NJ Salt Watch: Assessing Road Salt Impacts on NJ Freshwaters

Executive Summary

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Background

Excess road salt use from winter road management is driving a rise in ambient freshwater chloride levels in the U.S. (Corsi, De Cicco, Lutz, & Hirsch, 2015; Dailey, Welch, & Lyons, 2014; Hintz & Relyea, 2019; Kolesar, et al., 2018; Szklarek, Gorecka, & Wojtal-Frankiewicz, 2022). Median chloride concentrations in NJ freshwaters have tripled since 1997 (NJDEP, 2022), reflecting the increasing trend observed in baseline chloride levels in the U.S. since the use of road salt gained momentum with the expansion of the highway system in the 1960s (Dailey, Welch, & Lyons, 2014; Ophori, Firor, & Soriano, 2019; Transportation Research Board, 1991). Road salt is an effective tool to reduce the risk of traffic accidents, however the amount of salt required to melt ice is generally less than the general public perceives. More salt does not necessarily lead to safer traveling conditions and what remains on impervious surfaces after the snow melts is swept "away" into freshwater systems, where it accumulates over time and causes a cascade of physical, chemical, and biological effects that threaten ecosystems and surface, ground, and drinking water quality (Kaushal, et al., 2021). Road salt is the single greatest contributor of chloride to the environment in streams of the northeastern U.S. (Nava, et al., 2020; Overbo, Heger, & Gulliver, 2021), exacerbated further in urban streams disconnected from riparian zones and floodplains that receive direct road discharge from the storm sewer system (Slosson, Lautz, & Beltran, 2021).

Chloride is a common parameter used to measure salinity and its impact on aquatic biota. Lethal chloride levels vary widely between species though functional freshwater streams and lakes of the northern Mid-Atlantic U.S. typically have chloride concentrations below 50-100 mg/l (Kaushal, et al., 2005; MD Department of the Environment, 2009). The NJ Department of Environmental Protection (NJDEP) set a regulatory threshold of 230 ppm chloride to indicate chronic impairment according to the Surface Water Quality Standards (SWQS) used to protect the ecological condition and other "designated uses" of NJ waterbodies (NJDEP, 2017; Surface Water Quality Standards, 2023). NJDEP considers acute impairment to occur when chloride concentrations exceed 860 ppm.

NJ reports on the condition of its waterbodies as grouped by HUC-14 subwatershed (MAP). Of 958 HUC-14s in NJ, NJDEP considers just eight (0.8%) to be impaired for chloride according to the 2018/2020 Integrated Report of surface water quality (NJDEP, 2022). 305 HUC-14 subwatersheds (32%) do not have sufficient data for a chloride assessment to be made. NJDEP is tasked with monitoring water quality statewide to fulfill their responsibility to the Clean Water Act, though the agency may not be afforded the resources to monitor all 119 parameters across all 958 HUC-14s during the most critical periods of the year when pollutant concentrations may be at their worst. A widespread team of volunteers with the right set of tools, information, and guidance can help government agencies to fill in gaps in geographic, temporal, and parameter-specific data.

In 2018, NJDEP funded The Watershed Institute, an environmental nonprofit organization located in Central NJ, to launch the NJ Watershed Watch Network, a new program to help connect the agency with external data contributors and stakeholders and to increase the volume of qualified data to supplement the data set for regulatory assessment. The Network assists Community Water Monitoring (CWM)[1] groups to achieve their data quality objectives through resource and template development, training, technical assistance, and small grants. In response to rising concerns over road salt impacts across the state, the Network launched the NJ Salt Watch project in December 2020, adapting protocols as a regional partner of the national IWLA Salt Watch project (IWLA, 2024) (Figure 1).

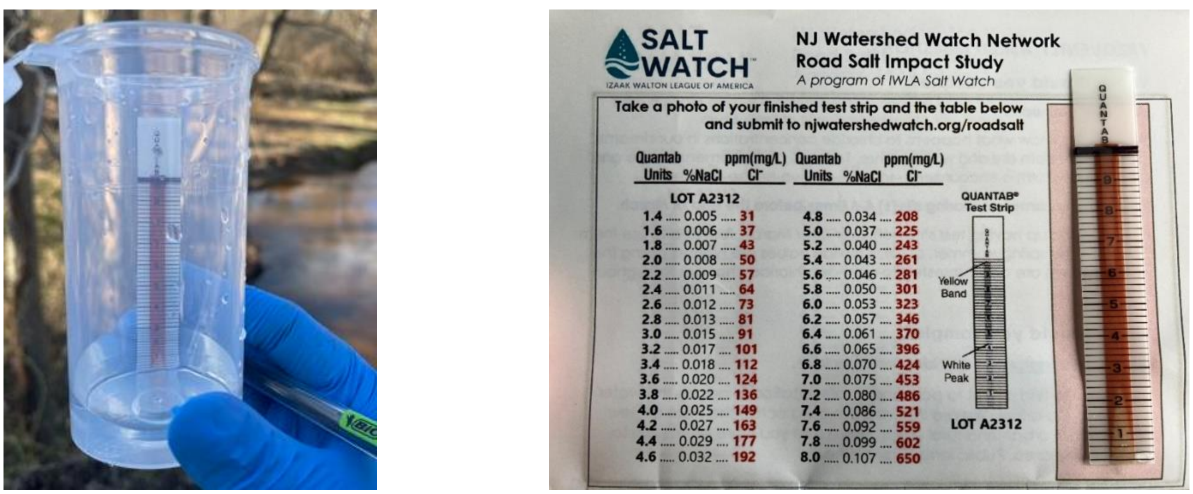

Figure 1: Left: NJ Salt Watch volunteer conducts a chloride test at Hockhockson Brook (Reagan Volk, Mar. 9, 2023). Right: Completed test strip is photographed on top of the calibration conversion card provided with the NJ Salt Watch kit (Megan Mink at Spring Garden Lake, Feb. 26, 2023). Photos are submitted to Survey123

[1] NJDEP and the NJ Watershed Watch Network use the term *Community Water Monitoring*, a synonym for other commonly used terms like *volunteer monitoring*, *community science*, *participatory science*, and *citizen science*.

with the volunteer interpretation of the result which lies at the tip of the white peak on the test strip. In this example, a Quantab unit of 2.4 converts to a chloride measurement of 64 ppm.

Using test strips received through direct mail and via partner organizations, approximately 300 NJ Salt Watch volunteers contributed chloride data from freshwater streams, ponds, and lakes across the state to the Watershed Watch Network through an ArcGIS Survey123 form. Individuals were guided to collect measurements in freshwater nontidal waterbodies 4-6 times over the course of a winter season. NJ Salt Watch data collected over three winter seasons was evaluated to determine the current condition and extent of chloride contamination in NJ freshwaters; assess the impact of road salt, as measured by snowfall and developed land cover, on freshwater chloride concentrations; and evaluate whether current regulatory determinations and actions align with the urgency required to address chloride contamination.

Science Highlights

More than 2,200 chloride measurements were submitted by participants and grouped into 425 distinct monitoring sites, primarily in the northern half of the state from January to March. Volunteer activity and efficiency increased with each project year, from 402 data points submitted in 2020-2021 to 1,025 in 2022-2023. Activity was concentrated around regional partners in the northwest water region (Musconetcong Watershed Association and Foodshed Alliance), central NJ (The Watershed Institute), the freshwaters of the north Atlantic coast (Clean Ocean Action), and near statewide headquarters for the Americorps NJ Watershed Ambassador Program (Figure 2). 11% (n=252) of all chloride measurements exceeded the SWQS of 230 ppm and 35% (n=762) were considered low, with chloride levels below 50 ppm. While 63 sites (15%) had mean or median chloride readings above the 230 ppm SWQS, 51 sites had sufficient data to be declared impaired (8 or more measurements). The results are presented to the public in greater detail in an ArcGIS Online Story Map at this link: https://arcg.is/eH4GG.

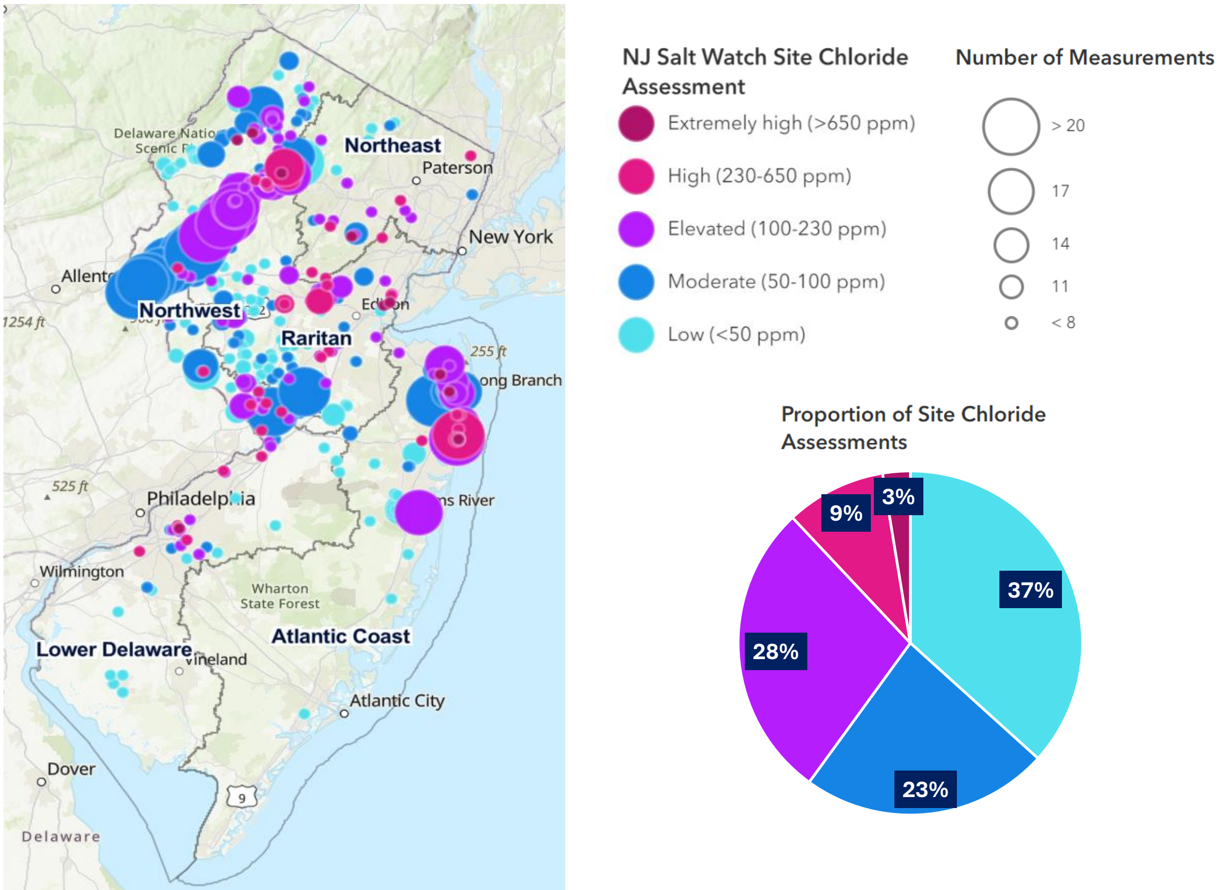

Figure 2: NJ Salt Watch activity was concentrated in the northern part of the state. The number of readings at each site (indicated by the size of the point) varied between 1 (n=107) to 31 (n=1), with the most recorded along the Musconetcong River, the SW-NE line of measurements in the northwest water region. On average, there were 5 measurements collected from each site over the three-year period, often by multiple contributors. Volunteers recording data at the lower ranges (blue points) contributed fewer data points, suggesting that they considered low chloride levels as evidence that they did not need to return to their site. This was particularly evident in the Raritan Basin and South Jersey.

Table 1: Summary statistics of chloride measurements by weather condition

	Count	Median	Mean	IQR	SD
Snow	216	90	153	123	177
Snowmelt	263	85	135	118	162
Rain	981	85	116	91	127
Dry	586	64	100	80	127
NA	159	81	86	52	88

As expected, chloride concentrations in NJ surface waters fluctuated with weather conditions and variability in annual and seasonal climate. Wilcoxon pairwise comparisons showed significant differences between readings collected during dry and wet weather ($W=361322$, $p=3.6 \times 10^{-8}$), with the highest mean chloride levels measured during snow and snowmelt, as opposed to rain and dry conditions (Table 1). The greatest number of chloride readings exceeding the 230 ppm SWQS occurred during the first project year, which had the most snowfall at 35 inches on average in central NJ (NOAA, 2024). The proportion of exceedances declined with each successive sample year, corresponding with a drop in annual snowfall totals to 16 inches in year 2 and 2 inches in year 3. Average chloride levels peaked after snow events in February and March but remained elevated for 1-2 months after the final snow event, suggesting a gradual release of chloride from soil and groundwater to surface waters (Figure 3). Exceedances of the chloride SWQS were observed from December to April, with and without snow.

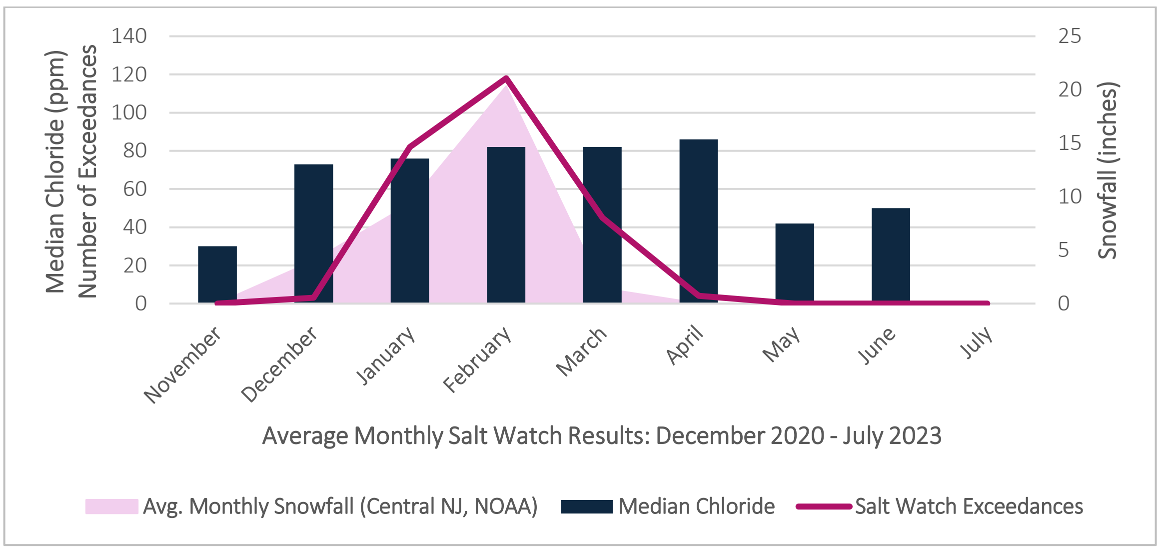

Figure 3: Median monthly chloride measurements were elevated from December to April, with exceedances above the 230 ppm SWQS observed primarily from January to March. The number of exceedances tracked closely to mean monthly snowfall totals of Central NJ.

Chloride levels were also correlated with the proportion of developed impervious land within its HUC-14 subwatershed (Figure 4). Median chloride levels did not exceed the 230 ppm SWQS when development was less than 25% of the HUC-14. Conversely, median chloride did not drop below 56 ppm when forest covered less than 10% of the HUC-14. Mean chloride exceeded the 230 ppm SWQS primarily in HUC-14 subwatersheds with greater than 40% developed land and/or less than 40% forested land. There were exceptions where mean chloride exceeded SWQS despite their HUC-14 subwatersheds and/or municipalities having less developed and/or more forested land, listed in Table 5 in the main report. This suggests an alternate variable, like salt application behavior or saltwater intrusion, is contributing additional chloride in these HUC-14s.

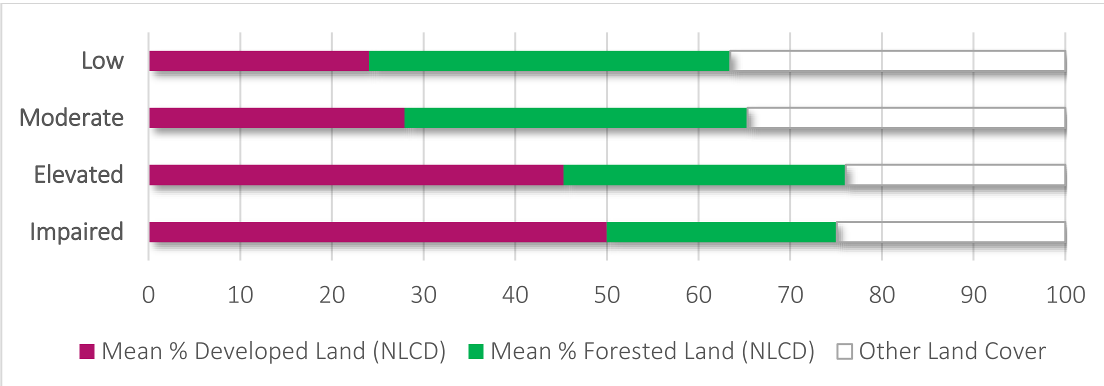

Figure 4: The "average" HUC-14 subwatershed in each chloride condition category is characterized above with the percent of forested and developed land cover. The proportion of developed land is higher in elevated and impaired HUC-14s.

Data were collected in 200 HUC-14 subwatersheds and there were sufficient data to make an assessment determination in 96 HUC-14s (Figure 5). Of those 96 HUC-14s, just one is considered impaired for chloride by the NJDEP 2018/2020 Integrated Report (IR) (NJDEP, 2022). Using NJDEP assessment methods and standards (NJDEP, 2017; Surface Water Quality Standards, 2023), 42 HUC-14s are considered impaired using NJ Salt Watch data. Clearly, NJ Salt Watch data suggests a greater level of chloride impairment than is currently documented by NJDEP. If additional HUC-14s are added to the list of impaired waters in the next IR cycle, they would become eligible for a Total Maximum Daily Load (TMDL), a management plan to reduce chloride loading, and on the regulatory route toward pollutant reduction. As of February 2024, the data has been sent to NJDEP for review and discussion has begun about how to proceed on these targeted HUC-14s.

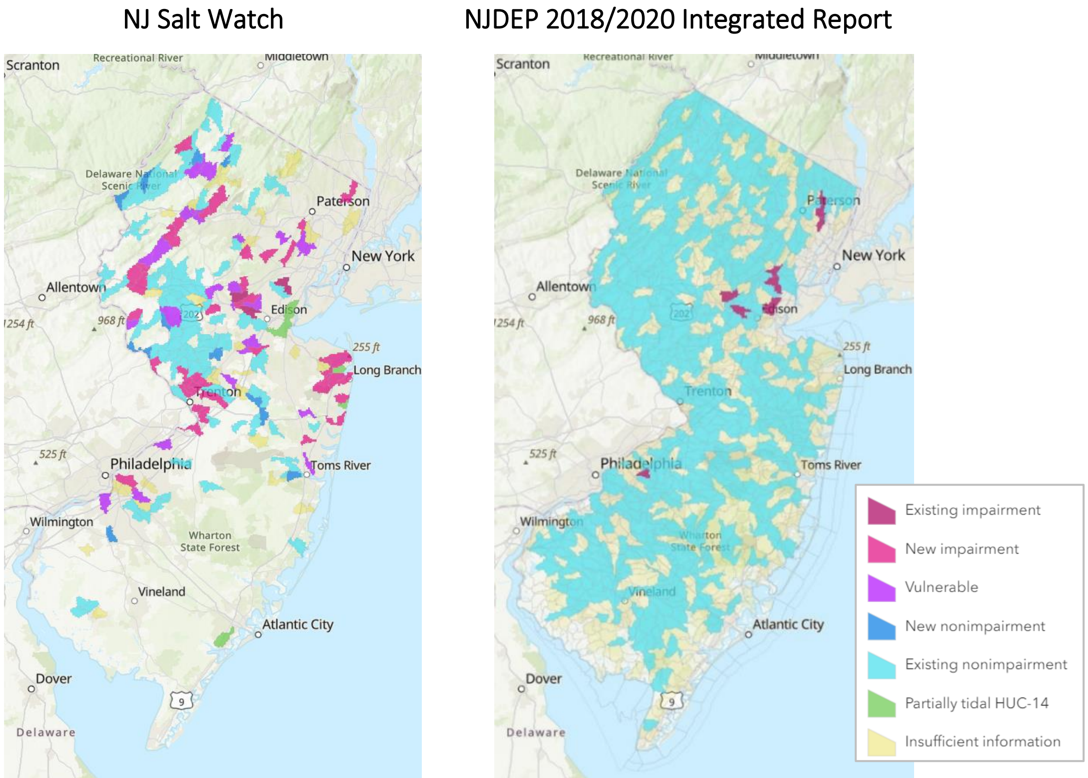

Figure 5: Comparing geographic distribution and extent of chloride assessments by NJ Salt Watch (n=200 HUC-14s) and the 2018/2020 NJDEP IR (n=519 HUC-14s with sufficient data). 38 new impairments were identified by NJ Salt Watch participants in HUC-14s considered nonimpaired or unassessed by the 2018/2020 IR (pink). 11 HUC-14s currently unassessed for chloride by NJDEP met the conditions for nonimpaired Salt Watch status (dark blue). In 85 HUC-14s, NJ Salt Watch data did not contradict NJDEP's nonimpaired chloride assessment (light blue). Not yet found to be impaired under the current SWQS, 25 HUC-14s may be vulnerable to impairment as evidenced by elevated Salt Watch chloride readings (purple).

Business Highlights

NJ Salt Watch is a project of the NJ Watershed Watch Network program, which is hosted at The Watershed Institute, and funded by NJDEP. There is a complex web of nonprofits, municipalities, regional and state agencies, schools, and community members that constitute NJ Salt Watch's target stakeholders and market and a single market can fill multiple project roles. NJ Watershed Watch Network crowdsources participants to NJ Salt Watch through email channels, social media, local press, and word of mouth by scout troops, school groups, municipalities, and other environmental organizations. Once volunteers register, the goal is to retain their attention long enough for them to use up their supply of test strips and report their data accurately. Project participants produce a data set for the NJ Watershed Watch Network to share directly with other data users or interpret it into maps, charts, and graphs to disseminate to commercial salt applicators, municipalities, schools, and the general public. This represents a tangible exchange of data between the generator and the user.

There is another exchange occurring between the entities that regulate salt application and the salt applicators who are compelled to follow the regulations. NJDEP defines the minimum thresholds required for statewide salt application, though municipalities have the authority to further reduce their road salt impact through local agreements and ordinances. Typically, municipal Departments of Public Works (DPWs) manage local roads and the NJ Department of Transportation (NJDOT) manages state roads, while private businesses and residents are responsible for the management of their own properties. Education and engagement initiatives that center best management practices (BMPs) are necessary to advocate for the behavior change that we wish to see from these markets (Figure 6). Besides reducing the amount of road salt applied, a number of BMPs, like switching to using liquid brine over rock salt, also result in a significant cost savings – which can certainly be used as a selling feature for alternative strategies.

Figure 6: Excess road salt piles up at an intersection in Ewing, NJ (Feb. 26, 2021). Some salt-spreading trucks continue to unload salt while stopped at an intersection or around turns, leading to large piles like this one that remain on the road until the next runoff event. One road salt BMP that is easily implemented and saves money for the salt applicator is to turn off spreaders while the truck is idling.

Cost effectiveness was a struggle with the administration of the NJ Salt Watch project. As volunteer interest and activity have more than doubled since the start of the project, so too has the price of Hach low-range chloride test strips. The average cost to mail a packet of 6 test strips increased from $8.43 in 2020 to

$15.41 in 2024. Considerations are being given to reduce test strip waste and keep overall costs level so the project can remain free for participants.

Summary

A collaborative effort is essential for monitoring and addressing the evolving conditions of our freshwater ecosystems in the face of increasing anthropogenic inputs. The emergence of community-based initiatives like NJ Salt Watch highlights the importance of engaging a broad array of people to produce comprehensive environmental assessments. NJ Salt Watch is an outreach tool in itself, informing the community directly about their impact on their waterbodies and providing them with the data to make a local case for change. A simple point of entry to community science for people across the state, NJ Salt Watch sampling materials are delivered to a volunteer's home for free and they can opt to monitor any waterbody that is meaningful to them. Returning to the same monitoring spot multiple times over the course of a winter season, participants learn first-hand about their local environment and arm themselves with information to advocate for its protection. Timely and relevant data is produced for regulators and road salt applicators to provide real-time reports on chloride concentrations. Tracked along with snowfall, and ideally with more precise road salt application data, NJ Salt Watch data will help us to understand a problem that has been shown across colder climates in developed areas for decades. If we salt the land, we salt the water.

Community scientists are capable of contributing data to government agencies to fill in gaps in geographic, temporal, and parameter-specific data with the potential to aid regulatory actions like 303(d) listing, TMDL development, and municipal stormwater ordinances to be able to align regulatory action to the urgency required to address chloride contamination. However, chloride levels may be progressing more quickly than regulatory action can reasonably control. A large-scale education and engagement initiative is essential to shift municipal and private property manager behavior and reduce anthropogenic salt inputs to restore and protect water quality. Stricter management of road salt application practices by municipal DPWs and NJDOT are necessary to control freshwater salinization.

It is in the best interest of the NJ Watershed Watch Network to extract value from the Watershed Institute's deep bench of staff to amplify the NJ Salt Watch message across target markets. Policy, education, and communication specialists can transform chloride data into information and actionable items for the community to learn about their impact and reduce their own watershed footprint. The dedication already shown by the NJ Salt Watch volunteers themselves show that they may make the best advocates for change. The Watershed Institute can utilize the connections built with the NJ Watershed Watch Network by engaging NJ Salt Watch's diverse audience and deploying policy and communications staff to guide advocacy efforts toward road salt reduction. NJ Salt Watch also benefits the NJ Watershed Watch Network in turn with the chance to connect with other nonagency water quality data contributors to market Network products and leverage their communication media and network of volunteers. Ultimately, the project resulted in a net gain in value, with about $30,000 in expenses resulting in $75,000 of estimated volunteer contributions.

NJ Salt Watch and my PSM degree will be forever linked in my mind since I started them both in the fall of 2020. While I was developing the study design, I had the opportunity to focus class projects on the topic of road salt and freshwater salinization to gain a better understanding of its drivers and the matrix of physical, chemical, and biological consequences that result. The PSM program has allowed me to build upon more than 12 years of experience with The Watershed Institute, where I have been afforded many opportunities to explore my own passions and create new projects and programs that have the capacity to produce meaningful change. I hope to see the results of this project, combined with those of many other related initiatives, lead to true measurable improvements in winter road management and water quality.

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