Nelson Institute for Environmental Studies
UNIVERSITY OF WISCONSIN–MADISON

A Blueprint for Salt Sustainability on the University of Wisconsin-Madison Campus

2019 WATER RESOURCES MANAGEMENT PRACTICUM REPORT

PREFACE

Introduction to the Water Resources Management Program

The Water Resources Management (WRM) master's degree program is a collaborative and interdisciplinary graduate program in the Nelson Institute for Environmental Studies at UW-Madison. Since the 1970s, this project has served as an interactive and immersive experience for the program's students. It focuses on current issues in water resources management within Wisconsin. The practicum is one of the finest and most impactful examples of the "Wisconsin Idea" — that is, the notion that the boundaries of the institution extend to those of the state.

THE WISCONSIN IDEA & PURPOSEFUL ACTION

This *Blueprint* combines two of the university's fundamental principles: the Wisconsin Idea, which is a long-standing tradition in which knowledge gained at the university influences Wisconsin beyond the boundaries of the classroom; and "purposeful action," which encourages the application of knowledge and skills to solve problems in the community, the development of partnerships, and leading for positive change.

The 2018–2020 WRM cohort established and worked with an advisory committee representing more than ten groups of stakeholders from different facets of the university and Madison communities to develop a *Blueprint for Salt Sustainability on the UW-Madison Campus.* This project ultimately engaged more than 30 stakeholders involved in the management and use of salt on the UW-Madison campus, including facility managers; academics and researchers; engineers; Facilities Planning & Management (FP&M) staff; regional organizations; communication specialists; and planners.

Some university stakeholders were already working toward reducing salt use on campus and innovating to advance sustainable salt use practices. This *Blueprint* leverages current practices and encourages innovation in a pathway for the University to achieve a 25 percent reduction in salt use. Each of the *reduction opportunities* outlined in the *Blueprint* are interconnected. Each opportunity works in harmony with the others to reduce salt use on campus. To realize the greatest impact, all opportunities should be implemented.

TABLE OF CONTENTS

LIST OF TABLES AND FIGURES

List of Tables

List of Figures

A BLUEPRINT FOR SALT SUSTAINABILITY ON THE UNIVERSITY OF WISCONSIN-MADISON CAMPUS

2018–2020 Water Resources Management Master's Cohort

Brittany Cobb | Abigail Ernst | Brian Flynn | Tristyn Forget | Yangbo Peng | Gwen Saliares | Lydia Salus | Wei Tang | Michael Webber

PROJECT INTRODUCTION

Salt pollution is a major concern for local water resources in Dane County. Every piece of salt that is used eventually ends up in our fresh water. **It only takes one teaspoon of salt to pollute five gallons of water** to the chronic level of 230 mg/l established by the United States Environmental Protection Agency (Benoit, 1988). At this threshold, long term exposure can decrease growth, reproduction, and survival rates of freshwater organisms (Benoit, 1988). In Wisconsin, the Chronic Toxicity Criterion means that the chronic threshold should not be exceeded for more than four days once every three years (Wis. Admin. Code Sec. NR 105.03(15), 2010).

Because the University of Wisconsin-Madison is one of the top salt users in the county, changes to its patterns of salt use on campus would have significant impacts on area freshwater resources. Students in Water Resources Management (WRM), a collaborative and interdisciplinary master's degree program in the Nelson Institute for Environmental Studies at UW-Madison, examined current salt use on the campus. The 2018–2020 WRM cohort identified opportunities for UW-Madison to improve local water quality through a reduction in salt use.

The methods used to identify opportunities for more efficient salt use on campus outlined in this project can be reproduced and applied beyond campus boundaries – an example of the Wisconsin Idea. UW-Madison is essentially a city within a city. By implementing the recommendations set forth in this document, UW-Madison has the opportunity to lead salt sustainability efforts and serve as a model for other campuses and cities across the country.

SALT POLLUTION BACKGROUND

Chloride pollution is the result of salt, most commonly known as sodium chloride, dissolving in water and entering our freshwater resources. There are two main sources of salt use on the UW-Madison campus; water softening and winter deicing. Between these two sources, chloride can take different paths to water resources (Figure A.1). On UW-Madison's 936-acre campus, seventy-eight percent of the stormwater drains into Lake Mendota via storm sewers, overland flow, and by way of Willow Creek (Water Resources Management, 2004). As a result, Lake Mendota is the major recipient of the salt used for winter deicing on campus. Campus wastewater, which contains chloride from the water softening process, is sent to the Madison

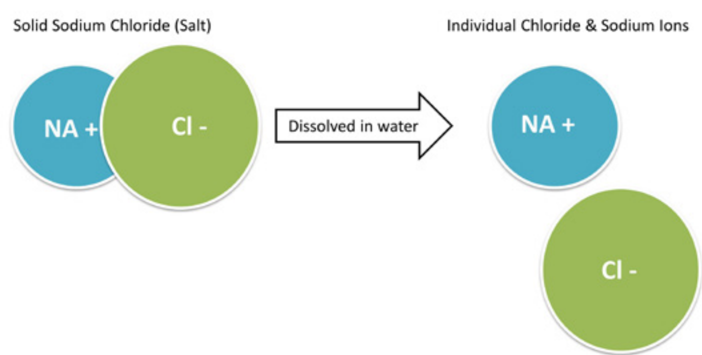


Figure A.1. When salt (sodium chloride) is dissolved in water, it is separated into its individual ions, sodium and chloride. Sodium chloride is represented here because it is the most common form of salt and is used for both water softening and winter deicing; however, it is not the only form of salt.

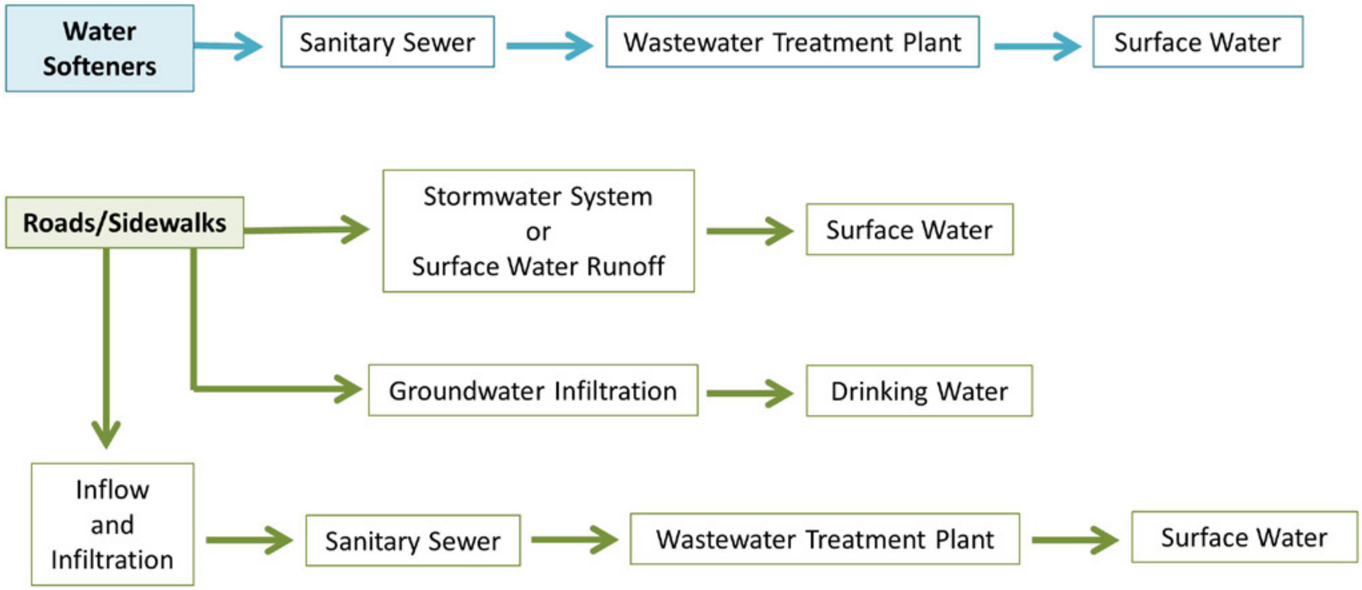


Figure A.2. Pathways that salt takes to get to our freshwater resources.

Metropolitan Sewerage District's Nine Springs Wastewater Treatment Plant.

Chloride is not reactive in the environment, meaning that it will accumulate in a water body and need to be flushed out of an ecosystem in order to reduce its concentration. Water quality monitoring conducted by Dane County has shown trends of increasing chloride levels in waters around the county (Madison and Dane County Public Health, 2017). Figure A.3 shows these increasing chloride trends in the Yahara chain of lakes (Sorsa & Wenta, 2018). Since the 1960s, chloride concentrations in the Yahara Lakes have risen between 40–100 mg/L (Sorsa & Wenta, 2018).

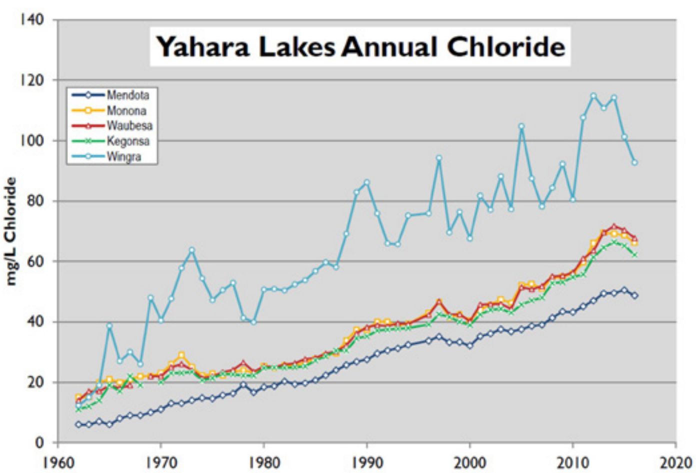


Figure A.3. Chloride concentrations of the five lakes in the Yahara chain of lakes from 1938–2016. The trend for all five lakes is increasing (Madison and Dane County Public Health, 2017).

Monitoring of drinking water wells also shows increasing sodium and chloride concentrations from salt, including drinking water wells serving the UW-Madison campus (Madison and Dane County Public Health, 2017). In 2018, the well closest to the UW-Madison campus, Well 14, showed sodium levels between 50 – 58 mg/L which exceeds the EPA guideline for sodium levels in drinking water of 20 mg/L (Madison Water Utility, 2019). These levels are generally not harmful to human health but could be a concern for people on extreme salt-restricted diets. According to the City of Madison, the amount of sodium ingested by drinking two liters of water per day from Well 14 would be similar to the amount found in a piece of bread (City of Madison, n.d.). Additionally, chloride is what causes the "salty" taste, and in a concentration above 250 mg/L, the chloride in the water will be perceptible. Well 14 is on track to exceed this taste threshold within the next 17 years (City of Madison, n.d.). Well remediation or treatment technologies are costly to install and operate (City of Madison, n.d.).

Impacts

At high levels in the environment, salt has environmental, economic, and public health impacts (Table A.1). Source reduction of chloride is the best option for mitigating the impacts associated with salt overuse. Removing chloride from the influent at the NSWTP with treatment-only solutions could cost between $400 million and $2.3 billion over a 20-year period (AECOM, 2015), which would increase utility rates for the communities MMSD serves. Moreover, remediating a drinking water well could cost between $4 million and $8 million (J. Grande, personal communication, April 13, 2020).

Table A.1. Salt-related impacts. (For more information on these impacts, refer to Section 2.)

Environmental	Economic	Public Health
• High levels of chloride in the environment negatively impact aquatic organisms and terrestrial plants (Madison and Dane County Public Health, 2017; Environment Canada and Health Canada, 2001; Hintz et al., 2017) • Higher salinity levels in water benefit aquatic invasive species while harming native, more sensitive species (Hintz & Relyea, 2017; Kaushal et al., 2005) • Saline water can interfere with lake mixing and lead to algae blooms (Environment Canada and Health Canada, 2001; Hintz et al., 2017; Kaushal et al., 2018)	• UW-Madison spends over $358,000 annually on salt alone (Section 4, Table 4.1) • When including salt-related damages, UW-Madison likely spends over $2 million annually (Section 4, Table 4.3) • Negative impacts on aquatic ecosystems also impact lake recreation-related income (WDNR, 2019) • Wastewater treatment to remove chloride would be extremely expensive (AECOM, 2015) • Drinking water upgrades would be extremely expensive	• Salt can remobilize metals in the soil and lead to an increase in heavy metal concentrations in ground water (Kaushal et al., 2018; Nelson et al, 2009) • Water has a taste threshold of 250 mg/L of chloride; some Madison-area wells are near that level (City of Madison, n.d.) • Rock salt on sidewalks has also been shown to have negative impacts on the paws of dogs and cats (Wisconsin Salt Wise, n.d.)

SALT ON THE UW–MADISON CAMPUS

To determine what reduction opportunities are possible on campus, we gathered baseline data to find out how much salt is currently being used. We found that **during the 2018–2019 school year, UW-Madison used a total of 3.56 million pounds of salt** (Figure A.4); 48 percent was used by water softeners and 52 percent for winter deicing. For context, **this amount is enough salt to pollute the entirety of Lake Wingra to the EPA's chronic limit of 230 mg/L of chloride.** Salt use is individually managed by a vast network of different stakeholders (Figures A.5 and A.6); there is no central campus tracking system for salt use. Because of the many disparate systems being used to track salt use, we believe that this figure is an underestimate of the actual amount of salt used on campus.

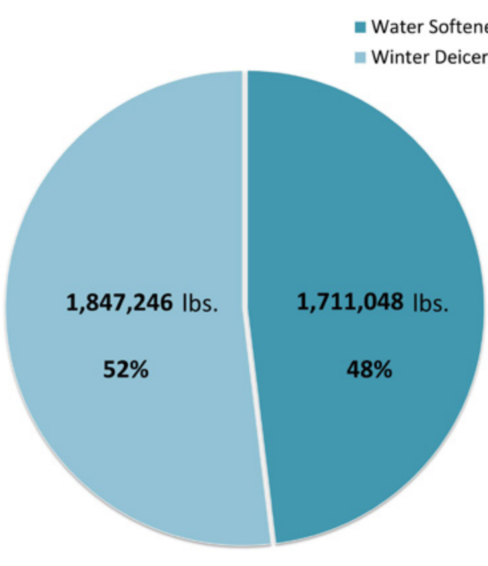


Figure A.4. UW-Madison's total salt use. This is likely an underestimate of the actual amount due to gaps in knowledge.

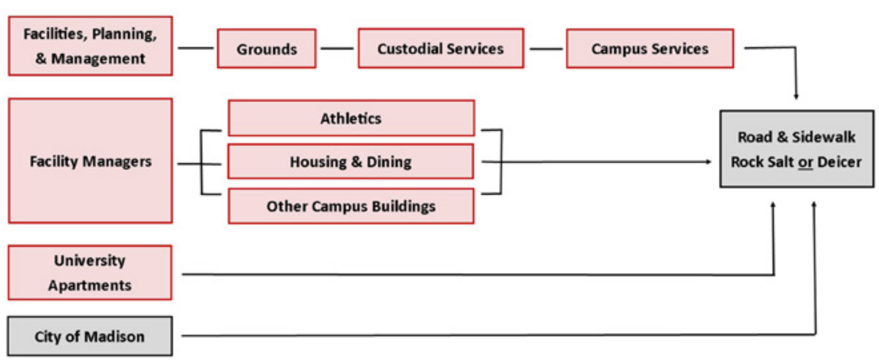


Figure A.5. Campus programs that apply road salt/deicer in the winter.

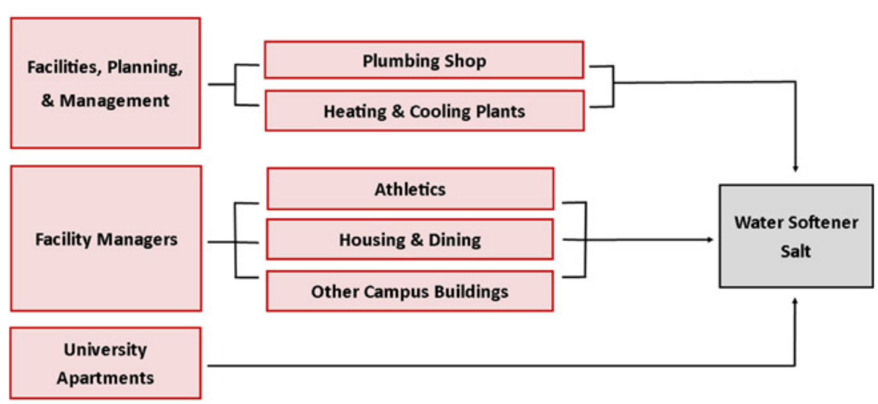


Figure A.6. Campus programs that manage water softeners.

Water Softeners

Water softening is used to protect appliances, boilers, and plumbing from scale build-up caused by hard water. There are 226 water softeners on campus, which we estimate to account for 1,712,000 pounds of salt used in 2018, nearly half of the total campus salt use. This, again, is likely an underestimate due to inconsistencies related to purchasing and salt use records. By replacing outdated and/or inefficient water softeners on campus alone, the university could reduce its annual salt use by approximately 204,000 to 303,000 pounds and between $24,000–$36,000 per year in water softener salt purchases, or up to $576,000 over the 16-year lifespan of the equipment (Section 6).

Winter Deicing

Stormwater monitoring on campus after salt application identified surges of extremely high levels of chloride into the environment (Section 13). Contributing to the identified surges were the estimated 1,847,246 pounds of winter de-icing salts applied to campus sidewalks, stairs, and roads during the 2018–2019 season. Over the past two decades, the price of a ton of road salt has increased by 260%, going from $30/ton in 2000 to $78/ton in 2019 (Schmidt, 2019). With 895 tons of road salt used during the 2018–2019 winter season, the campus spent an estimated $69,810 on raw salt alone for winter deicing. Road salt also has corrosive impacts on infrastructure and vehicles, which can impose significant costs. Altogether, the damages and direct costs related to rock salt use on campus for the 2018–2019 winter season are estimated to cost the university over $2.3 million (Section 4). By implementing sustainable salting practices and increasing staff training, the university could see significant annual savings in both direct and indirect costs.

SALT USE INVENTORY PROCEDURE

The steps we took to identify salt-reduction opportunities are summarized below; for specific details, refer to Sections 11, 13, and 14.

WATER SOFTENERS

1. **Identified and contacted network of water softener managers on campus.**
2. **Administered a survey and conducted interviews to determine where softeners were located, general information about them, and how much salt they were using.**
3. **Organized site visits to verify unknown information about water softeners.**
4. **Worked with Hellenbrand Water Center to analyze the efficiency of the water softeners in a group of residence halls and optimized the softeners in a case study based on the findings.**
5. **Worked with local wastewater treatment plant monitoring program to corroborate water softener salt use findings.**
6. **The FP&M Plumbing Shop identified a list of water softeners that were old, had outdated technology, or were inefficient and should be prioritized for replacement.**

WINTER DEICING

7. **Identified and contacted network of all departments and individuals responsible for winter maintenance on campus.**
8. **Administered a survey and conducted interviews to determine where road salt was being used, how much was being used, current application policies and practices, and barriers for improvement.**
9. **Stormwater outlets into Lake Mendota were inventoried and the most representative, accessible locations were sampled. Sampling took place during storm events in order to capture the "first flush" of chloride as well as the levels present in the continued discharge.**
10. **Worked with the winter maintenance network to identify pathways that could be closed for the season, equipment that would make salt application more efficient, and opportunities to improve winter maintenance policies and practices.**

TOTAL SALT USE

11. **Combined surveys and monitoring results to get a total amount of salt used on campus and identify key opportunities for more efficient salt use.**

IDENTIFIED REDUCTION OPPORTUNITIES

The source-reduction strategies identified in this *Blueprint* focus on reducing excessive salt use by increasing efficiency of campus practices and technologies without harming the soft water supply, campus plumbing infrastructure, or public safety. **Altogether, reducing salt use by 25 percent as outlined in this Blueprint (Table A.2.) the university would save an estimated $600,000 each year** (Section 4) **and protect over 337 million gallons of water.** The actual reduction may surpass 25 percent because opportunities like staff training and increased organization can contribute to more efficient salt use.

Table A.2. Summary of the potential calculable reductions in salt use that could be achieved if the actionable next steps outlined in this *Blueprint* (Section 6) are implemented on the UW-Madison campus. The total value represents 25% of the 3,560,000 pounds of salt used on campus in 2018–2019.

Opportunity	Annual Reduction in Salt Use (Pounds)
Optimizing softeners for efficient settings	274,463
Replacing manual, old, and inefficient softeners	203,731
Installing permeable pavement in 50% of parking lots	165,200
Implementing brine pre-treatment in University Apartments	84,000
Using a 5% sand/salt mix	54,000
Heating and cooling plant brine reclamation	50,000
25% energy reduction campaign	50,000
Sidewalk closures at University Apartments	8,112
Sidewalk closures on main campus	4,326
Total Reduction (Pounds)	**893,832**

Structural Changes

Ensure that equipment and technology is operating as efficiently as possible and that UW-Madison stakeholders have the equipment and technology necessary to efficiently manage salt use.

UW-Madison does this in a variety of ways already. For example, Grounds utilizes anti-icing brine pretreatment ahead of imminent storms and closes redundant stairways during the winter.

However, while campus salt managers engage in activities that aim to economically use salt, sustainable salt use programs can be expanded to a greater extent on campus to incorporate additional best management practices. To address this gap, we recommend the following:

WATER SOFTENERS

- **Replace outdated and malfunctioning water softeners (Table 6.3).**
- **Optimize inefficient water softeners (Table 6.2).**
- **Upgrade manual controls on Walnut Street Heating & Cooling Plant water softeners.**
- **Pilot new water conditioning and salt-free technologies (Table 7.1).**
- **Record water softener efficiency in the Water Softener Inquiry Dashboard so campus-wide comparisons of salt use efficiency can be made.**
- **Install brine reclamation systems at the Charter Street and Walnut Street Heating & Cooling Plants (Table 6.7).**

ROAD SALT

- **Close sidewalks and pathways to reduce salt application area (Tables 6.9 and 6.10).**
- **Fix problem areas where structural issues lead to icy pathways; for example, low spots in the sidewalk or downspouts discharging onto a sidewalk.**
- **Incorporate permeable pavement in parking lots across campus (Table 6.5).**
- **Construct storage for sand.**
- **Support staff with tools and trainings for that can improve sidewalk salting efficiency (e.g., headlamps, pavement temperature readers, salt application devices capable of low application rates).**
- **Incorporate the use of brine pre-treatment for University Apartments winter maintenance practices, which has shown to reduce the need for rock salt by 20–30 percent (Fifield, 2017).**
- **Utilize water softener brine for anti-icing across campus.**
- **Reduce percent salt in salt/sand mixtures from 10 to 5 percent (WisDOT, 2015).**
- **Post informational signage at closed sidewalks to inform patrons how this action can reduce salt use and benefit university infrastructure and the local environment.**

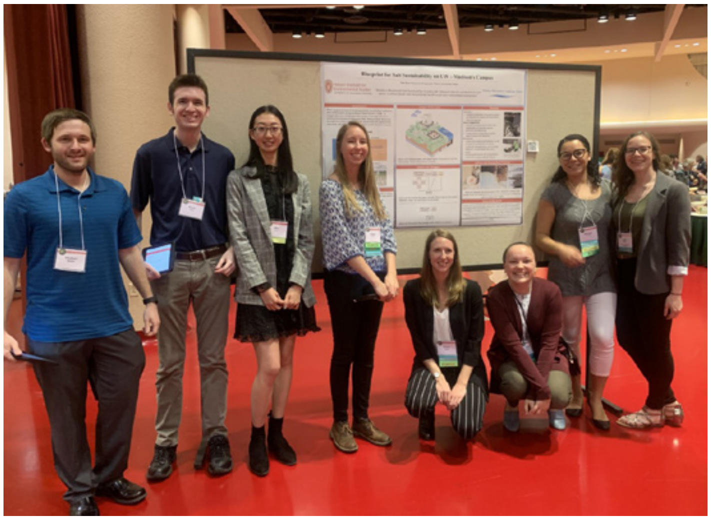
Policy and Procedural Changes

Establish salt management policies and procedures so that salt use can be managed comprehensively and cohesively across campus.

The University lacks a comprehensive salt management plan and consistent messaging about salt use

Because of the University's complexity and size, salt use tracking is currently siloed. UW-Madison salt managers have their own methods for managing and tracking salt use. Management policies and procedures vary from building to building and department to department. To address this gap, we recommend the following:

- **Require minimum efficiency performance standard of 4,000 grains/gallon (MMSD, 2015) for installation of new water softeners.**
- **Establish a new campus-wide outdoor salt use policy-and-procedure manual that incorporates the best management practices outlined in this Blueprint, including language specific to each department's responsibilities.**
- **Develop an official calibration protocol for each type of outdoor application equipment and determine a minimum frequency at which to check the calibration of the equipment.**
- **Institute a formal policy for salt use recording and reporting for water softening and road salt.**
- **Improve training for staff who apply winter salt and make management decisions (e.g., work with Wisconsin Salt Wise to make programming more accessible by adding training sessions for employees who work second or third shifts; share a winter application training video to all campus applicators and interested parties; use Canvas to track who has completed the training; and consider the organizational training certification from the City of Madison).**



Institutional and Management Changes

Institutionalize an emphasis on salt sustainability throughout university curriculum, management plans, research, and sustainability efforts and ensure that there are funds and staff to support this work.

The university already incorporates key environmental topics into campus curriculum, management plans, and research and sustainability efforts in innumerable ways on campus. For example, the Office of Sustainability runs the Green Fund, the university is enrolled in the Sustainability Tracking, Assessment & Rating System (STARS) program, and the Nelson Institute for Environmental Studies has a diverse curriculum that incorporates stewardship of local natural resources.

However, a significant gap exists between these campus initiatives and sustainable salt use. Chloride pollution needs to be incorporated into the larger campus discourse in order to be able to effectively address this issue on campus. To address this gap, we recommend the following:

ACCOUNTABILITY & MANAGEMENT

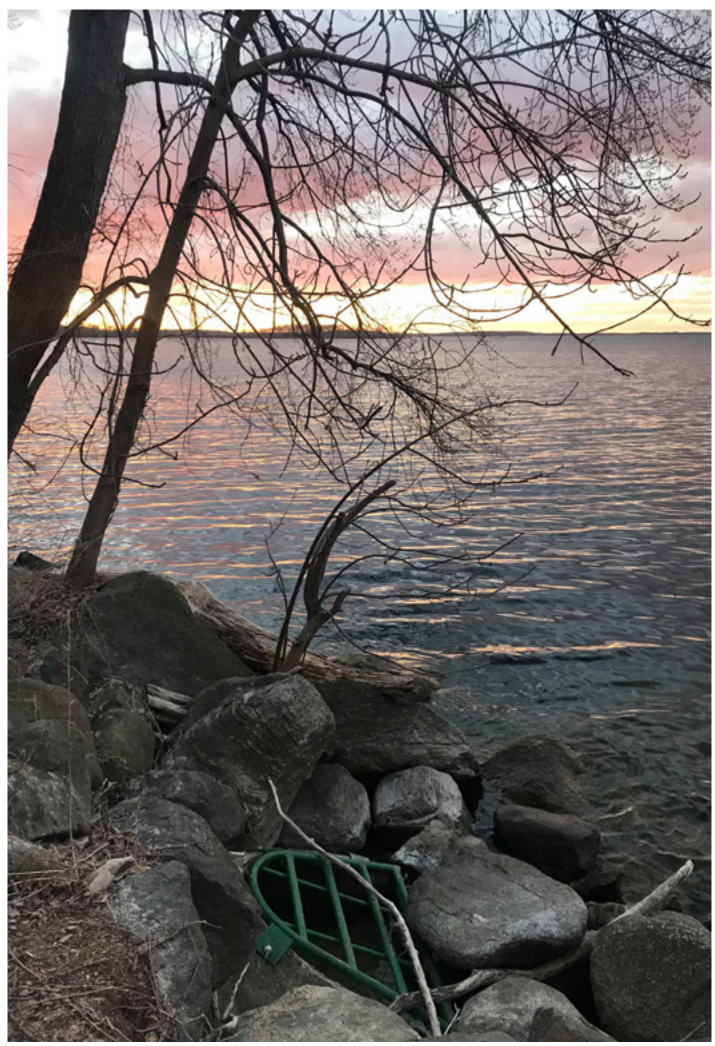
- **Standardize salt use tracking for water softener management and for winter salting activities and consolidate the salt use information into an annual salt use inventory that is reported to the Second Nature Resilience Commitment by the Office of Sustainability.**
- **Establish an annual meeting of salt applicators and managers to set salt reduction goals, check on progress, and update and adapt policies and procedures. Create annual reports from these meetings highlighting key findings to share with the university and public.**
- **Utilize annual facility manager meetings to review salt management policies and procedures and share resources.**
- **Manage expectations of university staff, students, and public patrons to gain support for salt reduction efforts by providing accessible, informative tools and signage (e.g., create and utilize "sidewalk closed" signs that inform patrons how the action reduces salt use; post online maps of closed pathways so pedestrians can plan alternate routes; and share a Salt Awareness Learning Tool (SALT)).**
- **Improve accountability by using the GIS salt tracking dashboards (Section 12) to update salt use data in real time, fill in gaps in knowledge, and make it accessible in one location to prioritize applications for funding and check progress of salt reduction initiatives. FP&M and building managers are encouraged to take ownership of these tools.**

SYNERGIES WITH EXISTING CAMPUS RESEARCH & SUSTAINABILITY EFFORTS

- **Launch a campus-wide campaign to improve knowledge and emphasize the importance of sustainable salt use using common messaging (e.g., "more salt use does not equal less ice").**
- **Incorporate chloride-related content into course curricula across departments and disciplines.**
- **Incentivize university labs and researchers to investigate chloride source reduction opportunities and effectiveness on campus.**
- **Amplify the current Water Conservation Campaign by the Office of Sustainability as a method for reducing the amount of soft water needed.**
- **Incentivize university labs, researchers, and students to continue chloride monitoring in Willow Creek, the 1918 Marsh, adjacent lakes and storm sewer outlets.**
- **Support a research project to be funded by the Green Fund Program to quantify the relationship between water use and salt use as the foundation for the Water Conservation Campaign.**
- **Build partnerships between internal entities including the Office of the Chancellor, the Office of Sustainability, FP&M, and building managers and external entities including Wisconsin Salt Wise and the City of Madison in order to collaborate on research and share training and educational materials.**
- **Initiate an energy reduction campaign focused on heating and cooling to reduce salt used for boiling water that provides energy for campus (Table 6.8). This initiative could be included as a STARS program initiative, campus dorm initiative, or other existing campus initiative.**
- **Add salt reduction initiatives to the list of potential Green Fund projects.**

Conclusion

Over the last 80 years, the background levels of chloride in the freshwater resources around campus have been studied and shown to be steadily rising, which could lead to the degradation of Madison's aquatic ecosystems. Source reduction of chloride is an economically viable solution to halting these trends and mitigating the impacts associated with salt overuse. In order to have the greatest long-term effect, the idea of "salt sustainability" needs to extend into all areas of campus. UW-Madison can use its robust research capabilities to explore ways to more efficiently use salt to protect Madison's valuable water resources for generations to come.



The 2018–2020 Water Resources Management master's degree cohort

Back row (from left to right): Abigail Ernst, Brian Flynn, Wei Tang, Tristyn Forgét
Front row (from left to right): Lydia Salus, Brittany Cobb, Michael Webber, Yangbo Peng, Gwen Saliares

Acknowledgements

The 2018–2020 Water Resources Management master's degree cohort would like to sincerely thank the individuals who patiently answered our questions, connected us with a network of resources, and donated their time to provide valuable input and feedback on our project. We would especially like to thank our partner, the Madison Metropolitan Sewerage District, and our project advisors. In addition, we appreciate the support of the University of Wisconsin-Madison Facilities, Planning & Management (FP&M).

Project Partners: Madison Metropolitan Sewerage District

Martye Griffin | Madison Metropolitan Sewerage District

Catherine Harris | Madison Metropolitan Sewerage District

Kathy Lake | Madison Metropolitan Sewerage District

Project Advisors

David Hart | University of Wisconsin Aquatic Sciences Center

Jennifer Hauxwell | University of Wisconsin Aquatic Sciences Center

Stakeholder Advisory Committee

Ellen Agnew | FP&M–Grounds

Hilary Dugan | Center for Limnology

Chris Egger | FP&M–Environment, Health & Safety

Sarah Fuller | Capital Area Regional Planning Commission

Phil Gaebler | City of Madison Engineering

Matt Ginder-Vogel | UW-Madison Department of Civil & Environmental Engineering

Mary Hamel | UW-Madison Department of Planning and Landscape Architecture

John Magnuson | UW-Madison Department of Integrative Biology & Center for Limnology

Melissa Nergard | FP&M–Office of Sustainability

Marcella Otter | FP&M–Plumbing Shop

William Selbig | United States Geological Survey

Bret Shaw | UW-Madison Department of Life Sciences Communication

Contributing Stakeholders

Caitlin Bourbeau | Applied Populations Lab

Bonnie Willison | Wisconsin Sea Grant

Cultural Linguistic Services

Other engaged stakeholders

Kris Ackerbauer | FP&M–Physical Plant Services

Svetlin Borisov | UW-Madison University Apartments

Andrew Gossfeld | FP&M–Utilities & Energy Management

Mike Henry | UW-Madison Residence Hall Facilities

Steve Heitz | FP&M–Custodial Services

James Lazarcik | Water Science and Engineering Laboratory

David Liebl | Engineering Professional Development

Jeff Pollei | FP&M–Utilities & Energy Management

Jim Post | FP&M–Utility Mapping Specialist

Paul Robbins | UW-Madison Nelson Institute for Environmental Studies

Brad Schenkel | FP&M–Custodial Services

Anita Thompson | UW-Madison Department of Biological Systems Engineering

Kevin Weber | UW-Madison University Apartments

David Zuhde | Hellenbrand Water Center

UW-Madison building and facility managers

HOW CHLORIDE ENTERS THE ENVIRONMENT

There are two main sources of salt use on the UW-Madison campus; water softening and winter deicing. Every piece of salt that is used eventually ends up in our fresh water. Where, and when it gets there, is dependent on the source and the pathway it takes. Since it only takes one teaspoon of salt to pollute five gallons of water, the impacts can add up quickly. Chloride pollution is the result of salt, most commonly sodium chloride, dissolving in water and entering our freshwater resources (Figure 1.1). Between these two sources of salt, chloride can take various different paths to water resources.

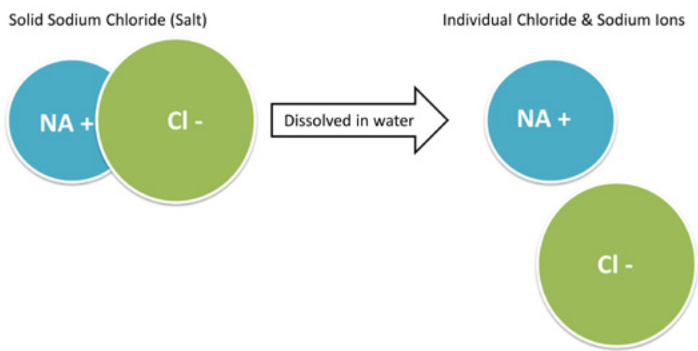


Figure 1.1. When salt (sodium chloride) is dissolved in water, it is separated into its individual ions, sodium and chloride. Sodium chloride is represented here because it is the most common form of salt and is used for both water softening and winter deicing; however, it is not the only form of salt.

Water Softeners

Water softening is used to remove dissolved ions such as calcium and magnesium from the water used in commercial, industrial, and residential buildings. These dissolved ions can damage plumbing, boilers, and appliances by causing scale build-up. Water hardness can vary; however, according to the United States Geological Survey, Madison has "very hard" water, meaning that the water has more than 180 mg of calcium carbonate per liter (USGS, n.d.). Therefore, water softeners are widely used throughout the area to protect plumbing, infrastructure, and appliances.

Water softeners work by adding salt to a brine tank where it is dissolved into sodium and chloride ions. As hard water flows through the softening system, an ion exchange occurs — the calcium and magnesium ions in the hard water are switched for sodium ions in the salt brine — which produces soft water. The water softener then flushes the brine containing calcium, magnesium, and leftover chloride into the sanitary sewer. This process is known as "regeneration" and allows for the softening process to continue. The more a water softener regenerates, and the more salt used per regeneration, the more chloride that is discharged to the sanitary sewer system. Monitoring of 146 apartments in University Housing, a neighborhood within the University Apartments community, showed that more than 400 pounds of salt was discharged in one week (Section 11). Wastewater from the UW-Madison campus goes to the Madison Metropolitan Sewerage District (MMSD) Nine Springs Wastewater Treatment Plant.

Figure 1.2. Water softeners in Dejope Residence Hall and Bradley Residence Hall, respectively. Photo credit: Brittany Cobb

Winter Deicing

Winter deicing practices have also been recognized as a significant source of chloride to the environment (Corsi et al., 2015; Environment Canada and Health Canada, 2001; Novotny et al., 2009). Winter "deicers" is an umbrella term that includes both rock salt, which is sodium chloride, and ice-melt, which can include various other forms of salt, such as magnesium chloride and calcium chloride. Deicers are used to keep roads, sidewalks, parking lots, and other access paths clear of ice in the winter. When salt is applied to icy surfaces, it lowers the freezing point of water and causes the ice to melt. Stormwater monitoring on campus after salt application identified surges of extremely high levels of chloride into the environment (Section 11). As these surges enter local waterways, they have the potential to harm fish and other aquatic organisms (Madison and Dane County Public Health, 2017).

Chloride is not reactive in the environment, meaning that it will build up in concentration unless it is flushed out of a water body. Water quality monitoring conducted by Dane County has shown trends of increasing chloride levels in waters around the county (Figure 1.3) (Madison and Dane County Public Health, 2017). Since the 1960s, chloride concentrations in the Yahara Lakes have risen 40–100 mg/L (Sorsa & Wenta, 2018).

Wells monitored within Dane County also show increasing chloride levels, especially in wells located near major trafficways (Madison and Dane County Public Health, 2017). This indicates increasing levels

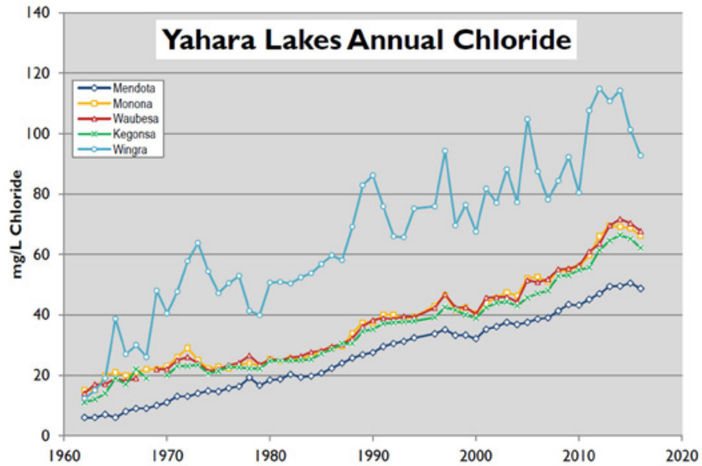


Figure 1.3. Chloride concentrations of the five lakes in the Yahara chain of lakes from 1938–2016. The trend for all five lakes is increasing (Madison and Dane County Public Health, 2017).

of chloride in groundwater drawn from both the upper and lower aquifers (Sorsa & Wenta, 2018). Most people in Madison receive their drinking water from these aquifers. It is worth noting that surface water and groundwater are connected in numerous ways, and the trends are often mimicked in one another. The groundwater chloride levels around Madison follow this trend, increasing along with the surface water concentrations in the area.

The pathways of rock salt used on roads and sidewalks can be complex. Stormwater and snowmelt dissolve the salt that has been applied to roads and sidewalks and carry it into the storm sewers that empty directly into surface waters. For much of the UW-Madison campus, storm water flows into Lake Mendota. 78 percent of UW-Madison's 936-acre campus drains into Lake Mendota via storm pipes, overland flow, and Willow Creek (Water Resources Management, 2004). The remaining 22 percent of the campus area drains into Lake Monona through city stormwater pipes (Water Resources Management, 2004). Runoff may also infiltrate into the soil and eventually be discharged into groundwater (Sorsa & Wenta, 2018). Chloride that gets into the soil can be remobilized and added to groundwater through infiltration, or to streams through baseflow (Daley et al., 2009). Additionally, road salt can make its way into the sanitary sewer system through inflow and infiltration, which is the process of water on the land surface entering the sewerage system through manhole covers and fissures in the pipes underground. Salt that enters these systems has the same fate as water softener salt, flowing to the wastewater treatment plant.

Section 2

IMPACTS OF CHLORIDE IN THE ENVIRONMENT

Environmental Impacts

Quantitative limits for chloride have been established by both the United States Environmental Protection Agency (EPA) and the Wisconsin Department of Natural Resources (WDNR) that mark important thresholds. The Chronic Toxicity Criterion used by the WDNR is a concentration of 395 mg/L over a four-day period. This is considered the concentration chloride-sensitive organisms can tolerate if the limit is not exceeded for more than four days once every three years (Wis. Admin. Code Sec. NR 105.03(15), 2010). Long term exposure at this concentration is harmful to aquatic life. The Acute Toxicity Criterion used by the WDNR, 757 mg/L of chloride, is the "daily maximum concentration not to be exceeded more than once every three years" (Sorsa & Wenta, 2018). Negative impacts will be seen if this level is reached at any point in time. At this acute level, adverse effects and mortality has been observed in some small freshwater species (Environment Canada and Health Canada, 2001; Hintz et al., 2017). The EPA has set the chronic limit for chloride at 230 mg/L and the acute limit at 860 mg/L (EPA, 2014).

In addition to the impacts on aquatic life, increasingly saline water can also interfere with the process of lake mixing, cause harm to soils and vegetation, and promote eutrophication (Environment Canada and Health Canada, 2001; Hintz et al., 2017; Kaushal et al., 2018). More saline waters also benefit invasive species by increasing stress on native species while making the environment more habitable for invasive species (Hintz and Relyea, 2017; Kaushal et al., 2005).

Public Health Impacts

Chloride moving through soil can remobilize heavy metals via an ion exchange process like the water softening process (Environment Canada and Health Canada, 2001; Kaushal et al., 2018). According to a study on the effects of sodium chloride and magnesium chloride (another common type of salt) on heavy metal mobilization in the soil, sodium chloride released the largest amount of copper and lead, while magnesium chloride released more cadmium (Nelson, Yonge, & Barber, 2009). These remobilized metals are then released into the environment and can have health impacts.

Additionally, salt infiltration has been observed in five of Madison's 22 drinking water wells (City of Madison, n.d.). Well 14, near the west side of the UW-Madison campus, has seen the greatest increases in chloride concentrations. At the current rate of pollution, Well 14 will reach the taste threshold of 250mg/L of chloride around the year 2032. Rock salt also contributes to sodium to levels in drinking water. In 2018, the level of sodium in Well 14 surpassed the level

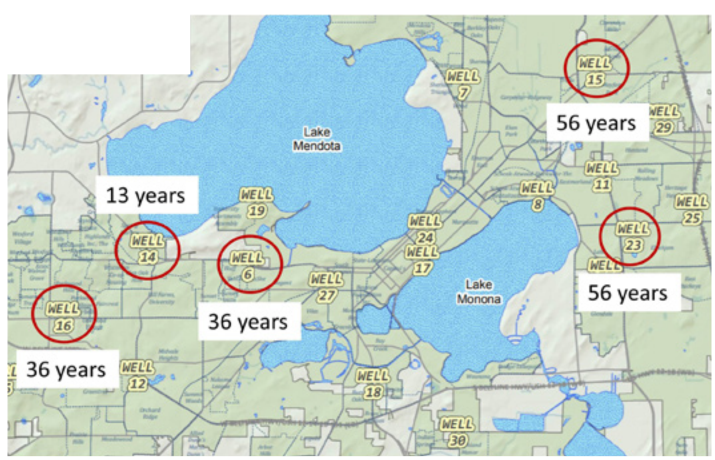


Figure 2.1. These five public drinking water wells in Madison, Wisconsin, have experienced salt intrusion. The numbers indicate the years it will take from 2019 to reach the taste threshold (City of Madison, n.d.). Image originally from Madison Water Utility (2013) adapted by Abigail Ernst (2019)

that the EPA recommends for drinking water, above which the water tastes salty (Madison Water Utility, 2019). These levels are generally not harmful to human health but could be a concern for people on extreme salt-restricted diets; the amount of sodium ingested by drinking two liters of water per day from Well 14 would be similar to the amount found in a piece of bread (City of Madison, n.d.).

Rock salt on sidewalks has also been shown to have negative impacts on the paws of dogs and cats. Long-term exposure from constant walking on salt-laden surfaces can lead to health problems and increased trips to the vet (Wisconsin Salt Wise, n.d.).

Economic Impacts

While treatment plants effectively remove most harmful pollutants from our waters, chloride removal is not usually part of the process. Technology does exist that can remove chloride from water, but it is extremely expensive. For MMSD to implement this type of technology, the capital, operation, and maintenance costs would between $400 million and $2.3 billion over a 20-year period, which would significantly increase treatment costs for utility users (AECOM, 2015). Moreover, remediating a drinking water well could cost between $4 million and $8 million (J. Grande, personal communication, April 13, 2020) depending on a myriad of conditions including current water quality, treatment technologies, treatment goals, and potential property acquisition.

The major direct costs of using salt for winter maintenance and water softeners is incurred through the materials, equipment and labor. UW-Madison spends more than $358,000 annually on salt alone. Winter deicing can cause scaling and corrosion of infrastructure such as roads and buildings (Kaushal et al., 2018) as well as damage to vehicles.

Trophic cascades and eutrophication triggered by elevated chloride concentrations can decrease water clarity and the abundance of economically and recreationally important fisheries which can impact drivers of Wisconsin's economy such as fishing and tourism. Wisconsin ranks third in the country as a non-resident fishing destination and brings in billions of dollars of revenue from fishing-related equipment and economic activity (WDNR, 2019). Moreover, fishing is an important cultural activity. Fish such as walleye are a traditional staple of the Ojibwe, who hunt in the ceded territory in northern Wisconsin.

Section 3

CASE STUDIES: SUSTAINABLE SALT USE PRACTICES IN ACTION

Universities, hospitals, counties, apartment complexes and other entities are taking action to become more salt sustainable. The case studies listed in the table below describe water softening and winter deicing practices that can be implemented on the UW-Madison campus to achieve salt use reductions while maintaining public safety and infrastructural integrity.

Visit the Wisconsin Salt Wise Partnership website to discover more sustainable water softening and winter salting practices: https://www.wisaltwise.com/Case-Studies

Table 3.1. Sustainable practices implemented by local stakeholders.

Entity	Location	Sustainable Practices Implemented
Water Softeners		
UnityPoint Health – Meriter Hospital	Madison, WI	Meriter Hospital in Madison, Wisconsin, started using "Green Machines" in 2010 for the water used for heating and cooling at the hospital. These machines use electricity to condition the water rather than using salt-dependent ion exchange mechanisms. By doing this, the hospital has prevented 140 tons of salt from entering the sanitary sewer system (UnityPoint Health – Meriter, n.d).
Winter Salting		
Lucky/Steve Brown Apartments	Madison, WI	These apartments reclaimed brine from the building's water softeners to pretreat the walkways around the building in preparation for winter storm events. (Gresch, 2018)
Jefferson County Highway Department	Jefferson, WI	The Jefferson County Highway Department increased its use of brine to pretreat roads in the county and reduced salt use by 30–40% in one season. (Hinterthuer, 2019)
Illinois State University	Normal, IL	Made brine in a salt brine plant on campus in 2017. The grounds crew can make the brine mixture for half the cost of purchasing the brine from an external source. (Nelson, 2017)
Mayo Clinic	Rochester, MN	Sent staff to "smart salting" training offered by the Minnesota Pollution Control Agency and updated its salt use policies to use calibrated salt spreading equipment and only apply salt where and when it is needed. The new outdoor salt use policy has resulted in a 60% reduction in salt use. (Marohn, 2019)
University of Minnesota – Twin Cities	Minneapolis, MN	Uses a series of tunnels and skyways called the "Gopher Way" which allows university patrons to navigate campus during the winter months. (University of Minnesota, 2020)
Ryerson University	Toronto, ON	Piloted a brine project on its downtown campus in which a brine pretreatment was used on 20 locations across the campus in anticipation of winter storm events, resulting in a 20–60% reduction in salt use on campus roads and walkways. (WWF, 2019)

Section 4

COST ANALYSIS

Reducing the amount of salt used on campus not only has positive environmental impacts but will also result in cost savings for the university. Water softener salt, rock salt, and ice melt cost the university an estimated $358,320 each year (Table 4.1).

Table 4.1: Estimated annual cost of salt on UW-Madison's campus.

Material	Water softener salt	Rock salt	Ice Melt
Cost/ton	$326*	$78**	$326***
Tons/year (Sec. 10)	856	895	29
Annual Cost	$279,056	$69,810	$9,454
Total Cost	$358,320		

*Value obtained from Plumbing Shop purchasing records that show the cost of a 50-lb bag of water softener salt to be $8.15.
**Value obtained from Schmidt (2019) showing that a ton of rock salt cost $78 in 2019.
***Value obtained from residence hall and University Apartments purchasing records that show a 50-lb bag of ice melt to be $8.15.

Over the past two decades, the price of a ton of rock salt has increased by 260 percent, from $30/ton in 2000 to $78/ton in 2019 (Schmidt, 2019). With 895 tons of rock salt used during the 2018–2019 winter season, the campus spent an estimated $69,810 on rock salt. The direct cost of salt also includes labor, which is estimated to be $150 per ton of salt (Dindorf et al., 2014).

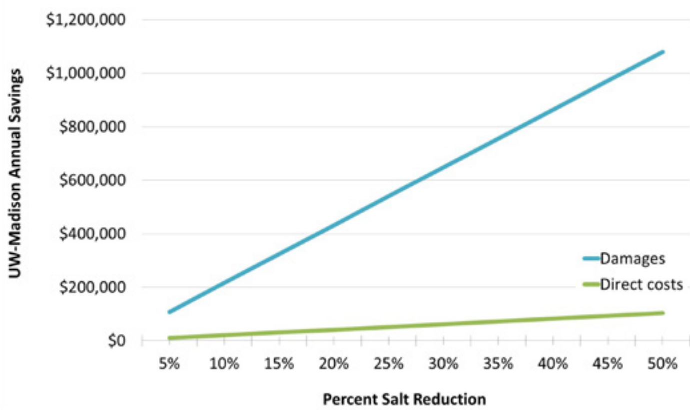
It is also important to include the damages associated with salt use, especially rock salt, when considering the current cost of salt on campus. Rock salt has corrosive impacts on infrastructure and vehicles, which can add up to major costs. Table 4.2 shows the range of damages rock salt can have. The values in this table are from a Minnesota report and are not specific to UW-Madison, but they demonstrate the magnitude of potential damages associated with rock salt use.
The environmental impacts caused by chloride pollution can also have negative economic impacts on the university. With increasing chloride levels in the surface waters on campus — Lake Mendota in particular — costs can begin to accumulate along with decreasing ecologic health.

Altogether, direct costs and the damages related to salt use on campus for the 2018–2019 winter season are estimated to be more than $2.3 million (Table 4.3). By reducing its annual rock salt use, UW-Madison could see significant cost savings (Figure 4.1). Specifically, by meeting the 25 percent reduction we are recommending in this *Blueprint*, the university would save approximately $600,000. This is an estimate, since the amount of rock salt needed and applied will vary each year, and the damage costs are not based on local studies; however, it is still indicative of the magnitude of potential savings that sustainable salt practices present.

Table 4.3. Damages and direct costs associated with rock salt use on campus.

Type of Cost	Cost per ton of salt	UW-Madison annual cost
Damages Cost*		
Extra road maintenance	$615	$550,425
Tree damage	$110	$98,450
Infrastructure damage	$1,460	$1,306,700
Ecosystem damage	$227	$203,165
Direct costs		
Labor*	$150	$136,500
Materials**	$78	$69,810
Total	**$2,640**	**$2,365,050**

*Dindorf et al. (2014)
**Schmidt (2019)



*Based on 2018–2019 salt use data
Figure 4.1. The direct and damages potential cost savings from reducing salt use on the UW-Madison campus.

Table 4.2. Damages per ton of rock salt. This table is adapted from a 2014 Minnesota Pollution Control Agency (MPCA) report titled "The Real Cost of Salt Use for Winter Maintenance in the Twin Cities Metropolitan Area."

Damages Cost	Extra road maintenance	Tree damage	Infrastructure damage	Ecosystem damage	Overall Cost
High Estimate	$615/ton	$110/ton	$1,460/ton	$227/ton	**$2,412/ton**

Section 5

RECOMMENDATIONS

Findings from our inventory, monitoring, and outreach efforts informed the development of a suite of recommendations for UW-Madison to implement in order to reduce its chloride contributions to the environment by 25 percent. Structural, policy and procedural, and institutional changes need to be made in conjunction with one another to effectively change how salt is used on the UW-Madison campus.

The following source-reduction strategies focus on reducing excessive salt use by increasing efficiency of campus practices and technologies without harming the soft water supply, campus plumbing infrastructure, or public safety. The actual reduction that can be achieved may surpass 25 percent, because opportunities like staff training and increased organization can contribute to more efficient salt use.

Structural Changes

Ensure that equipment and technology is operating as efficiently as possible and that UW-Madison stakeholders have the equipment and technology necessary to efficiently manage salt use.

UW-Madison does this in a variety of ways already. For example, Grounds utilizes anti-icing brine pretreatment ahead of imminent storms and closes redundant stairways during the winter.

However, while campus salt managers engage in activities that aim to economically use salt, sustainable salt use programs can be expanded to a greater extent on campus to incorporate additional best management practices. To address this gap, we recommend the following:

WATER SOFTENERS

- **Replace outdated and malfunctioning water softeners (Table 6.3).**
- **Optimize inefficient water softeners (Table 6.2).**
- **Upgrade manual controls on Walnut Street Heating & Cooling Plant water softeners.**
- **Pilot new water conditioning and salt-free technologies (Table 7.1).**
- **Record water softener efficiency so campus-wide comparisons of salt use efficiency can be made.**
- **Install brine reclamation systems at the Charter Street and Walnut Street heating and cooling plants (Table 6.7).**

WINTER DEICING

- **Close sidewalks and pathways to reduce salt application area (Tables 6.9 and 6.10).**
- **Fix problem areas where structural issues lead to icy pathways; for example, low spots in the sidewalk or downspouts discharging onto a sidewalk.**
- **Incorporate permeable pavement in parking lots across campus (Table 6.5).**
- **Construct storage for sand.**
- **Create tools and trainings for staff that can improve sidewalk salting efficiency (e.g., headlamps, pavement temperature readers, salt application devices capable of low application rates).**
- **Incorporate the use of brine pre-treatment for University Apartments winter maintenance practices, which has shown to reduce the need for rock salt by 20–30 percent (Fifield, 2017).**
- **Utilize water softener brine for anti-icing across campus.**
- **Reduce percent salt in salt/sand mixtures from ten to five percent (WisDOT, 2015).**
- **Post informational signage at closed sidewalks to inform patrons how this action can reduce salt use and benefit university infrastructure and the local environment.**

Policy and Procedural Changes

Establish salt management policies and procedures so that salt use can be managed comprehensively and cohesively across campus.

The University lacks a comprehensive salt management plan and consistent messaging about salt use

Because of the University's complexity and size, salt use tracking is currently siloed. UW-Madison salt managers have their own methods for managing and tracking salt use. Management policies and procedures vary from building to building and department to department. To address this gap, we recommend the following:

- **Require minimum efficiency performance standard of 4,000 grains/gallon (MMSD, 2015) for installation of new water softeners.**
- **Establish a new campus-wide outdoor salt use policy-and-procedure manual that incorporates the best management practices outlined in this *Blueprint*, including language specific to each department's responsibilities.**
- **Develop an official calibration protocol for each type of outdoor application equipment and determine a minimum frequency at which to check the calibration of the equipment.**
- **Institute a formal policy for salt use recording and reporting for water softening and road salt.**
- **Improve training for staff who apply winter salt and make management decisions (e.g., work with Wisconsin Salt Wise to make programming more accessible by adding training sessions for employees who work second or third shifts; share a winter application training video to all campus applicators and interested parties; use Canvas to track who has completed the training; and consider the organizational training certification from the City of Madison).**

Institutional and Management Changes

Institutionalize an emphasis on salt sustainability throughout university curriculum, management plans, research, and sustainability efforts and ensure that there are funds and staff to support this work.

The university already incorporates key environmental topics into campus curriculum, management plans, and research and sustainability efforts in innumerable ways on campus. For example, the Office of Sustainability runs the Green Fund, the university is enrolled in the STARS program, and the Nelson Institute for Environmental Studies has a diverse curriculum that incorporates stewardship of local natural resources.

However, a significant gap exists between these campus initiatives and sustainable salt use. Chloride pollution needs to be incorporated into the larger campus discourse in order to be able to effectively address this issue on campus.To address this gap, we recommend the following:

ACCOUNTABILITY & MANAGEMENT

- **Standardize salt use tracking for water softener management and for winter salting activities, and consolidate the salt use information into an annual salt use inventory that is reported to the Second Nature Resilience Commitment by the Office of Sustainability.**
- **Establish an annual meeting of salt applicators and managers to set salt reduction goals, check on progress, and update and adapt policies and procedures. Create annual reports from these meetings highlighting key findings to share with the university and public.**

- Utilize annual facility manager meetings to review salt management policies and procedures and share resources.
- Submit an annual progress report to the UW-Madison Office of the Chancellor. Such a report should also be shared with external collaborators (e.g. City of Madison, Dane County, Wisconsin Salt Wise).
- Manage expectations of university staff, students, and public patrons to gain support for salt reduction efforts by providing accessible, informative tools and signage (e.g., create and utilize "sidewalk closed" signs that inform patrons how the action reduces salt use; post online maps of closed pathways so pedestrians can plan alternate routes; and share a Salt Awareness Learning Tool (SALT)).
- Improve accountability by using the salt use inventory and Water Softener Inquiry Dashboard (Section 12) to update salt use data in real time, fill in gaps in knowledge, and make it accessible in one location to prioritize applications for funding and check progress of salt reduction initiatives. FP&M and building managers are encouraged to take ownership of these tools.

SYNERGIES WITH EXISTING CAMPUS RESEARCH & SUSTAINABILITY EFFORTS

- Launch a campus-wide campaign to improve knowledge and emphasize the importance of sustainable salt use using common messaging (e.g., "more salt use does not equal less ice").
- Incorporate chloride-related content into course curricula across departments and disciplines.
- Incentivize university labs and researchers to investigate chloride source reduction opportunities and effectiveness on campus.
- Amplify the current Water Conservation Campaign by the Office of Sustainability as a method for reducing the amount of soft water needed.
- Incentivize university labs, researchers, and students to continue chloride monitoring in Willow Creek, the 1918 Marsh, adjacent lakes, and storm sewer outlets.
- Support a research project to be funded by the Green Fund Program to quantify the relationship between water use and salt use as the foundation for the Water Conservation Campaign.
- Build partnerships between internal entities including the Office of the Chancellor, the Office of Sustainability, FP&M, and building managers, and external entities including Wisconsin Salt Wise and the City of Madison, in order to collaborate on research and share training and educational materials.
- Initiate an energy reduction campaign focused on heating and cooling to reduce salt used for boiling water that provides energy for campus (Table 6.8). This initiative could be included as a Sustainability Tracking, Assessment & Rating System (STARS) program initiative, campus dorm initiative, or other existing campus initiative.
- Add salt reduction initiatives to the list of potential Green Fund projects.

QUANTIFIED REDUCTIONS

In this section we break down the calculations and assumptions associated with the recommendations that had quantifiable reductions. These recommendations resulted in an estimated 25 percent annual reduction in salt use on campus (Table 6.1).

Opportunity	Annual Reduction in Salt Use (Pounds)
Optimizing softeners for efficient settings	274,463
Replacing manual, old, and inefficient softeners	203,731
Installing permeable pavement in 50% of parking lots	165,200
Implementing brine pre-treatment in University Apartments	84,000
Using a 5% sand/salt mix	54,000
Heating and cooling plant brine reclamation	50,000
25% energy reduction campaign	50,000
Sidewalk closures at University Apartments	8,112
Sidewalk closures on main campus	4,326
Total Reduction (Pounds)	**893,832**

Table 6.1. Summary of the potential calculable reductions in salt use that could be achieved if the actionable next steps outlined in this Blueprint are implemented on the UW-Madison campus. The total value represents 25 percent of the 3,560,000 pounds of salt used on campus in 2018–2019.

The reductions calculated in this Blueprint are based the total campus salt use for the 2018–2019 winter season for rock salt use and the 2018 calendar year for water softener salt use; a long-term average of the amount of salt used on the UW-Madison campus does not currently exist. Total salt use on campus varies annually due to winter weather conditions and campus demand for soft water. Since we only have salt use data for the 2018–2019 season, all of these calculations will be based on the assumption that average winter conditions would be similar to those of the 2018–2019 season.

Optimizing Water Softeners for Efficient Settings: 274,463-lb. Reduction

A 2016 water softener optimization study by MMSD found that optimizing residential water softeners resulted in a 27 percent reduction in salt use (MMSD, 2015). We used this percent reduction to calculate the estimated savings on the UW-Madison campus (Table 6.2). By optimizing all the water softeners that can be, the university could save roughly 274,463 pounds of salt per year.

Table 6.2. Savings from optimization.

Salt use from softeners not recommended for replacement (lbs)	Savings from optimization (lbs)
1,016,530.00	**274,463.10***

*Assumes that the average reduction from optimizing all softeners that have not been recommended for replacement would be 27 percent.

Replacing Old, Inefficient Water Softeners: 203,731-lb. Reduction

Replacing water softeners has shown a range of reduction potentials. For this section, we will show a high and low estimate of salt reduction achieved by taking action on the water softeners recommended for replacement (Table 6.3) based on the results of two studies (Table 6.4). The high estimate is from a case study conducted by Hellenbrand Water Center on an apartment complex (McDonald, 2016), which found a roughly 70 percent reduction in salt use from replacing the softener. The low estimate is from a water softener optimization study by MMSD (MMSD, 2015), which reported a 47 percent reduction in salt use.

Table 6.3. Campus water softeners recommended for replacement.

Water Softeners Recommended for Replacement	
Softeners 6–16 years old*	**Current salt use (lbs/year)**
Influenza Research Institute	9,600.00
Annex Service Building	9,504.00
Primate Annex	4,152.00
Wisconsin Energy Institute	1,860.00
McArdle	2,100.00
Taylor Hall	2,004.00
Morgridge Institute for Research (two softeners)	10,464.00
Agriculture Bulletin	2,496.00
DeJope (two softeners)	48,072.00
Porter Boat House	4,896.00
Union South	60,480.00
Softeners >16 years old**	
Walnut St. Heating and Cooling Plant	150,000.00
Bock labs (two softeners)	4,992.00
Waisman Center (two softeners)	30,000.00
McArdle (two softeners)	4,200.00
Jorns Hall	2,400.00
Recommended by FP&M	
WARF	1,000.00
UW Club	4,500.00
Ingraham	1,500.00
HC White	2,000.00
Pyle Center	2,000.00
Memorial Library	1,500.00
Engineering Centers	66,250.00
Grounds	500.00
Enzyme	7,000.00
Total (lbs/year)	**433,470.00**

Table 6.4. High and low reduction estimate.

Total salt use for softeners recommended for replacement (lbs)	High-estimate savings (lbs)	Low-estimate savings (lbs)
433,470.00	**303,429.00***	**203,730.90****

*Assumes that the average reduction from replacing all recommended softeners would be 27 percent.
**Assumes that the average reduction from replacing all recommended softeners would be 70 percent

Permeable Pavement in 50 percent of Parking Lots: 165,200-lb. Reduction

By replacing 50 percent of parking lots with permeable pavement, the university could save 165,200 pounds of salt annually. This percentage was chosen as a realistic long-term goal described in the UW-Madison Green Infrastructure and Stormwater Management Master Plan (2015). Research has shown permeable pavement only needs zero percent to 25 percent of salt routinely applied to normal asphalt (Selbig & Buer, 2018; Houle, et al. 2009). Therefore, calculations for the amount of salt saved per year are based on a 75 percent reduction as a low estimate.

Table 6.5. Potential reductions from replacing 50 percent of parking lots with permeable pavement.

Winter salt used per year in parking lots (lbs)	Salt saved per year (lbs)
440,700	**165,200***

*Assumes that the average reduction in salt for all permeable paved parking lots would be 75 percent.

Implementing Brine Pre-Treatment at University Apartments: 84,000-lb. Reduction

Utilizing brine pre-treatment has been found to reduce salt use by 30 percent (Fifield, 2017). Using this value, we found that University Apartments, which used an estimated 280,000 pounds of road salt in the 2018–2019 season, could save roughly 84,000 pounds of salt annually by applying brine pre-treatment before storms (Table 6.6).

Table 6.6. Savings from brine pre-treatment at University Apartments.

Road salt used by University Apartments (2018–2019) (lbs)	Salt saved per year (lbs)
280,000	**84,000***

*Assumes that University Apartments would only apply brine when appropriate. Also assumes that the 30 percent reduction seen in the Fifield (2017) study would be applicable at UW-Madison.

Using a 5 Percent Salt/Sand Mix

The university currently uses a 10 percent salt/sand mix for traction when temperatures are too low for salt to be effective at melting ice. During the 2018–2019 season, the university used 1,087,200 pounds of this mix, which equates to 108,720 pounds of salt. According to the Wisconsin Department of Transportation (WiDOT, 2015), an acceptable salt/sand mixture is defined as a 5 percent salt/sand ratio. By switching to a 5 percent mix, the university can reduce annual salt usage by 54,360 pounds.

Calculations:

1,087,200 *0.05 = 54,360 lbs of salt

Savings: 108,720 – 54,360 = 54,360 lbs of salt saved

Heating and Cooling Plant Brine Reclamation: 50,000-lb. Reduction:

Sweet brine reclamation recycles waste brine back to the water softener's brine tank in place of a portion of fill water and is then reused. MMSD reported that sweet brine reclamation systems reduce salt use by an estimated 25 percent (MMSD, n.d). By implementing sweet brine reclamation on both heating and cooling plants on campus, the university could save an estimated 50,000 pounds of salt annually (Table 6.7).

Table 6.7. Potential salt savings from brine reclamation at campus heating and cooling plants.

Heating and cooling plant	Amount of salt used (lbs/year)	Potential salt savings (tons/year)
Walnut Street	150,000	37,500
Charter Street	50,000	12,500
Total potential savings (lbs)		**50,000***

*Assumes that both heating and cooling plants would see a 25 percent reduction.

25 Percent Energy Reduction Campaign: 50,000-lb. Reduction

Heating and cooling plants use salt to soften the water used to produce steam. Combined, the two heating and cooling plants on campus use about 100 tons of salt per year, so by reducing energy consumption by 25 percent, we can reduce salt use at the plants by 25 tons, or 50,000 pounds (Table 6.8).

Table 6.8. Annual salt reduction from reducing energy used for heating and cooling on campus by 25 percent.

Total salt used at the plants (2018) (1bs)	Total savings (lbs)
200,000	**50,000***

*Assumes a 1:1 ratio between energy reduction and salt reduction.

Sidewalk Closures at University Apartments: 8,112-lb. Reduction

Table 6.9 shows the potential salt savings from closing sidewalks in the University Apartments neighborhood. Savings are based on an estimated application rate of 0.04 lbs/ft2 derived from the total amount of salt used over the whole neighborhood per application.

Table 6.9. Salt reduction potential from closing sidewalks in the University Apartments neighborhood.

Length of sidewalks (ft)	Area of sidewalks (ft²)	Applicatio n rate (lbs/ft²)	Salt saved per application (lbs)	Approximate number of applications (2018–2019)	Salt saved per year (lbs)
975	3900	0.04	156	52	**8,112***

*Assumes an average width of sidewalks of four feet.

Calculations:

- Length of path = 975 ft
- Sidewalk area = (975 ft) * (4 ft) = 3,900 ft2
- Application savings = (.04 lbs/ft2) * (3,900 ft2) * (52 applications) = 8,112 lbs/yr

Sidewalk Closures on Main Campus: 4,326-lb. Reduction

Table 6.10 shows potential salt savings from closing sidewalks on the main campus. Savings are based on an average pretreatment application rate of 5.75 lbs/1000ft2 and average dry application rate of 8 lbs/1000ft2 for a 25-degree day with snow (Fortin and Dindorf, 2012).

Table 6.10. Potential salt savings from closing sidewalks on the main campus.

Path number	Length of path (ft)	Sidewalk area (ft²)	Pre-treatment (lbs saved/year)	Dry application (lbs saved/year)
1	311	1244	286	398
2	308	1232	283	394
3	609	2436	560	780
4	174	696	160	223
5	137	548	126	176
6	137	548	126	176
7	77	308	71	99
8	115	460	106	148
9	115	460	106	148
10	115	460	106	148
11	115	460	106	148
12	125	500	115	160
13	149	596	137	191
14	88	352	81	113
15	88	352	81	113
16	112	448	103	143
17	600	2400	552	768
Total salt saved per year (lbs)			**3,105***	**4,326***

*Assumes the average width of sidewalks on campus is four feet (sidewalk lengths measured using Google Earth ruler tool); also assumes approximately 40 applications in 2018–2019.

Calculations:

– For path 1
- Length of path = 311 feet
- Sidewalk area = (4 ft) * (311 ft) = 1,244 ft2
- Pretreatment savings = (5.75 lbs / 1000 ft2) * (1,244 ft2) * (40 applications) = 286.12 lbs/yr
- Dry application savings = (8 lbs/1000 ft2) * (1,244 ft2) * (40 applications) = 398.08 lbs/yr

It is important to note that key recommendations listed in Section 5, including calibrating winter salt application equipment, utilizing campus water softener brine for anti-icing across campus, fixing problem areas where structural issues lead to icy pathways, and constructing storage units that would keep sand dry, would contribute additional reductions beyond the 25 percent reduction that could be achieved by implementing the recommendations described in this section. However, more information is required to develop estimates of their potential impact on campus salt use.

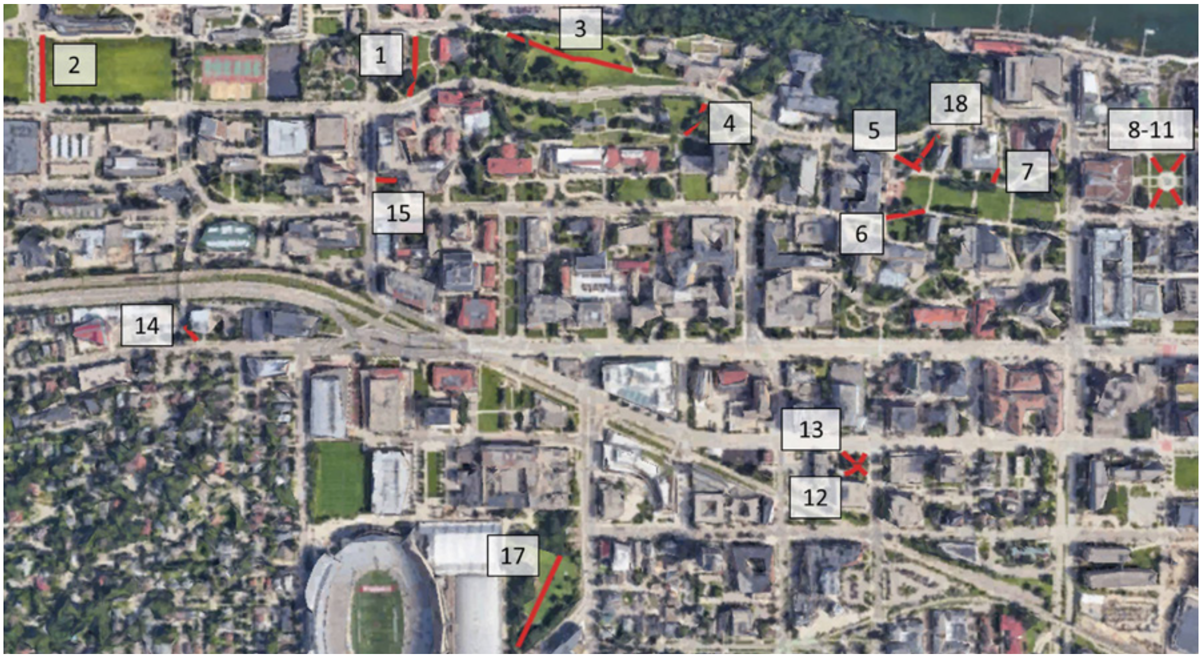


Figure 6.1. Map depicting the 18 sidewalk paths that could be potentially closed during the winter season.

Figure 6.2. Map depicting the paths in the University Apartments neighborhood that could be potentially closed during the winter season.

UNQUANTIFIABLE REDUCTIONS

While the structural recommendations outlined in this *Blueprint* (Section 6) would have quantifiable impacts on the amount of salt used by the university, other actions that cannot be quantified would likely result in additional reductions in salt use. The following recommendations aim to institutionalize an emphasis on salt sustainability throughout university curricula, management plans, research, and sustainability efforts.

Sources of chloride can be reduced by increasing staff and public awareness about salt sustainability (Section 10) and improving training for those who apply winter salt and make management decisions. While the Grounds employees are certified winter salt applicators, other staff on campus have no formal training. Having informed staff making decisions about salt application and application equipment calibration can reduce the amount of salt applied on campus roads, sidewalks, and parking lots. Case studies have found that training staff has the potential to reduce salt use by 30 percent (MPCA, n.d.; MPCA, 2017; NHDES, 2016).

Outdoor winter maintenance policies vary across campus departments and lack specific language that defines responsibilities and best management practices by departments. This *Blueprint* recommends the development of a comprehensive outdoor salt use policy for all winter maintenance managers on campus, specifying the responsibilities of each department. A formal, campus-wide winter salt use inventory will help paint a clearer picture of where and how winter salt is applied on campus. Further, sustainable salt use efforts can be reviewed during an annual meeting of all winter maintenance stakeholders (Figure 11.1) where the effectiveness of best management practices, equipment and technology, and policies can be reviewed to ensure the efficient use of salt.

Similarly, several different university departments manage water softeners (Figure 11.2). A formal, campus-wide salt use and equipment inventory tracking system, such as the online dashboards described in Section 12, would allow managers from different departments to keep records of the salt used by their water softeners as well as the efficiency and condition of the water softening equipment. An annual meeting of university water softener managers would allow them to prioritize actions for future improvements, discuss use and management of softened water, and explore ways to improve efficiency.

A key feature in these recommendations is the importance of filling knowledge gaps. Despite the inventory and monitoring efforts of this project, the amount of salt used on campus and where it is being used are not completely accounted for. It is essential to fill these knowledge gaps in order to have a more accurate understanding of the impact of implementing sustainable salt use practices and policies. Expanding research and monitoring efforts on campus to include chloride is one way to help accomplish this goal.

Improving public knowledge about sustainable salt use and incorporating salt sustainability into campus discourse, planning, research, and curricula will help increase support for sustainable salt use practices (Figure 7.1). These actions will be essential in reducing the university's salt use beyond the levels that can be achieved through the recommendations outlined in Section 6.

Figure 7.1. Example of signage to close sidewalks and stairways to encourage acceptance of changed salt use policies. The QR code connects patrons to this project's website for more information: https://nelson.wisc.edu/graduate/water-resources-management/salt-sustainability.php (Designed by Yangbo Peng).

ANALYSIS OF ALTERNATIVES

The following analysis provides considerations for alternatives to traditional water softening technologies and rock salts.

Water Softening Alternatives

Water softening is the process of removing hardness ions from water through ion exchange, using sodium ions derived from salt to displace calcium and magnesium ("hardness") ions. Water conditioning, on the other hand, can either remove the hardness ions or prevent them from forming scale by suspending them in the water. Water conditioning technologies offer salt-free alternatives to water softening (Table 8.1). Ion-exchange water softeners account for most of the water softeners on the UW-Madison campus; however, the campus also utilizes reverse-osmosis systems. The following section defines and compares alternative water conditioning technologies.

Captive deionization: An electric current is used to attract ions in the water to an anode and cathode with high surface areas. Ions are stored on the anode and cathode until the system is regenerated. A backwash and citric acid cleaning are required.

Electrically induced precipitation: An electric current is used to form a "soft precipitate" from dissolved hardness ions on an electrode. A backwash is required to flush the ions from the electrode.

Ion exchange: Salt is added to a brine tank, where it dissolves into sodium and chloride ions. The brine is added to a resin tank, where the sodium and chloride ions stick to resin beads. As hard water flows through the resin tank, the hardness ions are exchanged with sodium. The brine must be flushed out to regenerate the resin beads.

Magnetic treatment: A strong magnet is installed around a pipe to create a magnetic field. As water flows through the pipe, it passes through the magnetic field and the hardness ions form a "soft precipitate."

Table 8.1. Analysis of alternative water conditioning technologies. Data compiled from literature review (C3 Water Inc, 2015; Kotb & Aziz, 2013; Thomure & Fox, 2013; Water Resources Center, n.d.; WQA Magnetics Task Force, 2001).

Technology	Cost	Salt	Pros	Cons
Captive deionization	High	No	• Removes almost all hardness ions • No salt released to environment	• Unproven technology • Requires backwash and citric acid cleaning
Electrically induced precipitation	High	No	• Reduces scale build-up by 50% • No salt released to environment	• Unproven technology • Requires backwashing to clean electrode
Ion exchange	Moderate	Yes	• Effective at removing hardness ions • Technology is reliable • Easy to bypass fixtures to let hard water flow • Widely available and studied	• Releases salt into the environment • Requires frequent recharges • High long-term operating costs • Resin beads need to be replaced
Magnetic water treatment	Low	No	• May reduce scale build-up by up to 50% • No salt released to environment • Little to no maintenance	• Unproven technology
Nucleation-assisted crystallization	Low	No	• Comparable to ion exchange water softener; reduces scale build-up by 90% • No salt released to environment • Does not require backwashing • Less maintenance • Reduces energy costs	• Less effective with very hard water • Limits scale build-up but does not remove hardness • Can be damaged by chemical impurities • May require a filter • Media must be replaced every three years • No ANSI* standards for testing effectiveness
Reverse osmosis	High	No	• Effective at removing hardness ions and providing continuous soft water • No salt released to environment • Systems are effective at small or large scales	• Regular filter changes needed • Requires a lot of water

*American National Standards Institute

Nucleation-assisted crystallization: Hardness ions accumulated on a nucleation-assisted crystallization media and are crystallized. The hardness ions are converted to microscopic crystals and are suspended in the water.

Reverse osmosis: A sequence of membranes and filters remove hardness ions and other contaminants from the water.

Winter Deicing Alternatives

Rock salt is applied to roads and sidewalks in the winter to melt ice and allow for safe commuting on campus. Alternative methods to improve winter road conditions include the use of organic and chemical substances. The following section describes and compares some of more widely used alternatives (Table 8.2). However, these alternatives are generally not recommended due to obvious drawbacks.

Table 8.2. Analysis of winter salting alternatives. Data compiled from literature review. (Rubin et al., 2010; Fay & Shi, 2011; Chappel, 2014)

Alternative	Cost	Salt	Pros	Cons
Sweet beet juice and brine	Low	Low	• Reduces amount of road salt required • Allows melting at lower temperatures • Less corrosive	• Beet juice contains sugar that can be consumed by aquatic organisms and lead to poor water quality
Liquid cheese brine	Low	No	• Increases melting • Increases brine effectiveness	• Can add excess nutrients to water bodies, resulting in poor water quality
Acetate-based deicers	High	No	• Increases ice melting at lower pavement temperatures	• Unproven technology • Harmful to aquatic insects
Sand	Low	No	• Creates traction	• Does not lead to ice or snow melt • Can lead to excessive sedimentation of water bodies

Section 9

LOCAL FUNDING OPPORTUNITIES

Supplemental funding opportunities could be used to alleviate some of the economic challenges associated with the implementation of several of the recommendations in this *Blueprint*. For example, FP&M replaces water softeners when they have the funds but with supplemental funding, they could replace and optimize additional softeners which would result in a significant decrease in salt use and chloride contributions to our freshwater resources. This section summarizes various funding opportunities in the area that could be used to assist in the implementation of salt reduction opportunities (Table 9.1).

Table 9.1. Local funding opportunities that can aid in reaching salt reduction goals.

Funding Opportunity	Description
Chloride Reduction Grant Program	Madison Metropolitan Sewerage District offers grants and rebates that incentivize projects that help advance their chloride reduction goals. Funding is available for softener replacement and optimization, road salt reduction practices, and innovative projects that reduce chloride contributions to the sewer system. https://www.madsewer.org/Programs-Initiatives/Chloride-Reduction/Chloride-Grants
Dane County Environmental Council	The Dane County Environmental Council annually distributes grants focused on implementing environmental initiatives that enhance Dane County environmental resources and benefit residents. Grants are available for both educational efforts and capital investments. https://environmentalcouncil.countyofdane.com/grants.aspx
Green Fund	The Green Fund is an initiative by UW-Madison's Office of Sustainability. The fund supports student-led projects that address opportunities for environmental sustainability on a campus scale. https://sustainability.wisc.edu/greenfund/
Urban Water Quality Grant Program	This program, sponsored by Dane County, makes cost-share funds available for projects focusing on improving the quality of storm water runoff that enters Dane County streams, rivers, and lakes. Funds can also be used to support public awareness and education of water quality issues and improvement practices. https://wred-lwrd.countyofdane.com/assistance/uwqg

Section 10

LEARNING TOOLS

Linked below are two learning tools developed to help spread awareness of salt sources, pathways, and effects as well as how to correctly apply salt in the winter.

Salt Awareness Learning Tool (SALT)

To improve awareness of the sources, pathways, and costs of salt overuse and associated solutions, an interactive graphic, called the Salt Awareness Learning Tool (SALT), was created. SALT will be posted on the MMSD website, available for other organizations to share on their platforms to improve knowledge at a larger scale.
www.maps.aqua.wisc.edu/salt/

Winter Salting Guide Videos

Through conversations with the custodial department, we determined that the staff would benefit from an updated and more UW-Madison-focused salt applicator training video. We created a new video to improve knowledge about the effects of salt overuse and to demonstrate proper techniques for winter sidewalk maintenance and salt application. The video also improves accessibility by including subtitles in the most common languages spoken by custodial staff: English, Spanish, Tibetan, Hmong, and Nepali. *The Winter Salting Guide for Maintenance Professionals* can be viewed on the Wisconsin Sea Grant *YouTube* channel:
www.youtube.com/watch?v=Ok-9gH722Zno&t=5s

We produced a second video to help homeowners, businesses, and interested individuals to reduce salt use at an individual level. *The Winter Salting Guide for Homeowners* is also available on the Wisconsin Sea Grant YouTube channel:
www.youtube.com/watch?v=ct04luWoplM&t=3s

Section 11

INVENTORY RESULTS

The results of the campus-wide salt use inventory are described below including the network of salt managers on campus and how they interact with each other as well as each salt use managers primary responsibilities, total salt use, current practices, opportunities for improvement, and barriers to using salt more sustainably. The two key steps of conducting the campus-wide salt use inventory were (1) identifying the network of stakeholders and (2) quantifying salt use on campus.

Identifying Stakeholders

To develop this *Blueprint*, we first had to determine the network of stakeholders who use and manage salt on the UW-Madison campus, their roles and responsibilities, and how they interact with each other. We conducted interviews with each stakeholder involved in salt use decision-making which enabled us to detail the locus of control. Figures 11.1 and 11.2 illustrate the network of stakeholders responsible for the application of winter salt and the management of water softeners, and where any interaction might occur.

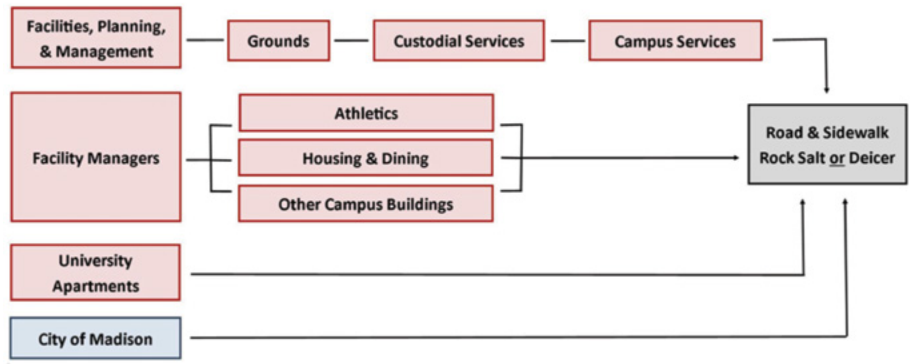


Figure 11.1. Campus programs that apply rock salt/deicer in the winter.

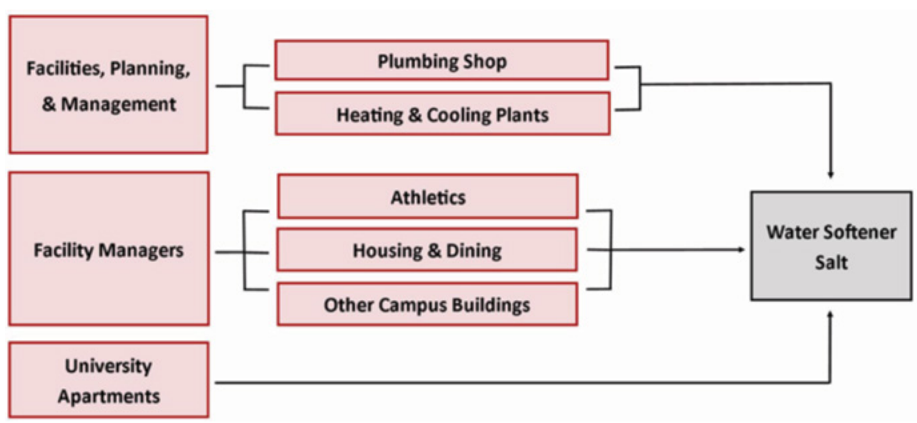


Figure 11.2. Campus programs that manage water softeners.

Quantifying Salt Use on Campus

Our next step was to determine the amount of salt being used and where it was being used on campus. To do so, we created and distributed a survey to facility managers on campus to inquire about salt use in their buildings and details about the water softeners such as their make, model, and age. The survey included questions about winter maintenance protocols and salt use. The FP&M Plumbing Shop supplemented our survey by providing us with water softener records for the buildings they oversee. Additionally, Grounds provided records of their salt use for the 2018-2019 winter season. We compiled all this information into a single spreadsheet in order to organize all campus salt use data in one place. This spreadsheet was used to calculate the total amount of salt used on the UW-Madison campus and as input data for our interactive, online geographic information system (GIS) dashboards. More details about the GIS dashboards can be found in Section 12.

Figure 11.3: Cohort members looking at the salt stored by the Physical Plant in the Environmental Services shed on Herrick Drive. Photo Credit: Yangbo Peng

Total Salt Use

The total known amount of salt used on the UW-Madison campus is 3.56 million pounds during the 2018–2019 school year for winter deicing and water softening purposes (Figure 11.3). For context, this amount is enough salt to pollute the entirety of Lake Wingra to the EPA's chronic limit of 230 mg/L of chloride. Due to gaps in knowledge, this likely underestimates the actual amount of salt used on campus.

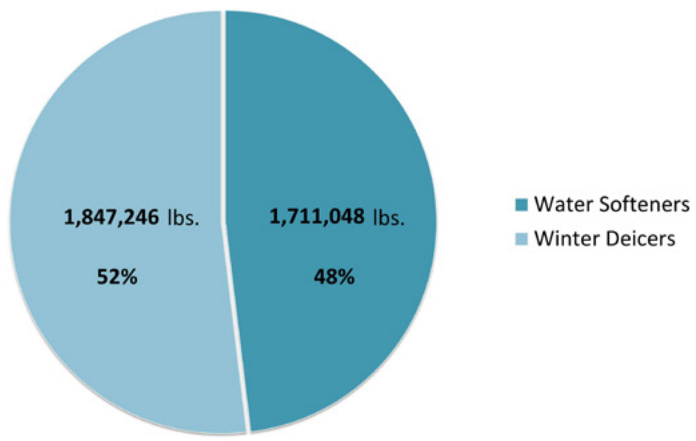


Figure 11.4. UW-Madison's total salt use broken down by water softeners and winter deicers including rock salt and ice melt

Water Softener Salt Use

The stakeholders responsible for managing water softeners used approximately 1.712 million pounds of salt in 2018 to produce soft water for the UW-Madison campus (Figure 11.4).

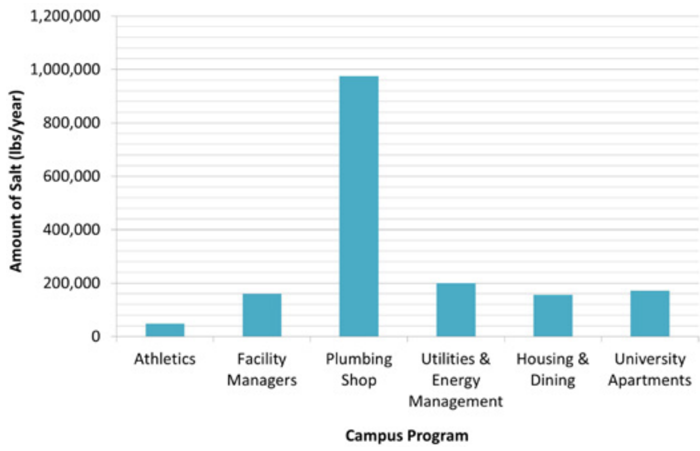


Figure 11.5. UW-Madison's water softener salt use in 2018.

PLUMBING SHOP

The FP&M Plumbing Shop currently manages 169 water softeners on campus. Managers of buildings that have these water softeners submit purchase requests for salt, which is often ordered in bulk quantities. Currently, all purchasing and salt use data is kept in paper form. One Plumbing Shop staff member is responsible for delivering pallets of water softener salt to each building and refilling the softeners based on a predetermined bi-weekly or monthly schedule. The Plumbing Shop plumbers are all certified through the State of Wisconsin.

The Plumbing Shop must balance salt consumption with the services that they supply to the campus. Soft water is used to limit damage caused to plumbing infrastructure by hard water. The Plumbing Shop replaces water softeners with more efficient models when funds are available. Most of the salt reductions achieved by the Plumbing Shop

Table 11.1. Water softeners and salt usage managed by the FP&M Plumbing Shop.

FP&M Plumbing Shop	
What the campus program manages	169 campus water softeners
Managers	Certified plumbers
Uses of salt	Softened water for • Domestic (e.g. sinks or showers) • Commercial dishwashing • Commercial laundry • Boilers • Cooling towers • Industrial process • Rinse water • Laboratory • Reverse osmosis systems
Amount of salt used in 2018	974,000 lbs
Current salt sustainability practices	Replace old, time-based regeneration, or inefficient water softeners as the budget allows
Opportunities	• Water softener replacement • Water softener optimization • Improved record keeping
Constraints	• Funding • Balancing consumer needs, protecting university infrastructure, and salt sustainability

result from updating water softeners to newer, more efficient models with automatic, demand-initiated regeneration controls. In the past, the Plumbing Shop has leveraged rebate funding from MMSD to make updating campus water softeners more affordable.

UTILITIES AND ENERGY MANAGEMENT

At the Charter Street plant, all salt used for water softening stays in the plant for "boiler water makeup." Softened water is used in the boilers that generate steam to prevent scale build-up in pipes. At the Walnut Street plant, softened water is sent to and used at UW Hospital. The Walnut Street plant stopped using its own softened water for boiler make-up in 2015; that supply comes from the West Campus Cogeneration facility. Steam from the heating and cooling plants is distributed to campus buildings via a network of underground pipes. Softened water is not used in the cooling towers at either of the plants; both the Charter and Walnut Street plants use treated water from Lake Mendota in their cooling towers.

In 2013, the water softeners at the Charter Street plant were replaced and updated with models that use automated Zeolite controls. Two of the water softeners at the Walnut Street plant are more than 40 years old and the other two are more than 30 years old. Industrial water softeners need to be replaced about every 30 years. The Walnut Street plant water softeners are currently controlled manually.

Both plants receive 25 tons of salt at a time; the Charter Street brine tank is filled once per year and the Walnut Street plant's tank is filled three times per year. Operators periodically check the resin in the softeners and repair or replace the resin beads to keep them operating efficiently. Water hardness is tested at every shift to help determine how many gallons can pass through the softener before it needs to regenerate. At the Walnut Street plant, 200,000 gallons of water go through the water softeners between regenerations. Both plants have three back-up water softeners for redundancy.

The plants supply the steam and chilled and softened water to the university. The plants can conserve salt if energy demand is reduced. In the future, FP&M Utilities & Energy Management is looking to keep the brine waste from the Walnut Street plant for use as a pre-treatment for winter deicing on campus. The department also suggested reclaiming "sweet brine" to be reused in the softeners.

Table 11.2. Salt usage by FP&M Utilities & Energy Management.

FP&M Utilities & Energy Management	
What the campus program manages	Two heating and cooling plants
Uses of salt	Softened water for boiling water used to generate steam
Amount of salt used annually	200,000 lbs/year
Current salt sustainability practices	• Test and replace resin as it degrades • Updated Charter Street softeners to more efficient models in 2013
Opportunities	Water softener replacement Reduce campus energy use • Increase the amount of cogeneration on Campus • Add an additional steam generator to make more energy • Add additional chillers at the Charter Street Plant • Install a thermal storage tank at the Charter Street Plant
Constraints	• Funding • Balancing consumer needs, protecting university infrastructure, and salt sustainability

HOUSING AND DINING

University Housing currently manages 26 water softeners in the Southeast Residence Halls, Lakeshore Residence Halls, and dining facilities. A mechanical maintenance team is responsible for maintaining the softeners in these areas. The team purchases softener salt from Kreger Salt Sales and bulk salt from Compass Minerals for bulk tanks that make salt brine.

Sellery and Dejope residence halls both have bulk brine tanks that serve multiple buildings. In the Southeast area, the Sellery brine tank provides liquid brine to water softeners located in Sellery Hall, Ogg Hall, Witte Hall, Smith Hall, and the Gordon Dining & Event Center. In the Lakeshore area, the Dejope Hall brine tank provides liquid brine to softeners located in Dejope Hall, Phillips Hall, and Four Lakes Dining. Both Sellery and Dejope use demand-initiated regeneration controls.

Other buildings, such as Kronshage, Tripp, and Adams residence halls, provide soft water to neighboring buildings that do not have water softeners. Kronshage feeds soft water to all houses of Kronshage Hall, Cole Hall, and Sullivan Hall. Tripp and Adams feed soft water to each of their respective houses.

Table 11.3. Water softeners and salt usage in housing and dining facilities.

Housing and Dining	
What the campus program manages	26 water softeners from residence/dining halls in Southeast and Lakeshore areas
Uses of salt	Domestic water use (e.g. showers, sinks)
Amount of salt used in 2018	Approximately 156,000 lbs
Current salt sustainability practices	Use low flow faucets Emonix Controls • Used in some of the larger buildings • Saves on average about 30% salt usage Some remodeled buildings are LEED Certified
Opportunities	Humphrey Hall water softener replacement • 15-20 years old • Will be replaced sometime this year
Constraints	Dining halls' salt usage is difficult to determine as they share brine tanks with residence halls

UNIVERSITY APARTMENTS

As part of a capital improvement project, all water softeners serving University Apartments were updated in 2013 to Capital Windsor models that were more efficient and used less salt. University Apartments buildings are divided into zones, and a mechanic assigned to each zone is responsible for filling the water softeners. The average bag count per month for the entire University Apartments community is 285 fifty-pound bags. The softened water supply is used for domestic purposes such as faucets and showers. Reducing the amount of water softener salt used could result in the shortened lifespan of plumbing equipment.

Table 11.4. Water softeners and salt usage at University Apartments.

University Apartments	
What the campus program manages	Approximately 100 residential water softeners
Uses of salt	Domestic water use (e.g., showers, sinks)
Amount of salt used in 2018	Approximately 172,000 lbs
Current salt sustainability practices	2013 capital improvement project replaced all water softeners with Capital Windsor models
Opportunities	Water softener optimization
Constraints	• Funding • Balancing consumer needs and salt sustainability • Damage to plumbing infrastructure from hard water

UW ATHLETICS

The UW-Madison Department of Athletics is responsible for the four water softeners in its facilities. Camp Randall Stadium accounts for the greatest usage of water softener salt. LaBahn Arena and the Kohl Center share a softening system in which LaBahn receives soft water from Kohl Center. In addition to regular plumbing, soft water uses include ice hockey rink water as well as a cooling tower.

Table 11.5. UW Madison Department of Athletics water softeners and salt usage.

Athletics	
What the campus program manages	Four water softeners
Uses of salt	• Domestic water use (e.g. showers, sinks) • Cooling tower • Jet ice/hockey sheet water
Amount of salt used in 2018	Approximately 54,000 lbs
Current salt sustainability practices	• Low flow faucets • Low flow showerheads

FACILITY MANAGERS

In buildings that are not managed by the FP&M Plumbing Shop, individual facility managers are responsible for ordering water softener salt and ensuring that the water softeners' brine tanks are filled. Facility managers do not need to be certified plumbers. Record keeping is inconsistent among facility managers; some keep detailed purchasing and maintenance records and others have very few or no records for salt purchases and equipment condition.

Table 11.6. Water softeners and salt usage under individual facility managers.

Facility Managers	
What the campus program manages	Water softeners not managed by FP&M Plumbing Shop
Uses of salt	Softened water for • Domestic (e.g. sinks or showers) • Dishwashing • Laundry • Industrial process • Rinse water • Laboratory • Reverse osmosis systems
Amount of salt used in 2018	Approximately 160,000 lbs
Current salt sustainability practices	No cohesive salt sustainability practices across facility managers
Opportunities	• Water softener replacement • Water softener optimization • Improved record keeping
Constraints	• Funding • Balancing consumer needs and salt sustainability • Damage to plumbing infrastructure from hard water

Winter Deicing

The stakeholders responsible for winter deicing used approximately 1.79 million pounds of salt during the 2018–2019 season on UW-Madison campus roads, sidewalks, stairs, and entryways (Figure 11.5). Additionally, these campus programs used 58,000 pounds of ice melt during the 2018–2019 winter season.

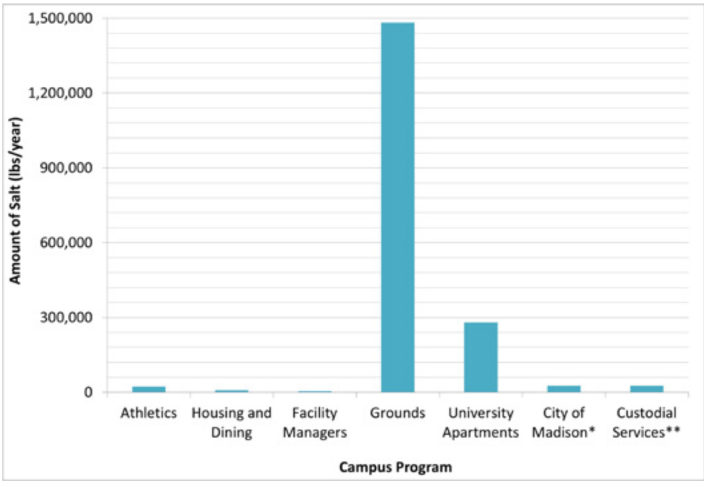


Figure 11.6. UW-Madison's 2018–2019 winter salt use including rock salt and ice melt.
*Estimate of the amount of rock salt spread on campus by the City of Madison, assuming an average temperature of 25° F, 33 storm events in Wisconsin in 2018–2019, and one application per storm event.
**Custodial Services does not track the amount of rock salt it uses.

GROUNDS

The FP&M Grounds department consists of 43 people — four are supervisors, one is a landscape architect, and the remaining 38 comprise a single crew that maintains all of UW-Madison's major roadways, walkways, and stairways. The Grounds crew clears snow from, and applies salt to, all roads that are not maintained by the City of Madison, in addition to the main campus sidewalks and stairways. Sidewalks and stairs leading to buildings are often covered by other departments such as Custodial Services, Waste & Recycling, or Housing & Dining. Grounds provides bulk salt, purchased by the ton, to Custodial Services, Waste & Recycling, and UW Athletics. UW Athletics pays Grounds for the salt. Grounds contracts Daniels Construction to clear main roadways and parking lots with large snowplows, but these contractors do not spread any road salt. Daniels Construction has 20 to 30 people who do the plowing around campus.

All Grounds crew members are certified by Wisconsin Salt Wise. Supervisors communicate general advice on what type of deicing material to use on a given day and whether to apply salt or wait until the end of a snowstorm. At temperatures of 15° F or lower, Grounds will apply a 10 percent salt/sand mixture to create traction on the roads and walkways. Grounds has implemented a road salt reduction initiative in which crew members apply liquid brine acquired from Dane County to pretreat some roads and sidewalks. Parking lots are cleared by Daniels Construction and then salted by the Grounds crew.

The Grounds crew clears snow and applies rock salt with a variety of equipment; hand-spreading of salt is rarely done. Grounds tries to keep equipment up-to-date and well-kept. Future purchases might include newer road sanders that have digital controls for the spreaders to help more efficiently spread the material.

Grounds must maintain a balance between salt conservation and public safety. The City of Madison requires the campus to attempt to clear snow and apply salt within 24 hours of a snowfall. Crew members typically have the UW-Madison campus cleared several hours after a snowfall, usually before students arrive for morning classes. If more sidewalks and stairways on campus could be closed without increasing liability, the amount of salt applied during winter could be reduced. Additionally, capital improvement projects such as heated entryways would reduce the need for salt to be applied adjacent to building entryways and walkways.

Table 11.7. FP&M Grounds responsibilities and salt usage.

FP&M Grounds	
What the campus program manages	Campus roads Major sidewalks and
Uses of salt	Winter deicing
Equipment	Pretreatment: • ATVs Salting: • Road sanders like the county has for main roadways • Pickup trucks with smaller sanders for main sidewalks • Tool cats for narrow sidewalks on campus • N-beam machine for the small sidewalks on campus • Hand salting for steps Snow removal: • Trucks fitted with snowplows • ATV with snowplow attachment • ATV with brush attachment
Amount of salt used during the 2018–2019 season	1.482 million lbs
Current salt sustainability practices	• Brine pretreatment • Replacing and updating equipment as needed
Opportunities	• Close sidewalks • Improved calibration protocols
Constraints	• Funding • Balancing public safety and salt sustainability

CUSTODIAL SERVICES

FP&M Custodial Services crews clear snow and then salt sidewalks, entryways, stairways, and ramps leading to building entrances. Custodial Services obtains rock salt from the Grounds bulk stock. Custodial Services also uses Iceaway Turbo magnesium chloride and Peladow calcium chloride ice melt products when temperatures are too low for rock salt to be effective. All deicer is purchased separately from Grounds. Custodial Services does not apply any sand because of the associated in-building clean up. For snow removal and salt application, third-shift crews attend to all of campus, second-shift crews attend to their assigned buildings, and first-shift crews are a response team that services all of campus. Supervisors determine when crews apply salt; disability access and building entrances are cleared first. The university's snow removal manual has not been updated since 2014 and does not contain protocols specific to the services by custodial crews.

An informal system exists for building managers to request five-gallon buckets of salt from Custodial Services to be made available at building entrances. Custodial Services also supplies rock salt and deicers to Campus Services if needed. There is no formal reporting system for how much bulk salt Custodial Services uses or how much rock salt is requested by facility managers.

The current custodial workforce includes approximately 400 custodians, about one-third of whom do not speak English as their first language. Though custodians are taught English as a Second Language (ESL) on the UW-Madison campus, a language barrier exists for communicating application protocols. Custodial Services does not certify their crew members through the Wisconsin Salt Wise program. Currently, Custodial Services uses a video from the Minnesota Pollution Control Agency to train crew members. The applicator training video is outdated, not specific to UW-Madison's campus, and is only offered in English.

Table 11.8. FP&M Custodial Services deicing responsibilities and salt usage.

FP&M Custodial Services	
What the campus program manages	Sidewalks adjacent to buildings Building entrances Ramps and stairways leading to building entrances
Uses of salt	Winter deicing
Equipment	Snow/ice removal: • Shovels • Scrapers • Kubotas • Toro Ground Masters • Salt application: • Hand broadcasting
Amount of salt used during the 2018–2019 season*	No available information
Amount of deicer used during the 2018–2019 season*	26,000 lbs
Current salt sustainability practices	Snow removal before salt application
Opportunities	• Improved training video offered in multiple languages • Get staff Wisconsin Salt Wise certified • Improved record keeping • Update campus snow removal policy
Constraints	• Language barriers • Balancing public safety and salt sustainability • Staff turnover

*Includes rock salt and deicer used by Campus Services.

CAMPUS SERVICES

Campus Services only uses salt or ice melt provided by Custodial Services at campus buildings. Campus Services does not purchase rock salt or ice melt; their winter salt use is included in Custodial Services totals. Campus Services truck crews do not apply any salt or ice melt in the winter. Staff are shown the winter salt applicator training video that was made by the Minnesota Pollution Control Agency.

HOUSING AND DINING

For winter deicing, University Housing manages the areas of Southeast Residence Halls, Lakeshore Residence Halls, and the dining facilities. The housekeeping and grounds maintenance team is responsible for applying a commercial ice melt composed of sodium chloride and magnesium chloride to entryways of buildings. They only apply this in icy or slippery conditions and do not use it to eliminate snow buildup. They purchase this ice melt from Kreger Salt Sales. In addition, Custodial Services supplies barrels with a salt/sand mixture to some high-traffic housing and dining locations where ice accumulates quickly, including areas with inclined concrete pads or steps.

UNIVERSITY APARTMENTS

University Apartments directs its grounds crew under its own "Snow Removal Procedures Manual," which is updated annually. The University Apartments grounds crew oversees snow removal and deicing for the parking lots, Eagle Heights Drive, sidewalks, and walking

Table 11.9. University Housing deicing responsibilities and salt usage.

Housing and Dining	
What the campus program manages	Entryways of residence/dining halls in Southeast and Lakeshore areas
Uses of salt	Winter deicing
Equipment	Salt application: • Spreader
Amount of deicer used during the 2018–2019 season	8,000 lbs
Current salt sustainability practices	• Deicer is not used to eliminate snow buildup • Using new equipment

paths on the University Apartments neighborhood. Custodial staff assist with these responsibilities as needed. The procedures manual outlines protocols for snow and ice removal in different zones on the University Apartments neighborhood and identifies priority zones for snow removal and salt/sand application.

Residents can file a work order to address slippery conditions. When a work order is received, the University Apartments' Apartment Facilities-Trades and Grounds staff responds and takes appropriate action at the site. The Assistant Director of Trades and Grounds and several other University Apartments grounds personnel have taken the Dane County calibration course, but no staff is a certified applicator through the Wisconsin Salt Wise program. The "Snow Removal Procedures Manual" does not specify any salt application rates because equipment is frequently replaced and the condition of the salt in their stockpile changes the way equipment is calibrated. The University Apartments grounds crew has a policy of applying salt down to bare pavement. Currently, University Apartments shuts down one major walkway during the winter.

The community includes families and elderly persons. Having clear pavement is a priority for University Apartments because it is a school route for children. While University Apartments grounds has a "salt on bare pavement" policy, some of the brushing equipment is

Table 11.10. University Apartments deicing responsibilities and salt usage.

University Apartments	
What the campus program manages	Eagle Heights Drive All sidewalks and building entryways within the University Apartments neighborhood
Uses of salt	Winter deicing
Equipment	Snow/ice removal: • Skid steers with buckets • Trucks with plows • Snow blowers • Scrapers • Shovels Salt application: • ATVs with broadcast salters • Cups for hand broadcasting
Amount of salt used during the 2018–2019 season	280,000 lbs
Current salt sustainability practices	• Snow removal before salt application • Update equipment as needed
Opportunities	• Add Ventrac SSV brooms to fleet for sweeping in small spaces • Get staff Wisconsin Salt Wise certified • Close additional sidewalks • Build storage unit for Turbo sand • Conduct outreach to residents about what conditions to expect in the winter
Constraints	• Unique community layout makes using some equipment challenging • Balancing public safety and salt sustainability • Managing customer expectations

inadequate for snow removal in the small spaces between buildings. Moreover, University Apartments would like to incorporate the use of Turbo sand into its winter maintenance procedures but does not have an adequate location to store the sand if they were to purchase it.

UW ATHLETICS

UW Athletics is responsible for clearing snow and applying salt to the sidewalks and entryways adjacent to its athletic facilities and sports complexes. The LaBahn Arena, Kohl Center, and Porter Boathouse use calcium chloride pellets instead of rock salt. Camp Randall Stadium uses a combination of magnesium chloride and calcium chloride deicer.

Table 11.11. UW-Madison Department of Athletics deicing responsibilities and salt usage.

Athletics	
What the campus program manages	Sidewalks and entryways next to athletic facilities and sports complexes
Uses of salt	Winter deicing
Equipment	Salt application: • Hand spreading • RTV spreader • Temperature ranges
Amount of deicer used during the 2018–2019 season	Approximately 22,000 lbs
Opportunities	Attend annual meeting of all UW-Madison outdoor salt applicator programs

FACILITY MANAGERS

Facility managers apply rock salt or ice melt to building entryways or stairs leading to the building(s) they manage. Facility managers can purchase their own rock salt and ice melt, or they can ask Custodial Services to leave a five-gallon bucket of salt in the entryways of their building(s). There is no formal system for recording how much salt they request from Custodial Services or purchase themselves.

Some facility managers do not apply salt beyond what is applied by Custodial Services. Others use shakers or hand-held broadcast spreaders to spread rock salt in front of their buildings. Some managers indicated in our survey that they use temperature ranges to determine when to apply salt, while other facility managers indicated that they did not use any application protocols. None of the facility managers that responded to our survey are certified winter salt applicators. Some facility managers expressed interest in becoming certified, while others expressed disinterest.

Table 11.12. Deicing responsibilities and salt usage of facility managers.

Facility Managers	
What the campus program manages	Entryways to the building(s) they manage
Uses of salt	Winter deicing
Amount of salt used during the 2018–2019 season	4,000 lbs
Amount of deicer used during the 2018–2019 season	6,000 lbs
Current salt sustainability practices	Using temperature ranges to determine when to apply salt
Opportunities	• Develop a protocol for applying salt • Attend Wisconsin Salt Wise applicator training • Improved record keeping

CITY OF MADISON

City of Madison snowplows apply salt to Park Street and University Avenue on campus. The southern segment of Park Street changes from a four-lane to a two-lane road as it runs north through campus. University Avenue is a four-lane road. The segments of these major roadways that run through the UW-Madison campus total about three-quarters of a mile. Assuming an average application rate of 300 pounds per lane mile and one application per winter storm event, city trucks apply approximately 9,520 pounds to these segments of road per year. This is likely an underestimate because the calculation assumes that salt is only applied once for every winter storm event and does not consider multiple applications per storm or applications that may take place in the days following a storm event.

Section 12

HOW TO USE GIS SALT TRACKING DASHBOARDS

The Water Softener Inquiry Dashboard, developed by the 2018–2020 WRM cohort, is based on geographic information systems, or GIS, to spatially display data. The Water Softener Inquiry Dashboard (Figure 12.1) provides a snapshot of the current conditions of water softeners on the UW-Madison campus and can be used as an educational and decision-making tool for softener managers. Data from the inventory was entered into a survey using the Survey 123 app on ArcGIS Online, which created a map layer with point data representing each water softener. This map layer was then used to create the dashboard, which would display the data with a spatial component. The data within the dashboard can be updated by editing the entries in the survey, and the dashboard itself can be edited through ArcGIS Online; the dashboard is accessible for managers via a link (www.arcg.is/0THjXu). As seen in Figure 12.1, the location of water softeners on the UW-Madison campus are represented by the data points on the map, and all the known data for each water softener can be seen on the righthand side in the details box. Key data such as softener age and monthly salt use has been pulled out in separate boxes because this data can be used to determine which softeners should be considered for replacement or optimization.

When the dashboard is opened, the user can select which managing group they want to view data for from the dropdown menu, as seen at the top right corner of Figure 12.1. This will alter the map of softener locations, along with the other data boxes, to only show the data points relating to that specific managing group. This makes it easier for the user to identify the softeners managed by each group and can allow for easier comparison of equipment characteristics such as salt use, efficiency, and age.

The dashboard should be shared with all water softener managers on the UW-Madison campus so they can see how their softeners compare to others in terms of monthly salt use and efficiency. The dashboard should be managed by an employee within the Office of Sustainability to ensure that the inventory and dashboard are updated on an annual basis, so the snapshot of conditions remains current.

In addition, the Winter Salt Bucket Inventory Dashboard (Figure 12.2) provides a snapshot of where five-gallon buckets filled with salt are utilized throughout the winter across campus by facility managers or Custodial Services. Data from the salt use inventory was entered into a survey using Survey 123, which created a map layer with point data representing individual salt buckets. The map layer was used to create the Winter Salt Bucket Inventory Dashboard to spatially display how these buckets are distributed and how much salt they use. Figure 12.2 shows the location of the reported salt buckets. If the user clicks on a specific point, data about that salt bucket — such as the manager, salt use, and salt application practices — will appear on the right-hand side of the dashboard. The type of salt used, salt use per building, total number of reported buckets, and managers interested in becoming certified applicators are also reported at the bottom of this dashboard. The data within the dashboard can be updated by editing the entries in the survey, and the dashboard itself can be edited through ArcGIS Online. The dashboard is accessible to managers via a link (www.arcg.is/1X1bDD).

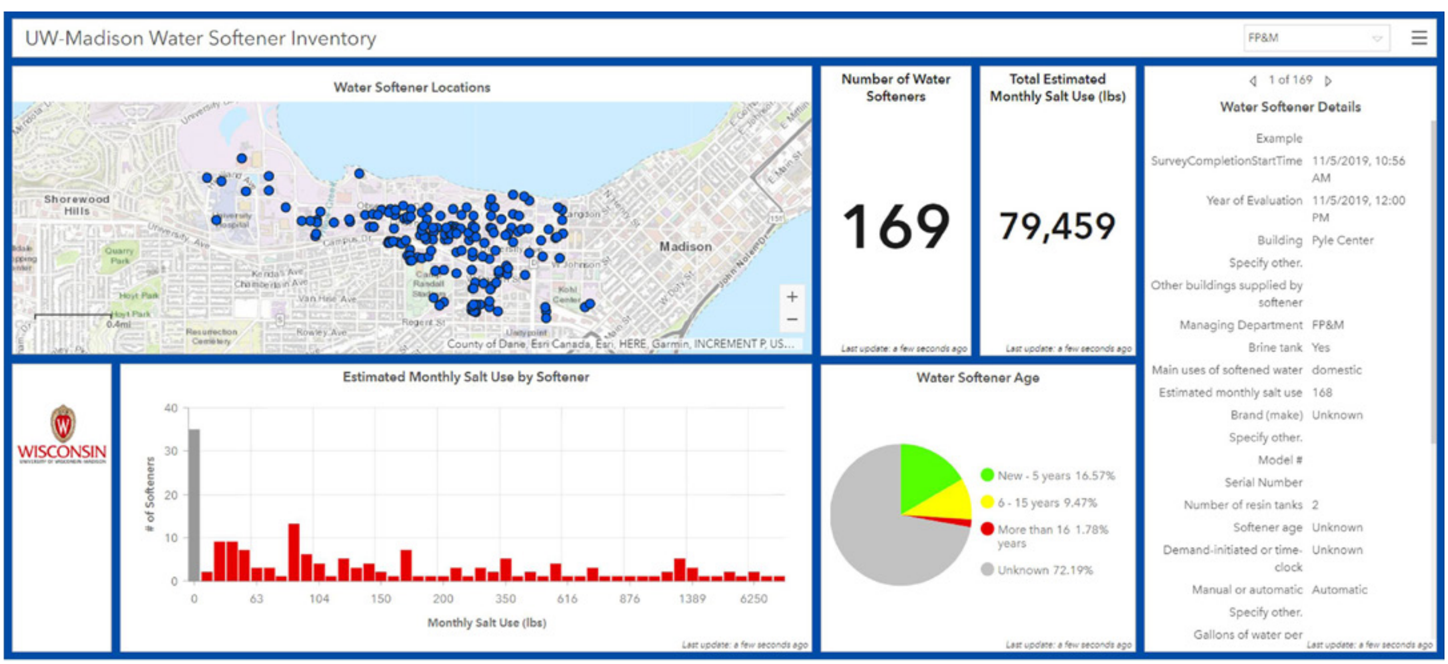


Figure 12.1. Screenshot of the Water Softener Inquiry Dashboard displaying inventory data for UW-Madison water softeners.

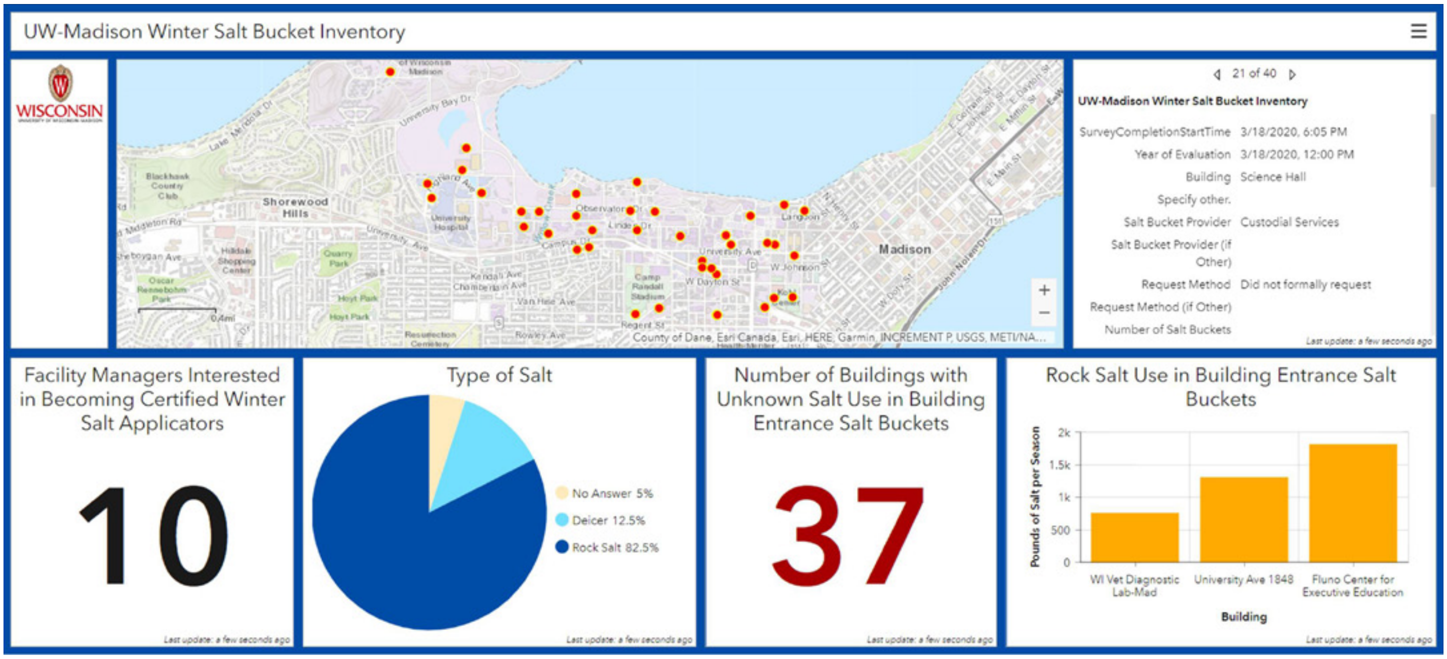


Figure 12.2. Screenshot of the Winter Salt Bucket Inventory Dashboard displaying inventory data for UW-Madison winter salt bucket use.

The dashboard should be shared with all winter maintenance managers on the UW-Madison campus so they can report their salt use and compare their salt management to others across campus. The dashboard should be managed by an employee within the Office of Sustainability or the Environment, Health & Safety office to ensure that the inventory and dashboard are updated annually.

Section 13

MONITORING PROTOCOLS AND RESULTS

How monitoring sites were selected and the methods for monitoring chloride levels in storm water, surface water, and wastewater on campus are described in the following section. Also described in this section are the results of our monitoring efforts as well as opportunities for future studies to advance current methodology and increase available data.

To record levels of chloride in water resources around campus, we focused on monitoring each portion of the localized "salt cycle." Our monitoring regime consisted of four distinct projects: continuous monitoring of Willow Creek, stormwater sampling of outlets into Lake Mendota, wastewater sampling from a site on campus, and optimizing water softeners in a group of campus residence halls. Each of these projects focused on a separate pathway that salt follows to enter the environment. The original approach adopted by our cohort during the project was constrained by resources available to us, such as duration of the project, funding, and labor.

Continuous Monitoring

STUDY AREA AND HYPOTHESIS

The Willow Creek watershed includes the west side of the UW-Madison campus and extends into the west side of Madison. Much of the watershed falls within residential areas which generate most of the runoff to the storm sewers. The creek drains into Lake Mendota west of the Natatorium and east of UW-Hospital. The creek is located entirely on the UW-Madison campus.

We expected the downstream location to show higher levels of chloride than upstream due to additional chloride contributions from campus. We also expected peaks of conductivity after snowmelt and precipitation events through the winter and spring. Finally, we expected chloride concentrations to stay below chronic and acute levels through the summer and exceed chronic and acute levels through the winter and spring due to winter deicing.

Figure 13.1. Locations monitored for chloride on the UW-Madison campus.

METHODS

To compare chloride contributions from campus to upstream neighborhoods, two HOBO freshwater conductivity data loggers were deployed in Willow Creek. One device was placed upstream of campus and the other was placed on campus right before the creek empties into Lake Mendota. Probes were secured in the flowing portion of the channel using cinder blocks and buoys. The cinder blocks held a rope in place and the sensor was secured halfway up the rope in a protective PVC pipe casing. The buoy kept the system at a constant depth by floating on the surface, and this was all secured to a railing above.

The probes were installed in Willow Creek on July 12, 2019, and programmed to take measurements every minute. On September 27, the probes were switched to taking measurements every five minutes to reduce excessive data. The data was retrieved bi-weekly using a HOBO waterproof shuttle. In addition, grab samples and depth measurements were also taken. The grab samples were tested for conductivity in the Center for Limnology Laboratory using a separate conductivity probe to calibrate the results. The grab samples were also tested for chloride concentration in the Water Science and Engineering Laboratory using ion chromatography (IC). The chloride concentration was used to establish a chloride-conductivity relationship to indicate when acute and chronic levels were exceeded.

Figure 13.2. Willow Creek upstream data and sample collection. Photo Credit: Wei Tang

Figure 13.3. Willow Creek downstream data and sample collection. Photo Credit: Brittany Cobb

Figure 13.4. Conductivity calibration in the Center for Limnology. Photo Credit: Wei Tang

FINDINGS

On average, we found lower chloride concentrations at the downstream location. One explanation for these results is that Willow Creek flowed backward during high lake-water conditions, allowing water from Lake Mendota to dilute the downstream monitoring site, resulting in lower observed concentrations. This conclusion was made through visual observation of the creek. The full conductivity dataset can be seen in the two graphs below. Figure 13.5 shows the upstream conductivity from July 2019 through February 2020. Figure 13.6 shows the downstream conductivity from July 2019 through February 2020. Conductivity was not properly measured at the downstream location between December 21, 2019 to January 31, 2020 because the water level in the creek was extremely low resulting in the logger being above surface level for the majority of the time.

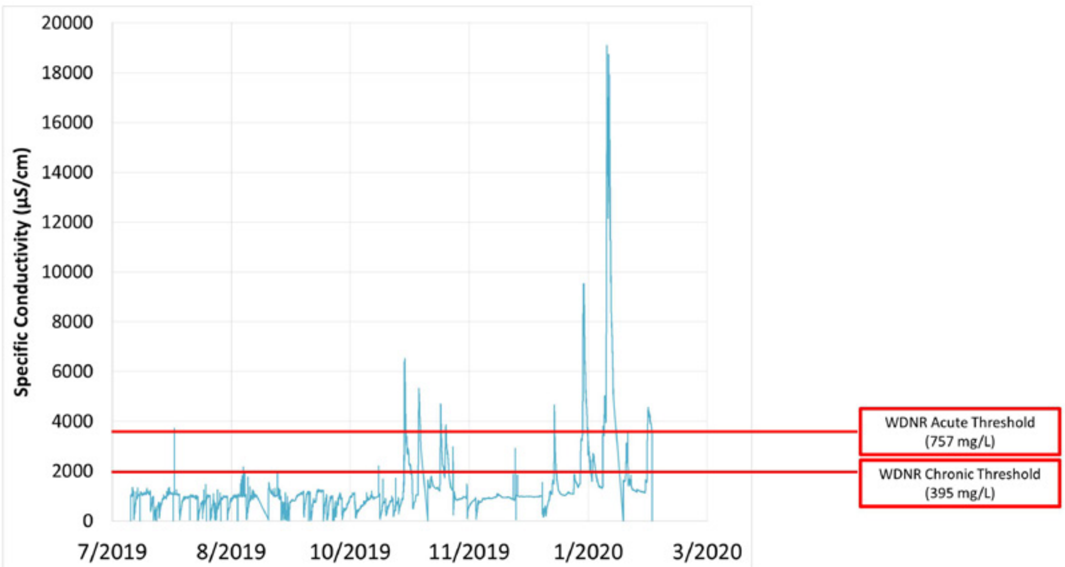


Figure 13.5. Upstream conductivity in Willow Creek, July 2019 through February 2020.

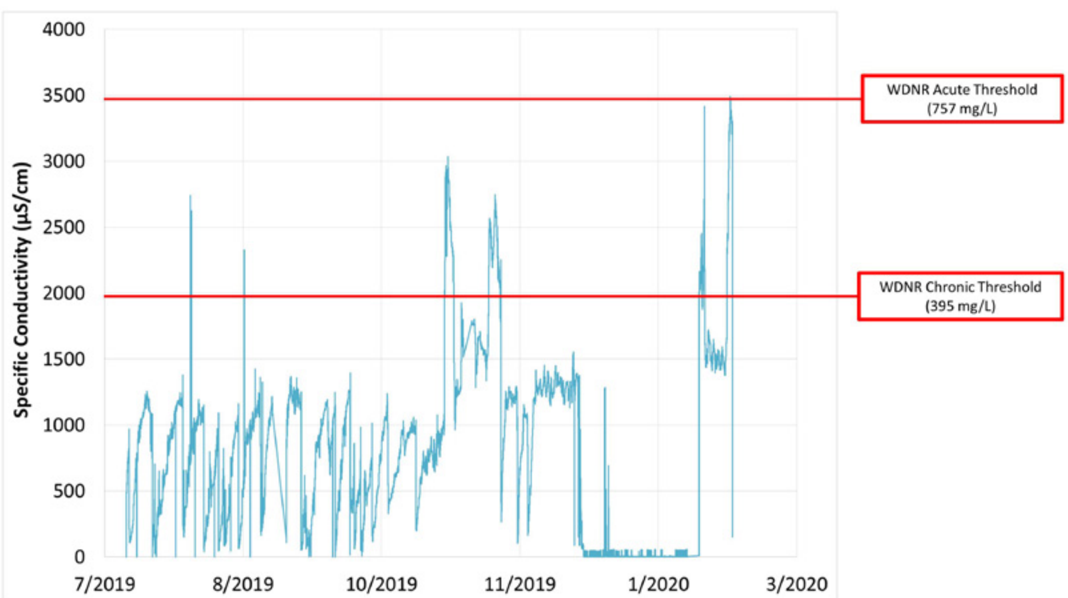


Figure 13.6. Downstream conductivity in Willow Creek, July 2019 through February 2020.

SUGGESTED IMPROVEMENTS

The downstream monitoring location could be moved to a location farther upstream to compensate for lake-water intrusion. Quantitatively considering the impact of downstream dilution would be needed to isolate the campus' contribution of chloride to the creek for any future study.

In addition to conductivity, flow rate, depth, and a cross-sectional area should be measured at both upstream and downstream locations. If a cross-sectional area is calculated and combined with the flow rate and chloride concentrations, a chloride load into Lake Mendota from Willow Creek could be calculated. An acoustic doppler current profiler (ADCP) is recommended to measure water velocity for a cross-sectional area. In addition, more frequent grab samples of surface water from Willow Creek should be taken in addition to those obtained when retrieving loggers. This will provide more data to construct the regression curve of conductivity and chloride concentration.

Stormwater Monitoring

STUDY AREA

Three storm sewers were monitored on campus as indicated in Figure 13.1. The first and second locations discharge into Lake Mendota and the third location discharges into Willow Creek, which ultimately flows into Lake Mendota. A considerable number of storm sewer outlets on campus were under water at the time of sampling. Due to these conditions, the locations we were able to sample were limited by accessibility.

METHODS

The first location was monitored bi-monthly, from April until October 2019, when the first snow event occurred. The second location was sampled in March 2019 but was discontinued due to construction. The third location was also monitored in October 2019 to compare chloride levels to the first location. Field preparation included labeling bottles with name, date, time, and location. Grab samples were then taken within 30 minutes of the beginning of rainfall in order to capture the initial flush of chloride, and samples were taken for at

Figure 13.7. Cohort member taking stormwater samples at Location 3 during the first rain event in 2019. Photo credit: Wei Tang

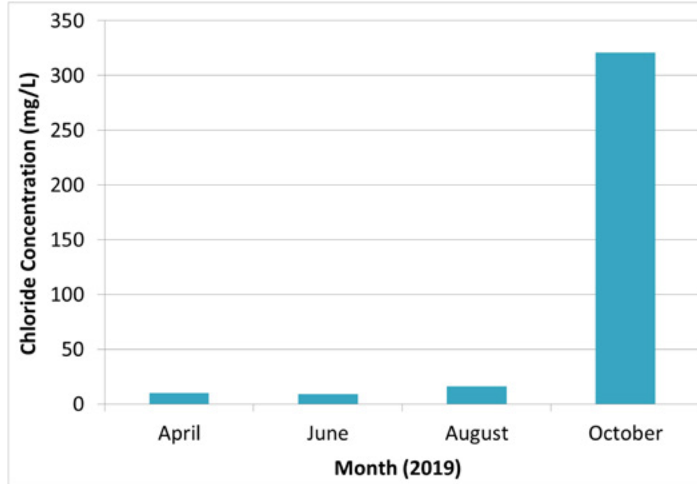


Figure 13.9. Chloride concentrations (mg/L) at Location 1 from spring through fall of 2019.

least two hours. Each grab sample was taken 15 or 20 minutes apart depending on the storm intensity. Higher-intensity storms were sampled every 15 minutes and lower-intensity storms were sampled every 20 minutes. Samples were then taken to the UW-Madison Water Science and Engineering Laboratory and tested for chloride concentrations using IC. The chloride concentrations and conductivity were related with a linear regression (Figure 13.8)

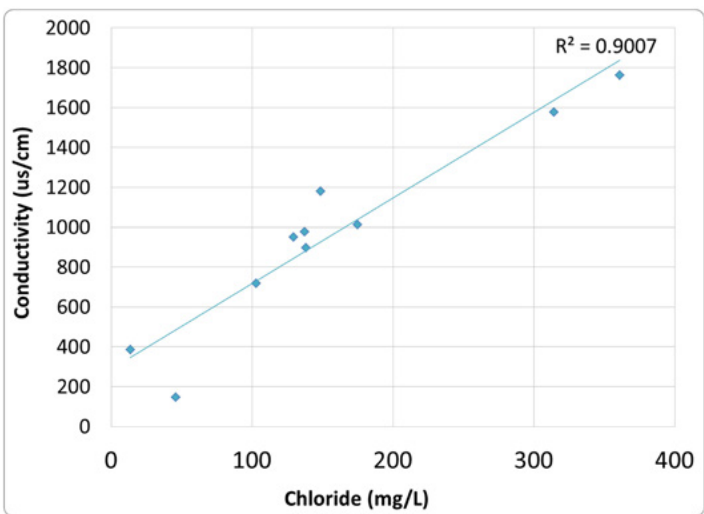


Figure 13.8 Chloride-conductivity linear regression.

FINDINGS

The data showed that the chloride concentrations during summer range from 9–16 mg/L. The concentrations during the October sampling were over 300 mg/L and approach the WDNR chronic standard of 395 mg/L. The data can be seen in Figure 13.9. Since the October samples were taken very soon after snowfall and deicing activities, the large increase in concentration can likely be attributed to this. Since road salt application is the main contributor of salt into storm sewers, the data shows that the deicing activities on the UW-Madison campus result in high-chloride runoff flowing into Lake Mendota.

SUGGESTED IMPROVEMENTS

The depth of the effluent in the storm sewer pipe was also measured. The depth, coupled with the cross-sectional area of the pipe, can be used to calculate flow volume and the mass of chloride associated with a specific area. If an improved storm sewer map is created that indicates the "watershed area" of each storm sewer outlet, the discharges from each pipe could be attributed to specific areas of campus.

Due to the high lake levels limiting the storm sewers that could be sampled, we recommend monitoring additional storm sewers (when lake levels allow) to identify other areas that may be discharging stormwater with high levels of chloride.

Wastewater Monitoring

To better understand campus chloride contributions to the sanitary sewer system, we analyzed wastewater monitoring data from University Houses that was provided by MMSD.

STUDY AREA

University Houses is comprised of 146 apartments and is one of the three neighborhoods in the University Apartments community. Samples were taken at a point after the confluence of all the wastewater from the neighborhood. In doing so, contributions from each building were included in the data.

METHODS

Six days of 24-hour flow-proportionate composite samples were collected from August 20, 2019 through August 27, 2019.

FINDINGS

The results indicated that, for the majority of the week, around 80 pounds of salt was discharged every day. For the whole week, 403 pounds were discharged, which gives an estimate of over 10.5 tons of annual salt usage. Chloride concentrations ranged from 195 mg/L to 821 mg/L throughout the week. The estimated chloride load for each day of sampling can be seen in Figure 13.10.

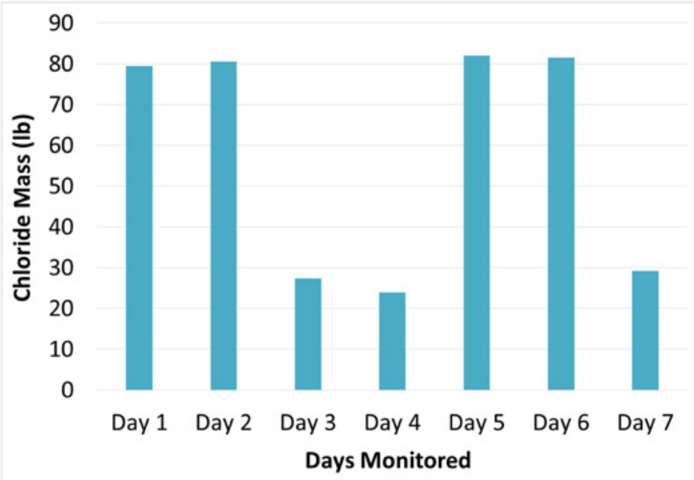


Figure 13.10. Chloride load (lbs per day) in wastewater for the University Houses.

SUGGESTED IMPROVEMENTS

This type of sampling could be used to quantify the impact of water softener optimization. If a round of sampling was done prior to optimization, and another round completed afterward, the sets of samples could be compared to determine the effectiveness of the optimization. This data would be useful in more precisely estimating a potential savings if other building managers optimized their water softeners.

Water Softener Optimization

STUDY AREA AND EQUIPMENT

The study focused on the optimization of water softeners in five residential halls in Lakeshore Residence Hall community; Dejope, Holt, Leopold, Bradley, and Phillips Halls. Dejope Hall has a Hellenbrand TNT-600 System 7; Holt Hall has a Hellenbrand TN-300 Triplex System 14; Leopold Hall has a Hellenbrand TN-300 Twin System 9; Bradley Hall has a Hellenbrand HE 13 Twin Alt; and Phillips Hall has a Capital FCM 480 Triplex Progressive flow.

Figure 13.11. Water softeners in Dejope Hall. Photo Credit: Brittany Cobb

METHODS

The optimization was performed by Hellenbrand Water Center, one of the water softener equipment suppliers for UW-Madison. The water softeners were analyzed for current system salt settings and optimized for better salt efficiency while maintaining acceptable soft water.

FINDINGS

The percent reduction from optimization varies by water softener. While some of the softeners saw a large reduction in salt use, others were either already fully optimized and any further salt reduction would only be possible through replacement. The water softener in Phillips Hall saw a 20 percent decrease in salt usage with optimization and would see a 53 percent decrease by replacing the system with a high efficiency water softener. Holt Hall saw a 11 percent decrease in salt usage and would see a 29 percent decrease if the system was replaced. Dejope Hall saw no decrease in salt usage from optimization because the system was already set to optimal standards but would see a 49 percent decrease in salt usage if the system was replaced. Leopold Hall could not be optimized because it was already on a brine reclamation system but would see a 27 percent–37 percent decrease in salt usage if the system was replaced. Bradley Hall already had a high efficiency system; therefore, optimization or system replacement would not change the salt usage. This variability is taken into consideration for our final recommendations and showcases the importance of a combination in optimizations and replacements for the greatest amount of salt savings.

FUTURE IMPROVEMENTS

Wastewater monitoring at a point of confluence for discharge from multiple water softeners can show chloride levels before and after optimization which is one way to compare potential, calculated savings to in-field data.

Relevant Research of 1918 Marsh

The 1918 Marsh lies on the west side of campus, and its watershed falls mainly within the campus boundaries. According to Emeritus Professor John Magnuson of the UW-Madison Center for Limnology, a major source of concern for the marsh is excessive chloride loading from snow stored next to the marsh. Magnuson also stated that stormwater drainage from UW Hospital parking lots and Highland Avenue is a concern.

Figure 13.12. Snow pile in the 1918 Marsh in June 2019. Photo Credit: Yangbo Peng

From 2012 to 2016, grab samples were collected from the 1918 Marsh and its watershed and analyzed at the Center for Limnology using ion IC (Dugan, 2017). Results from this study showed that from January to March, chloride concentrations in the marsh were significantly high. For these months, more than 50 percent of the samples exceed the WDNR chronic standards of 395 mg/L, with the maximum concentration of 12,790 mg/L seen in February 2012. The percentages of samples exceeding WDNR chronic and acute standards per month over the period of 2012 to 2016 can be seen in Figure 13.13.

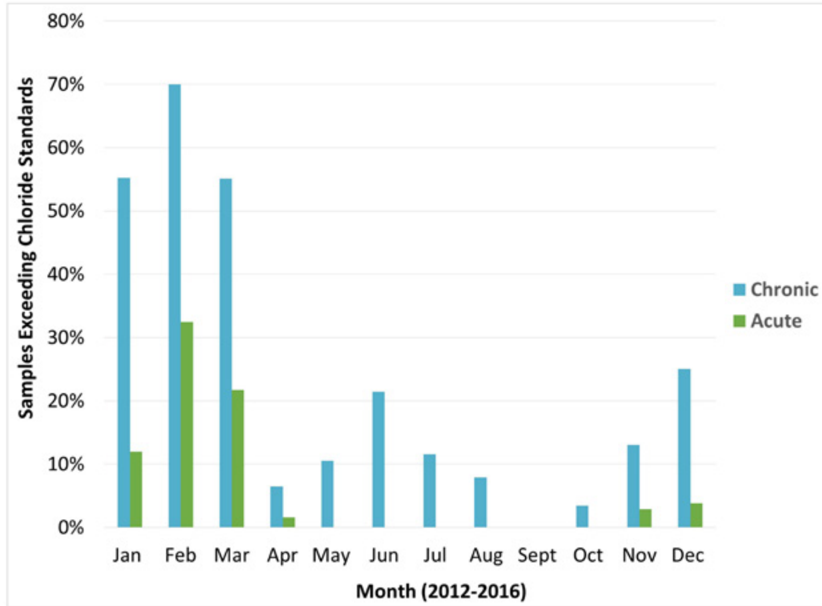


Figure 13.13. Percentage of samples in the marsh flow path and watershed exceeding WDNR chronic and acute criteria, 395 mg/L and 757 mg/L, respectively.

Section 14

OUTREACH EVENTS

As a method for expanding knowledge around salt overuse and best practices, the WRM cohort hosted informational meetings and public engagement events with interested organizations to share project findings. Additionally, cohort members attended several conferences to share the findings of the campus-wide salt use inventory and the recommendations outlined in the *Blueprint*.

Table 14.1. Outreach and public engagement opportunities.

Opportunity	Type	What	How
Madison Metropolitan Sewerage District	Public utility service	Wastewater treatment facility serving Madison and several other communities	In-depth informative meetings throughout entirety of project
Madison Water Utility	Public utility service	Public entity responsible for serving Madison and several other communities with high quality water for consumption and fire protection	Informative meeting to share project methods and findings
Nelson Institute for Environmental Studies	Public higher education entity	UW-Madison academic unit	Several meetings held with school officials to find pathways for *Blueprint* implementation
Office of Sustainability	Public higher education entity	UW-Madison program	Several meetings held with administrative officials to find pathways for *Blueprint* implementation. Educational collaboration with student members to increase acceptance of winter salting best practices.
Edgewood College	Private higher education entity	Private college	Meeting with facility managers to share *Blueprint* methodology
Madison Area Technical College	Public higher education entity	Public technical college	Informal meeting to share *Blueprint* methodology with facility managers
American Family Insurance	Private entity	Private business with large campus	Meeting with facility managers to share *Blueprint* methodology
Friends of Lake Wingra	Community organization	Community organization focused on protecting Lake Wingra	Educational meeting and activity session to share findings and best practices with interested community members
Nelson Institute Earth Day Conference (2019, 2020)	Conference	Annual conference on environmental topics	2019 poster session sharing planned research 2020 Presentation on findings
Water@UW Spring Symposium	Symposium	Annual meeting on water-related research by individuals associated with UW-Madison	Presentation on findings

Section 15

MOVING FORWARD: IMPLEMENTING RECOMMENDATIONS

Over the last 80 years, research has shown that the background levels of chloride in the freshwater resources around campus have been steadily rising. Source reduction of chloride is an economically viable solution for halting these trends and mitigating the impacts associated with salt overuse. UW-Madison should use the pathway outlined in this *Blueprint* to more efficiently use salt to protect Madison's valuable water resources for generations to come.

Implementing the recommendations outlined in this *Blueprint* will require the cooperation of an interdisciplinary network of campus stakeholders. Structural, policy and procedural, and institutional changes need to be made in conjunction with one another to effectively change how salt is used on the UW-Madison campus. The source-reduction opportunities presented in the *Blueprint* are stakeholder driven strategies that focus on reducing excessive salt use by 25 percent by increasing efficiency of campus practices and technologies without harming the soft water supply, campus plumbing infrastructure, or public safety. Incorporating salt sustainability into campus master planning and curricula will ensure the long-term sustainability of the university's source reduction efforts.

Visit the WRM Salt Sustainability website to access the resources discussed in this report.
www.nelson.wisc.edu/graduate/water-resources-management/salt-sustainability.php

REFERENCES

AECOM. (2015). *Chloride compliance study — Nine Springs Wastewater Treatment Plant final report.* Prepared for Madison Metropolitan Sewerage District. Retrieved from: www.go.wisc.edu/24h75z

BENOIT, D. (1988). *Ambient Water Quality Criteria for Chloride.* United States Environmental Protection Agency, 44015-88-001. Retrieved from: www.epa.gov/sites/production/files/2018-08/documents/chloride-aquatic-life-criteria-1988.pdf

CHAPPEL, B. (2014). Cheese to the rescue: Surprising spray melts road ice. *National Public Radio.* Retrieved from: www.npr.org/sections/thetwo-way/2014/01/21/264562529/cheese-to-the-rescue-surprising-spray-melts-road-ice

C3 WATER INC. (2015). *City of Guelph residential water softening and salinity water use reduction.* C3 Water Inc. Breslau, ON. Retrieved from: www.guelph.ca/wp-content/uploads/ResidentialWaterSofteningSalintyWaterUseReduction_Sept2015.pdf

CITY OF MADISON. (n.d). *Road salt and Madison's drinking water.* Retrieved from: www.cityofmadison.com/water/sustainability/road-salt-and-madisons-drinking-water

CORSI, S., DE CICCO, L., LUTZ, M., & HIRSCH, R. (2015). River chloride trends in snow-affected urban watersheds: increasing concentrations outpace urban growth rate and are common among all seasons. *Science of the Total Environment, 508*, 488–497. www.dx.doi.org/10.1016/j.scitotenv.2014.12.012

DALEY, M., MCDOWELL, W., & POTTER, J. (2009). Salinization of urbanizing New Hampshire streams and groundwater: Effects of road salt and hydrologic variability. *Journal of the North American Benthological Society,* 28(4), 929–940. www.doi.org/10.1899/09-052.1

DINDORF, C., FORTIN, C., BROOKE, A., & ERDMANN, J. (2014). *The real cost of salt use for winter maintenance in the Twin Cities metropolitan area.* Minnesota Pollution Control Agency. www.pca.state.mn.us/sites/default/files/wq-iw11-06bb.pdf

DUGAN, H., HELMUELLER, G., & MAGNUSON, J. (2017). Ice formation and the risk of chloride toxicity in shallow wetlands and lakes. *Limnology and Oceanography Letters,* 2(5), 150–158. doi: 10.1002/lol2.10045 Retrieved from www.aslopubs.onlinelibrary.wiley.com/doi/full/10.1002/lol2.10045

ENVIRONMENT CANADA AND HEALTH CANADA. (2001). Priority substances list assessment report: Road salts. *Canadian Environmental Protection Act 1999.* Retrieved from: www.go.wisc.edu/ru17wi

ENVIRONMENTAL PROTECTION AGENCY. (2014). National Recommended Water Quality Criteria, Aquatic Life Criteria Table. Retrieved from: www.epa.gov/wqc/national-recommended-water-quality-criteria-aquatic-life-criteria-table

FAY, L., & SHI, X. (2011). Laboratory investigation of performance and impacts of snow and ice control chemicals for winter road service. *Journal of Cold Regions Engineering, 25*(3), 89–114. Retrieved from: www.ascelibrary.org/doi/pdf/10.1061/%28ASCE%29CR.1943-5495.0000025

FIFIELD, J. (2017). Using cheese, molasses brine to treat roads with less salt. *Stateline.* Retrieved from: www.go.wisc.edu/mq48rh

FORTIN, C., & DINDORF, C. (2012). *Minnesota snow and ice control: Field handbook for snowplow operators.* Minnesota Local Road Research Board 2005-01 REV. Retrieved from: www.mnltap.umn.edu/publications/handbooks/documents/snowice.pdf

GRESCH, M. (2018). Bitter brine reclaim for winter maintenance. Road Salt Symposium. Minneapolis, MN. Retrieved from: www.freshwater.org/wp-content/uploads/2018/02/mike-Gresch-2018-1.pdf

HINTERTHUER, A. (2019). *Want to reduce road salt impacts on ecosystems and infrastructure?* Just add water. Center for Limnology. University of Wisconsin-Madison. Retrieved from: www.go.wisc.edu/661a16

HINTZ, W., MATTES, B., SCHULER, M., JONES, D., STOLER, A., LIND, L., & RELYEA, R. (2017). Salinization triggers a trophic cascade in experimental freshwater communities with varying food-chain length. *Ecological Applications, 27*(3), 833–844.

HINTZ, W., & RELYEA, R. (2017). A salty landscape of fear: Response of fish and zooplankton to freshwater salinization and predatory stress. *Oecologia,* 185, 147–156. www.link.springer.com/article/10.1007/s00442-017-3925-1

HOULE, K., ROSEEN, R., BALLESTERO, T., BRIGGS, J., & HOULE, J. (2009). Examinations of pervious concrete and porous asphalt pavements performance for stormwater management in northern climates. *World Environmental and Water Resources Congress 2009,* 1–18.

KAUSHAL, S., GROFFMAN, P., LIKENS, G., BELT, K., STACK, W., KELLY, V., BAND, L., & FISHER, G. (2005). Increased salinization of freshwater in the northeastern United States. *Proceedings of the National Academy of Sciences,* 102(38), 13517–13520.

KAUSHAL, S., LIKENS, G., PACE, M., UTZ, R., HAQ, S., GORMAN, J., & GRESE, M. (2018). Freshwater salinization syndrome on a continental scale. *Proceedings of the National Academy of Sciences, 115*(4), E547–E583.

KOTB, A., & AZIZ, A. (2013). *Scientific investigations on the claims of the magnetic water conditioners. Annals of Faculty Engineering Hunedoara,* 11(4), 147. Retrieved from: www.annals.fih.upt.ro/pdf-full/2013/ANNALS-2013-4-23.pdf

MADISON AND DANE COUNTY PUBLIC HEALTH. (2017). *Water quality in Dane County: Overview, current challenges, and recommen-dations.* Retrieved from: www.publichealthmdc.com/documents/WaterQualityReport201707.pdf

MADISON METROPOLITAN SEWERAGE DISTRICT (MMSD). (2015). *Optimization of water softeners for reduced influent chloride.* Retrieved from: www.madsewer.org/Portals/0/ProgramInitiatives/ChlorideReduction/Water%20Softener%20Study%20Final%20Report%20111615.pdf

MADISON METROPOLITAN SEWERAGE DISTRICT (MMSD). (2015). Water softening best practices guidelines. Retrieved from: www.go.wisc.edu/pyss65

MADISON METROPOLITAN SEWERAGE DISTRICT (MMSD). (n.d.). *Salt reduction resources and examples.* Retrieved from: www.madsewer.org/Programs-Initiatives/Chloride-Reduction/SaltReductionResources

MADISON WATER UTILITY. (2013). *Your Water Source* [map]. Retrieved from: www.cityofmadison.com/water/documents/YourWaterSource%20Map.pdf

MADISON WATER UTILITY. (2019). *Well 14 quality report.* Retrieved from: www.cityofmadison.com/water/documents/Well14QualityReport.pdf

MAROHN, K. (2019). *Mayo clinic goes on a low-salt diet – for roads and sidewalks.* Minnesota Public Radio News. Retrieved from: www.go.wisc.edu/59s5z8

MCDONALD, J. (2016). *Salt Wise, Soft Water Training: Case Study - Apartment Buildings* [PowerPoint slides]. Retrieved from: www.madsewer.org/Portals/0/ProgramInitiatives/ChlorideReduction/Salt%20Reduction%20Examples/9%20Hellenbrand%20Apartments%20Case%20Study.pdf

MINNESOTA POLLUTION CONTROL AGENCY (MPCA). (2017). Success stories: Salt reduction and cost saving examples. *Minnesota stormwater manual.* Retrieved from: www.stormwater.pca.state.mn.us/index.php?title=Success_stories:_salt_reduction_and_cost_saving_examples

MINNESOTA POLLUTION CONTROL AGENCY (MPCA). (n.d.). Salt applicators: Smart salting training. Retrieved from: www.pca.state.mn.us/water/salt-applicators

NELSON, B. (2017). *ISU is reducing its salt intake.* Illinois State University News. Retrieved from: www.news.illinoisstate.edu/2017/11/isu-reducing-salt-intake/

NELSON, S., YONGE, D., & BARBER, M. (2009). Effects of road salts on heavy metal mobility in two eastern Washington soils. *Journal of Environmental Engineering 135*(7). www.go.wisc.edu/r714n0

NEW HAMPSHIRE DEPARTMENT OF ENVIRONMENTAL SERVICES (NHDES). (2016). Best management practices and salt use minimization efforts in chloride-impaired watersheds of New Hampshire: A guidance document for private developers and contractors. Environmental Fact Sheet (WD-WMB-26). Retrieved from: www.des.nh.gov/organization/divisions/water/wmb/was/salt-reduction-initiative/documents/wmb-26.pdf

NOVOTNY, E., SANDER, A., MOHSENI, O., & STEFAN, H. (2009). Chloride ion transport and mass balance in a metropolitan area using road salt. *Water Resources Research 45*(12).

RUBIN, J., GARDER, P., MORRIS, C., NICHOLS, K., MCKEE, P., STERN, A., & JOHNSON, T. (2010). *Maine winter roads: Salt, safety, environment and cost.* Margaret Chase Smith Policy Center, The University of Maine. Retrieved from: www.umaine.edu/wp-content/uploads/sites/2/2010/02/Winter-Road-Maint-Final.pdf

SALT SMART SAVE MORE (online image). (n.d.) Retrieved from www.saltsmart.org/

SCHMIDT, M. (2019, November 7). As salt prices climb, Wisconsin looks to brine for cheaper, better solution. *Wisconsin State Journal.* Retrieved from: www.go.wisc.edu/0k3e4l

SELBIG, W., & BUER, N. (2018). Hydraulic, water-quality, and temperature performance of three types of permeable pavement under high sediment loading conditions. *U.S. Geological Survey Scientific Investigations Report 2018–5037*, www.doi.org/10.3133/sir20185037

SORSA, K., & WENTA, R. (2017). *2016 road salt report.* Madison and Dane County Public Health. Retrieved from: www.publichealthmdc.com/documents/RoadSaltRpt2016.pdf

SORSA, K., & WENTA, R. (2018). 2017 road salt report. Madison and Dane County Public Health. Retrieved from: www.publichealthmdc.com/documents/Road%20Salt%20Report%202017.pdf

THOMURE, T., FOX, P. (2013). *Evaluation of alternatives to domestic ion exchange water softeners.* WateReuse Research Foundation. Project 08-06. Retrieved from: www.watereuse.org/wp-content/uploads/2015/12/Webinar-WateReuse-08-06.pdf

UNITED STATES GEOLOGICAL SURVEY (USGS). (n.d.) Hardness of water. Retrieved from: www.go.wisc.edu/6jq7dy

UNITYPOINT HEALTH – MERITER. (n.d.). Going green. Retrieved from: www.unitypoint.org/madison/going-green.aspx

UNIVERSITY OF MINNESOTA. (2020). The Gopher way. Parking and Transportation Services. Retrieved from: www.pts.umn.edu/walk/gopher-way-%E2%80%94-tunnels-and-skyways

UNIVERSITY OF WISCONSIN–MADISON (2015). Green infrastructure and stormwater management master plan. Retrieved from: www.go.wisc.edu/1et872

WATER QUALITY ASSOCIATION. (2001). *WQA magnetics task force report.* Retrieved from: www.premierwatermn.com/documents/WQA-Magnetics-Task-Force-Report-2001.pdf

WATER RESOURCES CENTER. (n.d.). *Water softener alternatives (Water conditioners, non-salt-based systems).* University of Minnesota-Twin Cities. Retrieved from: www.wrc.umn.edu/sites/wrc.umn.edu/files/residential_water_softening_alternatives_fact_sheet-_finalchedit.pdf

WATER RESOURCES MANAGEMENT PROGRAM. (2004). *Innovating stormwater management on the University of Wisconsin-Madison campus.* Nelson Institute for Environmental Studies. Retrieved from: www.nelson.wisc.edu/docs/2003-screen.pdf

WIS. ADMIN. Code Sec. NR105.03(15) (2010).

WISCONSIN DEPARTMENT OF NATURAL RESOURCES (WDNR). (2019). Fishing Wisconsin: Set your hook. Reel in *the reward.* Retrieved from: www.dnr.wi.gov/topic/fishing/outreach/AdvertisingFishRegulations.html

WISCONSIN DEPARTMENT OF TRANSPORTATION (WisDOT). (2015). *Manual of environmental best practices for snow and ice control.* Western Transportation Institute. Project 99006/CR13-01. Retrieved from: www.clearroads.org/wp-content/uploads/dlm_uploads/Manual_ClearRoads_13-01_FINAL.pdf

WISCONSIN SALT WISE. (2014). *Overview.* Retrieved from: https://www.wisaltwise.com/Overview

WORLD WILDLIFE FUND (WWF). (2019). Salt in the city: we need less of it. *WWF-Canada Blog: Freshwater.* Retrieved from: www.blog.wwf.ca/blog/2019/06/26/salt-in-the-city-we-need-less-of-it/

Nelson Institute for
Environmental Studies
UNIVERSITY OF WISCONSIN–MADISON