EXECUTIVE COMMITTEE ON THE OCCOQUAN SEWERSHED

October 6, 2021

How to Participate in Today's Meeting

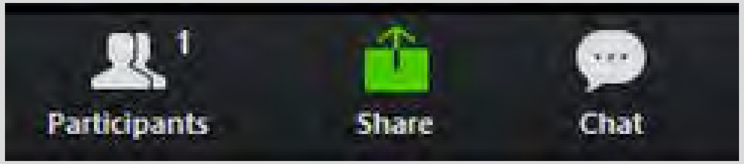
- Small groups
- Q&A
- Chat
- Mute/Unmute

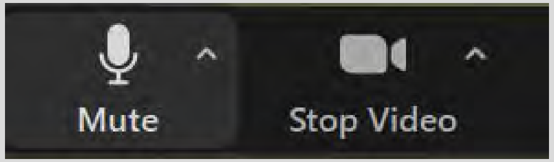
Meeting Team

Kristin Rowles

Stantanu Bhide

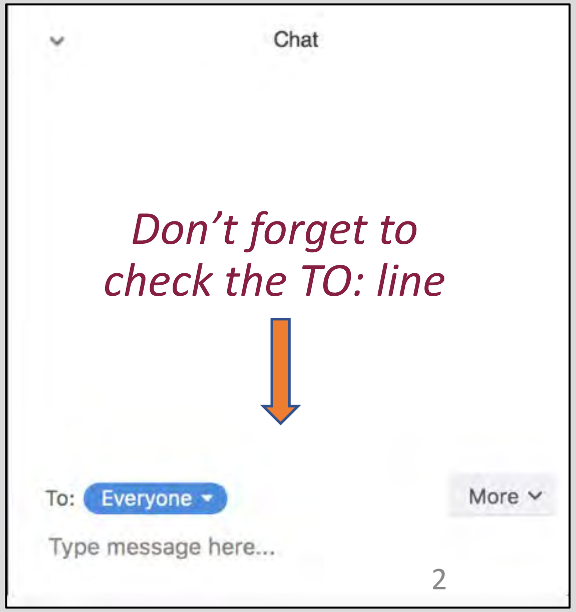
Lauren Krauss





A couple of things we will be doing:

- Muting
- Adjusting names (M: ECOS member, R: Research team member)
- Recording



Don't forget to check the TO: line

ECOS Members

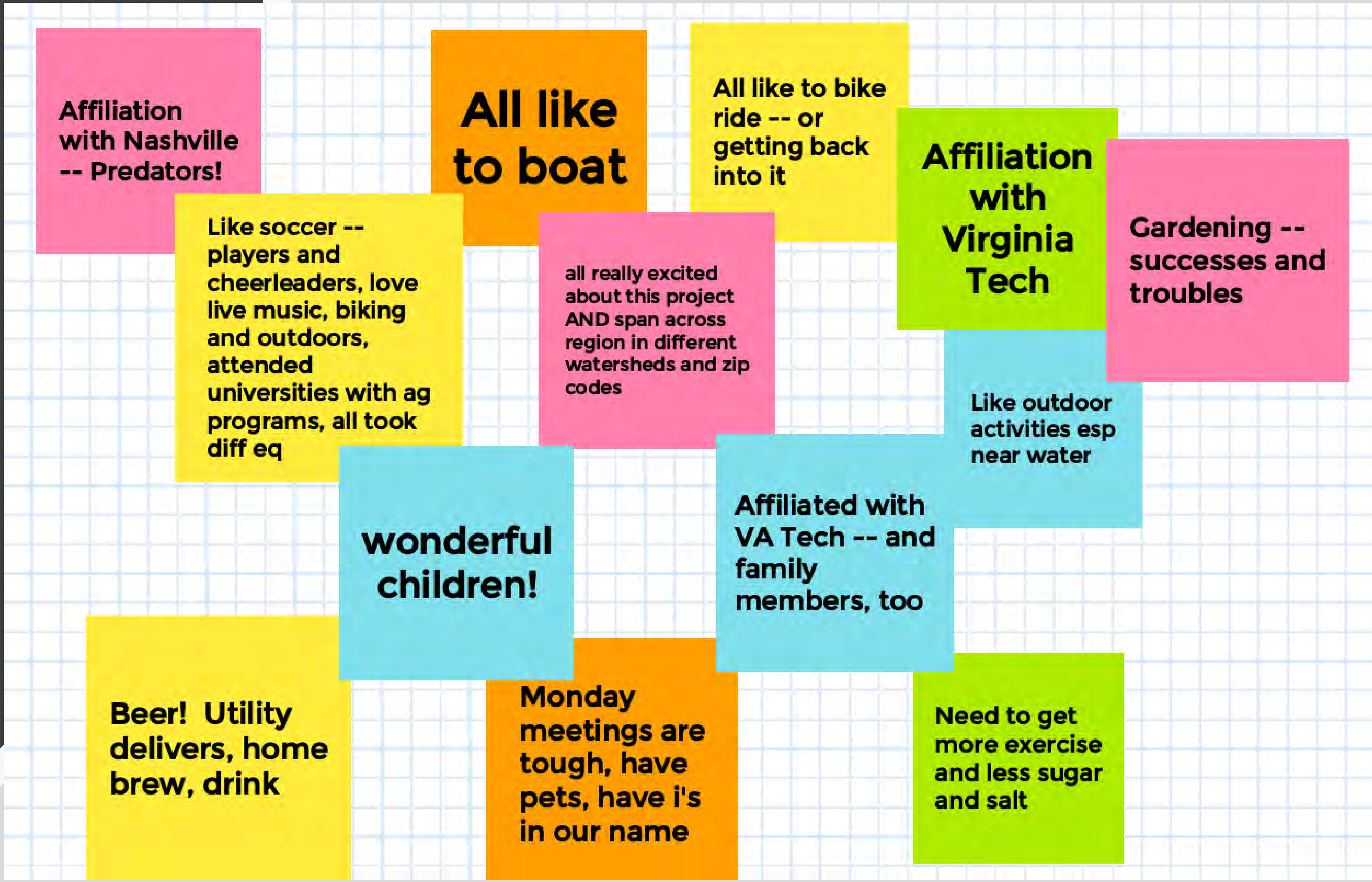
Chesapeake Bay Foundation	Joseph Wood
Chesapeake Bay Trust	Jana Davis
Environmental Protection Agency	Brian Frazer
Fairfax County	Shannon Curtis, Ellie Codding, Steve Winesett
Fairfax Water	Jamie Bain Hedges, Greg Prelewicz
Fauquier County Water & Sanitation Authority	Ben Shoemaker
Hazen & Sawyer	Erik Rosenfeldt
Interstate Commission on the Potomac River Basin	Heidi Moltz, Christina Davis
Izaak Walton League of America	Emily Bialowas
Loudoun Water	Pam Kenel
City of Manassas	Tony Dawood
City of Manassas Park	Allan Rowley
Metropolitan Washington Council of Governments	Steve Bieber, Karl Berger, Heidi Bonnaffon

Micron	Kyle Malone
Northern VA Regional Commission	Norm Goulet
OWML	Adil Godrej
Prince William County	Thomas Smith, Madan Mohan
Prince William County Service Authority	John Derosa, Don Pannell
Rodgers Consulting	Jack Vega
The Water Research Foundation	Harry Zhang
WIT Advisors	Phil Sexton
UOSA	Bob Angelotti, Mishelle Noble-Blair, Brian Owsenek
USGS	John Jastrom, Andrew Sekellick, James Webber
Virginia Department of Environmental Quality	Tom Faha, Sara Sivers, Bryant Thomas
Virginia Department of Health	Raven Jarvis
Virginia Department of Transportation	Lauren Mollerup, Michael Fitch, Robert Prezioso

Project Team Members

VIRGINIA TECH	Stanley Grant Shantanu Bhide Marc Edwards Kaitlyn Fausey Erin Hotchkiss Lauren Krauss Kathryn Lopez Ayella Maile-Moskowitz	Kent Mendoza Emily Parker Meg Rippy Kristin Rowles Todd Schenk Caitlin Shipman Peter Vikesland
NC STATE UNIVERSITY	Tom Birkland Yinman Zhong	Emily Berglund Kingston Armstrong
VANDERBILT® SCHOOL OF ENGINEERING	Jesus Gomez-Velez	Gabriel Perez Mesa Yadong Zhang
UNIVERSITY OF MARYLAND	Sujay Kaushal	Carly Maas
JOHNS HOPKINS UNIVERSITY	Payam Aminpour	

A Common Thread



Since May…

White Paper on ECOS 1

Reversing Freshwater Salinization

Science, Policy, Stakeholder Engagement

Drinkable Water, Healthy Ecosystems

Convergence Research

NSF-GCR: Catalyzing Stakeholder-Driven Solutions to Inland Freshwater Salinization

The Executive Committee for the Occoquan Sewershed (ECOS) Meeting #1 (5/24/21)

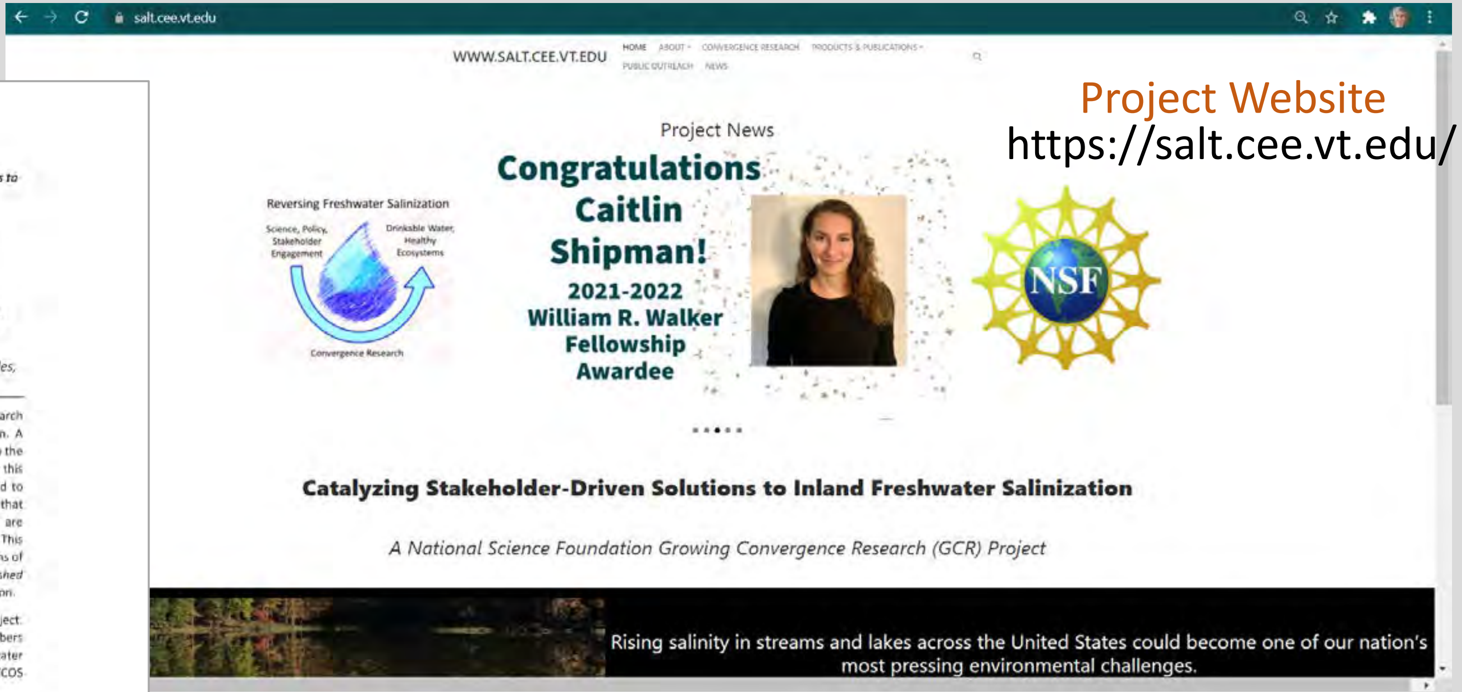
SUMMARY WHITE PAPER #2021-1

Authored by the Governance Team (Payam Aminpour, Thomas Birkland, Emily Berglund, Stanley Grant, Megan Rippy, Kristin Rowles, and Todd Schenk)

Overview of project and ECOS: This National Science Foundation Growing Convergence Research (NSF-GCR) funded project is devising innovative solutions to inland freshwater salinization. A growing imbalance of salt in our ecosystems and water supplies may be posing new threats to the natural and human systems that rely on freshwater resources. While scientists can document this growing concern and evaluate potential interventions to address it, there is an urgent need to develop collaborative approaches among scientists, policymakers, and other stakeholders that ensure research remains grounded in real-world conditions and recommended solutions are tailored to those conditions with the buy-in of leaders that can facilitate real-world change. This project, which is focused on the Occoquan Reservoir, a drinking water supply source for millions of residents in Northern Virginia, features an *Executive Committee for the Occoquan Sewershed (ECOS)*, which is comprised of key stakeholders from across Virginia and the mid-Atlantic Region.

Purpose of the White Paper: Stakeholder engagement is a critical component of this project. Accordingly, the research team holds quarterly meetings with approximately 40 ECOS members who collectively represent a broad cross section of perspectives and opinions on inland freshwater salinization. This document briefly summarizes some of the key outcomes from the first ECOS meeting ("ECOS 1"), held via ZOOM on May 24, 2021.

Purpose of the ECOS 1 Meeting: The purpose of ECOS 1 was to elicit: 1) long-term goals for the Occoquan Reservoir (both generally, and with respect to rising salinity); and (2) information deficits

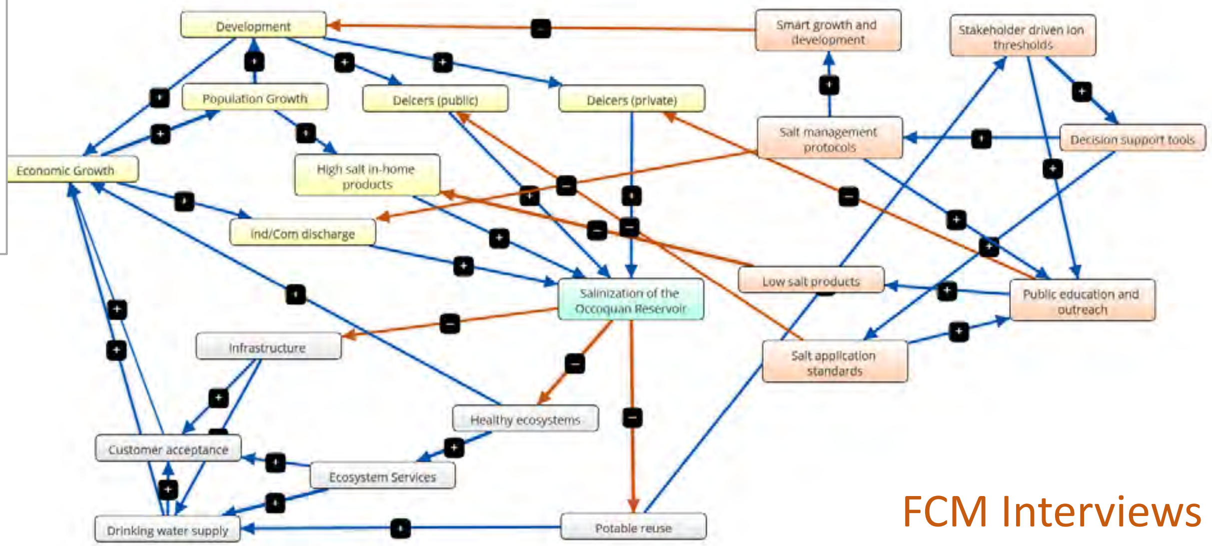


Project Website

https://salt.cee.vt.edu/

Field Work

Ion Flux Study



FCM Interviews

Meeting Objectives & Agenda

OBJECTIVES

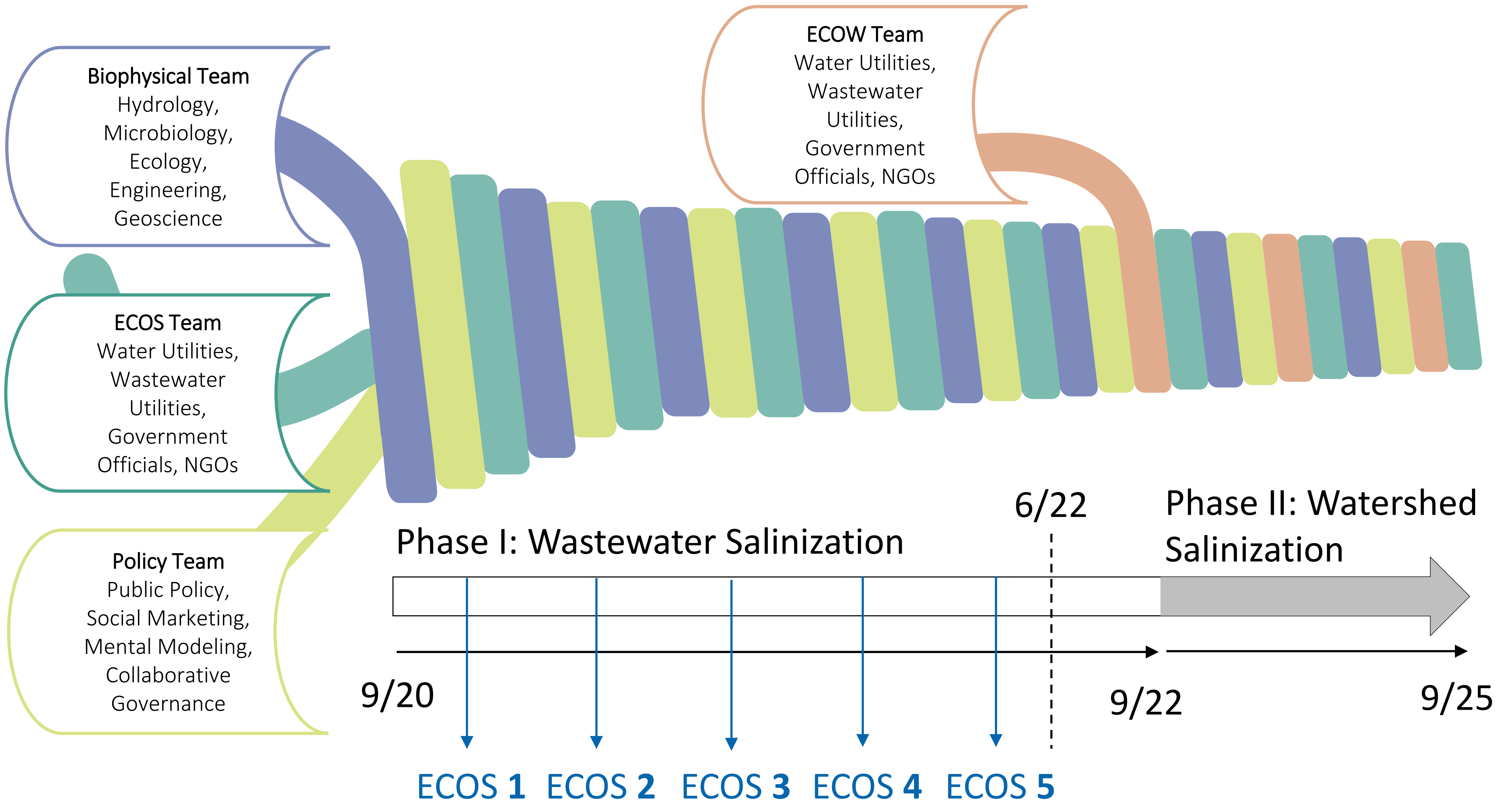
- Understand the project's ***biophysical research***
- Discuss information needs in relation to the ***project research plan***
- Understand and discuss the initial aggregated ***Fuzzy Cognitive Maps***

AGENDA

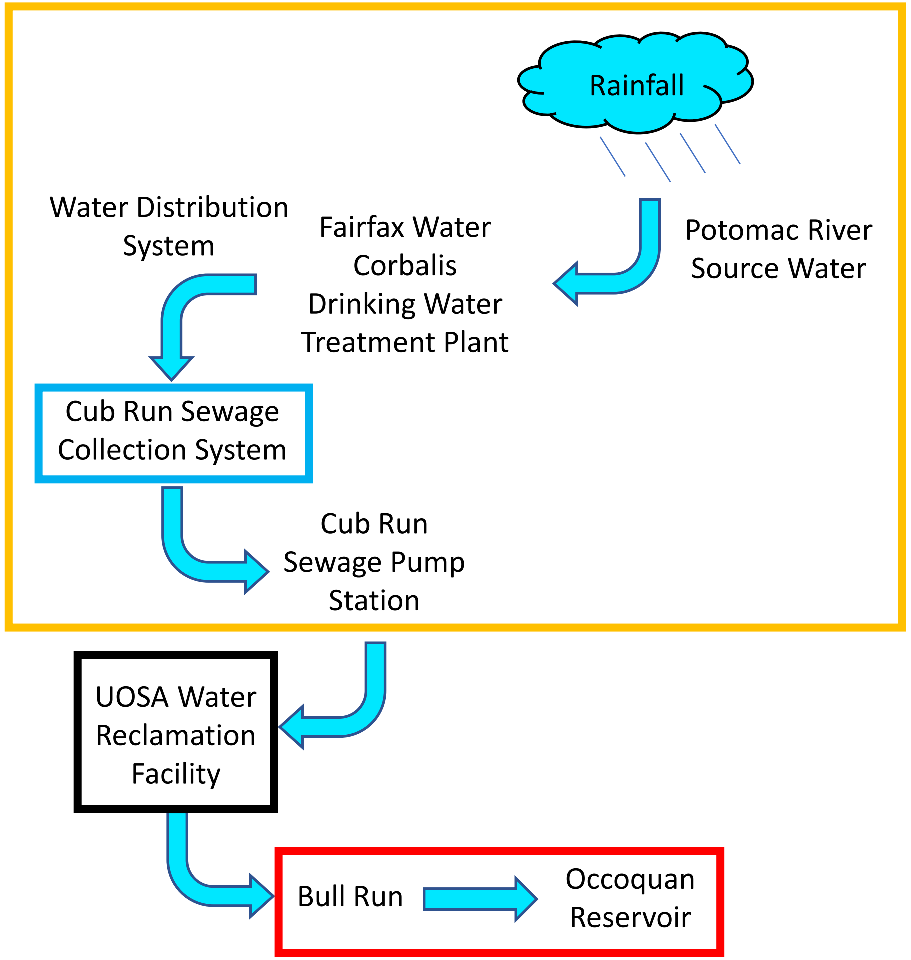
1:00	Welcome & Meeting Overview
1:10	Biophysical Research Overview
2:10	Information Needs
2:30	Small Group Discussions: Information Needs & the Research Plan
2:50	BREAK
3:00	Fuzzy Cognitive Map Results
3:25	Small Group Discussions: Fuzzy Cognitive Maps
3:45	Wrap-Up & Next Steps
4:00	Adjourn

BIOPHYSICAL RESEARCH OVERVIEW

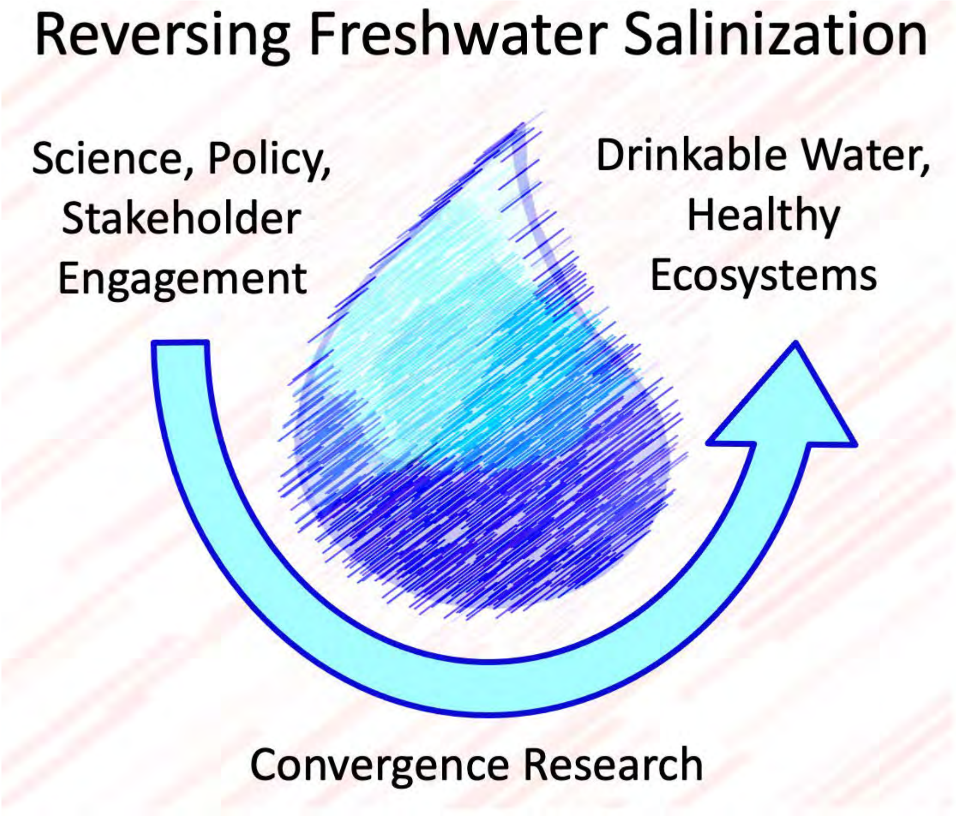
NSF Salinization Project: Big Picture



Rain-to-Reservoir: A series of short films from the GCR Biophysical Team



1. Shantanu Bhide (5:33) “Improved estimation of sodium added by UOSA during wastewater treatment”
2. Caitlin Shipman (4:56) “Ion Flux Study: Introduction”
3. Stanley Grant (12:12) “Ion Flux Study Preliminary sodium results”
4. Gabriel Perez (6:16) “Sewer flow and solute transport modeling”
5. Carly Maas (5:03) “Spatial and temporal ion patterns along Bull Run ”



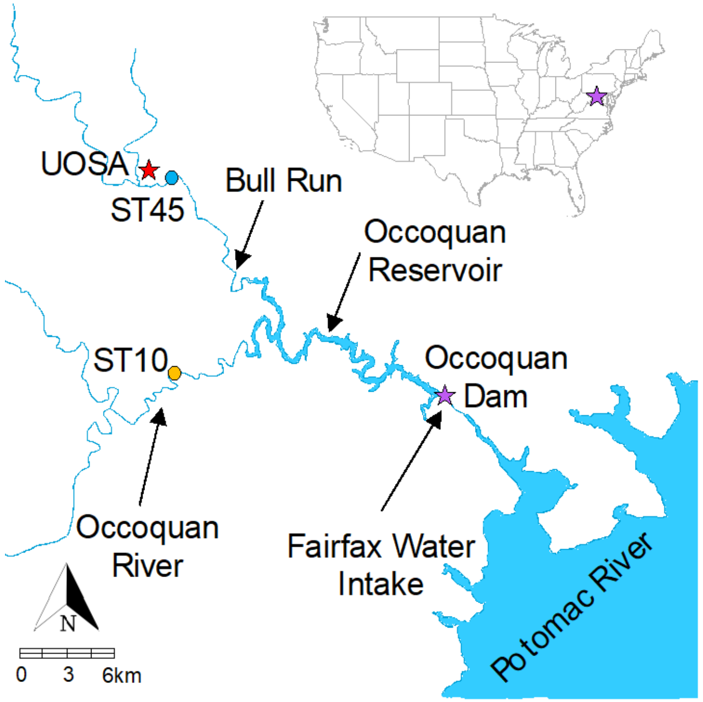
Revised Sodium Balance in UOSA's Sewershed

Shantanu V. Bhide & Stanley B. Grant

Occoquan Watershed Monitoring Laboratory

Virginia Tech

Background

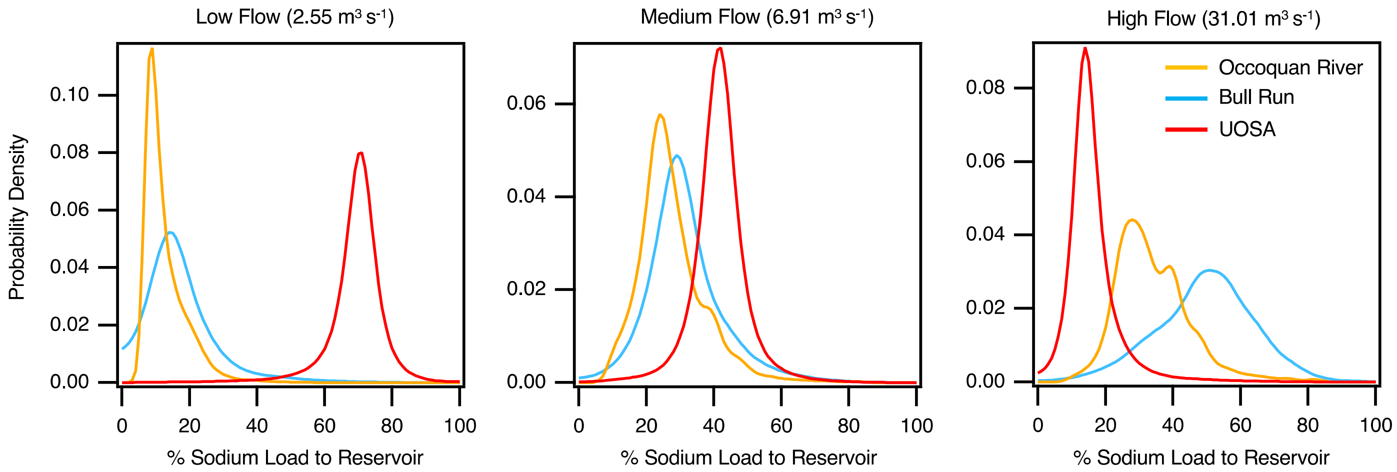



nature sustainability
ARTICLES
https://doi.org/10.1038/s41893-021-00713-7
Check for updates

Addressing the contribution of indirect potable reuse to inland freshwater salinization

Shantanu V. Bhide[1], Stanley B. Grant[1,2], Emily A. Parker[1], Megan A. Rippy[1,2], Adil N. Godrej[1], Sujay Kaushal[3], Greg Prelewicz[4], Niffy Saji[4], Shannon Curtis[5], Peter Vikesland[6], Ayella Maile-Moskowitz[6], Marc Edwards[6], Kathryn G. Lopez[6], Thomas A. Birkland[7] and Todd Schenk[2,8]

Inland freshwater salinity is rising worldwide, a phenomenon called the freshwater salinization syndrome (FSS). We investigate a potential conflict between managing the FSS and indirect potable reuse, the practice of augmenting water supplies through the addition of highly treated wastewater (reclaimed water) to surface waters and groundwaters. From time-series data collected over 25 years, we quantify the contributions of three salinity sources—a water reclamation facility and two rapidly urbanizing watersheds—to the rising concentration of sodium (a major ion associated with the FSS) in a regionally important drinking-water reservoir in the Mid-Atlantic United States. Sodium mass loading to the reservoir is primarily from watershed runoff during wet weather and reclaimed water during dry weather. Across all timescales evaluated, sodium concentration in the reclaimed water is higher than in outflow from the two watersheds. Sodium in reclaimed water originates from chemicals added during wastewater treatment, industrial and commercial discharges, human excretion and down-drain disposal of drinking water and sodium-rich household products. Thus, numerous opportunities exist to reduce the contribution of indirect potable reuse to sodium pollution at this site, and the FSS more generally. These efforts will require deliberative engagement with a diverse community of watershed stakeholders and careful consideration of the local political, social and environmental context.



Treated wastewater constitutes a greater fraction of sodium mass load entering the reservoir during dry weather

Background

Sodium mass load discharged from UOSA to Bull Run originates from

- *Chemicals used in water treatment*
- *Chemicals used in wastewater treatment*
- *Permitted discharge (microfabrication facility)*
- *Human excretion by UOSA's service population*
- *Unknown sources (down-drain disposal)*

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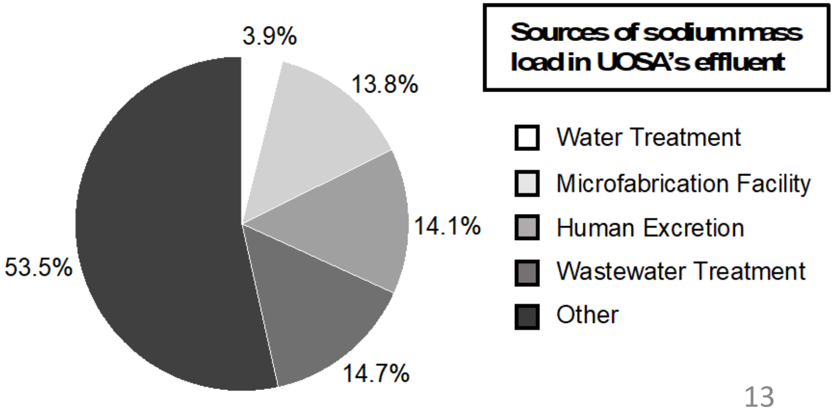
For 2017 contribution from chemicals used in wastewater treatment was estimated ~15 %, now revised to ~4% based on new data and correcting an error in original calculations



Revision Methodology

*For 2017, UOSA provided data on **monthly use (gal/month)**, **density (lb/gal)** and **solution strength (% by weight)** for*

- *Sodium bisulfite ($NaHSO_3$)*
- *Sodium hypochlorite (NaOCl)*
- *Sodium hydroxide (NaOH)*

Step 1: Calculate sodium content per gallon for each chemical

$$\frac{Na^{+}(lb)}{gal} = density\left(\frac{lb\ solution}{gal}\right) \times\ strength\left(\frac{lb\ chemical}{lb\ solution}\right) \times \frac{Na\ atomic\ mass\ (lb)}{molar\ mass\ (lb)}$$

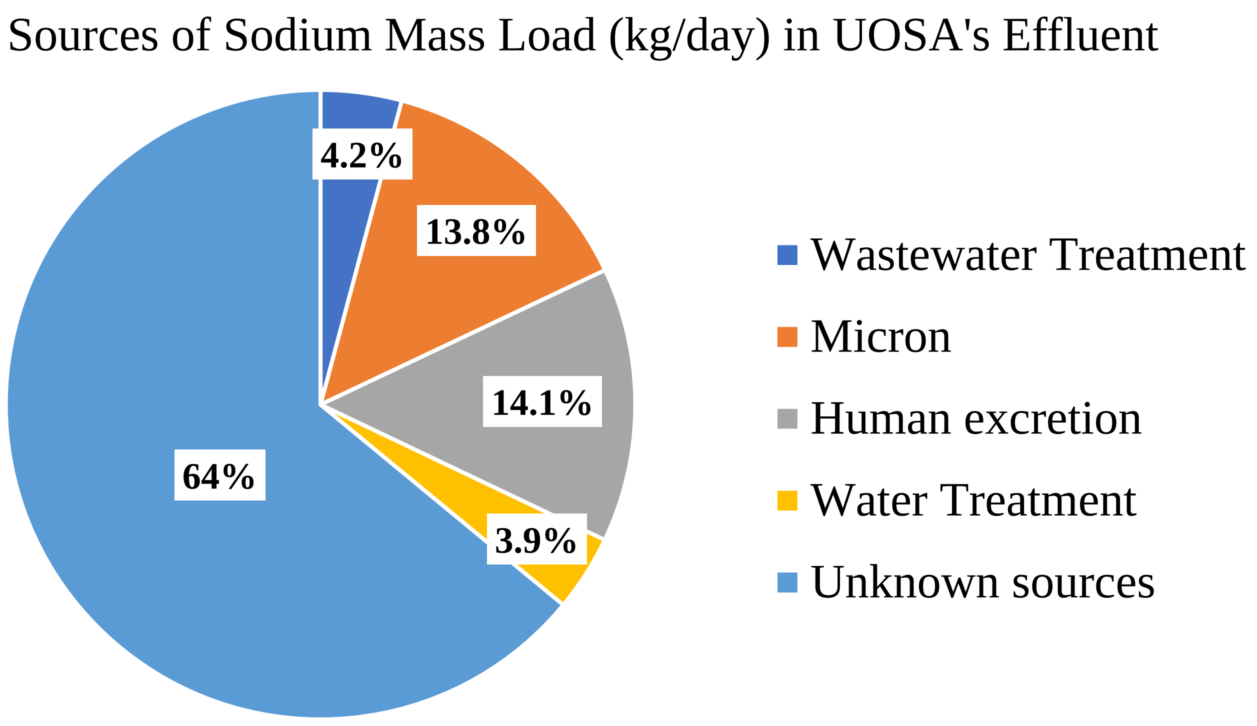
Step 2: Multiply value in Step 1 by total monthly usage of each chemical

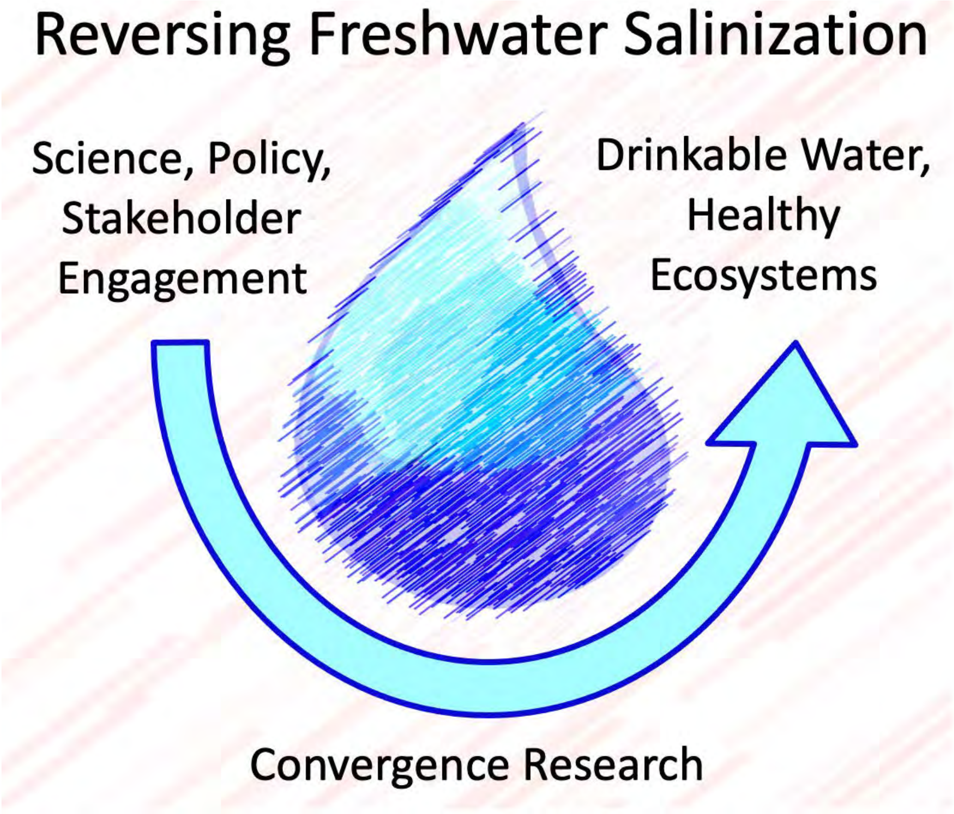
$$\frac{Na^{+}(kg)}{day} = \frac{Na^{+}(lb)}{gal} \times\ chemical\ use\left(\frac{gal}{month}\right) \times \frac{0.45}{no.of\ days\ in\ a\ month}$$

Revised Results for 2017

Averaged over 2017, contribution of chemicals used in UOSA's treatment process to the daily sodium mass load in UOSA's reclaimed water is estimated to be 4.2%

***<u>Next Step</u>**: submit new estimate to Nature Sustainability in the form of an erratum*





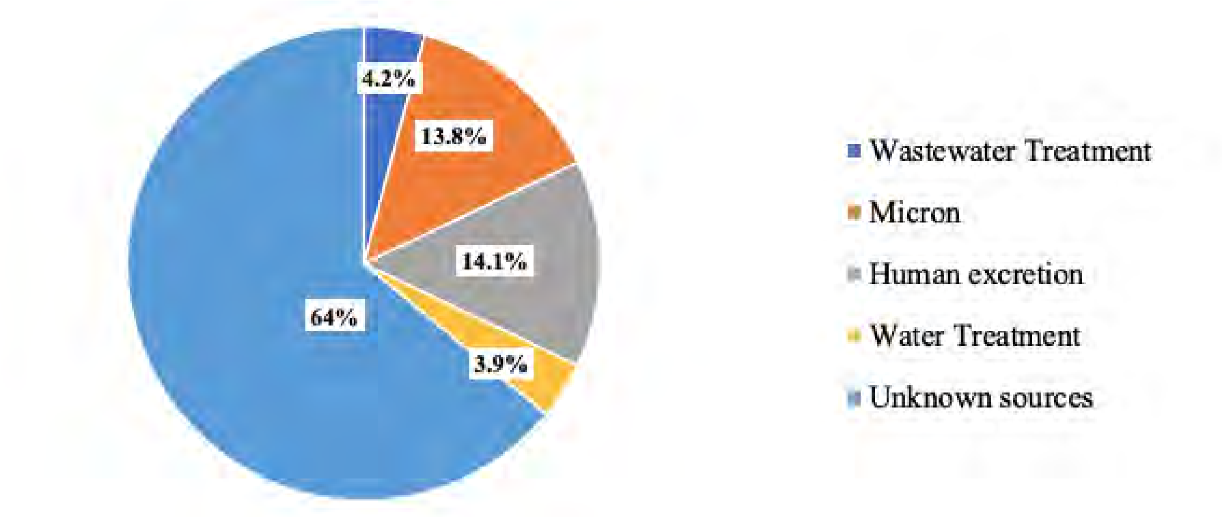
Introduction: Fairfax County Sewer Ion Flux Study

Caitlin Shipman, Stanley Grant, Shantanu Bhide, Lauren Krauss and the Biophysical Team

Occoquan Watershed Monitoring Laboratory

Virginia Tech

Sources of Sodium Mass Load in UOSA's Effluent During Dry Weather Periods:



Bhide, S.V., Grant, S.B., Parker E.A. *et. Al*. (2021) Addressing the contribution of indirect potable reuse to inland freshwater salinization. *Nature Sustainability.* https://doi.org/10.1038/s41893- 021-00713-7.

Goal:

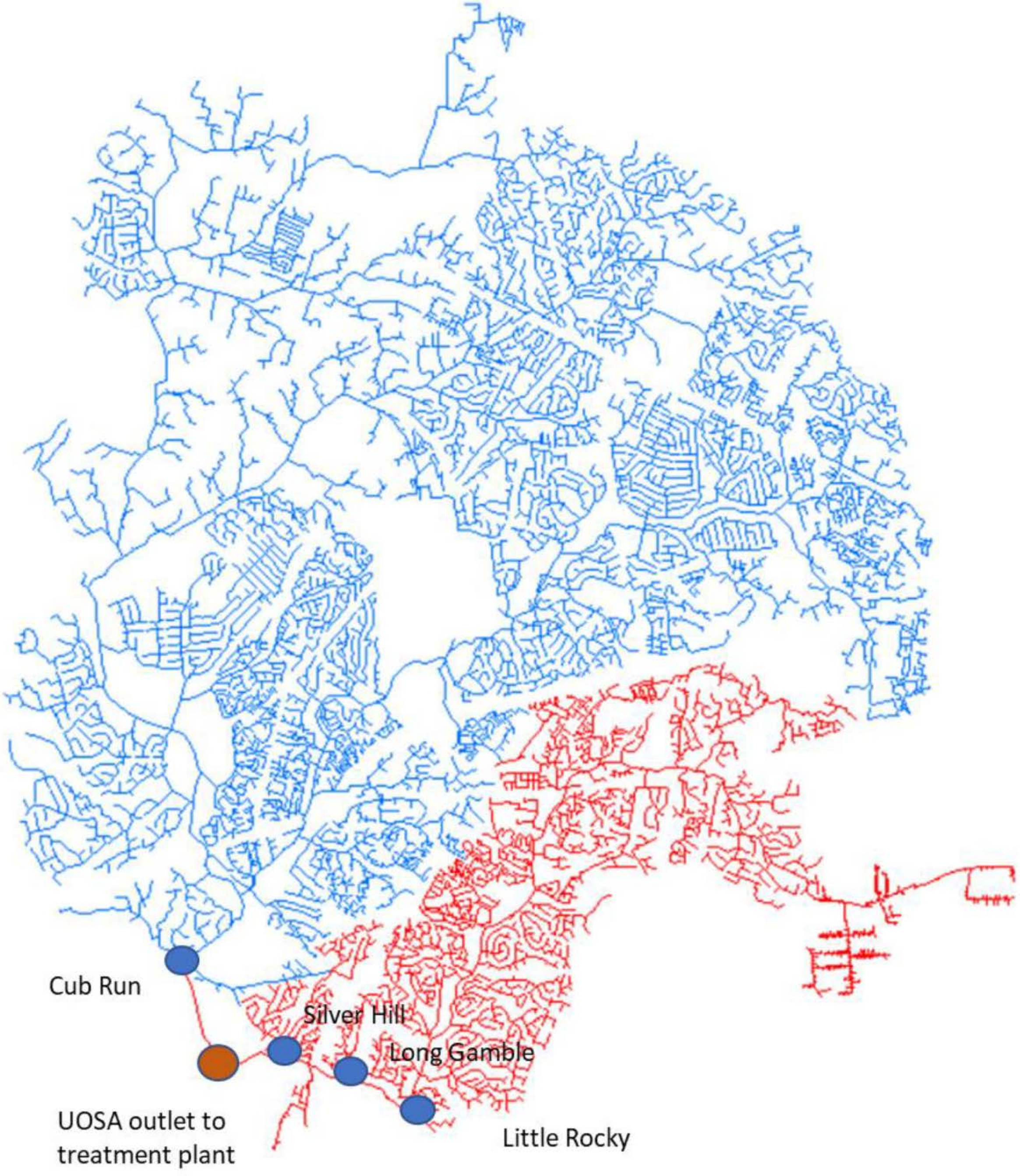
Identifying specific sources of ions draining from the Fairfax County sewer network through the Cub Run Pump Station to UOSA.

Study questions:

- What are the contributions from various sources to the ion concentrations in the sewage at the Cub Run pump station?

  - Parse out any contributions from the following sources:
    - Raw water from the Potomac River,
    - Drinking water treatment,
    - Household use,
    - Groundwater infiltration.

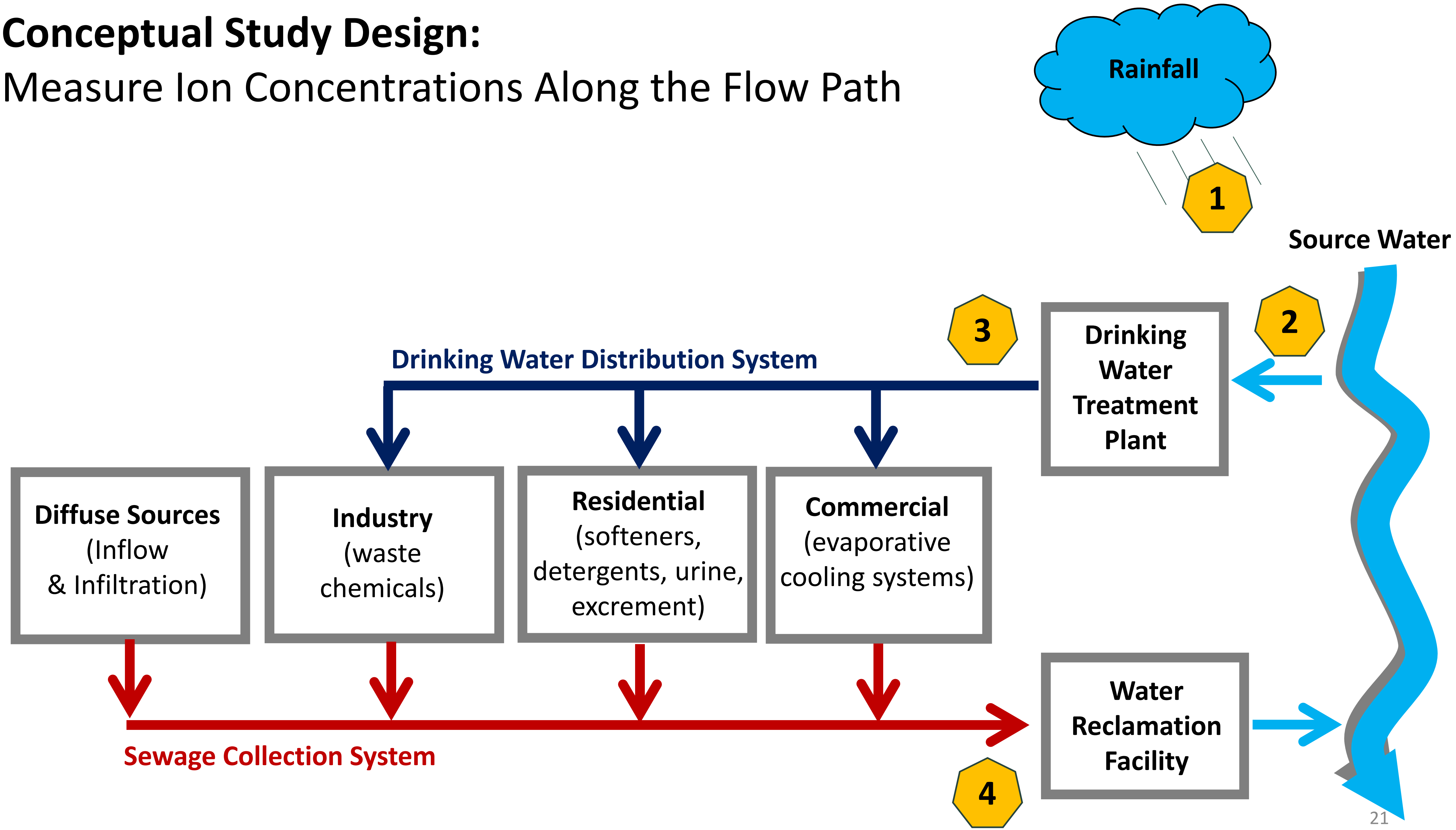
Study Site:
Portion of Fairfax County's Sanitary Sewer Network Draining to UOSA's Cub Run Pump Station



Statistics on the Cub Run Sewer Network

- Drinking water supplied primarily by Fairfax Water's Corbalis Water Treatment Plant
- Land Use Area distribution:
  - Residential (Low, Medium, & High Density) = 31.3%
  - Commercial and Industrial = 14.5%
  - Other (Recreation, Public, Institutional and Open Land) = 54.2%
- Approximately 41,600 residential connections
- Approximately 121,000 people served by the network

Conceptual Study Design:
Measure Ion Concentrations Along the Flow Path



Summary of Sampling Locations and Timing

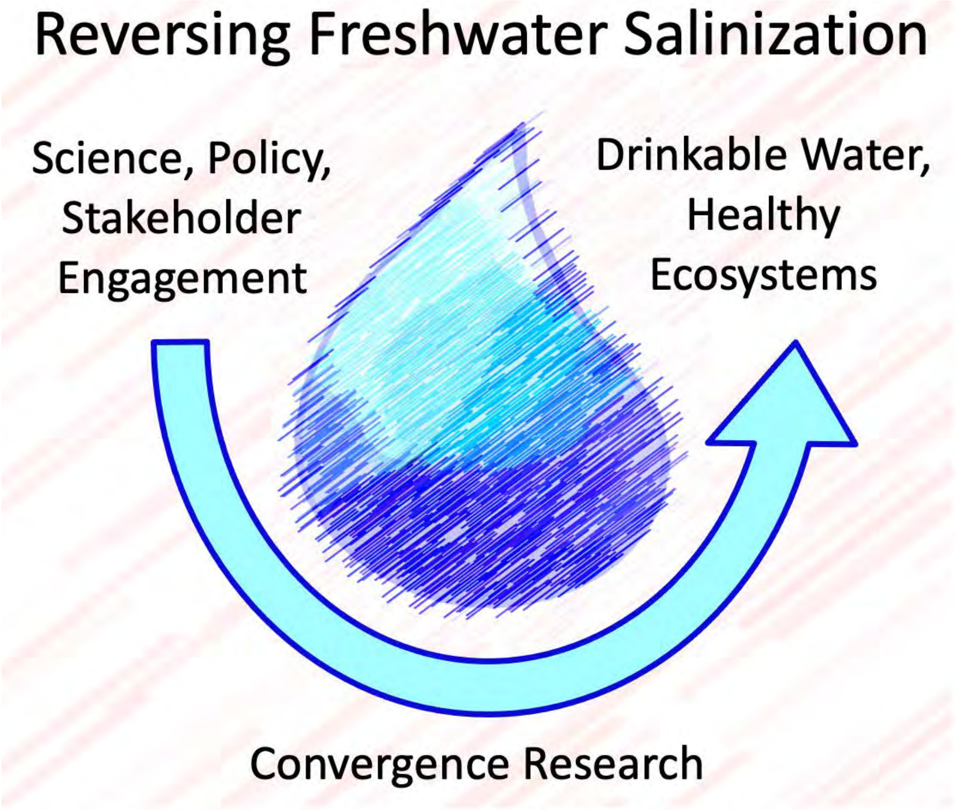
1. **Rainwater** (once on 7/13/21)
2. **Source Water** (Potomac River, daily from 7/3 to 7/23/21)
3. **Finished Drinking Water** (Fairfax Water Corbalis Treatment Plant, daily from 7/4 to 7/24/21)
4. **Sanitary Flow** (Cub Run Sewage Pump Station, hourly from 7/7 to 7/26/21)

UOSA → **Bull Run** → **Occoquan Reservoir** → **Fairfax Water Griffith Water Treatment Plant**

Occoquan Reservoir → **Potomac River (downstream of the Corbalis Water Treatment Plant)**

Data collected during the study:

- 460 samples were analyzed for:
    - Anions (Cl, SO_4, NO_2, NO_3)
    - Cations (Na, NH_3, K, Mg, Ca)
- Hourly measurements of the groundwater marker, Radon222
- Hourly flow at the Cub Run pump station (courtesy of UOSA)
- Separation of the hourly sewage hydrograph at the Cub Run Pump Station into **groundwater infiltration** (**GWI**), **base wastewater flow** (**BWF**) and **rainfall derived inflow and infiltration** (**RDII**) (courtesy of Gabriel Perez and Jesus Gomez-Velez)



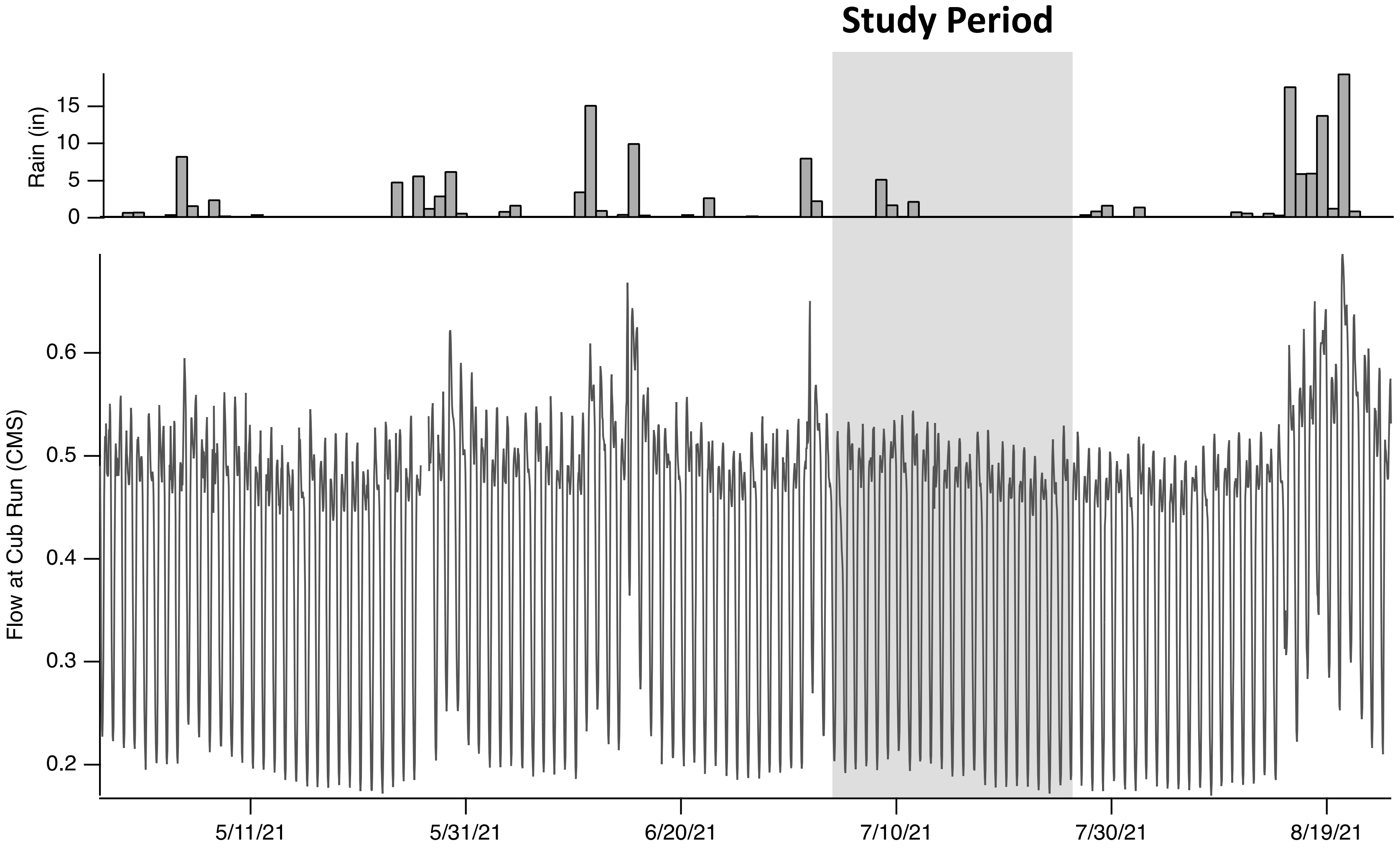
Preliminary Analysis of Sodium Sources in the Cub Run Sewershed

Stanley B. Grant, Caitlin Shipman, Shantanu Bhide and the Biophysical Group

Occoquan Watershed Monitoring Laboratory

Virginia Tech

Cub Run Ion Flux Study: Weather Conditions*



*Data courtesy of David Tolson, UOSA

Sodium Measurements

1 **Rainwater**

Increase of > 8.3 mg/L

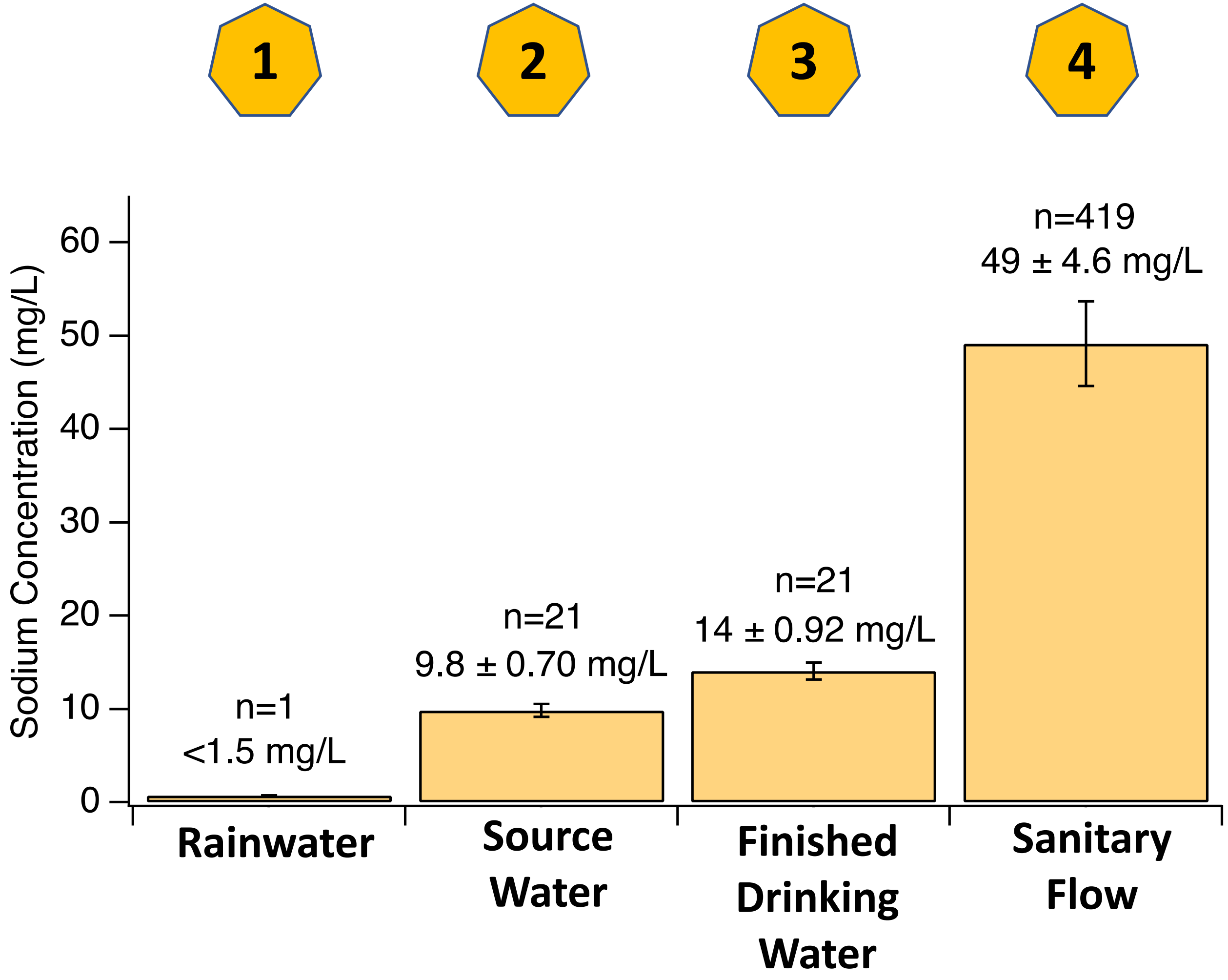
2 **Source Water (Potomac River)**

Increase of 4.2 ± 1.2 mg/L

3 **Finished Drinking Water (Corbalis DWP)**

Increase of 35 ± 4.7 mg/L

4 **Sanitary Flow (Cub Run Pump Station)**



UOSA → Bull Run → Occoquan Reservoir

→ Fairfax Water Griffith Drinking Water Treatment Plant

→ Potomac River (downstream of the Corbalis Treatment Plant)

Sewer Hydrograph Separation

1 **Rainwater**

↓

2 **Source Water (Potomac River)**

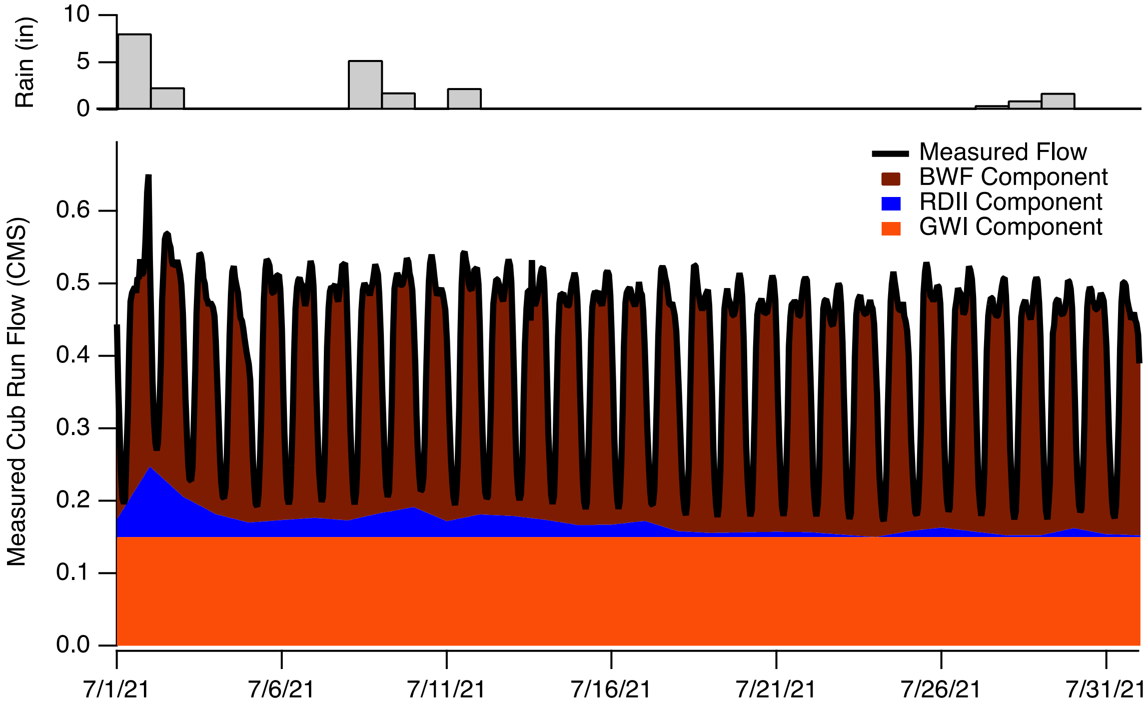
↓

3 **Finished Drinking Water (Corbalis DWP)**

↓

4 **Sanitary Flow (Cub Run Pump Station)**

↓



Water in the sewer network →

Groundwater Infiltration (**GWI**)	Rainfall Derived Infiltration and Inflow (**RDII**)	Base Wastewater Flow (**BWF**)

UOSA → **Bull Run** → **Occoquan Reservoir**

↗ **Fairfax Water Griffith Drinking Water Treatment Plant**

↘ **Potomac River (downstream of the Corbalis Treatment Plant)**

Sodium Load Balance

Key

C = sodium concentration (e.g., ppm) at the Cub Run pump station

Q = flow rate (e.g., MGD) at the Cub Run pump station

Key

- Measured
- Hydrograph Separation
- To be Determined

Sodium mass loading out of the sewer network

Groundwater Infiltration **(GWI)**	Rainfall Derived Infiltration and Inflow **(RDII)**	Base Wastewater Flow **(BWF)**
$C_{\mathrm{GWI}} \times Q_{\mathrm{GWI}}$	$C_{\mathrm{RDII}} \times Q_{\mathrm{RDII}}(t)$	$C_{\mathrm{BWF}}(t) \times Q_{\mathrm{BWF}}(t)$

$$C_{\mathrm{Measured}}(t) \times Q_{\mathrm{Measured}}(t)$$

Sodium from Finished Drinking Water

Sodium from residential & commercial Sewage

$$C_{\mathrm{BWF}}(t) = C_{\mathrm{FDW}}(t) + C_{\mathrm{Sewage}}$$

Sodium Load Balance

Sodium concentration in groundwater

$C_{\mathrm{GW}} = C_{\mathrm{GWI}} + C_{\mathrm{RDII}}$

Sodium concentration in sewage

C_{Sewage}

Groundwater Infiltration (**GWI**)	Rainfall Derived Infiltration and Inflow (**RDII**)	Base Wastewater Flow (**BWF**)

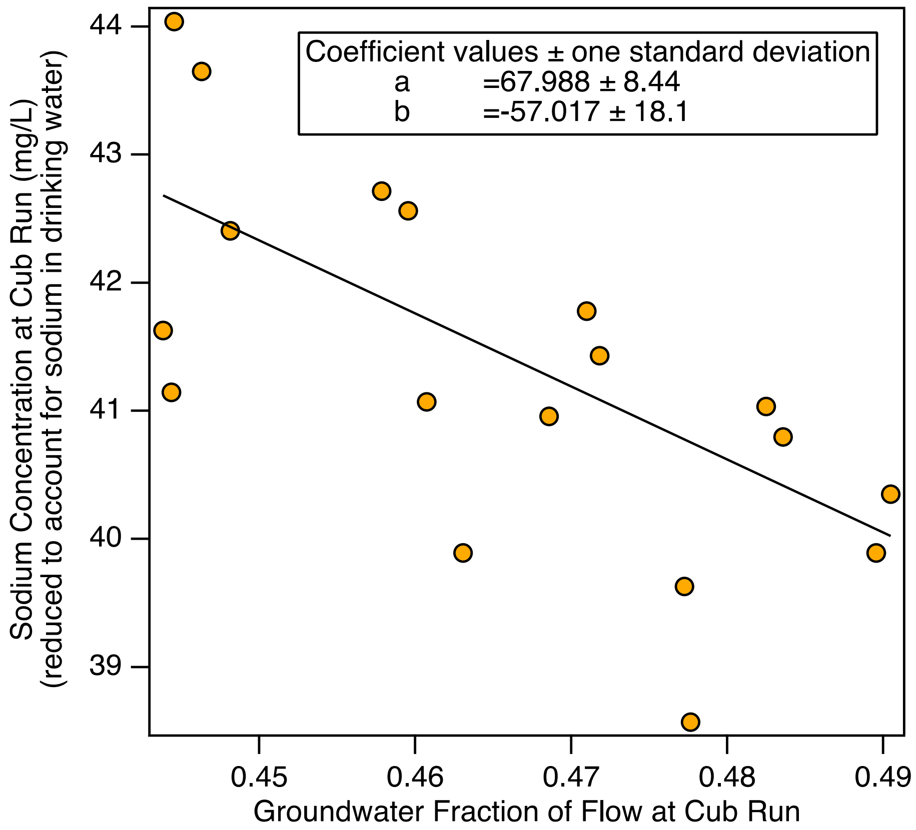
Fraction of flow at the Cub Run pump station that is groundwater

$$f_{\mathrm{GW}} = \frac{Q_{\mathrm{GWI}} + Q_{\mathrm{RDII}}}{Q_{\mathrm{Measured}}}$$

Two end-member mixing model (end-members are sodium concentration in groundwater and sewage)

$$\underbrace{C_{\mathrm{Measured}}(t) - C_{\mathrm{FDW}}(t) f_{\mathrm{BWF}}(t)}_{\textit{measured or known}} = \underbrace{C_{\mathrm{Sewage}}\left(1 - f_{\mathrm{GW}}(t)\right) + C_{\mathrm{GW}} f_{\mathrm{GW}}(t)}_{\textit{fraction of flow at Cub Run PS that is Ground Water is known}} = \begin{cases} C_{\mathrm{Sewage}}, f_{\mathrm{GW}} \to 0 \\ C_{\mathrm{GW}}, f_{\mathrm{GW}} \to 1 \end{cases}$$

Sodium in Groundwater vs Sewage

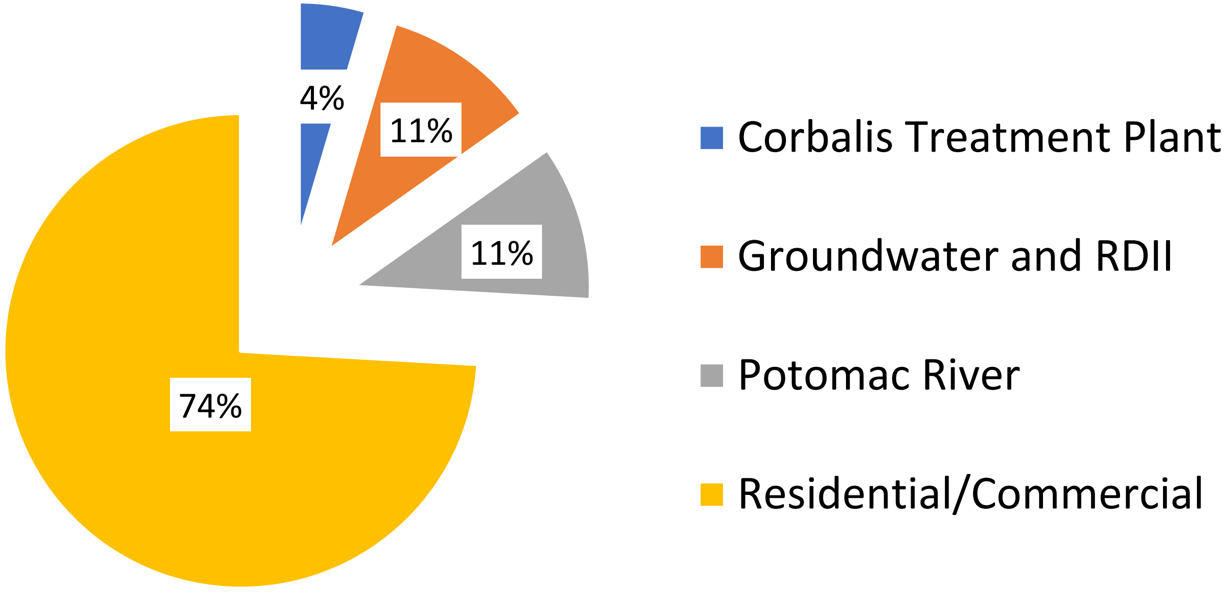


$$\left\{ \begin{array}{l} C_{\text{Sewage}} = 68 \pm 8 \text{ mg/L} \\ C_{\text{GW}} = 11 \pm 20 \text{ mg/L} \end{array} \right.$$

Daily average sodium concentration measured at the Cub Run pump station declines with increasing groundwater fraction; i.e., ***groundwater is diluting the sodium in sewage****.*

Preliminary Sodium Source Results

Average source breakdown for sodium load discharged to UOSA from the Cub Run Pump station for 3 weeks in July 2021



Take Home Lessons

- A significant fraction (approximately 75%) of the sodium load entering UOSA from Cub Run pump station, and then passing through UOSA to Bull Run, is added by residential and commercial connections in the sewershed
- During dry weather, UOSA accounts for between 60 and 80% of the sodium load entering the Occoquan Reservoir from the Bull Run and Occoquan River tributaries*
- Thus, during dry weather upwards of 45 to 60% of the sodium load entering the reservoir could be from residential and commercial sewage
- Sodium load from these sources is likely to increase, given Transportation Area Zone (TAZ) growth projections: 12% increase in residential and business populations in the Cub Run sewershed between now and 2040

*Bhide, S.V., Grant, S.B., Parker E.A. *et. al*. (2021) Addressing the contribution of indirect potable reuse to inland freshwater salinization. *Nature Sustainability.* https://doi.org/10.1038/s41893- 021-00713-7.

Study Limitations

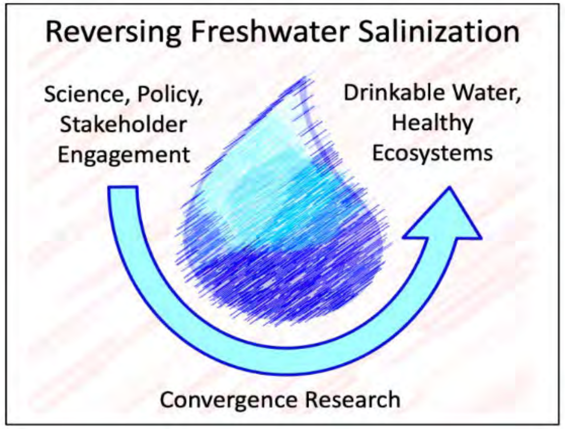
- We and our partner organizations collected and analyzed nearly 500 samples, but only for three weeks during the summer:
  - how representative are these results for other time periods?
  - What about potential impacts of COVID (e.g., on human behavior vis a vis down drain sodium disposal)?
- These results are from a portion of one of the sewer networks that drains to UOSA. UOSA also services the City of Manassas, City of Manassas Park and portions of Prince William County.
- How well do these results represent less residentially intensive sewer networks? (e.g., Micron discharges sodium to the City of Manassas sewer network)

Possible Next Steps

- Extend these preliminary results for sodium to the other ions measured
- Explore the implications of these results for drinking water, infrastructure corrosion and ecosystem health
- More data would help constrain the problem
  - Continuous flow and specific conductance measurements at key points in the sewershed
  - Focused studies to measure ion fluxes from small neighborhoods with little inflow and infiltration
  - Merge with lab studies focused on ion content of common household products (in Blacksburg, led by Kent Mendoza and his advisor Peter Vikesland)
- Perhaps a social marketing intervention, using sewer subsheds in Cub Run or elsewhere, to determine if sodium loads from residential/commercial customers can be reduced?
- **As the meeting progresses, looking forward to hearing from you about what you think the next steps should be!**

Thank you to…

- **Fairfax Water** for collecting daily samples from the raw and finished water at the Corbalis Water Treatment Plant (Jojean Bolton & Meg Carlson)
- **UOSA** for installing and maintaining the sewage sampling system upstream of the Cub Run Pump Station (Randy Allen & Nate Wells) and providing flow data (David Tolson)
- **OWML** for helping us design and troubleshoot the sewage sampling system (Harold Post & Doug Holladay), and for helping us get up and running on the Thermo Fischer Ion Chromatograph (Dongmei Alvi & Joan Wirt)
- **Graduate students** for collecting and analyzing samples 24 hours per day (Caitlin Shipman, Shantanu Bhide & Lauren Krauss)
- **Gabriel Mesa-Perez and Jesus Gomez-Velez** for hydrograph separation



Characterization Occoquan Sewershed

Using wastewater sources and network topology to discretize and model a complex conveyance system

Gabriel Perez, Jesus Gomez-Velez, Yadong Zhang, and *The Biophysical Team*

Environmental Flow & Transport
VANDERBILT UNIVERSITY

Virtual ECOS Meeting 2
October 06, 2021

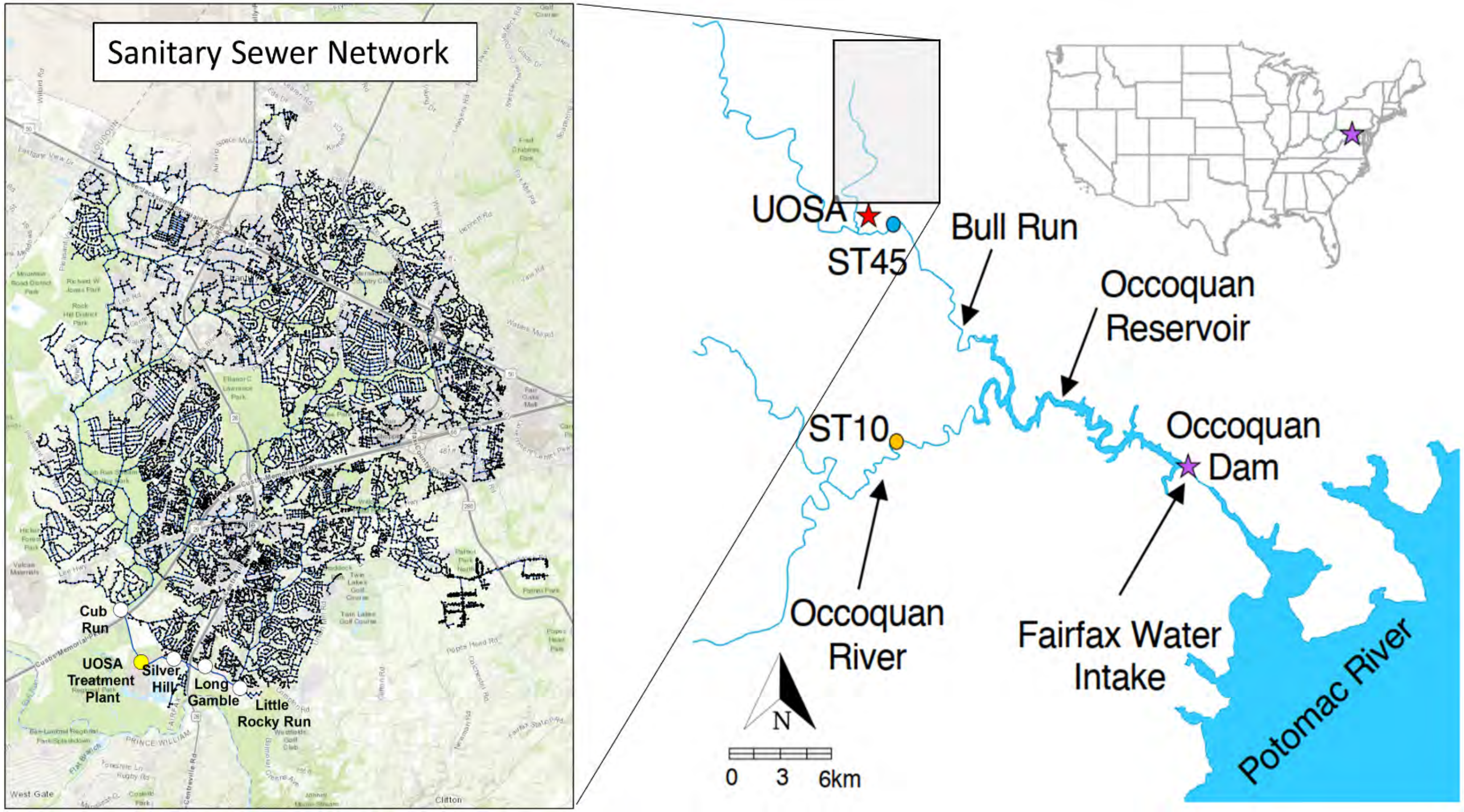
Rationale: If we are to reduce ion pollution discharged to the Occoquan Reservoir from UOSA, we must first quantify the **relative importance of various ion sources** within the sanitary sewer networks that drain to UOSA.

The UOSA Sewer Network

(Portion of Fairfax county that drains to the UOSA treatment plant)

Pumping Stations

UOSA Treatment Plant



Novel and transferrable learning and predictive tools

Develop (verify + validate) and deploy geostatistical and physics-based models to

Objectives:

O1: Characterize and quantify the contributions to sanitary flow from sources discriminated by **water user type** (e.g., residential, commercial, industrial)

O2: Characterize and quantify the contributions to sanitary flow from **groundwater** and **inflow and infiltration** induced by rainfall events (i.e., I/I)

O3: Aggregate the sewer network into physically consistent spatial units for sampling, analysis, and upscaling

Why is this work important?

Identify critical points within the network (sub-sewersheds) to efficiently sample and diagnose the sewershed system

Estimate changes on sanitary flows under current and future demographics and land-use changes

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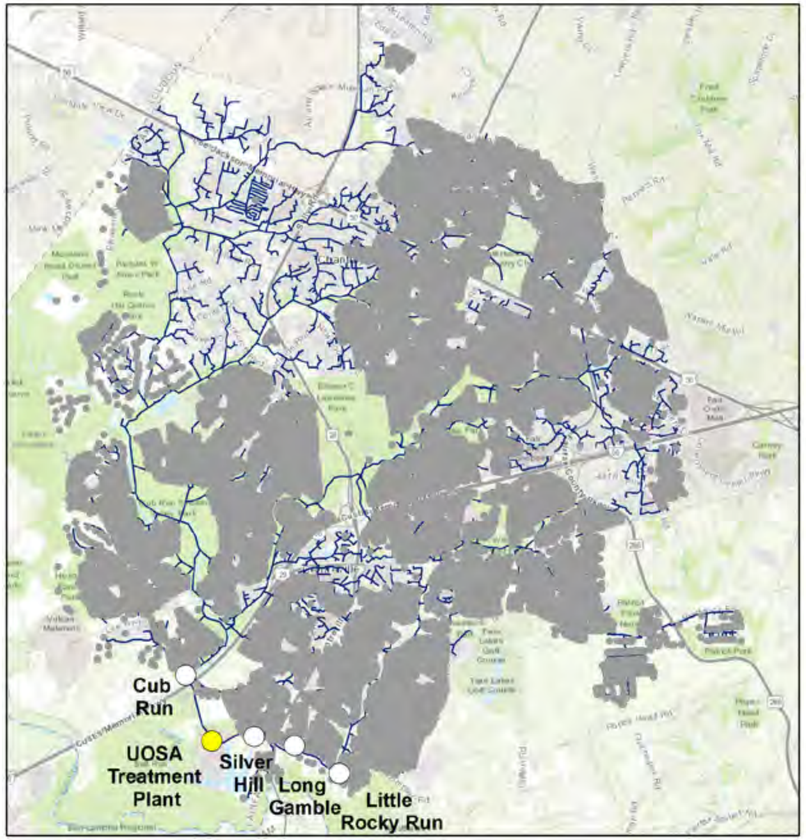
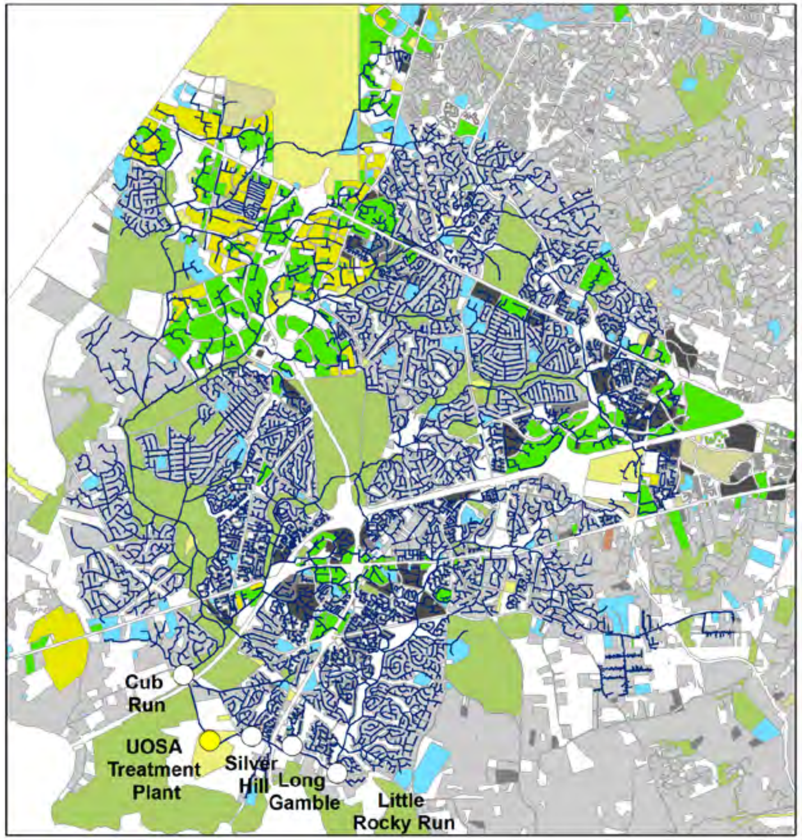
Data sources to estimate sewage flow contribution from different water users

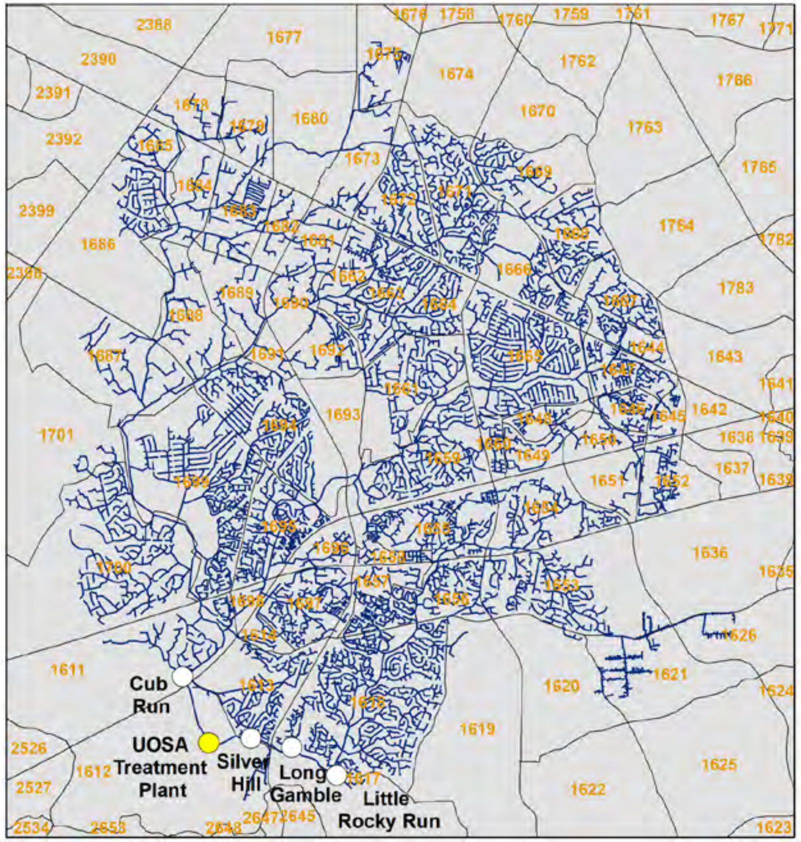
Housing Units (CENSUS)



Land Use



Transit Area Zones



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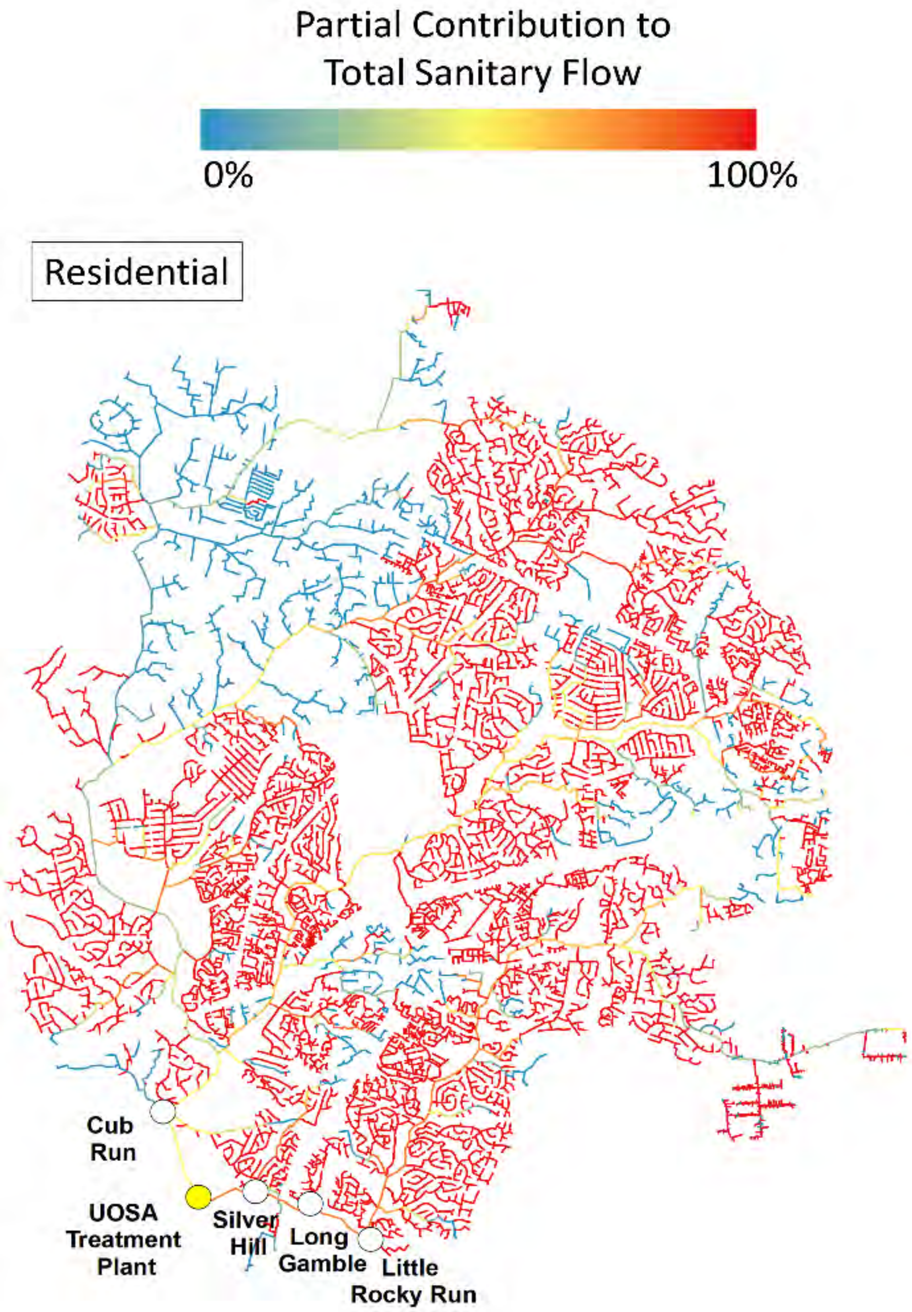
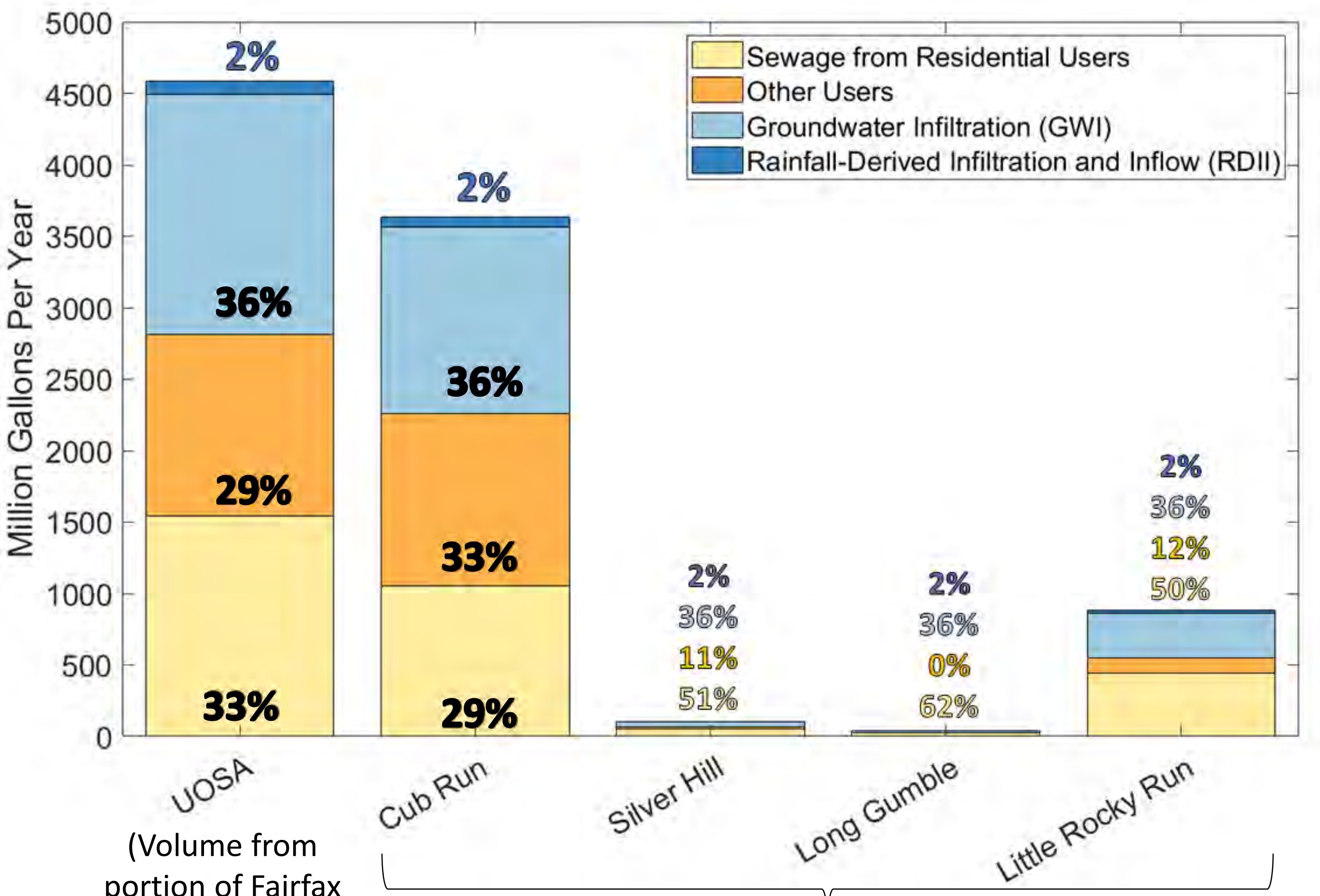


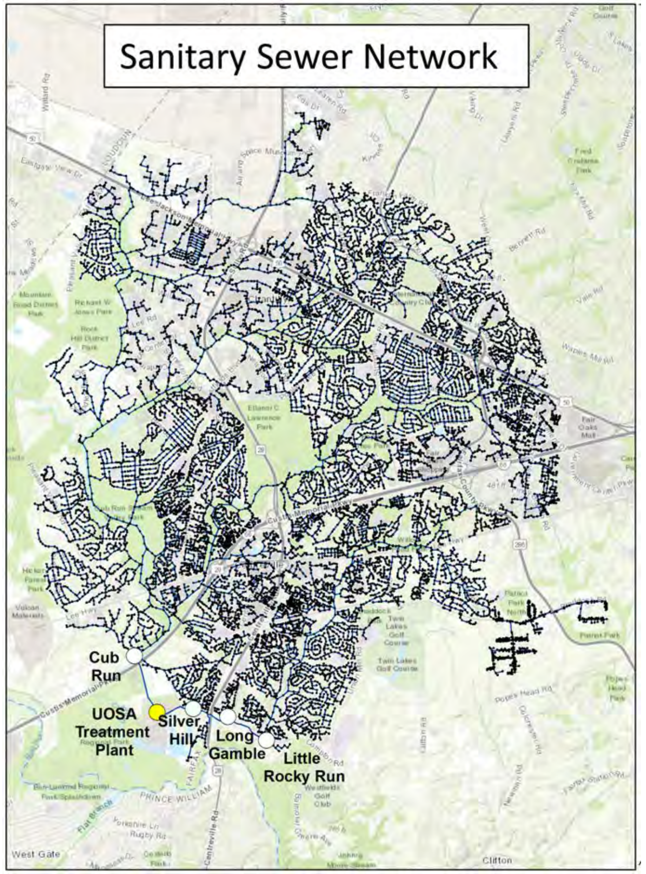
Relative contribution from water user types to sewage flow

Relative contributions from water user type, groundwater, and inflow



(Volume from portion of Fairfax county)

Pumping Stations



Preliminary results

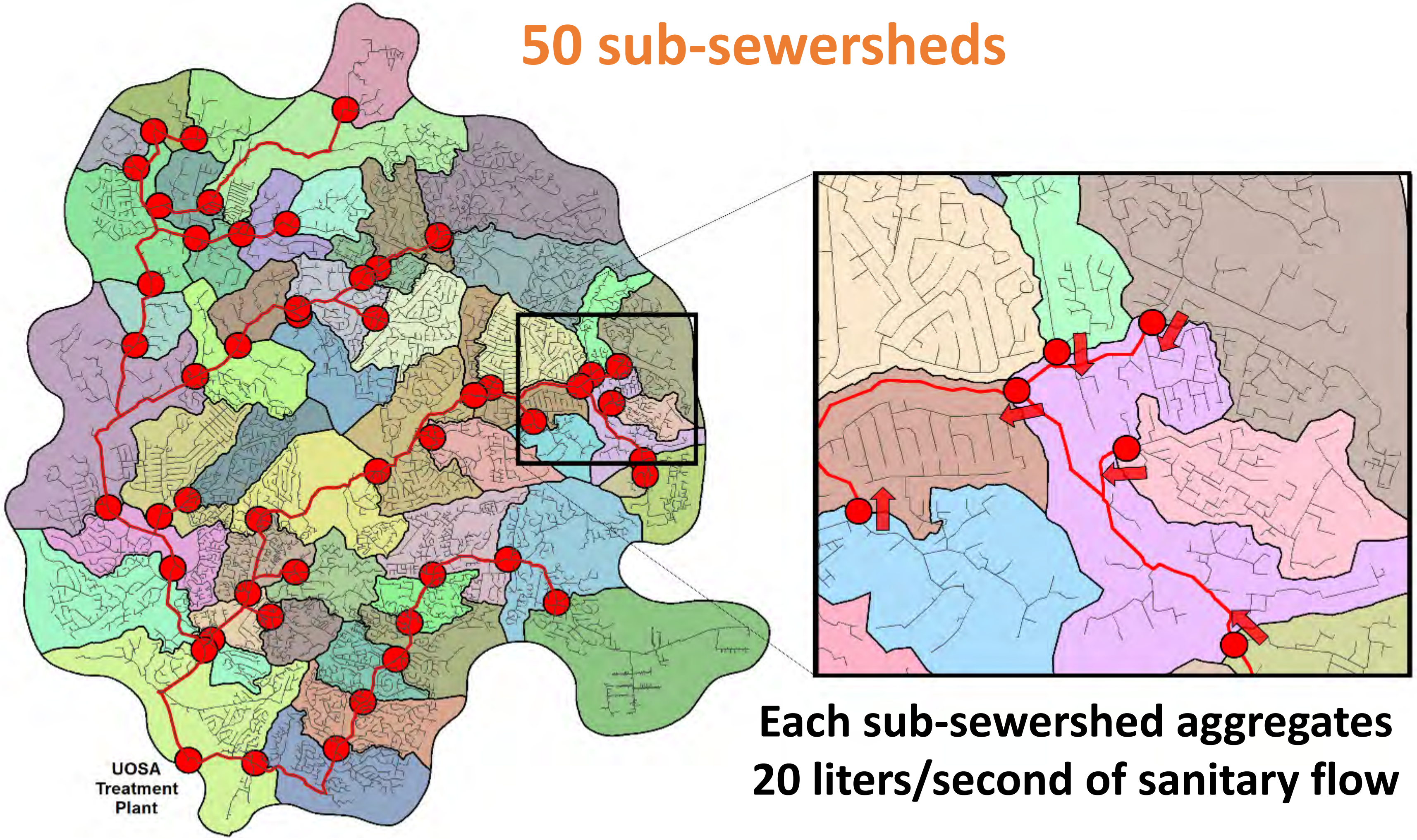
Sub-sewershed units

Defining physically consistent units for sampling and diagnosis

Rationale:

- Discretize the system into coarser units with comparable sources for reduced-complexity modeling
- Identify units that have comparable physical properties to sample and interpret observations within a consistent frame of reference

50 sub-sewersheds



Each sub-sewershed aggregates 20 liters/second of sanitary flow

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What's next?

1. Development of a new physics-based modeling framework for sewer network systems, including water flow and solute transport

2. Use of the modeling framework to explore:
   - Intervention scenarios
   - System characteristics under current and future demographics (e.g., using the Transit Area Zones (TAZ) data)
   - Quantification of uncertainty

Take-away points

1. Water users contribute approx. 62% of sewage flow (approx. 33% from residential users and 29% from other users).

2. The Groundwater Infiltration (GWI) contributes approx. 36% while that Rainfall-derived Infiltration and Inflow (RDII) contributes approx. 2%.

3. The sewer network can be characterized by 50 sub-sewersheds, each aggregating 20 liters/second of sanitary flow.

Attenuation of Different Chemical Cocktails Longitudinally along Bull Run

Carly Maas

Sujay Kaushal

University of Maryland College Park Department of Geology

GOAL: Can Bull Run naturally attenuate ions, metals, nutrients, and organic matter downstream?

1 Rainwater

2 Source Water

3 Finished Drinking Water

4 Sanitary Flow

UOSA → Bull Run → Occoquan Reservoir → Fairfax Water Griffith Drinking Water Treatment Plant

Occoquan Reservoir → Potomac River (downstream of the Corbalis Treatment Plant)

WHAT CHEMICALS FROM THE UOSA EFFLUENT TRAVEL TO THE RESERVOIR?

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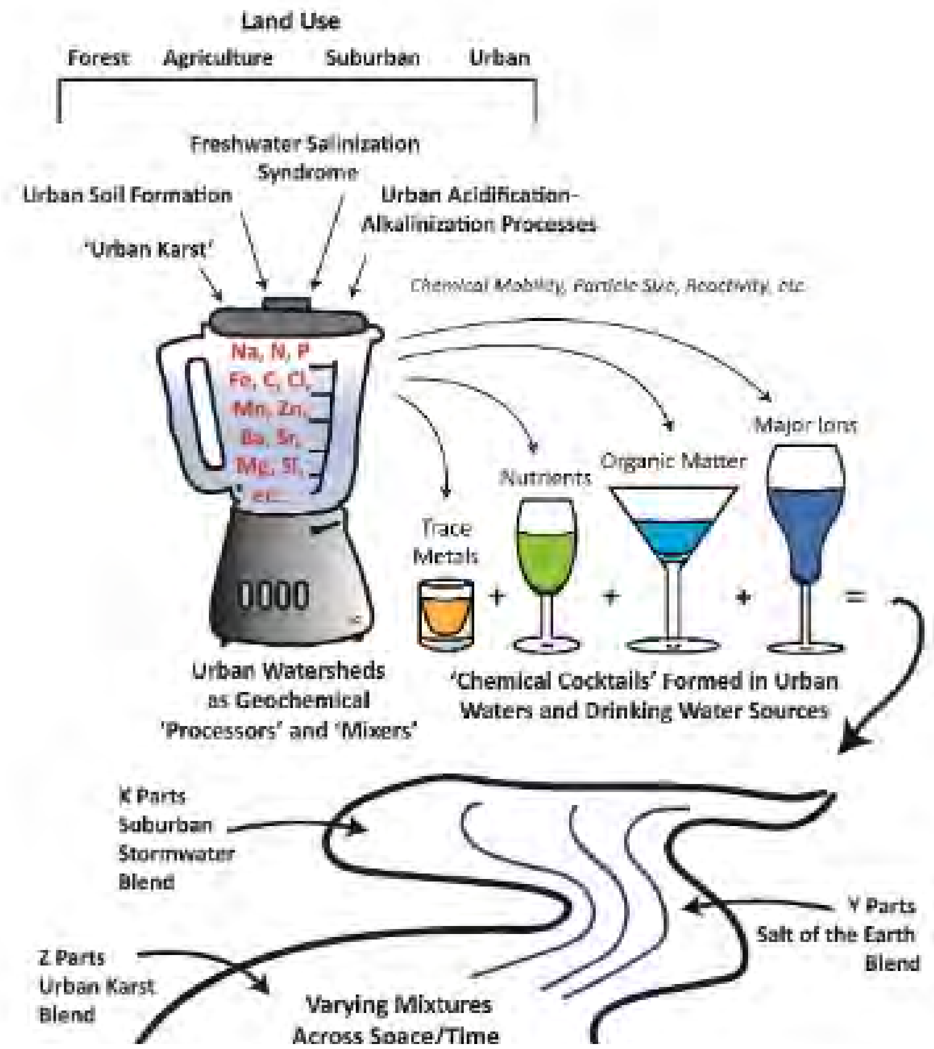
Chemical Cocktails



- **Chemical Cocktails**: formation of novel elemental combinations and signatures due to urbanization
  - Depends on land use
  - Retention, release, and transformation of ions, metals, nutrients, and organic matter

What makes it downstream?

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Kaushal et al. (2020), *sensu* Morel et al. (2020), Galella et al. (2021)

Study Questions

- (1) How are chemical cocktails transformed, retained, and released longitudinally from wastewater effluent?
- (2) How do shifts in land use influence water quality?

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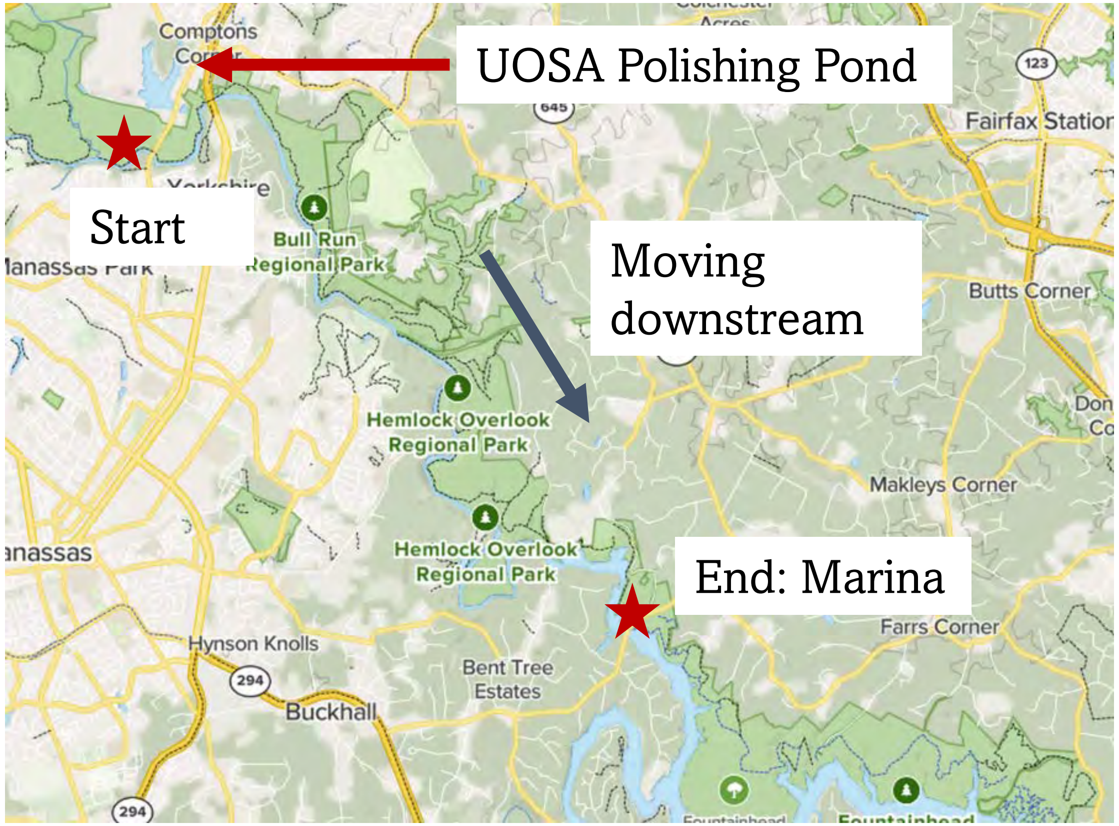
Method: Field Sampling

- Collect grab samples and field data (SC, pH, temperature, dissolved oxygen)
- Measured for ions, metals, nutrients, organic matter



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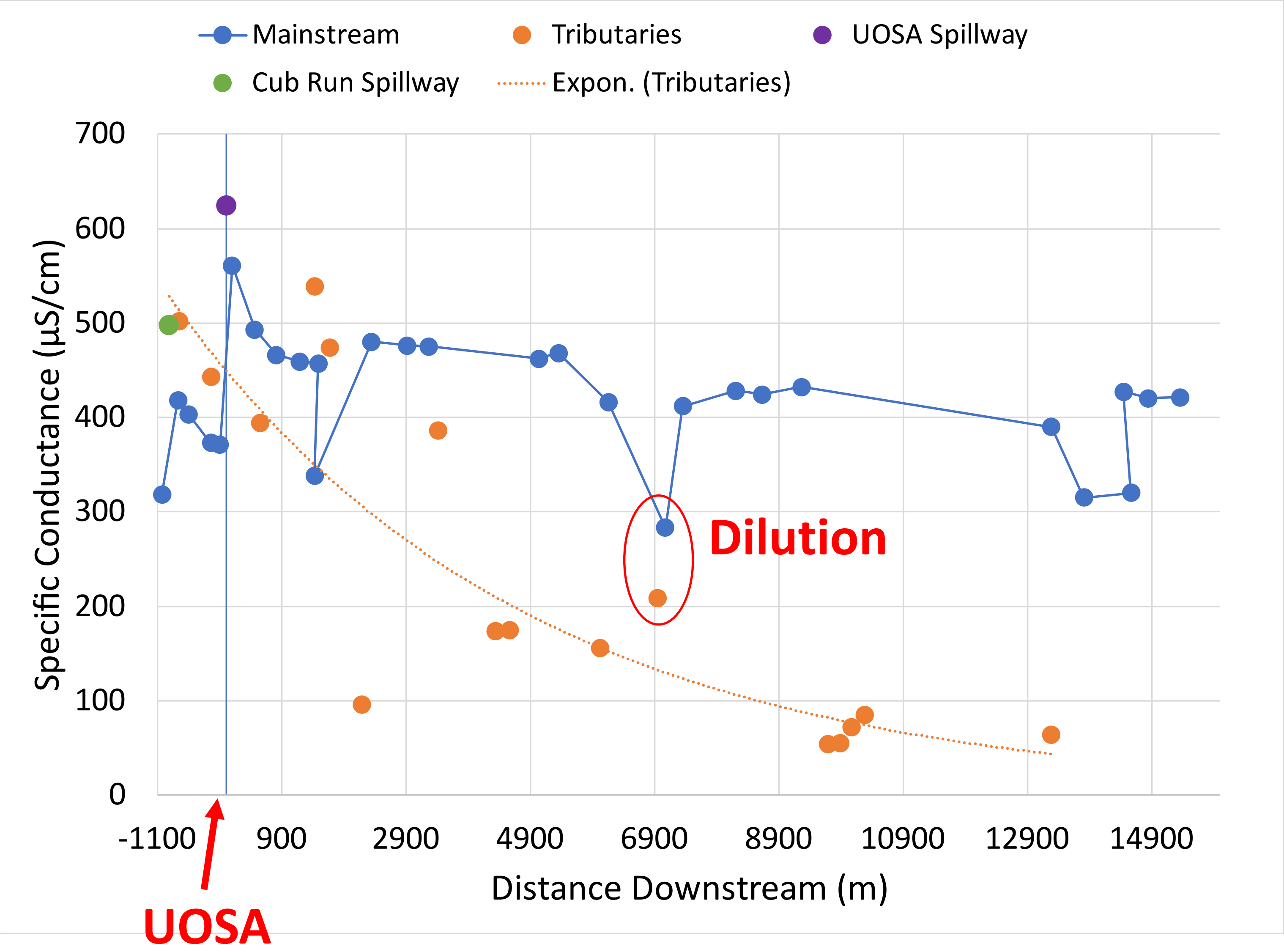
Specific Conductance Attenuation: Jan



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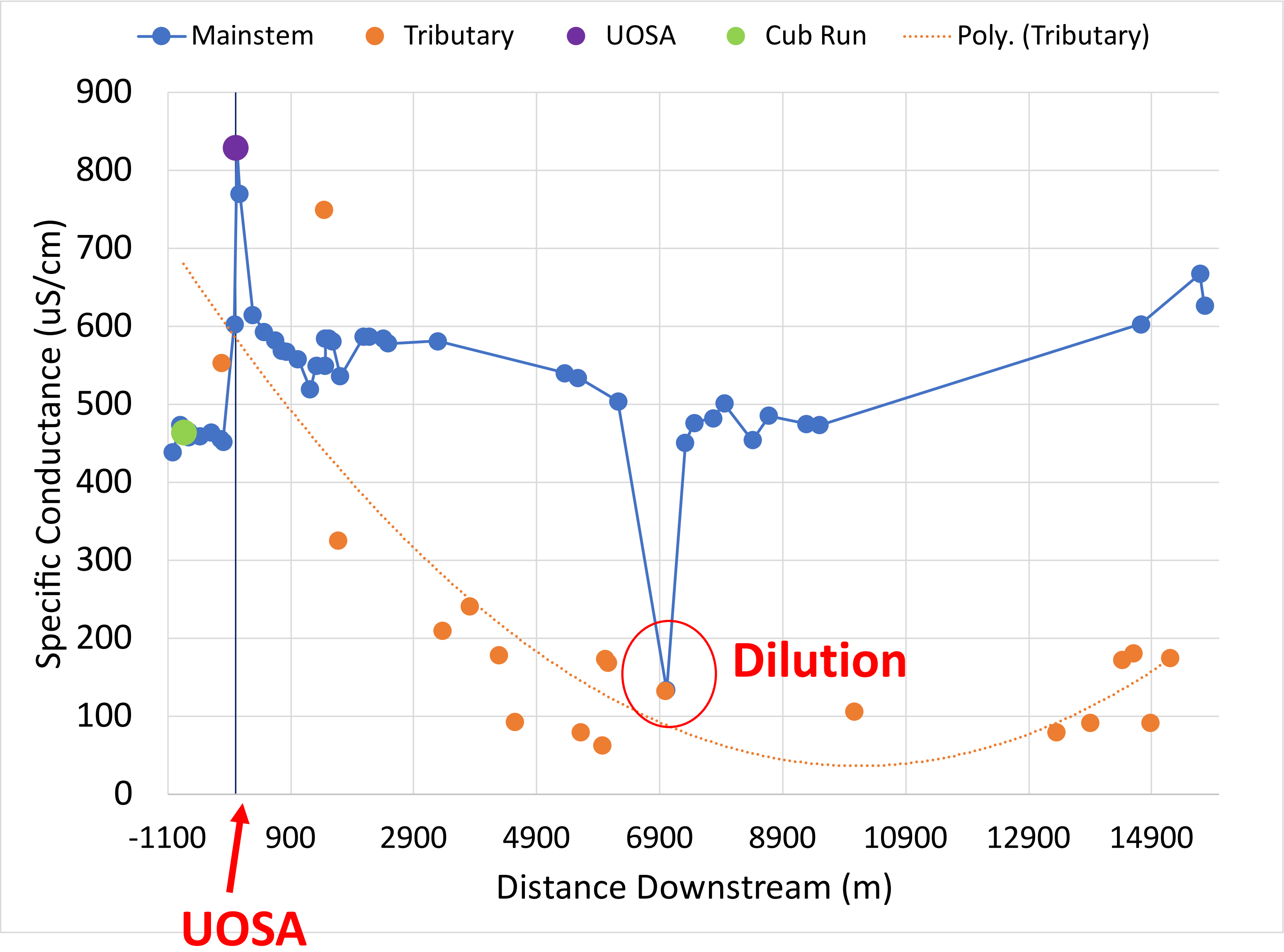
Specific Conductance Attenuation: Sept.



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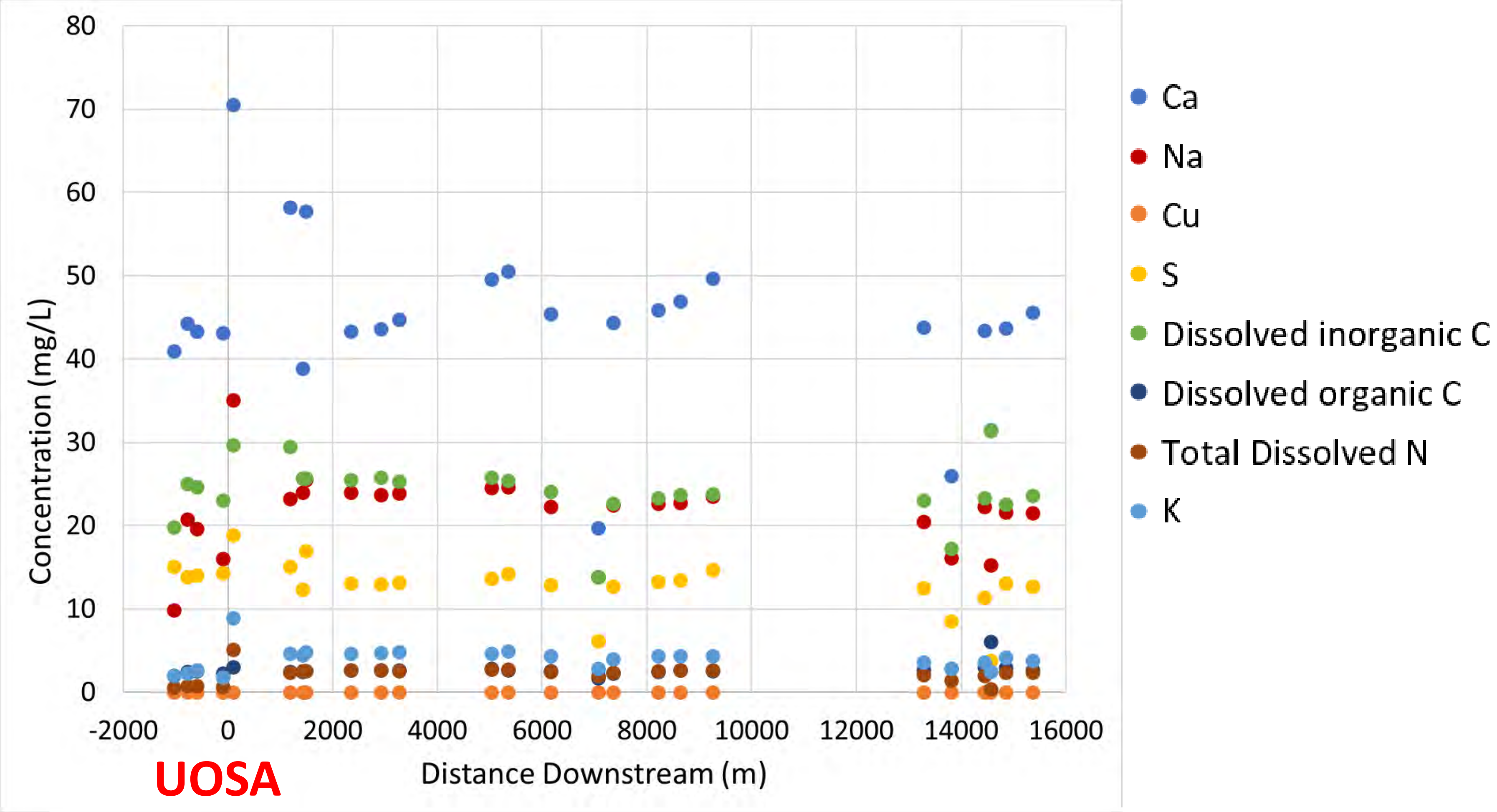
Next Steps: Chemical Cocktails

- Use multivariate statistics to compare winter and summer ion, metal, nutrient, and organic matter data.



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Take-Aways:

- 1. Attenuation of specific conductance in winter and summer (ion, nutrients, and organic matter coming soon!)
- 2. Attenuation of ions, specific conductance, and nutrients in the winter
- How are chemical cocktails retained, released, and transformed longitudinally in Bull Run?

UMD and VT Sampling Team – Thank you!

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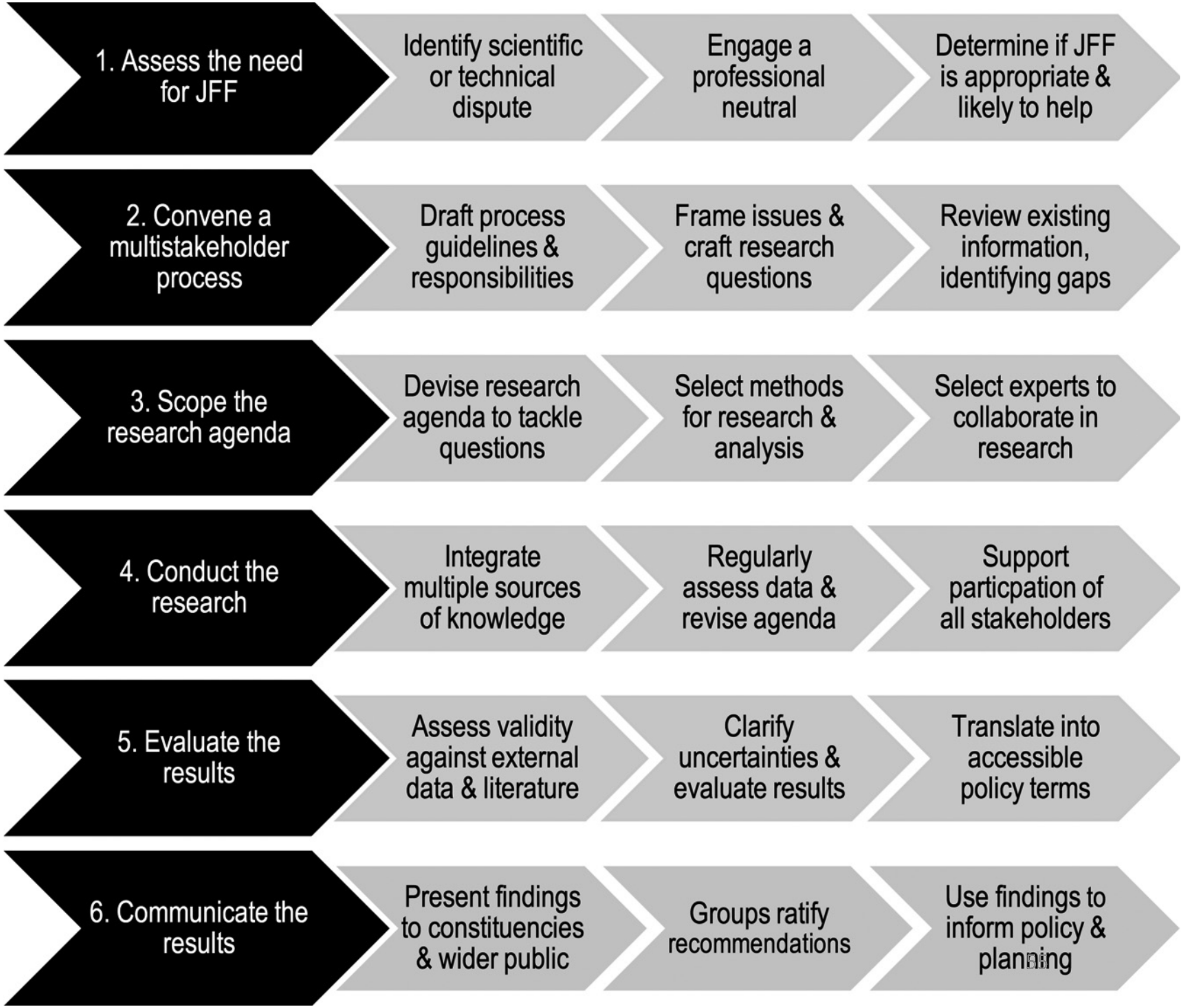
INFORMATION NEEDS

Todd Schenk and Meg Rippy, Virginia Tech

Joint Fact-Finding

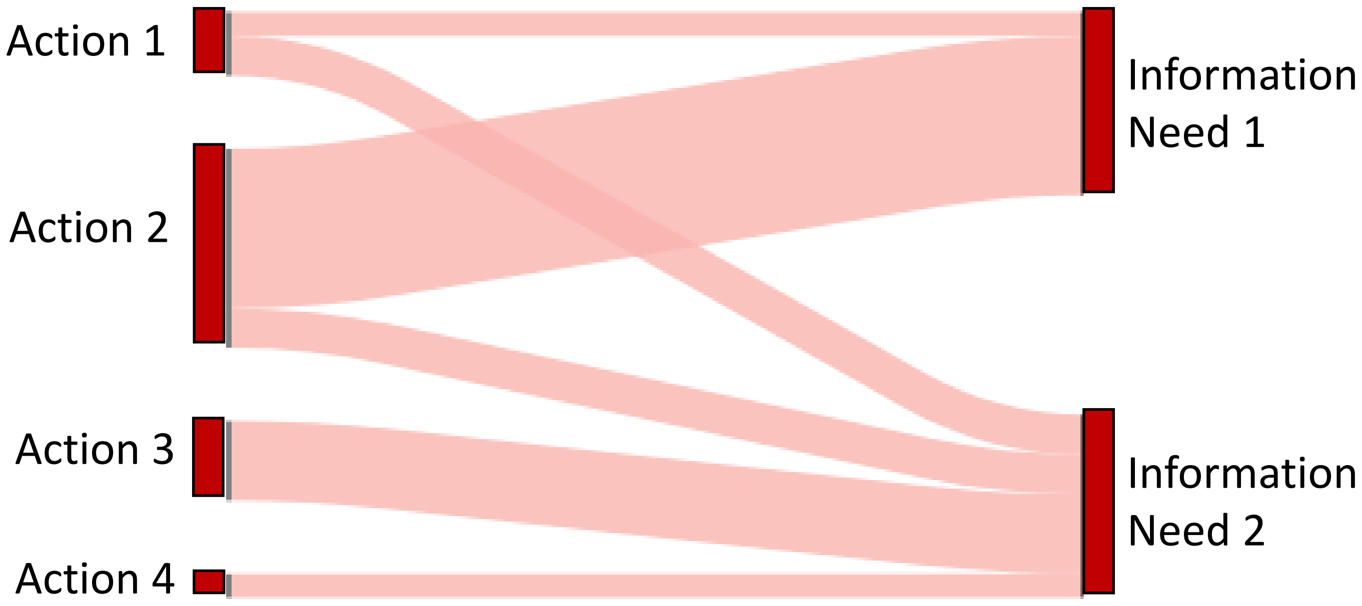


Source: Schenk, T. and M. Matsuura (2017). Introduction: The theory and practice of joint fact-finding. Joint Fact-Finding in Urban Planning and Environmental Disputes (Matsuura and Schenk, eds.) London and New York: Routledge. P. 5.

Where to Begin?

Start our discussion of information needs with one of the first products to come out of the FCM interviews conducted this summer, which is a simple mapping of management actions that you told us may need be taken to address freshwater salinization in the Occoquan to the information needs you felt were most necessary to guide those actions

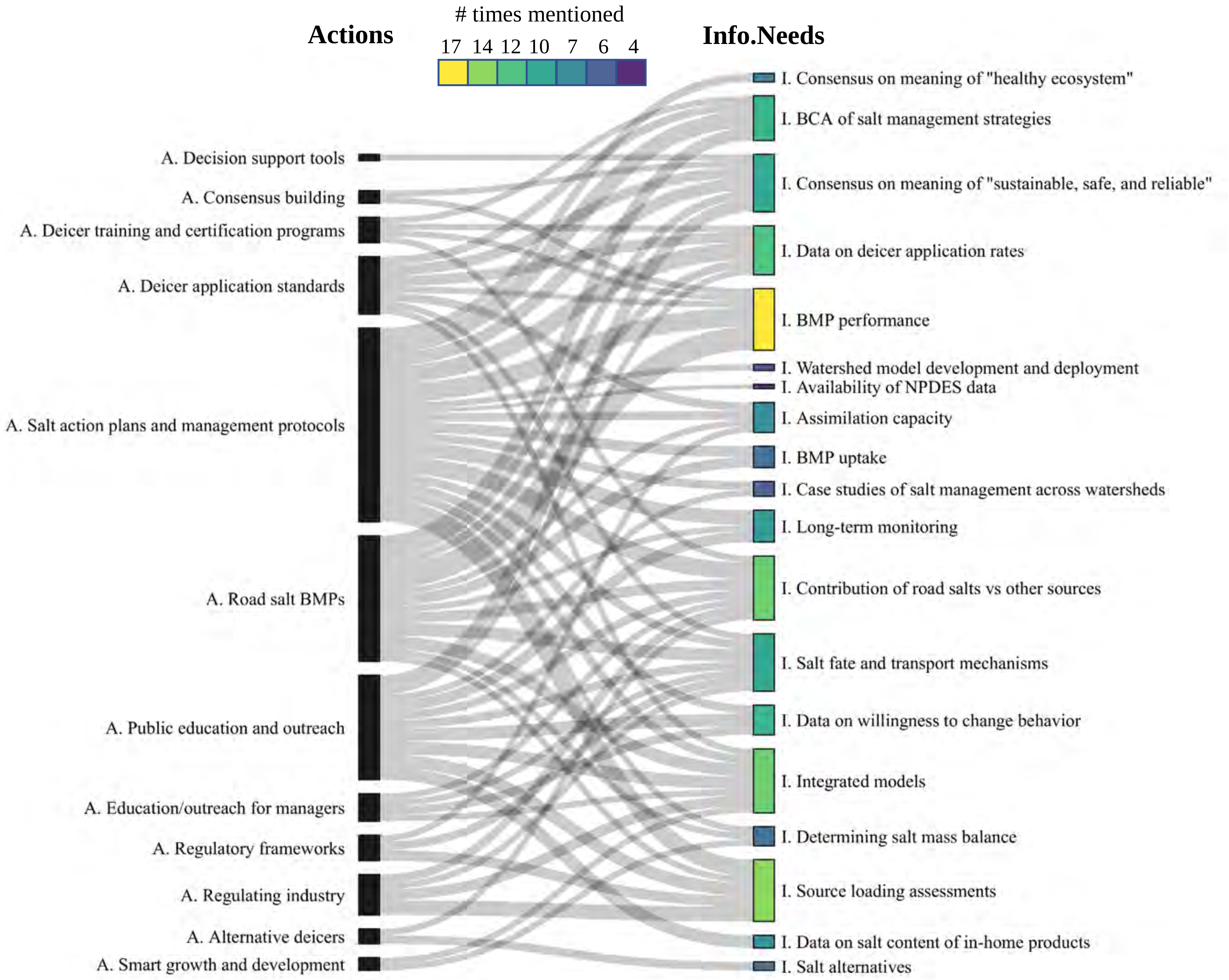
Visualize relationships between actions and information needs using a Sankey Diagram



Sankey diagrams are simply a way of illustrating connections between concepts

The number of times an action is paired with a given information need is represented by the weight of the connection between them

Actions that have many connections to information needs (or visa versa) have larger base nodes *(colored rectangles)*



ECOS Sankey Diagram

Only common information need – action pairs are shown in this diagram

4 or more people (~10% of respondents) needed to mention a connection between an information need and an action for it to be reported here

Node size reflects the number of times an action is connected to one or more information needs (or visa versa)

Information needs colorscale represents the popularity of each need *(the total number of people that identified it as important irrespective of its association with any given action)*

To take a closer look at the Sankey diagram, I'm going to bring up an interactive version

file:///C:/Users/megri/Documents/Sankey_again.html

Now we're going to take a moment to think about how some of the information needs illustrated in the Sankey map back to the kinds of projects that are presently (or could be) undertaken by the biophysical team

FREQUENTLY MENTIONED
(10-17 people)

- Best management practice performance
- Source loading assessments
- Contribution of road salts vs other sources
- Integrated models
- Data on deicer application rates
- Data on willingness to change behavior
- Benefit-Cost Analysis of salt management strategies
- Consensus on meaning of "sustainable, safe, and reliable"
- Salt fate and transport mechanisms

LESS FREQUENTLY MENTIONED
(4-9 people)

- Long-term monitoring
- Data on salt content of in-home products
- Assimilation capacity
- Consensus on meaning of "health ecosystem"
- Best management practice uptake
- Determining salt mass balance
- Long-term trends
- Salt alternatives
- Triple bottom line investigations
- Case studies of salt management across watersheds
- Availability of NPDES data
- Watershed model development and deployment

RARELY MENTIONED
(1-2 people)

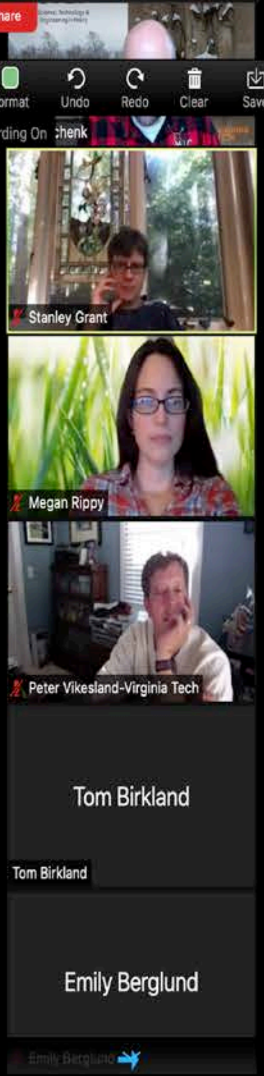
- Climate change impacts
- Life cycle assessment
- Recent vs legacy salt
- Salt residence times
- Short-term dynamics
- Tradeoffs across ions
- Vulcan quarry assessment
- Amount of imperviousness created per increment of growth
- Near-real-time monitoring (conductivity)
- Data on current behaviors and how they are expected to change
- Data on how behaviors respond to education and outreach
- Accountability and verification of certification programs
- Projections of salinization under business as usual
- Benefit-Cost Analysis of information needs
- Consensus meaning of "Aquatic health"
- Decision support tools for winter salt management
- Defining what a certification program is for Virginia
- Impact of IPR on salt ions
- Modeling salt from sewer networks
- Weather nowcasts/ forecasts
- Monitoring of salts from wastewater (for example, TDS)
- Understanding your audience and tailoring information
- Information on cost savings associated with curbing salt use
- List of actionable things people can do to adjust their salt use
- Near-real-time monitoring (ions and conductivity)

Research team categorization

The research team categorized information needs into the following groups:

- **Addressing (currently)**
- **Phase II (planned)**
- **Not planned but possible**
- **Out-of-scope (for project)**

	Addressing	Not necessary and/or possible	Potential future	Out-of-scope
BMP performance				
Source loading assessments				
Contribution of road salts vs other sources				
Integrated models				
Data on deicer application rates				
Data on willingness to change behavior				
BCA of salt management strategies				
Consensus on meaning of "sustainable, safe, and reliable"				
Salt fate and transport mechanisms				



	Addressing	Not necessary and/or possible	Potential future	Out-of-scope
Consensus on meaning of "healthy ecosystem"				
Watershed model development and deployment				
Assimilation capacity				
BMP uptake				
Case studies of salt mgmt. across watersheds				
Long-term monitoring				
Determining salt mass balance				
Data on salt content of in-home products				
Salt alternatives				
Availability of NPDES data				

	Addressing	Not necessary/ possible	Potential future	Out-of-scope
Climate change impacts	♥ ✓ ✓	✓		
Recent vs legacy salt	♥ ✓ ✓			
Salt residence times	♥ ✓ ✓			
Tradeoffs across ions	♥ ✓ ✓			
Near-real-time monitoring (conductivity)	♥ ✓ ✓			
Impact of IPR on salt ions	♥ ✓ ✓			
Monitoring of salts from wastewater (for example, TDS)	♥ ✓ ✓			
List of actionable things people can do to adjust their salt use	♥ ✓✓ ✓			
Modeling salt from sewer networks	✓ ✓ ✓ ♥			
Near-real-time monitoring (ions and conductivity)	✓ ♥ ✓ ✓			

Addressing (currently)

- Source loading assessments
- Consensus on meaning of "sustainable, safe, and reliable”
- Salt fate and transport mechanisms
- Long-term monitoring
- Data on salt content of in-home products
- Determining salt mass balance
- Watershed model development and deployment
- Assimilation capacity

Integrated models

Phase II (planned)

- BMP performance
- Contribution of road salts vs other sources
- Data on deicer application rates
- BMP uptake

Not planned but possible

- Data on willingness to change behavior
- BCA of salt management strategies
- Consensus on meaning of “health ecosystem”
- Case studies of salt management across watersheds

Out-of-scope for project

- Focus on salt alternatives
- Availability of NPDES data

Addressing (currently)

- Focus on recent vs legacy salt
- Focus on salt residence times
- Focus on tradeoffs across ions
- Near-real-time monitoring (conductivity)
- Focus on impact of IPR on salt ions
- Focus on modeling salt from sewer networks
- Focus on monitoring of salts from wastewater (for example, TDS)
- List of actionable things people can do to adjust their salt use
- Near-real-time monitoring (ions and conductivity)
- Focus on climate change impacts

Phase II (planned)

Not planned but possible

Out-of-scope for project

Discussion Groups: Information Needs

Goals: **Clarify what information needs are, and their categorization**

Discussion questions (going around small group):

1. Which information need is most important to you?

2. What does it mean to you? Are there specific information products associated with this need that you would want to emphasize?

3. Do you agree with its categorization? If not, would you change the project scope?

Addressing (currently)

Source loading assessments

Consensus on meaning of "sustainable, safe, and reliable"

Salt fate and transport mechanisms

Long-term monitoring

Data on salt content of in-home products

Determining salt mass balance

Watershed model development and deployment

Assimilation capacity

Integrated models

Phase II (planned)

BMP performance

Contribution of road salts vs other sources

Data on deicer application rates

BMP uptake

1. **Which information need is most important to you?**
2. **What does it mean to you? Are there specific information products associated with this need that you would want to emphasize?**
3. **Do you agree with its categorization? If not, would you change the project scope?**

Not planned but possible

Data on willingness to change behavior

BCA of salt management strategies

Consensus on meaning of "health ecosystem"

Case studies of salt management across watersheds

Out-of-scope for project

Focus on salt alternatives

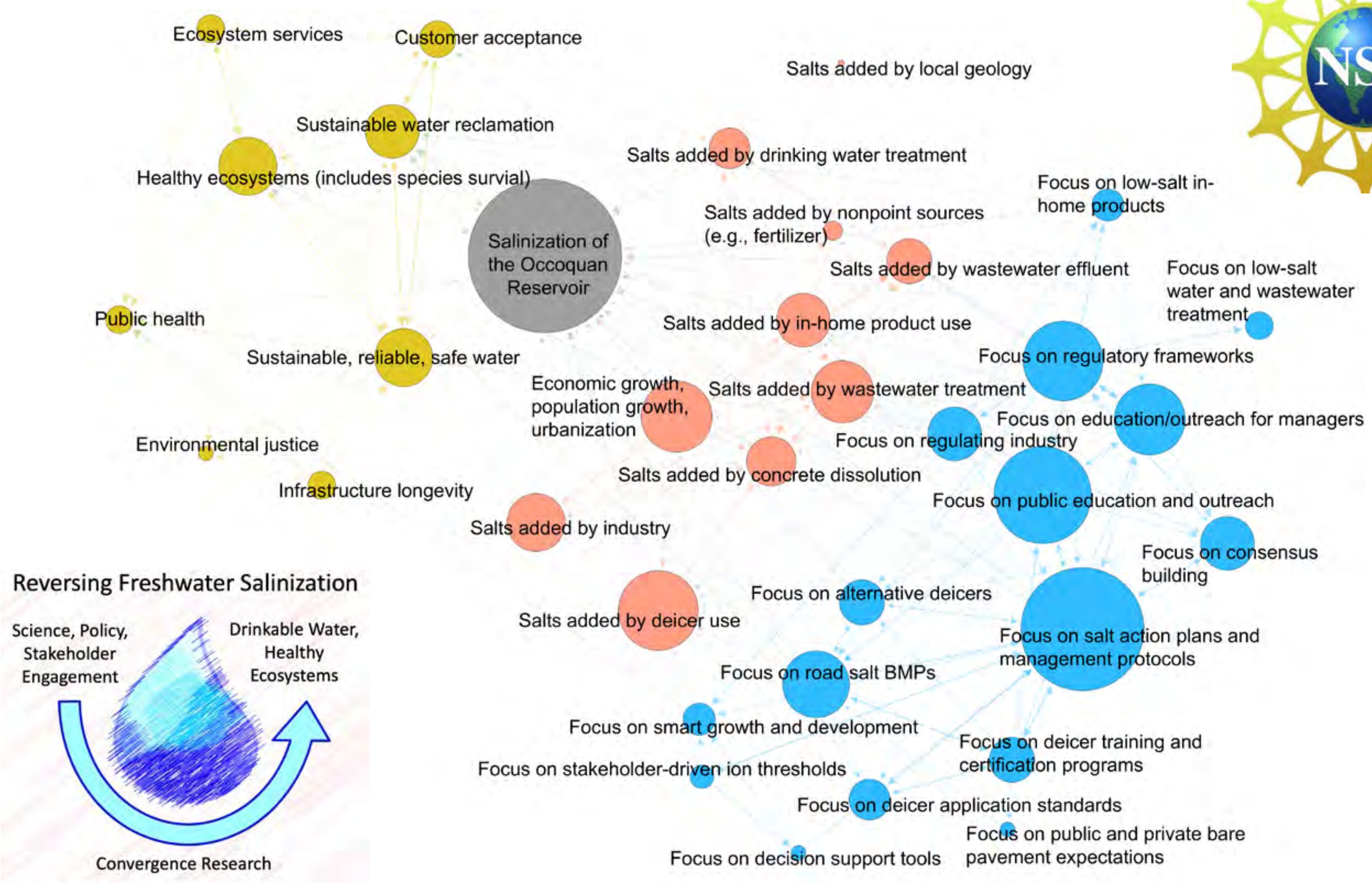
Availability of NPDES data

FUZZY COGNITIVE MAP RESULTS

Meg Rippy, Virginia Tech

Preliminary FCM Results

- Mental models of freshwater salinization in the Occoquan Reservoir-



Over the summer we worked with most of you (**thank you**) to create FCMs of freshwater salinization in the Occoquan

FCM generation focused on 4 types of concepts:

1) Causes of salinization,
2) Consequences of salinization
3) Actions that could be taken to mitigate salinization,
4) The information needed to make taking actions possible *(addressed earlier today – not the focus of this talk)*

During FCM construction you were presented with tables for each concept type and asked to select concepts you felt were most important to you (max of 7 per type)

There was freedom to create and add your own new concepts if you felt something was missing from the concept table

Across the 39 members of ECOS, 35 surveys were completed

Today's Goal: Tell you what we've done with all of your models

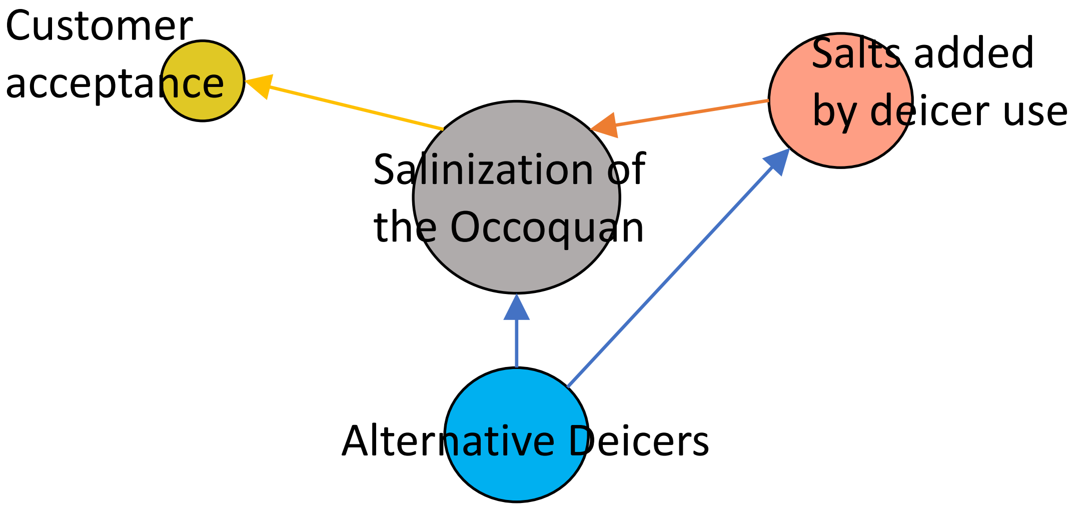
1) Aggregated results of everyone's FCMs
   (all concepts kept, no simplifications)

2) Illustrate how we've chosen combine or drop concepts to facilitate interpretation (reduced set of concepts common across individuals)

3) Work with this reduced set of concepts to identify groups of individuals with different mental models of freshwater salinization within ECOS

4) Characterize the mental models of each group to better understand the different perspectives we have right now about freshwater salinization in the Occoquan

Recap: Interpreting an FCM

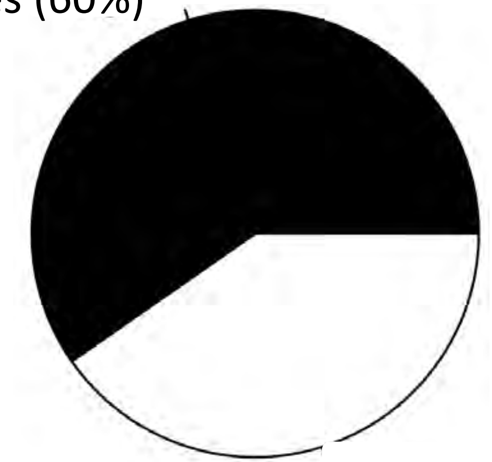


For simplicity, the FCMs I'll show today de-emphasize the magnitude of relationships between concepts. That information is still there. We're just focusing more on the concepts themselves at this stage

- Arrow direction still indicates which concepts impact other concepts
- Node color indicates concept type (Causes, Consequences, Actions)
- Node size indicates the number of direct connections a concept has to other concepts *(a measure of relative importance because the more connections a concept has, the higher its impact will be in model simulations)*

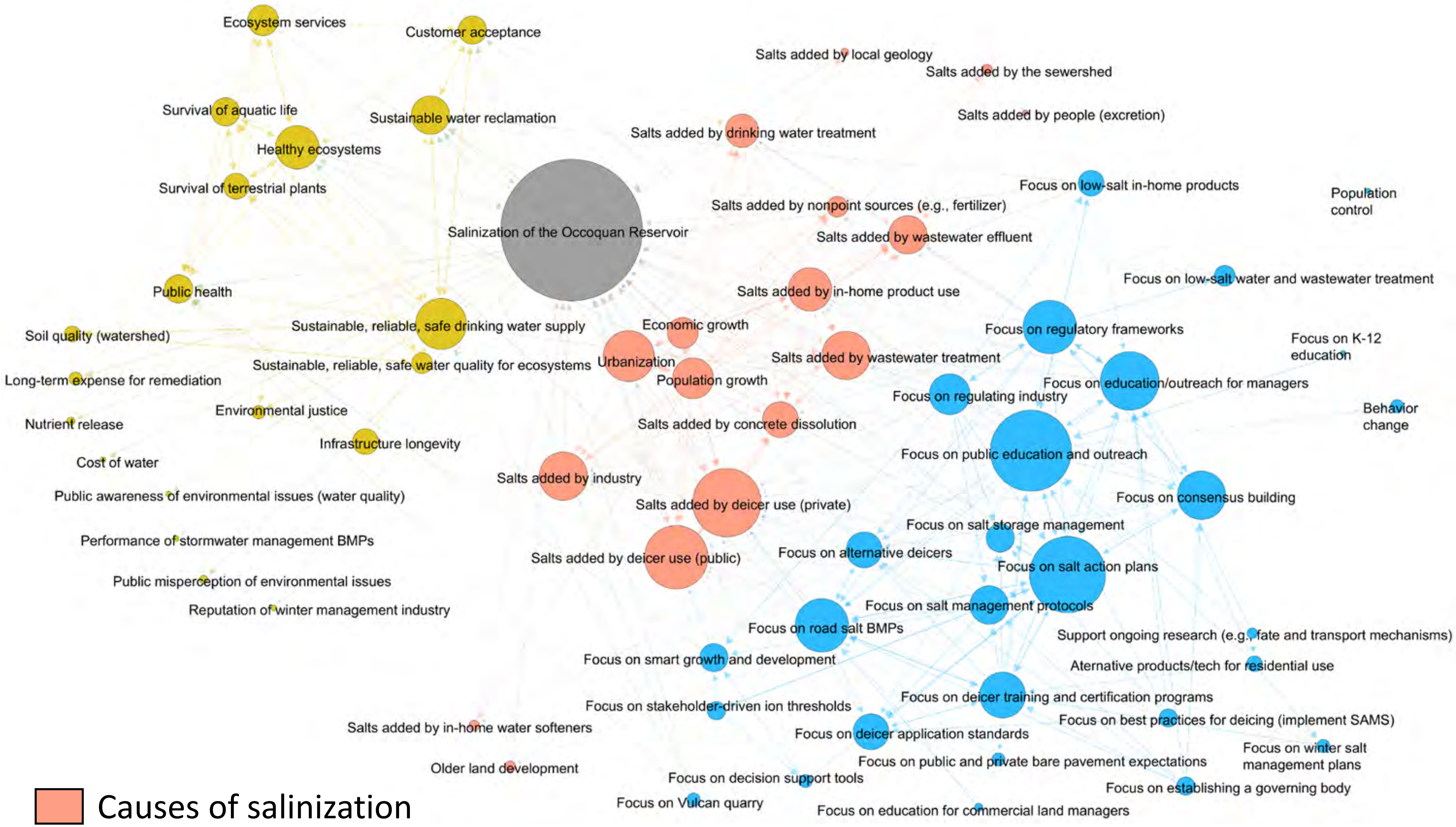
Start by looking at the aggregated results of everyone's FCMs (all concepts kept, no simplifications ,model)

The un-simplified FCM contains 63 unique concepts
- 1 given (Salinization of the Occoquan)
- 16 causes of salinization
- 18 consequences of salinization
- 28 actions that might be taken to reduce salinization



Many of the concepts selected came directly from the concept tables provided, which arose out of ECOS1, but a substantive fraction represent entirely new concepts

The un-simplified model is extremely complex!



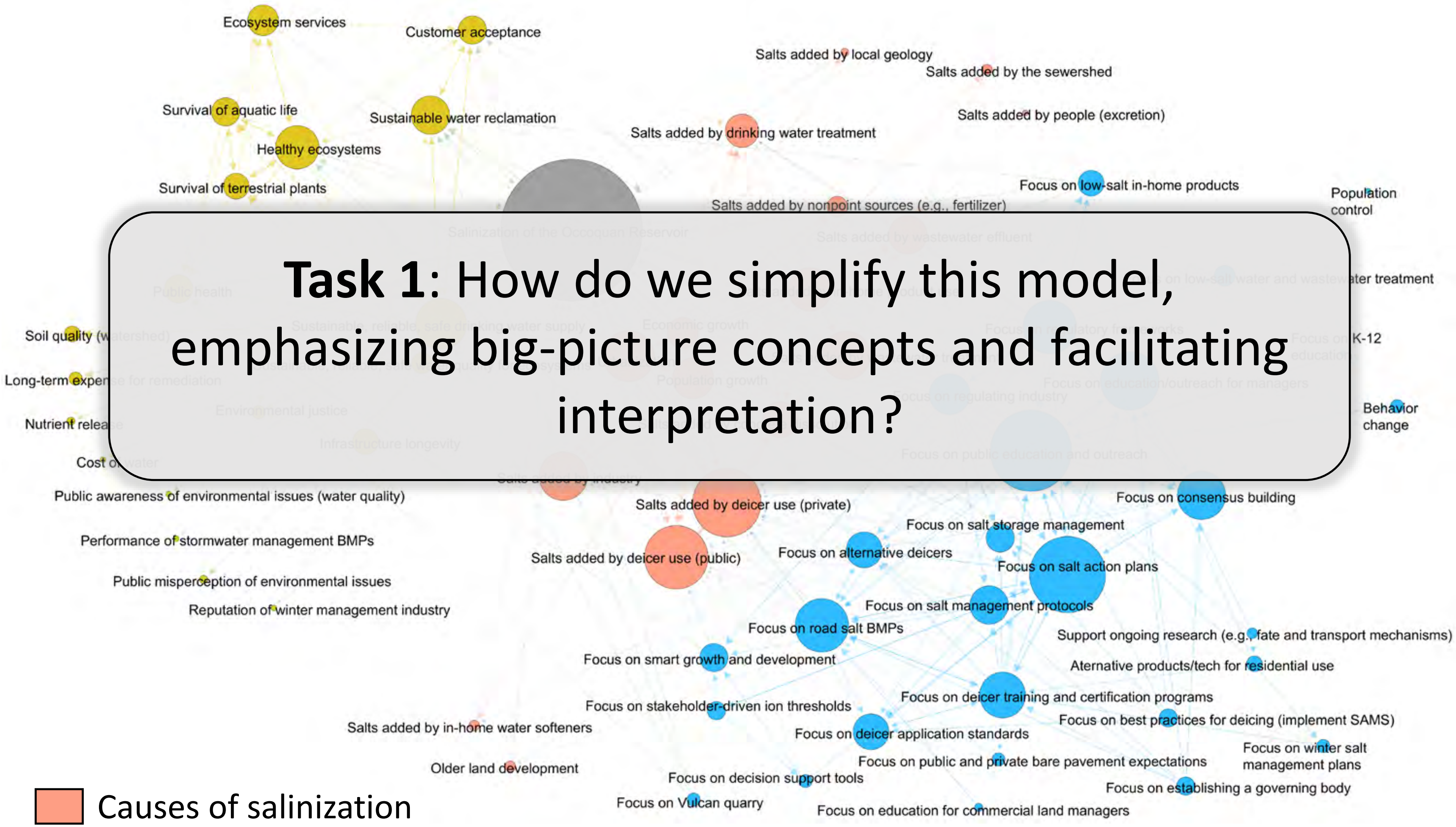
Causes of salinization

Consequences of salinization

Actions

***Node Size:** Relative importance*

The un-simplified model is extremely complex!



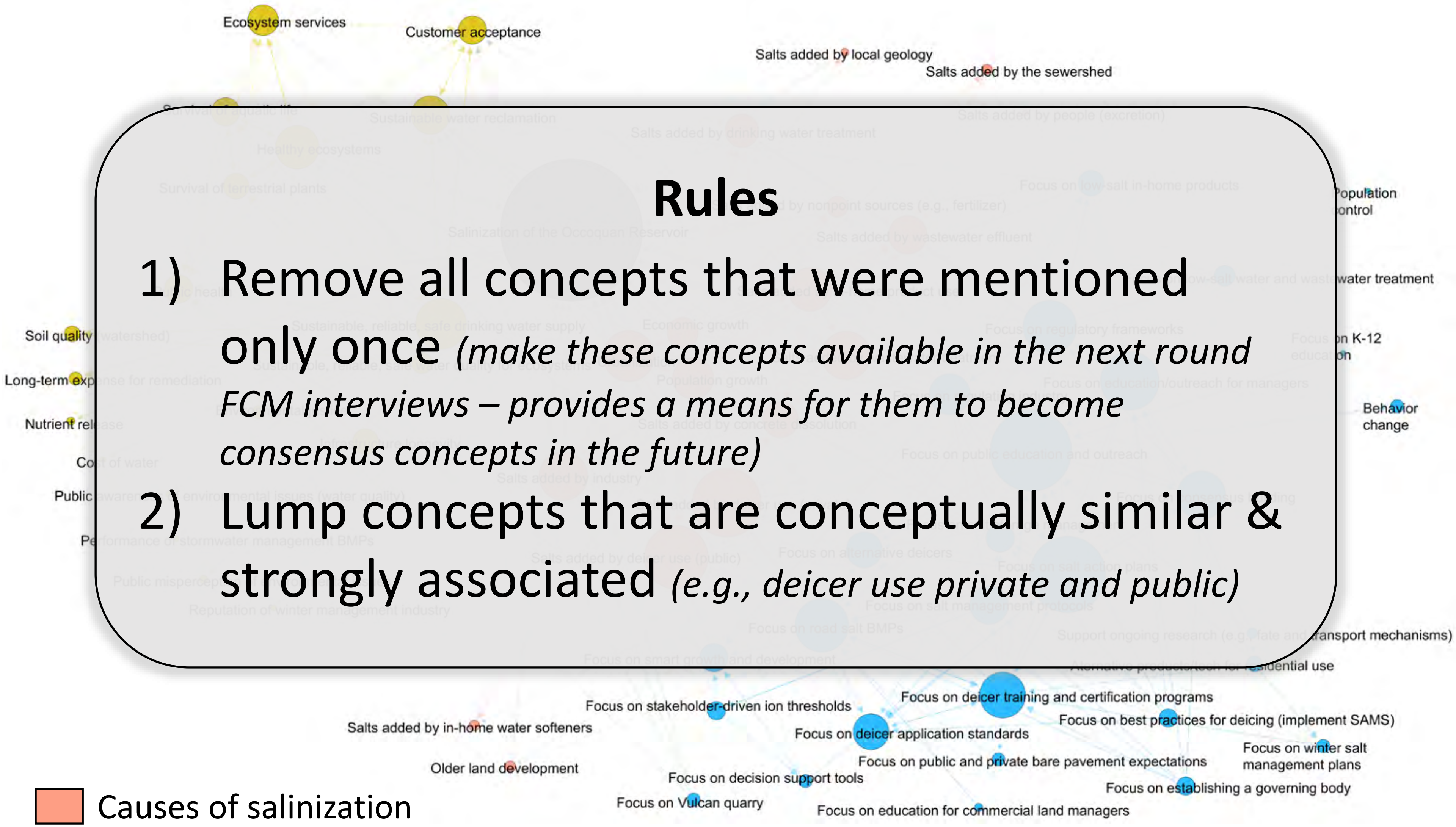
Task 1: How do we simplify this model, emphasizing big-picture concepts and facilitating interpretation?

Causes of salinization

Consequences of salinization

Actions

The un-simplified model is extremely complex!



Rules

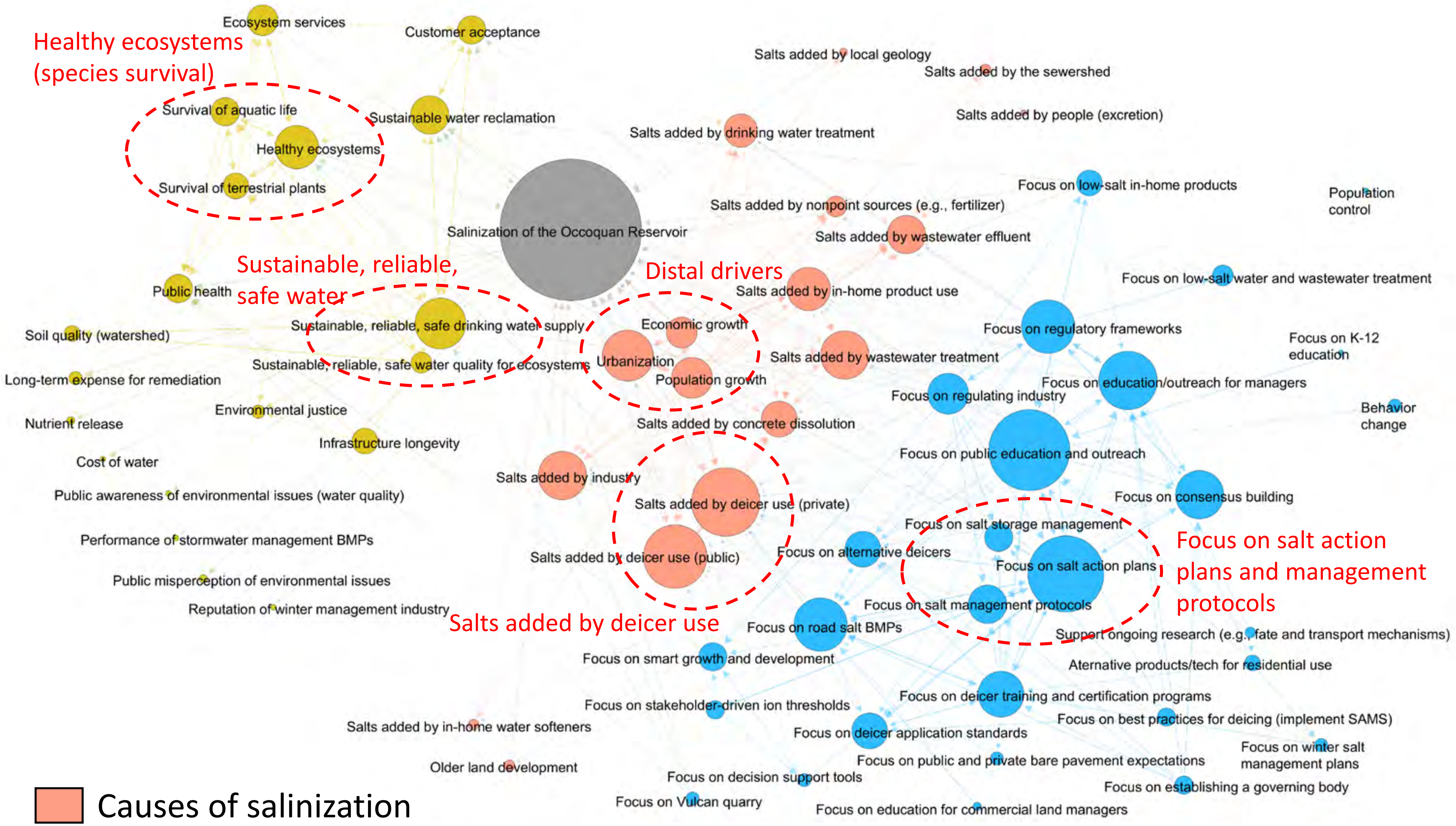
1) Remove all concepts that were mentioned only once *(make these concepts available in the next round FCM interviews – provides a means for them to become consensus concepts in the future)*
2) Lump concepts that are conceptually similar & strongly associated *(e.g., deicer use private and public)*

Causes of salinization

Consequences of salinization

Actions

Concepts to be lumped…..

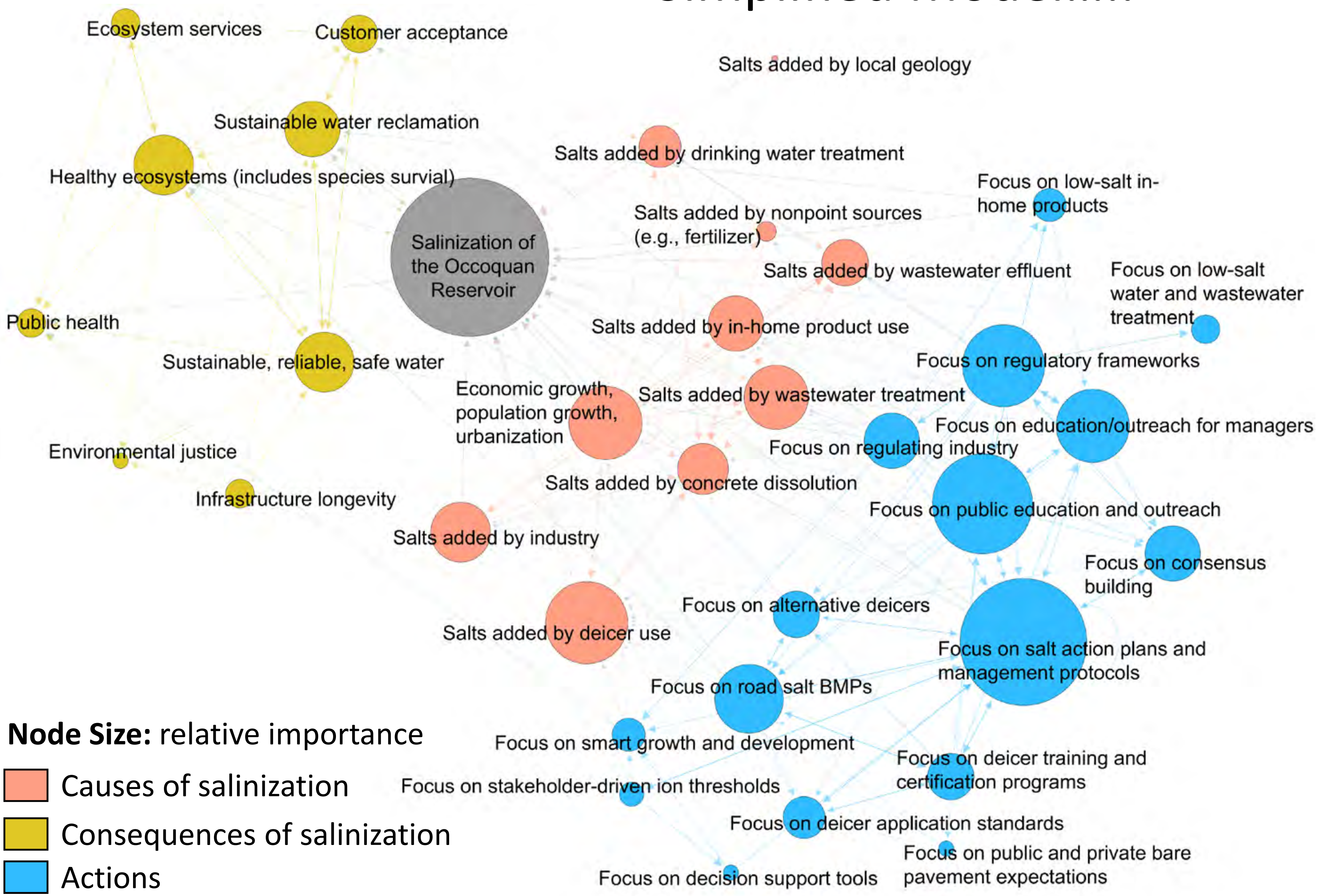


Causes of salinization

Consequences of salinization

Actions

Simplified Model…..



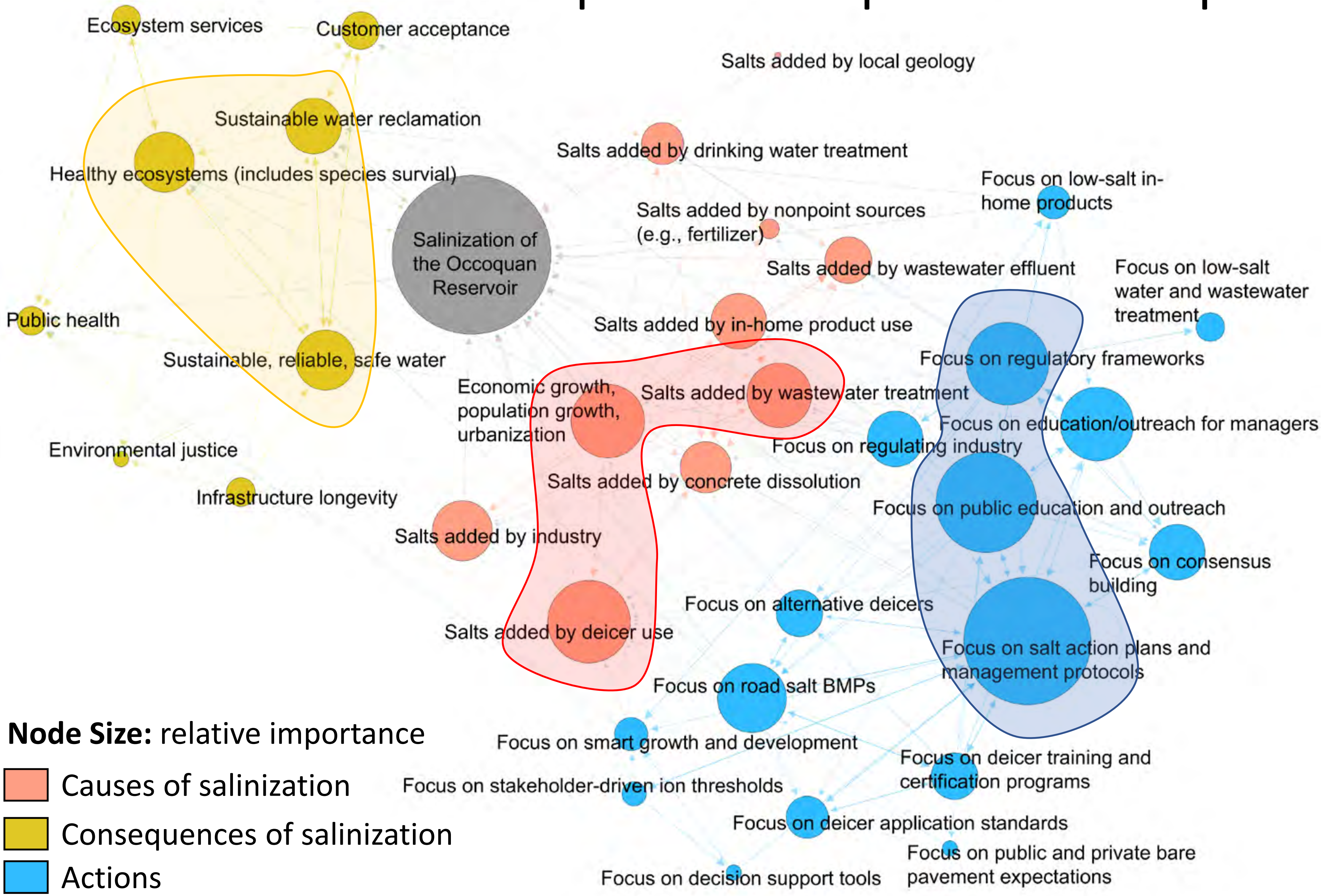
Node Size: relative importance

Causes of salinization

Consequences of salinization

Actions

Top 3 most important concepts



Node Size: relative importance

Causes of salinization

Consequences of salinization

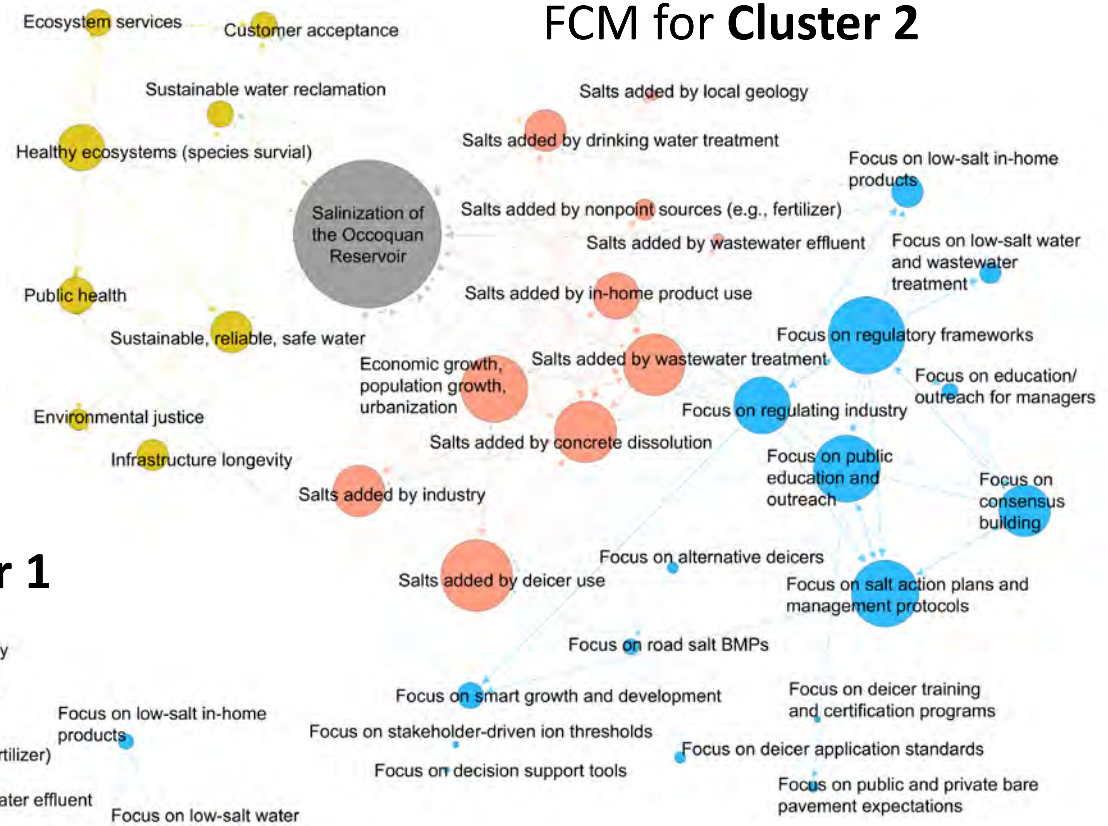
Actions

Our simplified model focuses on collective perspectives across all ECOS members (lumped model)

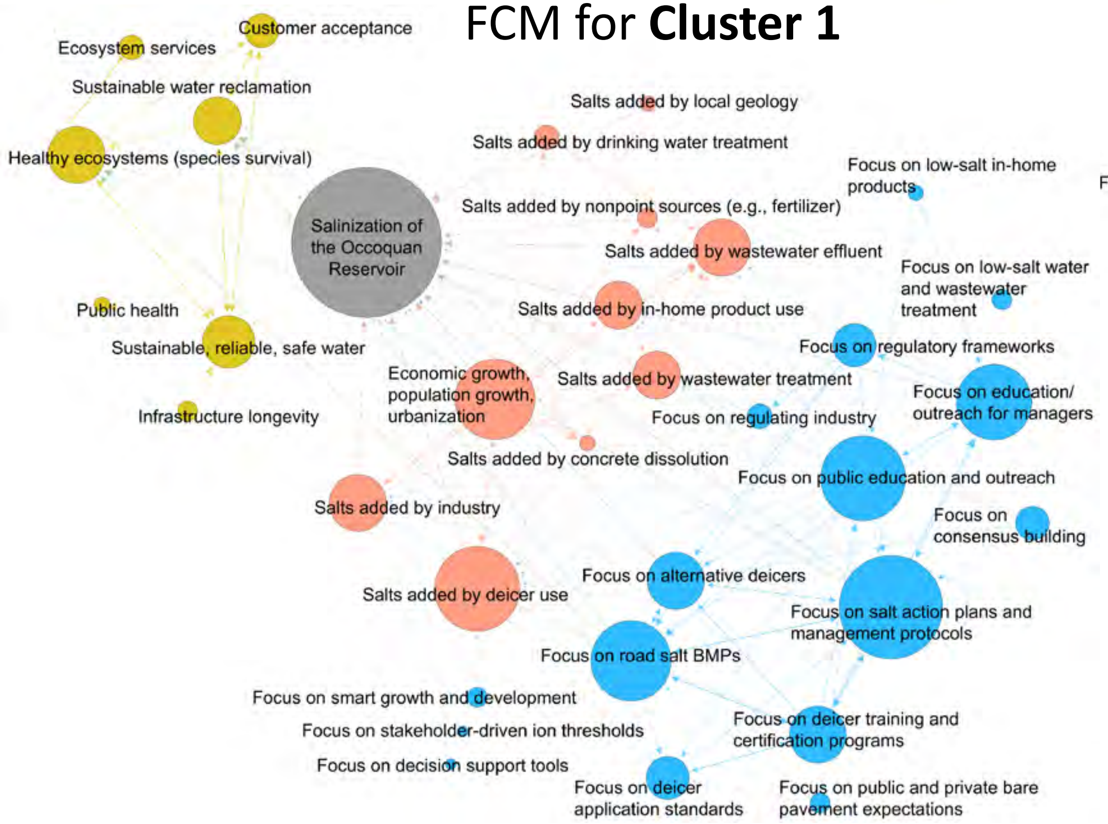
We can unpack this a bit using ordination techniques and cluster analysis to determine if there are groups of stakeholders within ECOS whose perspectives about freshwater salinization significantly differ

This analysis identified at least 2 significant clusters of stakeholder FCMs *(two unique perspectives)*

FCM for **Cluster 2**

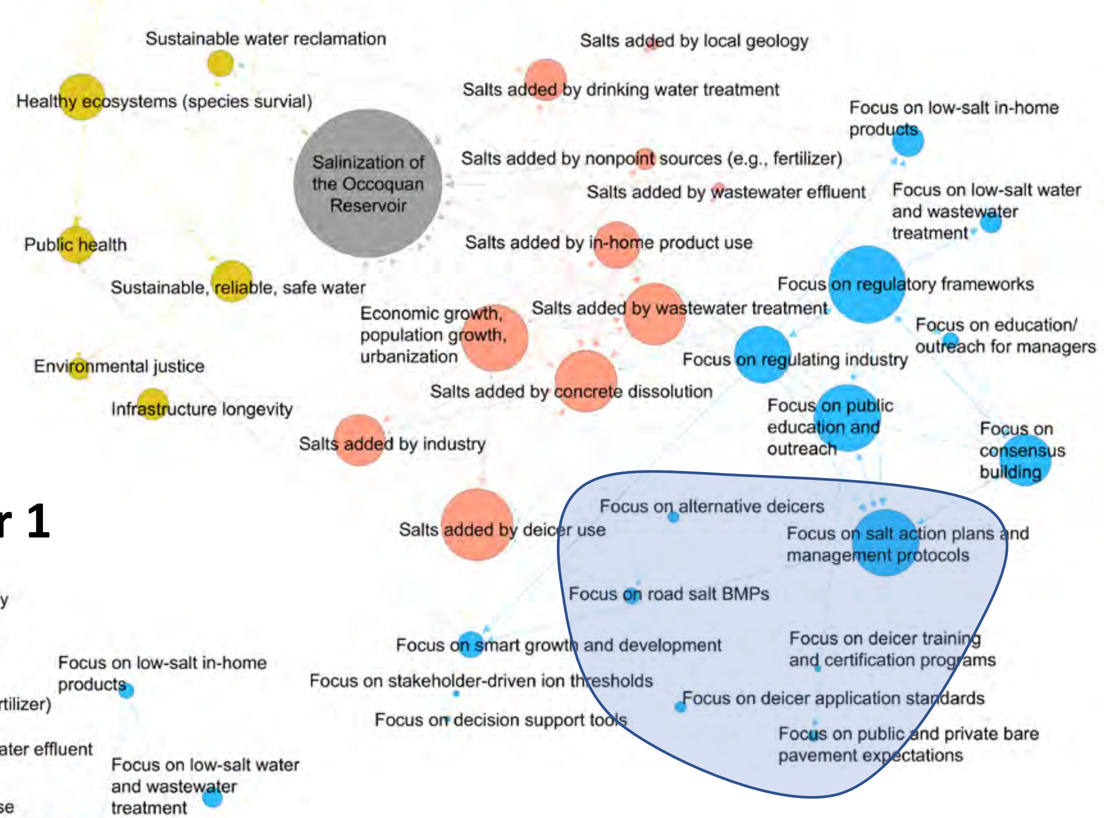


FCM for **Cluster 1**



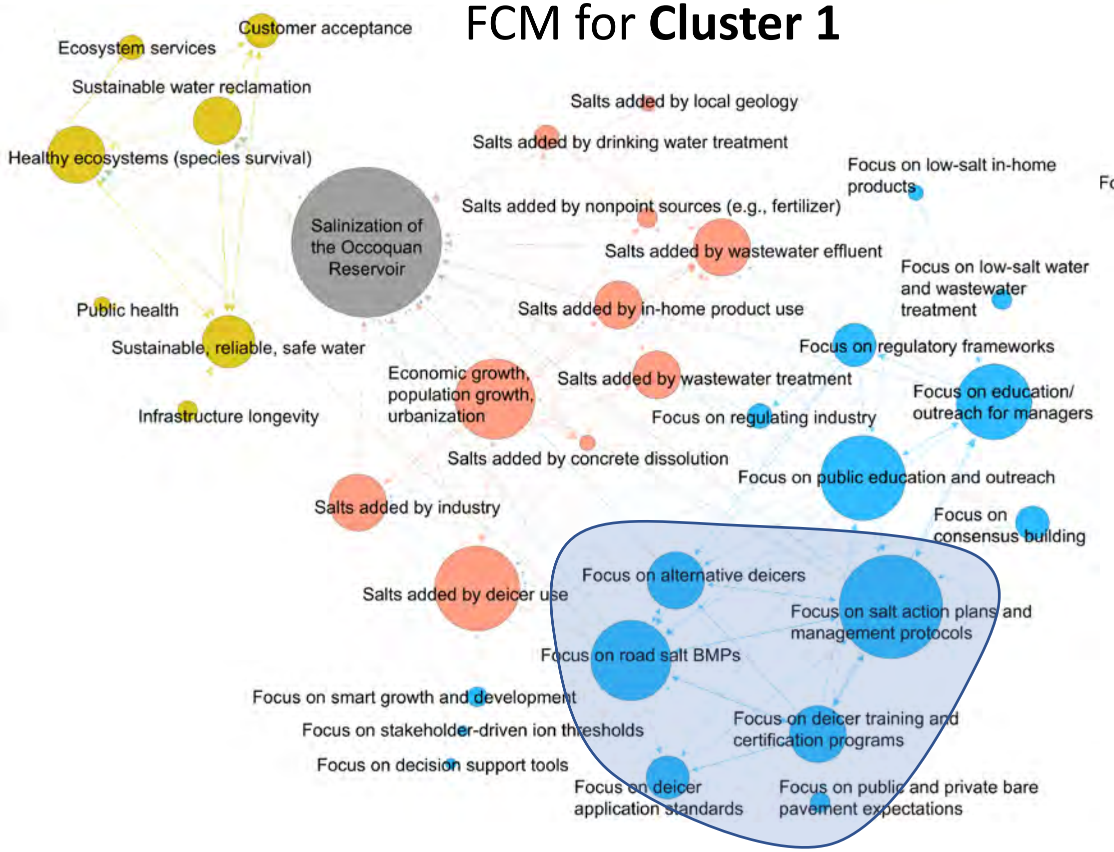
Aggregated FCMs for individuals in each of these clusters

FCM for **Cluster 2**



Road-salt actions have higher relative importance

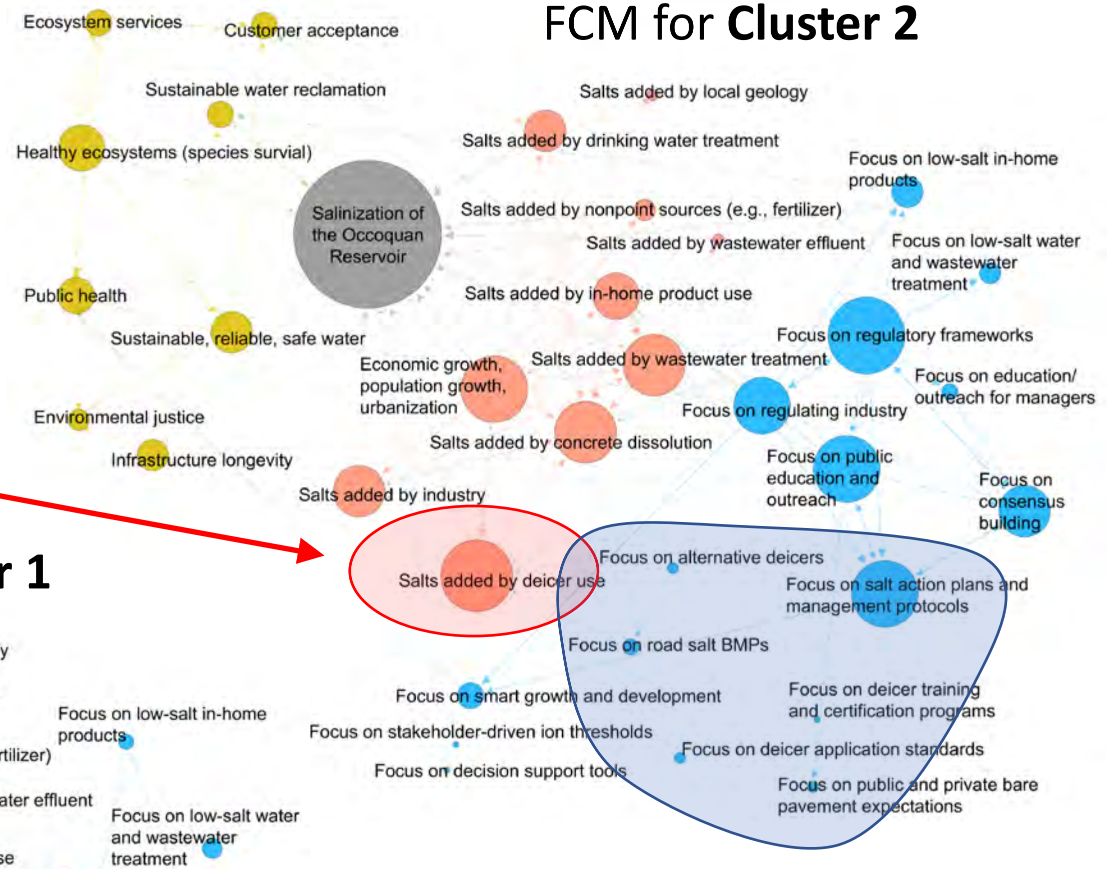
FCM for **Cluster 1**



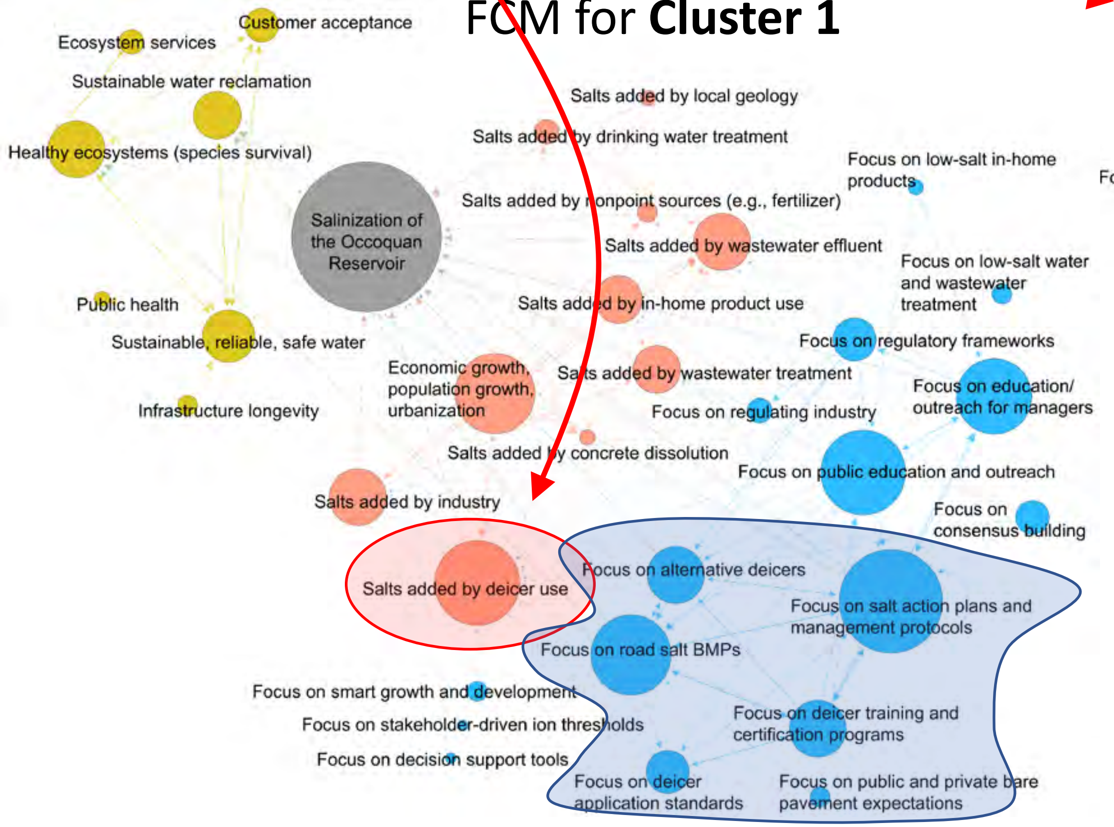
Road-salt actions are have lower relative importance

This is not to say that deicers weren't perceived as important salt sources in both groups

FCM for **Cluster 2**



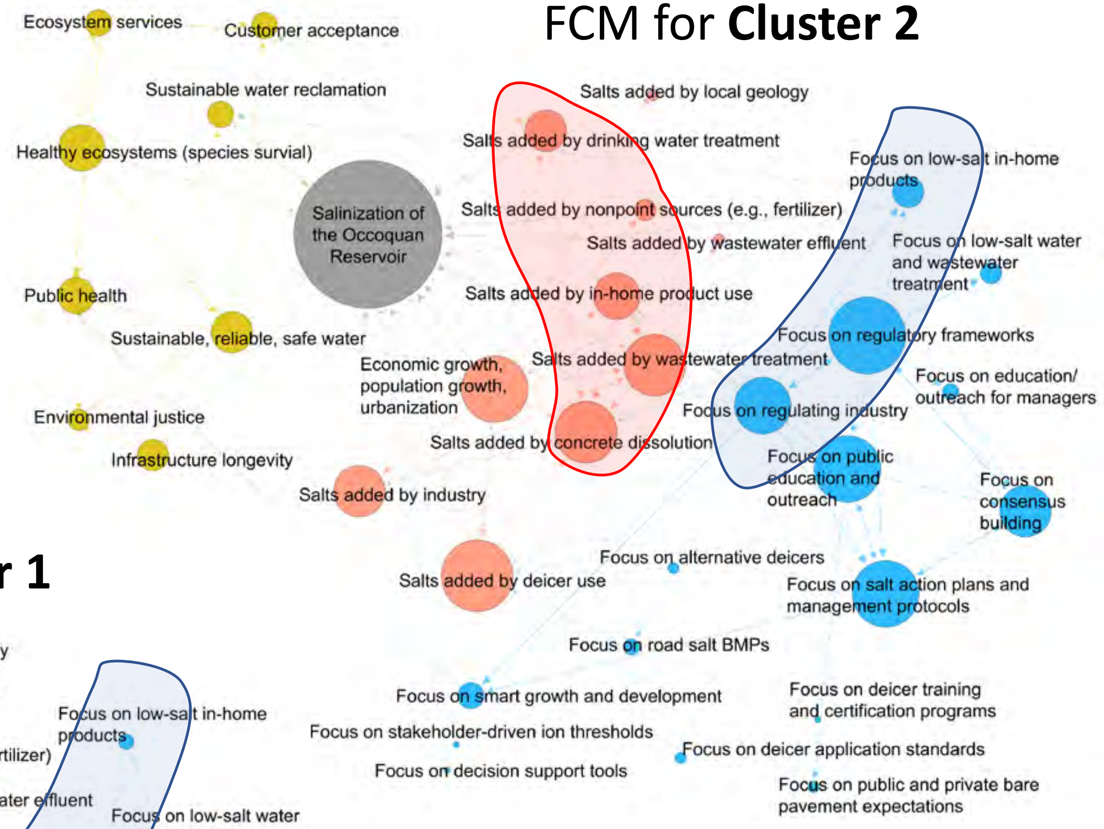
FCM for **Cluster 1**



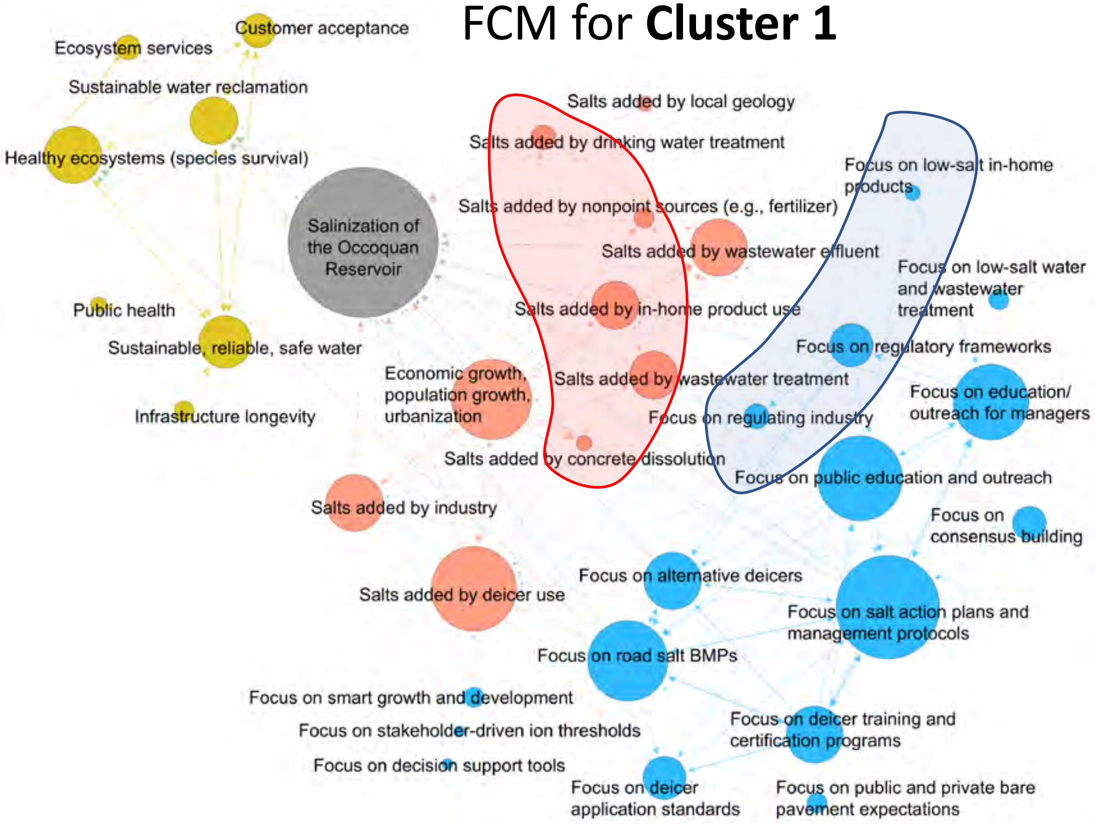
Management actions preferred by individuals in cluster 2 focused less on road salt than those in cluster 1

Emphasis on additional salt sources in Cluster 2: Salts from *concrete dissolution and water/wastewater treatment* all have higher relative importance in cluster 2

FCM for **Cluster 2**



FCM for **Cluster 1**



Actions taken to mitigate deicers may be less central in cluster 2 because a broader range of salt sources need to be addressed *(leads to increased emphasis on actions that are broad spectrum, like regulation or target non-deicer sources)*

Take Home Message (FCM clustering)

We have identified at least two different shared perspectives about freshwater salinization among all of you (there could be more)

These two perspectives differ in their degree of emphasis on deicers/deicer mitigation vs other salt sources and mitigation measures

- Everyone agrees that deicers are important…it's the relative importance of other sources/management actions that differs

Because the management actions favored by each group are not the same, facilitating communication across the groups is likely to be important for convergence among ECOS members (and ultimately compromise management solutions)

Recap and Address Future FCM Directions

Main Message 1: At this point we have collected 35 FCMs and identified 34 core concepts included in an aggregated mental model of freshwater salinization

Future Direction 1: To make sure we've adequately captured each of your perspectives with these core concepts we will be reaching out to you individually *(by survey or interview)* to check in and make sure you are satisfied with how your individual model was represented

Future Direction 2: We also plan to solicit feedback regarding the 30 or so new concepts generated during the interviews, with the goal of determining which concepts should be included in updated concept tables for the next wave of interviews during which everyone will have the opportunity to update their FCM

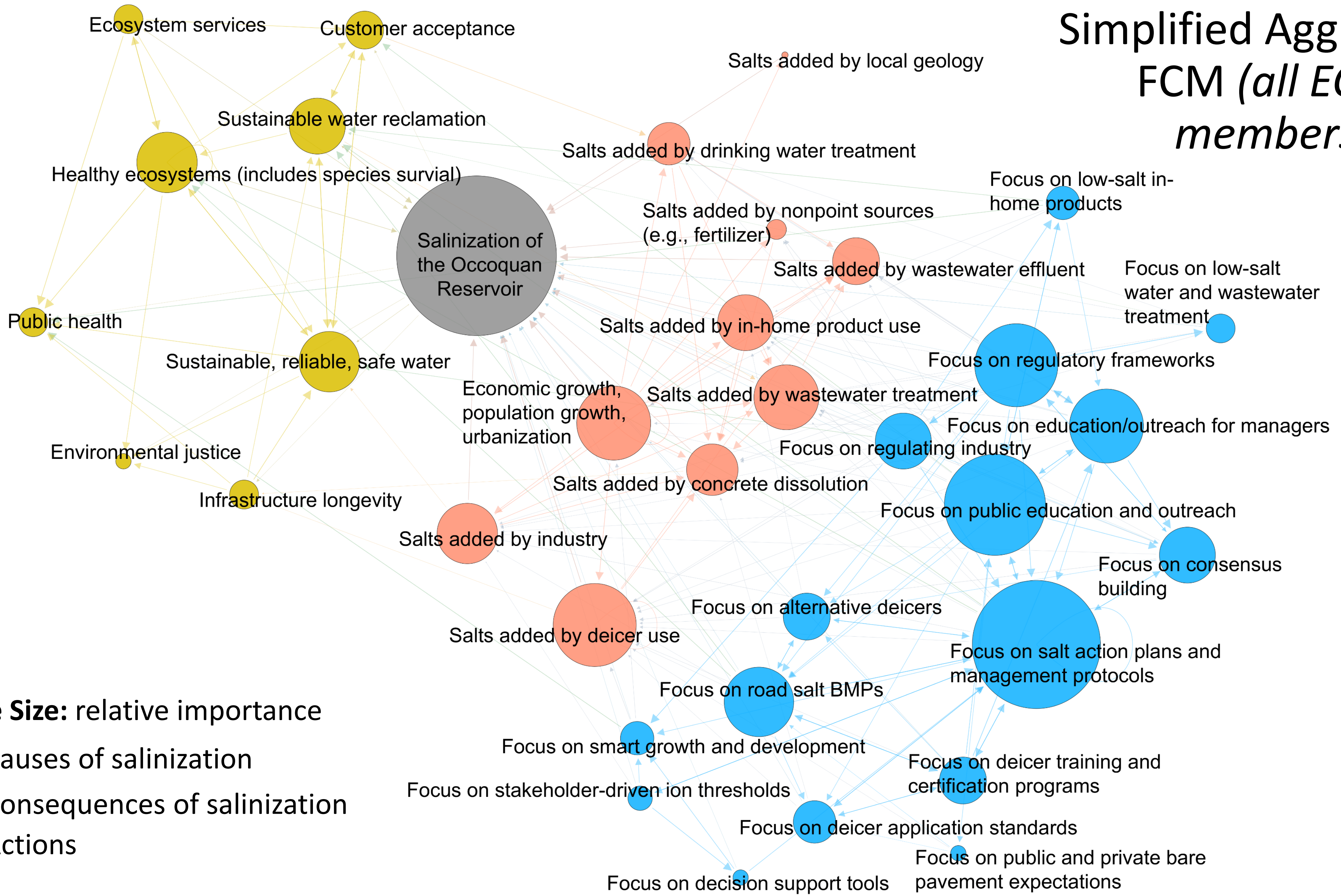
Recap and Address Future FCM Directions

Main Message 2: Our preliminary analysis of your FCMs suggests that individual mental models tend to cluster into 2 groups differentiated by their degree of emphasis on deicers/deicer mitigation vs other salt sources and mitigation measures

Future Direction 3: This is something we want your perspectives on. Does it sound right to you, or does it not resonate? To what degree do you identify with one or the other of these groups?

This is something we'll focus on a little bit more in our next breakout session

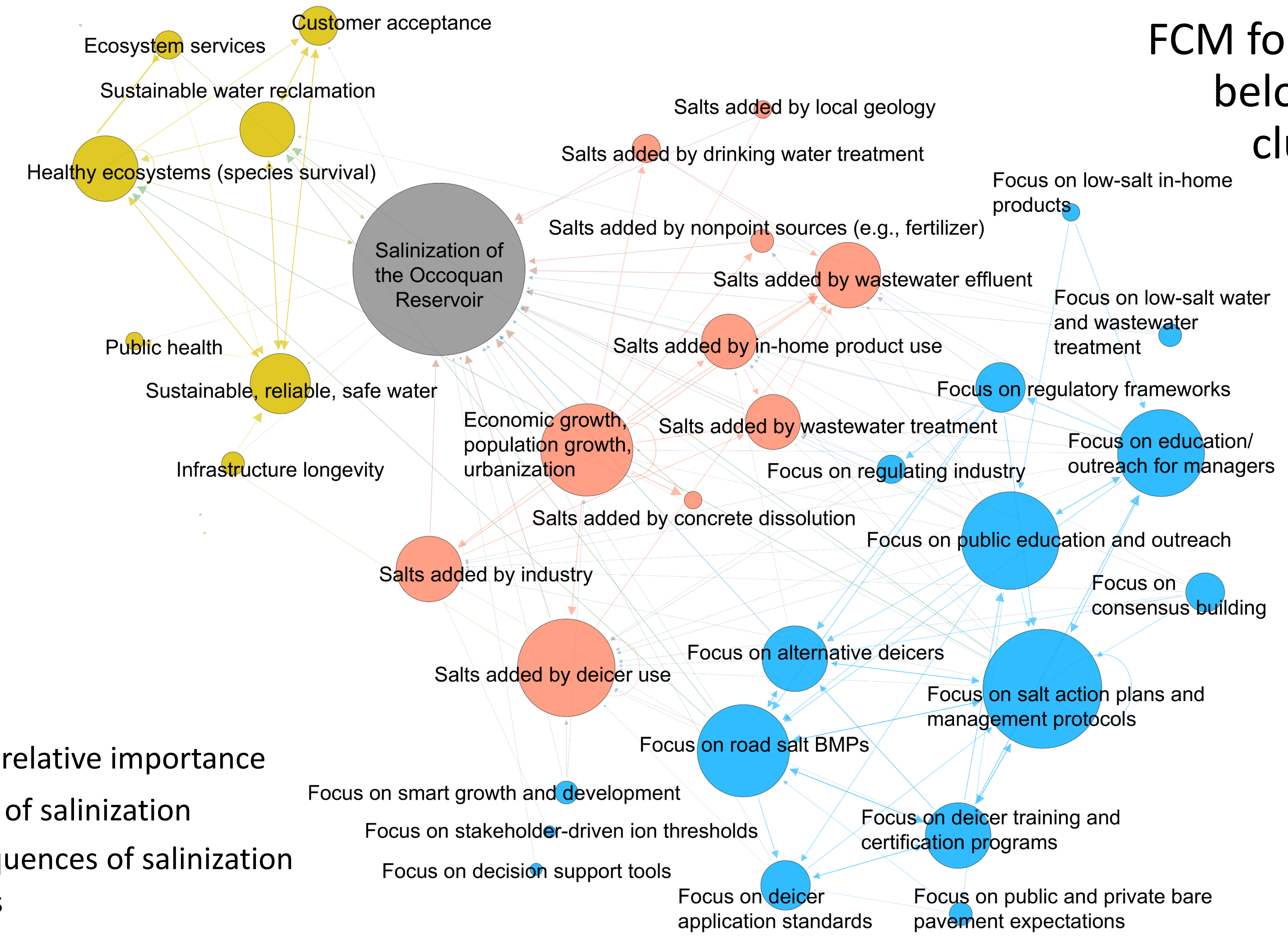
Simplified Aggregated FCM *(all ECOS members)*



Node Size: relative importance

- Causes of salinization
- Consequences of salinization
- Actions

FCM for individuals belonging to cluster 1



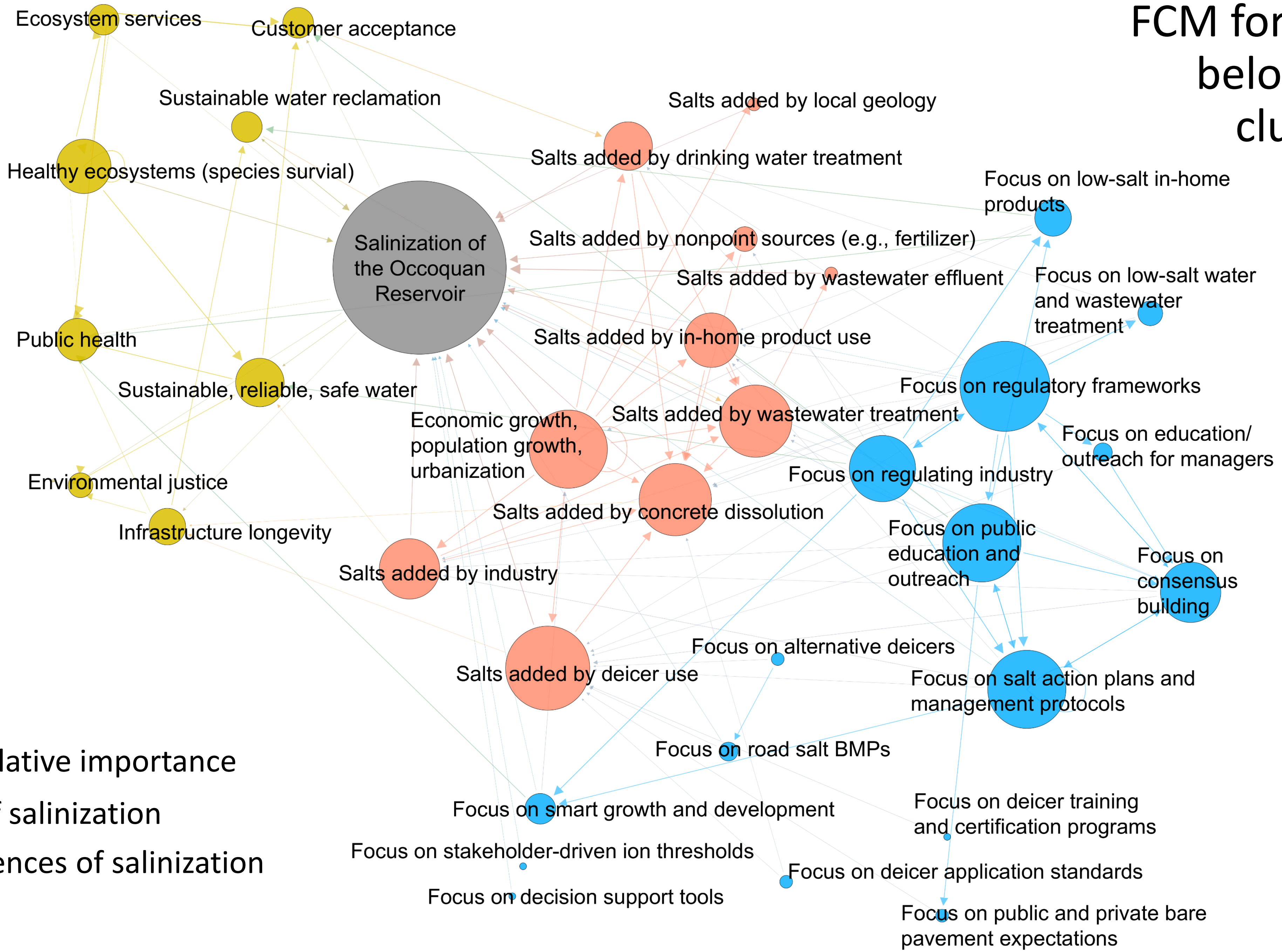
Node Size: relative importance

Causes of salinization

Consequences of salinization

Actions

FCM for individuals belonging to cluster 2



Node Size: relative importance

- Causes of salinization
- Consequences of salinization
- Actions

Next Steps

Biophysical Research – Videos & White Papers: Posted to Project Website October

ECOS Member Interviews November-January

Next ECOS Meeting January