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Water Softeners Research Needs Workshop Proceedings

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WATER SOFTENERS RESEARCH NEEDS

WORKSHOP PROCEEDINGS

2011

WERF

The Water Environment Research Foundation, a not-for-profit organization, funds and manages water quality research for its subscribers through a diverse public-private partnership between municipal utilities, corporations, academia, industry, and the federal government. WERF subscribers include municipal and regional water and wastewater utilities, industrial corporations, environmental engineering firms, and others that share a commitment to cost-effective water quality solutions. WERF is dedicated to advancing science and technology addressing water quality issues as they impact water resources, the atmosphere, the lands, and quality of life.

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TABLE OF CONTENTS

LIST OF ACRONYMS

ATU	Advanced wastewater treatment units
BOD	Biological oxygen demand
Cl	Chloride
COD	Chemical oxygen demand
Na	Sodium
NOWRA	National Onsite Wastewater Recycling Association
RFP	Request for proposals
TDS	Total dissolved solids
U.S. EPA	United States Environmental Protection Agency
WERF	Water Environment Research Foundation
WQA	Water Quality Association

Keywords: Water softeners, onsite water treatment systems, salt.

CHAPTER 1.0

INTRODUCTION

1.1 Background

The Water Environment Research Foundation, in partnership with the U.S. Environmental Protection Agency (U.S. EPA), the National Onsite Wastewater Recycling Association (NOWRA), the Water Quality Association (WQA), the Coalition of Alternative Wastewater Treatment, the National Association of Wastewater Transporters, and other stakeholders, sponsored a research workshop to identify short, mid and long term research needs of the water softener and onsite systems industry. The workshop was designed to identify technical issues and needed research centered on evaluating whether there are negative impacts to onsite systems as a result of water softener brine, and if so, what can be done to mitigate the problem. The principal stakeholders included the water softener industry, the treatment system manufacturers, and state and local environmental health officials.

In 2002, the U.S. EPA released an update to its decentralized system design manual to assist in proper construction of onsite systems. However, the manual did not include sufficient guidance on the potential impacts of water softeners or steps to mitigate them. Because there was no consensus on key technical issues, WQA and NOWRA met in 2007 to develop a common set of goals to move the research agenda forward. Although research projects have taken place, a comprehensive stakeholder driven research agenda was needed to address important unresolved technical issues around the use of water softeners and onsite systems performance. In an informal survey taken by WERF during the States Onsite Regulators Association meeting on June 24, 2009 in Atlanta, Georgia, state regulators expressed the need for more scientific information on potential links between onsite systems performance and water softener issues which could help inform their regulatory decision making.

1.2 Objectives

The principal objective of the workshop was to identify three to six discrete priority issues or concerns that need to be answered in the area of potential or suspect effects caused by water softener discharges to onsite wastewater systems, and what research and funding would be necessary to address these issues. Some areas to be addressed at the workshop were:

1. History of the issue
2. Stakeholders’ concerns and perceptions
3. Key research questions remaining

4. Known questions: N and Cl concentration, septic tank settling, ATU performance, filter plugging, definition of limits and using real science, define a monitoring plan or protocol.
5. Maintenance aspects: Do softeners change/increase maintenance practices? Are softener issues a reflection of weak maintenance on softeners and onsite system?
6. Regulatory aspects: Regulators issues related to softeners
7. Define potential research projects, means of funding, and partnerships

Many water softener-wastewater system concerns come from manufacturers of onsite wastewater treatment systems. Some manufactures of advanced wastewater treatment units (known as ATUs) state in their product literature that the company will not honor their warranties of performance guarantees if regeneration waters from household water softeners are discharged to the system. Research is needed to ascertain specific information and data about these systems and issues. This workshop includes perspectives and information from stakeholders about water softener discharges to onsite wastewater treatment systems.

1.3 Approach

The Planning Committee composed of representatives of different stakeholders in the water softener industry prepared an agenda, helped identify speakers and the approach for the discussions with the support of a facilitator and WERF. The steps used in this workshop to identify and prioritize the research needs were the following and a more detailed description of the outcomes is reported in Chapters 2.0 and 3.0:

Step 1: Presentations by practitioners, academia, researchers, and other experts on the technical background and current state of the science regarding water softeners

Step 2: Presentations by regulators, manufacturers, and other industry representatives on their issues and perspectives

Step 2: Breakout sessions to identify priorities in the topics identified by the Planning Committee to help focus the discussions

Step 3: Plenary sessions to discuss the identified priorities and prioritization of the key areas

Step 4: Breakout sessions to further develop and refine the content of the research needs identified and prioritized

Step 5: Plenary session to discuss the refined research needs and identification of integrating factors

Step 6: Preparation of proceedings report

CHAPTER 2.0

WORKSHOP OVERVIEW

2.1 Identification of Research Needs

Workshop participants were asked to focus on the primary objective of the meeting: *to identify priority topics for research on possible impacts, if any, of water softener discharges to onsite wastewater systems.* The starting point of this effort was to break the participants into six small discussion groups. Groups composed of stakeholder representatives were asked to consider research needs from a particular predetermined perspective. Two groups focused on septic tank performance, two groups focused on advanced treatment unit performance and two other groups focused on soil impacts and interactions. Within each of these perspectives, the groups were requested to think about wastewater characterization issues, treatment process concerns and maintenance requirements.

Each of the groups had a designated convener. The rest of the participants were able to choose which group they wanted to join. The groups had 90 minutes for their conversations and deliberations. To begin, the groups were asked to consider what issues and concerns were key to resolving uncertainties about possible water softener effects, positive and negative, on onsite systems. Then they were to come up with a list of up to five ideas for research that would most significantly and usefully advance the collective knowledge. Each group self-facilitated. They were asked to record their list of possible research topics on flipcharts. No other notes of the discussion were taken.

The six groups came up with a combined total of 28 research ideas (one was added later in the Plenary Session). Each group made an oral presentation to the full assembly of participants. The presentations summarized the results from the groups' work and briefly described the purpose of each prospective research topic. Other group participants were able to ask clarifying questions. These are the 29 research ideas (with their vote tallies):

1. Wastewater characteristics	6 votes
2. Sludge characteristics	0 votes
3. Effluent filter	0 votes
4. Softeners and tank size	0 votes
5/9. Softeners and nitrification	15 votes
6. Softeners and sludge settling	9 votes
7. Softeners impact on cation ratio	0 votes
8. Softeners and nuisance (e.g. slime) growth	0 votes
10. Softeners and emerging technologies	6 votes
13. Softeners and iron removal	9 votes
14/20. Backwash inflow and effluent clogging	17 votes

15.	BOD, TSS and FOG impacts on effluent	33 votes
16.	Wastewater characteristics	43 votes
17/11.	Tank sedimentation and stratification	41 votes
18/12.	Chemical impacts on tank performance	23 votes
20.	Maintenance and tank performance	22 votes
21.	Clogging mat characterization	0 votes
22/26.	Clogging mat functionality	14 votes
23/24.	Soil profile chemical balance	8 votes
25.	Softeners impact on vegetation	0 votes
27.	Soil plugging and permeability issues	28 votes
28.	Distribution system maintenance	0 votes
29.	Survey of onsite systems	37 votes (Added during Plenary discussions)

The facilitator next led a full group effort designed to develop some consensus about the highest priorities from among the proposed topics. The first step considered whether duplicate topics existed and whether it would make sense to combine any of the topics. After discussion, six pairings of topics were made that were either basically the same issue or closely related (the pairings were items 5 + 9, 11 + 17, 12 + 18, 14 + 20, 22 + 26, and 23 + 24). Subsequently, a more general conversation took place looking across all of the suggestions to see if anything important might be missing or if there were suggestions for improving the focus of any particular idea. This resulted in one new project being added to the list (#29, a survey of existing onsite systems with and without water softeners). Suggestions were also adopted to expand the 12 + 18 pairing to include anaerobic analysis and to expand the 14 + 20 pairing to consider possible corrosive effects of water softeners.

The second step of the full group effort was to individually vote on the top priorities. Each participant was given 15 votes which could be cast, with no more than three votes going to any one topic. The topics which received the most votes were:

# 16	Identifying wastewater influent and effluent characteristics (43 votes)
# 17/11	Sedimentation and stratification in septic tanks (41 votes)
# 29	Survey of onsite systems with and without softeners (37 votes)
# 15	Effects on septic tank effluent (33 votes)
# 27	Soil plugging and permeability issues (28 votes)

At the conclusion of voting, the full group assessed the overall output to determine if any of the next tier of vote-getters should also be elevated into the top group. There was recognition that all topics, even those that received few votes, were important. However, in the interest of bringing focus to the highest priority issues, there was a consensus that no other topics be added to the original five. Suggested modifications were given to three of the original five: the wastewater characterization topic (#16) might usefully include some look at Fats, Oils, and Grease, Total Dissolved Solids and water hardness (from topic #1); the sedimentation topic (#17/11) might be strengthened by incorporating some of the parameters from the sodium calcium ratio on settling (topic # 12); and the septic tank survey (#29) might benefit by specifically considering nitrogen and phosphorus concentrations (from topic #5/7).

2.2 Development of Priority Research Topics

Once agreement on the top five topics was reached, the participants self-selected which one they wanted to help develop further. The resulting five groups met separately for 90 minutes to begin addressing the following:

1. Description of the research need
2. Identification of technical, regulatory, management, financial, and other key issues
3. Estimated cost to do the research
4. Explanation of why addressing this research need is important
5. Identification of potential financial partners for the research
6. Desired research outcomes at the basic, applied, or demonstration level as appropriate
7. Identification of who should do the research

When the small groups completed their preliminary assessment of the research need, they gave a brief report to the full group, with opportunity for clarifying questions to be answered. Each group identified a similar core cadre of potential financial partners (WERF, U.S. EPA, WQA, and NOWRA). All of the groups said that they had difficulty coming up with good estimates of the potential cost for the research. In total, the groups projected a need of $1.8 million to do the proposed work. Several participants believed that the actual costs would turn out to be much higher. A few participants asked whether there should be some sequencing of the research (e.g. that it might be useful for the septic tank survey to be done prior to some of the characterization research), however, participants stated that it would make little difference and that whatever could be funded should commence as soon as possible. In addition, it was stated that there needs to be good coordination among these research projects to ensure the researchers all know what is going on and are able to take advantage of what has already been learned.

A number of other suggestions for moving forward came out of the general discussion. Several participants echoed the importance of keeping the research focused and not trying to do too much. It is also considered extremely important that in the further conceptualization of the research, all relevant and affected parties contribute. This will be necessary to ensure these parties' appropriate concerns will be addressed. Also it was emphasized that using reputable, objective researchers and certified labs will be critical to the acceptability of the work.

2.3 Next Steps

This report summarizes the proceedings of the research needs workshop including the priorities identified by the participants, and detailed information that should be considered in further developing these concepts and issuing requests for proposals. WERF will work with stakeholders, subscribers, and other industry actors to explore collaboration on these important research areas.

CHAPTER 3.0

REFINED RESEARCH NEEDS

3.1 Introduction

This chapter contains the refined research needs information developed by the participants on each of the top five topics. This information addresses the following areas:

1. Description of the research need
2. Identification of technical, regulatory, management, financial, and other key issues
3. Estimated cost to do the research
4. Explanation of why addressing this research need is important
5. Identification of potential financial partners for the research
6. Desired research outcomes at the basic, applied or demonstration level as appropriate
7. Identification of who should do the research

This information serves as guidance for conducting the research in these areas and assisting in the development of requests for proposals. The information was developed for each of the following top five topics:

1. Identifying wastewater influent and effluent characteristics
2. Sedimentation and stratification in septic tanks
3. Survey of onsite systems with and without softeners
4. Effects on septic tank effluent
5. Soil plugging and permeability issues

The participants of the workshop also made suggestions for modification to three of the original five topics. These are the suggestions:

1. Identifying wastewater influent and effluent characteristics–
Research in this topic should make sure to include explorations of FOG, TDS and water hardness in the wastewater characteristics.

2. Sedimentation and stratification in septic tanks–
Research in this topic should be strengthened by incorporating some of the parameters from the sodium calcium ratio on settling.

3. Survey of onsite systems with and without softeners–
Research in this topic would benefit from specific consideration of nitrogen and phosphorus concentrations.

3.2 Topic 1: Identifying Wastewater Influent and Effluent Characteristics

Key Issues

- Water supply quality
- Hot water only effects
- Influent
- Effluent
- Bypass with regenerate

Research Need/Question Development

1. Description/explanation of research need:
   - Characterize both the background (raw) water and the effluent water from the household (tank influent). Tank influent with and without softeners regenerant (including unsoftened).
   - Parameters to analyze: common anion and cations, TDS, FOG, TS, TSS, COD, BODs, TKN, surfactants as measured by: LAS, MBAS, and CTAS.
   - Estimate prior to sampling best and worst with respect to regenerant water.
   - Paper calculations can be done in advance to determine predictability.
   - Literature review.
2. Identification of key technical, regulatory, managerial, financial, organizational, and community issues as appropriate.
   - Regulations in some states restrict the use of softeners. Some manufacturers limit warranties of equipment.
3. Estimated cost/Level of investment needed for such research need.
   - $250,000
4. Explanation of why addressing this need is important.
   - Prediction of effects and treatment depends on characterization.
5. Identification of potential financial partners to include in the research:
   - NRECA, WRF, WQRF, EPA, NSF, NOWRA, States
6. Desired outcomes of research at the basic, applied, and demonstration levels as appropriate.
   - Knowledge of the impact that water softening has on wastewater characteristics.
7. Identification of who is best suited to conduct the research (i.e., is WERF the right organization? Should EPA take the lead? Is there another organization who should lead?) No specific organization was identified.

3.3 Topic 2: Sedimentation and Stratification in Septic Tanks

Key Issues on Sedimentation

- Density differentiation
- Dispersion system
- Seasonal impact
- Tank geometry
- Stratification TDs
- Aerobic/anaerobic settling
- Does NA+CL (with CA+MG backwash) stratify in a tank and affect solids carryover?

Research Need/Question Development

1. Description/explanation of research need:
    - Stratification of sodium, chloride, hardness, TDS with septic tanks, with softener regeneration discharges.
2. Identification of key technical, regulatory, managerial, financial, organizational, and community issues as appropriate
    - Identify several septic tanks with softener discharges in the field with the help of researchers, regulators, or dealers.
3. Estimated cost/Level of investment needed for such research need:
    - $200K
4. Explanations of why addressing this need is important.
    - It has been claimed that stratification can lead towards operational problems.
5. Identification of potential financial partners to the research.
    - EPA, WERF, WQRF, Salt Institute, ORENCO, NAWT
6. Desired outcomes of research at the basic, applied, and demonstration levels as appropriate.
    - Clear identification of elements in the septic tank.
7. Identification of who is best suited to conduct the research (i.e., is WERF the right organization? Should EPA take the lead? Is there another organization who should lead?) WERF

Key Issues on Chemistry

- Mono/divalent ration
- Polymer characterization
- Kinetics of polymer formation
- What is NA:CA ration effect on settling in tank?
- At what ratio is this unacceptable

Research Need/Question Development

1. Description/explanation of research need:
    - Objectively characterize what exists and occurs in a softened water septic tank with and without receiving softener regeneration discharge

- Stratification/Density Gradient/Dispersion
- Cation ratios, monovalent:divalent
- Septic tank content characteristics
- Effluent filtrate characteristics
- Septic tank effluent characteristics (BOD/TSS/FOG)

♦ Stratification cannot be done in a lab; it must be conducted in the field.

2. Identification of key technical, regulatory, managerial, financial, organizational, and community issues as appropriate.
   - ♦ Development of bench-scale model to alter the ratio as many times as possible to identify the effects.
   - ♦ Bench-scale would be the most complex step; after that would be determining the level of water softening.
   - ♦ The key is to properly identify operating septic tanks that run on of soft water.
   - ♦ Why can't we use a septic tank? Because of the varying levels of septic tanks. Perhaps a model could be used, but other problems occur, such as a lack of equilibrium.
3. Estimated cost/Level of investment needed for such research need:
   - ♦ Bench-scale: $100K
   - ♦ Field study: $500K
   - ♦ Expand the sample size and keep costs down with proper contracting and training.
   - ♦ Grad students could be used to help with costs.
4. Explanations of why addressing this need is important.
   - ♦ Questions about water softener discharge effects have been raised; we want to settle it.
5. Identification of potential financial partners to the research.

   WERF, EPA, WQRF, Salt Institute, NAWT
6. Desired outcomes of research at the basic, applied, and demonstration levels as appropriate.
   - ♦ Measurable effects of dispersion and settling of anaerobic softened wastewater and of aerobic softened wastewater with and without softener regeneration discharge.
7. Identification of who is best suited to conduct the research (i.e., is WERF the right organization? Should EPA take the lead? Is there another organization who should lead?) WERF should manage

Additional Notes from the Plenary Discussions/Presentations on this Topic

In his presentation at the workshop (see copies of the slides in Appendix B), John T. Novak, Ph.D. of Virginia Tech, reported a significant new concept and premise to the workshop attendees. That concept is the ratio of monovalent to divalent and polyvalent cations – the ratio for example of sodium and/or potassium to calcium, magnesium iron, and/or aluminum. Professor Novak has found in studies of municipal wastewaters that if the monovalent to divalent (M/D) cation ratio gets out of a correct proportion then solids, proteins, and slimy bacterial polysaccharides disperse and carry over rather than flocculate and settle as they should in any wastewater treatment. If true for septic tanks as well, it could be the explanation why pumpers and others sometimes note a homogenized mixture "milk shake" appearance inside septic tanks and a slime carryover build-up on septic tank effluent filters and in drain field laterals in some septic tanks but not at others.

Dr. Novak reported for example that: 1) Cations Have a Dramatic Effect on Flocculation and Settling Characteristics of Wastewaters; 2) Biopolymer Matrices such as Proteins and Bacterial Polysaccharides Suspended Soil Particles are Negatively Charged; 3) Divalent and/or Polyvalent Cations are Needed to Coagulate and Separate Out Wastewater Constituents; and that 4) the Mono/Divalent (M/D) Cation Ratio Needs to be Less Than 2 on a Milliequivalent to Milliequivalent (Meq/Meq) Basis.

Dick Hanneman of the Salt Institute commented that this is the same phenomenon with salt and blood pressure. It is only when the sodium gets out of a proper proportion with other divalent and polyvalent cations that sodium is associated with hypertension. Milk, for example contains 8,000 mg/liter of TDS. Yet milk is healthy because all of the electrolytes – Na+, K+, Ca++, and Mg++ – are well balanced, i.e., in good proportion. A high level of sodium with proportionate levels of calcium and magnesium equals no ill effects. It is the same with clay soils. Overabundance of sodium alone causes clay swelling and loss of percolation. Calcium and magnesium on the other hand counteract sodium and add permeability to soils.

Participants found Dr. John Novak's concept important because it helps shed light on the key differences between water softeners and septic tanks. That is:

1. The ratio of monovalent to divalent (M/D) cations:
   – the ratio for example of sodium and/or potassium to calcium and/or magnesium
2. Dr. Novak finds if the M/D cation ratio gets out of a correct proportion then
   – solids, proteins, and slimy bacterial polysaccharides disperse and
   – carry over rather than flocculate and settle as they should in any wastewater treatment.
3. If true for septic tanks as well, it could be the explanation why pumpers and others sometimes note a homogenized mixture "milk shake" appearance inside septic tanks and a slime carryover build-up on septic tank effluent filters and in drain field laterals in some septic tanks but not all.

Workshop participants stated that this research is important because it is a critical factor within septic tanks and that if the appropriate M/D cation ratio can be identified, then this could easily be checked (analyzed) in tanks where any issue arises (real time). If the ratio is out of the determined correct proportion, it would be easy to adjust it with little or no impact on the water softener. For example, if the tank becomes deficient of calcium between regenerations, a small bleed of hard water (e.g., hard water to the cold side of the kitchen faucet) could perhaps be bypassed to the waste line or the homeowner could be instructed to flush a small packet of say innocuous calcium chloride or gypsum each day. It is important to explore this concept as it relates to anaerobic septic tanks and the contents of septic tanks. This focused question should be able to be explored and answered in a laboratory bench scale test with much better control of extraneous variables, much better certainty, and at much less expense than a septic tank field study would entail. It was stated that the first priority should be to explore a laboratory bench study of the monovalent to divalent (M/D) cation ratio effects in anaerobic septic tanks. It was discussed that WERF would be the right organization to manage this research with potential funding support from the Water Quality Research Foundation.

3.4 Topic 3: Survey of Onsite Systems With or Without Softeners

Key Issues

- ♦ With and without softeners
- ♦ Survey of nitrification/phosphorus
- ♦ Maintenance (e.g. does softener have a greater impact on corrosion?)

Research Need/Question Development

1. Description/explanation of the research need:
   - ♦ To use scientific/statistical approach to determine if water softeners have negative impacts on residential onsite wastewater systems.
2. Identification of key technical, regulatory, managerial, financial, organizational, and community issues as appropriate.
   - ♦ Utilize a survey/assessment tool to collect data needed to evaluate if there are problems.
   - ♦ Survey tool can utilize previously identified data/ information needed from NOWRA/WQA Residential Evaluation Survey Instrument and the Creekwood, NC study.
   - ♦ Data can be stored in a database.
   - ♦ Homeowners need to be made aware of their involvement (communicate with homeowners).
   - ♦ Geographic diversity is important (fair statistical evaluation).
   - ♦ Ensure large enough sample size (100 homes @ $500/per home)
3. Estimated cost/Level of investment needed for such research need:
   - ♦ $100K-$150K (estimated $500/home to conduct survey, based on NC study)
4. Explanations of why addressing this need is important.
   - ♦ Both septic systems and water treatment systems are components of decentralized systems. As a nation, onsite systems are a critical and growing part of the nation's infrastructure. Majority of onsite systems have private wells, many of which have softeners. Water softeners provide many necessary benefits to homeowners. Onsite systems are a critical component to protecting public health and the environment. So, it is critical to determine if softeners are causing problems with onsite systems ability to properly treat wastewater. And, if so, how can this best be addressed?
5. Identification of potential financial partners to the research.
   - ♦ WQA, NOWRA, WERF, equipment manufacturers, EPA, NAWT
6. Desired outcomes of research at the basic, applied, and demonstration levels as appropriate.
   - ♦ Is there verifiable, statistical evidence of whether water softeners cause adverse impacts to onsite wastewater systems?
   - ♦ Suggestion: Implement concurrent studies.
   - ♦ Suggestion: Take samples/conduct research for other areas of study while inside homes.
   - ♦ Suggestion: Identify state(s) that do a good job of tracking installations and repairs, and use their database(s).

- ♦ Question: Is there a way to develop a model with the data collected? (Perhaps increase database or sample size)

7. Identification of who is best suited to conduct the research (i.e., is WERF the right organization? Should EPA take the lead? Is there another organization who should lead?) WERF

Onsite Survey Approach

1. Is there a visible problem Y/N
   - ♦ Ensure geographic diversity/fair representation
   - ♦ Two-stage study
     - ▪ Complete 100 homes
     - ▪ Anecdotal/informal information?
2. Problems identified:
   - ♦ GPS location
   - ♦ Family size and structure (census)
   - ♦ Under any RME
   - ♦ Water supply
     - ▪ Well – private?
     - ▪ Well – public?
       - This will bring about other issues, such as chemistry and well surface.
   - ♦ Softener?
   - ♦ System
     - ▪ Traditional/conventional
     - ▪ Gravity/Pumped?
   - ♦ Tank size and age
   - ♦ Garbage Disposal
   - ♦ Effluent filter (if so, what is the cleaning frequency?)
   - ♦ Last pumped
   - ♦ Condition
     1. Three defined layers
     2. Is there corrosion? If so, where?
     3. Chemistry
        - BOD
        - Effluent
        - TSS
        - Phosphorous
        - TDS
        - NACL

- Define layers/depth
    - TDS layers: 2-3

3.5 Topic 4: Effects on Septic Tank Effluent

Key Issues

- Softened water with backwash
- Softened water without backwash
- Unsoftened water

Research Need/Question Development

1. Description/explanation of research need:
    - To evaluate septic tank effluent (BOD, TSS, FOG, TDS, anions, and cations.
    - To determine if water softener backwash has any effect on treatment efficacy of a standard septic regeneration tank with no effluent filter.
2. Identification of key technical, regulatory, managerial, financial, organizational, and community issues as appropriate.
    - Site location
    - Standardization/characterization of incoming wastewater as well as sourcewater.
    - Discovery of violations and how to reconcile with regulations.
    - Third party - peer review.
    - Approach: constructive research project; add known quantifiers.
    - Problems/issues include non-backwash/non-softened water; with a constructive research project, we are limited to softened with backwash samples.
    - Need a bench study, as well
3. Estimated cost/Level of investment needed for such research need:
    - $150K (controlled)
    - $100K (uncontrolled)
    - $150K (constructive)
    - $120K-$150K (on-site)
    - If the on-site surveys could correspond with other on-site surveys, it will cut the cost.
    - Based on foundation of softwater/wastewater or softened vs. non-softened water.
4. Explanations of why addressing this need is important.
    - To determine effectiveness of treatment and potential impacts on downstream system components.
5. Identification of potential financial partners to the research.

    WQA, NOWRA, EPA, WERF, Manufacturers, NAWT
6. Desired outcomes of research at the basic, applied, and demonstration levels as appropriate.

- To determine if water softener backwash has any effect on treatment efficacy of a standard septic regeneration tank with no effluent filter. And to arrive at BMP for water softeners and onsite systems.

7. Identification of who is best suited to conduct the research (i.e., is WERF the right organization? Should EPA take the lead? Is there another organization who should lead?) Universities, EPA, community health departments

3.6 Topic 5: Soil Plugging and Permeability Issues

Key Issues

- Chemical (ions)
- Biologic (BOD, FOG)
- Physical (TSS, TGS)
- Hydraulic (flow)

Research Need/Question Development

1. Description/explanation of research need*:*
   - Define potential effect of water softening on soil permeability and biomat.
2. Identification of key technical, regulatory, managerial, financial, organizational, and community issues as appropriate
   - Regulatory - prohibition of water softening regeneration water from entering the onsite wastewater treatment system.
3. Estimated cost/Level of investment needed for such research need:
   - Literature review: $100,000
   - LTAR and Biomat Microbiology: $950,000
4. Explanations of why addressing this need is important.
   - Water softening and onsite wastewater treatment systems are a critical component of our water infrastructure. These systems must be able to work cooperatively to serve a portion of our population.
5. Identification of potential financial partners to the research.
   - WQA, WERF, SORA, EPA/ORD, NSF, CIDWT, Salt Institute, MOU Partners, AWWA, WHO
6. Desired outcomes of research at the basic, applied, and demonstration levels as appropriate.
   - Literature review: Identify critical thresholds for soil chemical properties (Ca, Mg, Na) relative to clay dispersion
   - Quantify the effect of water softening on soil LTAR
   - Quantify the biomat microbiology relative to water softening
   - Identify potential mitigation methods to counteract chemical effects on soil permeability.
7. Identification of who is best suited to conduct the research (i.e., is WERF the right organization? Should EPA take the lead? Is there another organization who should lead?) No specific organization was identified.

APPENDIX A

WATER SOFTENERS RESEARCH NEEDS WORKSHOP AGENDA

Water Environment Research Foundation
Collaboration. Innovation. Results.

Water Softeners Research Needs Workshop

November 2-3, 2009
Sheraton Suites – Old Town Alexandria, Virginia
801 N. Saint Asaph Street, Alexandria, VA 22314 (703) 836-4700

FINAL AGENDA

Day 1: 1:00 PM – 6:00 PM – (Plenary Sessions are all in Salon 3 of the hotel)

1:00 Welcome and Introductions
Claudio Ternieden, Assistant Director of Research, WERF
Joyce Hudson, Manager, Decentralized Wastewater Program, US EPA

1:15 Overview of workshop motivation, history of issues, goals, agenda, and final products
Bruce Engelbert, Facilitator
MDB, Inc.

1:30 Plenary Session A: Technical Background (15 min each (average))
Moderated by Bruce Engelbert, Facilitator

1. **Introduction of Ion Exchange and the Underlining Science**
   Philip Pedros, Ph.D., P.E., FR Mahony & Associates and Northeastern University

2. **Wastewater Characterization of Systems with Water Softeners**
   Tom Konsler, Orange County, North Carolina

3. **The Effect of Chlorides on Microbiological Transformations Including BOD Removal, Nitrification/Denitrification and Anaerobic Processes**
   Dr. JoAnn Silverstein, Department of Civil, Environmental and Architectural Engineering, University of Colorado

4. **Salts, Septic Tanks and Biological Processes - Friends or Foes?**
   Alan Rimer, Director of Water Reuse, Black & Veatch Corporation (By phone);

5. **Related WERF Research – An Overview**
   Jeffrey Moeller, Senior Program Director, WERF

Questions and Answers (30 min)

3:30 Coffee Break

4:00 Plenary Session B: Stakeholders Perspective Background (15 min each):

1. Onsite Wastewater Treatment Systems Manufacturers' Perspective:
   Terry Bounds, ORENCO (By phone)
2. Water Softeners Systems Manufacturers Perspective:
   Joe Harrison, Water Quality Association
3. Waste Transporters Perspective:
   Tom Ferrero, National Association of Waste Transporters
4. State Regulators Perspective:
   John G. Hayes, State of Delaware

Questions and Answers (30 min)

5:30 Plenary Session C: Overview of Day 1 and Introduce Structure, Topics, and Goals for Work Sessions for Day 2

6:00 Adjourn Day 1

<u>Day 2:</u> 8:30 AM – 5:00 PM

7:45 – 8:30 Breakfast Presentation: Phillip Pedros, Ph.D. (Moderator)
Mono & Divalent Cat Ions and Their Effect on Settling
John T. Novak, Ph.D., P.E., Virginia Tech

8:30 Plenary Session D: Set Structure, Topics, and Goals for Work Sessions for Day 2
Bruce Engelbert, Facilitator

8:45 Breakout Work Sessions 1: Identify Priorities
(Breakouts will be assigned by topics and rooms assigned onsite)

- Identify Research Needs; Organized into two groupings for each of the three topics for small group discussions:

  Goal: Define key research needs/questions/challenges relative to the three breakout topics;
  Process Items: Small group discussions; 6 small breakouts with 2 groups for each of 3 main topic areas); Planning Committee Members will help lead each breakout to achieve goal; Document discussions in flipcharts; report out by a spokesperson of the group;

  Breakout Work Session Topics:

  1. Performance in Septic Tanks (with and without softeners):
     a. Wastewater characterization
     b. Treatment Processes
        i. Chemical
        ii. Biological
        iii. Physical
     c. Maintenance Issues
  2. Advance Treatment Unit Performance
     a. Wastewater characterization
     b. Treatment Processes
        i. Chemical
        ii. Biological
        iii. Physical
     c. Maintenance Issues
  3. Soil Interface – interaction of the salt and the soil treatment areas
     a. Effluent characterization
     b. Treatment Processes
        i. Chemical
        ii. Biological
        iii. Physical
     c. Maintenance Issues

10:30 Coffee Break

10:45 Plenary Session E: Facilitated Presentations from Workgroups, Feedback on Breakout Work Session 1, and Prioritization Exercise
Each group will be given 5 minutes to present summarized results and get feedback from the group. The facilitator will also work with the participants to prioritize (rank) the research areas.

(All participants will discuss and suggest modifications to research needs from all groups)

12:30 PM – 1:30 PM - Lunch on your own. Pre-order menus available at registration desk

1:30 Breakout Work Session 2: Further Develop and Refine Content of Research Needs Identified and Prioritized
Based on the results of Breakout Work Session 1 and Prioritization Exercise in Plenary Session E, new random small groups will be assembled to further develop and refine the associated research priority needs by describing the following:

- Description/explanation of the research need
- Identification of key technical, regulatory, managerial, financial, organizational, and community issues as appropriate
- Estimated cost/Level of investment needed for such research need
- Explanation of why addressing this need is important
- Identification of potential financial partners to the research
- Desired outcomes of research at the basic, applied, and demonstration levels as appropriate
- Identification of who is best suited to conduct the research (i.e. Is WERF the right organization? Should EPA take the lead? Is there another organization who should lead?)

3:00 Coffee Break

3:15 Plenary Session F: Presentation of Refined Research Needs
Each group will a few minutes to present a case for the research they further developed and refined, and why it should be funded

4:00 Plenary Session G: Identification of Key Integration Issues
Facilitated discussion of how needs interrelate, and how research should be approached in the big picture

4:45 Closing Remarks and Discussion

5:00 Adjourn

APPENDIX B

WATER SOFTENERS RESEARCH NEEDS WORKSHOP PRESENTATIONS AND SUMMARIES

AN INTRODUCTION TO ION EXCHANGE AND ITS USE FOR WATER SOFTENING

WERF Workshop November 2 & 3, 2009

Philip B. Pedros, Ph.D., P.E.

f.r. mahony & associates, inc.
frma

Northeastern
UNIVERSITY

Agenda

- Hardness
- Treatment
- Ion Exchange
- Products of Softening
- Common Home Softener
- Conclusions

Hardness

- Theoretically – the sum of the soluble concentrations of polyvalent cations
  - Calcium (Ca^{2+})
  - Magnesium (Mg^{2+})
  - Iron (Fe^{2+})
  - Manganese (Mn^{2+})
  - Strontium (Sr^{2+})
  - Lead (Pb^{2+})
  - Others (zinc, copper, cadmium...)

Neglect

Hardness

- Hardness divided into two types.
  - Carbonate hardness – polyvalent cations associated with HCO_3^- and CO_3^- ions
  - Non-Carbonate hardness – polyvalent cations associated with other ions
    - Chloride (Cl^-)
    - Sulfate (SO_4^{2-})

Hardness

- Practically – the sum of the soluble concentrations of calcium (Ca^{2+}) and magnesium (Mg^{2+})

- Hardness expressed as mg/l as $CaCO_3$
  - Grains/gallon

Why Treat?

- Hardness is a nuisance
  - Scale in pipes and hot water heaters
  - Fouling of heat exchangers
  - The deterioration of fabrics
  - High soap consumption
  - Formation soap scum
- Removal of hardness - *softening*

Treatment Options

- Chemical precipitation (Large Plants)
  - Lime-soda softening
- Membrane Processes
- Ion Exchange (Home systems)

Ion Exchange

- Chemical reaction between ions in a liquid phase with ions in a solid phase.
  - Reversible
  - Maintain electroneutrality
- Water to be treated flows over a material that allows for an exchange of ions
  - Exchange material must be specific

Exchange Materials

- Synthetic polymeric resins
  - 3-D cross linked polymer matrix
  - Covalent bonded functional group
    - Fixed ionic charge
  - Polymer, polystyrene or polyacrylic
  - Cross link is divinylbenzene (DVB)

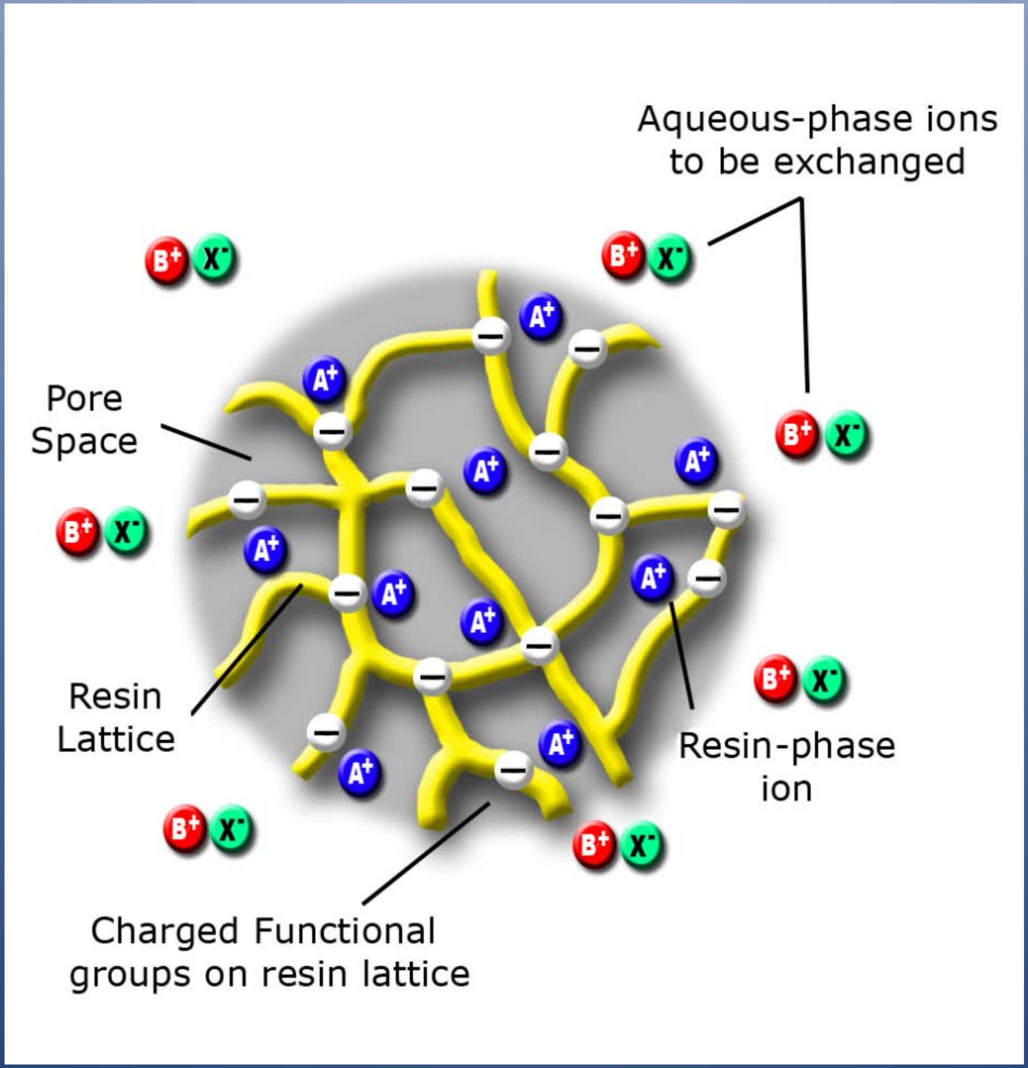
Properties of Ion Exchange Media

- Engineering Properties
  - Capacity (# of functional groups)
  - Selectivity
    - Dilute solution, affinity for higher valence
- Physical Properties
  - Swelling
  - Particle size
  - Stability

Exchange Resins

- Four types based on functional group
  - Strong acid cation (SAC)
  - Weak acid cation (WAC)
  - Strong base anion (SBA)
  - Weak base anion (WBA)
- Water softening SAC

Schematic of SAC Resin



Equations

- Exchange Reaction

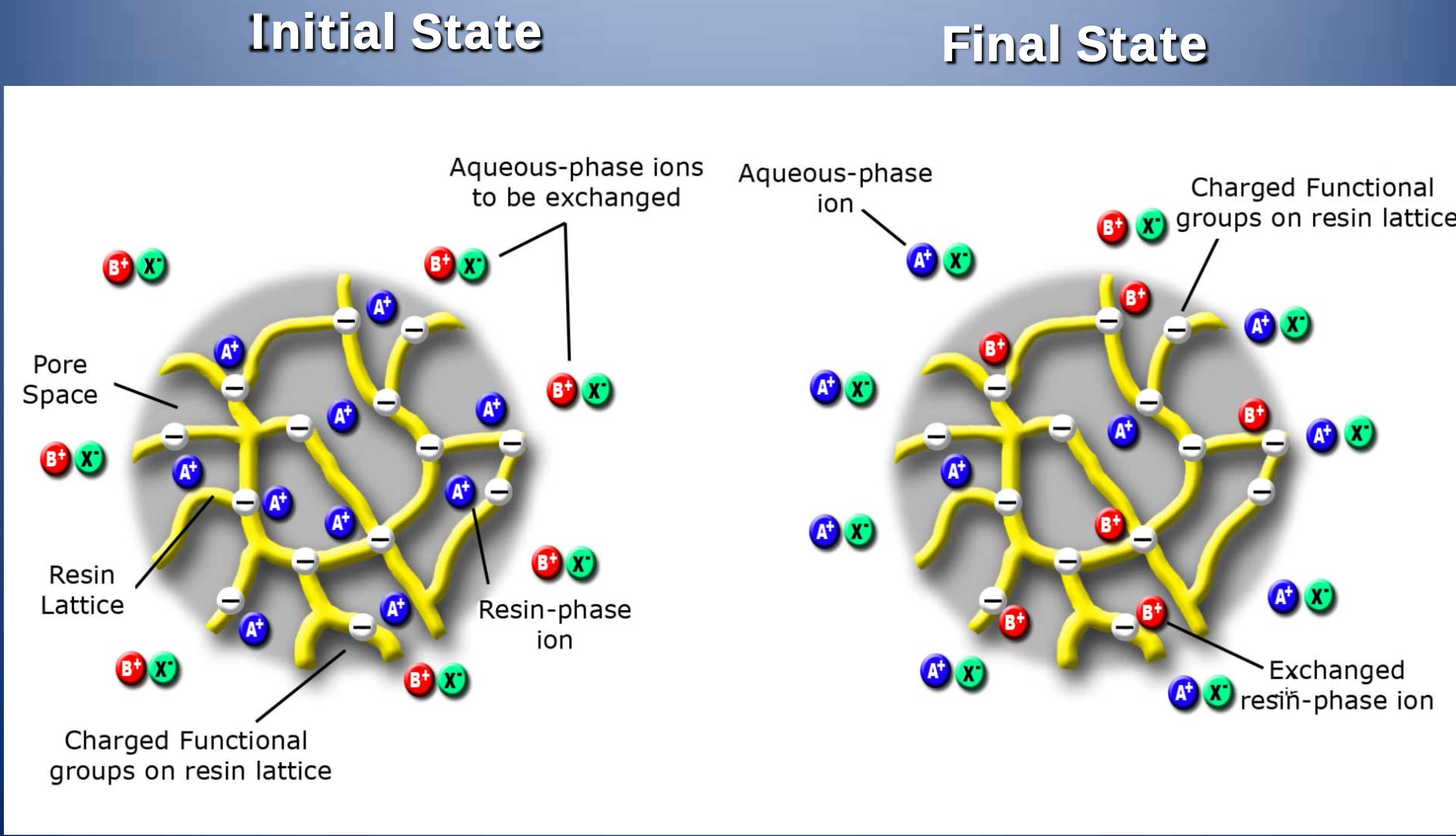
$$n[RSO_3^-]Na^+ + M^{n+} \Rightarrow [nRSO_3^-]M^{n+} + nNa^+$$

- Regeneration Reaction

$$n[RSO_3^-] + nNaCl \Rightarrow n[RSO_3^-]Na^+ + nM^{n+}Cl^-$$

- RSO_3^- - Immobile sulfonated resin
- Na^+ - Presaturant sodium ion
- M^{n+} - Ion of charge n^+ to be exchanged
- NaCl - Sodium chloride regenerant solution

Ion Exchange



Crittenden et al. 2005

Equations

- Accounting for relevant species
  - Carbonate
    - Bicarbonate (HCO3-)
  - Non-carbonate
    - Chloride (Cl^-)
    - Sulfate (SO_4^{2-})

Equations for Calcium

- Softening

$$Na_2[RO_3^-]+Ca(HCO_3)_2 \Rightarrow Ca_2[RO_3^-]+2NaHCO_3$$

$$Na_2[RO_3^-]+Ca(SO_4) \Rightarrow Ca_2[RO_3^-]+Na_2SO_4$$

$$Na_2[RO_3^-]+Ca(Cl_2) \Rightarrow Ca_2[RO_3^-]+2NaCl$$

- Regeneration

$$Ca_2[RO_3^-]+2NaCl \Rightarrow Na_2[RO_3^-]+CaCl_2$$

Equations for Magnesium

- Softening

$$Na_2[RO_3^-] + Mg(HCO_3)_2 \Rightarrow Mg_2[RO_3^-] + 2NaHCO_3$$

$$Na_2[RO_3^-] + Mg(SO_4) \Rightarrow Mg_2[RO_3^-] + Na_2SO_4$$

$$Na_2[RO_3^-] + Mg(Cl_2) \Rightarrow Mg_2[RO_3^-] + 2NaCl$$

- Regeneration

$$Mg_2[RO_3^-] + 2NaCl \Rightarrow Na_2[RO_3^-] + MgCl_2$$

What the Equations Indicate

- Products of softening include:
  - Sodium bicarbonate ($NaHCO_3$)
  - Sodium sulfate (Na_2SO_4)
  - Sodium chloride ($NaCl$)
- Products of regeneration include:
  - Calcium chloride ($CaCl_2$)
  - Magnesium chloride ($MgCl_2$)

Equations Applied to All Ions

- Additional metal ions replaced may include:
  - Iron (groundwater 1.0 – 10.0 mg/l)
  - Manganese (0.1 – 1.0 mg/l)
- Concentrations typically limited to 5 mg/l (McGowan 2000)
- Removal of additional ions typically requires increased regeneration

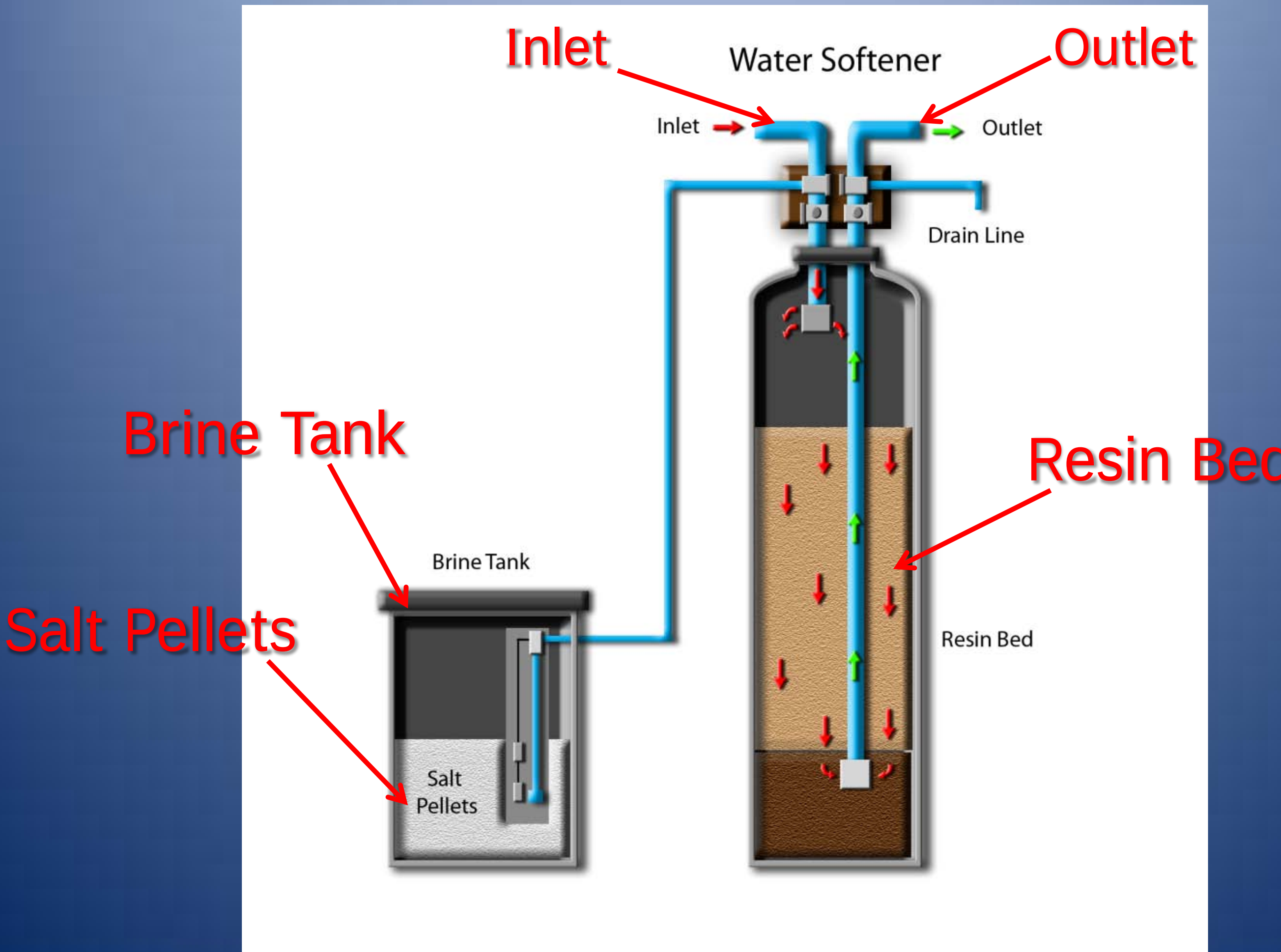
Regeneration

- Exhausted resin is regenerated
- Factors affecting regeneration
  - Quantity of salt
    - Highest recovery 3-5 lbs-salt/ft.^{3} resin (Rohm & Haas 1978 and Ionac® 2008)
    - Typical regenerant levels:
    - 4-20 lbs-salt/ft.^{3} resin (Ionac® 2008)
    - 4-10 lbs-salt/ft.^{3} resin (Purolite® 2008)
    - 5 moles $NaCl/Ca^{2+}$ (Fair, Geyer & Okun 1968)

Regeneration

- Factors affecting regeneration
  - Concentration of salt
    - 10% optimum (Rohm & Haas 1978)
    - 8 – 20% (Dowex® 2008, Purolite® 2008 and Ionac® 2008)
  - Flow rate
    - 0.5-1.5 or 0.25-0.90 gpm/ft.^{3}-resin (Ionac® 2008 and Purolite® 2008)

Cocurrent Ion Exchange



Conclusions

- Products of softening & regeneration include:
  - Sodium bicarbonate ($NaHCO_3$)
  - Sodium sulfate (Na_2SO_4)
  - Sodium chloride ($NaCl$)
  - Calcium chloride ($CaCl_2$)
  - Magnesium chloride ($MgCl_2$)

Conclusions

- Consideration of the softening process and fate of treated water:
  - Wastewater characterization
    - What ions are present?
    - What is chloride concentration within the system?
  - Affect on settling
  - Affect on biochemical transformations
  - Affect on soils

Thank You & Questions

Magnesium Crystals

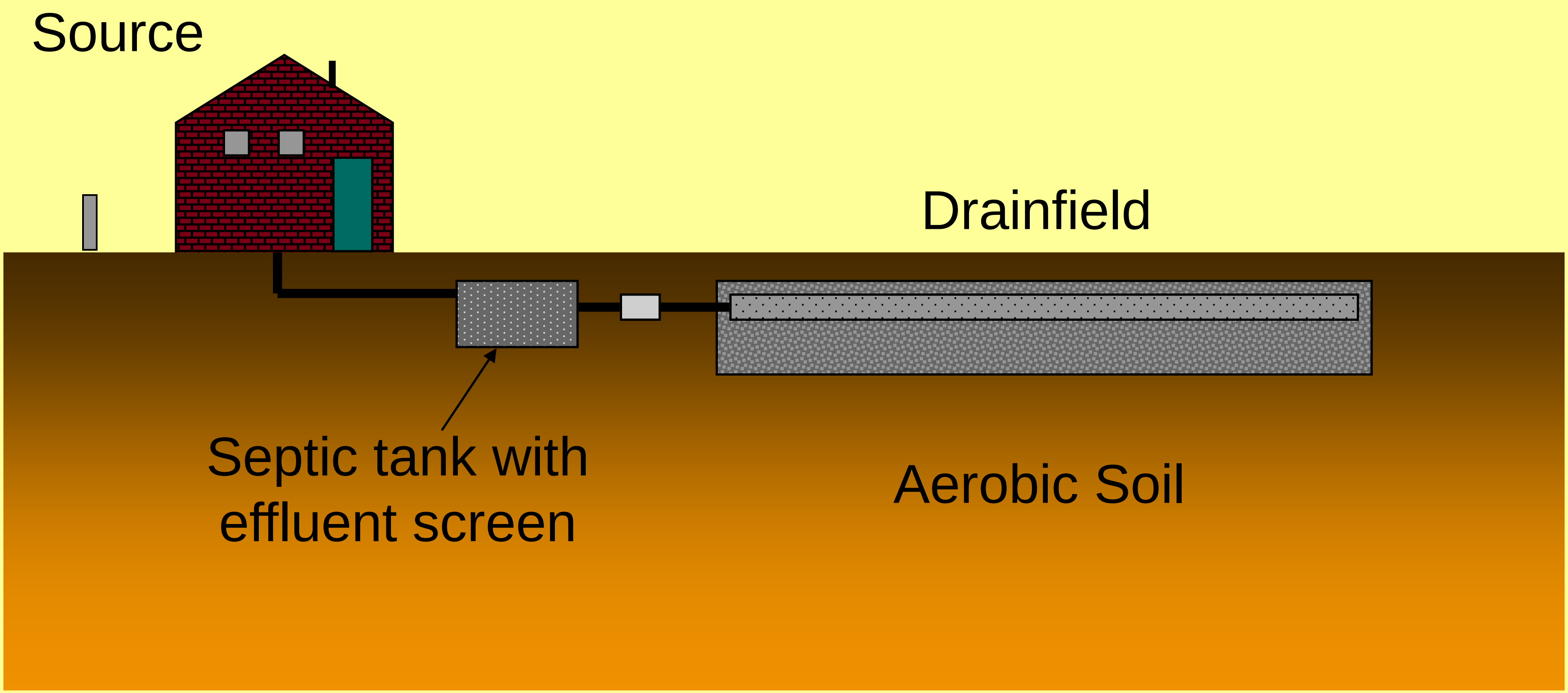
Septic Tank Function and Investigating the Effect of Water Softener Discharge

Nancy Deal, Tom Konsler, Albert Mills, David Lindbo, Roland Coburn, Joseph Harrison, Barbara Grimes, Bruce Lesikar, John Buchanan, and Matthew Byers

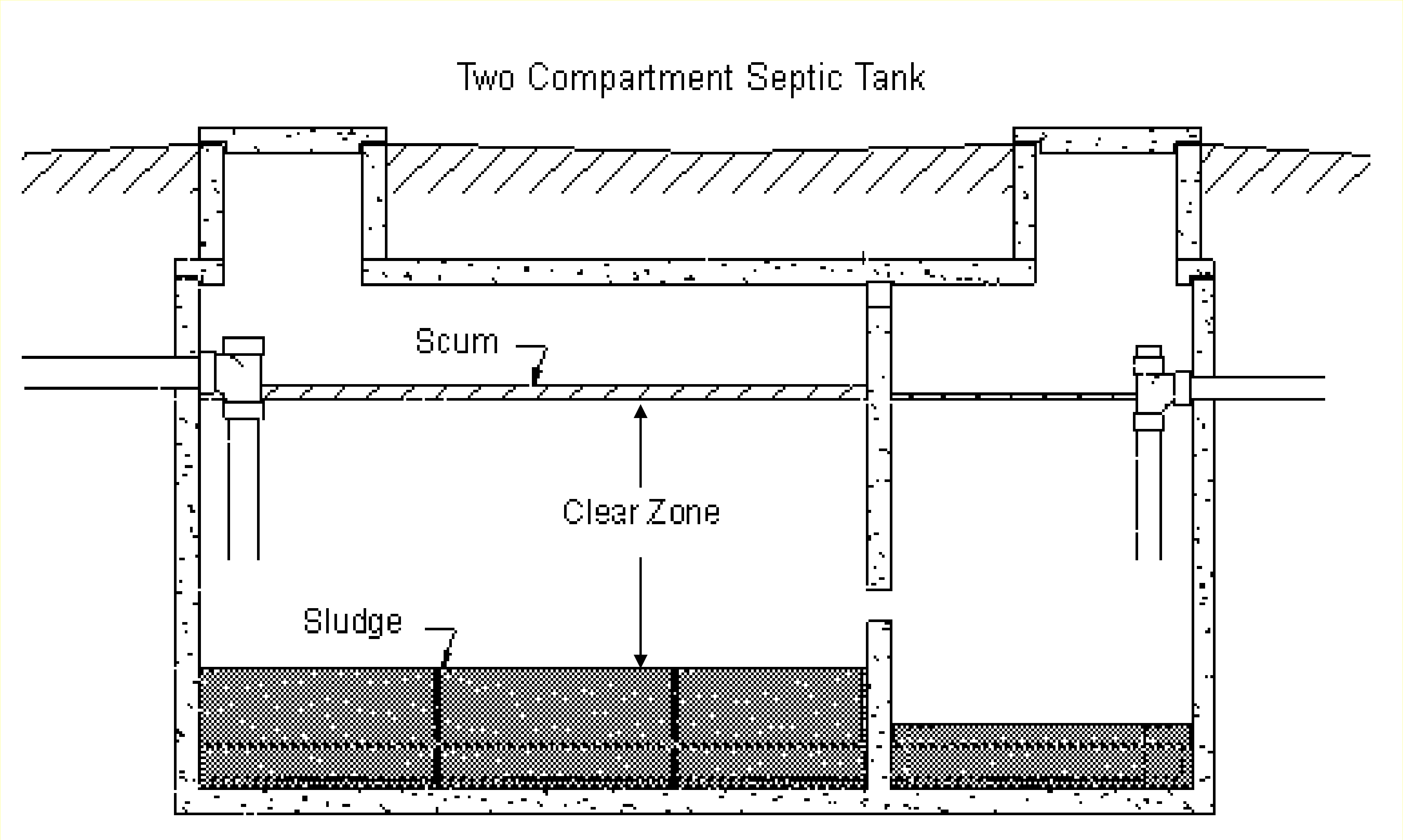
Presented at: WERF Water Softener Research Workshop

November 2-3 2009

Basic Gravity Wastewater System

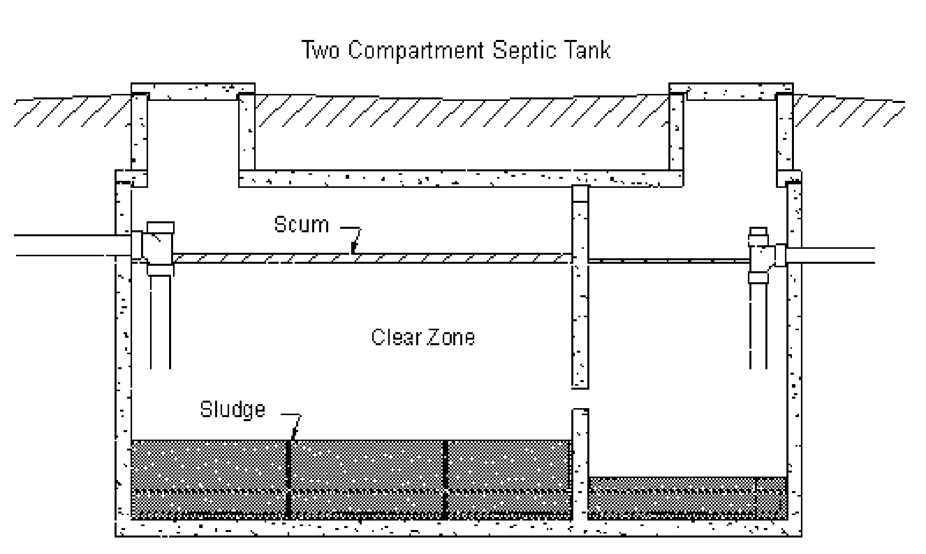


Two-compartment Septic Tank



Function of the Septic Tank

- Solids separation: settling & floatation
- Anaerobic digestion
- Storage of accumulated solids for later removal



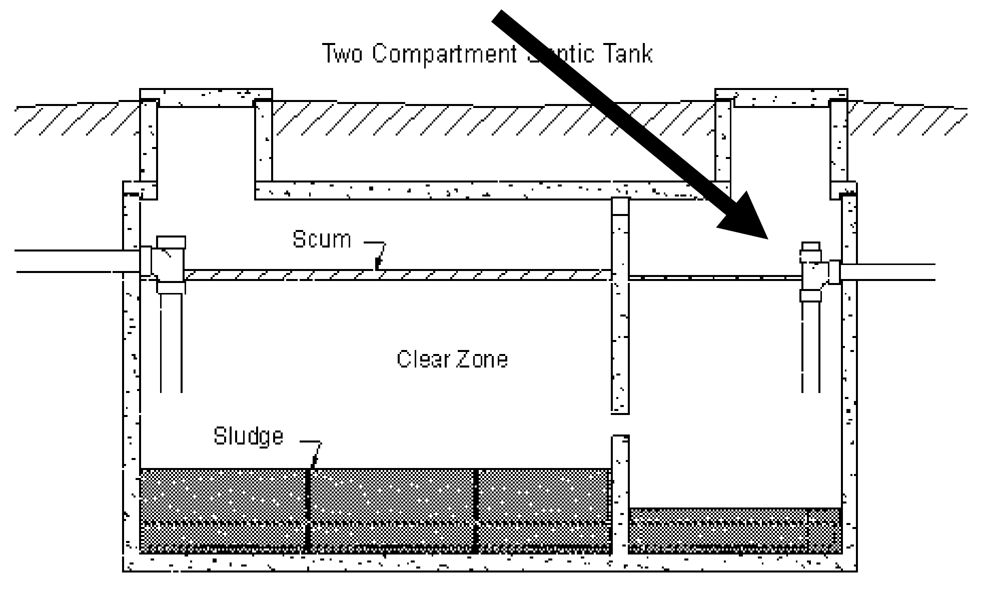
Average Treatment Capacity for Septic Tanks

Parameter	Average Raw Sewage Influent	Average Septic Tank Effluent	% Removal
BOD (mg/L)	308	122	60
TSS (mg/L)	316	72	77
FOGs (mg/L)	102	21	79

Seabloom, R.W., T.R. Bounds, and T.L. Loudon. 2005.

Effluent Screens

- Assist in removal of suspended solids
- Filter screen typically 1/16" – 1/8"
- Require periodic maintenance
- Should have grade-level access



Typical Effluent Screen

Effluent Screens

Tanks and Effluent Screens
The Big Picture

- Cheap, simple, and reliable solids removal
- Low-maintenance basic biological treatment
- Primary treatment is fundamental to the proper function of the entire WW system

Investigating the Effects of Water Softener Backwash on Septic Tank Performance

Does adding water softener backwash to septic tanks adversely affect septic system performance?

Observations of Malfunction in the Presence of Softener Backwash

- Premature clogging of effluent screens
  - 1 year or less

- Lack of tank stratification
  - Scum
  - Clear zone
  - [illegible]

- [illegible] inhibition of biological activity

Anecdotal evidence

Possible Impacts

- Physical
- Chemical
- Biological

Scientific Research

- Biological inhibition due to Na and Cl
  - Not proven but primarily studied in aerobic systems
- Negative affect on solids accumulation
  - Not proven but not widely studied
- Re-suspension of solids
  - Not studied in situ
- Negative effect of Na on soil structure
  - Appears to be dependent upon inherent soil chemical properties

Where we are…

- No conclusive scientific evidence of problems
- Anecdotal observations to the contrary
- Debated for decades

2007/2008 Pilot Study in NC

- Self-funded effort
  - NC State University
  - NC DENR
  - Orange County Health Department
  - Local Water Treatment professionals
- Observers from:
  - CIDWT
  - NOWRA
  - WQA

Small Study / Lots of Data

- Pilot study to develop standard protocol
- Purpose was not to draw conclusions from this 13 home study
- Protocol development for sampling, data gathering, team building, data analyses
- Enormous number of data points were collected
- Small sample size makes the authors hesitant to release results without more research

2007/2008 Survey logistics

- Homeowner survey
- Evaluation of water softener unit configuration and optimization
- Visual and quantitative analyses of septic
- Laboratory analyses
- Flow-through test

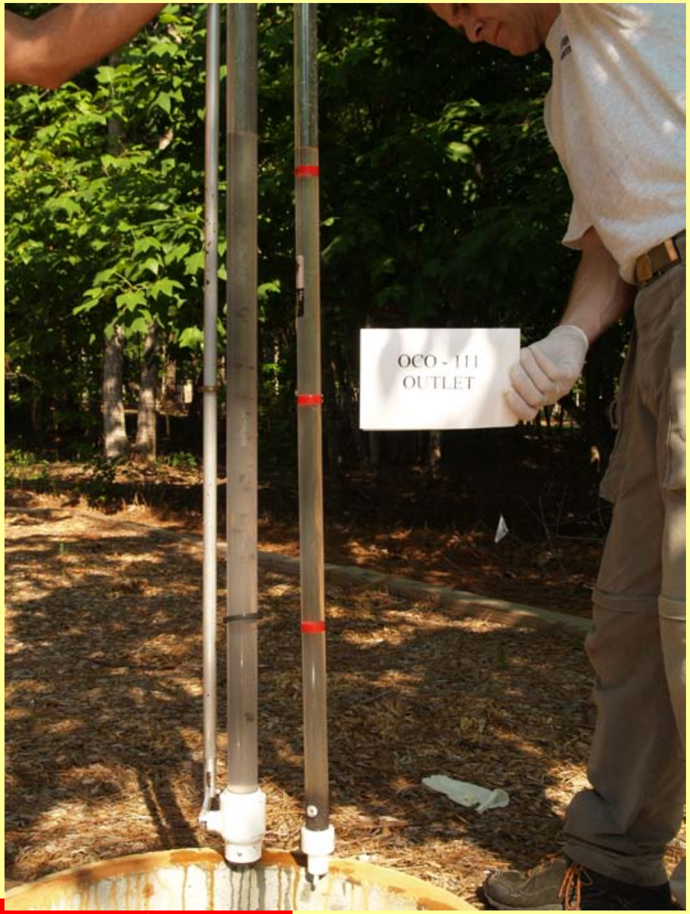
- GOAL: Develop a sampling protocol for broader studies

Homeowner survey

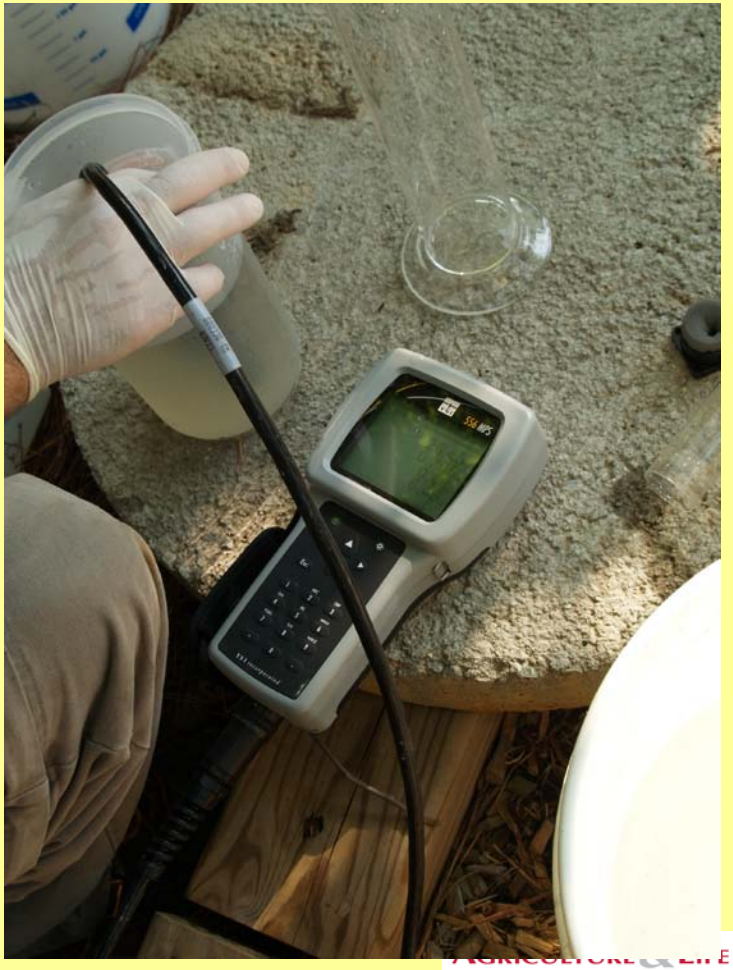
- Attempt to characterize “normal” wastewater
  - Hydraulic
    - Number of people
    - Flow patterns
    - Plumbing fixtures
  - Organic
    - Garbage Disposals
    - Toilet Tissue
    - Oils, soap brands
    - Additives

Visual and quantitative analyses

- Solids accumulation



- pH, DO, Conductivity, Specific Gravity



Lab Analyses of Wastewater, Water, and Backwash Water

Wastewater

- Inorganic chemicals
- pH
- BOD
- TKN
- NH^3
- NO^x
- TSS
- TDS
- Microscopic characterization

Source Water

- Inorganic chemicals
- pH
- Conductivit
- Hardness

Backwash Water

- Inorganic chemicals
- pH
- TDS
- Conductivity
- Specific Gravity

Detailed Evaluation of Water Softener Equipment

Performed by Water Treatment professionals

Flow-through Test to Measure Screen Clogging Rate

Defining the Survey Area

- Cooperative owner
- Close proximity
- Common water source
- 2-compartment tank with an effluent screen and access risers
- Homes with and without water treatment and backwash discharge

Challenges to Studying Septic Systems

- Fundamental variability of users
  - Hydraulic
  - Organic
- Age of systems
- Technological variations
- Maintenance activities

What we found

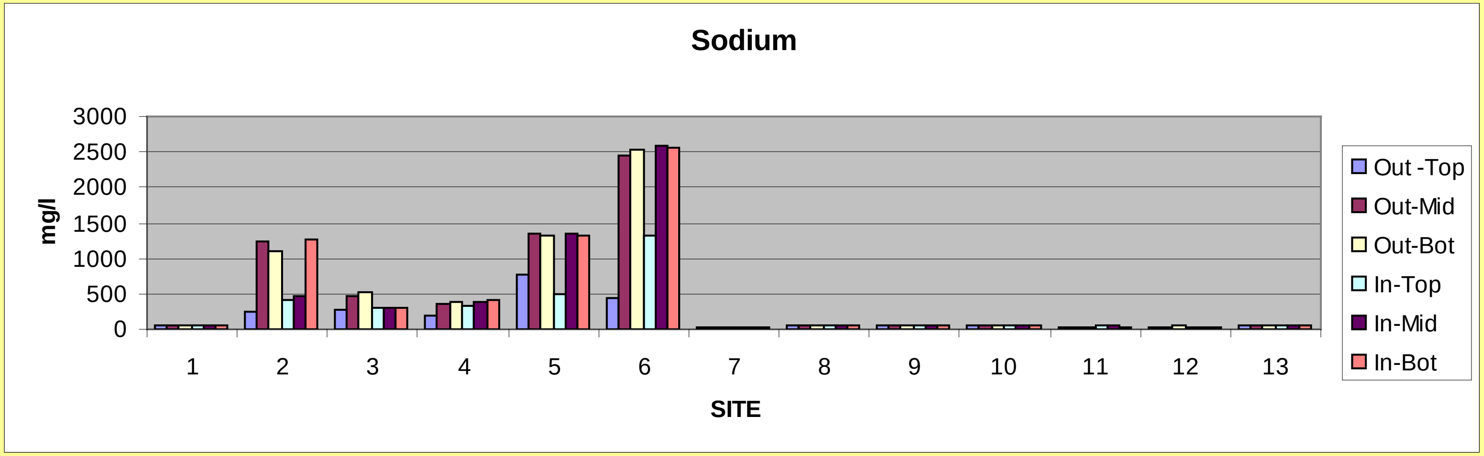
Data Challenges

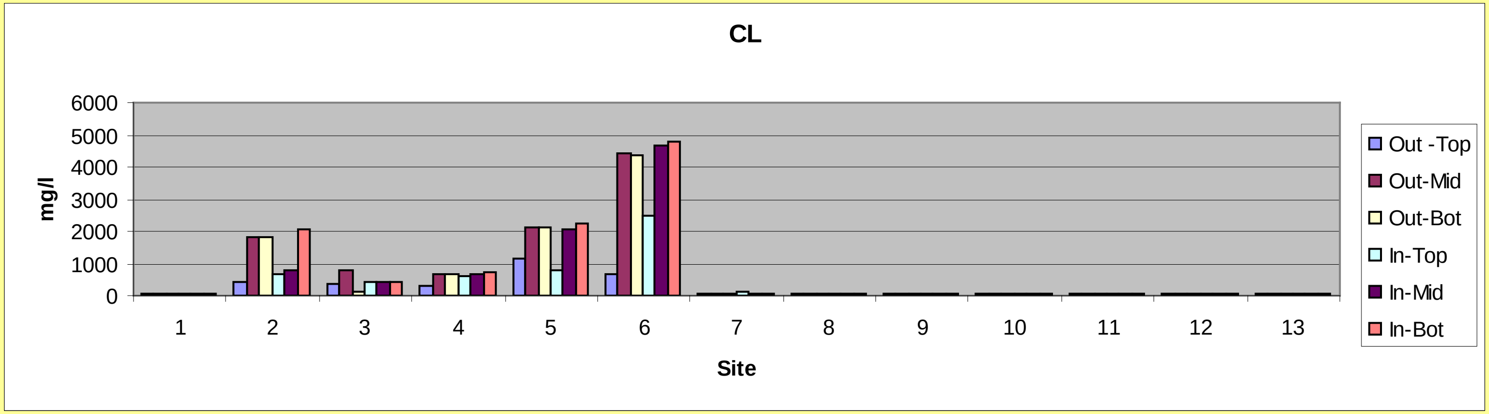
Unable to get results related to treatment efficacy

- Microbial populations
- BOD

What we found

- Elevated Na and Cl in tanks receiving backwash






OCo 106
~~Outlet~~
INLET


Orange Co.
Site 106
Inlet


OCo 106
Outlet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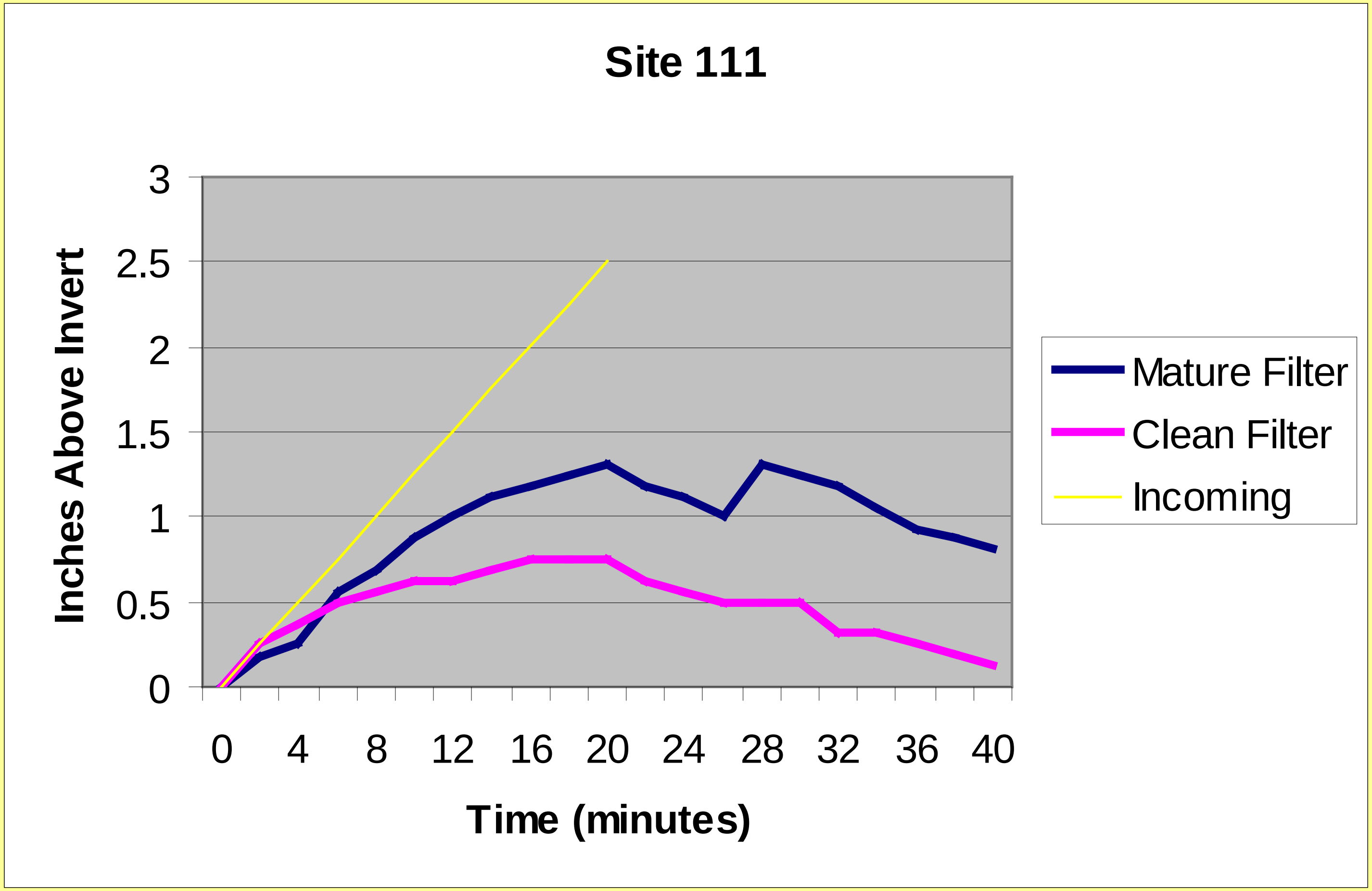
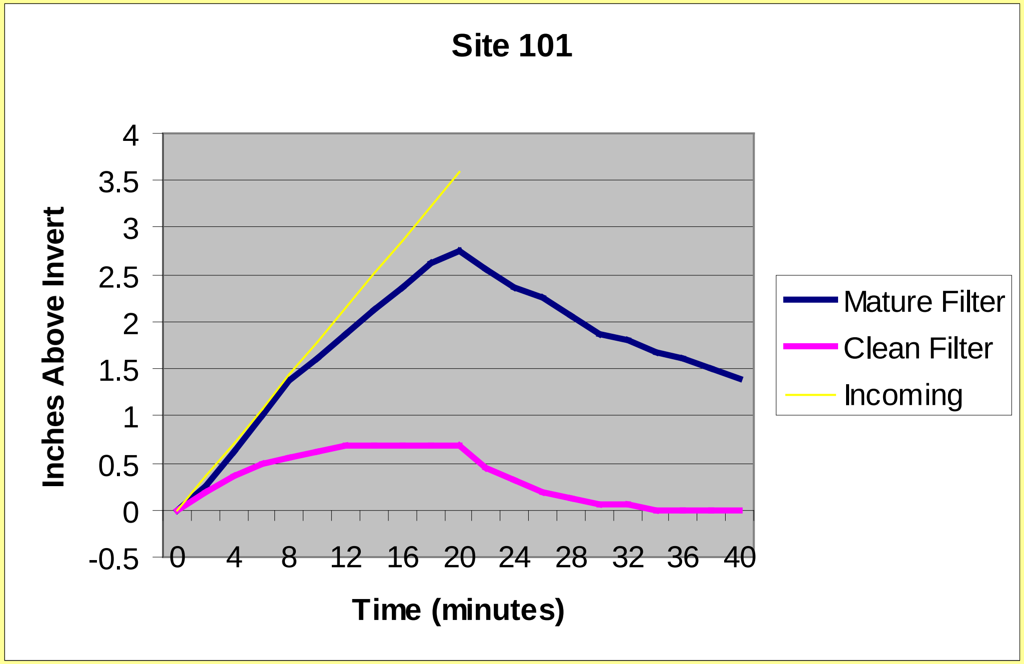
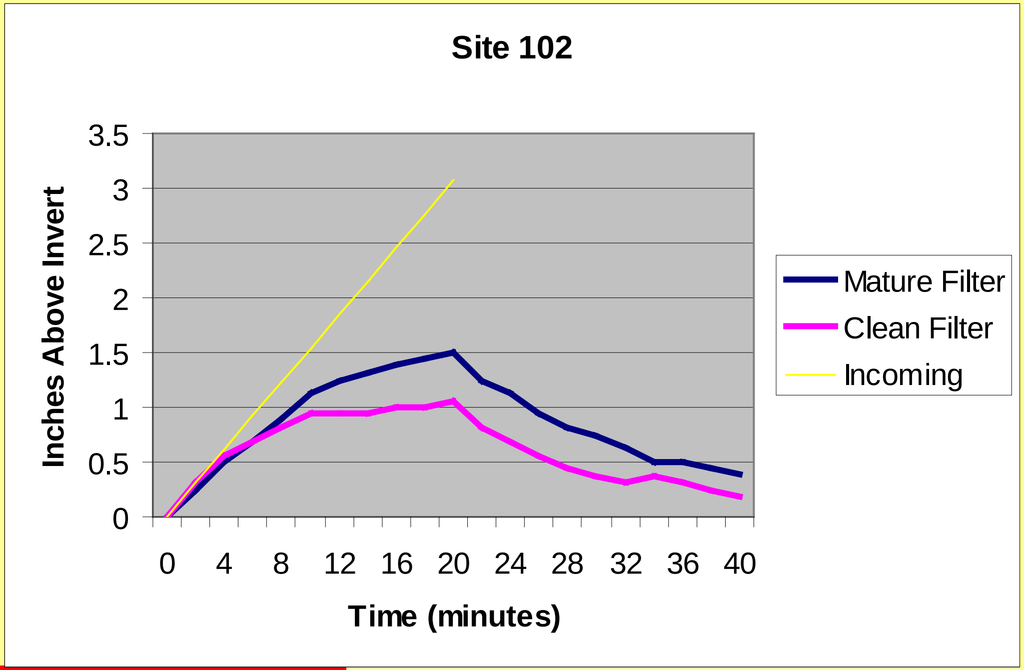
Flow-Through Curves

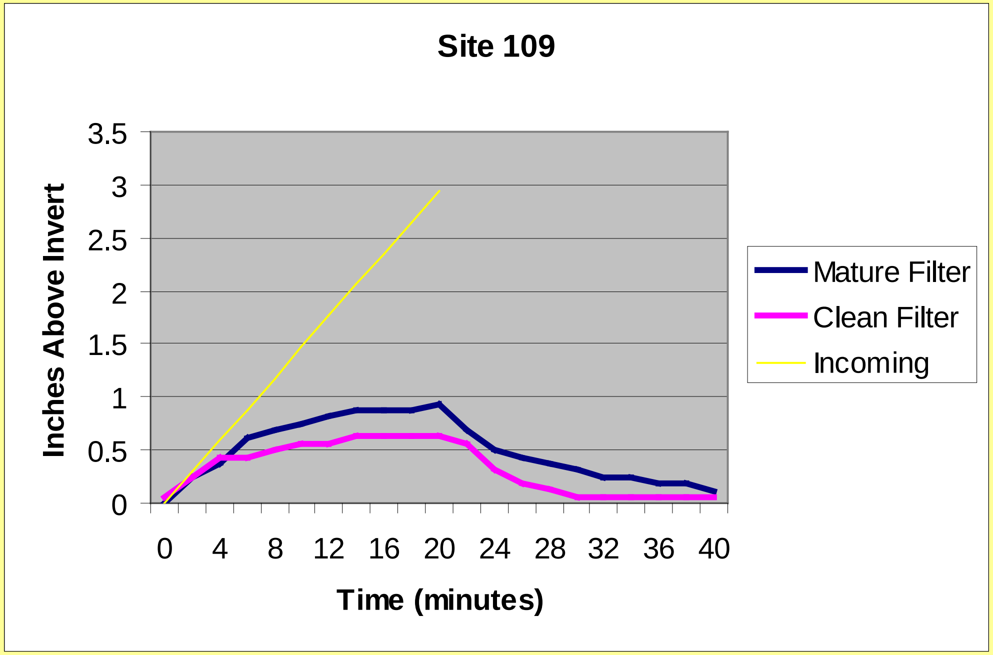




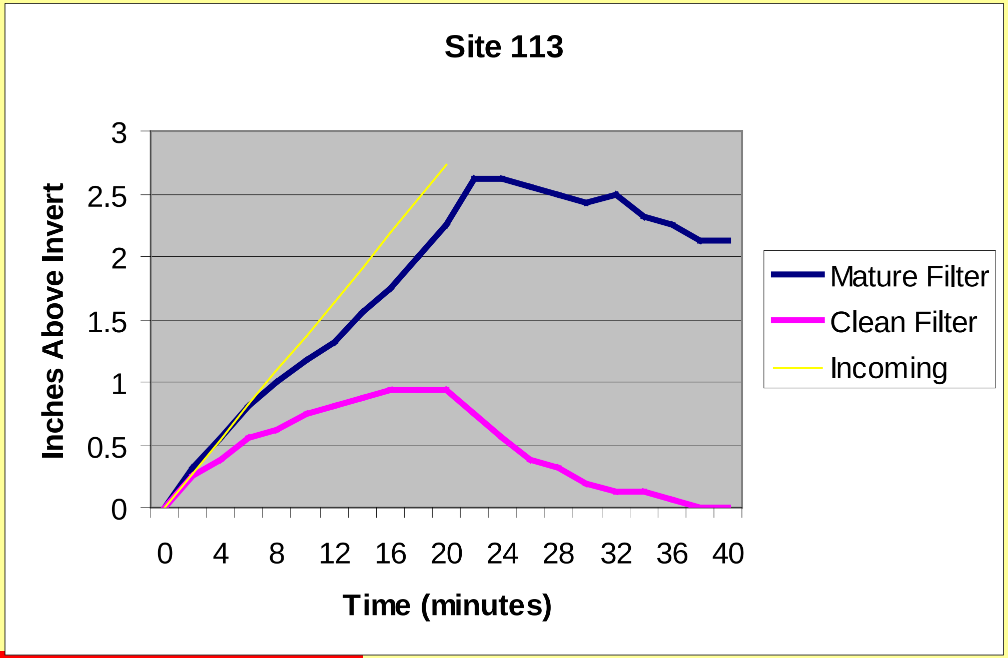
4 residents
Softener / no discharge
Pumped over 1 year ago



6 residents
Softener and discharge
Just pumped



Pumped 3 years ago
4 residents
No softener



Pumped 2 years ago
4 residents
No softener

Reasonable use of this data

- A starting point for establishing a protocol
- Identify interesting individual conditions
- More numbers are needed for significance
- Need biological indicators
- Best management practices
  - Water treatment
  - Septic systems

What’s next?

- Define ‘malfunction’ and “adverse effect”
- Consider alternative study design
  - Target reports of malfunctions and apply screening survey tool
  - Visit corresponding number of sites with no problems
- Grant funding to expand the study

Thank you.

Effect of Salinity on Microbial Transformations:
BOD Removal, Nitrification/Denitrification and Anaerobic Processes

JoAnn Silverstein
Dept. Civil, Environmental & Architectural Engineering
Univ. Colorado, Boulder

Water Softeners Research Needs Workshop
Water Environment Research Foundation
November 2-3, 2009

Scope

- Microbial effects
  - Populations
  - Toxicity
  - Adaptation
- Treatment of high salinity discharges
  - Municipal treatment processes
  - Industrial treatment processes

Effects of salinity on microorganisms

- Osmotic pressure and membrane integrity
- Specific enzyme inhibition
- Dispersal of extracellular polymers, deflocculation and detachment
- Reduction in population diversity, resilience
- Halotolerant versus halophilic populations. Halophiles dominate at > 20% NaCl.

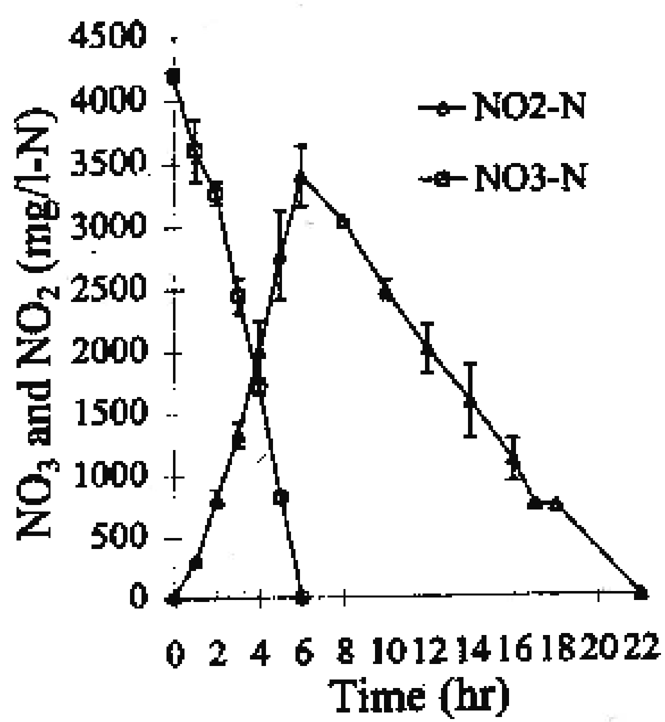
Biological Processes

- Aerobic oxidation of cBOD
- Nitrification
- Denitrification
- Anaerobic treatment (UASB, UESB, sludge digestion, methanogens)
- Collection system

Denitrification in a lab SBR with high salt, high nitrate conditions

	Nominal Influent Nitrate Concentration		
Constituent	2,700 ($mg/L\ NO_3$-N)	5,400 ($mg/L\ NO_3$-N)	8,200 ($mg/L\ NO_3$-N)
KNO_3 (g/L)	19.61	39.23	58.84
K_2SO_4 (g/L)	4.55	9.09	9.09
KCl (g/L)	6.12	12.23	12.23
NaCl (g/L)	35.62	71.24	71.24
$NaHCO_3$ (g/L)	15.79	31.58	31.58
H_3PO_4 (g/L)	1.72	3.43	3.43
TDS (g/L)	48	162	180
Ionic Strength	0.8	2.7	3.0
pH	7.2	7.2	7.2

SBR Denitrification. TDS = 180 g/l.

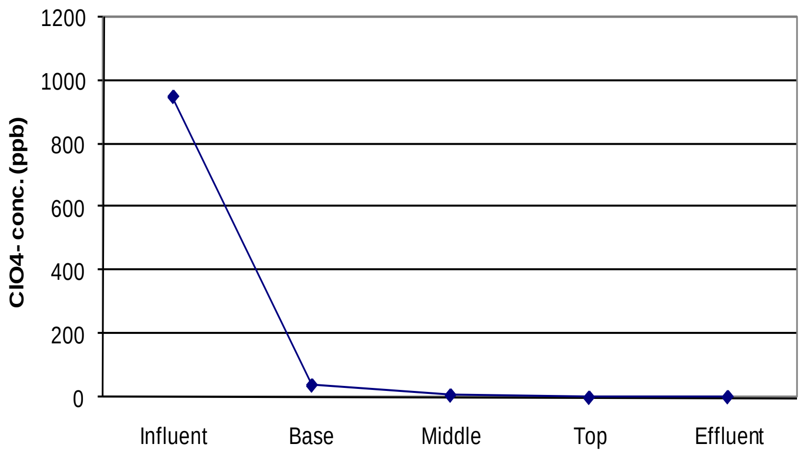


Influent NO_3-N (mg/L)	MLSS (g/L)	Ionic strength	r_{NO3} (mg-NO_3-N/ g-MLSS/hr)	r_{NO2} (mg-NO_2-N/ g-MLSS/hr)
2,700	12	0.8	50 ± 12	25 ± 6
5,400	30	2.7	23 ± 0.5	12 ± 0.1
8,200	38	3.0	19 ± 0.5	6.3 ± 0.5

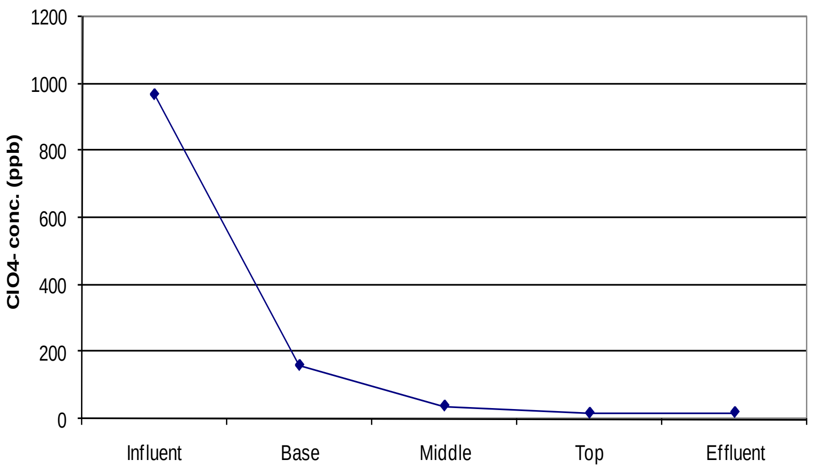
Upflow biofilm reactors for perchlorate reduction

Effect of salinity on perchlorate reduction in an upflow biofilm reactor

TDS = 4,300 mg/l; EC = 8 mS



TDS < 200 mg/l;

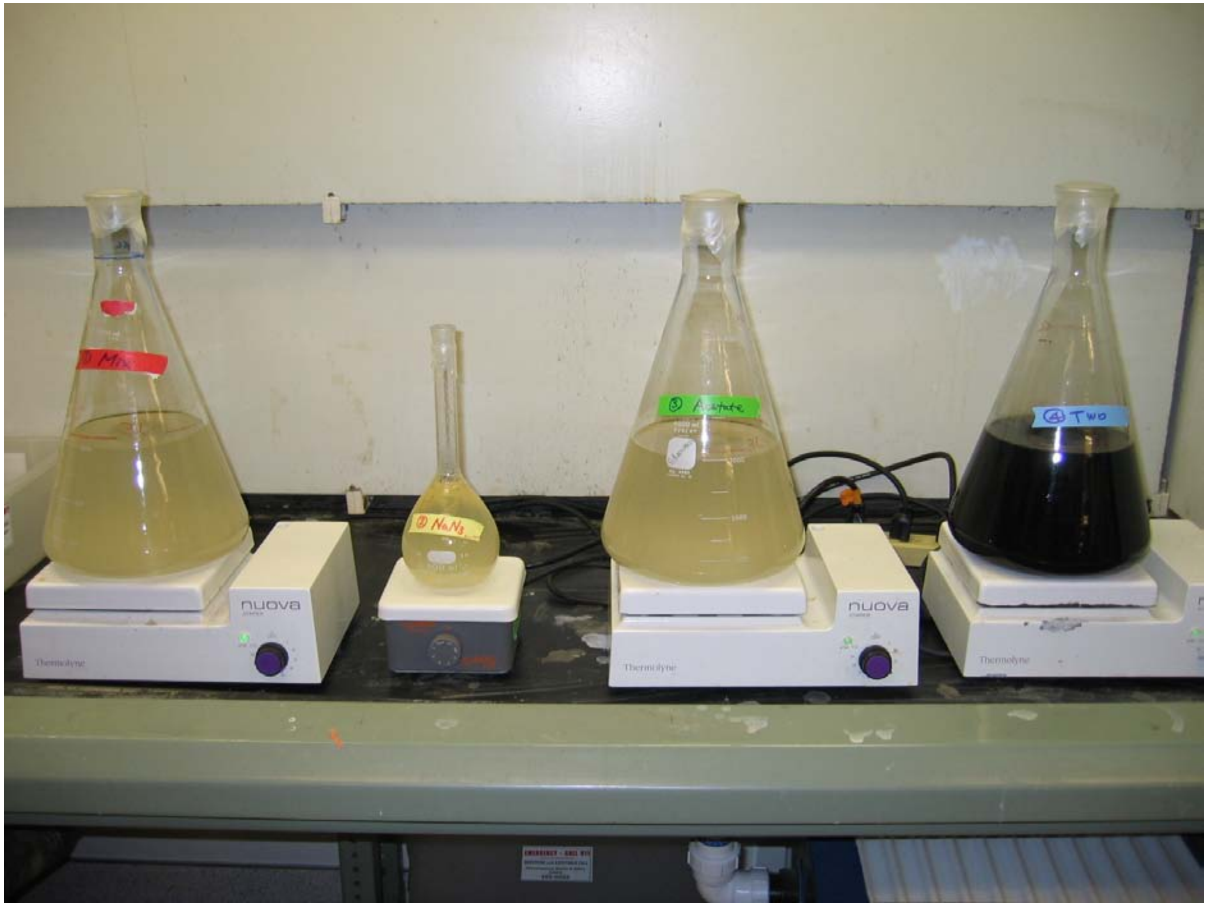


ClO_4 Reduction in Plug Flow Biofilm reactors with 8-hour Hydraulic Residence Time

Influent ClO_4 (ppb)	Salinity (TDS) (ppm)	DO (ppm)	Effluent ClO_4 (ppb)
1,000	<200	1 - 2	BDL*
1,000	4,300	1 - 2	BDL*

*Below Detection Level of 4 ppb

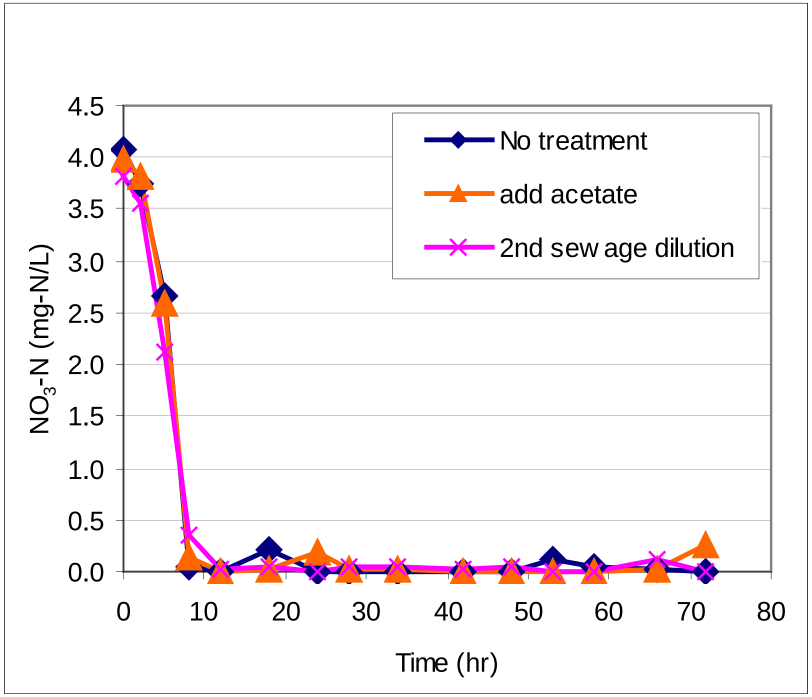
Flask reactors for reduction of perchlorate (ClO_4^-) and nitrate (NO_3^-) in sewage



Synoptic sampling of sewer after discharge of IX brine from vault to sewer

Analysis	**MH H736** March 17, 2005 1:00 a.m. Concentration	**MH H670** March 17, 2005 7:00 a.m. Concentration	% Increase (+) % Reduction (-)
NO3 – N	**104 mg/L**	**8.42 mg/L**	**- 92**
SO4	491 mg/L	952 mg/L	**+ 93**
ClO4	**340 µg/L**	**230 µg/L**	**- 32**
Cl	**10,400 mg/L**	**8,140 mg/L**	**-22**
Li	0.13 mg/L	0.10 mg/L	**-23**
pH	7.28	7.91	
DO	4.64 mg/L	0.48 mg/L	
Temp.	82	80	

Perchlorate and nitrate reduction in IX brine diluted 28:1 with sewage. EC = 3.1 mS



Summary of reported biological process effects

Process	Salinity levels at inhibition	Inhibitory effects
Aerobic oxidation of BOD	Variable: 1 - !0% NaCl	Reduction in specific rates, range 25-50%
Nitrification of high ammonia wastes	10 g/l NaCl 525 mM: 14 g/l NaCl, 20 g/l $NaNO_3$, 8 g/l Na_2SO_4	NO_2 accumulation, Reduction in SNR, ammonia accumulation, toxicity, O_2 limitation. Reduction in NOB species
Denitrification by activated sludge	160 – 180 g/l TDS	NO_2 accumulation Synergistic NO_2 toxicity linked to pH.
Anaerobic Processes: fish waste processing, digesters	3 – 16 g/l Na	50% reduction in methane production. Presence of other salts (sea water) and acclimation (40-90 days) reduced toxicity

General observations

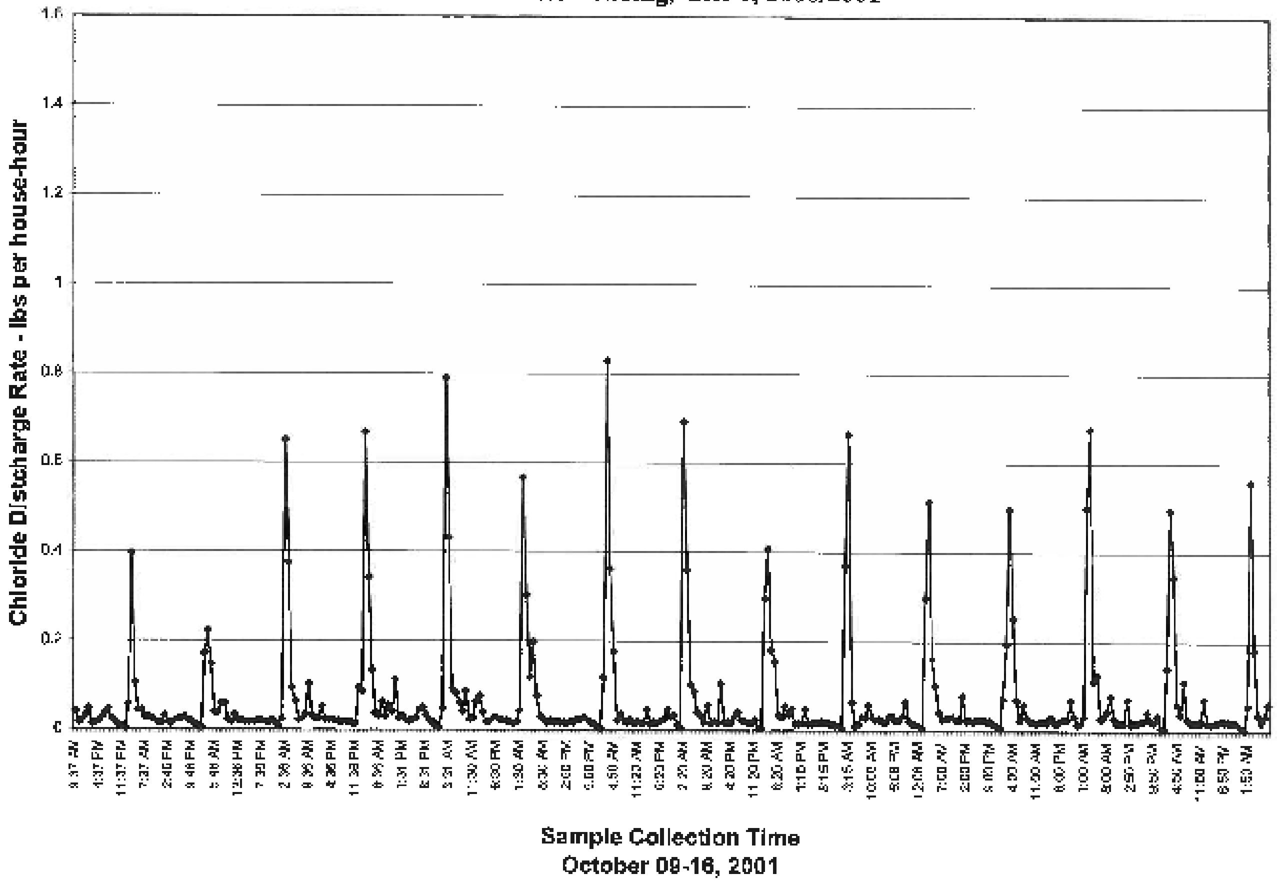
- General osmotic effects: various salts inhibit
- Synergistic effects at high salt strength: reduced rates lead to accumulation of inhibitory parent and intermediates, pH effects, reduced O2
- Specific ion effects: NaCl toxicity mitigated by presence of other ions
- Acclimation is important, time and biomass retention. Use of attachment media, increase SRT

System effects

- Corrosion
- Biological treatment does not affect salinity. Exceed permit levels based on TMDL is a concern.
- Santa Clarita study of home water softeners on chloride discharge

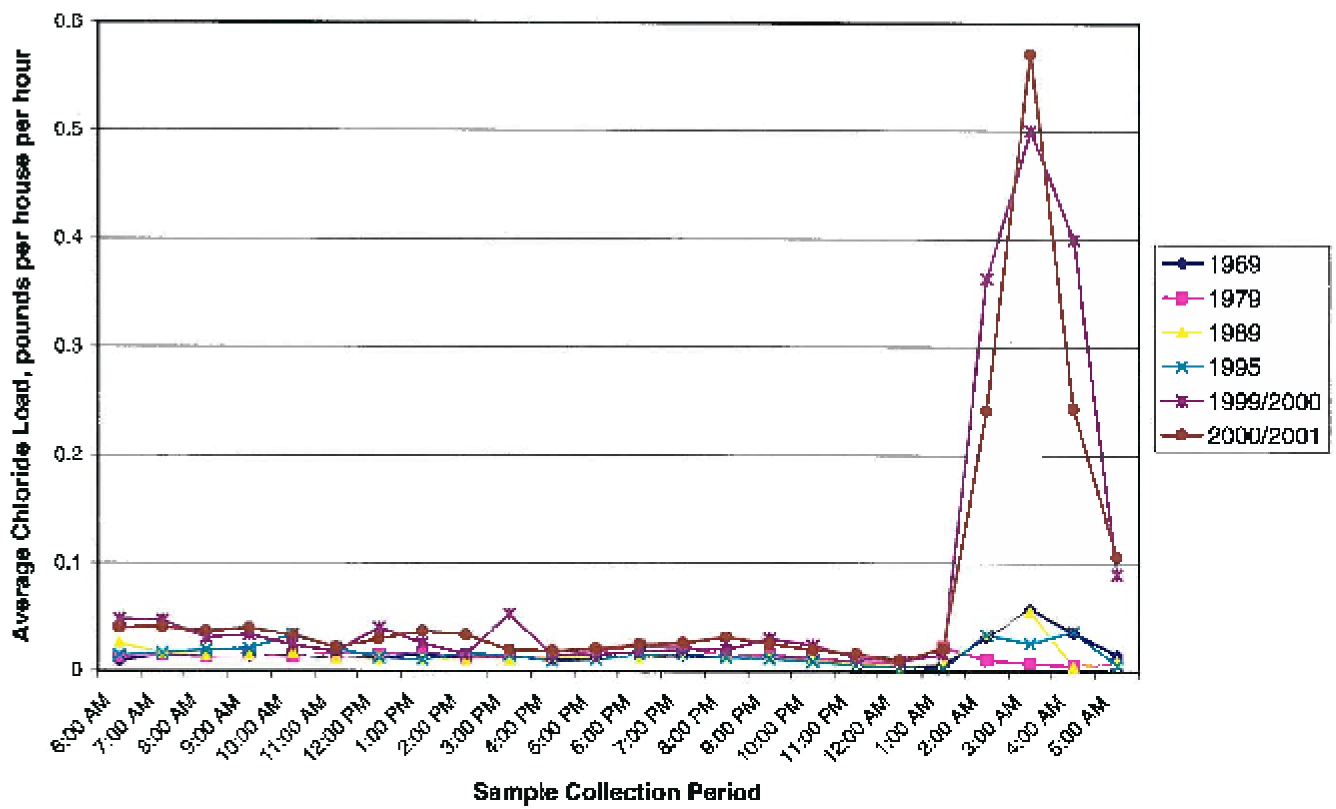
Chloride discharge to sewer in neighborhood with 61% of homes with SRWS

Figure 4.6.4.6-15
Chloride Mass Loading, Site 6, 2000/2001



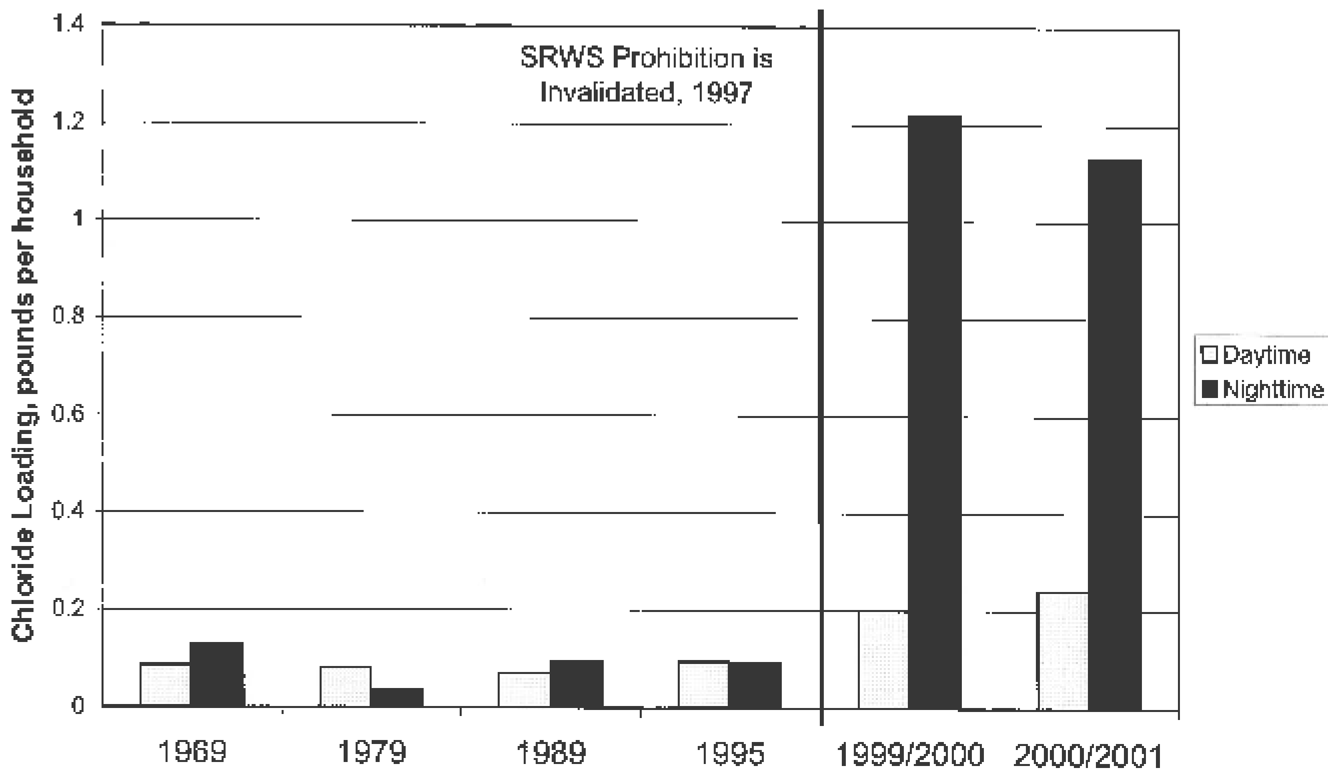
Wastewater chloride load to Santa Clarita WRP sewer. SRWS prohibition lifted in 1997

Figure 4.6.4.6-7 Average Hourly Wastewater Chloride Load



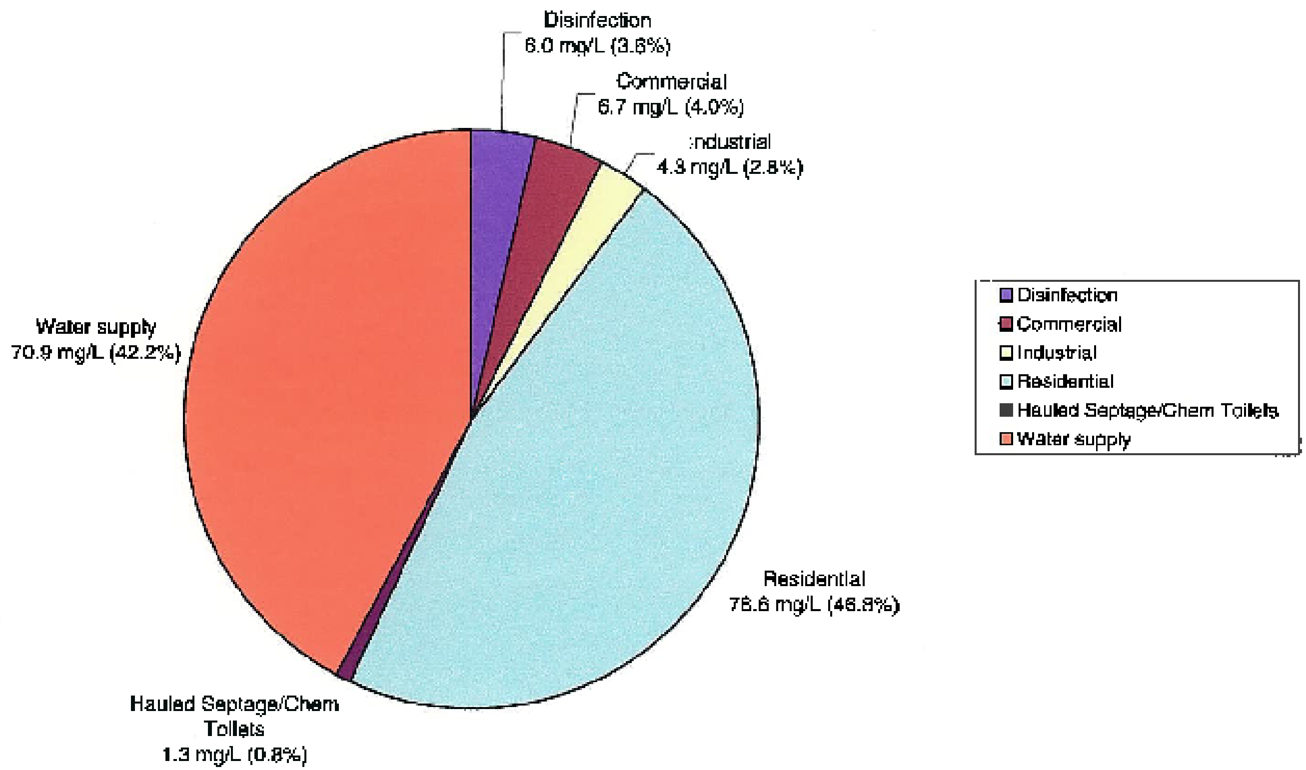
Chloride loading to Santa Clarita wastewater above water supply background level

Figure 4.6.4.6-6
Chloride Loading Above Water Supply Based on Time of Day



Effect of auto-regenerating residential water softeners on Santa Clarita wastewater reclamation plant effluent chloride (County Sanitation Districts of Los Angeles County, 2002)

Figure 6.1-1 Santa Clarita WRPs Effluent Chloride Concentrations (168 mg/L)
2001 Conditions



SCVJSS Chloride Source Report (DRAFT) F - 43

Salts, Septic Tanks & Biological Processes - Friends or Foes?

Alan E. Rimer PhD PE DEE
Director – Water Reuse
Black & Veatch

WERF

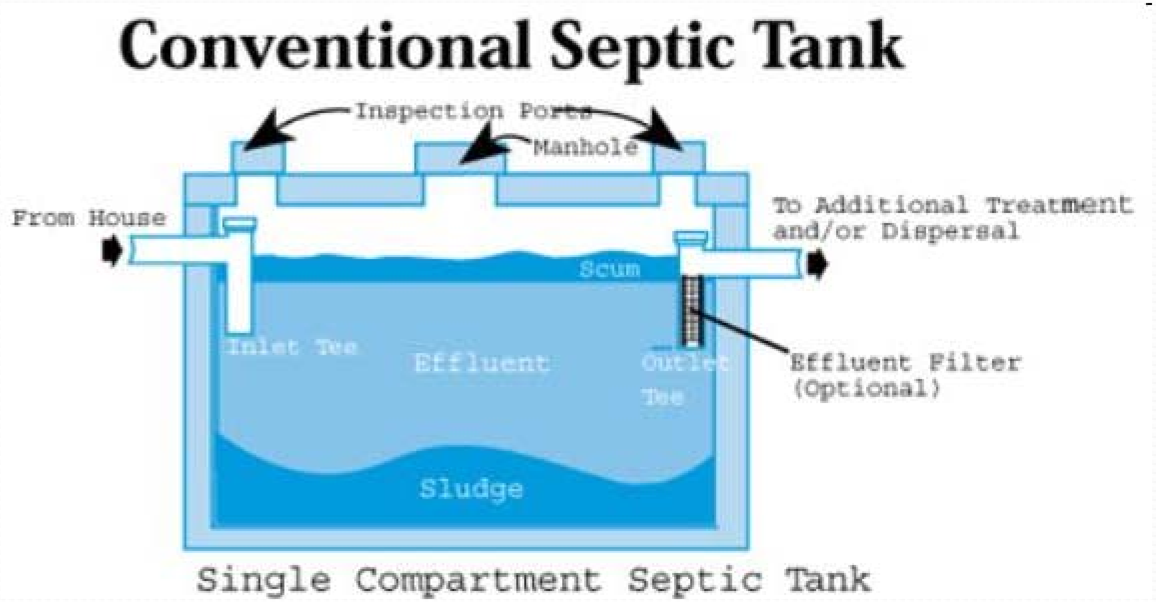
What is on the Agenda This Afternoon?

- Septic Tanks – A primer
- Water Softening – A Primer
- Impacts of Softeners on Septic Systems
- Impacts of softeners on POTWs
- Future Research

Septic Tanks – A Primer

- This audience really does not need a primer on septic tanks but let us set the stage
- The "system" is really a septic tank and drainfield which work together
- The septic tanks removes solids
- The drainfield distributes the clarified wastewater to the soil horizon

Septic Tank Operation

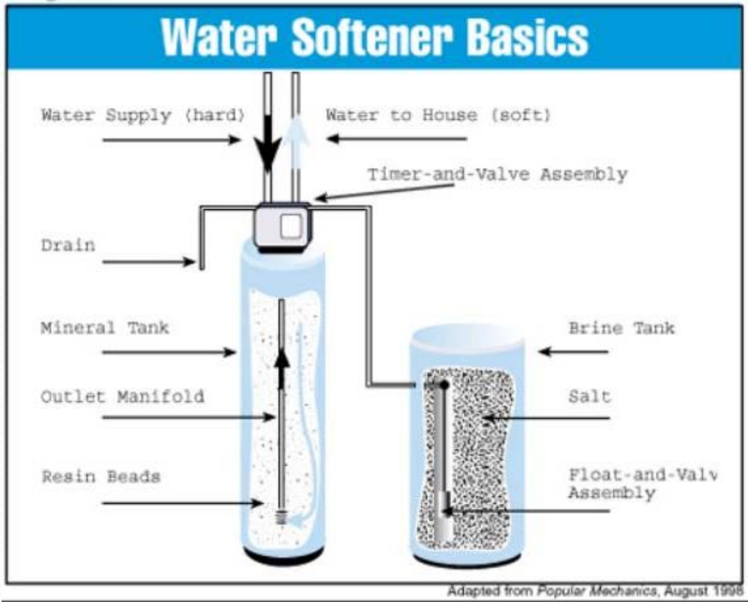


From National Small Flows Clearinghouse

- Primary settling & solids management
- Drainfields

Water Softening

Figure 1



Adapted from *Popular Mechanics*, August 1998

- Used to soften “hard” water
- Ion exchange exchanges calcium & magnesium with sodium producing brine during regeneration

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Impacts of Softeners on Septic Tanks

- Do water softeners hurt septic tank bacteria?
- Does the additional amount of water used for regeneration affect a septic system's performance?
- Does the concentrated salt water (brine) generated in regeneration decrease the drainfield's adsorption capacity?

How do the Bacteria Feel?

- According to most researchers, aerobic bacteria are quite adaptable
  - Our findings indicate there is a possible threshold
- The story is not quite as clear on the impact on anaerobic bacteria
  - Industry view
  - Detractor view

Impacts - Increased Water Discharge

- There are diverging opinions on whether the increased discharge creates a problem
  - Most say it does not while a few say it does
  - If a water softener is to be used, upsize the tank to accommodate the additional flow?
    - The flow probably does not exceed that of a washing machine
    - Tank design is important

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Impact of Brine on drainfields

- The increased salt concentrations in the backwash (brine) may have an impact
  - Some research indicates that it does reduce the adsorptive capacity
  - But some say the calcium-rich backwash has been demonstrated to increase the porosity of clay soils
- Who is correct?

Impacts on POTWs

- POTWs are aerobic systems
- A study completed for the WateReuse Foundation (WRF) and WERF indicated that impacts might be significant if the salts from softeners (and power plants) were very high, but little actual data to support
- Unlikely that you would see a problem in a septic tank (but they are anaerobic)

So What to Do

- The purpose of this conference is to look at water softener research needs!
- For septic tanks:
  - Evaluate impact of hydraulic loading and thus increase septic tank size
  - Evaluate impact on the bacteria in the septic tank
  - Evaluate drainfield soil impacts

Level the Playing Field

- In all of this, little has been said about septic tank maintenance
- None of this research will be meaningful if the proper maintenance is not provided to the septic tank
- Poor tank performance creates problems in the drainfields
- Know your underlying soils
- Know what folks are putting into the tanks besides brine!!

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Questions

Alan E. Rimer

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rimerae@bv.com

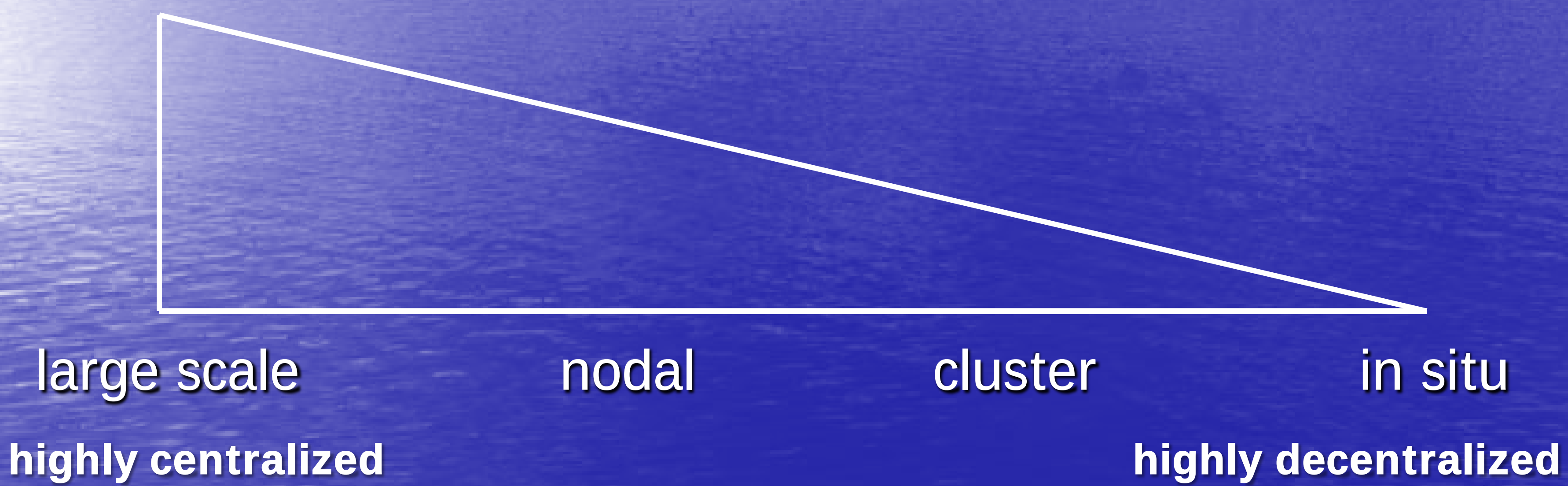
Water Environment Research Foundation
Collaboration. Innovation. Results.

Related WERF Research – An Overview

Jeff Moeller, P.E.,
Water Environment Research Foundation
jmoeller@werf.org

Water Softeners Research Needs Workshop
Alexandria, VA
Nov. 2-3, 2009

A Continuum of Options for Wastewater Treatment...



- Paul Reiter, Executive Director, IWA

“Decentralized systems are a fundamental element of an emerging paradigm of urban sustainability – at every scale.”

- Paul Brown, Executive Vice-President, CDM

NOWRA Annual Conference 2007, co-sponsored by WERF

Sound science and information is...

- Essential for good decision-making, and
- Critical to the credibility of the decentralized wastewater industry

NDWRCDP

National Decentralized Water Resources Capacity Development Project

National Decentralized Water Resources Capacity Development Project

- EPA grant-funded research program on decentralized systems administered by WERF since 2003
- Mission: To improve the capacity of public and private entities to respond to the increasing complexities of, and expanding need for, decentralized wastewater and stormwater systems through identification and support of research and development.

NDWRCDP Partners

WERF
Water Environment Research Foundation
Collaboration. Innovation. Results.

CIDWT

NOWRA
National Onsite Wastewater Recycling Association
3540 SOQUEL AVE., SUITE A // SANTA CRUZ, CA 95062
P 800.966.2942 (831.464.4884) // F 831.464.4881

Coalition for Alternative Wastewater Treatment

EPRI
ELECTRIC POWER RESEARCH INSTITUTE

National Rural Electric Cooperative Association
A Touchstone Energy® Cooperative

NDWRCDP Research Areas

- Environmental Science and Engineering
- Management and Economics
- Regulatory Reform
- Training and Education

- 40+ projects valued at $8 million; Phase 2
- All products available through www.werf.org or at www.ndwrcdp.org

Examples of NDWRCDP Projects Relevant to Water Softeners

- Factors Affecting the Performance of Primary Treatment in Decentralized Wastewater Systems (04-DEC-7)
- Influent Constituent Characteristics of the Modern Waste Stream from Single Sources (04-DEC-1)
- Development of Quantitative Tools to Determine the Expected Performance of Unit Processes in Wastewater Soil Treatment Units (DEC1R06)

WERF WQA/NOWRA Workshop

Conference call, Monday, 11/2/2009 (4:00 PM)

Terry Bounds PE… A Manufacturer's Perspective

Our perspective may not be universally accepted by all manufacturers of wastewater treatment products, but it is a perspective that many within the **onsite** industry feels strongly about, and the concern is not just limited to those of us who are manufacturers.

Our perspective is that regenerate-brines *do not belong in biological wastewater treatment processes* (either aerobic or anaerobic).

Water softener regenerate brine is simply heavily salt/mineral-laden water containing no organic or pathogenic contaminants … and it can be handled responsibly by other means.

In 1980, the Water Quality Research Council published and titled their … *Consumer Bulletin No. 01/80 … "WATER SOFTENERS POSE NO PROBLEMS FOR **SEPTIC TANKS**."*

The report cites two key references:

1st ref —The study by the National Sanitation Foundation (NSF) **"The Effect of Home Water Softener Waste Regeneration Brines on Individual <u>Aerobic Wastewater Treatment Plants</u>," 1978, performed for the WQRC. (underlining mine)**

NSF's Standard 40 test for aerobic plants does not confirm the effects of water softener brine on the performance of **septic tanks**.

Two-500 gpd home aeration plants — <u>not</u> septic tanks — 'listed by NSF' for conformance with NSF/ANSI Standard 40 **Class II.** (Class II effluent must not exceed 60 mg/L BOD_5 and 100 mg/L TSS for more than 10% of the test period.)

One plant was established as the base control plant and the other was fed a brine solution at 3.5 pounds per regeneration and regenerated twice as frequently as is typically recommended by water softener manufacturers. The plants were loaded at 250 gpd (expressed as equivalent to 5 occupants at 50 gpcd). Therefore, the systems were loaded at half their listed capacity. The median influent BOD_5 was 153 mg/L and TSS was 208 mg/L.

Control plant … The median effluent BOD_5 was 23 mg/L (ranged 5-85) and TSS was 34 mg/L (ranged 7-126).

Test plant … The median effluent BOD_5 was 20 mg/L (ranged 6-77) and TSS was 27 mg/L (ranged 4-60).

Even though I feel it's statistically important to report median values, it would be more consistent, with respect to typical NSF reporting, to report mean or average values, and use median values to illustrate skew.

While the test outcome appears to bode well for the Test plant, it's based on dilute loading conditions. Real home influent characteristics are very much higher in organic strength and especially in fats, greases, and oils, which factor into the problems posed by backwash brine that are noted by service providers.   NSF's Standard 40 test only provides a short 6 months window of information, and it is typical to see many systems perform adequately a year or more before showing signs of effluent degradation, and greater servicing needs.

Real test flows will fall in the range of 2 to 3 occupants, and according to the values given by the water softener folks, a regeneration contains about 6 pounds of salt … and back in the 1980's it was common to find people setting their regeneration as frequently as every other day. (They were under the impression that it posed no problems, so, why not?)

Regardless … **Septic tanks** represent an **anaerobic** process … they are designed to collect wastewater and passively, under quiescent conditions, segregate settleable and floatable solids (into *sludge and scum layers*), to accumulate, consolidate, and store solids, to retain a high percentage (90%±) of fats, greases and oils, digest organic matter and discharge primary treated effluent.

<u>It was wrong of WQRC to claim "Water Softeners Pose No Problems for Septic Tanks," based on NSF's evaluation of a complete-mix, suspended-growth, aerobic process (an ATU)</u>.

And, regardless of the Class II test, field-related problems have led many NSF-listed ATU's to prohibit the discharge of backwash brine into their system.

2nd **ref** — The study ***"Potential Effects of Water Softener Use on Septic Tank <u>Soil Absorption</u> On-Site Wastewater Systems,"*** University of Wisconsin-Madison, done by Jerry Tyler, Corey, et al., 1978, for the Water Quality Research Council. (underlining mine)

The focus of Dr. Tyler's paper was the effects on soil structure and permeability, not septic tank performance per se! Septic tanks were discussed in the paper as a component of the septic system. In a discussion with Dr. Tyler I learned that the University's Biology department hypothesized the information presented on the Osmotic Potential.

The septic tank portion of the paper supported no conclusions, only suppositions regarding the 'potential' osmotic affect on the bacterial activity within the tank.

*Dr. Tyler stated that, no attempt in his work was made to determine **"ion specific effects in the septic tank";** they only measured the osmotic potentials of tanks with and without water softeners. Dr. Tyler further explained, during our discussion, that the university's biology department provided the comments regarding the "potential effect" to the microbes in the tank. However, they did not provide additional comments on any other potential environmental treatment aspects … From that perspective: **the effects on sludge-settling characteristics; the effects of softening on the solubilization of solids or the chemical emulsification of fats/greases/oils by household detergents and other cleaning compounds; the dispersion effects on particle settlement, coagulation, segregation, ammoniafacation, mineralization; the accumulation and stratification effects relative to high chloride concentrations; or effluent overall degradation. (<u>The effect on ST effluent quality was not tested or measured</u>.)** Throughout the document are comments and statements explaining that little "<u>real world</u>" data was discovered in their literature search (pages 48 & 52**). Dr. Tyler, on page 50 of this paper, states that "septic tank flora are very complex and in need of further study." On page 52 he quotes Weibel, et al., 1954, stating that "more research on salt stratification in septic tanks is needed."***

On page 55, Dr. Tyler concludes, that <u>limited information was available and that additional work, specifically in the septic tank, was needed.</u>

Winneberger also reported that the brine settles to the bottom, stratifies, accelerates sludge accumulation, and reduces hydraulic retention time (*see Pages 33-35 ...Septic Tank Systems: a Consultant's Tool Kit*). He also discusses how solids tend to sheet across the top of the brine layer.

<u>The Wisconsin report, as I understand it, was intended to address the effects of salts in onsite **soil absorption** systems, and to that extent, it demonstrated an acceptability to load 'soils' with the 'salt brine from water softeners.'</u>

It was wrong of WQRC to take what was presented in the Wisconsin report with respect to **septic tanks** and claim, without so much as one qualifier, that "**Water Softeners Pose No Problems for Septic Tanks**."

It is misleading to continue to promote and promulgate that claim without addressing the many other critical physical and biological activities within septic tanks. And it is misleading to continue to ignore the many other warnings shared in the Wisconsin report that suggest a great need for a more thorough understanding of the sensitive flora and fauna micro life.

Many times we've presented our own field observations as well as those of other onsite service providers, operators, regulators, and users … and we continue to hear that

"Water Softeners Pose No Problems for Septic Tanks." Yet backwash brine tends to be the common denominator with respect to lots of problematic sites, and rerouting it away from the wastewater treatment tends to clear up the problems. (Another typical characteristic is that these sites tend to have little or no scum accumulation within the tank, have grease-clogged drainfields or other treatment and dispersal media, and require greater servicing of effluent filters and pumps.)

National Small Flows Clearing House, WV, contacted many of us and reported on our combined finding, thoughts, and concerns. As has been the case with WQRC, they continue to defend their premise without consideration of the many factors that were left unresolved by the referenced research.

Biological (organic) processes provide little treatment for inorganic backwash brine solutions, so there is no real benefit to mixing it with the organic matter. And adhering to strict environmental engineering practices and design manuals — with respect to establishing salinity values, oxygen transfer rates, and ionic effects relative to organic treatment processes — is every bit as important for individual home-based treatment units as it is for municipal sized plants. In fact, it is more important for home-based treatment units, since they don't receive daily operational oversight.

We can accept Dr. Tyler's work with respect to the effects of salts in soils, and directly bypass backwash brine to the final dose tanks and drainfield … or send it to its own dispersal trench, or surface discharge.

In considering further testing … the typical ATU's should meet Class I standards, not Class II … greater consideration should be given to treatment processes that require advanced levels of organic and solids removal. Further consideration must be given to those treatment processes requiring high levels of nutrient removal (*EPA's toxic threshold for nitrifying autotrophs is 180 mg/L chlorides, which is much lower than systems receiving brine*), and consideration must be given to the effects brine might have on disinfection devices.

The research should not ignore the cost and management ramification of operation and maintenance, accelerated pumpout frequencies, solids carryover to dispersal fields, regulations, and regulatory enforcement limitations.

We have always respected and promoted research and a thorough understanding of process capabilities and limitations … time after time we have taken the unpopular positions on such things as focusing greater efforts to produce watertight tanks, to ensure higher performance levels, to develop and build more sustainability into systems, to provide greater focus and attention to rule enforcement and compliance efforts, to ensure operators and service providers receive thorough training, to elevate designer and regulatory training programs, to bring greater academic attention to the onsite world, to press the fact that onsite systems are not temporary and substandard in comparison to central sewers (but are in many ways superior), etc. I mention these because it isn't always easy or pleasant to plea for greater efforts and education in the face of an industry where the lowest price typically wins. And we don't take these issues lightly or without great thought. We see this issue of passing water softener brine (an inorganic product) through organic processes as simply a means of shifting the responsibility of dealing with it. It's true that after nearly three decades, we have concerns that this effort is yet another attempt to get WERFs' and the EPA's sanctioning that the only option is to pass the backwash brine through the biological treatment processes, and that it "poses no problems to onsite systems." That thought is extremely disconcerting, especially for those of us who have dealt with it, and who are heavily regulated to ensure and maintain strict compliance levels.

We are not opposed to the use of water softeners, nor treating the softened water. We are, however, committed to protecting and ensuring the long-term sustainable performance of individual onsite biological processes, and the sure way (and most cost effective) is for the brine-regenerate to bypass the organic treatment processes.

We appreciate the attention that this subject is getting and encourage strong consideration regarding risks, consequences, reliability, manageability, and sustainability.

Thanks for listening.

WERF-USEPA Water Softeners Research Needs Workshop

November 2-3, 2009

Sheraton Suites Hotel

Old Town Alexandria, Virginia

Joseph F. Harrison, P.E. CWS-VI
Technical Director
Water Quality Association
4151 Naperville Road
Lisle, IL 60532
(630) 505-0160, ext. 512
jharrison@wqa.org

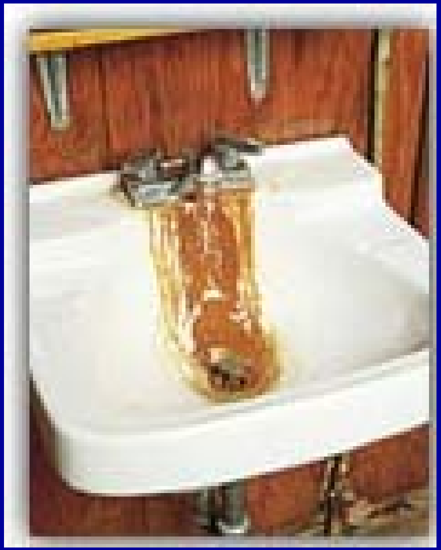
The Water Quality Association (WQA) Represents

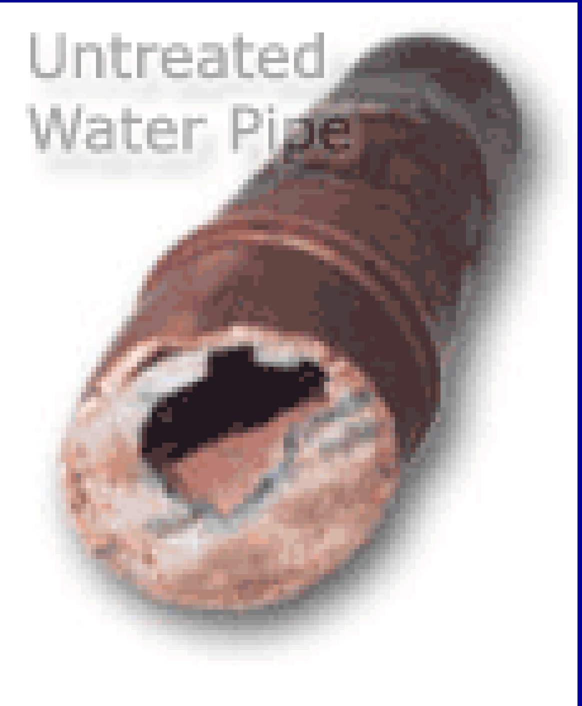
- 2500 Incorporated Companies and Corporations that:
- Manufacture and Sell Household Water Treatment Equipment
- Throughout All States, Canada, and the World.

Why Soften Hard Water?

- Soap/Detergent Waste
- Fabric Damage
- Pipe Scale
- Wasted Heating Energy
- Skin Problems
- Appliance & Fixture Damage
- Dishes & Glasses have spots
- Food and Drinks Taste Bad
- Wasted Time – as much as 40 hrs/year
- Harsh Chemical Cleaners


SOFT WATER
HARD WATER

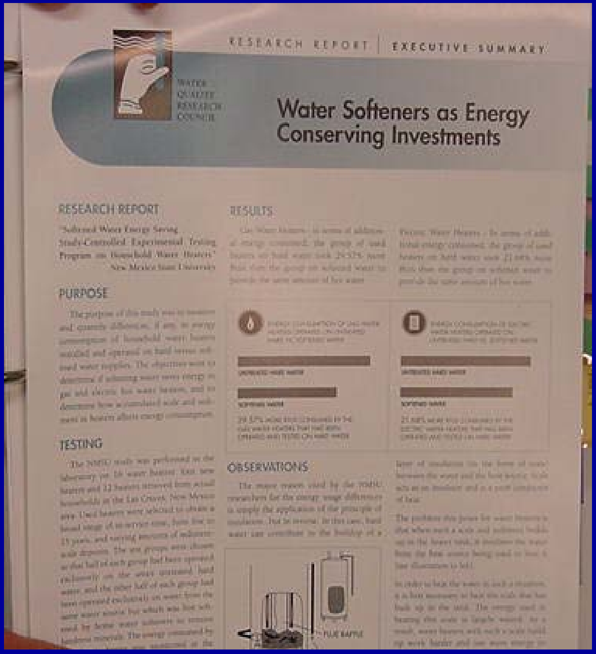



Untreated
Water Pipe

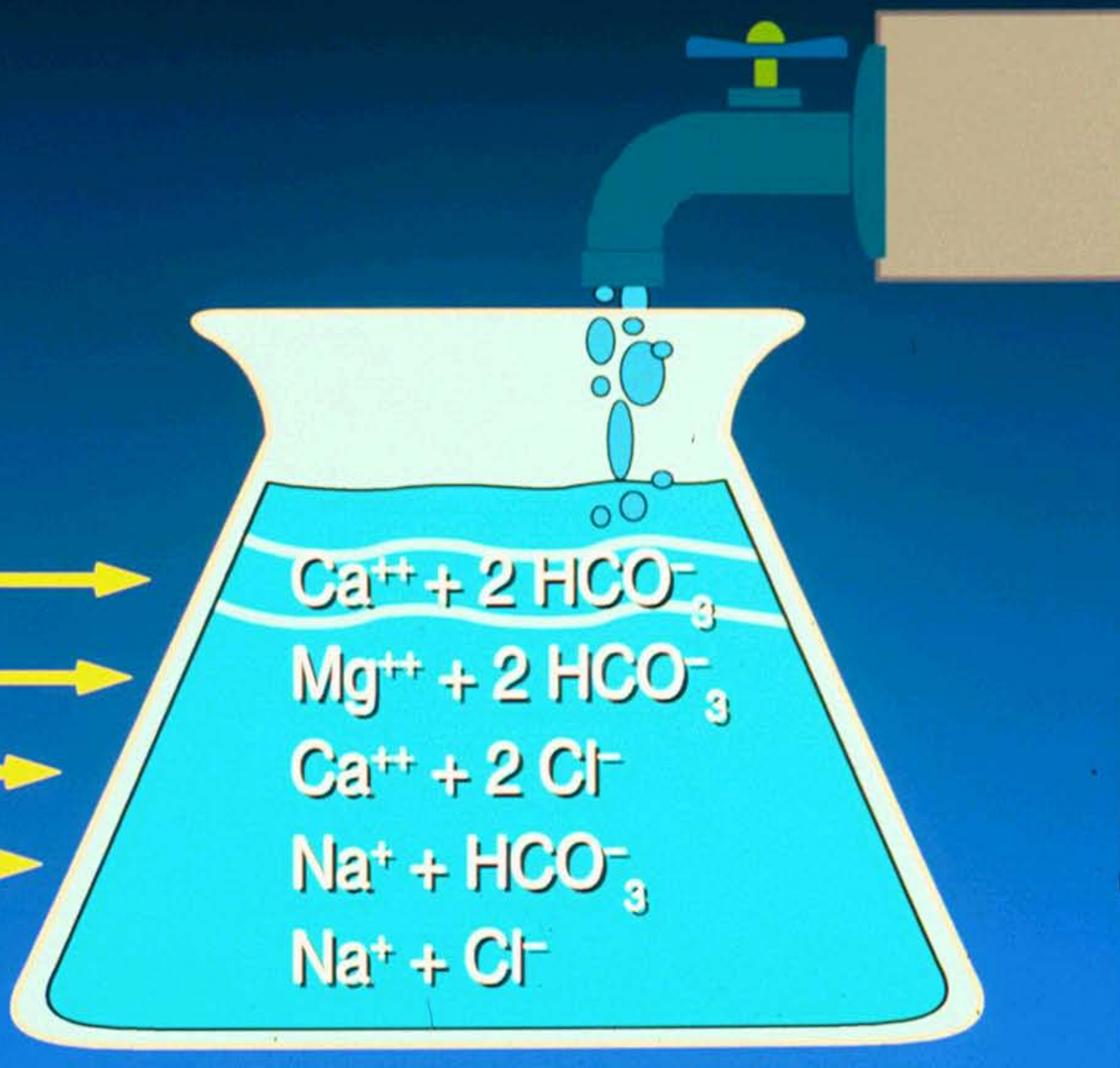
Benefits of Water Softening

- Saves washing costs.
- Helps control environmental pollution
- Saves water-heating energy.
- Helps water using appliances
- Better for bathing and household cleaning

- 25 – 75% savings in soaps, detergents, and cleansers
- 20 – 30% savings in clothing due to longer life
- 21 – 29% improvement in water heating efficiency



SALTS ARE IONIZED IN WATER



$Ca(HCO_3)_2 \leftrightarrow Ca^{++} + 2\ HCO_3^-$

$Mg\ (HCO_3)_2 \leftrightarrow Mg^{++} + 2\ HCO_3^-$

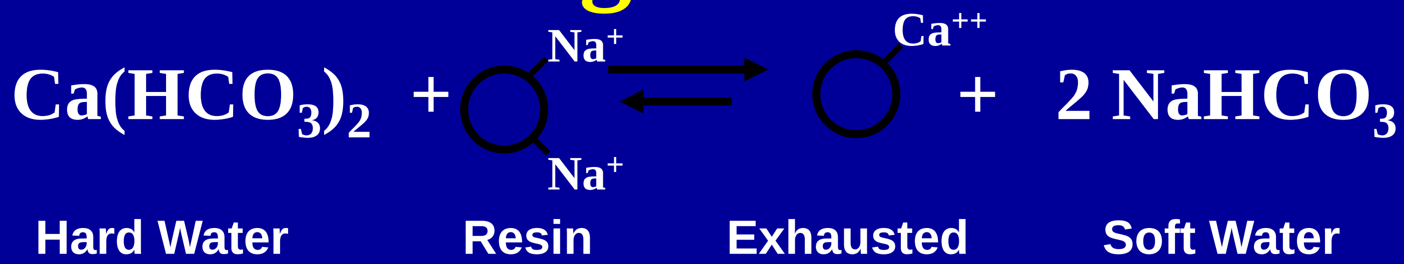
$CaCl_2 \leftrightarrow Ca^{++} + 2\ Cl^-$

$Na\ HCO_3 \leftrightarrow Na^+ + HCO_3^-$

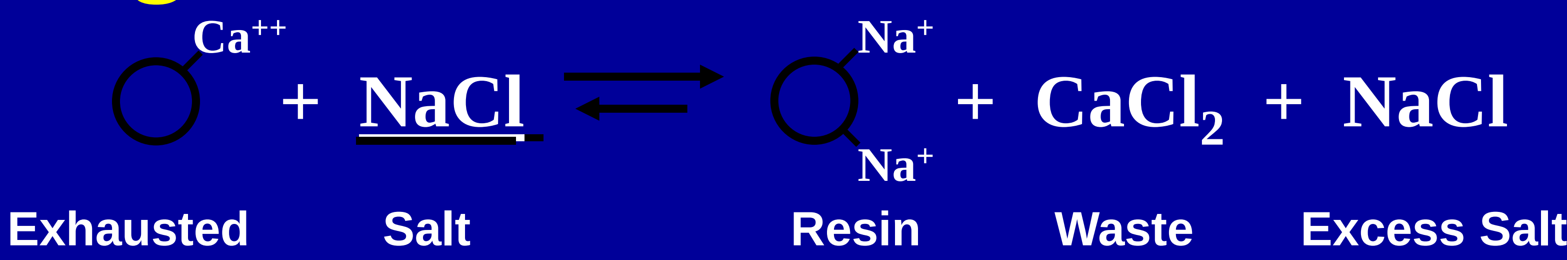
$NaCl \leftrightarrow Na^+ + Cl^-$

Softening Reactions

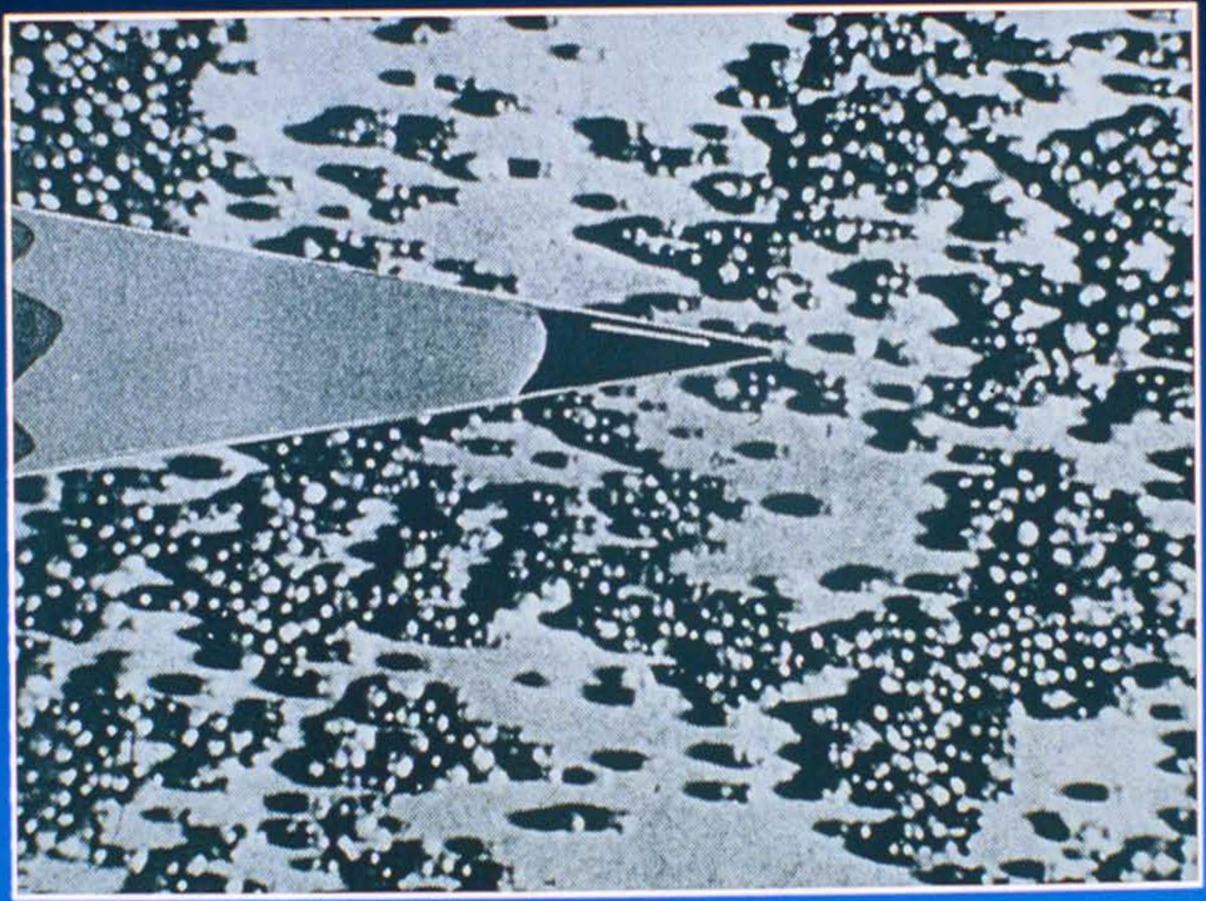
Water Softening



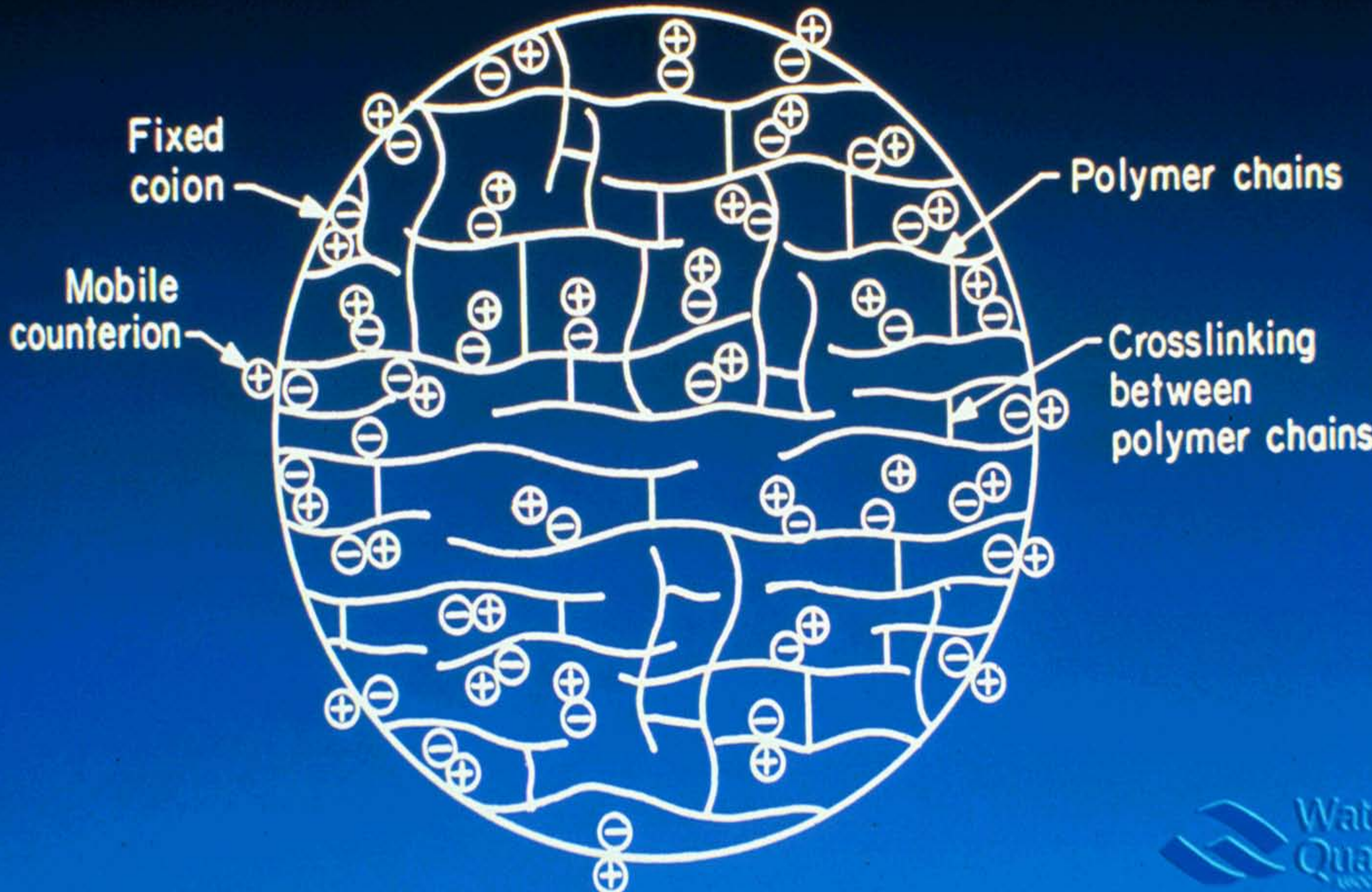
Regeneration



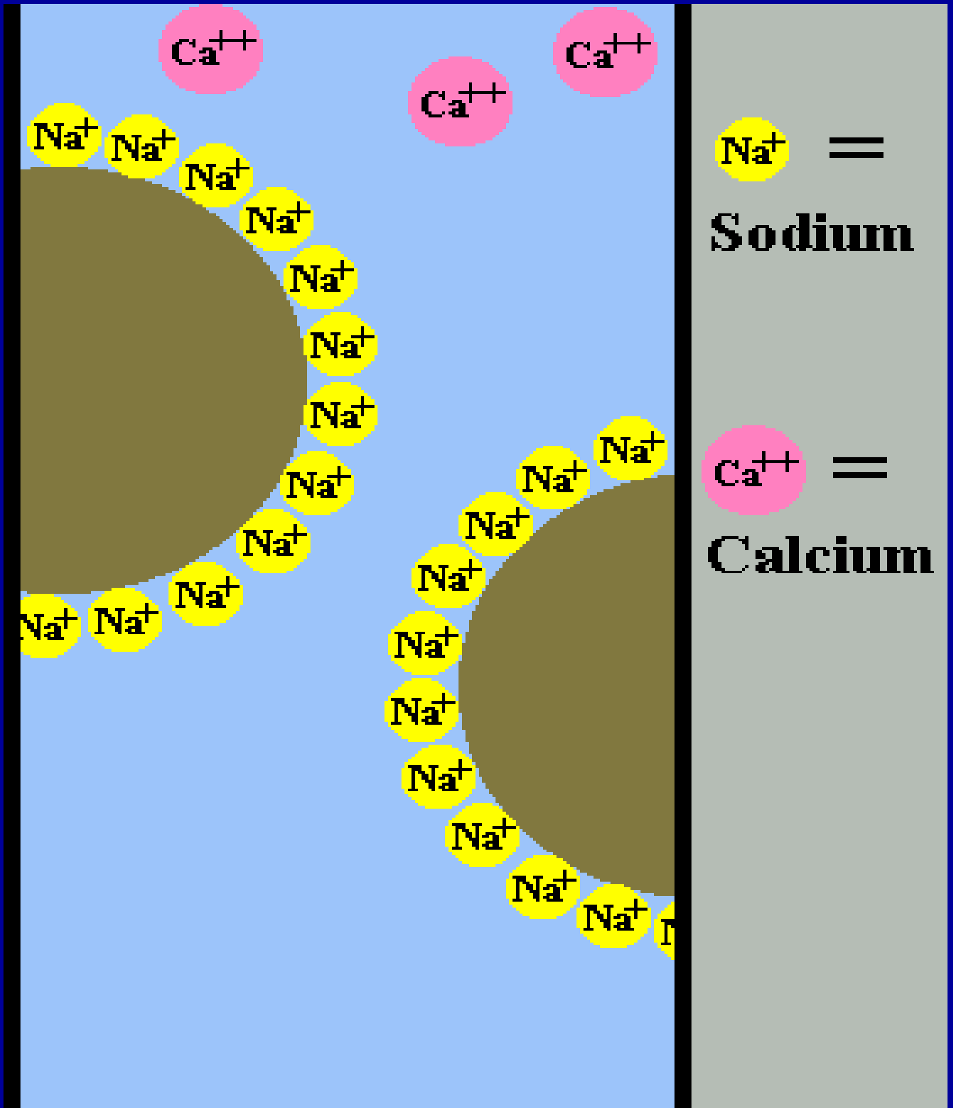
RESIN SIZE COMPARED TO PENCIL POINT

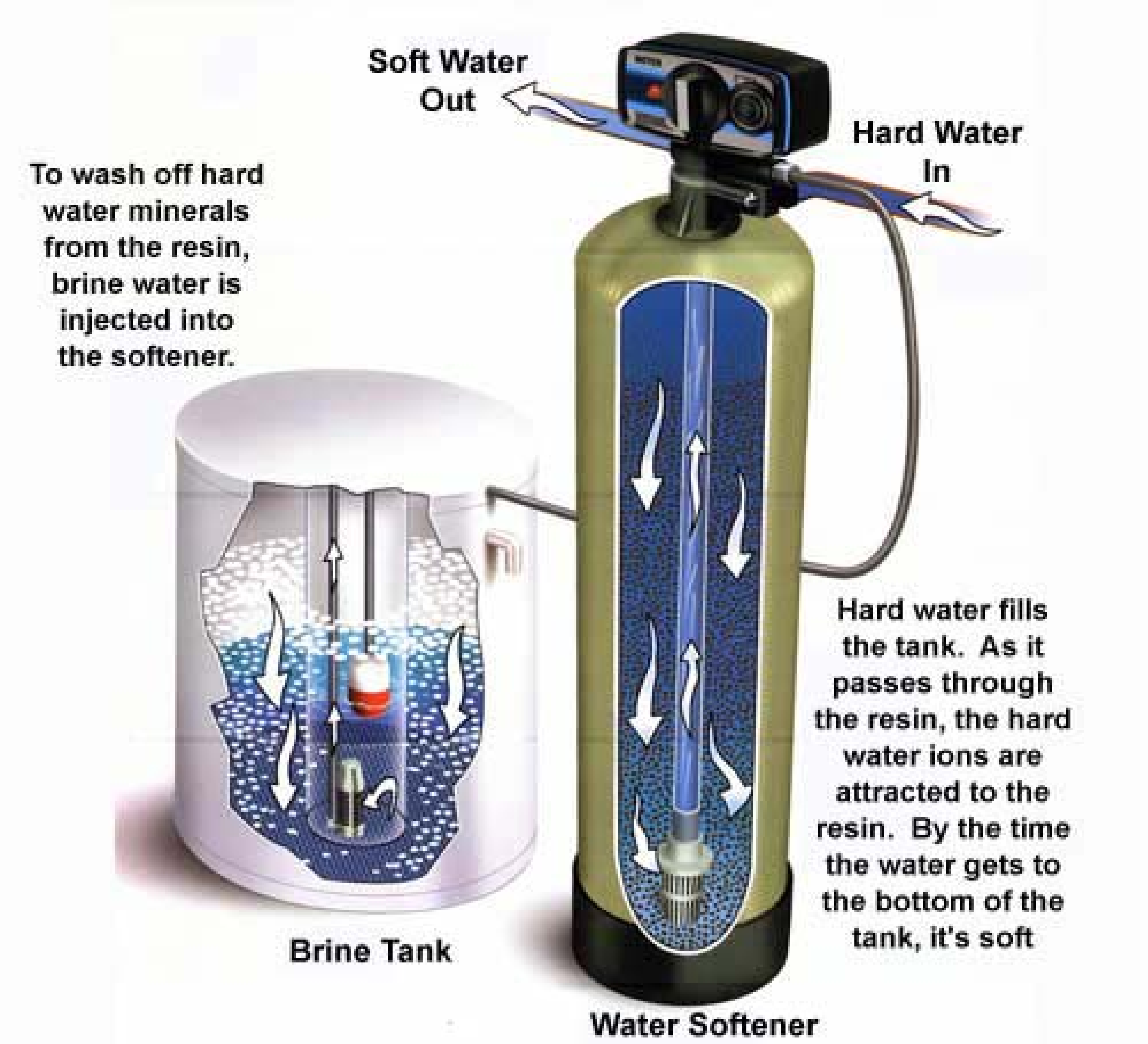


Ion Exchange Resin

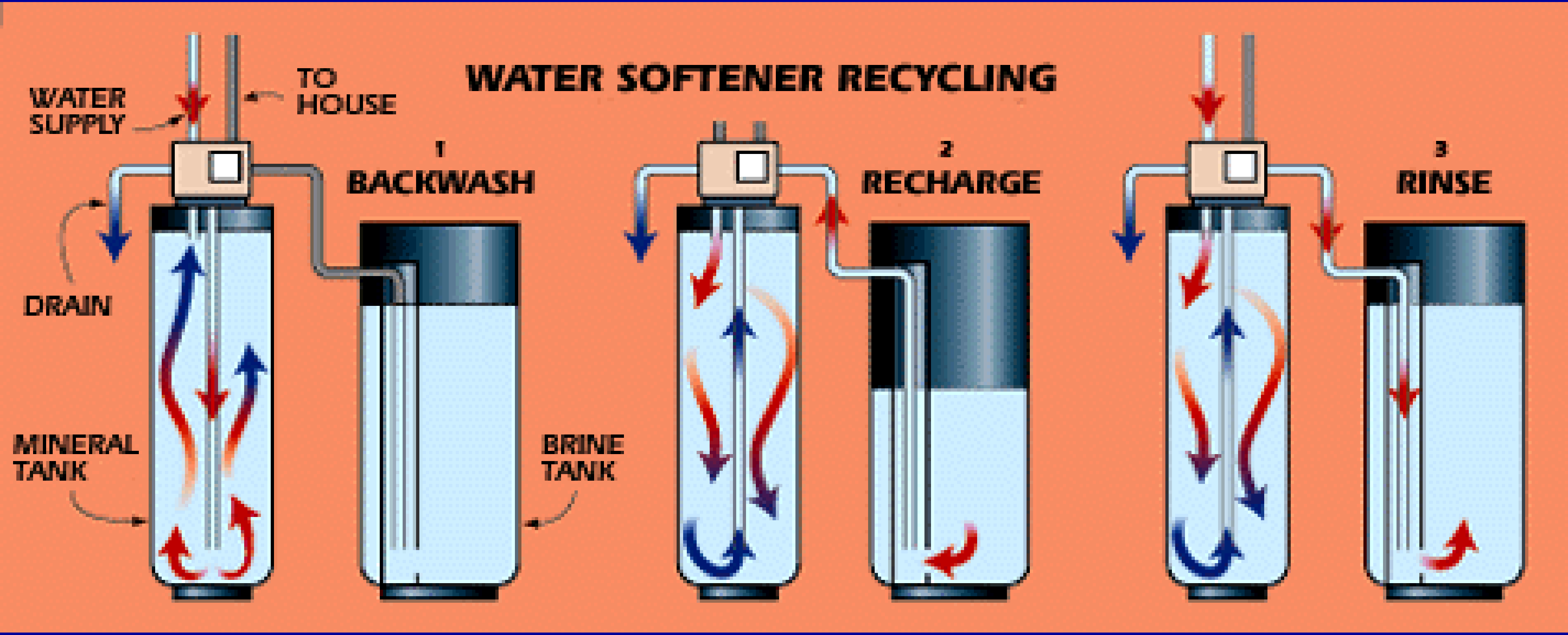


ION EXCHANGE WATER SOFTENING




Soft Water Out
Hard Water In
To wash off hard water minerals from the resin, brine water is injected into the softener.
Hard water fills the tank. As it passes through the resin, the hard water ions are attracted to the resin. By the time the water gets to the bottom of the tank, it's soft
Brine Tank
Water Softener

WATER SOFTENER IN REGENERATION CYCLES



Demand Initiated Regeneration (DIR)

Versus

Time Clock (TC) Water Softeners

Time Clock (TC) Controlled Regenerations

- Original Models
- Less Efficient
- Use About Twice as Much Salt

Demand Initiated Regeneration (DIR) Water Softener

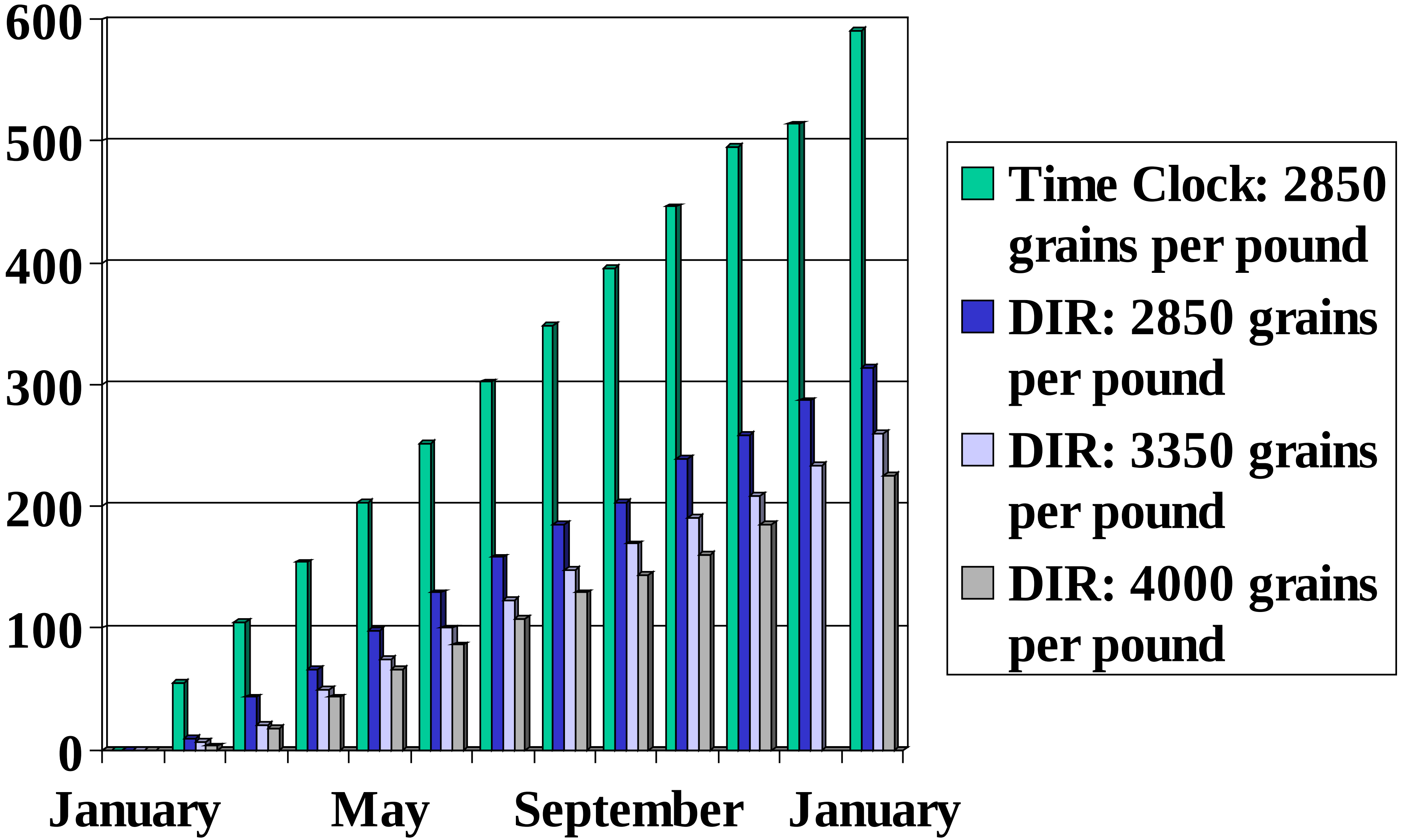
- Meter controlled.
- Sensor controlled.
- Present day modern units.
- Use about one-half the amount of salt.
- 90% of water softeners sold today are DIR.
- Salt discharge never gets out of proportion to household wastewater flow and discharge of water dilution to the wastewater system.

Efficiency Rated Softeners

- >3350 Grains of Hardness Exchange Per Pound of Salt
- 3-5 Pounds Of Salt Per Ft^3 of Resin
- Counter Current Regeneration
- < 5 Gallons of Regeneration Water Consumption or Discharge Per 1,000 Grains of Hardness Removed

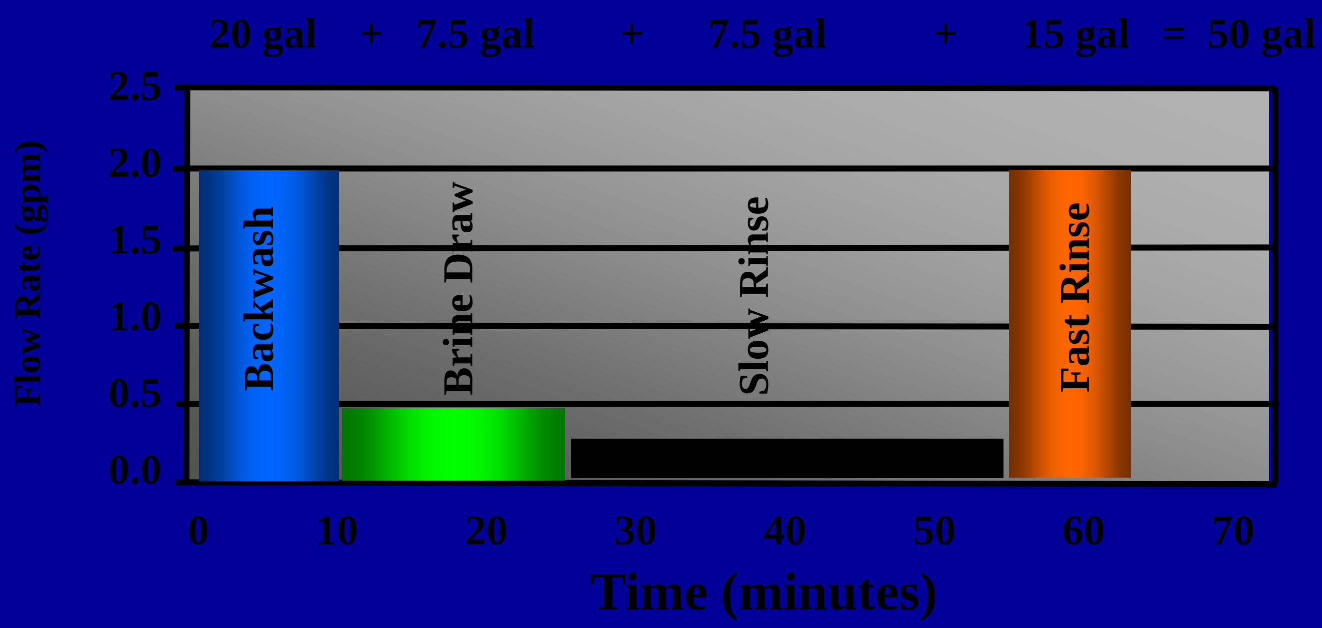
Household Water Softening -Water Softener Salt Usage

10 grains per gallon total hardness, 1.0 cubic foot cation exchange resin



Typical Softener (DIR) Discharge Flows

Demand Initiated Regeneration (DIR) POE Ion Exchange (e.g., Water Softener, Radium, Barium, etc. Removals) ~ 50 Gallons over ~ 1 Hour



How Much Salt Comes From a Household Water Softener?

Modern Household Water Softeners Use 5 to 8 pounds of NaCl Salt and 50 Gallons of Regeneration Water for About Each 1000 gallons of Soft Water Produced

Location of the Salt	Amount of NaCl Salt	Amount of Water	Concentration of Salt
In the Brine Tank	6.5 pounds	2.5 gallons	264,000 mg/L
In the Softener Regeneration Discharge	6.5 pounds	50 gallons	13,200 mg/L
In the Household Wastewater and in the Septic Tank	6.5 pounds	1000 gallons	660 mg/L

Discharge to Waste Water
DIR – Efficiency Rated Water Softener

(3350 Grains of Hardness Removal per Pound of NaCl)

Water Hardness Grains per Gallon (gpg)	Total Dissolved Solids Added mg/L	Gallons of Total Discharge per Week
5	179	25
10	358	50
15	537	75
20	716	100
30	1074	150

Example of Alleged Concerns About Water Softener Discharges:

1. Onsite system not designed for additional flow.
2. Salts/TDS might kill microbes in the treatment tank.
3. Brine alters the density in the settling tank causing solids to lift and carry over from the tank.
4. Salt causes concrete in the tank to degrade.
5. Sodium will swell clays in the drain field and prevent perking.

Fact or Speculation?

1. **Onsite system not designed for additional flow.**
   – Water softener wastes are lower in volume and rate of addition than waste from many automatic washers.
2. **Salts/TDS might kill microbes in the treatment tank.**
   – Bacteria divide and grow most rapidly and virulently at osmotic potential associated with about 17,000 mg/liter NaCl.
3. **Brine alters the density in the settling tank causing solids to lift and carry over from the tank.**
   – Maximum concentration of chlorides found in Creekwood Subdivision pilot study of operating septic tanks was 781 mg/liter chlorides (1300 mg/liter NaCl) for DIR softener discharges and 4814 mg/liter chlorides (7900 mg/liter NaCl) for TC softeners.
4. **Salt causes concrete in the tank to degrade.**
   – Concrete stands up well in sea water pillars and in cement brine tanks.
5. **Sodium will swell clays in the drain field and prevent perking.**
   – Calcium and magnesium divalent cations in the water softener waste discharge add permeability and counteract the effects of sodium on clay soils.

Summary of Water Softener Discharge Data for the Creekwood Septic Tank/Water Softener Study (July 11-12, 2007) in Orange County, North Carolina

Water Hardness: 5-18 grains per gallon

Site	Softener Type	Discharge To:	Softener Size (Cubic Feet)	Salt Setting (Pounds NaCl per Regeneration)	Pounds NaCl per Ft^3
101		Surface			
102	Timer	Septic	0.8	8	10
103	DIR	Septic	1.4	12	8.6
104	DIR	Septic	0.5	3.6	7.2
105	Timer	Septic	1.5	8	5.3
106	Timer	Septic	1.0	9	9

Creekwood Water Softener Data Cont'd

Site	Chlorides in the Discharge (mg/L)			Chlorides in the Septic Tank (mg/L)		
	Composite	Maximum	Minimum	Average	Maximum	Minimum
101				55	60.9	50.1
102	15779			1265	2062	439
103	14548	9300	11	431	781	118
104	6577	30000	29.8	566	718	295
105	12304	46400	10.9	1761	2215	802
106	7850	57200	61.3	3557	4812	643
DIR Average	10563	39650	20.4	499	750	207
Time Clock Average	11978	53250	36	2194	3030	628

Creekwood Pilot Study Notes

- The chlorides in the septic tanks receiving discharges from the Demand Initiated Regeneration (DIR) water softeners in Creekwood averaged 431 and 566 mg/liter.

- The chloride levels in the septic tanks receiving discharges from time clock controlled water softeners averaged two to eight times higher than the chloride concentrations in the septic tanks receiving discharges from the DIR controlled water softeners.

- DIR water softeners make the most sense any time that salt discharges or salt concentrations in the waste water are a concern. Even in low water use situations or perhaps especially in low water use situations DIR will prevent the salt discharges from getting out of proportion to the water discharges. This disproportion is what happened in the sites # 102, #105, and #106 homes in Creekwood.

Preponderance of Evidence As Seen From WQA's Perspective

- The water treatment industry does not see grassroots evidence from home owner customers of water treatment equipment causing waste system problems.
- 1 million household water softeners have been sold each year since the 1950's.
- A water softener life is about 10 years
- Estimate at least 30% of softeners on well water households and with private onsite wastewater systems.
- 3 million water softeners discharging for 40 years and more to onsite wastewater systems without apparent problems.

Water Softener
French Drain (Curtain Drain) Installation








French Drain Construction Specifics:

- Simplest of jobs; cost = $500
  - No stone, no backhoe and stone truck heavy equipment.
  - $50 of material.
  - 2 men for 2½ hours.
  - No utilities, no landscaping, plenty of room, natural downhill slope, easy access to the water softener.

- Was this necessary?
  - Torn up yard.
  - Set up possible problems for the water softener operation .
  - Everything had consistently worked fine for 7 years.
  - No standing water; no back up into the home.

- Yet, 25% -35% adder to the average cost of a water softener ($1500-$2000)!

Let’s Not Create Unnecessary Construction and Homeowner Hardships.

Let’s find the truth about water softener discharge effects on onsite wastewater systems.

Please have a successful Water Softener Research Needs Workshop.

Questions?

Joseph F. Harrison, P.E., CWS-VI

Technical Director

Water Quality Association

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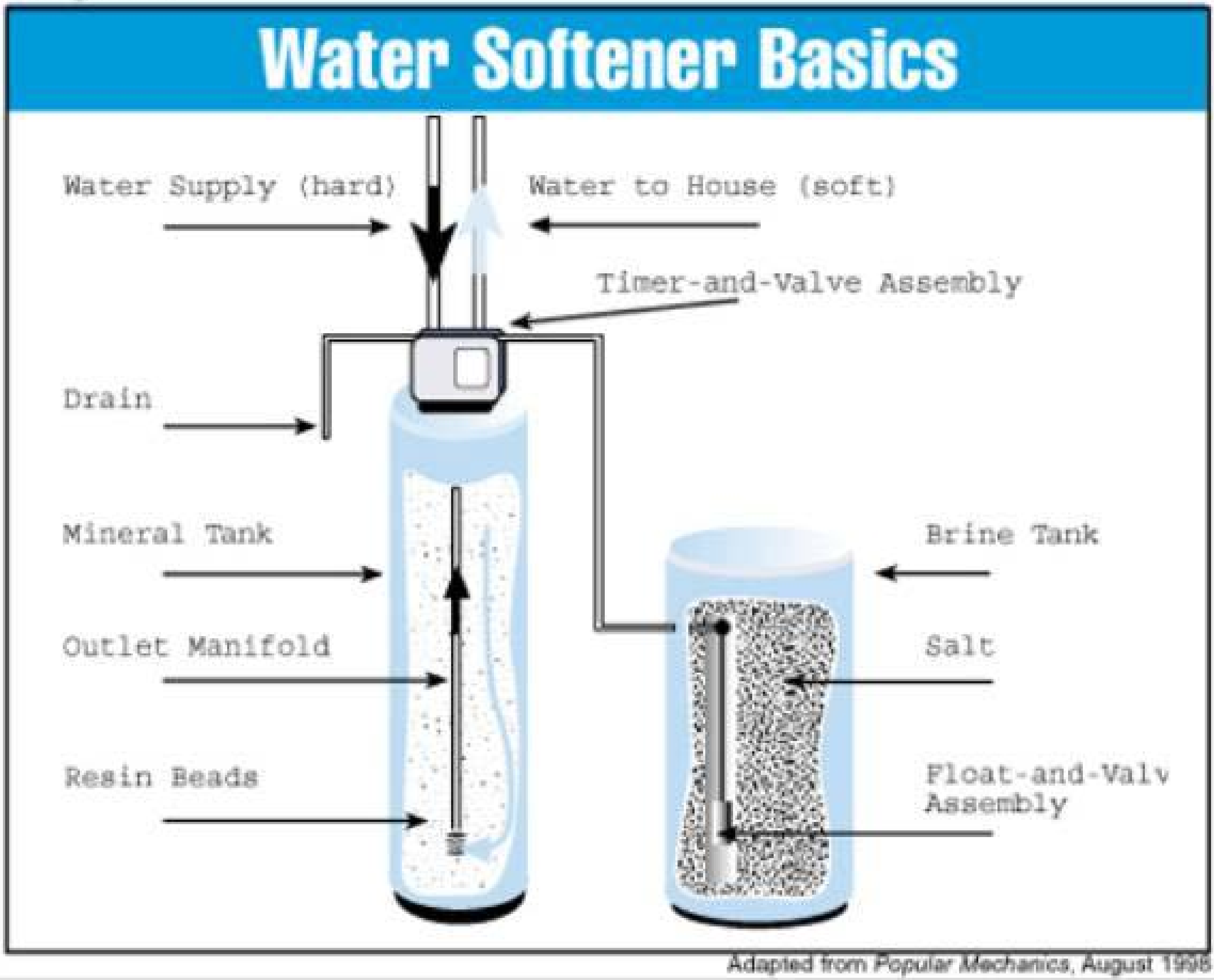
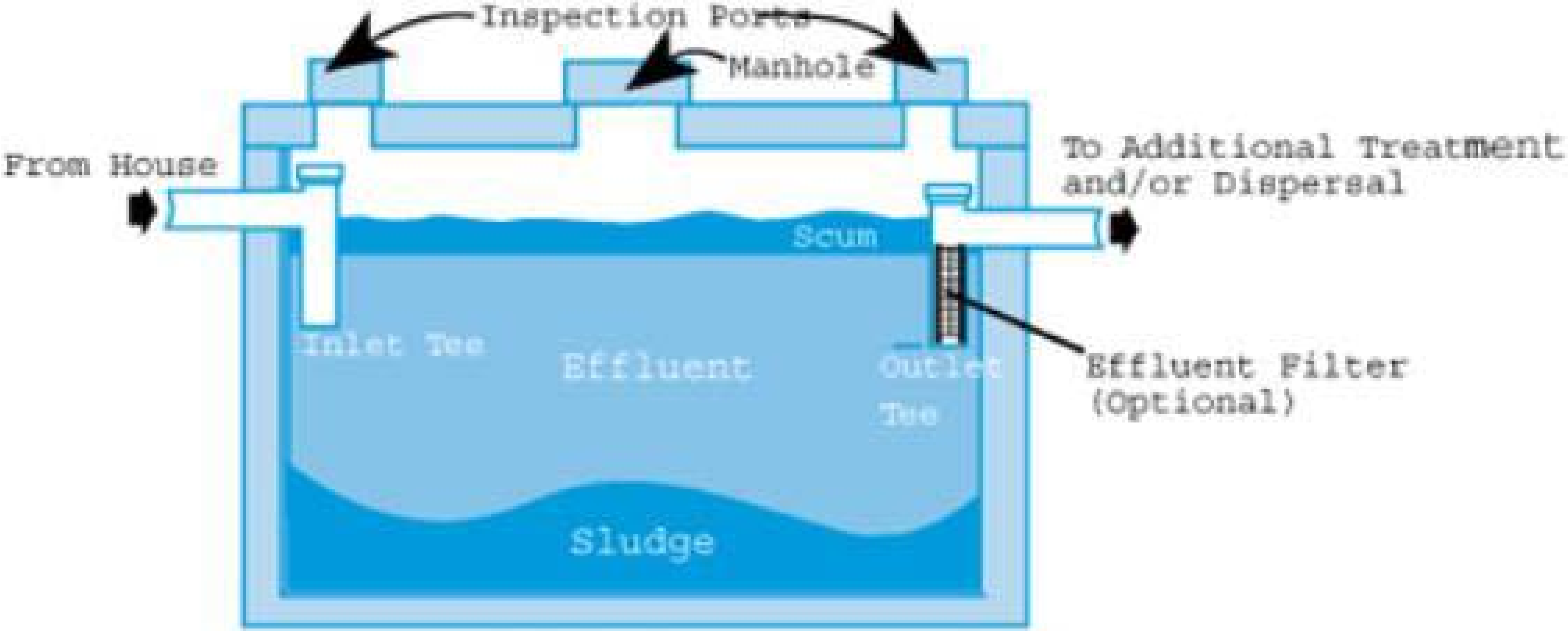
630-505-0160

jharrison@mail.wqa.org

Figure 1


Water Softener Basics
Water Supply (hard)
Water to House (soft)
Timer-and-Valve Assembly
Drain
Mineral Tank
Brine Tank
Outlet Manifold
Salt
Resin Beads
Float-and-Valv
Assembly
Adapted from Popular Mechanics, August 1998

Conventional Septic Tank



Single Compartment Septic Tank

How Much Salt Comes From a Household Water Softener?

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In the Household Wastewater and in the Septic Tank	6.5 pounds	1000 gallons	660 mg/L
In Ground Water (assuming 2 regenerations per week diluted over 1 acre with ~20 inches of rainfall (30% percolation) per year and ~50 feet of ground water in 20% aquifer porosity.)	6.5 pounds	~34,000 gallons	~ 20 mg/L

Proposed Water Treatment Discharge Restrictions

Within the last few years WQA has been asked to address regulatory codes prohibiting or proposing to prohibit water treatment backwash/regeneration discharges to septic tanks and advanced wastewater treatment units (ATUs) in the states of:

Connecticut,
Delaware,
Kentucky,
Maine,
Massachusetts,
Michigan,
Missouri,
Montana,
New Jersey,
New Mexico,
Rhode Island,
Texas

Alternative Waste Lines and Separate Disposal Systems are Difficult to Impossible for the Water Treatment Profession to Accommodate

- **Water Treatment Installations Commonly Occur After:**
  - **The Household Onsite Waste System is in,**
  - **The House Construction is Completed, and**
  - **The Yard Landscaping is Finished.**
- **A Second Waste Line Construction Means:**
  - **Construction Through Existing Concrete Foundations, Sometimes Through Existing Concrete Floors,**
  - **Trenching Through Finished Yards,**
  - **Engineering and Permitting Another Waste System, and**
  - **Expensive Disruptions Exceeding the Cost of the Water Treatment System.**

Millions of American families use on-site waste treatment to handle household waste.

Millions also use water softeners to eliminate the problems caused by hard water scale.

Water softeners periodically regenerate with a brine solution which is discharged to the septic system.

Is this harmful to the septic system??

These are some of the speculative issues we hear:

Seawate[illegible]t concentration of brine, is [illegible]buoyant than ta[illegible]r. Brine, therefor[illegible]se excess solids to [illegible]e from a septic t[illegible]

[illegible] sodium [illegible]ntrations caus[illegible]l to swell and re[illegible] in poor dra[illegible]

[illegible] softeners wast[illegible] amou[illegible]f water at high [illegible] that can overwh[illegible]e[illegible]ank.

Salt [illegible]is a preservative [illegible]n retard bacterial actio[illegible]ystem.

Update Since 2007

- Creekwood Septic Tank/Water Softener Pilot Study (July 11-12, 2007) in Orange County, North Carolina

- Water Softener Research Proposals from North Carolina State University and from Northeastern University Submitted to WERF Unsolicited Research Program in 2008
  - WERF Selection Committee did not include them in the 10 projects selected for further consideration.

- WQA – NOWRA Guidance for Use of Water Softening and Onsite Wastewater Treatment Equipment at the Same Site
  - Approved and Adopted by NOWRA and WQA Boards in 2009.

Guidance for the Use of Water Softening and Onsite Wastewater Treatment Equipment at the Same Site

by

Matt Byers, Joe Harrison, and Allison Blodig

This guidance document is a collaboration between the **Water Quality Association** (WQA) and the **National Onsite Wastewater Recycling Association** (NOWRA)

The use of water softening and water conditioning equipment in the United States is necessary in many homes. The use of onsite and decentralized wastewater treatment technologies, commonly called septic systems, is also necessary. Both water softening/conditioning and onsite wastewater treatment systems are commonly used together; in the majority of these cases no problems are indicated. However, there have been sporadic, mostly anecdotal reports of issues related to the use of both kinds of equipment at some sites. Experts in both fields are working together to better understand the interactions involved between water softeners and onsite wastewater systems. In the meantime, the WQA and NOWRA have collaborated to offer the following advice based on available knowledge:

1. When installing new onsite wastewater equipment, some onsite system manufacturers require that water softener regeneration water not be discharged in their wastewater treatment systems. In those cases, request them to provide an alternative for routing the water softener regeneration water around the waste treatment device that meets your local regulations or requirements as well as your site conditions. The local wastewater system installer should be able to accommodate the manufacturer's instruction.

2. If an issue arises where a water softener/onsite wastewater system interaction problem is suspected, inspect and assess the onsite wastewater system with a local expert on onsite wastewater systems and the water softener with a local expert on water softening/water conditioning systems. Generally, very few have skills in both areas. The local experts should consider using the screening tool that has been developed by this collaborative group as a guide, and they should return the information to either the WQA or NOWRA for tracking and evaluation purposes. The Water Quality Association provides a service to find qualified experts in home water treatment, including water softeners through its "Find a Water Professional" link on the WQA web site at www.wqa.org.

NOWRA provides a similar service called "Septic Locator" at www.septiclocator.com.

3. Be sure to inspect your home for possible sources of excess water consumption such as leaking toilet flappers and valves. Excess water flow to onsite wastewater systems is one of the largest issues related to onsite wastewater treatment system failures. Leaking household water can also create an extra and unnecessary load on your water treatment system. Be sure that sump pumps, floor drains, and roof drains do not discharge to the wastewater system.

1. Maintain your water softener system on a regular basis. Ensure that your water softener is installed correctly and is functioning properly. Ensure that your softener has been set to reflect the water hardness and iron level in your water supply. If the unit is a timer-operated softener, ask for help from your local water treatment dealer in setting the regeneration frequency to the optimum level, and not more frequently than needed. When the system is not being used, such as during a vacation, temporarily turn it off. Replace equipment as needed.

2. The use of strong disinfectants, "every-flush" toilet disinfection chemicals should be avoided. Bleaches and detergents should be used as directed on the product labels and according to water softener manufacturer recommendations. Drain cleaner use should be minimized. <u>Never</u> put expired drugs, other pharmaceuticals, motor oil, brake fluid, paints and thinners, solvents, herbicides, pesticides, anti-freeze, gasoline, chemical wastes, or excess grease into your onsite wastewater treatment system. The items listed should be excluded from ANY waste plumbing system, but they can create significant problems and even ruin onsite wastewater treatment systems.

3. All onsite wastewater systems require maintenance on a regular basis to ensure proper function. The nature and frequency of maintenance depends on the type of system installed. Seek guidance from state or local regulatory agencies, operation and maintenance manuals, or from a qualified local service provider. Be sure your onsite wastewater system has adequate access points for maintenance and that they are watertight, secure and tamper-resistant. Access points should be brought to grade. Potential maintenance points include septic tanks and effluent screens, pumps and controls, treatment devices, and effluent distribution components. Service, repair, and replace equipment as recommended by the manufacturer, regulatory authority, or installer.

If you have questions and/or need more information please contact:

National Onsite Wastewater Recycling Association (NOWRA)

P.O. Box 9279
Tacoma, WA 98490-0279
Phone - 253.770.6594
Fax - 253.770.0896

www.NOWRA.org

Water Quality Association (WQA)

International Headquarters & Laboratory
4151 Naperville Road
Lisle, IL 60532-3696
Phone - 630.505.0160
Fax - 630.505.9637

www.WQA.org

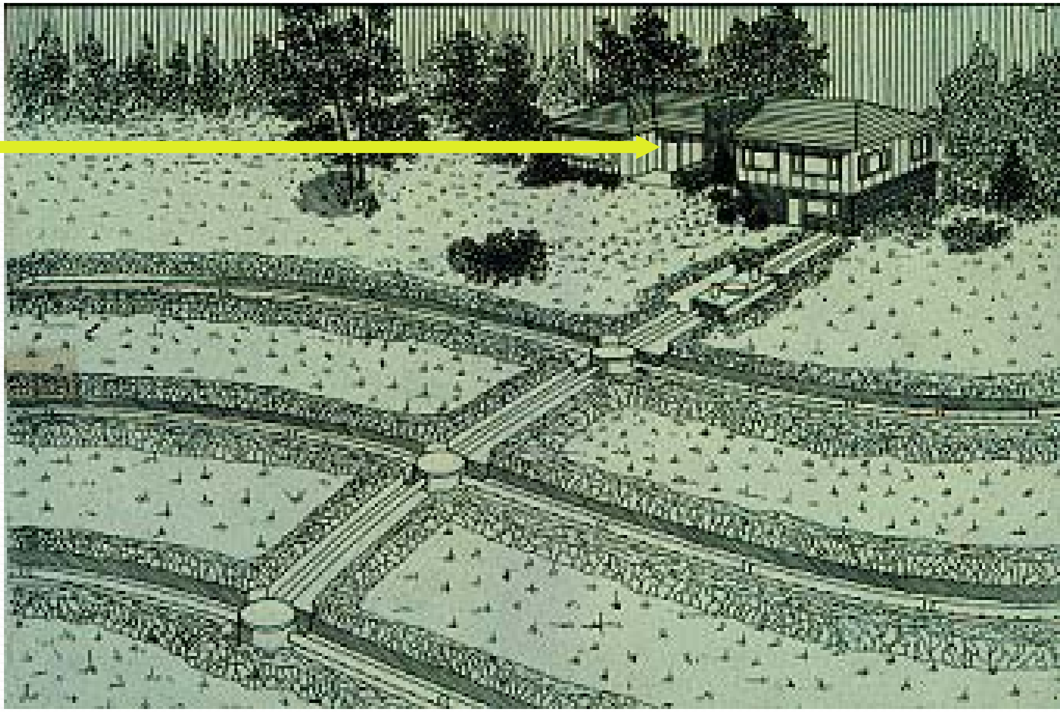
NATIONAL ASSOCIATION OF WASTEWATER TRANSPORTERS, INC.

System Overview and Information on Water Softeners

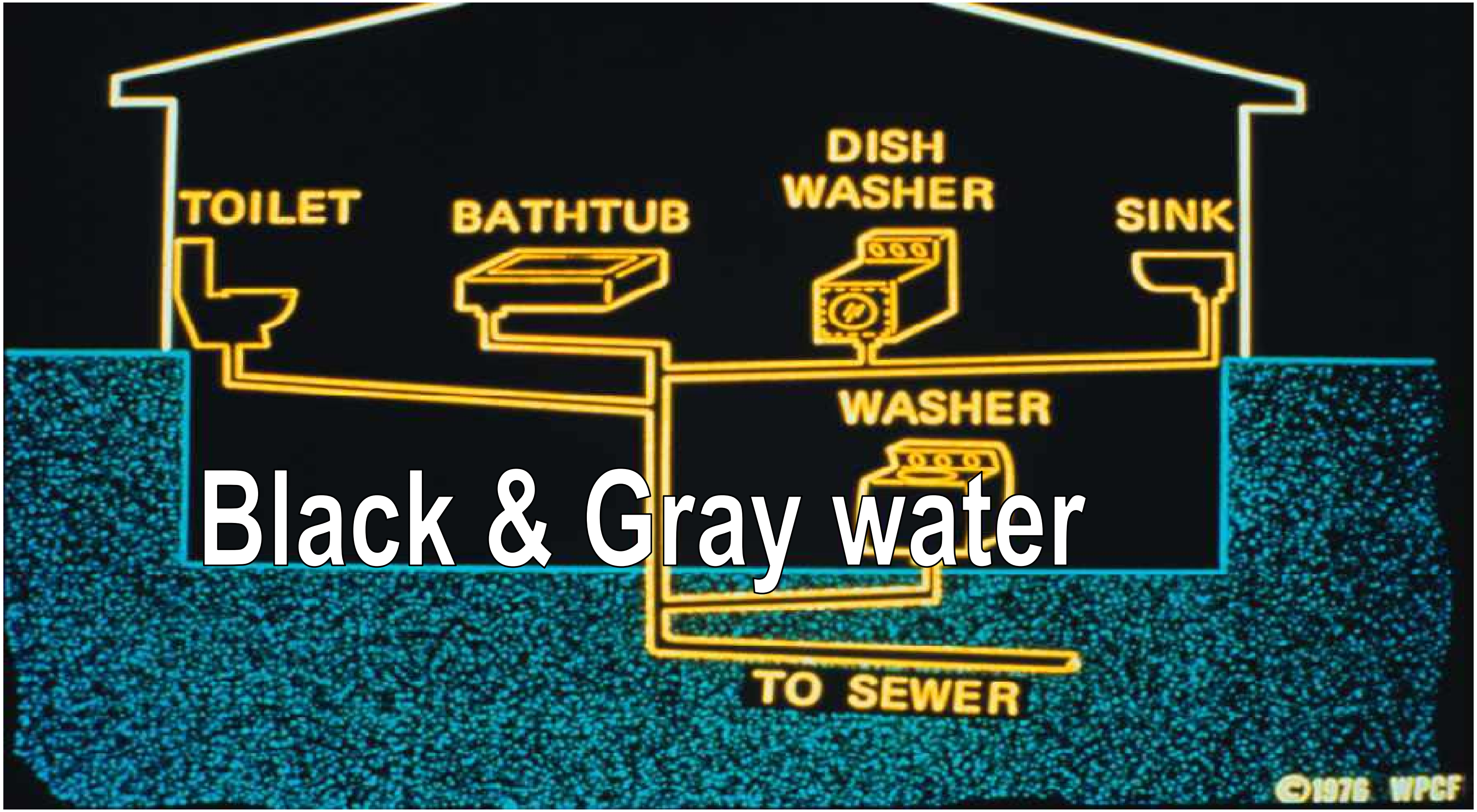
NAWT Survey

Going through the system

- Use

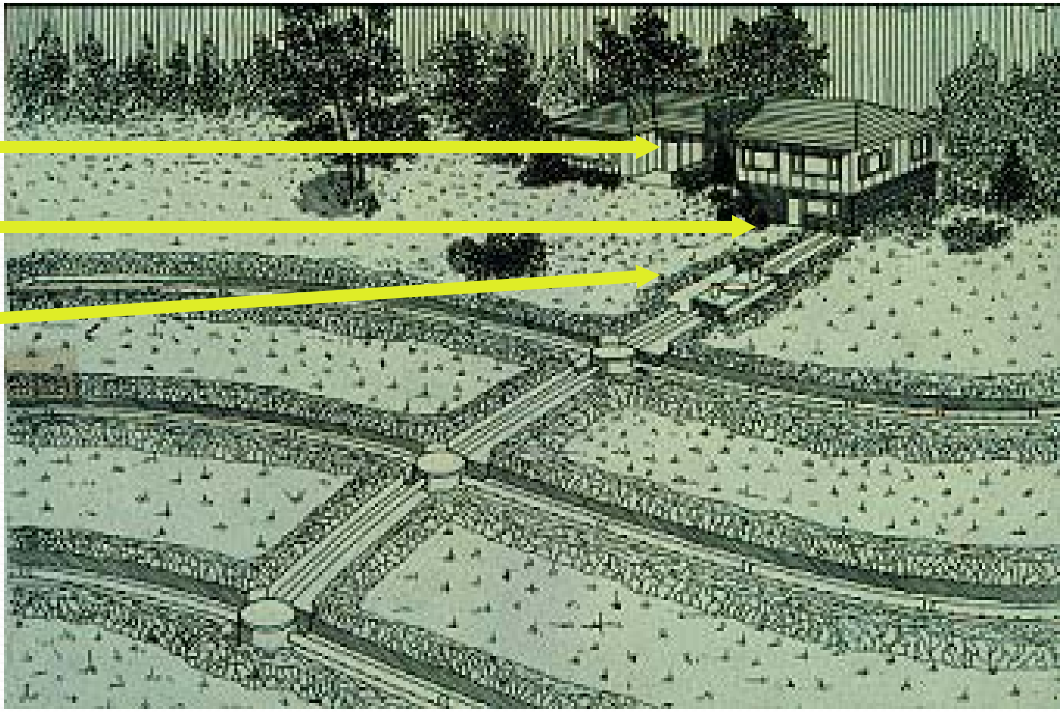


All wastewater is “dirty” & must be treated -

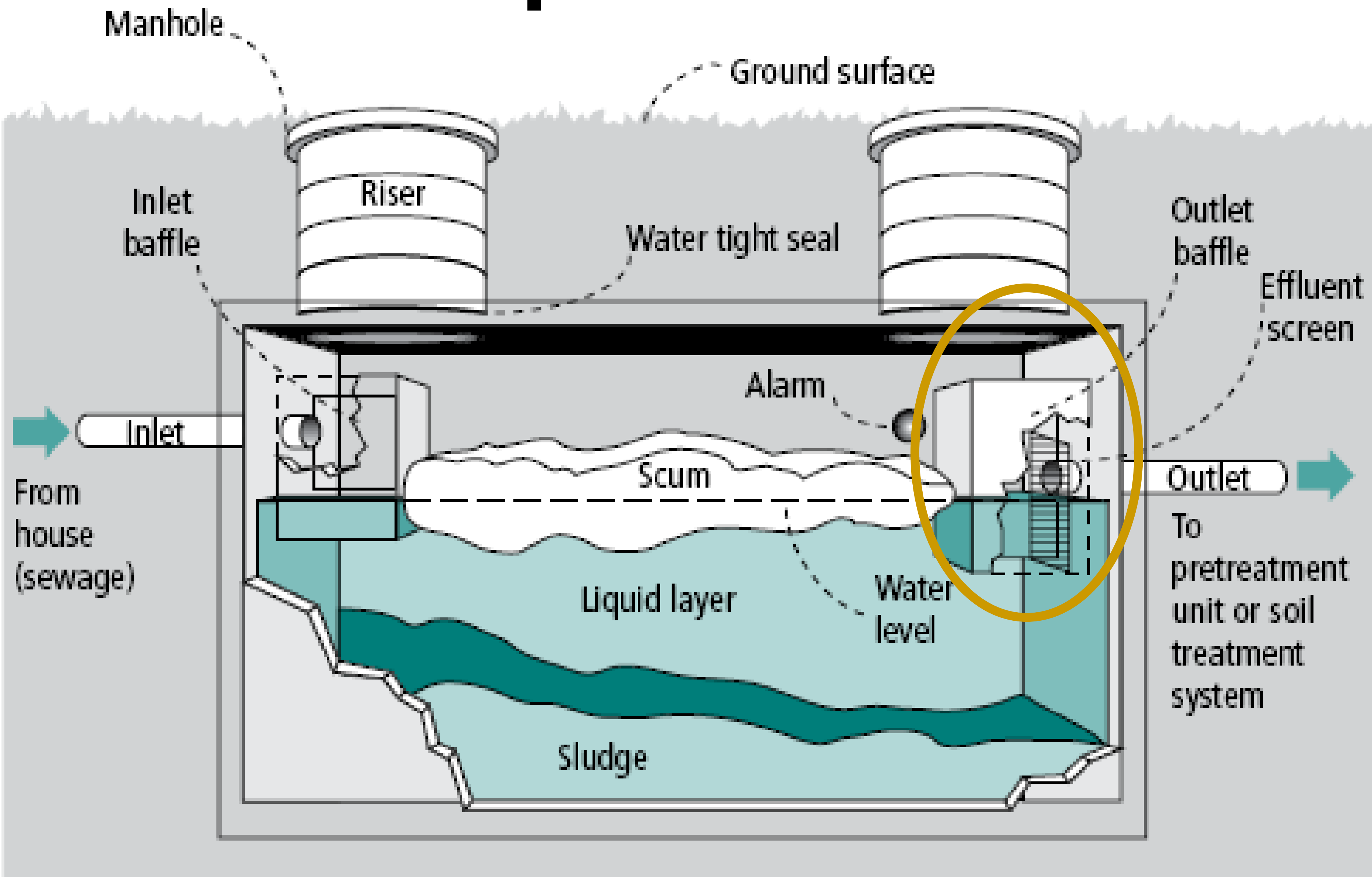


Going through the system

- Use
- Collection
- Pretreatment
  - Septic Tank
  - ATU
  - Treatment Filter



Septic Tank



Manhole
Ground surface
Riser
Inlet baffle
Water tight seal
Outlet baffle
Effluent screen
Alarm
Inlet
From house (sewage)
Scum
Outlet
To pretreatment unit or soil treatment system
Liquid layer
Water level
Sludge

Effluent screens on tanks:

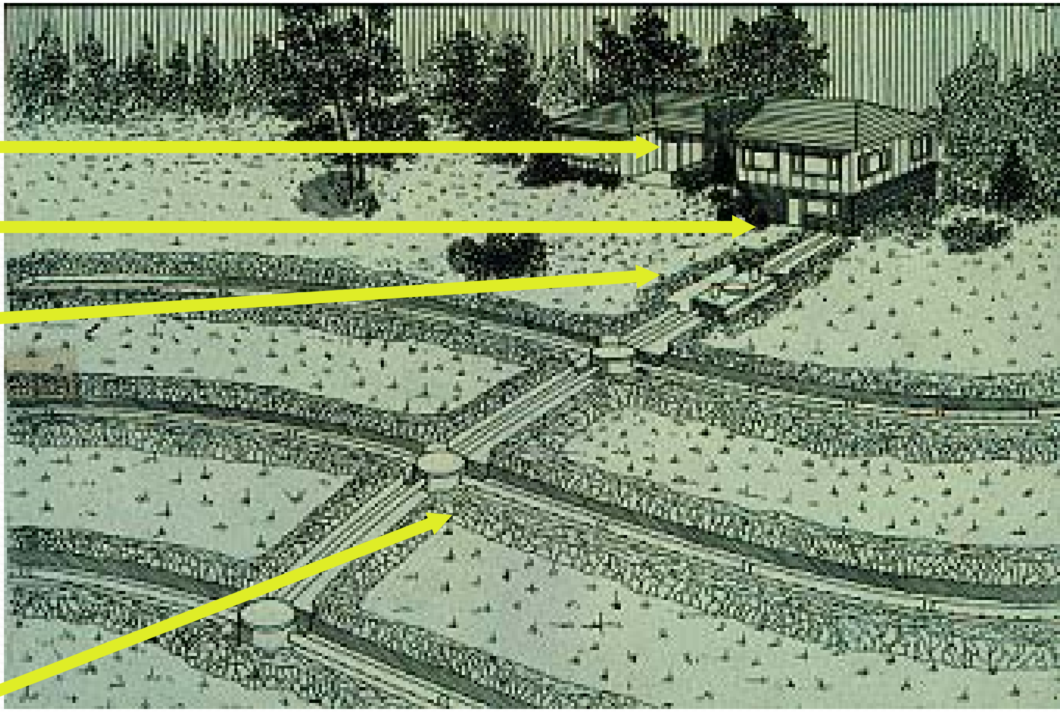
- Prevents suspended solids from leaving the tank
- Requires maintenance
- Prevent solids from entering the drainfield

Media Filter

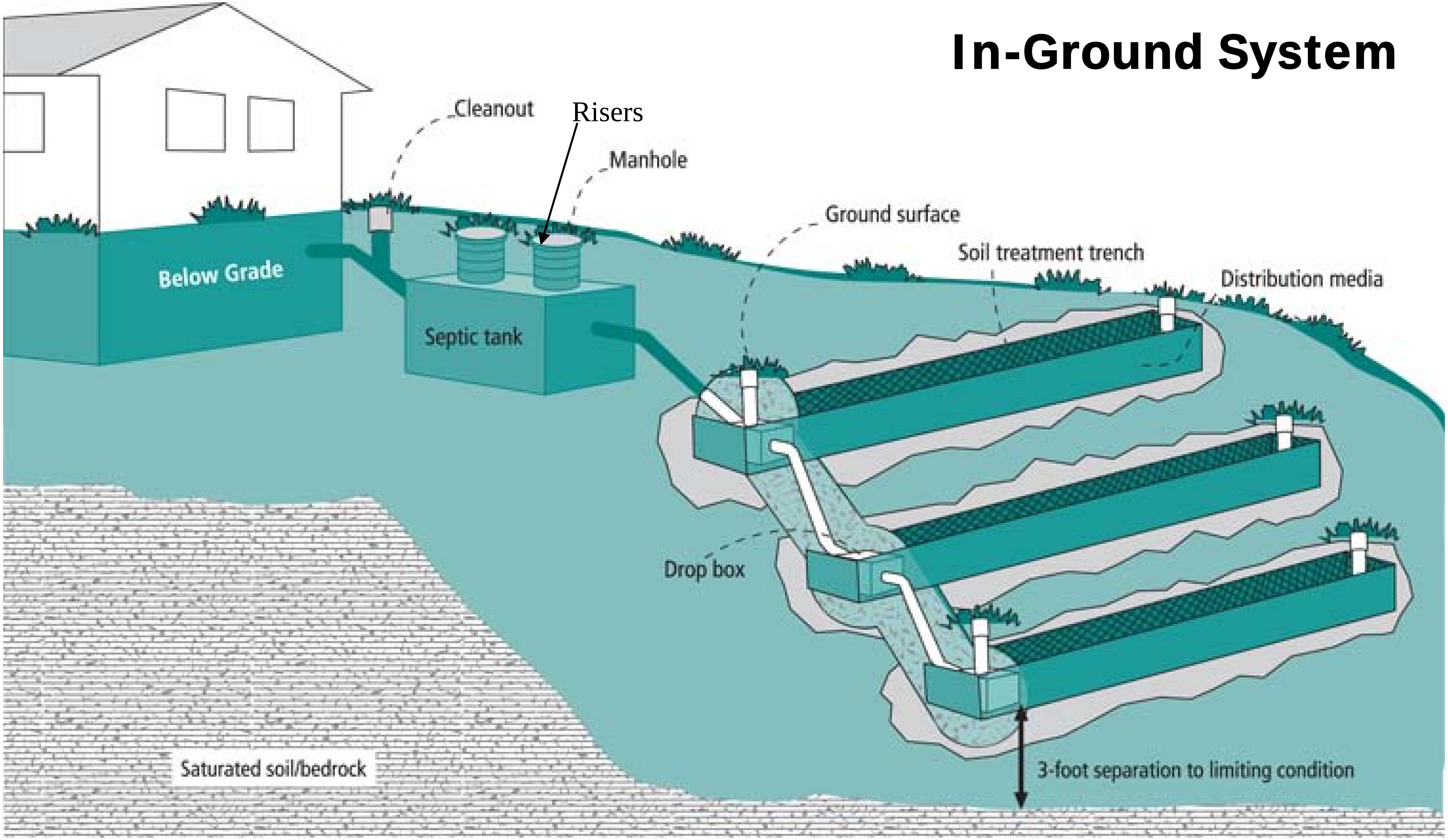
- **Sand**
- **Peat**
- **Textile**
- **Other**

Going through the system

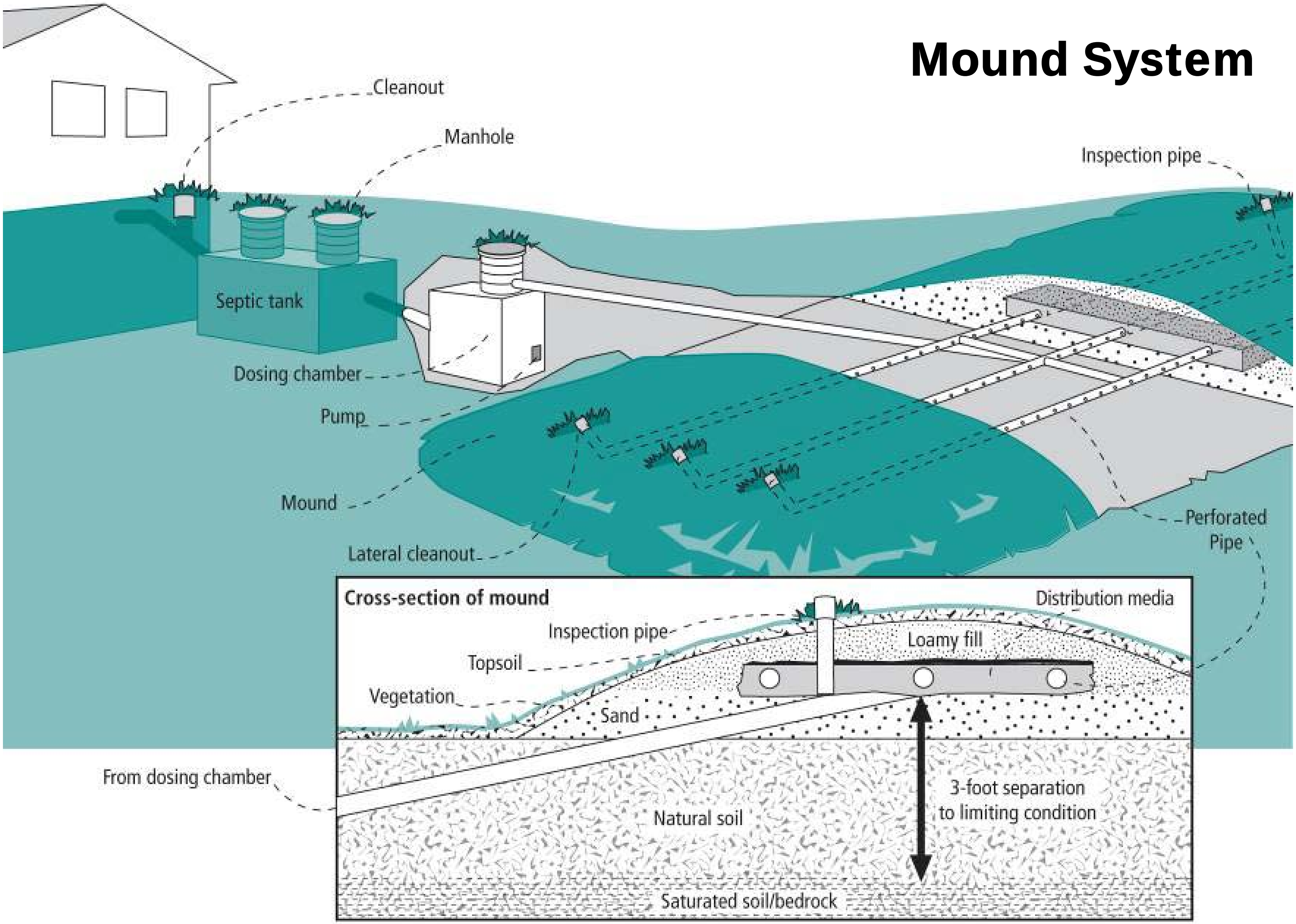
- Use
- Collection
- Pretreatment
  - Septic Tank
  - ATU
  - Treatment Filter
- Final treatment & dispersal
  - Soil treatment area STA
  - Soil
  - Soil System



System Components



Mound System

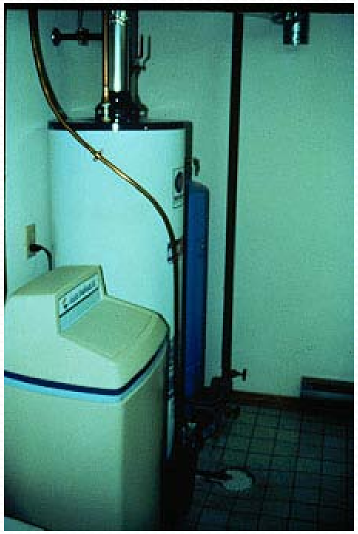


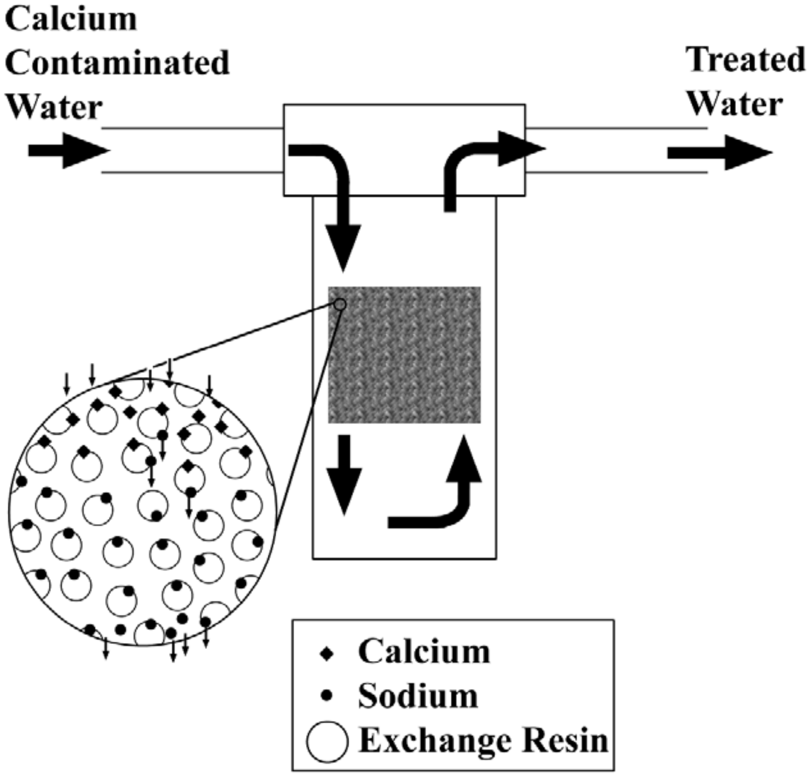
University of Minnesota Onsite Sewage Treatment Program

University of Minnesota Extension

Water Softeners

- Ion exchange device using a resin
- Ions in raw water exchanged with regenerant ion





Potential System Concerns

- Increase in hydraulic loading from recharge
- Upset biology in the septic tank
- Keeps solids from settling in the tank
- Does not allow formation of floating scum layer
- Causes excessive corrosion
- Impact on soil infiltration
- Upset biology in the soil

The NAWT Response

- For this workshop NAWT requested anecdotal comments by:
  - Email to Members, asking for experiences
  - Put out call on *Pumper* listserver
  - Cole Publishing's Online Forum
  - 30 responses
  - NAWT Training Workshops
  - Responses fell into 5 Categories

Hydraulic Overloading

- Concerns include the timing and amount of softener recharge
- Many comments about sticking valves
- Leaking water softeners

Settling Upsets

- Several comments that the increase in salinity does not allow solids to settle and therefore float out of the septic tank, plugging the effluent screen or the soil treatment system

Chemical/Biological upsets

- Causing non- normal conditions in the septic tank, lack of separation and settling in the tank.

Structural problems

- Attributed excessive corrosion in concrete tanks to the water softeners.

Damage of different types

- Excessive plugging in Media filters particularly peat filters.
- Reduced permeability and plugging in the Soil Treatment Area

2 of 30 Respondents

- Said “No Problems”

In Summary…

- Increase in hydraulic loading from recharge & leaks
- Upset biology in the septic tank
- Keeps solids from settling in the tank
- Does not allow formation of floating scum layer
- Causes excessive corrosion
- Impact on soil infiltration and pretreatment filters
- Upset biology in the soil

NATIONAL ASSOCIATION OF
WASTEWATER TRANSPORTERS, INC.

System Overview and Information on Water Softeners

NAWT Survey

www.NAWT.org
info@NAWT.org
(800) 236-NAWT

Delaware DNREC

- Introduction
- History
- Current Regulatory Requirements
- Issue’s & Beliefs
- Regulation Amendment Process
- Thoughts

Introduction

- John G. Hayes Jr., CPSS
- Environmental Scientist IV
- Delaware Dept. of Natural Resources & Environmental Control
- John.hayes@state.de.us

History

- In Delaware, regulations have dictated no water softener brine (backwash) allowed in on-site wastewater treatment and disposal systems since 1981.
- 1985 to 1992 regulation dropped requirement
- 2002 regulation update clarified disposal into curtain drains to avoid surface discharge.
- 2009 to present seeking truth about impacts

Current Requirements

- As of 2002 no water softener brine (backwash) allowed to be placed into on-site wastewater treatment and disposal system
  - All softener brine (backwash) to be disposed of into a curtain drain
  - Ground surface discharge is not allowed as per Surface Water Discharges regulations

Issue's & Belief's

- Extra flow generated is not being accounted for
- Brine killing micro-organisms in septic tank and treatment units
- Increase specific gravity in septic tank and allowing solids to float and travel through system
- Soils dispersion – decrease soil infiltration rate

Issue’s & Belief’s

- Sodium chloride eats away the concrete inside the septic tank
- Decrease the pH level in the septic tank
- Some problems with PVC pipe due to sodium chloride

Regulatory Amendment Process

- SAN December 2008
- 2 series of workshops to date
- DJ Shannahan, Sharp Water attended 2 workshops and started a discussion about water softeners and brine (backwash)
- Highly consider the proposal from this workshop and subsequent research to modify regulation requirements

Thoughts

- Would like to settle this issue once and for all
- The results should speak for the on-site industry, water quality industry and any others associated with brine/backwash
- Overall consensus is a must…
- What do we do with the biggest variable of all – the Homeowner?
- That's all I have, thank you. ☺

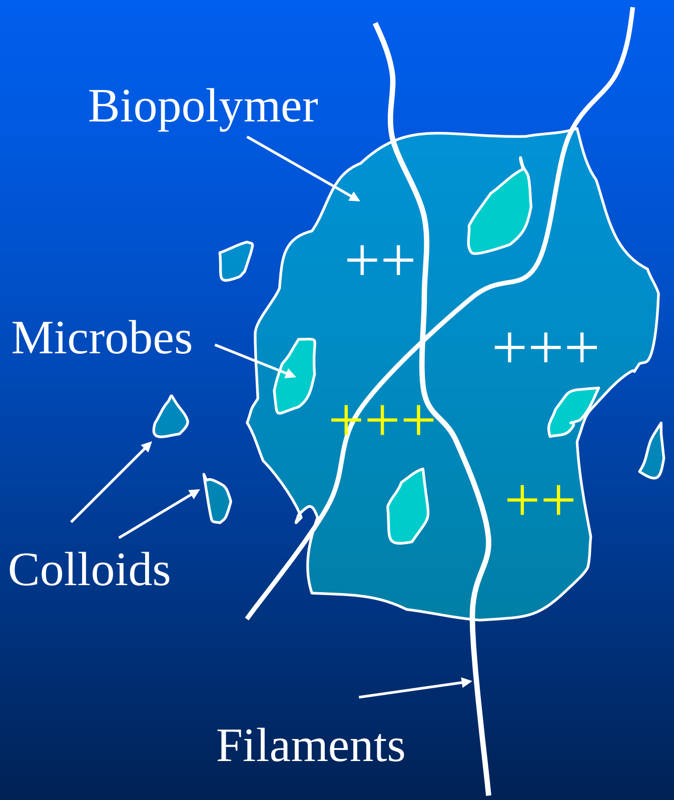
The effect of cations on wastewater and sludge characteristics

John T. Novak
Civil and Environmental Engineering
Virginia Tech

What are the issues of importance?

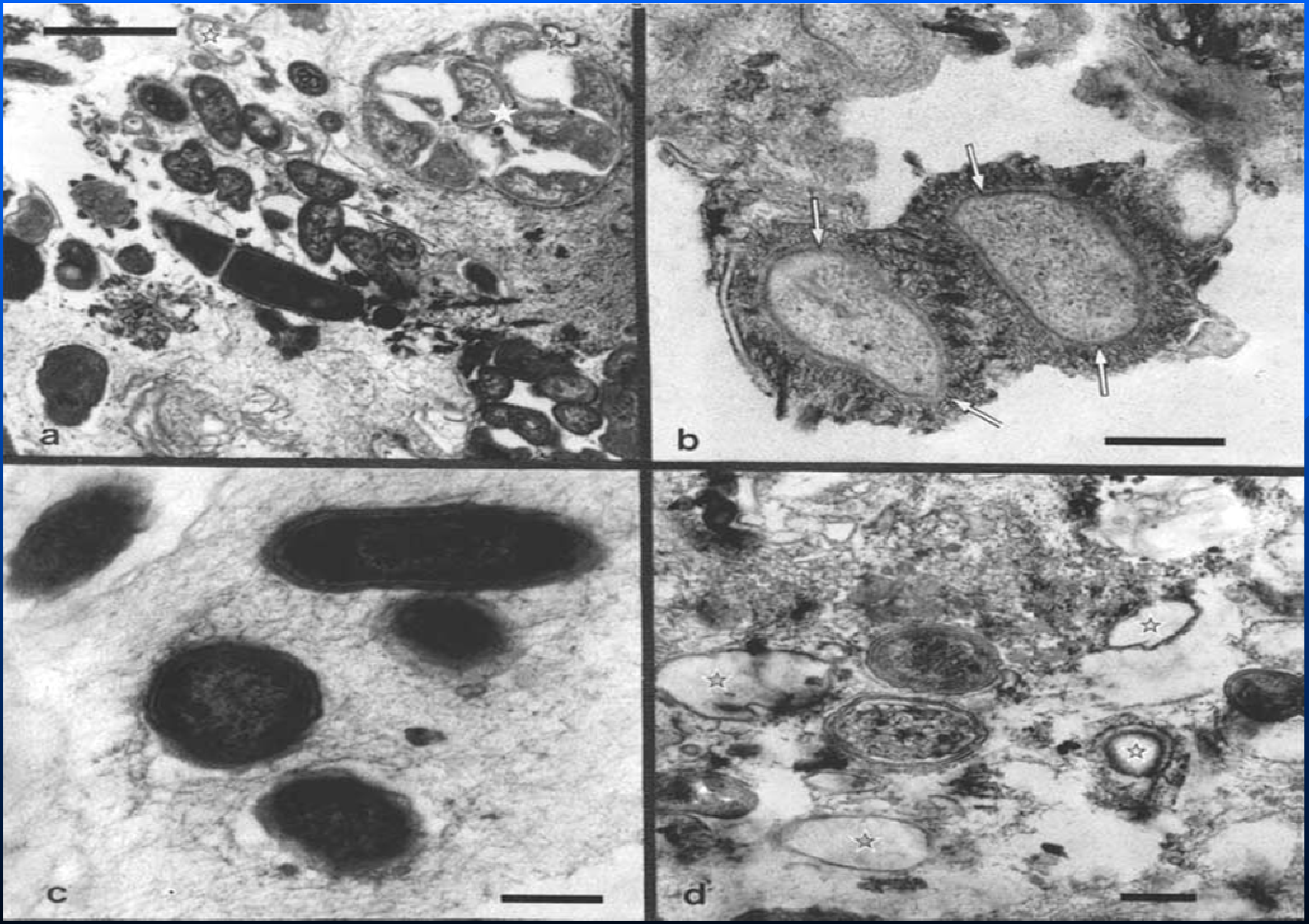
- Cations appear to have a dramatic effect on the flocculation and settling characteristics of wastewaters
- We have primarily investigated activated sludge but have ample evidence that this also impacts anaerobic systems
- Our focus has been on the negative effects of sodium
- This appears to be directly relevant to septic tanks and home softeners

Floc Structure



- Exocellular polymeric substances (EPS)
  - Protein & Polysaccharide
  - It accounts for much of the organic matter in floc
  - Negatively charged
- Cations
  - Provide binding capacity to the biopolymer network

Some photomicrographs of microbes



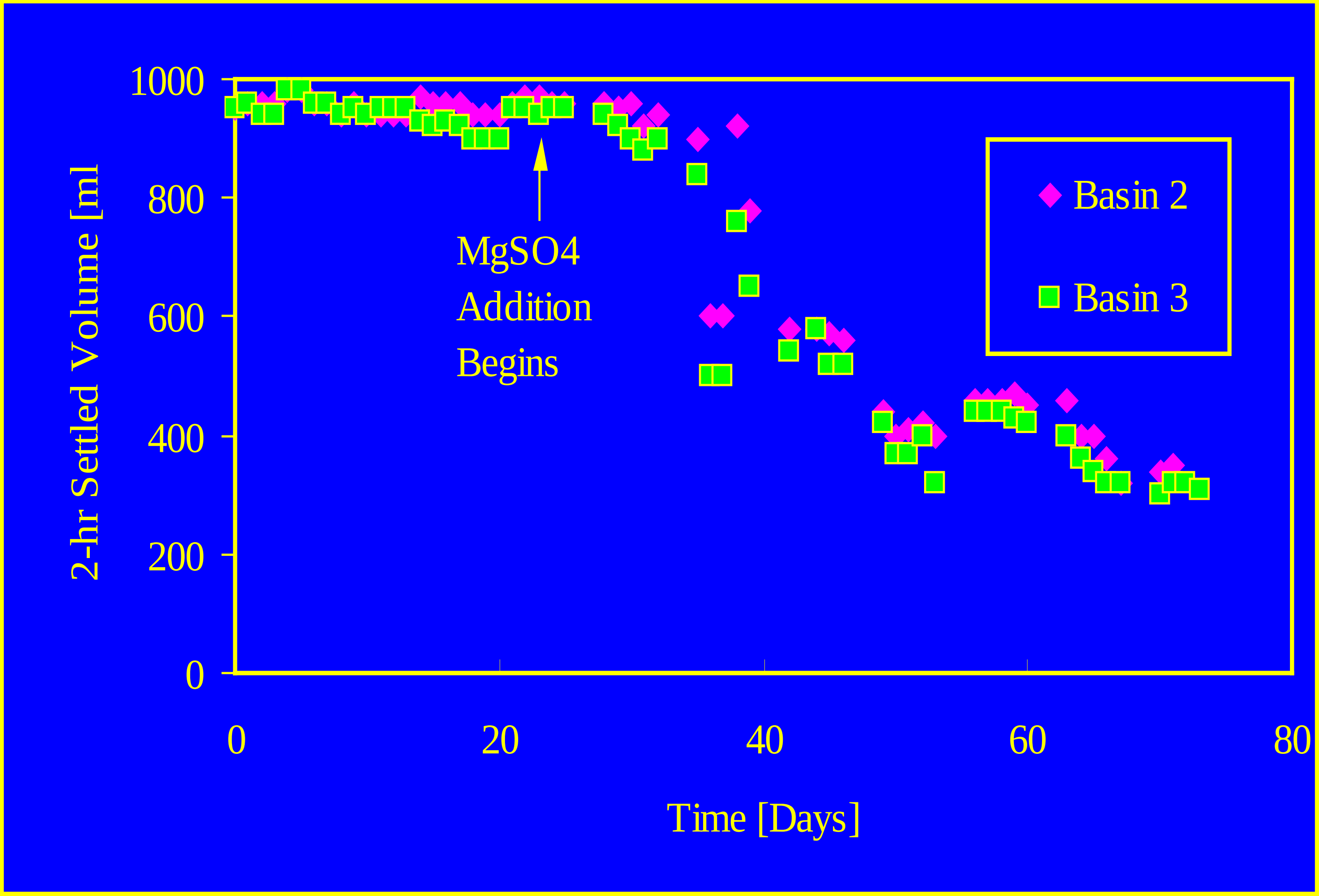
How did we get started in this line of research?

- Evidence from coagulation studies indicated that divalent cations were needed to initiate binding between anionic polymers and negatively charged surfaces
- The natural polymers in biological systems are anionic polymers and cells are negative surfaces
- Tests showed that monovalent cations were detrimental to flocculation

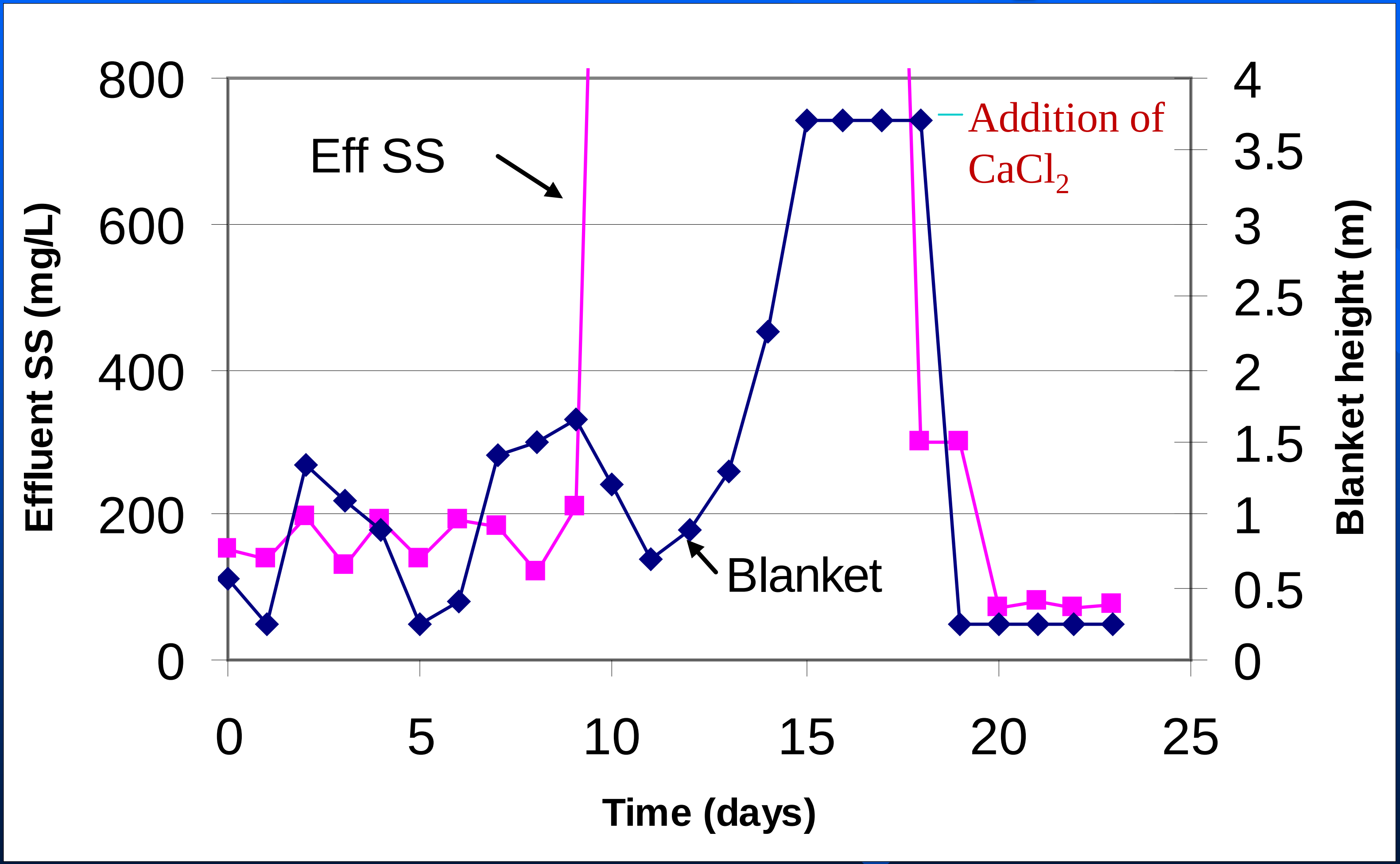
How did we get started in this line of research?

- Some field systems that had a failure of the activated sludge process got us interested
- In addition, classroom some lab experiments indicated that the lack of cations would result in deflocculation
- Tests that resulted in replacing centrate with distilled water resulted in deflocculation

Initially, we collected some field data – this is from Wilmington NC

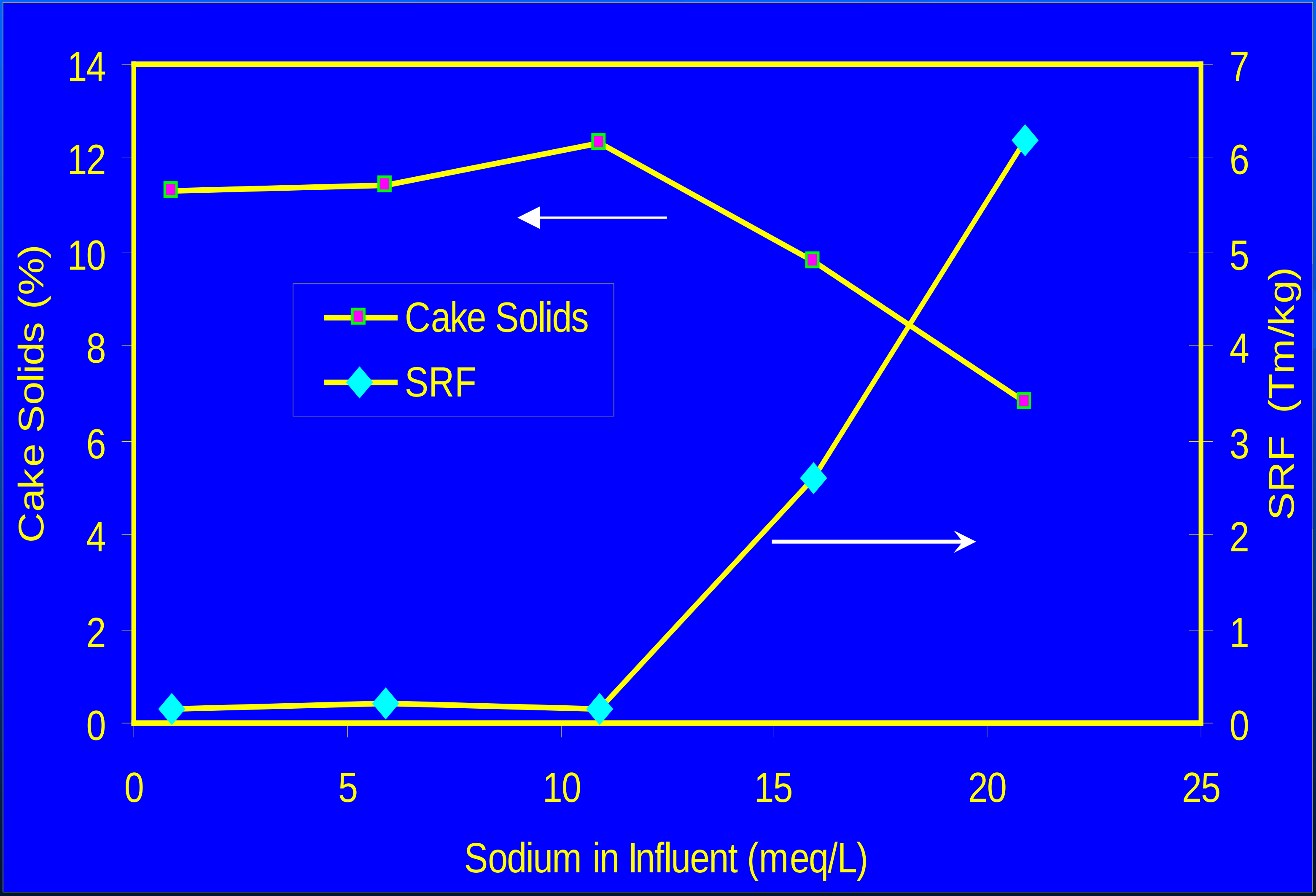


Also some data from a local industrial treatment plant

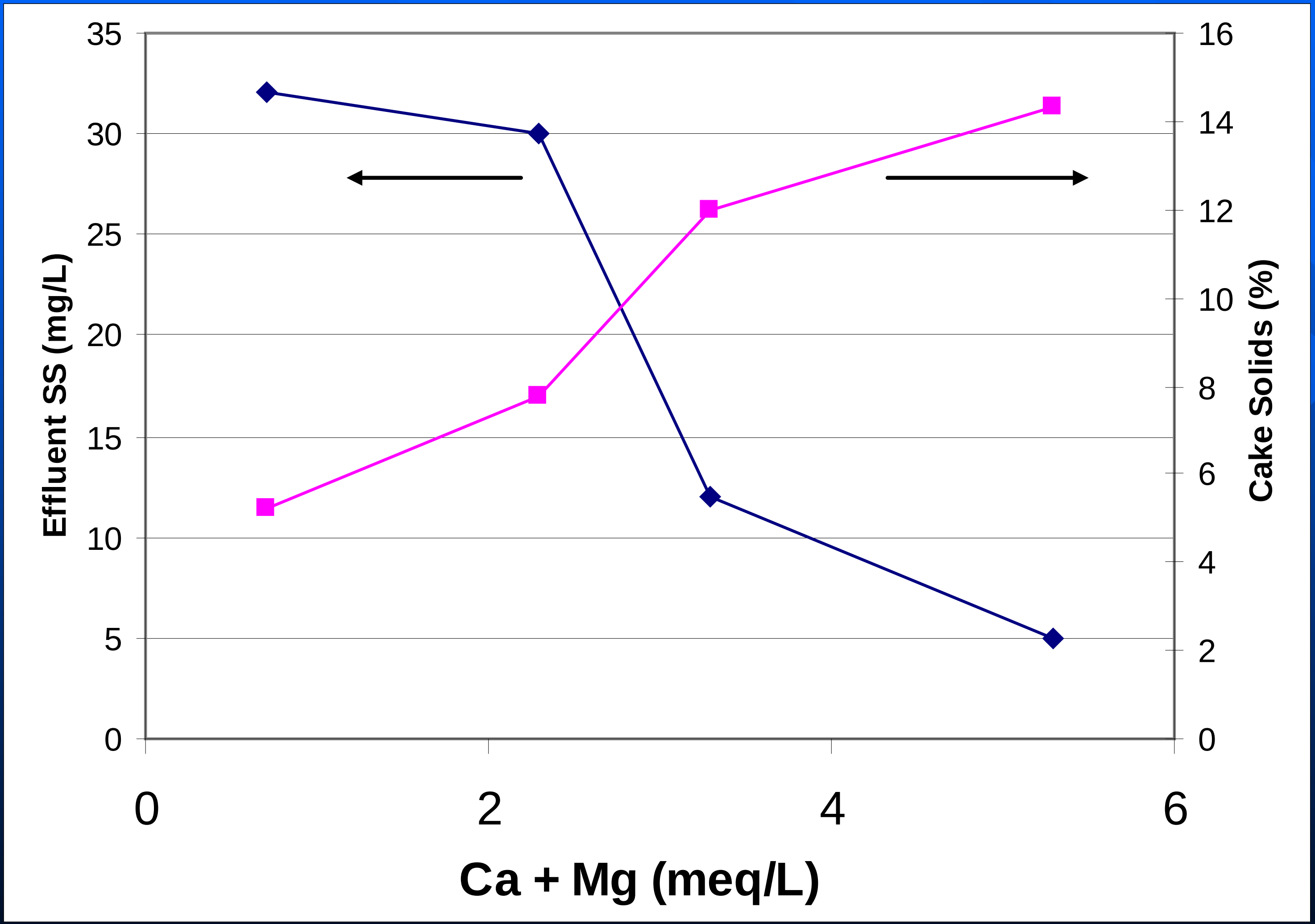


Matt Higgins and I began a series of studies that involved running reactors and providing different cations

Effect of Sodium (Higgins and Novak)

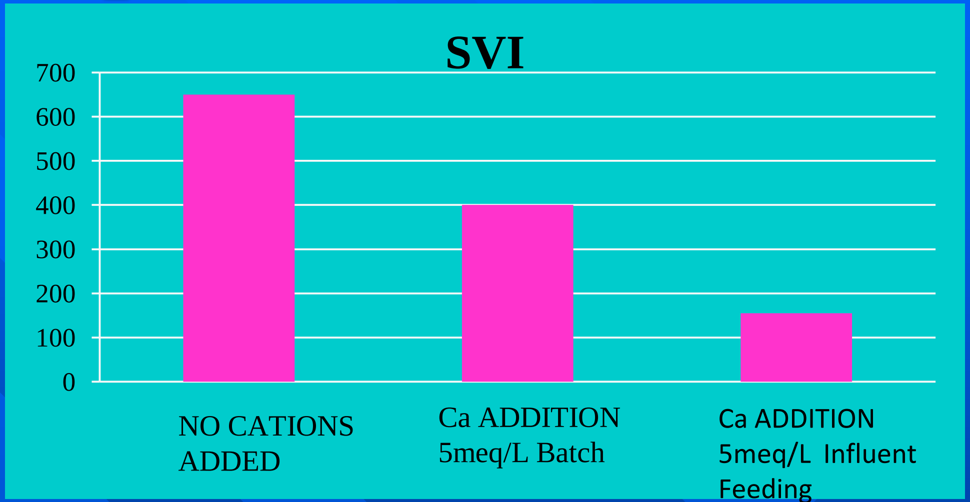


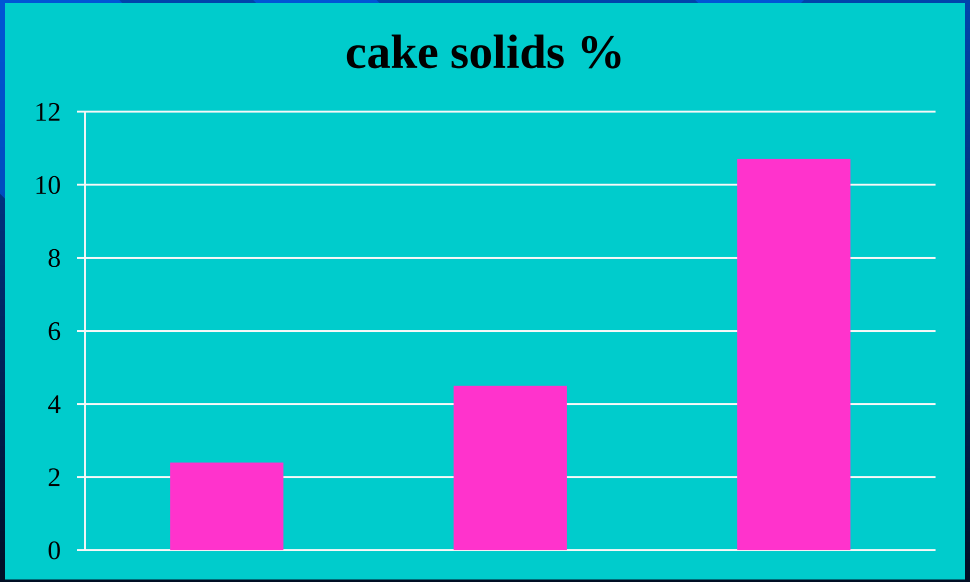
Effect of Ca and Mg addition



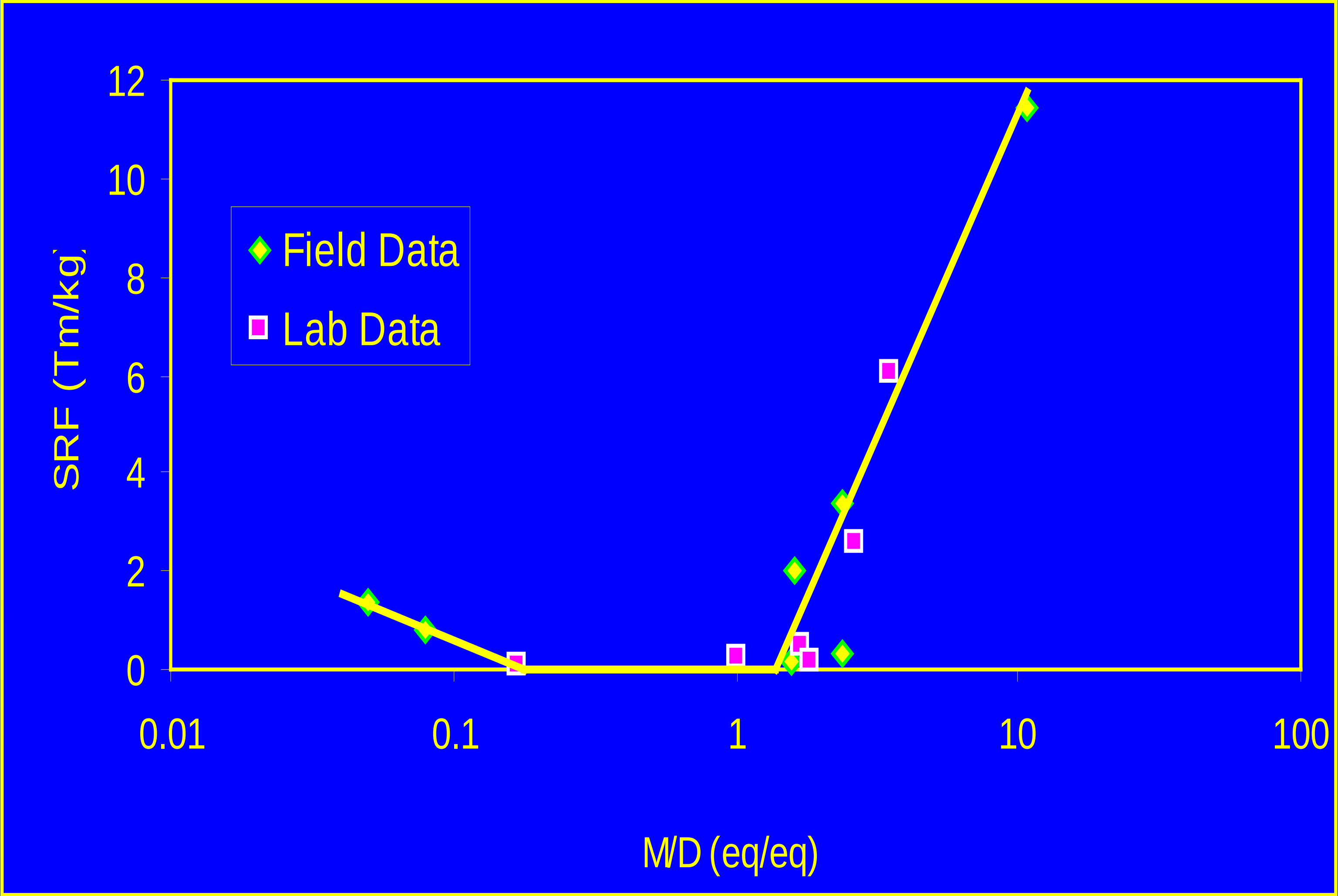
The way cations are fed has an impact

It usually takes one sludge age to change characteristics or flush excess sodium out of the system

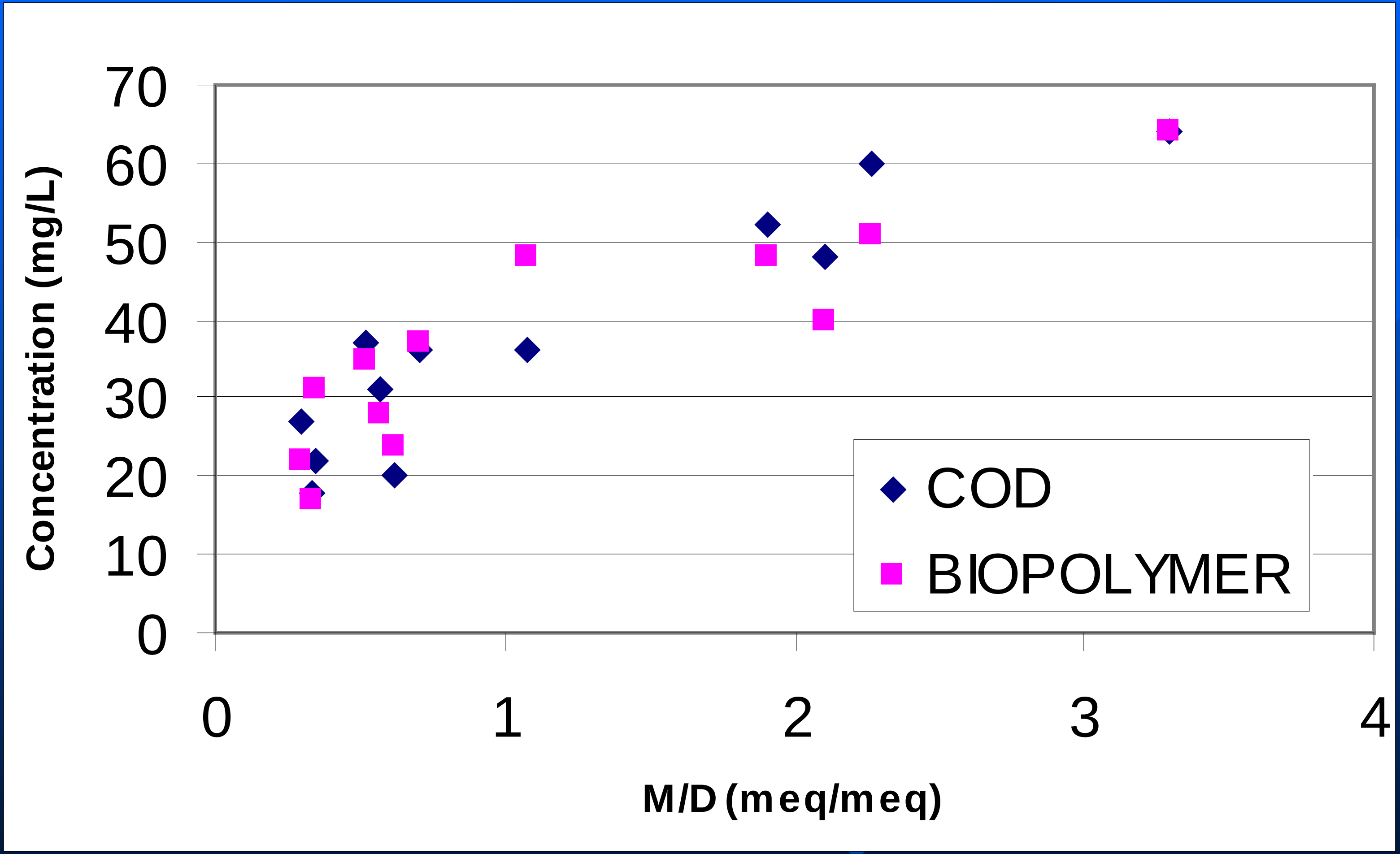




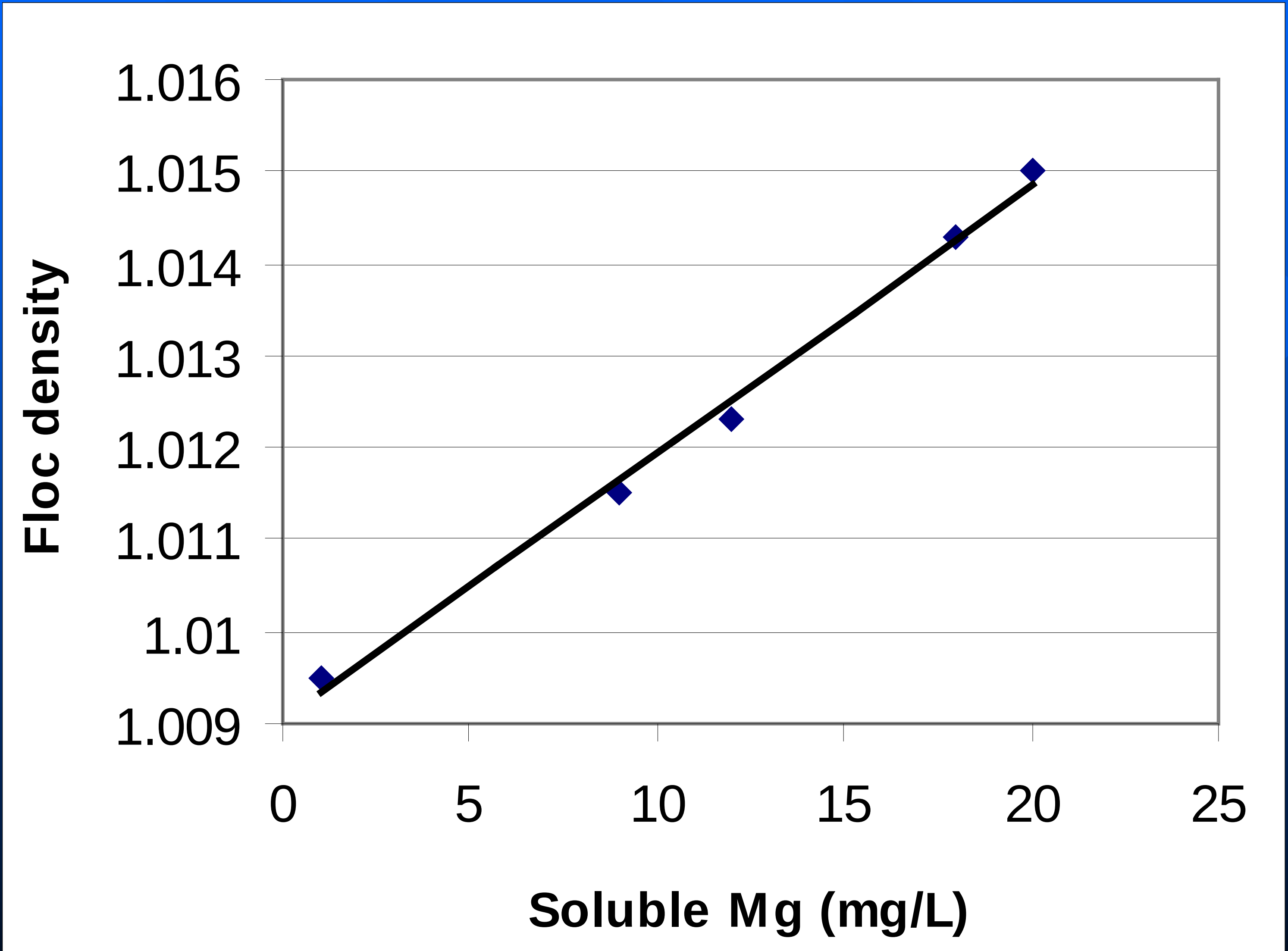
The M/D ratio (Higgins and Novak)



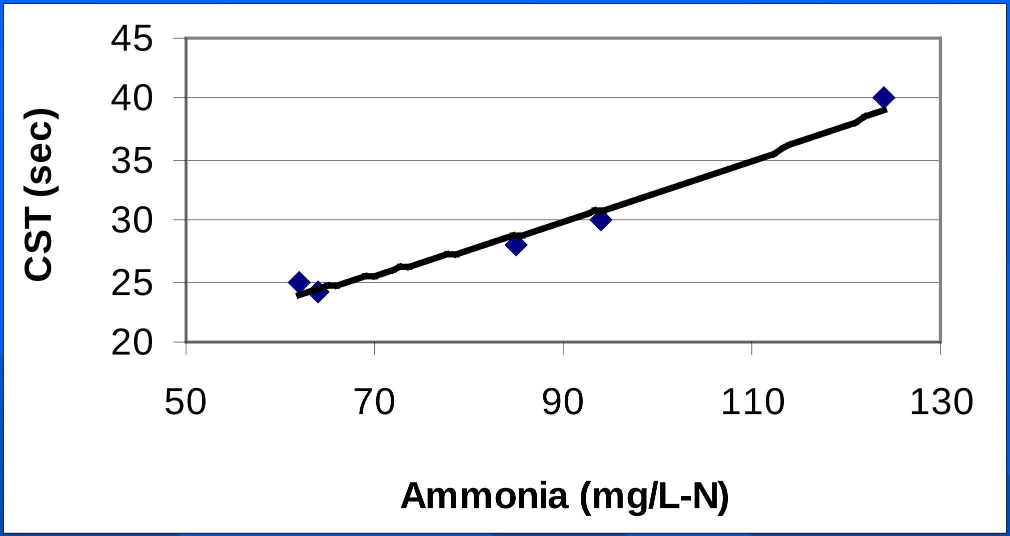
Effluent Data - field studies

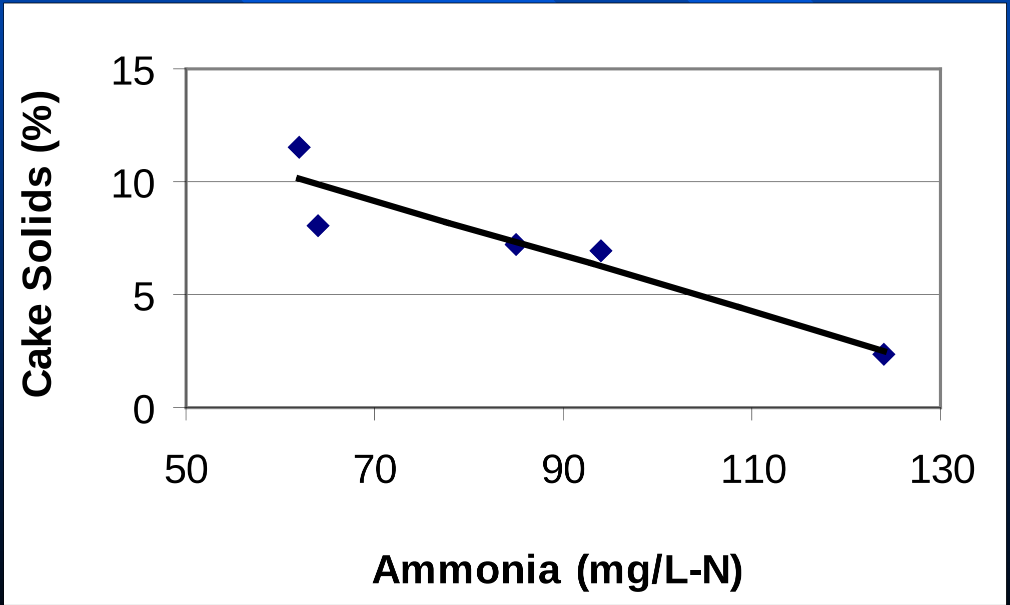


Floc Density – Wilmington NC



Ammonia also causes deflocculation

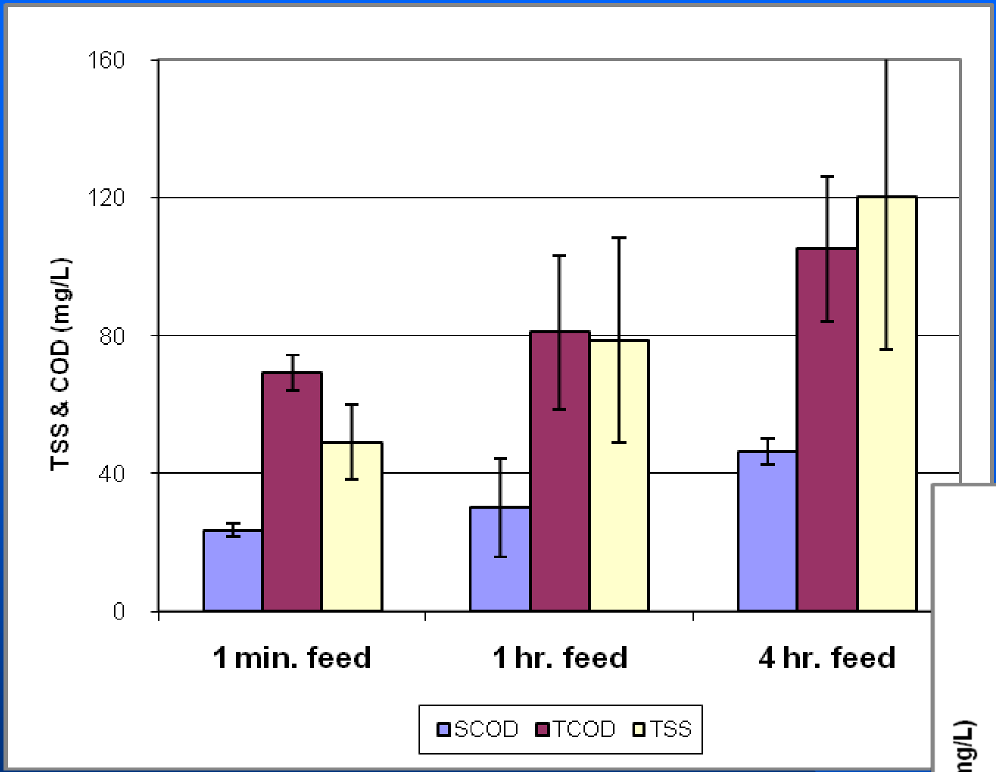




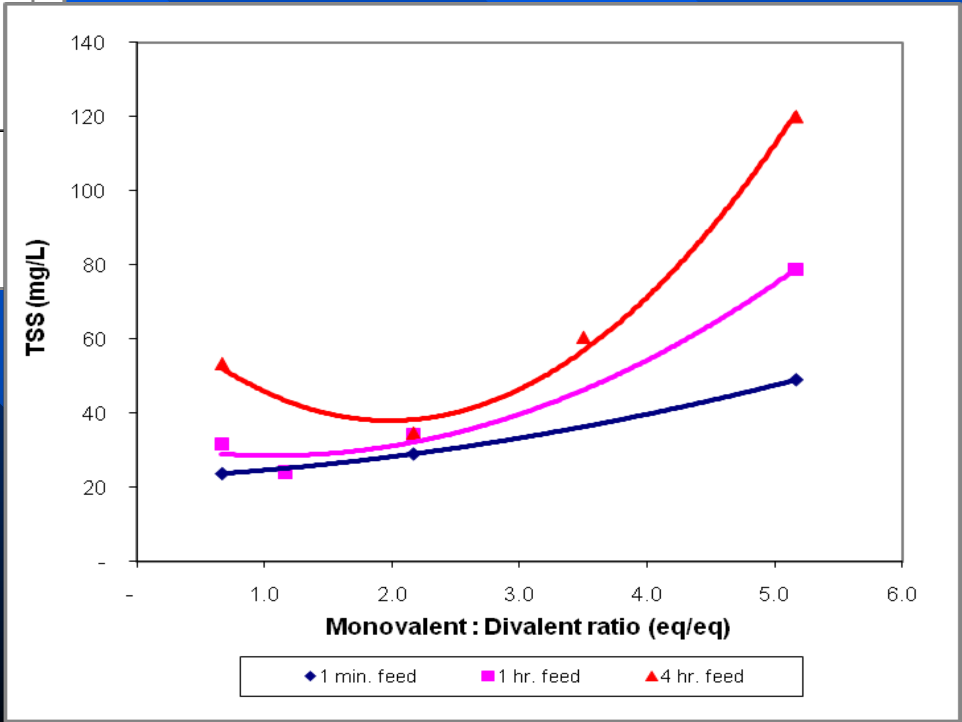
A recent study also points to the impact of feeding patterns

- If feeding results in high substrate pressure, the impacts of sodium are smaller
- We think this has to do with the type of biopolymer created

Some data – SBR with varying feeding times



When we fed over
1 minute, characteristics
Were not affected by
sodium



What have these studies told us?

- Monovalent cations cause low density flocs & high effluent COD (due to protein and polysaccharides)
  - We have seen this with Na, K and NH_4
- Addition of divalents improves characteristics

I have worked with some anaerobic lagoons

- Animal processing in some southern locations uses very low divalent cation water that has high natural sodium
- We have had success with divalent cation addition for anaerobic lagoon performance
- It appears that the effects of monovalents also applies to anaerobic systems
- In addition, these often have high ammonia

What would happen in a septic tank?

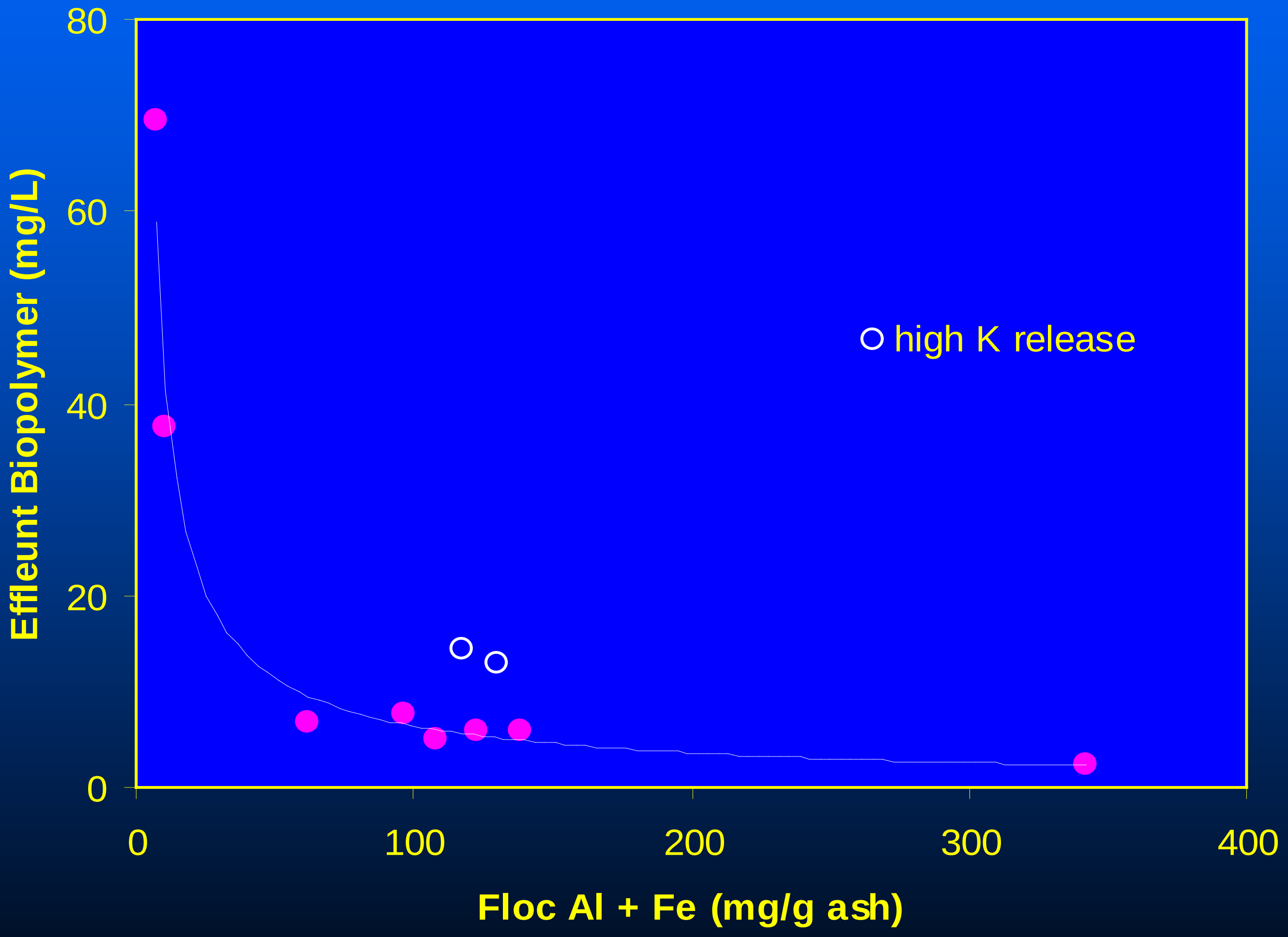
- Right after a septic tank is cleaned, the effluent would be high in COD and most of this would be soluble
  - This could lead to soil plugging due to high microbial growth
- When the tank is full, the effect on density would lead to overflow of the solids and this would be a big problem
- We have no data for this. It is simply speculation

In addition to mono and divalents, iron and aluminum are also important

- Both iron and aluminum contribute to better floc in activated sludge
- Their role in anaerobic systems for flocculation is unknown
- We have seen that if aluminum is added to the influent of an MBR system, fouling is much less
  - We think aluminum collects polysaccharides

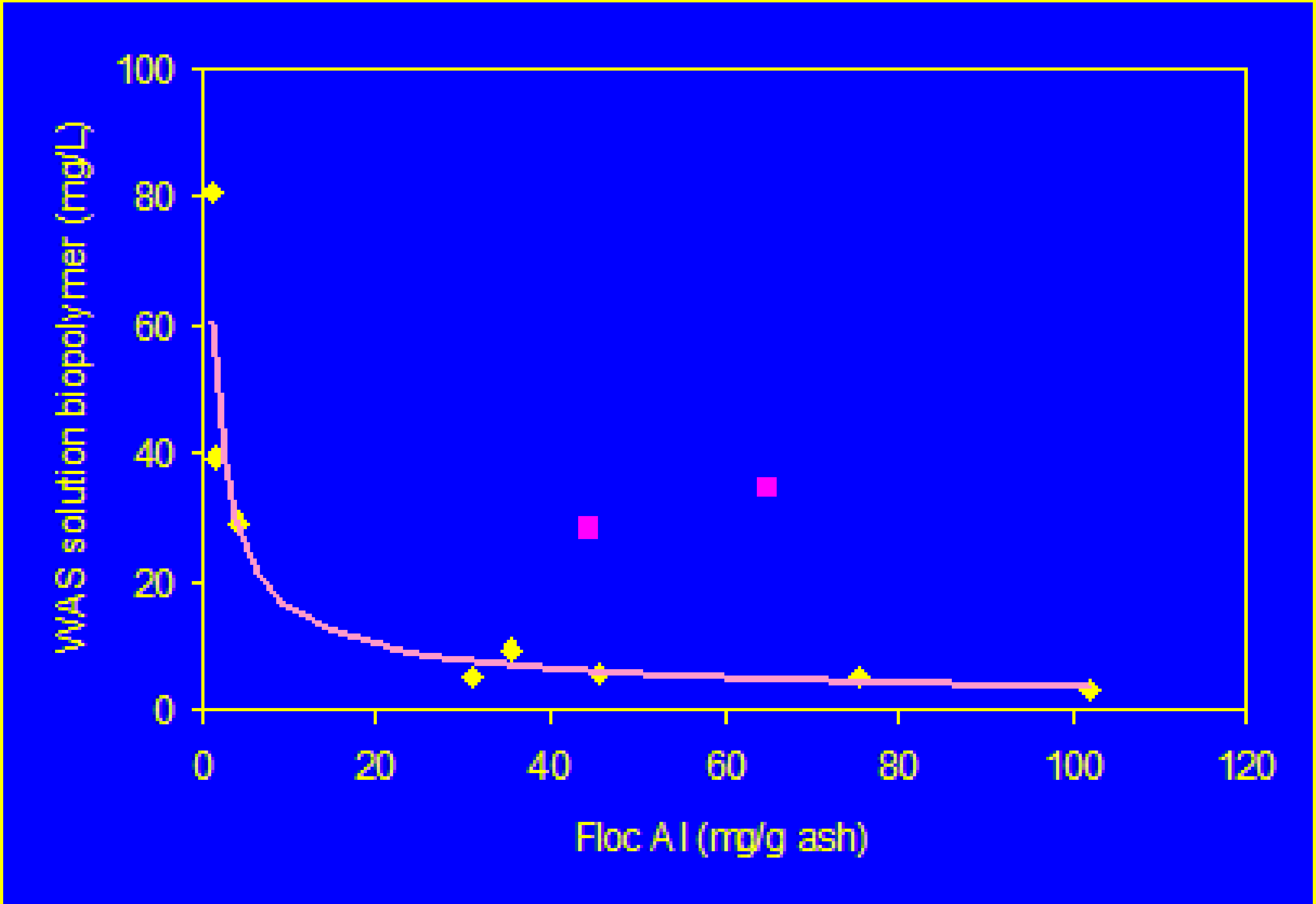
Effect of Floc Iron and Aluminum on Effluent Biopolymer

Iron and Aluminum serve as “collectors” of biopolymer



Aluminum seems very important

I have had success with industrial plants adding Al



What is the bottom line?

- The use of home softeners is likely to be negative for any wastewater plant but especially bad for septic tanks and other on-site systems
- I suspect these systems could be iron and aluminum limited also
- Softening of the entire water flow would be much worse than on the hot water stream

And as a researcher, I believe more research is needed

- Can the problem be minimized by operational changes? Specifically, should the tank be pumped more often?
- The role of iron and aluminum could be important. Do we need to add these?
- Some towns might want to look at effluent quality to see if ion exchangers are causing municipal problems

Acknowledgements

- Much of this work is based on the dissertations of Matt Higgins and Sudhir Murthy

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