of meeting Class B treatment requirements. SRT from the biological process is considered aerobic digestion.

Operational Differences

- How is equipment operating life different for membrane systems?
  - Potable Water Production
    - Membrane life expectancy somewhere near 10 years. Dual media filter beds typically last about that long before needing to be reworked.
  - Wastewater Treatment
    - Conventional WWTP treatment equipment has long lifespan exceeding that of membranes. Membranes would have to be replaced where conventional WWTP basins remain functional for decades. However, membrane life is comparable to life of aeration basin diffusers.

Monitoring and Reporting

- There are no differences in monitoring and reporting requirements for conventional and MBR plants on the wastewater treatment side.

- There are major monitoring and reporting differences for Potable Water Production membrane treatment plants when compared with conventional WTPs. All discussion here on ‘Monitoring and Reporting’ will concern Potable Water Production.

Monitoring and Reporting

- Potable Water Production
  - Two methods are required for monitoring and reporting performance and integrity of MF and UF membrane systems used in Potable Water Production.
    - Direct Integrity Test (DIT)
    - Indirect Integrity Test
  - Monitoring and reporting TOC in membrane treatment of drinking water.

Monitoring and Reporting

- Direct Integrity Test
  - DIT is used to verify there are no breaks or breaches in the membrane capable of allowing pathogens through the membrane barrier.
  - Purpose of the DIT is to verify the membrane barrier remains intact.
  - Most DIT testing relies on pressurizing the membrane system to minimum required pressures (or vacuum) and measuring the pressure (or vacuum) decay over time. Too much pressure or vacuum decay and the membrane fails the DIT. Too many membrane breaches.

Monitoring and Reporting

- Direct Integrity Test
  - Triggered:
    - A DIT must be performed on any membrane unit in which the effluent turbidity exceeds 0.15 NTU in two consecutive 5 minute readings.
  - Prescribed Minimum Interval:
    - Also For Bin 1 systems the DIT must be performed at least once every 7 days to ensure the system continues to provide removal credit equal to or greater than the removal credit awarded to the membrane system by TCEQ.
    - Systems that have been assigned to Bins 2-4 based on LT2 *Crypto* sampling results must complete DITs daily (at risk systems).

Monitoring and Reporting

- Direct Integrity Test
  - The new SWMORv15 incorporates the MMOR.
  - In order for membrane systems to use the new SWMORv15 they must first submit to TCEQ for approval, information on DIT resolution and sensitivity variables for their system.

Monitoring and Reporting

- Resolution (P_{test}): What is the pressure or vacuum required to detect a breach in the membrane of at least 3 microns (P_{test})?
  - P_{test} establishes the required pressure/vacuum for the DIT.
    - Example: P_{test} = 25 psi

- Sensitivity (LRV_{DIT}): How sensitive is the DIT? Is it sensitive enough to detect a breach in the membrane equal to or greater than the removal credit awarded to the membrane system by TCEQ?
  - If awarded 3-log removal credit then calculated LRV_{DIT} must be at least 3.0. If it is less than 3.0 then the membrane fails the DIT.
  - UCL must also be determined for the system. This is a psi/min value that indicates the max pressure/vacuum decay rate that is acceptable in the DIT.
    - Example: UCL = 0.7 psi/min; test is 5 min so $\leq$3.5 psi/DIT = Pass
    - Instrument used to measure pressure…how sensitive?

Monitoring and Reporting

- The new SWMOR v15 incorporates the MMOR
  - The MMOR requires the operator to enter once each month:
    - Calculated and approved (by TCEQ) P_{test} value in psi for the system.
    - TCEQ issued Log Removal Credit (LRC) for the system (3.0).
    - UCL which is the maximum permissible pressure/vacuum decay rate in psi/min at which the membrane will still pass the DIT.
  - Once those values have been entered, the initial pressure ($P_{initial}$), and pressure decay (ΔP) for each DIT is entered throughout the month and compared to the UCL to determine if the membrane passes the DIT.

Monitoring and Reporting

- Indirect Integrity Testing
  - Indirect integrity testing uses turbidity levels in the finished water to indirectly establish the integrity of the membrane.
  - Rising turbidity levels indirectly indicate a breach in the membrane.
  - Serves to provide monitoring of membrane integrity between DITs which may only be undertaken once every 7 days.

Monitoring and Reporting

- Indirect Integrity testing
  30 TAC 290.42(g)(3)(C)

  - The membrane system must be designed to conduct and record continuous indirect integrity monitoring on each membrane unit at least once every 5 minutes.

  - The turbidity of the water produced by each membrane unit must be measured using a laser turbidimeter

Monitoring and Reporting

- Indirect Integrity Testing

  - A system must immediately conduct a DIT on any membrane unit that produces filtered water with turbidity level above 0.154 NTU in two consecutive readings.

  - A system must immediately remove any membrane unit from service which fails a DIT. The unit may not be returned to service until it has passed the DIT.

Monitoring and Reporting

- TOC Monitoring and Reporting
  - Monitoring and reporting TOC in membrane treatment of drinking water in not the same as in conventional Potable Water Production plants. From 30 TAC 290.112(a):

    "Applicability. All community and non-transient, non-community public water systems that treat surface water or groundwater under the direct influence of surface water and use sedimentation or clarification facilities as part of the treatment process must meet the provisions of this section."

  - If sedimentation process or clarification process is not part of the plant treatment process then not required to remove TOC.

Lessons Learned

- TCEQ has changed requirements for verifying and reporting the results of DIT tests for membranes used in Potable Water Production.
  - When membrane treatment systems began to be used for potable water production in Texas, membrane systems were not required to report specifics of the DIT tests. That has changed.
  - Systems must prove resolution and sensitivity of the DITs and are required to report results of individual DITs with the new SWMORv15 (following approval of the DIT testing protocol for a given WTP site).

Lessons Learned

- Scaling potential of membranes
  - In some cases, highly alkaline waters have a tendency to form scale on the feed side of UF/MF membranes.
  - While this is expected to be a continual issue for RO/NF membranes, it is becoming more and more of an issue for UF/MF.
    - Potential is greater in 2^{nd} stage (and/or 3^{rd} stage) recovery NF/RO membranes.

Lessons Learned

- There are risks of fouling membranes as a result of upstream chemical use.
  - Membrane vendors are very quick to point out the risks of fouling membranes.
    - Use of settling aid or filter aid polymers upstream are frowned upon. Potential to foul the membranes. Some coagulants with polymer blended into the mixture may be ok, but must be reviewed by the membrane manufacturer.
    - Use of metal salts upstream (coagulants) must be carefully controlled. Dissolved metals (aluminum, iron, barium, strontium) and other potential foulants must be carefully controlled or prevented.

Lessons Learned

- There are risks of damaging membranes as a result of upstream chemical use.
  - NF/RO membranes intolerant of chlorine and other oxidants. Damage from chlorine is irreversible.
  - Common range of oxidant tolerance is 200–1,000 mg/L hours chlorine (1 mg/L chlorine for 200–1,000 hours)
    - What is the maximum chlorine dose to expose to membranes, recommended by most membrane vendors? None!
  - Sign of damage is decreased salt rejection rate.
  - Dechlorination may lead to increase in biofouling potential.

Lessons Learned

- There are risks of damaging membranes as a result of cleaning practices.
  - Some systems have seen damage to membranes as a result of cleaning agents used on membranes.
    - Introduction of some cleaning agents may actually break down the membrane and cause the membranes to become more porous. Caution must be used when altering cleaning procedures from Manufacturer's recommended (Potential warranty issues).
    - Might be best to try new ideas/procedures on only an element or two to determine if the procedure or chemical is safe before implementing on an entire array.

Lessons Learned

- There are risks of damaging membranes as a result of existing system design.
    - Some systems have seen damage to membranes as a result of debris from upstream piping.
        - Older piping and lower cost piping currently commercially available typically use cement mortar lining. Over time, the mortar breaks down and is passed downstream to the membrane system.
            - When installing new membrane systems, it is best to replace older cement mortar-lined piping with epoxy-coated piping to minimize debris passing to the membranes. The key issue is to minimize the amount of abrasive materials that can reach the membranes.

Lessons Learned

- DO/HS (Direct Osmosis/High Salinity) Modification for RO systems
  - Relatively new idea involving the use of highly saline (completely saturated brine solution) pulses on feed side of RO systems to use the osmotic potential to create a "backpulse" in RO systems to reduce fouling on feed side and maintain cleaner membranes.
    - Backpulse flushes off feed side of membranes.
    - Increases the interval between CIPs.

References

- TCEQ
  - Marlo Wanielista Berg, P.E.
  - David Williams, P.E.
  - Jack Schulze, P.E.

Summary

Questions?