Southeastern Wisconsin
Regional Planning Commission

Chloride Impact Study for the Southeastern Wisconsin Region

TAC Meeting
February 25, 2026

#279804

Speakers

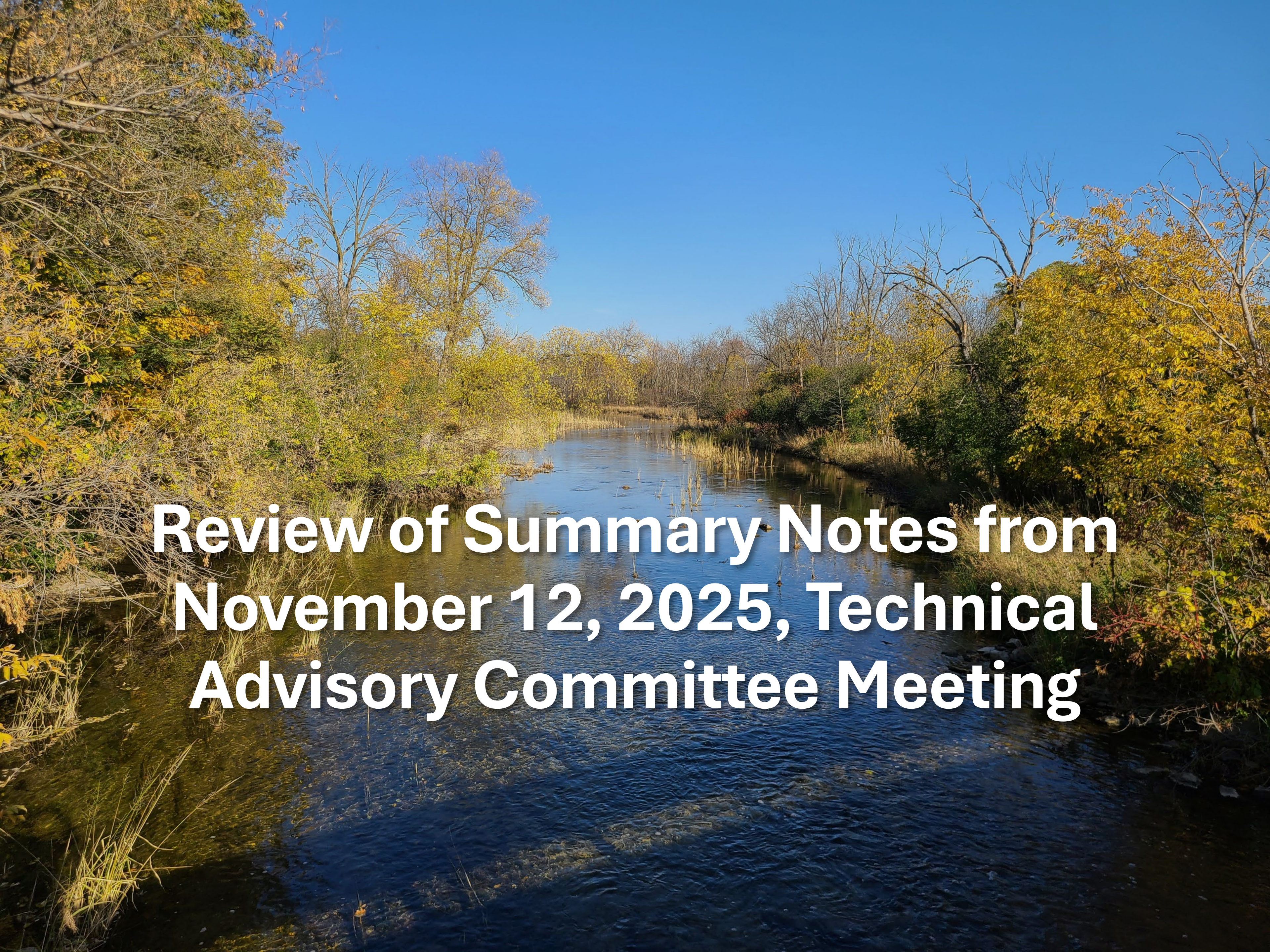
- Laura Herrick, Chief Environmental Engineer
- James Mahoney, Engineer
- Collin Klaubauf, Engineer

Agenda

- Review of Summary Notes from November 12, 2025, TAC meeting
- Review of preliminary draft chapters of SEWRPC Technical Report No. 66, *State of the Art for Chloride Management*
  - *Chapter 4 – Private Water Softening and Treatment*
  - *Chapter 5 – Other Chloride Sources*
- Next Steps

Chloride Study Reports

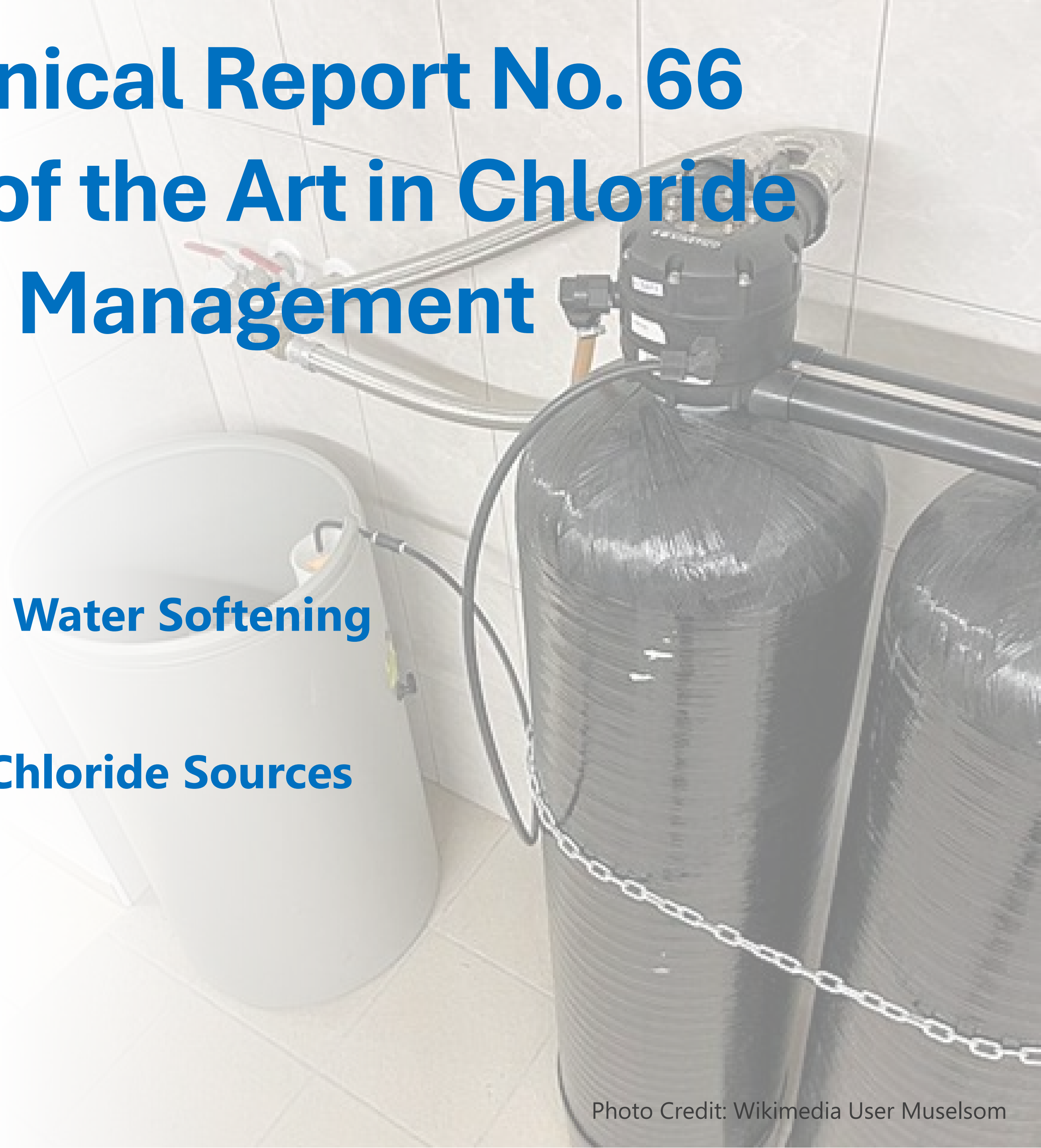
- *PR-57 A Chloride Impact Study for Southeastern Wisconsin*
- *TR-61 Field Monitoring and Data Collection for the Chloride Impact Study*
- *TR-62 Impacts of Chloride on the Natural and Built Environment*
- *TR-63 Chloride Conditions and Trends in Southeastern Wisconsin*
- *TR-64 Regression Analysis of Specific Conductance and Chloride Concentrations*
- *TR-65 Mass Balance Analysis for Chloride in Southeastern Wisconsin*
- ***TR-66 State of the Art for Chloride Management***
- *TR-67 Legal and Policy Considerations for the Management of Chloride*



Review of Summary Notes from November 12, 2025, Technical Advisory Committee Meeting

Technical Report No. 66
State of the Art in Chloride Management

- **Chapter 4 – Private Water Softening and Treatment**
- **Chapter 5 – Other Chloride Sources**



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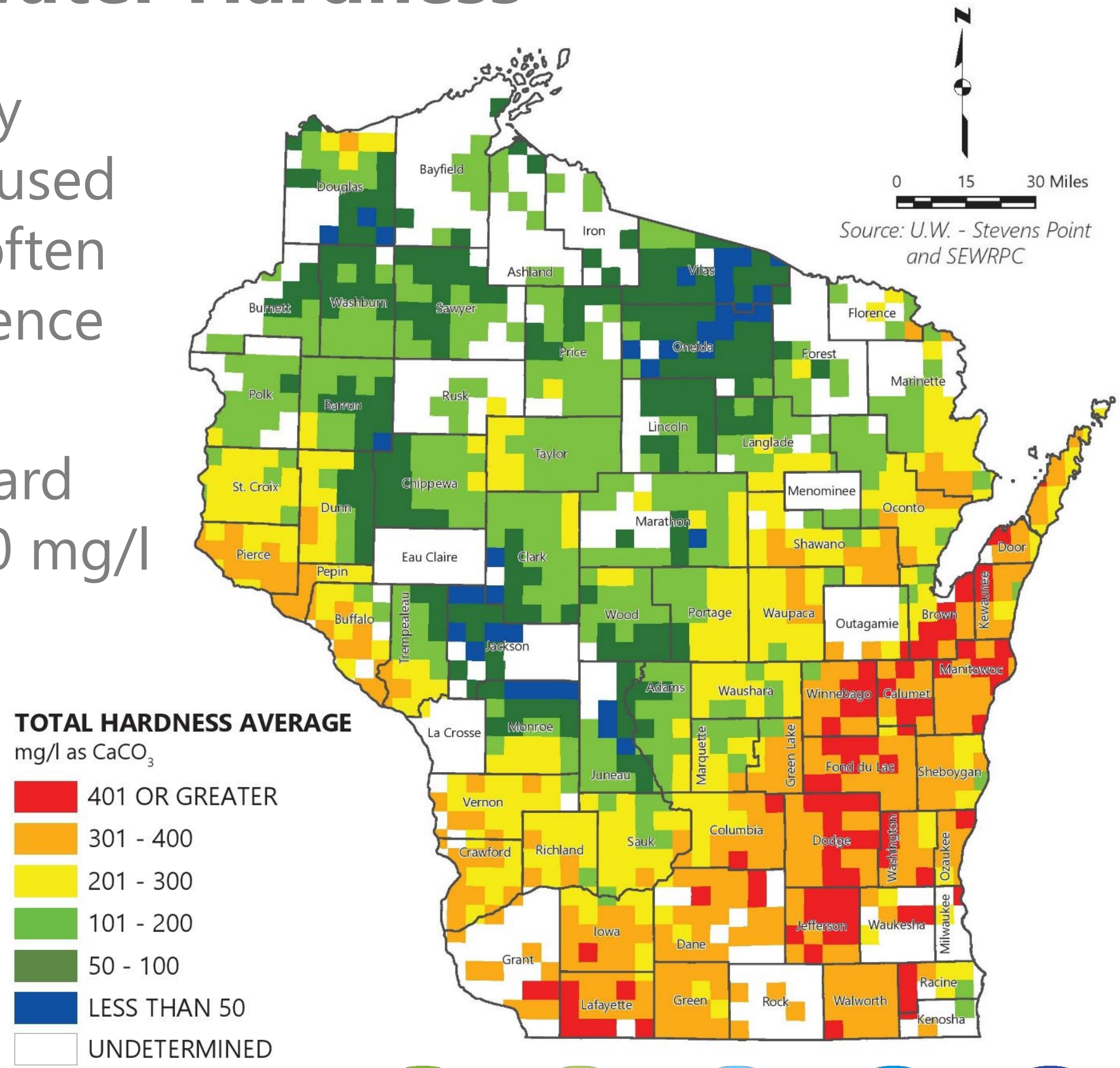
Chapter 4 – Private Water Softening and Treatment

Chapter Overview

- Introduction
- Conventional water softeners
- Alternate and emerging technologies
- Factors influencing water softening
- Impacts on septic systems

Groundwater Hardness

- Areas with naturally hard groundwater used as drinking water often have a high prevalence of water softening
- WI generally has hard groundwater (>120 mg/l as $CaCO_3$)



Hardness

- Hardness in water is primarily determined by the amount of Ca^{2+} and Mg^{2+} ions

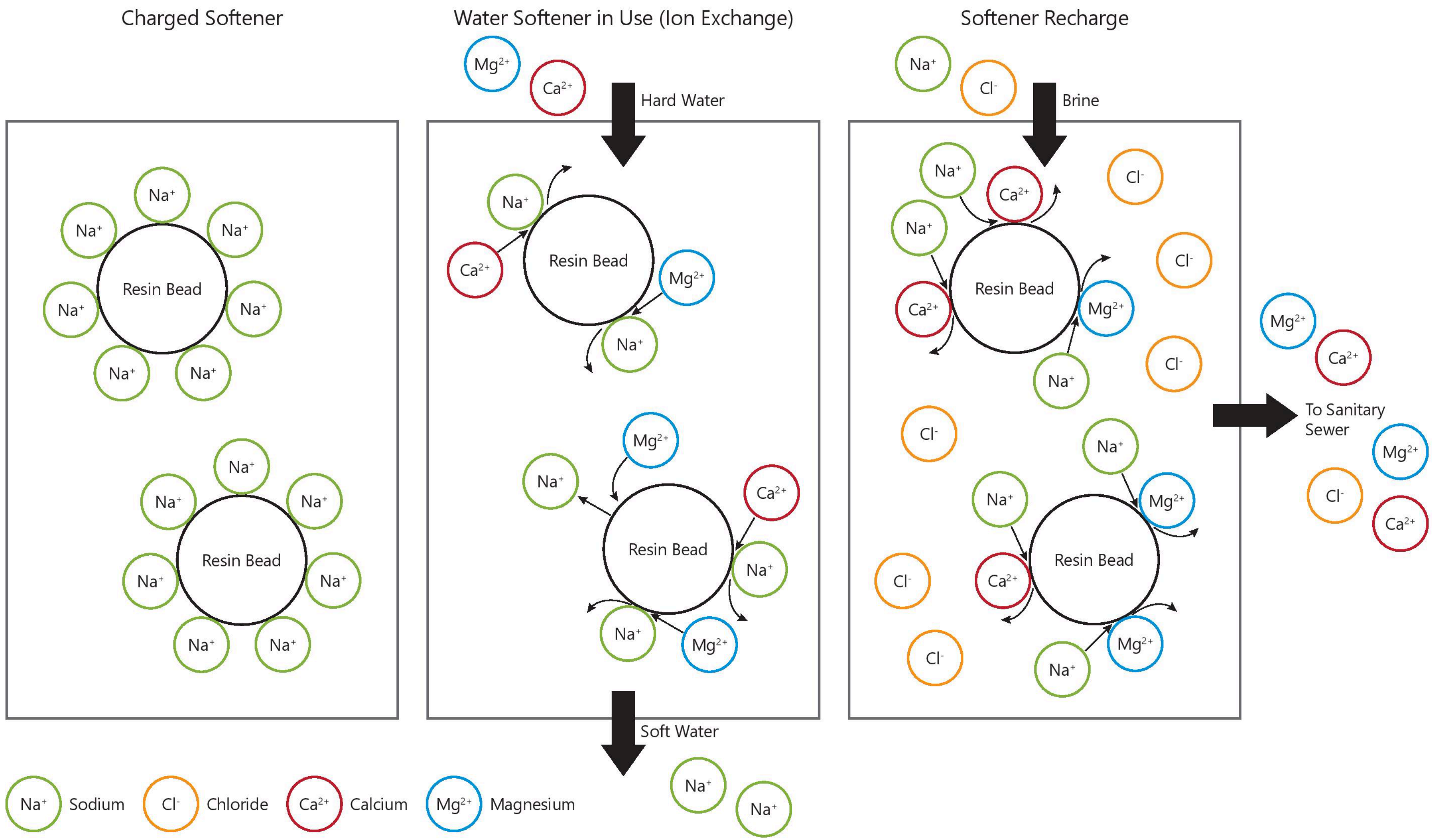
- Effects of excess hardness
  - No negative health impacts
  - Buildup of scale in plumbing and appliances
    - Decreases performance and efficiency
    - Can decrease usable lifespan
  - Inhibit lathering of soaps and other cleaning agents
  - Spotty dishes and glasses
  - Stiff laundry

- Hardness is commonly removed by water softening

Water Softening

- Ion-exchange technology
  - Point of entry
- Softening cycle
  - Ca^{2+} and Mg^{2+} ions in the water exchange with cations from an exchange resin
  - The exchange ion is typically Na^{+}
- Regeneration cycle
  - Flushes the system with a salt brine solution (sodium chloride (NaCl))
  - Na^{+} displaces Ca^{2+} and Mg^{2+} from resin, and the Cl^{-}, Ca^{2+}, and Mg^{2+} ions are discharged as wastewater

Water Softening



Source: SEWRPC

Timer-Based Softeners

- Regeneration cycle based on set time interval
- Older technology - less efficient
  - Regenerates too frequently during low water use periods
  - Gaps in service during high water use periods
- Very inefficient when homeowner is away

Demand-Based Softeners

- Regeneration cycle based on flow

- Newer technology - more efficient
  - Regenerates on as-needed basis

- Accommodates water use fluctuations

Alternate Softening Systems – Portable Exchange

- Ion exchange technology
- Self-contained tank
- Regeneration is done at service provider facility
  - Brine capture and treatment systems
  - No salt use in home
- No drain connection required
- No electricity used

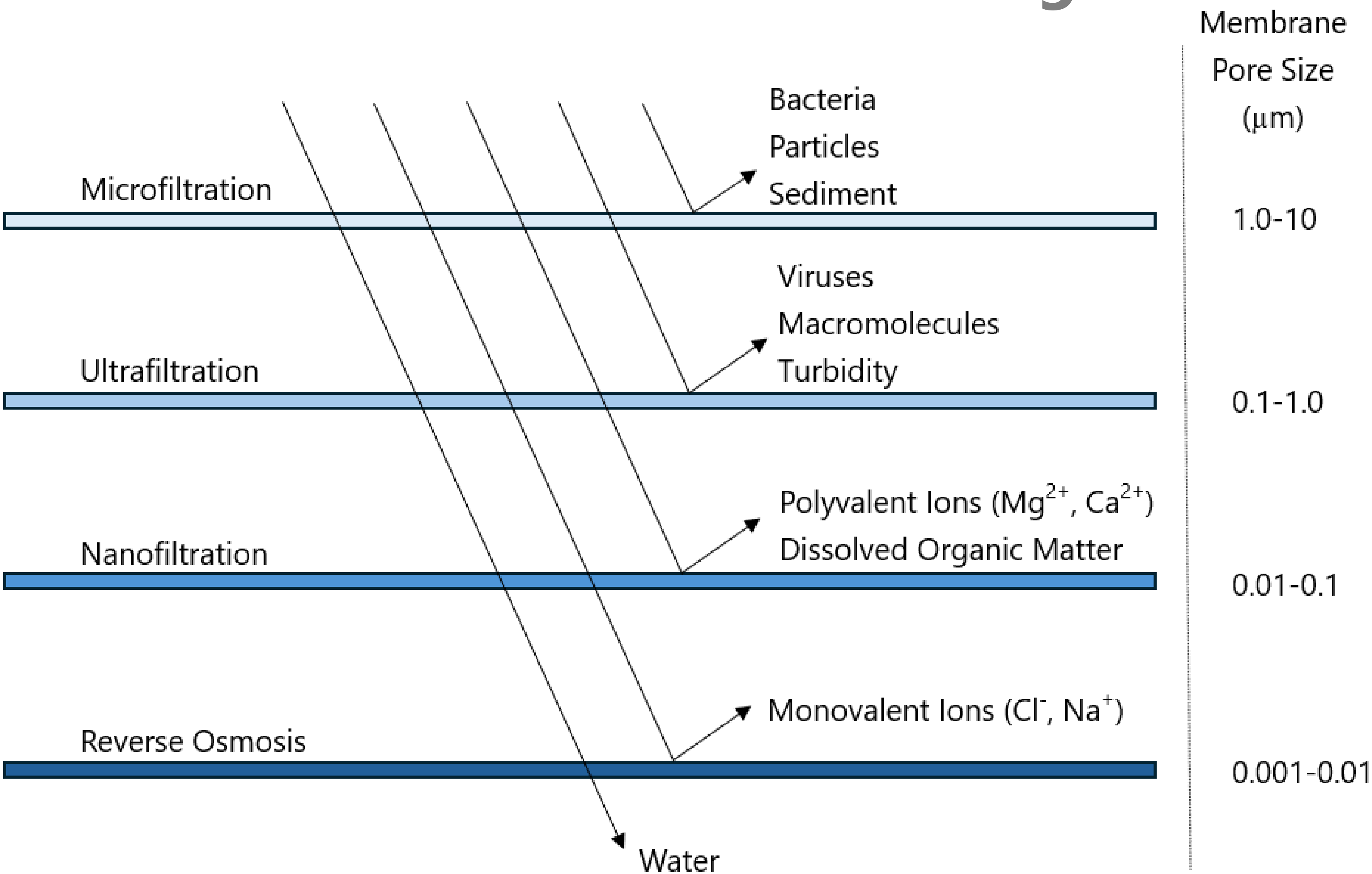
Reverse Osmosis (RO)

- Forces water through semipermeable membrane under high pressure
- Recovery rate can be up to 80%
- Removal efficiency of over 98%
- Can remove dissolved solids including chloride, phosphorus, nitrogen, mercury, sulfate, organic compounds, and other substances
- May not be appropriate for whole house water softening
  - Large amount of reject
  - Hardness can wear out membranes

Nanofiltration

- Pressure-driven membrane filtration, similar to RO
- Lower pressure than RO
  - Less energy consumption
  - Lower operating cost
- Removal efficiency of up to 99%
- Recovery rate of up to 95%
- Pretreatment required to reduce fouling
- Viable option for whole home water softening
  - Lower operating cost
  - Less water wasted
  - No chloride generated

Other Membrane Technologies



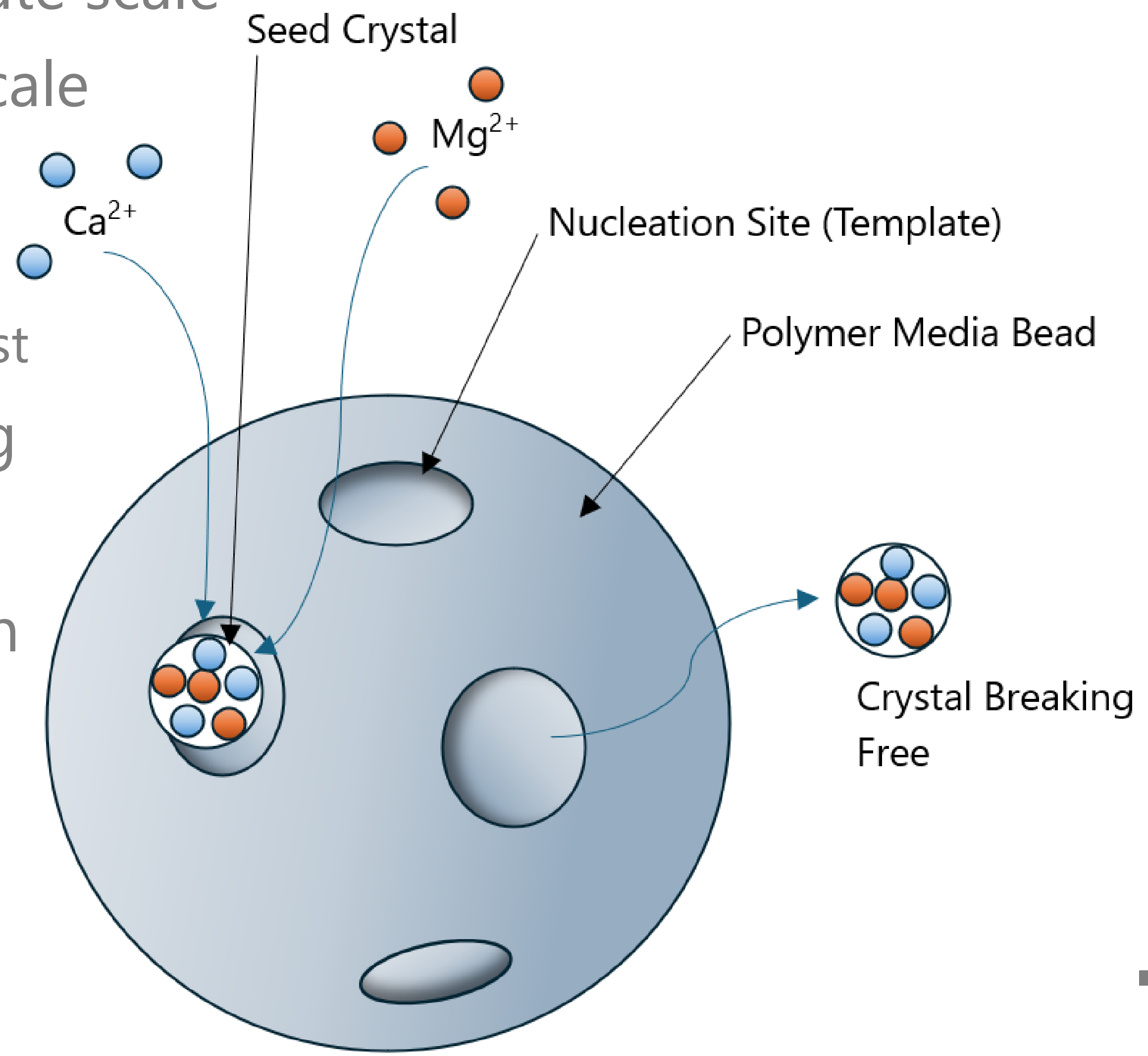
Emerging Technologies

- Water conditioners
  - Template assisted crystallization
  - Magnetic treatment
  - Electrically induced precipitation

- Capacitive deionization

Template Assisted Crystallization

- Forms microcrystals to bind Ca^{2+} and Mg^{2+}
- Do not dissolve or create scale
- Can remove existing scale
  - Restore flow capacity
  - Reduce energy use
  - Reduce water heating cost
- Pass through plumbing and body
- 90 percent reduction in scale buildup



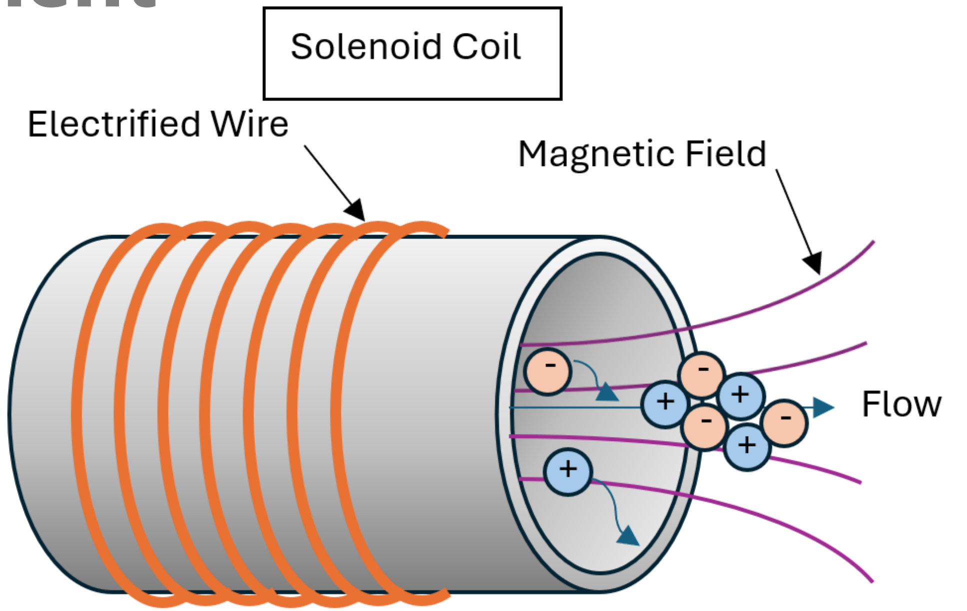
Template Assisted Crystallization

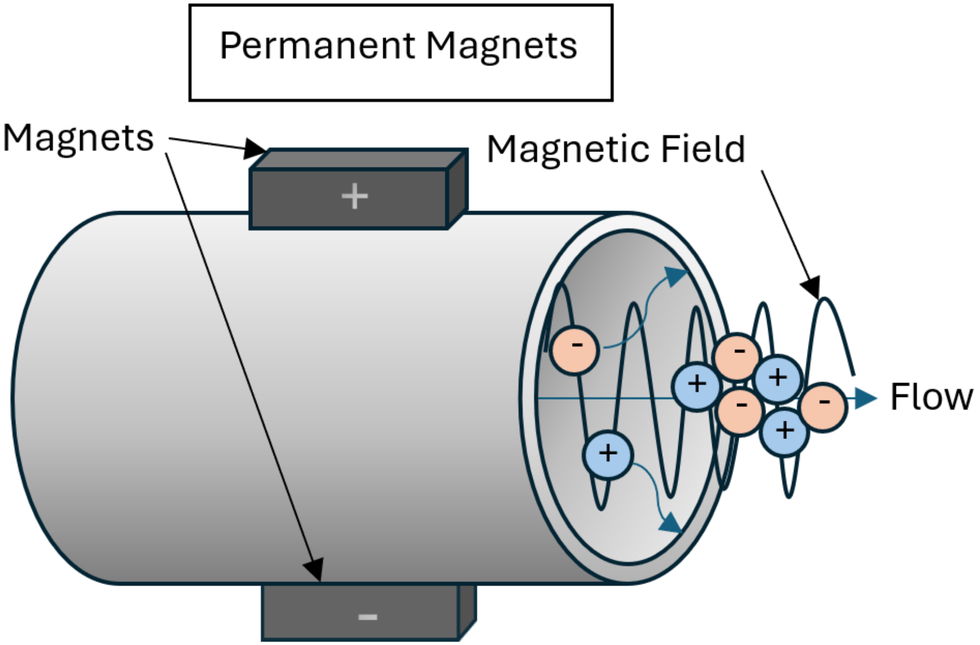
- Does not use salt
  - No chloride production
  - No sodium in finished water
  - Low maintenance
- No wastewater stream
- No electricity

Magnetic Treatment

- Utilizes magnetic fields
  - Solenoid coil
  - Permanent magnets

- Draws cations towards pipe wall and anions towards center
  - Creates soft scale
  - Easily removed



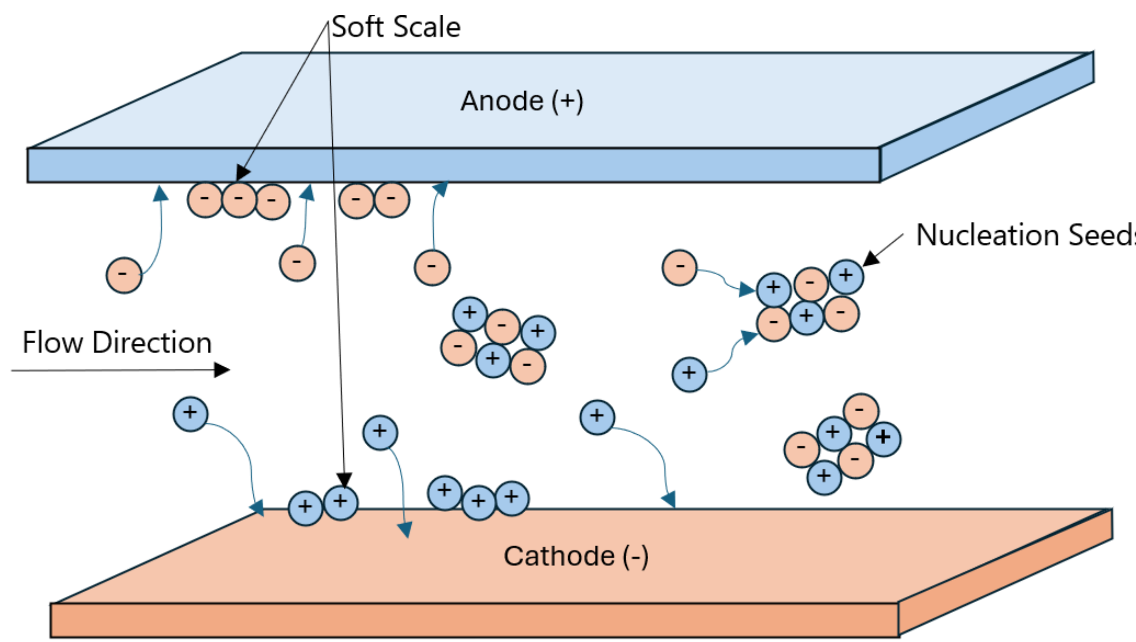


Magnetic Treatment

- Does not use salt
  - No chloride production
  - No sodium in finished water
- No wastewater stream
- Requires electrical connection (solenoid coil configuration)
- Divided opinion on efficacy
  - Some say no evidence of treatment benefits
  - Some say scale reduction up to 50 percent

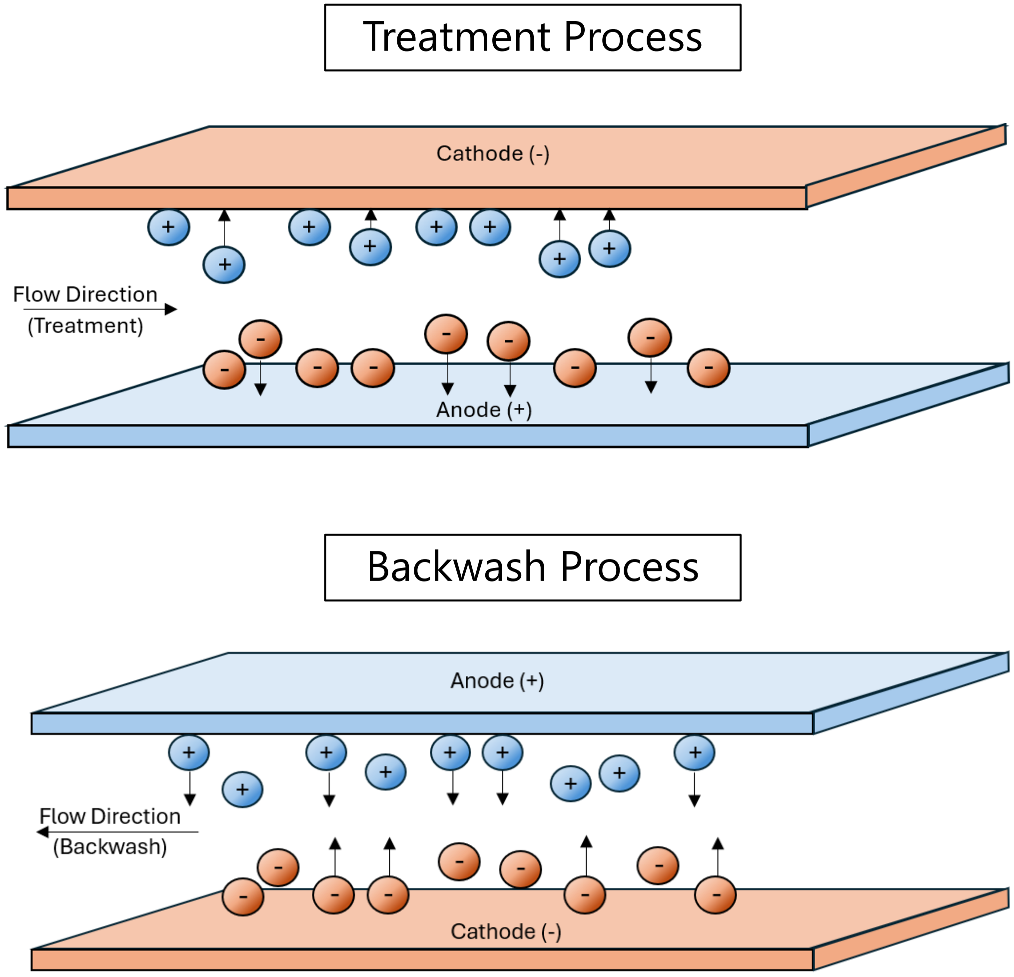
Electrically Induced Precipitation

- Uses electrical fields to precipitate out hardness
- Formation of nucleation seeds
  - Remain suspended in water throughout plumbing system
  - Removes existing scale
- No salt used – no chloride produced
- Scale reduction up to 50 percent



Capacitive Deionization

- Chemical-free water softening technology
- Electrodes capture ions
- Regeneration cycle backwashes the system
- Removes all ions, not just hardness
- Scale reduction up to 80 percent
- Power source and drain connection required



Summary of Emerging Technologies

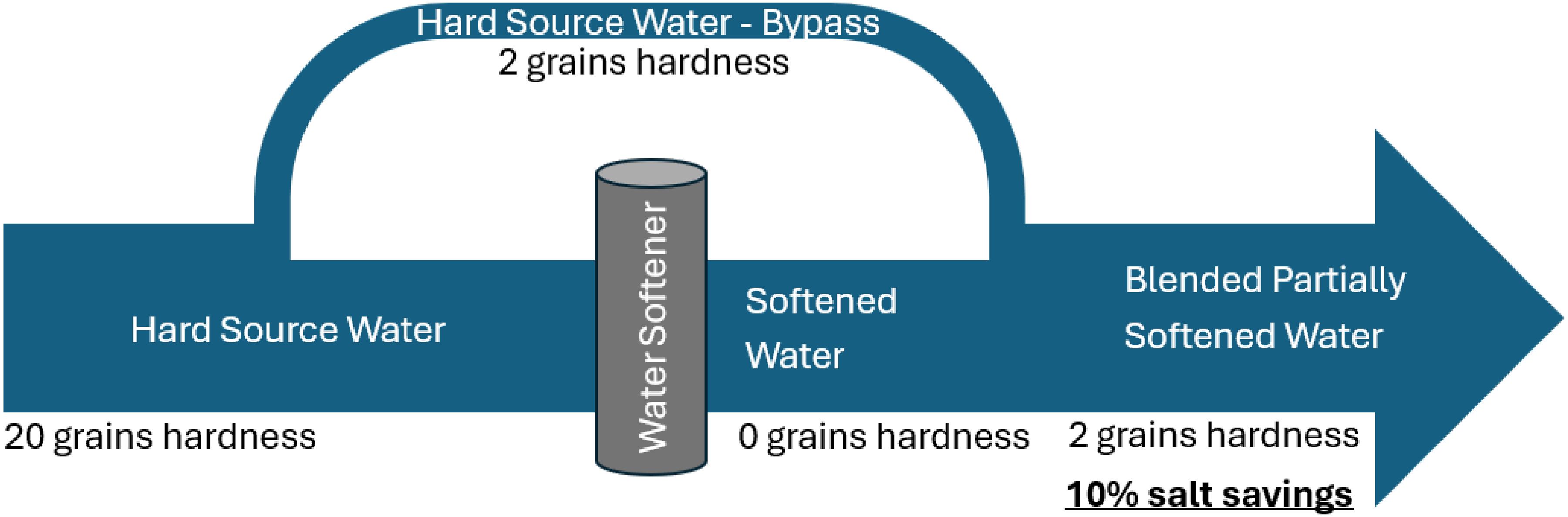
- No salt use and no chloride generation
- Some require no power supply or drain connection
  - Installation flexibility
  - Option for individual apartment units
  - No expensive new plumbing or electrical work
- More development is needed
  - Better understanding of treatment efficiency
  - Plumber training
  - Clearer understanding of costs

Factors Influencing Water Softening Performance

- Blending valves
- Calibration of ion exchange water softeners
- Information, education, and policy

Blending Valves

- Allows a portion of flow to bypass softener
  - Less flow passes through softener
  - Finished water has a certain amount of hardness
- Built-in or installed separately



Calibration of Softeners and Municipal Assistance

- Essential for efficient operation
  - Source water hardness
  - Softener capacity
  - Water use per person – timer systems only (70 gpdc)
- Recalibrate when source water hardness changes
  - Change in number of people in household – timer systems
- Municipal assistance
  - Education
    - Harmful impacts of chloride
    - Responsible water softener use
  - Financial assistance
    - Softener calibration services
    - Softener upgrades

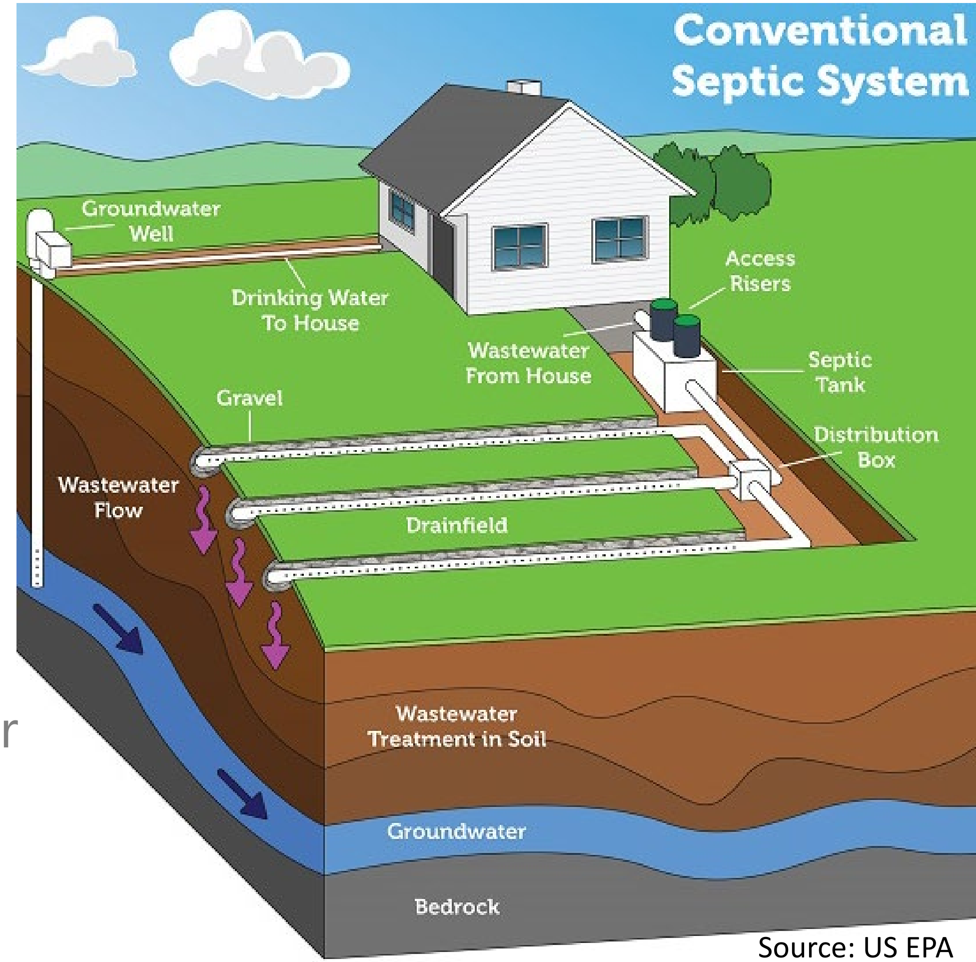
Impacts of Softening on Septic Systems

- Septic systems treat all wastewater for households not connected to municipal sanitary sewer
  - Sanitary flows
  - Shower
  - Laundry
  - Softener regeneration brine

- Two main configurations
  - Conventional
  - Mound

Conventional Septic Systems

- Septic tank
  - Solids removal via settling and flotation
  - Digestion of organic matter
- Drainfield
  - Filters through gravel and native soil
  - Removes coliform bacteria, viruses, and nutrients
  - Treated effluent enters groundwater
- Typically uses gravity flow
- Requires adequate depth to water table and acceptable native soil type

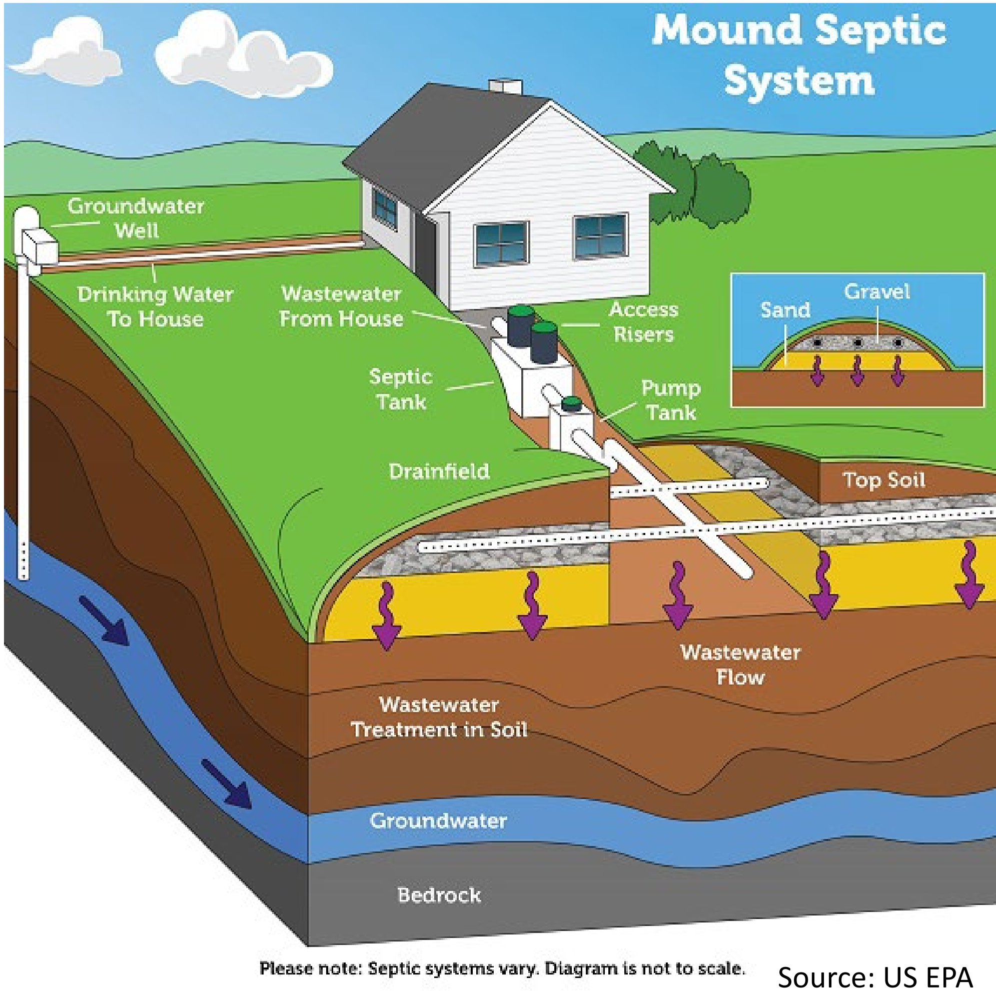


Source: US EPA

Please note: Septic systems vary. Diagram is not to scale.

Mound Septic Systems

- Same general process as conventional system
- Drainfield is in above-grade mound
- Pumped from septic tank to drainfield
- Viable alternative
  - Shallow soil depth
  - High groundwater
  - Shallow bedrock



Source: US EPA

Impacts of Water Softening on Septic Systems

- Four main areas of impact
  - Septic tank treatment performance
  - Drainfield performance
  - Tank corrosion
  - Hydraulic loading

- Scientific opinion is divided

- Recent studies show efficient softeners may not harm septic systems and may even improve performance

Questions?

Ch. 5 – Other Chloride Sources

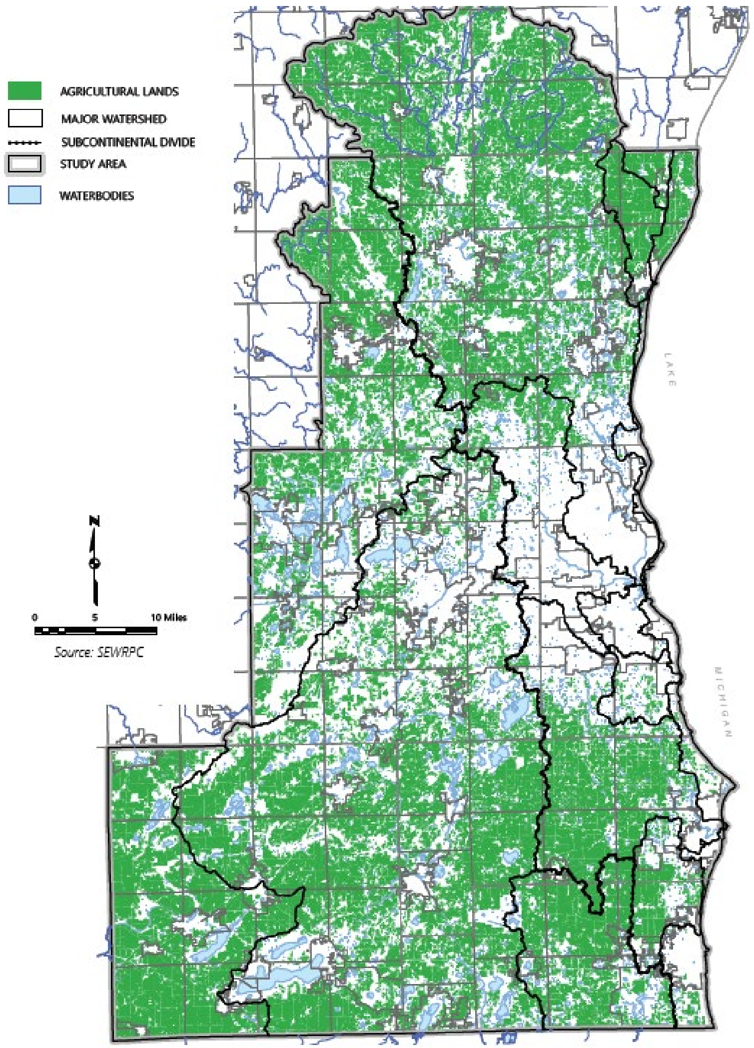
- Agricultural
  - Synthetic Fertilizer
  - Feedlots and Manure Management
- Industrial Food Processing
  - Dairy
  - Meat
  - Vegetable/Fruit Canning

Agricultural Fertilizer

- Background Information
- Alternatives to Potassium chloride
- Precision Agriculture Technologies
- Traditional Conservation Practices
- Controlled Release Fertilizers
- Drain Tiles and Drainage Control Systems
- Conclusions

Background Info – Ag Fertilizer

- 41.1% of study area is used for agricultural activities.
  - Corn, soybeans, and wheat
- Crops need nitrogen (N), phosphorus (P), and potassium (K).
- K is applied as potash
  - 95% of potash application in the U.S. is in the form of Potassium chloride (KCl).



Background Info – Ag Fertilizer

- KCl is 47% chloride by weight.
- When applied to a field, K is a macronutrient utilized by the plant roots, while Cl is a micronutrient less utilized.
- One study found that 94% of the Cl applied to a corn field remained after harvest.
- Excess Cl remains in the soil and can makes its way into surface or groundwater.

Alternatives to KCl

- There are alternative K fertilizers to KCl that contain little to no Cl
- Other synthetic fertilizers
  - Potassium sulfate (K_2SO_4)
  - Potassium nitrate (KNO_3)
  - Potassium thiosulfate ($K_2S_2O_3$)
- Mineral alternatives
  - Potassium-magnesium sulfate (langbeinite) ($K_2SO_4 \cdot 2MgSO_4$)
  - Potassium feldspar ($KAlSi_3O_8$)
- Soil amendments
  - Compost
  - Biochar
  - Glauconite

Alternative Synthetic K Fertilizers

- Potassium sulfate
  - Pros: Provides 2 macronutrients (K & S), no Cl
  - Cons: Less available K, expensive (3.6 to 5.5x more expensive apply equivalent K)
- Potassium nitrate
  - Pros: Provides 2 macronutrients (K & N), highly soluble, no Cl
  - Cons: N runoff can lead to harmful algal blooms, expensive (5.7 to 9.1x more expensive apply equivalent K)
- Potassium thiosulfate
  - Pros: Provides 2 macronutrients (K & S), no Cl, highly soluble, usually applied directly to the plant
  - Cons: Less available K, expensive (11.8 to 19.6x more expensive apply equivalent K)

Alternative Mineral K Fertilizers

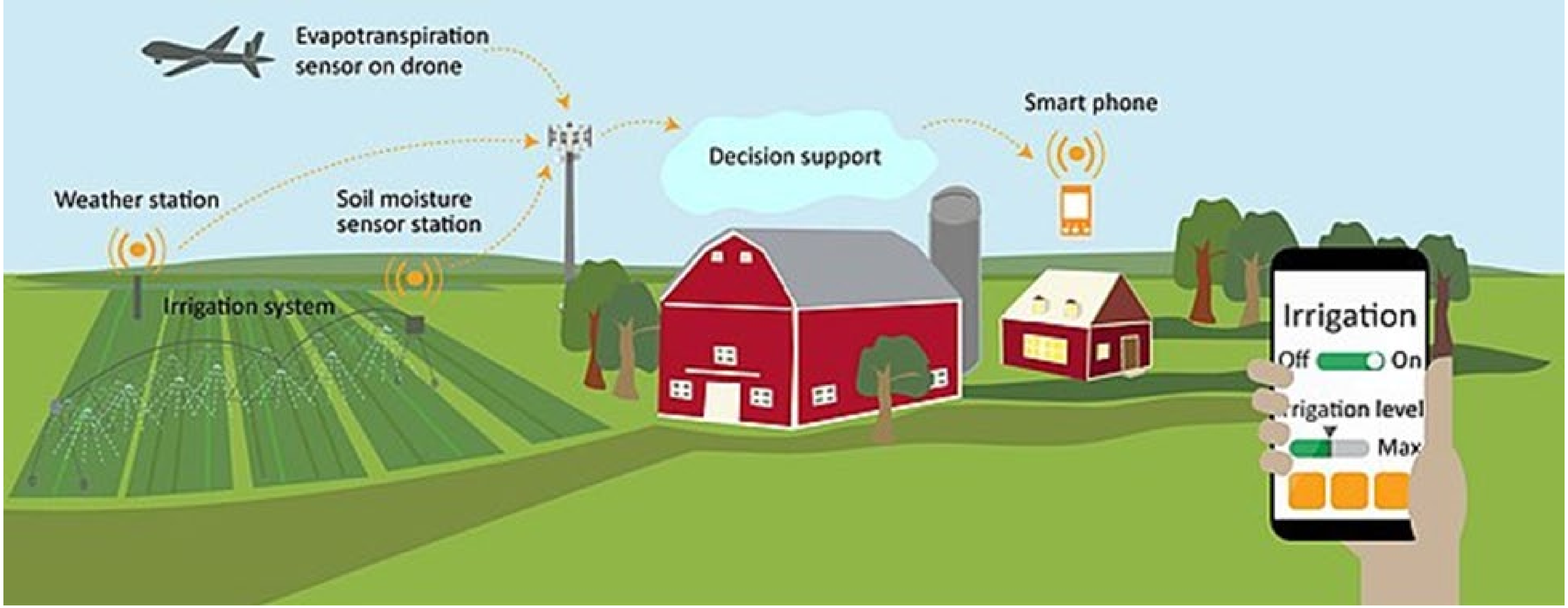
- Potassium-magnesium sulfate (langbeinite)
  - Pros: Provides K, Mg, & S, contains little to no Cl^-
  - Cons: Concerns over nutrient availability to plants, expensive (3.8 to 8.7x more expensive apply equivalent K)
- Potassium feldspar (stonemeal)
  - Pros: Highly available mineral in the ground (10% of weight in soils), little to no Cl
  - Cons: Commonly cited slow leaching of K^+ (recent studies show it may be faster), expensive (1.5 to 3.9x more expensive apply equivalent K)

Soil Amendments

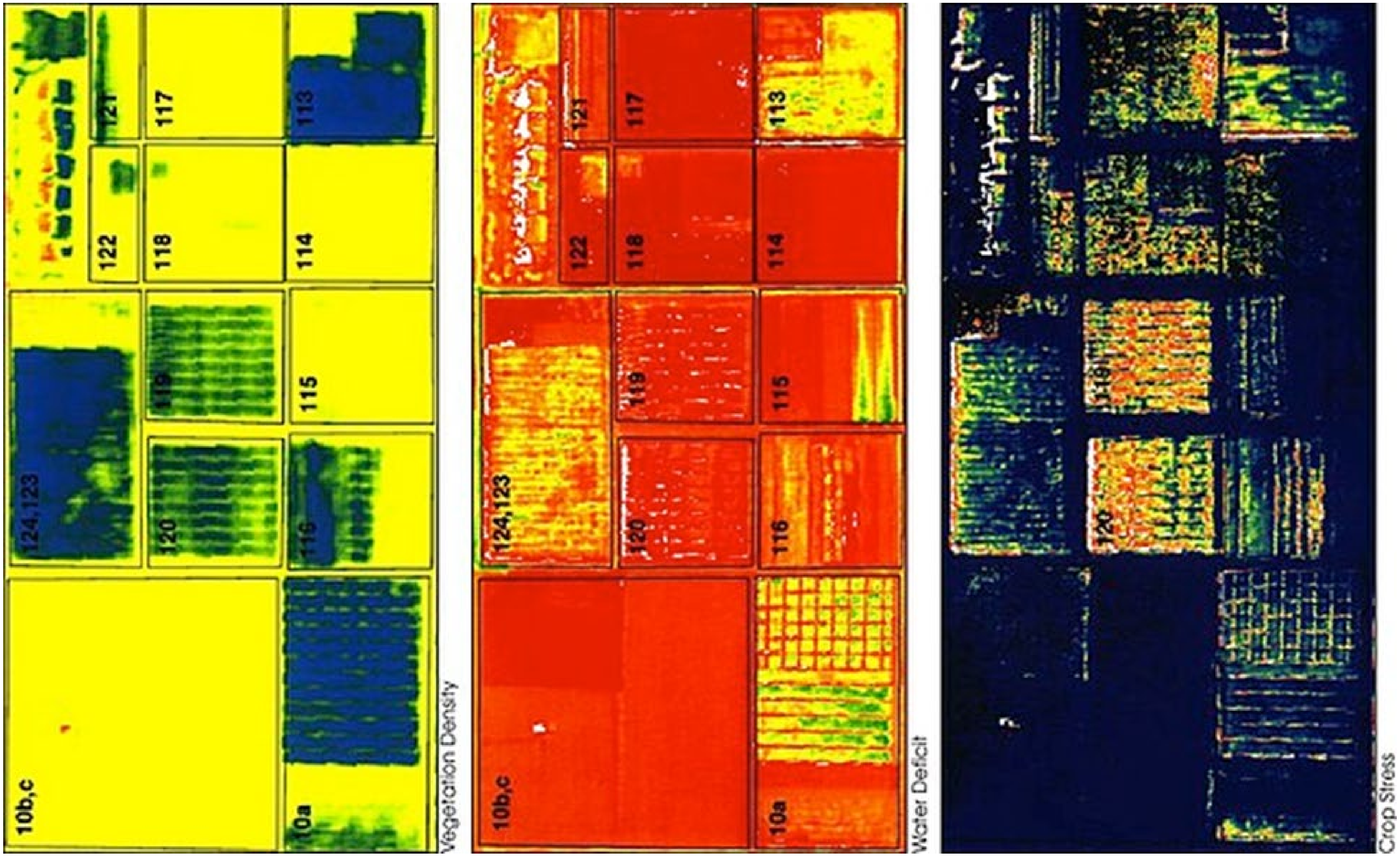
- These are not designed to replace KCl but rather improve soil health over time so that less fertilizer need to be applied in subsequent years.
- Compost
  - Pros: Supplies some K, improves soil health, moisture, nutrient retention, structure, microbial activity, contains little to no Cl
  - Cons: Does not provide enough K to replace KCl, variable composition, require initial investment in time, land, and machinery
- Biochar
  - Pros: Carbon rich material, improves soil structure, water and nutrient retention, long term carbon sequestration, no Cl
  - Cons: May not supply K in a meaningful manner, needs specialized equipment to create
- Glauconite (greensand)
  - Pros: Provides long term nutrient availability, contains little to no Cl
  - Cons: Gradual release of nutrients may not be sufficient for seasonal crops

Precision Ag Technologies

- Variable rate application of nutrients
  - I.e., apply nutrients in spots where they are needed and decrease applications in place where they are not.
  - Reduces over application of nutrients therefore nutrient loss through runoff.



Precision Ag Technologies



Traditional Conservation Practices

➢ Buffer Strips

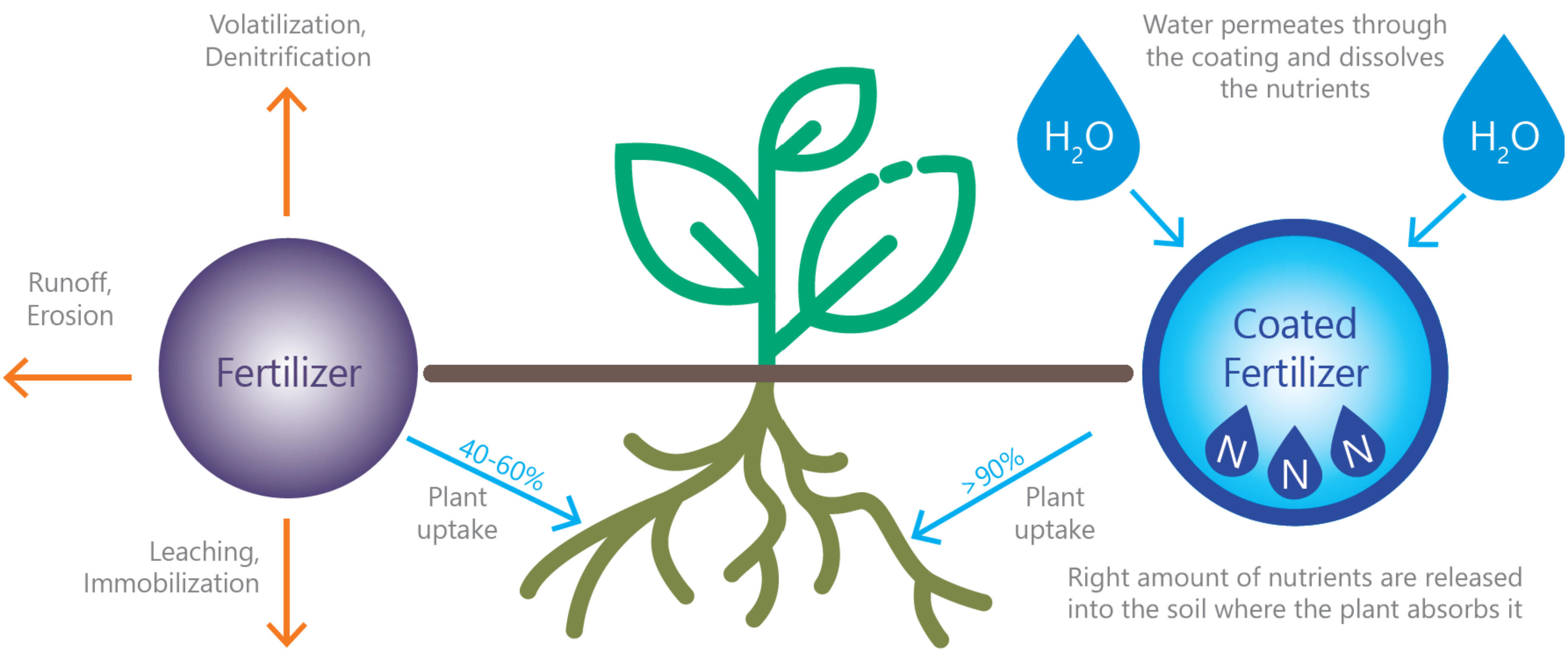
- Designed to intercept and slow runoff
- Uptake nutrients in runoff
  - N and P
- Cl is a micronutrient
- More work is needed to quantify Cl uptake

Traditional Conservation Practices

- Cover Crops
  - Cover the bare soil during non-growing season or between row crops during the growing season
  - Control soil erosion, stabilize soil surface, slow down water movement, minimize lost nutrients in runoff and wind.
  - Uptake nutrients
  - More work is need to quantify Cl uptake from cover crops

Controlled Release Fertilizers

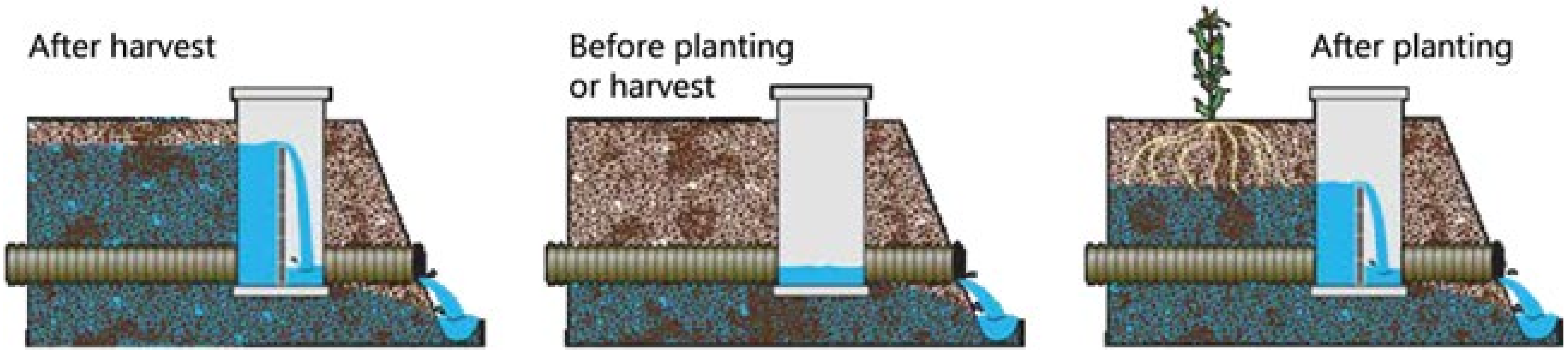
TRADITIONAL FERTILIZER: **CONTROLLED-RELEASE FERTILIZER:**



Drainage Control Systems

- Applied Cl ions can escape field through sub-surface drain tiles
  - Direct conduit to surface water
  - David et al. (2016) concludes riverine chloride response to chloride inputs from agricultural fertilizer was rapid, due to tile drainage.
- Drain tile control systems can be used to slow down export of Cl from fields, however, not reduce the overall amount of Cl in drainage water

Controlled Drainage



Concluding Remarks

- KCl is widely used as a fertilizer in agricultural fields.
- Alternatives are available but barriers to use are high.
- Traditional BMPs are unlikely to reduce Cl export from fields.
- Thus, a better approach to reducing Cl exports from fields is to minimize the amount of Cl being spread in the first place.
  - Precision Agriculture Technologies
  - Controlled Release Fertilizers
  - Soil Amendments
- More research is needed on:
  - Cl uptake from crops, buffer strips, cover crops
  - Methods to remove Cl from fields, runoff, or shallow groundwater
  - Methods of reducing the barriers to use of alternative fertilizers

Manure Management

- Background Information
- Nutrient Management Plans
- Regulations Regarding Smaller Animal Feeding Operations
- Other Manure Management Methods
- Conclusions

Background Info

- NaCl and other micronutrients containing Cl are commonly found in animal feed.
- Cl is excreted in manure which is then applied to agricultural fields as fertilizer (mainly for N and P).
- The amount of Cl in animal manure varies widely both in amount and in units reported.
  - TR 65 Ch. 3, Table 3.7
- Overall, animal manure represent 0.75 percent of the annual chloride loading to the Region.
  - As compared to local, state, and private road and parking lot deicing (58.7%)

Reducing Cl Exports from Manure

- There are no methods available to directly remove Cl from manure.
- Methods are better served focusing on ways to:
  - Apply manure in a more efficient manner
  - Reduce manure runoff from fields
- Methods to accomplish the above are:
  - Nutrient Management plans
  - Manure Incorporation
- As well as the previously mentioned precision agriculture technologies, buffer strips, and cover crops.

Nutrient Management Plans

- Guide the application of manure and other fertilizers to:
  - Meet crop nutrient needs
  - Minimize excess nutrient runoff
  - Improve crop yield
  - Reduce overall costs
- In WI, 1/3 of cropland acres are under NMPs
- Agricultural operations require NMPs if they:
  - Are a Concentrated Animal Feeding Operation (CAFOs)
  - Participate in the Farmland Preservation Program
  - Accept cost-sharing
  - Regulated under a local ordinance

Smaller AFOs

- Medium CAFOs
  - 300 to 999 animal units
  - AND have caused a Category I discharge to navigable waters or caused fecal contamination of a groundwater well.
- Small CAFOs
  - Less than 300 animal units
  - AND Category I discharge that has contribute a significant number of pollutants to navigable waters.

Manure Application/Incorporation

- Broadcast Application
  - Spraying manure ON TOP of soil.
  - Pros: Cheap, easy, quick. Can be done on all types of soil (i.e., frozen)
  - Cons: N is prone to loss from volatilization; P can easily runoff during rain or snowmelt
- By incorporating manure INTO the soil, losses can be reduced.
  - Manure is applied while soil is turned over or manure is injected below the surface

Concluding Remarks

- Animal waste is widely spread as manure on agricultural fields, providing nutrients (mainly N and P).
  - Contains some Cl
- Nutrient management plans are an effective method of improving manure application efficiency and protecting environmental resources.
- Manure incorporation and injection are effective ways to reduce nutrient losses.
- More research is needed on quantifying Cl content in animal waste.

Industrial Food Processes

- Background Information
- Typical In-Place Wastewater Treatment Processes
- Chloride Removal Alternatives
- Conclusions

Background Info – Dairy Processing

- Transformation of raw milk into products:
  - Pasteurized milk, cheese, butter, ice cream, whey powders, etc.
- Main contaminants in dairy processing wastewater:
  - Organic matters, fat, oil, grease, solids, N, and P
- Cl enters the wastestream through the brine used to salt cheese.
  - Other sources include water softening, cooling liquors, and the source water.
- Untreated dairy processing WW
  - Range of averages: 150 to 616 mg/L
- Treated dairy processing WW
  - 24.8 to 92.9 mg/L

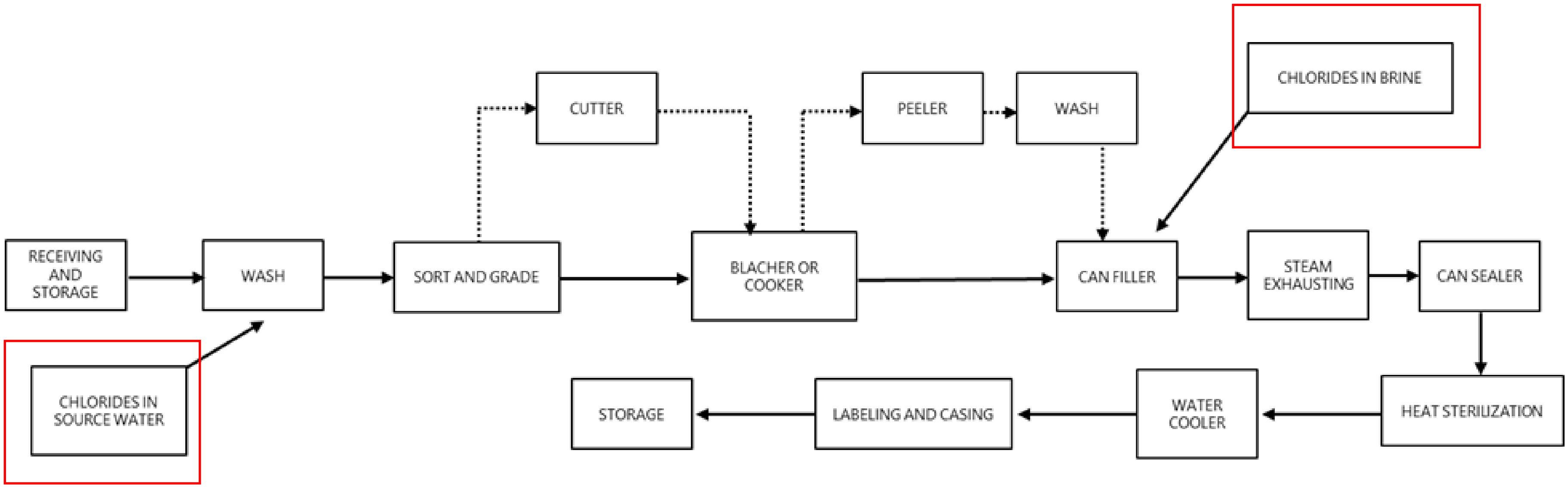
Background Info – Meat Processing

- Operations including
  - Slaughter of livestock, poultry, and small game
  - Further processing into meat products
  - Rendering waste from slaughter or further processing.
- Typical contaminants in meat processing WW:
  - Organic matter, fat, oil, grease, suspended solids, P, N, Na
- Cl enters wastestream through:
  - Hide processing, kosher slaughter, curing, smoking, pickling, and marinating
- Meat processing WW chloride conc: 675 mg/L
- Poultry processing WW chloride conc: 98.8 mg/L
- Rendering WW chloride conc: 467 mg/L

Background Info – Canning

- Fruit and vegetable canning produces:
  - Canned, pickled, and brined fruits and vegetables
  - Canned juice, canned jams/jellies, canned tomato sauces, pickles, etc.
- Primary objective of canning process is to destroy microorganisms and prevent recontamination.
- Typical contaminants include:
  - Organic matter and suspended solids
- Cl is introduced to the wastestream through process source water and can filler brine.
  - Brine is used to maintain flavor
- Brine has a salt concentration of 15,000 to 80,000 mg/L

Vegetable Canning Process Diagram



VEGETABLE CANNING

Typical In-Place Processes

- Typical WW treatment processes in food processing plants are similar to typical municipal wastewater treatment.
- At minimum, before being sent off site:
  - Preliminary treatment: Screening of large debris
- Can also include:
  - Primary treatment: Settling out particulates and floating solids
  - Biological treatments: Reduction of organic matter oxygen demand
  - Phosphorus removal: Using microorganisms to remove P from WW
  - Disinfection: Removal or inactivation of pathogenic microorganisms
  - Solids Handling: Preparation of solids generated from primary and biological treatment for off-site disposal
- These processes are not designed to remove chloride nor do they.

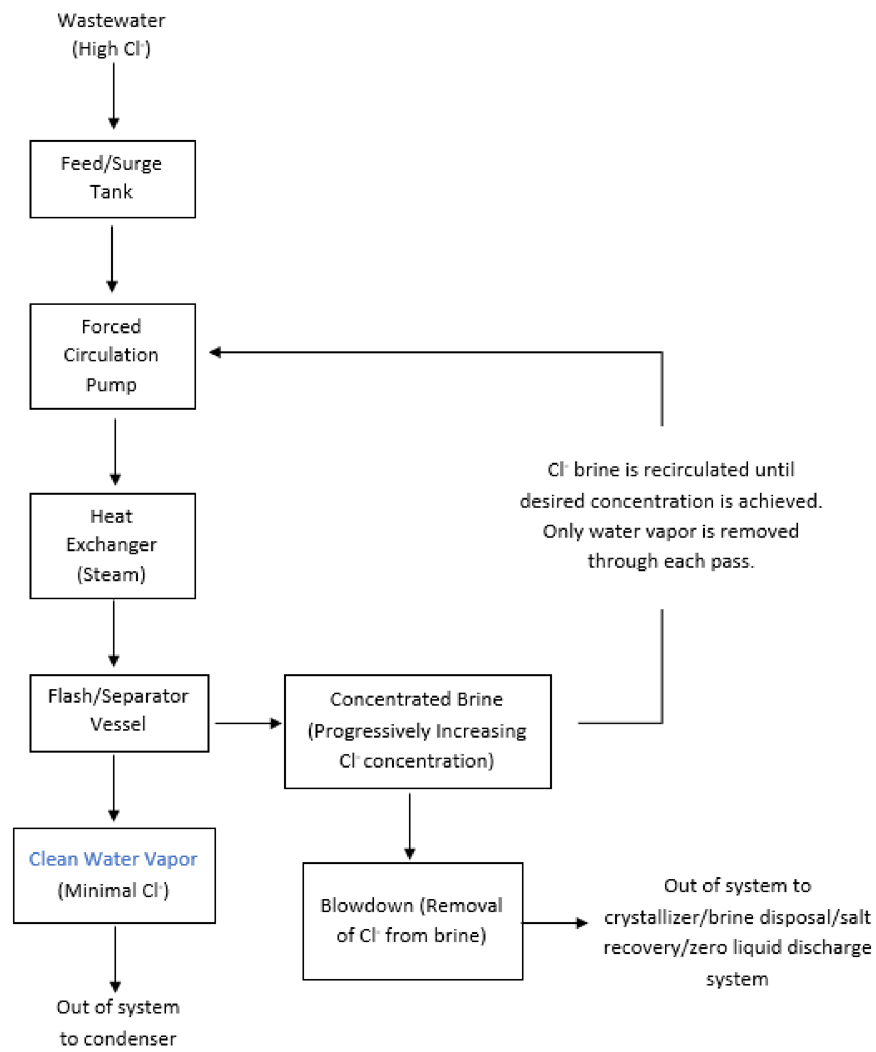
Chloride Removal Alternative

- Separate methods are needed to remove Cl
  - Reverse Osmosis
  - Brine Evaporation Ponds
  - Mechanical Evaporation Systems
  - Deepwell Injection

Brine Evaporation Ponds

- Evaporate water from salt-laden wastewater in the pond.
- Water vapor is salt free
- Leave behind salt deposits in pond
- Only work in areas with net evaporation climates
- Pros: Ease of construction, low maintenance, and minimal operator attention.
- Cons: Large land investment, impervious liner may break.
- Humid continental climate of SE WI not conducive.

Mechanical Evaporation Systems



Deepwell Injection

- Practice of disposing of waste via Class I wells used to inject waste into deep, confined rock formations.
  - Typically thousands of feet below local drinking wells.
- Class I well injection is prohibited in WI

Concluding Remarks

- Food processing industries that have elevated levels of Cl in their wastewater include dairy processing, meat processing, and fruit/vegetable canning.
- Typical wastewater treatment systems are not designed to remove chloride
- Reverse osmosis and mechanical evaporation systems represent methods to remove Cl from wastewater
- Methods used in other areas of the country include brine evaporation ponds and deepwell injection.
- Viable Cl management strategies should focus on source segregation of high Cl streams from other WW streams and targeted removal technologies.

Chapter Conclusions

- Use of synthetic fertilizers (KCl) contributes Cl to the environment.
- Cl in animal waste applied to agricultural fields as manure can also contribute Cl to the environment.
- Use of salt in the food processing industry introduces Cl to the wastestream which is not removed by conventional treatment techniques.
- For agricultural Cl sources, exports are better reduced through smarter applications to reduce the total amount of Cl on fields in the first place.
  - As opposed to trying to remove Cl from fields after application.
- Food processing Cl requires targeted technology to remove it.
  - Reverse osmosis or mechanical evaporation

Questions?

Chloride Impact Study – Next Steps

- Comments on draft chapters can be sent to Laura (lherrick@sewrpc.org)
- Comments are due by March 20, 2026

Chloride Impact Study – Next Steps

- Anticipate next TAC meeting in April 2026 to review the final chapter of TR-66 Chapter 2 (public and private deicing)
- Meeting agendas, presentations, and summary notes along with draft text are posted on project website

  www.sewrpc.org/chloride-study

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PARTNERS FOR A CLEANER ENVIRONMENT

SEWRPC
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Thank You

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