# REDUCING CHLORIDE DISCHARGES TO SURFACE WATER AND GROUNDWATER: A MENU OF OPTIONS FOR POLICYMAKERS

BY

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*Greater environmental protections and increased public safety are often believed to be synonymous, or at least to go hand-in-hand. Sometimes, however, those two goals are arguably in tension—for example, when the excess application of salt for winter deicing, in combination with other chloride sources, causes elevated chloride concentrations in waterways. Sodium chloride, commonly known as salt, has often played a critical role in human culture, trade, religion, economics, public safety, and even warfare. But it has a complicated legacy that includes potentially serious adverse consequences for human health and the environment, including deteriorated water quality, toxicity to aquatic and benthic organisms, adverse effects on vegetation, and impacts to drinking water supplies. Moreover, environmental chloride concentrations are on the rise, having approximately doubled over the past two decades. Hundreds of scientific studies have examined potential risks to human health and the environment associated with excess chlorides in the environment, especially those sourced from deicing operations. Yet little, if any, of that work has been directed toward developing legal and policy strategies to address the chloride issue.*

*This interdisciplinary Article examines the underlying causes of unsustainable chloride pollution from a scientific and engineering perspective, and then proposes a menu of responsive legal and policy options. These options include incentivized self-governance at the community or individual levels; informational strategies to encourage optimal chloride use levels for deicing and in water softening applications; direct legal and regulatory mechanisms or mandated best practices issued pursuant to the Clean Water Act, state regulations, or municipal ordinances; use of chloride alternatives such as green*

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*infrastructure and substitute deicing substances; integrated watershed management; and direct economic measures. The Article does not suggest that all these options are appropriate in every context, nor does it rank them from most to least useful. Those decisions are left to affected stakeholders.*

*Moreover, the Article does not suggest the elimination of chloride use in its most visible forms (winter maintenance and water softening). Rather, it suggests that such use be optimized. In that spirit, the Article examines the technical and legal contours of each option, and links the scientific underpinnings to the legal and policy dimensions. This approach increases the likelihood that ultimate policy decisions can be both legally defensible and scientifically sound.*



## I. CHLORIDE IN THE ENVIRONMENT

For thousands of years, sodium chloride—commonly known as salt—has played a critical role in human civilization. Over the centuries, it has at times been central to human culture, trade, religion, economics, public safety, and even warfare.[1] Yet it has a complicated legacy. Only quite recently have scientists begun to analyze the potentially toxic effects of chloride accumulated in the natural environment.[2]

Chloride is the negatively charged ion of many salts, such as sodium chloride. It is naturally found in both fresh and salt water, and at modest concentrations is essential to biotic life.[3] However, excess chloride concentrations may inflict serious harm on human health and the environment.[4]

### *A. Sources of Environmental Chloride*

Chloride from anthropogenic sources enters the environment via numerous routes, including snow and ice removal practices, salt storage facilities, wastewater treatment facility and septic system effluent, industrial facilities, agricultural operations, oil and gas wells, and natural sources such as atmospheric deposition.

*Snow and ice removal practices*. Chloride use in the United States has increased significantly since 1950, and the major factor has been the use of salt for deicing during the winter months.[5] Perhaps the most visible source to the environment, widespread use of chloride for snow and ice clearing began around 1960,[6] as transportation agencies began implementing "bare

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1 For a general discussion of the role of salt in human history, see *History of Salt?*, SALTWORKS, https://perma.cc/3UZ7-LVL8 (last visited Jan. 27, 2018).

2 Scientists began to recognize the detrimental effects of chloride in the environment as early as the 1960s. Steven R. Corsi et al., *A Fresh Look at Road Salt: Aquatic Toxicity and Water-Quality Impacts on Local, Regional, and National Scales*, 44 ENVTL. SCI. & TECH. 7376, 7376 (2010) [hereinafter Corsi et al., *A Fresh Look at Road Salt*]. Researchers at the Highway Research Board and the Environmental Protection Agency began warning of the dangers of excess salt usage in the late 1960s and early 1970s. *See generally* ROBERT C. BUBECK & RICHARD S. BURTON, U.S. GEOLOGICAL SURVEY, REP. NO. 87-4223, CHANGES IN CHLORIDE CONCENTRATIONS, MIXING PATTERNS, AND STRATIFICATION CHARACTERISTICS OF IRONDEQUOIT BAY, MONROE COUNTY, NEW YORK, AFTER DECREASED USE OF ROAD-DEICING SALTS, 1974–1984, at 3 (1989). A more complete catalog of the effects of chloride on human health and the environment is provided in Parts I.A. and I.B, *infra*.

3 MOLLY HUNT ET AL., CHLORIDES IN FRESH WATER 1 (2012), https://perma.cc/M3PG-XQRC; KATHLEEN LAKE ET AL., MADISON METRO. SEWERAGE DIST. ET AL., THE REDUCTION OF INFLUENT CHLORIDE TO WASTEWATER TREATMENT PLANTS BY THE OPTIMIZATION OF RESIDENTIAL WATER SOFTENERS 1, https://perma.cc/Y968-RZKZ (last visited Jan. 27, 2018).

4 *See* Mark Sagoff, *The Principles of Federal Pollution Control Law*, 71 MINN. L. REV. 19, 29–30, 68 (1986) ("Although pollution control law includes protections for the environment, its primary purpose is to protect public safety and health."); *see also* discussion *infra* Part I.D.

5 JOHN R. MULLANEY ET AL., U.S. GEOLOGICAL SURVEY, CHLORIDE IN GROUNDWATER AND SURFACE WATER IN AREAS UNDERLAIN BY THE GLACIAL AQUIFER SYSTEM, NORTHERN UNITED STATES 2 (2009) [hereinafter USGS, CHLORIDE IN GROUNDWATER].

6 *See* Walton R. Kelly et al., *Using Chloride and Other Ions to Trace Sewage and Road Salt in the Illinois Waterway*, 25 APPLIED GEOCHEMISTRY 661, 662 (2010) [hereinafter Kelly et al., *Using Chloride*] ("Application of salt as a road deicer in the USA began in earnest around 1960.").

pavement" policies;[7] though by some accounts, the practice was first employed in New Hampshire during or just before World War II.[8] Before that time, vehicles had navigated snowy and icy conditions using tire chains or studded "winter" tires.

Chloride-based deicing and anti-icing agents such as sodium chloride are now routinely used to clear snow and ice on impervious roadway surfaces.[9] Regions classified as "snowy"—meaning that they receive more than five inches of annual snowfall—contain over 70% of the nation's population and road surfaces.[10] As of 2011, road salt application in the United States had risen to about 19.5 million metric tons per year[11] and now accounts for roughly 20% of state transportation maintenance budgets.[12] The use of deicers on travel surfaces has been extremely effective, "reducing accident rates by a factor of 8 on two-lane highways and [a factor of] 4.5 on multi-lane highways."[13] Obviously, this is highly important from a public safety perspective; each year, over 1,300 people perish and more than 116,800 are injured in vehicle accidents during winter precipitation events.[14]

Today, put simply, "[r]oad salts are essential to the transportation and highway maintenance industry in the United States."[15] Road salt performs two functions when used to clear snow and ice. First, it lowers the freezing point of water, often by several degrees: "The more salt is dissolved in the water, the more the freezing point is depressed."[16] Second, it inhibits ice from forming in the first place. During the freezing process, water molecules arrange themselves into a more solid structure. Salt slows that process by adding impurities to the water and disrupting the water molecules' ability to organize.[17] Although some alternative deicing substances are available, salt is

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7 For example, the Wisconsin Department of Transportation implemented a "bare pavement" policy in 1956. RICK WENTA & KIRSTI SORSA, PUB. HEALTH MADISON & DANE CTY., ROAD SALT REPORT – 2015, at 2 (2016).

8 *See* HUNT ET AL., *supra* note 3; *see also* Corsi et al., *A Fresh Look at Road Salt*, *supra* note 2, at 7376 ("[R]oad salt usage in the United States has increased steadily beginning in the 1940s . . . ."); Victoria R. Kelly et al., *Long-Term Sodium Chloride Retention in a Rural Watershed: Legacy Effects of Road Salt on Streamwater Concentration*, 42 ENVTL. SCI. & TECH. 410, 410 (2008) [hereinafter Kelly et al., *Long-Term Chloride Retention*].

9 *See, e.g.*, Ann L. Allert et al., *Toxicity of Chloride Under Winter Low-Flow Conditions in an Urban Watershed in Central Missouri, USA*, 89 BULL. ENVTL. CONTAMINATION & TOXICOLOGY 296, 296 (2012).

10 *Snow and Ice*, FED. HIGHWAY ADMIN., https://perma.cc/D7TQ-2DUA (last modified Jan. 27, 2018).

11 Steven R. Corsi et al., *River Chloride Trends in Snow-Affected Urban Watersheds: Increasing Concentrations Outpace Urban Growth Rate and Are Common Among All Seasons*, 508 SCI. TOTAL ENV'T 488, 489 (2015) [hereinafter Corsi et al., *River Chloride Trends*].

12 *Snow and Ice*, *supra* note 10.

13 USGS, CHLORIDE IN GROUNDWATER, *supra* note 5, at 8.

14 *Snow and Ice*, *supra* note 10.

15 Curtis A. Cooper et al., *Effects of Road Salts on Groundwater and Surface Water Dynamics of Sodium and Chloride in an Urban Restored Stream*, 121 BIOGEOCHEMISTRY 149, 149 (2014).

16 Jenny Marder, *How Does Salt Battle Road Ice?*, PBS NEWS HOUR (Jan. 18, 2011), https://perma.cc/SZR4-WABW.

17 *Id.*

typically considered the most effective and least costly substance for performing these functions.[18]

Some salt used for deicing is carried by runoff to surface water, and the resulting "[d]etrimental impacts . . . [are] evident on local, regional, and national scales."[19] According to some studies, essentially "all chloride ions that enter the soil and groundwater can ultimately be expected to reach surface water."[20] This occurs after disposal and melting of snow cleared from roadways, through dispersal by splashing and spray from vehicles, and via wind.[21]

Although its usage for deicing is often considered an issue for state or local governments, up to half of the salt used for winter maintenance enters the environment after being used to treat commercial or residential surfaces under private ownership such as parking lots, driveways, and sidewalks.[22] This complicates the legal and policy analysis due to the relative difficulty of regulating or otherwise influencing those sources as compared to public sector sources.

*Salt storage*. Chloride can also enter the environment via runoff from outdoor salt storage, especially when stored in uncovered piles.[23] Uncovered piles lose about 20% of their salt volume each year, much of it flowing directly into waterways via runoff.[24] Many states have promulgated regulations that mandate particular storage practices or facility construction requirements to prevent or minimize such runoff.[25]

*Wastewater treatment facility and septic system effluent.* Although most researchers have concluded that winter deicing runoff is the dominant source of chloride in surface waters, other studies reveal that treated wastewater can also be a major chloride source.[26] Chloride is "non-reactive," meaning that there is little or no loss when chloride in wastewater passes through wastewater treatment facilities or septic systems.[27] Instead, chloride "remain[s] in solution."[28] This is because it "cannot be removed using standard wastewater treatment technology; therefore, chloride that arrives in wastewater passes through treatment plants and enters natural water bodies as treated effluent."[29] It can enter the waste stream contained in food,

18 *See* Daniel L. Kelting et al., *Regional Analysis of the Effect of Paved Roads on Sodium and Chloride in Lakes*, 46 WATER RES. 2749, 2749 (2012).

19 Corsi et al., *A Fresh Look at Road Salt*, *supra* note 2, at 7381.

20 ENV'T CAN. & HEALTH CAN., PRIORITY SUBSTANCES LIST ASSESSMENT REPORT: ROAD SALTS 1 (2001).

21 *Id.*

22 *See, e.g.*, N.H. DEP'T OF ENVTL. SERVS., WD-WMB-4, ENVIRONMENTAL FACT SHEET: ROAD SALT AND WATER QUALITY (2016), https://perma.cc/V8VR-3HVC.

23 HUNT ET AL., *supra* note 3, at 1.

24 *Id.*

25 *See, e.g.*, WIS. ADMIN. CODE Trans § 277.04(3) (2017).

26 *See* Kelly et al., *Using Chloride*, *supra* note 6, at 671.

27 USGS, CHLORIDE IN GROUNDWATER, *supra* note 5, at 8.

28 Corsi et al., *A Fresh Look at Road Salt*, *supra* note 2, at 7376.

29 LAKE ET AL., *supra* note 3, at xi. Reverse osmosis filtration can remove chloride but is expensive and energy intensive. *Id.* at 1.

beverages, cleaning products, and from water softeners.[30] An average person consumes about 4.7 pounds of salt per year, and releases about 2.9 pounds of that to wastewater discharges.[31] In contrast to these average discharges contained in human waste, "[w]ater softeners can release considerably larger amounts of chloride to the environment" through "septic systems, dry wells, or wastewater-treatment facilities."[32] One recent study showed that on average, home water softeners discharge about 0.56 pounds of chloride per day to wastewater systems.[33]

*Industrial facilities.* Some industries, especially food processing and chemical manufacturing, use or generate significant amounts of chloride and chloride salts.[34] Values for chloride discharges from publicly owned wastewater treatment facilities may include these sources.[35]

*Agricultural operations.* Agricultural operations use salt as a feed additive and in other products such as pesticides and fertilizers.[36] Researchers have recommended that improved agricultural practices that use less water could simultaneously reduce salt loading to freshwater.[37] The Colorado River Basin Salinity Control Program has effectively reduced salt loading to the river by about 1.3 million tons per year, largely through improved irrigation practices.[38]

*Oil and gas wells.* Oil and gas wells produce brine as an extraction byproduct[39] and are a "major anthropogenic source" of chloride in surface waters.[40] Excess chloride loading from oil and gas wells has led to high chloride concentrations in parts of the Colorado River.[41]

*Natural sources and atmospheric deposition.* Natural sources of chloride to surface and ground waters include the oceans, which themselves

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30 USGS, CHLORIDE IN GROUNDWATER, *supra* note 5, at 8.

31 *Id.* at 12.

32 *Id.*

33 LAKE ET AL., *supra* note 3, at xii.

34 GREGORY E. GRANATO ET AL., U.S. GEOLOGICAL SURVEY, REP. NO. 2015-1080, METHODS FOR EVALUATING POTENTIAL SOURCES OF CHLORIDE IN SURFACE WATERS AND GROUNDWATERS OF THE CONTERMINOUS UNITED STATES 2 (2015) [hereinafter USGS, METHODS FOR EVALUATING POTENTIAL SOURCES].

35 *Id.* at 21; USGS, CHLORIDE IN GROUNDWATER, *supra* note 5, at 3 fig.1, 5, 8.

36 *See* HUNT ET AL., *supra* note 3, at 2 (explaining that fertilizer made with potash contains mined salts and can result in chloride runoff to waterways); Kristin M. Gardner & Todd V. Royer, *Effect of Road Salt Application on Seasonal Chloride Concentrations and Toxicity in South-Central Indiana Streams*, 39 J. ENVTL. QUALITY 1036, 1036 (2010).

37 M. Canedo-Arguelles et al., *Saving Freshwater from Salts*, 351 SCIENCE 914, 916 (2016).

38 *Id.*

39 U.S. ENVTL. PROT. AGENCY, OIL FIELD CLEANUP AND TARGETED CONTROL OF INVASIVE BRUSH SPECIES REDUCE CHLORIDE IN THE COLORADO RIVER (2015), https://perma.cc/A3ZF-G5ED [hereinafter EPA, OIL FIELD CLEANUP]; *see also* WALTON R. KELLY ET AL., THE SOURCES, DISTRIBUTION, AND TRENDS OF CHLORIDE IN THE WATERS OF ILLINOIS 10 (2012).

40 U.S. ENVTL. PROT. AGENCY, AMBIENT WATER QUALITY FOR CHLORIDE—1988, at 1 (1988) [hereinafter EPA, AMBIENT WATER QUALITY].

41 *See* EPA, OIL FIELD CLEANUP, *supra* note 39 (attributing high chloride concentrations to, among other things, noncompliant oil and gas wells).

contain about 19,000 milligrams per liter (mg/L) of chloride;[42] soil/rock weathering interactions;[43] and minor levels of atmospheric deposition.[44]

The relative magnitude of these sources is difficult to evaluate because of highly localized variables. Studies undertaken in Milwaukee, Wisconsin watersheds appear to show that road salt is the dominant contributor due to winter spikes in chloride concentrations in surface waters.[45] Other studies claim that "[a]bout 70 percent of the salt consumed and dispersed to the environment each year is from sources *other than* deicing chemicals."[46] For example, in hard water communities, chloride concentrations in influent to treatment facilities are mostly composed of salt from water softeners, as shown in Table 1. Yet these results necessarily exclude the contribution of chloride-contaminated runoff that directly enters surface waters without passing through a treatment facility.

<table>
<tr><th>Study author</th><th>Year</th><th>Deicing and related runoff</th><th>Water softener use</th><th>Other industrial</th><th>Other or background</th></tr>
<tr><td>Madison, Wisconsin Metropolitan Sewerage District[47]</td><td>2015</td><td>7%</td><td>57%</td><td>18%</td><td>18%</td></tr>
<tr><td>Twin Cities Metropolitan Area[48]</td><td>2000–2007</td><td>27.5%</td><td colspan="3">72.5% from wastewater treatment facilities, collectively</td></tr>
<tr><td>State of New Hampshire[49]</td><td>2013</td><td>96%</td><td>2%</td><td>Not reported</td><td>2%</td></tr>
</table>

**Table 1: Relative contributions of various chloride sources to the environment**

42 USGS, CHLORIDE IN GROUNDWATER, *supra* note 5, at 2.

43 S.V. PANNO ET AL., ILL. STATE GEOLOGICAL SURVEY, DATABASE FOR THE CHARACTERIZATION AND IDENTIFICATION OF THE SOURCES OF SODIUM AND CHLORIDE IN NATURAL WATERS OF ILLINOIS 1 (2005); USGS, CHLORIDE IN GROUNDWATER, *supra* note 5, at 5.

44 *See* USGS, CHLORIDE IN GROUNDWATER, *supra* note 5, at 2 (finding that atmospheric deposition averaged 0.04 to 6.2 tons per square mile in the study area); *see also* Gardner & Royer, *supra* note 36, at 1036 (stating the magnitude of atmospheric deposition is dependent upon geographic locations).

45 *See* Corsi et al., *A Fresh Look at Road Salt*, *supra* note 2, at 7381; Corsi et al., *River Chloride Trends*, *supra* note 11, at 489, 492.

46 USGS, METHODS FOR EVALUATING POTENTIAL SOURCES, *supra* note 34, at 2 (emphasis added).

47 LAKE ET AL., *supra* note 3, at 3 tbl.1.

48 *See* Eric V. Novotny et al., *Chloride Ion Transport and Mass Balance in a Metropolitan Area Using Road Salt*, WATER RESOURCES RES., Dec. 2009, at 1, 12, W12410 ("Of the 120,000 [metric tons] of chloride added annually 87,000 . . . came from the four [wastewater treatment plants] (point sources) and 33,000 . . . came from road salt (nonpoint source).").

49 PHILIP TROWBRIDGE & ERIC WILLIAMS, N.H. DEP'T OF ENVTL. SERVS., ROAD SALT TMDLS AND ROAD SALT REDUCTION STRATEGIES IN NEW HAMPSHIRE (2013), https://perma.cc/7PL9-4PPZ. In more detail, the New Hampshire study concluded that 50% of chloride discharges to surface waters resulted from parking lot deicing; 27% from municipal road deicing; 9% from state road deicing; 7% from salt pile runoff; 3% from private road deicing; 2% from water softener discharge; 1% from food waste; and 1% from atmospheric deposition. *Id.*; *see also* ERIC WILLIAMS, N.H. DEP'T OF ENVTL. SERVS., SALT REDUCTION: AN OUTCOME FROM INTERSTATE 93 WIDENING (2012), https://perma.cc/Z3JF-9CWY (listing New Hampshire's allocation of salt).

### *B. Fate and Transport of Environmental Chloride*

Because numerous existing studies have demonstrated elevated chloride concentrations in surface waters and groundwater, the scope of this project did not include the collection of additional chloride data. Below, the results of existing comprehensive studies of chloride fate and transport mechanisms are distilled into nine principal findings that may be of special interest to policymakers selecting legal and policy strategies to address excess chloride issues.

*1. Elevated chloride concentrations are observed during all seasons and reach maximum levels during winter months.* Existing data bear out the intuitive expectation that chloride concentrations in waterways consistently increase[50] and eventually peak[51] during the winter months;[52] after all, that is the time frame during which the overwhelming volume of deicers are used.[53] Yet researchers have observed increasing chloride trends during all seasons, with elevated chloride concentrations persisting into the summer months.[54]

*2. Elevated chloride concentrations are a risk to aquatic life and limit the effectiveness of costly resource management and restoration efforts.* "Elevated salt concentrations in surface waters can exert an adverse impact on aquatic organisms."[55] "Long-term exposure . . . can cause a range of effects such as mortality, growth abnormalities, and reproductive failure in fishes and invertebrates."[56] The United States Environmental Protection Agency (EPA) regulates chloride as a water quality pollutant subject to the Clean Water Act[57] (CWA). EPA has set water quality standards for chloride at an acute toxicity level of 860 mg/L and a chronic toxicity level of 230 mg/L.[58] As noted above, studies have shown that exceedances of these standards

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50 Allert et al., *supra* note 9, at 296.

51 *Id.*; Gardner & Royer, *supra* note 36, at 1038 (noting "[d]istinct spikes" observed during winter).

52 Kelly et al., *Using Chloride*, *supra* note 6, at 668 ("Winter samples contained the greatest [chloride] concentrations and clearly show the influence of road salt runoff.").

53 Corsi et al., *River Chloride Trends*, *supra* note 11, at 495; *see also* Faranak Amirsalari et al., *Investigation of Correlation Between Remotely Sensed Impervious Surfaces and Chloride Concentrations*, 34 INT'L J. REMOTE SENSING 1507, 1517 (2013) (showing increased chloride concentrations resulting from road salt use during winter months).

54 Corsi et al., *River Chloride Trends*, *supra* note 11, at 495; *see also* Cooper et al., *supra* note 15, at 150, 161 (noting that potential chloride impacts were not considered in an over $5 million stream restoration project); Corsi et al., *A Fresh Look at Road Salt*, *supra* note 2, at 7381; ENV'T CAN. & HEALTH CAN., *supra* note 20, at 1 (noting high summer concentrations may result from travel time to surface waters coupled with low summer flow conditions).

55 Corsi et al., *River Chloride Trends*, *supra* note 11, at 489.

56 Allert et al., *supra* note 9, at 296.

57 Federal Water Pollution Control Act, 33 U.S.C. §§ 1251–1387 (2012).

58 EPA, AMBIENT WATER QUALITY, *supra* note 40, at 8–9 (noting that acute toxicity level is calculated such that a freshwater aquatic organism should not be affected unacceptably if ambient four-day average concentration of dissolved chloride does not exceed acute toxicity level more than once every three years on average and if the one-hour average (chronic) concentration does not exceed chronic toxicity level more than once every three years on average).

regularly occur during all seasons, not just winter.[59] Further, elevated chloride concentrations have adverse effects on vegetation and wetlands in environmentally sensitive areas, and excess concentrations "can destroy rare and endangered plant species."[60]

These effects also have the potential to negate costly efforts made to restore degraded urban waterways by reducing water quality and aquatic activity.[61] When not considered and mitigated, they limit the ability to restore streams and diminish a variety of ecosystem services.[62]

*3. Elevated chloride concentrations are highly correlated with impervious surfaces, especially roads, resulting from human development.*[63] Generally, greater urbanization and increased amounts of impervious surface demonstrate a strong positive correlation with increased urban runoff and surface water quality impacts.[64] Chloride is no exception, and it is certainly intuitive that larger impervious roadway areas necessitate increased deicer use. Studies have confirmed that chloride concentrations in surface waters are higher in areas with increased urbanization and impervious surfaces such as major highways.[65] In fact, the highest chloride concentrations in surface water were directly correlated with areas having the highest percentage of impervious surfaces.[66] In one study, an average 12.9% increase in impervious surfaces led to a corresponding *threefold*

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59 Corsi et al., *A Fresh Look at Road Salt*, *supra* note 2, at 7381; Corsi et al., *River Chloride Trends*, *supra* note 11, at 489, 495.

60 PANNO ET AL., *supra* note 43, at 1.

61 Cooper et al., *supra* note 15, at 151.

62 *Id.* at 163; *see also* J.B. Ruhl, *Ecosystem Services and Federal Public Lands: Start-Up Policy Questions and Research Needs*, 20 DUKE ENVTL. L. & POL'Y F. 275, 275–76 (2010) ("Ecosystem services are the economic benefits humans derive from the ecosystem structure and processes that form what might be thought of as natural capital. [Such] services flow to human communities in four streams: (1) provisioning services are commodities such as food, wood, fiber, and water; (2) regulating services moderate or control environmental conditions, such as flood control by wetlands, water purification by aquifers, and carbon sequestration by forests; (3) cultural services include recreation, education, and aesthetics; and (4) supporting services, such as nutrient cycling, soil formation, and primary production, make the previous three service streams possible." (footnote omitted)).

63 *But see* Corsi et al., *River Chloride Trends*, *supra* note 11, at 493 (hypothesizing that "land cover information alone cannot account for . . . chloride trends," and that other sources such as agricultural runoff must also be considered).

64 Amirsalari et al., *supra* note 53, at 1508; Gardner & Royer, *supra* note 36, at 1036 ("Urbanization . . . increases the potential for the deicer to be transported to surface waters."); Kelting et al., *supra* note 18, at 2754 (noting a "high correlation between road density . . . and chloride concentrations"); Philip R. Trowbridge et al., *Relating Road Salt to Exceedances of the Water Quality Standard for Chloride in New Hampshire Streams*, 44 ENVTL. SCI. & TECH. 4903, 4903 (2010) (reporting chloride concentrations "directly correlated with development"); *accord* M.K. Steele & J.A. Aitkenhead-Peterson, *Long-Term Sodium and Chloride Surface Water Exports from the Dallas/Fort Worth Region*, 409 SCI. TOTAL ENV'T 3021, 3021–22, 3026 (2011) (noting "[i]ncreasing salinity is one of the many impacts urbanization has on surface water quality," even in southern watersheds).

65 Amirsalari et al., *supra* note 53, at 1518–19; *see also* HUNT ET AL., *supra* note 3, at 1 (noting that in impervious areas, "runoff does not have a chance to soak into the ground before entering rivers, lakes, and streams").

66 Amirsalari et al., *supra* note 53, at 1518–19.

increase in chloride levels at water quality monitoring stations.[67] Another study revealed that chloride concentrations in lakes in watersheds without paved roads was an astonishing twenty-nine times lower than the concentration measured in lakes in watersheds with paved roads.[68] Similarly, watersheds with low levels of development had the lowest chloride concentrations in surface waters.[69]

*4. Despite reduction efforts, economic considerations, and technological advances, salt use and chloride concentrations in waterways continue to increase*. As awareness of the chloride problem grows, a few efforts have been made to curb overuse. Yet concentrations in waterways have continued to increase.[70] In Illinois, chloride concentrations in shallow groundwater have been steadily increasing since about 1960.[71] In fact, chloride concentrations in some waters used for the drinking supply have doubled over the past two decades.[72]

*5. About half of chloride applied as road salt enters aquifers before the next salting season*. Chloride contributions to surface and ground waters as a result of deicing have both a short-term and long-term component. The short-term chloride component is contained in surface water runoff via overland flow along with a small component of groundwater flow.[73] This chloride enters surface waters within six to twelve months of application.[74] Meanwhile, about 40% of the chloride applied in a watershed during the salting season enters the groundwater aquifer.[75] Over the long-term, the aquifer simultaneously, but more slowly, releases chloride acquired during previous salting seasons to the watershed.[76] The difference between these short-term and long-term releases accumulates in the watershed and causes a slow increase in chloride concentrations.

*6. Increased use of green infrastructure, and especially porous pavements, would significantly reduce chloride application requirements*.[77]

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67 *Id.* at 1523.

68 Kelting et al., *supra* note 18, at 2752.

69 Amirsalari et al., *supra* note 53, at 1518–19. *See generally* Hilary A. Dugan et al., *Salting Our Freshwater Lakes*, 114 PROC. NAT'L ACAD. SCI. U.S. 4453 (2017) (describing evaluation of 371 North American freshwater lakes, and finding a strong correlation between long-term salinization and impervious surroundings).

70 Walton R. Kelly et al., *Impacts of Road Salt Runoff on Water Quality of the Chicago, Illinois, Region*, 18 ENVTL. & ENGINEERING GEOSCIENCE 65, 65 (2012) [hereinafter Kelly et al., *Impacts of Road Salt*]; *see also* Kelly et al., *Using Chloride*, *supra* note 6, at 661–62; *see also infra* note 87 and accompanying text.

71 Kelly et al., *Impacts of Road Salt*, *supra* note 70, at 65; *see also* Corsi et al., *River Chloride Trends*, *supra* note 11, at 493 ("[C]hloride concentrations increased with time.").

72 *See, e.g.*, WENTA & SORSA, *supra* note 7 (reporting on the impacts of road salt in Madison, Wisconsin).

73 Nandana Perera et al., *Groundwater Chloride Response in the Highland Creek Watershed Due to Road Salt Application: A Re-Assessment After 20 Years*, 479 J. HYDROLOGY 159, 163–64 (2013).

74 *Id.* at 164.

75 *Id.*

76 *Id.*

77 Later Parts of this Article discuss various legal and policy strategies for reducing chloride discharges to waterways. One of these is encouraging the use of chloride alternatives

As described above, chlorides are often applied during winter months to assist in clearing snow and ice from roadways and other impervious travel surfaces.[78] Application volumes could be significantly reduced, of course, if water did not pool and form ice on the surface in the first place. Permeable pavements (also known as porous pavements) allow a sizeable fraction of precipitation to infiltrate immediately without pooling and freezing on the surface.[79] In other words, on porous pavements there is no standing water.[80] One study showed that porous pavements required 64% to 77% less salt to maintain equivalent or better surface conditions as compared to a traditional asphalt pavement.[81] When using these practices under ordinary maintenance conditions, "only minimal salting was needed . . . unless freezing rain created icy conditions."[82]

*7. Chloride input to waterways continues during non-snowmelt periods, probably because of chloride retention in groundwater and soils*. Although increases in urbanization and impervious surfaces often cause corresponding increases in chloride load to waters, additional transport results from long-term ecosystem storage of chloride in groundwater or soils.[83] Salt that enters soil and groundwater is retained and accumulated, acting first as a chloride sink and later as a reservoir that supplies excess chloride to surface waters.[84] Chloride recharge can occur during rain and snowmelt events.[85] This long-term retention of chloride is a cause for "much concern" because of the corresponding water quality impacts.[86]

*8. Elevated chloride concentrations persist in watersheds for many decades*. New decadal data from the United States Geological Survey (USGS) shows chloride concentrations in groundwater are rising in most parts of the United States, but especially in northern regions.[87] Other studies have found that elevated chloride concentrations persist for at least forty to

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such as "green infrastructure." For a more complete description of green infrastructure, see *infra* Part II.D.1.

78 *See supra* discussion Part I.A.

79 *See generally* Robert M. Roseen et al., *Assessment of Winter Maintenance of Porous Asphalt and Its Function for Chloride Source Control*, J. TRANSP. ENGINEERING, 2013, 04013007 (examining the performance of porous asphalt in freezing conditions for reduction of road salt application).

80 *Id.* at 8.

81 *Id.* at 7.

82 *Id.* at 8.

83 Kelly et al., *Long-Term Chloride Retention*, *supra* note 8, at 413.

84 Dustin W. Kincaid & Stuart E.G. Findlay, *Sources of Elevated Chloride in Local Streams: Groundwater and Soils as Potential Reservoirs*, 203 WATER AIR & SOIL POLLUTION 335, 336 (2009).

85 *See generally* Chad E. Reisch & Laura Toran, *Characterizing Snowmelt Anomalies in Hydrochemographs of a Karst Spring, Cumberland Valley, Pennsylvania (USA): Evidence for Multiple Recharge Pathways*, 72 ENVTL. EARTH SCIS. 47, 48, 56–57 (2014) (discussing the characteristics of internal runoff and diffuse infiltration through monitoring conductivity, water level, air temperature, and depth of snowpack).

86 Novotny et al., *supra* note 48, at 12.

87 *Decadal Change in Groundwater Quality: Comparing 1998–2001 to 2002–2012*, U.S. GEOLOGICAL SURV., https://perma.cc/WGG4-ZGWF (last visited Jan. 27, 2018) (select "Enter the mapper" to view interactive map).

seventy years, perhaps longer.[88] A 1993 study estimated that even if road salting in the Toronto area were stopped immediately, it would take decades before the chloride concentrations in shallow groundwater returned to pre-1960 levels.[89] Researchers studying the Twin Cities Metropolitan Area similarly concluded that it would take ten to thirty years for chloride concentrations in area lakes to return to predevelopment levels if road salt applications were eliminated; however, chloride levels would fall below EPA's chronic exposure standard if salt applications decreased by about 50%.[90]

*9. Surveys of those in the deicing industry reveal few efforts or incentives to reduce salt use*. In a recent survey, a majority of contractors indicated a preference for so-called "salt extra" contracts, meaning that the client (not the contractor) pays for the amount of salt applied.[91] This typically results in over-application of salt, and certainly provides no incentive for conservative practices.[92] Contractors also admitted that they rarely use pre-wetting or direct liquid application techniques, despite their proven effectiveness.[93] Moreover, contractors reported significant variation in application rates at similar conditions, revealing that some contractors may remain unsure of material requirements appropriate for given road and weather conditions.[94]

Finally, many contractors admitted applying excess salt to avoid slip-and-fall incidents and litigation.[95] Respondents reported that significant percentages of salt could be saved if litigation and insurance premiums were not a concern.[96] New Hampshire's version of what this Article terms the "incentivized self-governance" approach accounts for this problem by providing a liability waiver in exchange for voluntary participation in a training and reporting program intended to optimize deicer use.[97]

A survey of municipal chloride users yielded similarly discouraging results. For example, only 5% of municipalities report using anti-icing methods.[98] Only about 36% use pre-wetted salts.[99] Few municipalities reported using materials other than ordinary road salts for deicing purposes:

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88 Stephen B. Shaw et al., *Simple Model of Changes in Stream Chloride Levels Attributable to Road Salt Applications*, 138 J. ENVTL. ENGINEERING 112, 116 (2012).

89 *See* Kelly et al., *Impacts of Road Salt*, *supra* note 70, at 66.

90 Eric Vladimir Novotny & Heinz Gunter Stefan, *Projections of Chloride Concentrations in Urban Lakes Receiving Road De-icing Salt*, 211 WATER AIR & SOIL POLLUTION 261, 270 (2010).

91 KAMAL HOSSAIN & LIPING FU, UNIV. OF WATERLOO, OPTIMAL SNOW AND ICE CONTROL OF PARKING LOTS AND SIDEWALKS 6–7 (2015) (explaining that 60% of over 100 winter contractors surveyed prefer "salt extra" contracts).

92 *Id.* at 7.

93 *Id.*

94 *Id.*; *see infra* Part II.C (revealing similar variances in state guidance related to material requirements at given road and weather conditions).

95 HOSSAIN & FU, *supra* note 91, at 7.

96 *Id.* This reinforces the attractiveness of a liability waiver program such as New Hampshire's. *See* discussion *infra* Part II.A.

97 *See infra* Part II.A.

98 HOSSAIN & FU, *supra* note 91, at 9.

99 *Id.*

65% reported using sodium chloride, 35% use other chloride-based materials, 16% use abrasives such as sand, and none reported using organic salts.[100] Like the application contractors, the municipal survey results revealed significant variation in application guidelines, and nearly half of respondents admitted to issuing no guidelines at all for determining the best application rate for parking lots and other privately owned surfaces during a given weather event.[101]

### *C. Legal Consequences of Excess Environmental Chloride*

To date, little or no legal incentives or policies exist to avoid overuse of chloride. To the contrary, historically over-application and overuse of salt has been the "safe" strategy in light of potential liability concerns. That may change, however, given recent reports of citizen-instituted lawsuits against municipalities and private property owners for over-application of salt and the resulting environmental harms. Most recently, in November 2017, residents of Brighton, Michigan sued General Motors claiming that the company's use of road salt to clear ice from its nearby Milford proving grounds resulted in groundwater contamination causing health impacts and property damage.[102] The complaint alleges that General Motors "released hundreds of thousands of tons of salt . . . over the last several decades, leading to extremely high concentrations of sodium and chloride in surface and groundwater" that "migrated . . . in[to] water used by Plaintiffs."[103] The citizens alleged damages under two state laws—the Michigan Natural Resources and Environmental Protection Act[104] and the Michigan Environmental Protection Act[105]—and under common law theories including fraud, negligence, trespass, private nuisance, and public nuisance.[106] On December 29, 2017, General Motors moved to remove the action to federal court.[107]

In another case, a citizen alleged that the City of Omaha had over-applied salt in a floodplain—tantamount to open dumping of solid waste—and in the process violated the Resource Conservation and Recovery Act[108] (RCRA).[109] The court ultimately dismissed the lawsuit because it found the City's salt application practices to be consistent with the intended purpose

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100 *Id.* This is the case even though testing showed no significant differences between the performance of chloride-based salts and that of organic-based salts. *Id.* at 19.

101 *Id.* at 9.

102 *See generally* Class Action Complaint & Jury Demand, Moore v. Gen. Motors LLC, No. 2017-29670-CE (Mich. Cir. Ct. filed Nov. 30, 2017).

103 *Id.* at 5 (abbreviation omitted).

104 1994 Mich. Pub. Acts 2215 (codified in scattered sections of MICH. COMP. LAWS § 324).

105 MICH. COMP. LAWS §§ 324.1701–.1706 (2017).

106 Class Action Complaint & Jury Demand, *supra* note 102, at 17–23.

107 *See generally* General Motors LLC's Notice of Removal, Moore v. Gen. Motors LLC, No. 2:17-cv-14226-NGE-SSD (E.D. Mich. filed Dec. 29, 2017).

108 Resource Conservation and Recovery Act of 1976, 42 U.S.C. §§ 6901–6992k (2012) (amending Solid Waste Disposal Act, Pub. L. No. 89-272, 79 Stat. 992 (1965)).

109 Krause v. City of Omaha, No. 8:15CV197, 2015 WL 5008657, at *3 (D. Neb. Aug. 19, 2015).

of the product, and therefore not the equivalent of unlawful "discarding" under RCRA.[110] On appeal, the City again prevailed, with the Eighth Circuit concluding that the district court correctly determined that the salt application did not rise to the level of discarding solid waste.[111]

In contrast, however, some manure-spreading operators have recently been held liable under RCRA where the loads applied were far in excess of spreading requirements.[112] Because the manure applications were completely untethered to applicable best management practices and crop fertilization needs, the manure ceased to be a "useful product" and became "solid waste" for RCRA purposes.[113] The plaintiff in the Omaha case, who represented himself, did not make similar arguments related to the over-application of salt as compared to best practices, but certainly could have (and future plaintiffs might).

In another recent case, a citizen-plaintiff alleged that his property had been rendered undevelopable because the municipality's over-application of salt contaminated the groundwater underlying his property.[114] The court dismissed the suit because it found no imminent harm to human health or the environment, a requirement for RCRA liability.[115] It is conceivable that the court would have reached a different outcome if the groundwater was actively being consumed on the property—although, as discussed next, concerns over chloride are somewhat stronger in connection with environmental impacts than with human health impacts.

### *D. Elevated Chloride Concentrations in Surface Water and Groundwater Result in Public Health and Environmental Concerns*

Elevated chloride concentrations in water pose serious risks to human health and the environment. Reports of drinking water supplies contaminated with chloride have emerged in a number of locations.[116] USGS has called chloride contamination of drinking water supplies "[t]he primary concern for water quality" related to chloride.[117] A recent USGS study identified chloride contaminations above the EPA secondary maximum containment level (SMCL) in about 1.7% of drinking water wells.[118] Despite

110 *Id.* at *4.

111 Krause v. City of Omaha, 637 Fed. App'x 257, 258 (8th Cir. 2016).

112 Cmty. Ass'n for Restoration of the Env't, Inc. v. Cow Palace, LLC, 80 F. Supp. 3d 1180, 1221 (E.D. Wash. 2015).

113 *Id.*

114 Scotchtown Holdings LLC v. Town of Goshen, No. 08-CV-4720(CS), 2009 WL 27445, at *1 (S.D.N.Y. Jan. 5, 2009).

115 *Id.* at *2–3.

116 *See* PANNO ET AL., *supra* note 43, at 1 ("[Chloride] has adversely affected municipal and private water supplies in Illinois and other states.").

117 USGS, CHLORIDE IN GROUNDWATER, *supra* note 5, at 2; *see also* Kelly et al., *Using Chloride*, *supra* note 6, at 661 ("[Chloride] levels can make drinking water supplies non-potable or increase treatment costs substantially.").

118 USGS, CHLORIDE IN GROUNDWATER, *supra* note 5, at 15. The SMCL is a non-enforceable standard established by EPA as guidance to assist public water systems. *See Secondary Drinking Water Standards: Guidance for Nuisance Chemicals*, U.S. ENVTL. PROTECTION AGENCY,

this contamination, toxicity to humans is unreported except in special cases, such as congestive heart failure, but salts contribute to various heart ailments.[119] The use of ferrocyanide as an anti-caking agent for salt storage is a concern; it is very persistent in the environment, although its toxicity is relatively low.[120] Taste issues can arise at chloride concentrations greater than the 250 mg/L SMCL.[121]

The impact of chloride on the biotic environment can also be severe. Waters that exceed chloride criteria levels may exhibit acute and chronic toxic effects among various ecosystem populations.[122] These may include adverse effects on community structure, diversity, reproduction, and productivity, leading to reduced densities of bacteria, algae, plankton, and benthic and aquatic invertebrates.[123] Domino effects may result up the food chain; for example, zooplankton population losses deplete an important food source for larger organisms.[124] Some fish, insects, and microorganisms are even less tolerant of high chloride concentrations than plant life.[125] In turn, adverse effects among fauna may allow algae overgrowth, thus exacerbating existing problems of this type caused by excess nutrient levels.[126] In the Twin Cities Metropolitan Area, several lakes are projected to soon exceed chronic criteria on a year-round basis.[127]

Water quality, too, is degraded: thermal or chemical stratification is often observed, resulting in the prevention of dissolved oxygen from reaching the lower layers of the water body.[128] Groundwater salinization may

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https://perma.cc/Y43Q-SHRD (last updated Mar. 8, 2017) (revealing that EPA does not enforce SMCLs, and, rather, that "[t]hey are established as guidelines to assist public water systems in managing their drinking water for aesthetic considerations, such as taste, color, and odor").

119 Hypertension associated with sodium chloride intake is typically related to sodium rather than chloride and most sodium intake occurs through food consumption, not water consumption. *See* TRANSP. RESEARCH BD., NAT'L RESEARCH COUNCIL, HIGHWAY DEICING: COMPARING SALT AND CALCIUM MAGNESIUM ACETATE 99–100 (1991), https://perma.cc/KBY9-39S3 (referring to a survey done by the Food and Drug Administration that "food accounts for 98 to 99 percent of daily sodium intake" whereas drinking water only accounts for "1 to 2 percent").

120 ENV'T CAN. & HEALTH CAN., *supra* note 20, at 3. However, under certain environmental conditions, ferrocyanides may release volatile cyanide ions, making risk judgments significantly more complex. *Id.*

121 *See Secondary Drinking Water Standards: Guidance for Nuisance Chemicals*, *supra* note 118.

122 *See* Corsi et al., *River Chloride Trends*, *supra* note 11, at 495 ("Elevated chloride concentrations resulting from road salt application and runoff in watersheds have potential impacts on aquatic organisms.").

123 *Id.*

124 *Climate Impacts on Ecosystems*, U.S. ENVTL. PROTECTION AGENCY, https://perma.cc/L27H-365F (last updated Jan. 27, 2018).

125 *See generally* LORI SIEGEL, N.H. DEP'T OF ENVTL. SERVS., HAZARD IDENTIFICATION FOR HUMAN AND ECOLOGICAL EFFECTS OF SODIUM CHLORIDE ROAD SALT 7–10 & tbl.4 (2007), https://perma.cc/3QK7-NS3L (discussing chloride toxicity thresholds for various species).

126 *Accord Nutrient Pollution: The Problem*, U.S. ENVTL. PROTECTION AGENCY, https://perma.cc/BQ6P-U4BG (last updated Mar. 10, 2017).

127 Novotny & Stefan, *supra* note 90, at 261.

128 Novotny et al., *supra* note 48, at 1 (noting that the accumulation of chloride degrades water quality); *see also* BUBECK & BURTON, *supra* note 2, at 1, 13 ("As the chloride content increased, summer stratification and anoxic conditions in the bottom water continued later

impact benthic organisms, as well as serving as a reservoir for future chloride releases.[129]

Excess chloride also influences soil structures and vegetation.[130] This is especially relevant in regions with thin soils, which cannot absorb as much salt without damaging the soil composition and altering soil chemistry. Generally, sodium and chloride in soil "absorbs . . . moisture and displaces . . . calcium [that] plants need for sustenance, similar to the effect[s] of acid rain."[131] In extreme cases, tree mortality can result.[132] Finally, excess chloride impacts the non-biotic environment through corrosive effects on cars, roads, bridges, guardrails, street lights, fire hydrants, and other infrastructure.[133] One study estimated that on average, the equivalent cost of deicer corrosion is about thirty-two dollars per vehicle per year.[134] Deicing substances cause detrimental effects on both reinforced steel and concrete structures.[135]

Because chloride is so difficult to remove using traditional wastewater treatment approaches, use reduction (or put differently, optimization) appears to be the only effective management strategy.[136] However, "management or mitigation of this issue is complex. Solutions would require consideration of environmental, political, economic, and safety issues."[137] The Article addresses these issues next.

## II. Legal and Policy Options to Incentivize Optimal Chloride Use

This Part analyzes several legal and policy strategies for addressing excess chloride concentrations in surface waters and groundwater, and, where possible, identifies successful efforts underway using the identified strategy. These options include: 1) incentivized self-governance; 2) information dissemination; 3) direct regulatory strategies—i.e., relying on the CWA, state regulations, municipal ordinances, and mandated best practices; 4) chloride alternatives—i.e., green infrastructure and other salt alternatives; 5) integrated watershed management; and 6) direct legislation and/or taxing strategies. As stated at the outset, the intent of this work is to

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each fall. . . . Thermal stratification is the most important physical event in a lake's annual cycle . . . .").

129 Cooper et al., *supra* note 15, at 162.

130 *See* ENV'T CAN. & HEALTH CAN., *supra* note 20, at 2–3 (discussing the multitude of ways chloride can impact soil structures and vegetation).

131 Marcus Wolf & Brian Molongoski, *The Problem with Salt: Road Salt Contamination a Plague Across the State*, WATERTOWN DAILY TIMES (Aug. 7, 2016), https://perma.cc/HA5D-9XGN (citing Daniel L. Kelting, Executive Director of the Paul Smith's School of Natural Resource Management and Ecology).

132 *Id.* (citing John F. Sheehan, Adirondack Council Director of Communications).

133 Kelly et al., *Long-Term Chloride Retention*, *supra* note 8, at 410.

134 Xianming Shi et al., *Corrosion of Deicers to Metals in Transportation Infrastructure: Introduction and Recent Developments*, 27 CORROSION REVS. 23, 27 (2009).

135 *Id.* at 25–26.

136 *Accord* Corsi et al., *A Fresh Look at Road Salt*, *supra* note 2, at 7376 ("Currently, reduction in usage appears to be the only effective road-salt-runoff management strategy.").

137 *Id.* at 7382.

encourage optimization, not elimination, of chloride usage. Moreover, the Article does not propose a "one-size-fits-all" strategy to suit all municipalities; rather, the goal is to provide a menu of options for policymakers seeking to address chloride issues.

### *A. Incentivized Self-Governance*

The category of "incentivized self-governance" is intended to connote a category of programs under which regulated individuals or organizations take non-required action because they judge it to be in their best interests to do so, usually as a result of the provision of some incentive. This "incentivized" or "soft" governance approach has many legal and policy applications including health care reform,[138] higher education initiatives,[139] tax policy,[140] and other areas of the law.[141] It typically also enjoys the perception of not being unduly burdensome, as no one is required to take part in the program.

The soft governance approach can also be applied in the context of environmental law and policy.[142] As it relates to chloride reduction, this could be achieved via granting a liability waiver against damages associated with snow and ice conditions to contractors certified to employ deicing best management practices, absent extreme circumstances such as intentional wrongdoing. This addresses the widespread liability fears common to most deicing contractors, which undoubtedly lead to significant over-application of deicing salt.

The primary example of this is the New Hampshire Department of Environmental Services' (NHDES) innovative "Green SnowPro" program.[143] The program is described in the following Sections.

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138 *See* Louise G. Trubek, *New Governance and Soft Law in Health Care Reform*, 3 IND. HEALTH L. REV. 137, 139–41 (2006) (describing the values that can be observed from new governance and soft law in contemporary health care reform).

139 *See generally* Julie Rowland, Comment, *We Can Work It Out: Putting Our Best Foot Forward in International Higher Education Initiatives*, 2 PENN ST. J.L. & INT'L AFF. 118, 121 (2013) (exploring "legal and soft governance mechanisms involved" in international higher education).

140 *See generally* Allison Christians, *Networks, Norms, and National Tax Policy*, 9 WASH. U. GLOBAL STUD. L. REV. 1, 1 (2010) (demonstrating "how and why states use . . . soft governance . . . to develop global tax policy norms and achieve national tax policy goals").

141 *See generally* Anna di Robilant, *Genealogies of Soft Law*, 54 AM. J. COMP. L. 499 (2006) (explaining the genealogy and role of soft governance in private international law that has resulted in an increase in bodies of law and privatization of legal regimes).

142 *See, e.g.*, Andrea McArdle, *Lessons for New York: Comparative Urban Governance and the Challenge of Climate Change*, 42 FORDHAM URB. L.J. 91, 102–03 (2014) (arguing for an alternative approach to climate change policy focused on a transnational urban network that is "'regulate[d]' through the use of 'soft' law").

143 U.S. Envtl. Prot. Agency, *New Hampshire Road Salt Reduction Program Protects Personal Safety and the Environment*, NONPOINT SOURCE NEWS-NOTES, Jan. 2016, at 9, 9, https://perma.cc/65RW-L55A [hereinafter EPA, *Green SnowPro*].

*1. Program Origins*

NHDES, EPA, and the New Hampshire Department of Transportation jointly conducted water quality monitoring from 2002 through 2005 in four watersheds along Interstate 93 in New Hampshire.[144] This resulted in documented violations of water quality standards for chloride, triggering the need for a total maximum daily load (TMDL) study in these areas.[145] The CWA requires delegated state agencies to assess water bodies, and to determine if the presence of pollutants impairs the designated beneficial uses for that water body and cannot be controlled via ordinary permit limits.[146] The state must establish a TMDL to control discharges of pollutants causing exceedances in identified waters.[147] In the case of the New Hampshire I-93 waters, the authors of the TMDL study determined that road salt accounted for approximately 90% of chloride that was imported to the affected watersheds.[148] Further, the study reported that some watersheds remained above water quality standards almost 25% of the year.[149] Although most deicing occurs during the winter months, today this finding does not appear surprising given that more recent research has shown water quality exceedances during all seasons.[150] In order to meet water quality standards in the affected watersheds, the salt imports had to be decreased by 24% to 40% of the levels documented in 2007.[151]

New Hampshire decided to address the chloride problem, in part, by developing a training course "designed to educate commercial salt applicators and municipal staff responsible for snow and ice removal" about best practices for deicer application.[152] The training course, later denominated the "Green SnowPro" program, was first introduced in 2011 as part of a joint initiative between NHDES and the University of New Hampshire Technology Transfer Center.[153]

It was important for the program to be available to private deicing contractors, given current estimates that up to half of deicing applications occur on private property such as private roads, sidewalks, and parking lots.[154] Commercial applicators had expressed grave concern about programs advocating the application of less salt, given the potential legal liability

144 *Southern I-93 Corridor Chloride Impairment*, N.H. DEP'T ENVTL. SERVS., https://perma.cc/LX7C-CT5E (last visited Jan. 27, 2018).

145 *Id.*

146 *See* 33 U.S.C. § 1313(d)(1)(A)–(C) (2012).

147 *Id.* § 1313(d)(1)(D).

148 *See Southern I-93 Corridor Chloride Impairment*, *supra* note 144.

149 *Id.*

150 *See supra* notes 50–54 and accompanying text.

151 *Southern I-93 Corridor Chloride Impairment*, *supra* note 144.

152 *See* EPA, *Green SnowPro*, *supra* note 143.

153 *Id.*; Press Release, U.S. Envtl. Prot. Agency, New Hampshire Organizations and Residents Receive Prestigious EPA Environmental Award (June 26, 2013), https://perma.cc/Q5YM-MQ5N.

154 *See, e.g.*, N.H. DEP'T OF ENVTL. SERVS., *supra* note 22 (noting that, in four chloride-impaired watersheds in New Hampshire, road salt sources were 10%–15% from state roads, 30%–35% from municipal roads, and 45%–50% from private roads and parking lots).

associated with "slip and fall" cases and other related accidents that, it is often alleged, may be caused by icy conditions.[155]

To address this concern, administrators added what was to become the program's most innovative (and, for the private sector, most desirable) aspect: a statutory waiver of snow and ice related liability for program-certified commercial salt applicators.[156]

*2. Certification Requirements and Liability Waiver*

The program includes multiple levels of certification options. An individual who performs snow and ice removal services but does not hire employees may earn an Individual Certification.[157] Larger organizations with one or more employees may earn a Master Certification, which serves as an umbrella for the whole company.[158] A person who seeks certification under the program must complete several prerequisite steps. First, the person must complete the training course, which includes four to five hours of classroom learning on efficient and environmentally friendly winter maintenance practices.[159] The training covers basics of salt reduction, including equipment calibration, anti-icing, brine making, pre-wetting with brine, efficient application rate changes, and effective plowing techniques, among other things.[160] The next step is a thirty-minute examination covering the program topics.[161] If the person receives a passing score on the exam, the person is eligible to apply for the Voluntary Salt Applicator Certification and Liability Protection Program.[162]

Certified persons must also track salt use and report the results to a salt accounting system on an annual basis.[163] This record keeping includes the statutory requirement for the contractor to "keep a written record describing its winter road, parking lot and property maintenance practices. The written record shall include the type and rate of application of de-icing materials used, the dates of treatment, and the weather conditions for each event requiring de-icing."[164] The free tracking program is intended to hold applicators accountable and to measure the reduction in salt usage from year to year. However, there is no requirement that a certified person's salt application volume actually decreases from year to year.[165]

In addition to the initial requirements for certification, the program includes several ongoing tasks that certified persons must complete. For

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155 HOSSAIN & FU, *supra* note 91, at 7.

156 *See* EPA, *Green SnowPro*, *supra* note 143, at 9–10.

157 *Id.* at 10.

158 *Id.*

159 *Green SnowPro Training and NHDES Certification*, U.N.H. TECH. TRANSFER CTR., https://perma.cc/X2ZQ-FWES (last visited Jan. 27, 2018).

160 *Id.*

161 *Id.*

162 *Id.*

163 *See* EPA, *Green SnowPro*, *supra* note 143.

164 N.H. REV. STAT. ANN. § 508:22(II) (2017).

165 *See id.*

example, the program requires annual re-application at no cost.[166] Certified applicators must also complete a two-hour refresher every two years.[167]

In exchange for completing the certification program and complying with its ongoing requirements, certified applicators receive general liability protection against damages arising from snow and ice conditions. Specifically, pursuant to the waiver, commercial salt applicators that were certified by NHDES, and the property owners or managers who hired them, are granted liability protection against such damages so long as the applicators used the "best management practices for winter road, parking lot, and sidewalk maintenance adopted and published by the department of transportation and the department of environmental services."[168] However, the waiver does not apply if a court finds that the certified contractor acted with "gross negligence or reckless disregard of the hazard."[169] Certified persons are "presumed to be acting pursuant to the best management practices *in the absence of proof to the contrary*."[170] The liability waiver was a great incentive for applicators to become certified, and quickly became the cornerstone of the program.

In short, the New Hampshire program is one of the first to use a "soft governance" approach to create behavioral incentives for reducing chloride usage.[171]

*3. Program Evaluation*

The New Hampshire program carries several advantages. It stresses the need to balance both environmental and safety concerns, and motivates increased participation in several ways.

*Liability waiver*. First, the liability protection for program participants and those who hire them is unlike any other chloride reduction program. It addresses one of the greatest fears of deicing contractors, along with those who hire them and those who insure them: that they will be held liable for accidents resulting from remaining snow and ice that should have been removed.[172] Without such an incentive, over-application of salt is perceived to be the "safe" strategy for deicing contractors.[173]

*Environmental and Process Improvements.* Preliminary evaluative metrics show significant progress. According to NHDES, by the end of 2017, over 1,000 individuals have been trained and certified under the New

166 *See* N.H. CODE ADMIN. R. ANN. Env-Wq 2203.04(c)(2)(c), 2203.06 (2017); *see also* N.H. REV. STAT. ANN. § 489-C:2.

167 N.H. CODE ADMIN. R. ANN. Env-Wq 2203.06(a)(2)(b).

168 N.H. REV. STAT. ANN. § 508:22(I).

169 *Id.*

170 *Id.* (emphasis added).

171 *See* Barbara McMillan, *NHDES and Partners Are Hosting the 3rd Annual NH Salt Symposium*, N.H. DEP'T ENVTL. SERVS.: N.H. WATERSHED PROTECTION & RESTORATION F. (Aug. 31, 2016), https://perma.cc/8SEV-KCPT.

172 HOSSAIN & FU, *supra* note 91, at 7.

173 *Id.*

Hampshire program, mostly in the private sector.[174] Preliminary data show a downward trend in aquatic chloride levels, and salt use (as applied) is decreasing by 30%, per annual reports from certified contractors.[175] These reductions would result in corresponding cost savings for contractors and their clients.

*Cost savings due to forced efficiencies.* The training offers an opportunity for "efficiency-forcing" as participants learn best management practices.[176] In turn, this leads to cost savings for participants as salt use decreases.

*Marketing advantages.* Further, there is a significant marketing advantage for certified persons. The most direct aspect of this is that the liability waiver extends to those who hire certified contractors.[177] This means that a private entity hiring a contractor to keep, for example, its parking lot free of snow and ice can simultaneously gain the peace of mind of liability protection simply by hiring a certified contractor. Certified contractors will no doubt also market themselves as "green" to distinguish themselves from competitors. Certified contractors can use the program logo on their website and related marketing materials to demonstrate to current and potential clients their certification and its many benefits, including the liability waiver which is directly relevant to clients because it applies to them.[178]

*Insurance advantages.* Insurance companies in New Hampshire appear willing to give discounts if a business hires a certified snow removal contractor.[179] Insurers issuing policies in New Hampshire have already begun advising contractors on how best to limit liability under the program.[180] For example, one major insurer has told its insureds to fully document—with written records and photographs—treatment dates, times, and subsequent inspections, because under the statute, a certified person is assumed to be adhering to best practices only "in the absence of proof to the contrary."[181]

Despite these advantages, the New Hampshire program administrators have identified several ongoing challenges that should be addressed if and when the program is replicated elsewhere.

*Financial stability.* Program administrators expressed uncertainty about the continued financial viability of the program if the current fee structure remains unchanged. Currently, the training course costs $100 (for

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174 *See Green SnowPro Training and NHDES Certification*, *supra* note 159.

175 Interview with Patrick Woodbrey, Salt Reduction Coordinator, N.H. Dep't of Envtl. Servs. (Mar. 8, 2016); *see also* EPA, *Green SnowPro*, *supra* note 143 (citing "anecdotal information pointing to reductions in the amount of salt applied. . . . Many contractors have told us they've been able to use less" (quoting Patrick Woodbrey)).

176 Eric Williams, *Become a Certified Green SnowPro*, UNH T2, Fall 2011, at 1, 6.

177 *See* N.H. REV. STAT. ANN. § 508:22(I) (2017) (extending liability waiver to owners, occupants, and lessees of land maintained by a certified contractor).

178 EPA, *Green SnowPro*, *supra* note 143, at 10.

179 *Id.*

180 *See generally* THOMAS BROTHERS, LIBERTY MUT. INS., LIMITING SNOW PLOWING LIABILITY (2014), https://perma.cc/JRN3-PZES (discussing best practices for snow removal companies).

181 *Id.* at 6–9; *see also* N.H. REV. STAT. ANN. § 508:22(I) ("All commercial applicators, owners, occupants, or lessees who adopt such best management practices shall be presumed to be acting to the best management practices in the absence of proof to the contrary.").

individuals) or $200 (for corporate participants), but there is no annual fee.[182] If program participation continues to rise, the ongoing administrative burden may become untenable in the absence of some periodic fee.[183]

*Difficulties in program adoption and uptake*. Program administrators noted the difficulty in passing the statutes to create the liability waiver program. To do so took four legislative sessions, and in the end, the program survived only as a late addendum to a budget bill.[184] After passage, program administrators stressed the need to find early program "champions" who are willing to invest the time and money needed to become certified under the program.[185] New Hampshire program administrators conceded that it took some time for insurance companies and business owners, who hire salt applicators, to realize the benefits of this certification.[186] Finally, the danger of higher-than-desired program attrition exists due to the voluntary nature of the recertification path.[187]

*Legal strength of liability waiver.* Since the legislation was passed in 2013, there have been no incidents that have fully tested the liability waiver.[188] EPA reports that the program creators feel confident that it can withstand legal challenges because the program was "developed in close coordination with legal experts and insurance companies."[189]

More complex legal battles could arise in the future. For example, a certified person (or her insurance carrier) defending a slip-and-fall case would likely file a motion for summary judgment to end the case, citing the liability waiver statute. The plaintiff would no doubt produce evidence related to the parking lot or sidewalk conditions around the time of the injury. The success or failure of the motion for summary judgment would likely turn on whether a question of material fact exists as to whether the certified person followed best practices.[190] The case could turn on photographs or documentary evidence of the certified person's winter maintenance practices.

In addition to case-specific challenges based on questions of material fact, a more general (and perhaps constitutional) challenge to the statute could arise. For example, the statutory waiver could be challenged as a deprivation of a plaintiff's right to substantive due process, or a violation of state and federal rights to equal protection.

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182 *See Green SnowPro Training and NHDES Certification*, *supra* note 159 (listing the current fees for the course).

183 Interview with Patrick Woodbrey, *supra* note 175.

184 2013 N.H. Laws 287, 321–23; *see* Interview with Patrick Woodbrey, *supra* note 175.

185 Interview with Patrick Woodbrey, *supra* note 175.

186 *Id.*

187 *Id.*

188 *See* EPA, *Green SnowPro*, *supra* note 143, at 10.

189 *See id.*

190 *Cf.* Iannelli v. Burger King Corp., 761 A.2d 417, 419 (N.H. 2000) (noting that New Hampshire's summary judgment statute can be "called upon to dismiss some negligence actions," but "trial courts must be wary of its application," especially "in tort cases where there are generally more disputed issues of fact").

With respect to substantive due process, New Hampshire applies the "rational basis" test.[191] The statute appears likely to survive such a challenge, given that the rational basis standard presumes the validity of the statute and only requires that it be "rationally related to a legitimate government interest."[192] The test "contains no inquiry into whether legislation unduly restricts individual rights."[193] Here, the legislation appears closely related to the government interest in reducing chloride transport to surface waters and groundwater.[194] A court reviewing such a challenge must "inquire only as to 'whether the legislature could reasonably conceive to be true the facts' upon which [the legislation] is based."[195]

An equal protection challenge would involve a more complex analysis. First, a New Hampshire court would determine its "standard of review by examining the purpose and scope of the State-created classification and the individual rights affected."[196] New Hampshire courts apply three such standards: strict scrutiny for classifications based on suspect classes or affecting fundamental rights; intermediate scrutiny for classifications affecting "important substantive rights"; and rationality based review for all other classifications.[197] While it is not clear which of these standards would apply in the event of a constitutional challenge to the liability waiver, New Hampshire courts have found the use and enjoyment of property to be an important substantive right, with restrictions on that right subject to an intermediate scrutiny analysis.[198] "Under this test, the challenged legislation must be 'reasonable, not arbitrary, and must rest upon some ground of difference having a fair and substantial relation to the object of the legislation.'"[199] It must "be substantially related to an important governmental objective,"[200] and the government may not rely upon justifications that are hypothesized or invented post hoc in response to litigation, nor upon overbroad generalizations.[201]

Thus, an equal protection challenge to the liability waiver would turn on whether it is "reasonable" and whether it is "substantially related" to an important governmental objective, likely environmental protection.

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191 Cmty. Res. for Justice, Inc. v. City of Manchester, 917 A.2d 707, 716 (N.H. 2007).

192 *Id.*

193 Boulders at Strafford, LLC v. Town of Strafford, 903 A.3d 1021, 1029 (N.H. 2006).

194 *Accord* N.H. DEP'T OF ENVTL. SERVS., *supra* note 22 (discussing the amount of road salt that washes into the watershed).

195 *Cmty. Res. for Justice*, 917 A.2d at 717 (quoting Winnisquam Reg'l Sch. Dist. v. Levine, 880 A.2d 369, 371 (N.H. 2005)).

196 Estate of Robataille v. N.H. Dep't of Revenue Admin., 827 A.2d 981, 983 (N.H. 2003) (citing LeClair v. LeClair, 624 A.2d 1350, 1355 (1993)).

197 *Cmty. Res. for Justice*, 917 A.2d at 717.

198 *Id.*

199 *Id.* at 717–18 (emphasis omitted) (quoting Carson v. Maurer, 424 A.2d 825, 831 (N.H. 1980)).

200 *Id.* at 721.

201 *Id.* at 720 (citing United States v. Virginia, 518 U.S. 515, 533 (1996)).

### *4. Potential for Replication*

The innovative nature of the New Hampshire program makes it a likely candidate for duplication in other places. A few programs similar to New Hampshire's already exist or are pending before legislative bodies.

*Pending programs.* Legislation introduced before the Minnesota House of Representatives in 2016 would have created a program extremely similar to New Hampshire's. Minnesota Bill H.F. 2594 was referred to the Environment and Natural Resources Policy and Finance Committee, but appears to have stalled there.[202]

*Existing programs.* In 2009, Ontario, Canada launched its "Smart About Salt Council."[203] The Council is a nonprofit organization that "offers training to improve winter salting practices and recognizes industry leaders through certification."[204] The training for operators is similar to the New Hampshire program: a one-day course that covers fourteen different modules, including many of the same topics as those featured in the New Hampshire training.[205] To achieve certification, applicators must apply and demonstrate that they have met the program standards.[206] As in New Hampshire, accredited private contractors in some cases have received reductions in insurance premiums.[207] Further, an annual report regarding usage is required to maintain certification, and random audits are conducted to verify that applicators are following program standards.[208] However, there is a major difference between the Ontario and New Hampshire programs: in Ontario, no liability waiver program exists. For the reasons described above, the waiver is a cornerstone of the New Hampshire program.

The second category of legal and policy options studied in this Article fall into the general grouping of "informational strategies" to encourage optimal chloride usage.

## *B. Information Dissemination*

Environmental law and policy figures have long advocated the value of transparency and increased public consciousness of the environmental consequences of various policy and individual decisions.[209] Some

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202 *Introduction of Bills*, MINN. HOUSE REPRESENTATIVES (Mar. 8, 2016), https://perma.cc/3N5X-C2C4.

203 Lee Gould, *The Smart About Salt Council Launches New Online Training to Help Reduce Over Use of Winter Salt*, SMART ABOUT SALT (Aug. 3, 2017), https://perma.cc/7S7Q-2UHC.

204 *About: Mission, Vision, Values and Goals*, SMART ABOUT SALT, https://perma.cc/6LU5-MPGA (last visited Jan. 27, 2018).

205 *Training: Smart About Salt Trained Operator*, SMART ABOUT SALT, https://perma.cc/E49L-6FWR (last visited Jan. 27, 2018).

206 *Certify: Smart About Salt Certification*, SMART ABOUT SALT, https://perma.cc/8NHG-R5D6 (last visited Jan. 27, 2018).

207 *Certify: Certified Contractor*, SMART ABOUT SALT, https://perma.cc/8V5L-KK6J (last visited Jan. 27, 2018).

208 *Certify: Smart About Salt Certification*, *supra* note 206.

209 *See* David Markell, *"Slack" in the Administrative State and Its Implications for Governance: The Issue of Accountability*, 84 OR. L. REV. 1, 10 (2005) (noting "[t]he tide of

environmental laws, such as the National Environmental Policy Act[210] (NEPA), are almost entirely non-substantive, yet have been highly influential as information-forcing tools.[211] These strategies are no less applicable in the context of chloride policy development. They may be targeted to the public at large, or to chloride users in particular, to encourage the optimal usage of chlorides for a variety of purposes.

### *1. Informational Strategies Intended for the Public-at-Large*

Broad-based communications intended for the public at large tend to emphasize actual data showing the widespread overuse of chlorides (especially in the context of road salt and water softeners), and also illustrate strategies that empower ordinary citizens to take actions to reduce that usage. For example, "Wisconsin Salt Wise" is a general outreach effort created in 2015 pursuant to a partnership between Dane County; the City of Madison; the Madison Metropolitan Sewerage District; the City of Madison Water Utility; Public Health Madison Dane County; the University of Wisconsin-Madison Environment, Health, and Safety Department; and the Madison Area Municipal Storm Water Partnership.[212] The program interactively educates the public about the overuse of road salt. It features statistics that put the quantity of road salt used in perspective: it notes, for example, that it only takes one teaspoon of road salt to pollute five gallons of water.[213] It also provides objective information about salt usage: in 2015, Wisconsin used almost 670,000 tons of salt on its highways alone.[214] To make this statistic more relatable, the site illustrates other things that weigh 670,000 tons; for example: 53,500 school buses or 121,800 elephants.[215]

Salt Wise also teaches viewers how to optimize their personal salt use. The website is broken down into several distinct categories, dependent on a

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interest in increasing transparency and public involvement in governance, including environmental governance . . . [in] the United States"); Mark J. Spaulding, *Transparency of Environmental Regulation and Public Participation in the Resolution of International Environmental Disputes*, 35 SANTA CLARA L. REV. 1127, 1127 (1995) (concluding that "transparency and public participation provisions" associated with the North American Free Trade Agreement are "dramatic steps forward in the development of international environmental law").

210 National Environmental Policy Act of 1969, 42 U.S.C. §§ 4321–4370h (2012).

211 *Compare* Robertson v. Methow Valley Citizens Council, 490 U.S. 332, 350–51 (1989) ("[I]t is now well settled that NEPA itself does not mandate particular results, but simply prescribes the necessary process. . . . NEPA merely prohibits uninformed—rather than unwise—agency action."), *with* Robert W. Adler, *In Defense of NEPA: The Case of The Legacy Parkway*, 26 J. LAND RESOURCES & ENVTL. L. 297, 299–300 (2006) ("NEPA also serves very important and effective transparency and public accountability goals, by ensuring that environmental and other impacts, and core value judgments implicit in federal agency decisions, are fully disclosed and vetted publicly during the agency decision process.").

212 *Municipal Salt Resources*, WIS. SALT WISE PARTNERSHIP, https://perma.cc/2CRM-F6D9 (last visited Jan. 27, 2018).

213 *See Be Salt Wise*, WIS. SALT WISE PARTNERSHIP, https://perma.cc/WQM3-YM52 (last visited Jan. 27, 2018).

214 *Id.*

215 *Id.*

person's role in the community. The categories are: homeowners, municipal, motorists, emergency medical services (EMS), and salt applicators.[216] In each section, the website gives guidance, advice, and illustrations relevant to each audience.[217] The site also offers printable handouts so that the public can share the information with others.[218] The Wisconsin Salt Wise Partnership also offers workshops on effective winter maintenance of parking lots, driveways, sidewalks, and trails.[219]

*2. Strategies Intended for Salt Users*

Another set of informational strategies is comprised of more detailed communications that are targeted at salt users themselves. Many of these are government and municipal users. There are nearly 100,000 miles of local roads in Wisconsin, and every year over one billion dollars is spent to maintain them.[220] In 1983, the Wisconsin Transportation Information Center (TIC) was created to help local highway officials manage this large road system and road budget.[221] The Federal Highway Administration, Wisconsin Department of Transportation, and University of Wisconsin-Extension provide the funding, education, and technical assistance necessary for the TIC to operate.[222]

The TIC bolsters an effective informational strategy in other ways, as well. First, the TIC is a technical resource for local officials and highway maintenance staff. TIC publishes a periodic newsletter (*Crossroads*) and the *Wisconsin Transportation Bulletin*.[223] While the Wisconsin Salt Wise website

216 *Id.*

217 *Id.*

218 *E.g.*, WIS. SALT WISE, SALTING GOES BEYOND THE PAVEMENT, https://perma.cc/TLN4-F4XL (last visited Jan. 27, 2018).

219 *Effective Winter Maintenance Workshop (Parking Lots, Driveways, Sidewalks and Trails)*, WIS. SALT WISE PARTNERSHIP, https://perma.cc/WD2F-UVG9 (last visited Jan. 27, 2018).

220 *Workshops & Training*, U. WIS.-MADISON TRANSP. INFO. CTR., https://perma.cc/7HUE-JGEM (last visited Jan. 27, 2018).

221 *Id.*

222 *About TIC*, U. WIS.-MADISON TRANSP. INFO. CTR., https://perma.cc/9AW4-GMLH (last visited Jan. 27, 2018).

223 TIC's newsletter, *Crossroads*, includes articles relevant to winter maintenance such as "Winter Roads-Juggling Salt Supplies and Alternatives"; "The Truth about Sand and Salt for Winter Maintenance"; and "Hands-On with Equipment Calibration." *Crossroads Articles*, U. WIS.-MADISON TRANSP. INFO. CTR., https://perma.cc/DGR9-86FS (last visited Jan. 27, 2018). The TIC also produces and distributes the *Wisconsin Transportation Bulletin*, a series of fact sheets, which provide info on street and highway design, construction, maintenance, and management. The Wisconsin Transportation Bulletin also has some relevant and helpful sheets pertaining to road salt, relating to using salt and sand for winter road maintenance and pre-wetting and anti-icing-techniques for winter road maintenance. *See generally Using Salt and Sand for Winter Road Maintenance*, WIS. TRANSP. BULL. NO. 6 (Wis. Transp. Info. Ctr., Madison, Wis.), Aug. 2005, https://perma.cc/NW9Q-NY4B (describing the use of salt for deicing); *Pre-Wetting and Anti-Icing—Techniques for Winter Road Maintenance*, WIS. TRANSP. BULL. NO. 22 (Wis. Transp. Info. Ctr., Madison, Wis.), Dec. 2005, https://perma.cc/6DSK-X978 (suggesting strategies for more efficient uses of salt).

is effective as a public tool for education regarding salt use, the TIC offers a more technical informational tool.

In many cases, reducing the chloride load to the environment is dependent on action by governmental entities (e.g., in reducing the amount of roadway deicers applied), or corporate entities (e.g., in reducing the amount of deicers applied to private parking lots or sidewalks, or the amount used in food processing or other industrial pursuits). In those contexts, members of the public are generally limited to indirect strategies that limit chloride loading by exerting pressure on the relevant decision makers. Residential water softeners are a different case, however, in that their use is almost entirely discretionary on the part of private citizens.

Typically, residents use water softeners to remove minerals associated with hardness from the water.[224] In cases of extremely hard water, neglecting to soften can lead to blockages and may damage pipes and water heaters from buildup of scale.[225] Water softeners operate by "trading" the minerals for another substance, usually sodium chloride, in a chemical reaction consisting of an ion exchange process.[226] Specifically, "hardness ions in the water—[typically] calcium and magnesium—are exchanged on the . . . resin for sodium."[227] After the exchange process is complete, the resin is regenerated with a sodium chloride brine solution.[228] The regeneration process repopulates the resin with sodium ions, and the softening process recommences.[229]

The softener's brine efficiency[230] is "a measure of how much salt a softener system uses to remove hardness from the water."[231] It is generally determined based on "the grains [of hardness removal] capacity attained divided by the pounds of salt used to regenerate the resin."[232] There are a variety of ways to alter efficiency. Some of these include adjustments to the resin type, brine concentration and flow rate, rinse cycle lengths and regeneration initiation methods.[233] All of these factors can and should be taken into account during the system design process.[234] However, the primary variable in achieving brine efficiency is the salt dose.[235] Brine efficiency is higher at a lower salt dose (more hardness is removed per

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224 *See* USGS, CHLORIDE IN GROUNDWATER, *supra* note 5, at 8 (describing how water softeners are used to remove calcium and magnesium).

225 Bryan Swistock, *Water Softening*, PENN ST. EXTENSION, https://perma.cc/S3HV-JTV4 (last updated Nov. 9, 2017).

226 PENTAIR WATER SOLS., ACHIEVING BRINE EFFICIENCY IN WATER SOFTENING 1, https://perma.cc/G844-VUQJ (last visited Jan. 27, 2018).

227 *Id.*

228 *Id.*

229 *Id.*

230 One could also evaluate a softener's water efficiency—a measure of "how much water the system uses to regenerate"—but that is beyond the scope of this Article. *Id.*

231 *Id.*

232 Jerry Horner, *In Search of Softener Efficiency*, WATER QUALITY PRODUCTS, Mar. 31, 2010, at 12, 12, https://perma.cc/6838-GRT5; *see also* PENTAIR WATER SOLS., *supra* note 226, at 1.

233 Horner, *supra* note 232, at 12; *see also* PENTAIR WATER SOLS., *supra* note 226, at 1.

234 PENTAIR WATER SOLS., *supra* note 226, at 1.

235 *Id.* at 2.

pound of salt), although there are practical limits to the minimum salt dosage depending on water characteristics and output water quality requirements.[236] However, reducing the salt dosage comes with tradeoffs in system capacity and water efficiency.[237] Generally, it will be efficient to maintain a brine concentration of between 10%–14% and to operate at a very slow rate.[238] Optimized softeners use "as little excess sodium chloride as possible."[239] In turn, this "lowers system operating costs and reduces the level of [chloride] discharged into the environment."[240] Generally, digital systems with cycle times that can be adjusted have a better efficiency than mechanical systems.[241]

After the softened water is used in the home, it enters the wastewater stream along with the chloride it contains.[242] "Higher salinity increases the treatment costs and reduces the potential for reuse of wastewater for non-potable irrigation and industrial purposes."[243] It is very difficult to remove at wastewater treatment facilities and, therefore, is often discharged to the receiving water after persisting through the treatment process.[244] To reduce this ultimate loading, residents must correspondingly reduce salt usage in home water softeners. If this is not done, "the cumulative effects of each homeowner's excess use of salt and resulting brine discharge can have toxic effects for aquatic plants and animals."[245]

At the outset, according to municipalities, a homeowner should reevaluate whether a water softener is necessary. "Some homeowners soften their water even when it is not necessary, because they believe that very soft water is of superior quality."[246] When softening is required, the next step is to optimize usage patterns, which according to one study can reduce chloride usage by about 27%.[247] Similarly, replacing older or inefficient softeners can result in an even greater benefit of up to 47% chloride reduction.[248] This optimization process can occur during regular service calls.[249]

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236 *Id.*

237 *See id.* ("At a lower salt dose, there is less capacity per regeneration cycle . . . [and] more regeneration water is used . . . . So, while significant increases in brine efficiency can be achieved by decreasing the salt dose, its effect on water efficiency should be considered.").

238 Horner, *supra* note 232, at 12.

239 PENTAIR WATER SOLS., *supra* note 226, at 1.

240 *Id.*

241 Horner, *supra* note 232, at 12.

242 *Wastewater: Water Softener Issues*, CITY PASO ROBLES, https://perma.cc/N96L-8EBG (last visited Jan. 27, 2018).

243 *Id.*

244 *Id.*

245 DELAFIELD-HARTLAND WATER POLLUTION CONTROL COMM'N, WATER SOFTENERS AND THE ENVIRONMENT, https://perma.cc/XL84-ZG5D (last visited Jan. 27, 2018); *see also supra* notes 55–62, 116–137 and accompanying text (discussing public health and environmental impacts).

246 HAMBURG TOWNSHIP, SODIUM AND CHLORIDE AND WATER SOFTENERS, https://perma.cc/MY5M-QGXY (last visited Jan. 27, 2018).

247 LAKE ET AL., *supra* note 3, at xii.

248 *Id.*

249 *Id.* at 11.

Softener regeneration rate should generally be correlated with a hardness level appropriate for the water source. Many softeners have multiple settings, but the default setting may not be appropriate for a particular water supply.[250] Older water softeners that use a timer-based regeneration cycle have been prohibited by Wisconsin's plumbing code for over fifteen years and are likely less efficient at salt use.[251] By contrast, only softeners that use demand-initiated regeneration (meaning regeneration initiated by a meter or sensor) are "efficiency rated."[252] An on-demand softener tracks the amount of water used and regenerates only when needed; this can result in a salt use reduction of 30% or more.[253] Together, these savings result not only in lower salt costs for consumers but also benefit the environment.[254]

Part of the optimization process is simply to use less salt, when possible. According to some authorities, "[m]ost softener owners use at least twice as much salt to soften water as is necessary."[255] Moreover, it is much easier to add less salt at the beginning of the cycle than to remove it at the end: adding a pound costs about twenty cents but takes five dollars to remove.[256]

For all these reasons, several municipalities have taken aggressive legal approaches to regulating—or even eliminating—water softener use. Santa Clarita, California enacted the River Chloride Reduction Ordinance to begin the process of limiting chlorides discharged into the Santa Clara River.[257] A companion study found that the most significant controllable source of chloride entering the river was from residential self-regenerating water

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250 *See id.* at 29–30.

251 *Chloride Reduction*, MADISON METROPOLITAN SEWERAGE DISTRICT, https://perma.cc/D5ZF-GJV8 (last visited Jan. 27, 2018); *see also* WIS. ADMIN. CODE SPS § 382.40(8)(j) (2016) ("Ion exchange water softeners used primarily for water hardness reduction that, during regeneration, discharge a brine solution shall be of a demand initiated regeneration type equipped with a water meter or sensor unless a wastewater treatment system downstream of the water softener specifically documents the reduction of chlorides."); *Water Softeners*, MONTEREY ONE WATER, https://perma.cc/C2ER-X8WJ (last visited Jan. 27, 2018) (listing the harms of sodium softening and the benefits of sodium-free softening).

252 *See* PENTAIR WATER SOLS., *supra* note 226, at 1 (explaining that efficiency rated softeners have a minimum salt efficiency of at least 3350 grains per pound of salt used for regeneration, and must also meet a water efficiency of at most five gallons of regeneration water per 1000 grains of hardness removed).

253 *Water Softeners*, *supra* note 251; *see also Chloride Reduction*, *supra* note 251 (noting that optimization reduces salt usage, on average, by 27%).

254 DELAFIELD-HARTLAND WATER POLLUTION CONTROL COMM'N, *supra* note 245.

255 *Wastewater: Water Softener Issues*, *supra* note 242.

256 *Chloride Reduction*, *supra* note 251. The concept of regulating pollution-causing inputs, rather than outputs, has recently been highlighted in a number of settings. *See generally* David M. Driesen & Amy Sinden, *The Missing Instrument: Dirty Input Limits*, 33 HARV. ENVTL. L. REV. 65 (2009).

257 *See* Santa Clarita Valley Sanitation District of L.A. County, Cal., Santa Clara River Chloride Reduction Ordinance of 2008 (June 11, 2008) (stating "[t]he purpose of th[e] ordinance is to limit the discharge of chlorides into the Santa Clara River," and requiring property owners and tenants to remove all residential self-generating water softeners within 180 days after issuance of the ordinance).

softeners,[258] and recommended removing those softeners.[259] Salt-free water softener alternatives exist but to date have had limited market penetration.[260]

The third legal and policy option involves several strategies that could address the problem via directed regulatory efforts. These options are more aggressive than incentivized self-governance or informational strategies in that they burden the regulated community with affirmative obligations. For that reason, they are marginally less attractive given that their usage seems less likely than the other strategies already discussed.

### *C. Direct Regulatory Strategies*

Several potential regulatory strategies are examined here, including direct regulations, mandated or incentivized best management practices, sewer use ordinances, and even direct regulation under the CWA. Best management practices and guidance could also serve as an "informational strategy" to the extent that states or municipalities distribute them for informational purposes but do not require their implementation.[261]

*Regulations*. Generally, state regulations covering road salt application are rare. In Wisconsin, for example, the state Administrative Code contains only a general requirement that the Wisconsin Department of Transportation (WisDOT) must "inform and educate" its staff regarding "salt and other deicing material . . . activities in order to prevent runoff pollution of waters of the state."[262] This is likely in furtherance of the general requirement that WisDOT must "develop and implement a storm water management plan to control pollutants from . . . facilities" it owns.[263]

*Best management practices and guidance.* WisDOT does not itself perform winter maintenance activities; instead, it contracts with all seventy-two of the county highway departments for winter maintenance on all state, United States, and interstate highways.[264] Due to this structure, WisDOT issues statewide policies and guidance, but gives county highway departments significant discretion on winter maintenance activities, including road salt application. WisDOT guides county highway departments through the Wisconsin Highway Maintenance Manual and the Maintenance

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258 *See* SANITATION DISTS. OF L.A. CTY., SANTA CLARITA VALLEY SANITATION DISTRICT NEED FOR WASTEWATER SERVICE CHARGE RATE INCREASE 1–2, https://perma.cc/M84K-B998 (last visited Jan. 27, 2018).

259 *See id.* at 4 ("The most cost-effective component of any chloride reduction plan is the removal of salt-based automatic water softeners.").

260 *E.g.*, *Pelican NaturSoft Salt-Free Water Softeners*, PELICAN WATER SYS., https://perma.cc/99TX-72S2 (last visited Jan. 27, 2018).

261 *See* discussion *supra* Part II.B.1.

262 WIS. ADMIN. CODE Trans § 401.107(2) (2017).

263 *Id.* § 401.107(1).

264 WIS. DEP'T OF TRANSP., WINTER MAINTENANCE AT A GLANCE 2013–2014: KEEPING WISCONSIN MOVING DURING THE POLAR VORTEX 1, https://perma.cc/N9AT-F7FP [hereinafter WINTER MAINTENANCE AT A GLANCE]; *Winter Maintenance*, WIS. DEP'T TRANSP., https://perma.cc/G5XT-KCMZ (last visited Jan. 27, 2018).

Decision Support System (MDSS).[265] The Highway Maintenance Manual contains the policies, guidelines, and practices of WisDOT.[266] As the Department acknowledges, it is impossible to compile a manual that addresses or anticipates all possible situations.[267] Instead, the manual is meant to help establish goals and is not a minimum standard or absolute requirement.

The MDSS is a type of Road and Weather Information System (RWIS).[268] RWIS data generally is used by equipment operators and county highway departments to support their decision making when it comes to applying road salt.[269] The MDSS was first developed by the Federal Highway Administration and was initially deployed in Wisconsin in 2009.[270] "The MDSS combines state-of-the-art weather forecasting with WisDOT's rules of practice to generate treatment recommendations for plow routes statewide."[271] MDSS can "give[] recommendations for treatment up to 48 hours before a storm event."[272] DOT's guidance to the county highway commissioners is to "[f]ollow MDSS treatment recommendations and only deviate to higher application[s] . . . when necessary.[273] Using MDSS, or any RWIS for that matter, has many benefits, including cost savings, improved treatment recommendations, improved communications and accountability, and improved forecasting capabilities.[274] An RWIS increases the effectiveness of anti-icing and deicing programs, and helps to better manage materials, making it a best management practice.[275]

For purposes of comparison, the table below compares deicer application guidance from a number of representative states, including Illinois, Massachusetts, Minnesota, New Hampshire, New York, Ohio, and Wisconsin. State guidance provided to local salt applicators varies significantly in terms of its substance, level of detail, and incorporation into state regulation. The table reveals that the states provide markedly different recommendations regarding salt application even at identical weather and

265 *See* BUREAU OF HIGHWAY MAINT., WIS. DEP'T OF TRANSP., HIGHWAY MAINTENANCE MANUAL ch. 02, § 01, subject 01, at 1 (2014), https://perma.cc/KDW4-XQKS (stating that "[t]his manual has been prepared as a guide for all personnel involved in the maintenance of state highways," which would necessarily include county highway departments); *see also* BUREAU OF HIGHWAY MAINT., WIS. DEP'T OF TRANSP., HIGHWAY MAINTENANCE MANUAL ch. 06, § 25, subject 10, at 2 (2013), https://perma.cc/Q4GJ-8N6Z [hereinafter MDSS MANUAL] (requiring winter maintenance service providers to "[u]se [the Maintenance Decision Support System (MDSS)] as required to enhance winter operations decision making").

266 *Highway Maintenance Manual*, WIS. DEP'T TRANSP., https://perma.cc/2YQ6-2LQH (last visited Jan. 27, 2018).

267 *Id.*

268 MDSS MANUAL, *supra* note 265, at 1–2.

269 *See Frequently Asked Questions*, FED. HIGHWAY ADMIN., https://perma.cc/W2AN-H2ZW (last modified Jan. 27, 2018).

270 WINTER MAINTENANCE AT A GLANCE, *supra* note 264, at 8.

271 *Id.*

272 MDSS MANUAL, *supra* note 265, at 1.

273 Letter from Todd Matheson, State Maint. Eng'r, Wis. Dep't of Transp., to Cty. Highway Comm'rs (Feb. 12, 2014), https://perma.cc/5YKG-NYCR.

274 MDSS MANUAL, *supra* note 265, at 1.

275 *See* WINTER MAINTENANCE AT A GLANCE, *supra* note 264, at 4–5.

pavement conditions. In Wisconsin, the *Highway Maintenance Manual* gives model application rates for deicing and anti-icing based on pavement temperature and the type of weather.[276] However, the manual's guidance is rudimentary. Minnesota, on the other hand, has a comprehensive manual entitled the *Field Handbook for Snowplow Operators* which, among other things, offers application rate guidelines.[277] Minnesota's manual offers three different examples of guidelines, one put forth by the Minnesota Department of Transportation (MinnDOT) and two that are practiced in some Minnesota counties.[278] Minnesota's guidelines are much more detailed than those in other states. However, in every state, there is substantial discretion left to "boots on the ground" personnel.

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276 BUREAU OF HIGHWAY MAINT., WIS. DEP'T OF TRANSP., HIGHWAY MAINTENANCE MANUAL ch. 06, § 20, subject 25, at 2 (2008), https://perma.cc/6W6W-T9NA.

277 MINN. DEP'T OF TRANSP. ET AL., MINNESOTA SNOW AND ICE CONTROL: FIELD HANDBOOK FOR SNOWPLOW OPERATORS 15–19 (2d rev. 2012), https://perma.cc/KG55-NSUT.

278 *Id.*

| State | General Guidelines | 24 degrees, light snow |
|---|---|---|
| Illinois[279] | Apply 150–400 lbs. salt per lane mile depending on pavement temperature and other conditions; significant discretion left to "local conditions and policies" | Range 150–400 lb./lane mile depending on pavement conditions and precipitation accumulation rate |
| Massachusetts[280] | 240 lb. salt per lane mile at pavement temperatures 15–32°F; sand below 15°F; pre-wetting and pre-treatment guidelines vary based on pavement temperature | 240 lb./lane mile |
| Minnesota[281] | Application rate "depends on five factors: pavement temperature, application rate, precipitation, beginning concentration, and chemical type"; also varies with pre-wetting and trends; range from 35–300 lbs./lane mile | 70–140 lb./lane mile, pre-wetted, depending on whether temperature is rising or falling |
| New Hampshire[282] | Apply 250–300 lb./lane mile | 250 lb./lane mile |
| New York[283] | Guidelines based on pavement temperature, pavement condition, precipitation type, and whether salt is pre-wetted; range from 90–450 lb. per lane mile | 160 lb./lane mile |
| Ohio[284] | *Materials Application Guidelines* include detailed chart based on pavement temperature and precipitation, and whether salt is pre-wetted; range from 50–400 lb. salt per lane mile | 100–200 lb./lane mile |
| Vermont[285] | 0–400 lb./lane mile; provided as ranges rather than absolutes | 200–300 lb./lane mile |
| Wisconsin[286] | Anti-icing: 50–300 lb./lane mile for pre-wetted salt Deicing: 50–400 lb./lane mile for pre-wetted salt; rates depend on pavement temperature and other conditions | 100–200 lb./lane mile (anti-icing); 100–300 lb./lane mile (deicing) |

**Table 2: State deicing application guidelines at 24 degrees and light snow**

279 *See Guidelines for Salt Application*, ILL. INTERCHANGE (Ill. Tech. Transfer Ctr., Springfield, Ill.), Winter 2006, at 4, 11, https://perma.cc/JVX9-UDNF.

280 *Material Application Guidelines*, MASS. DEP'T TRANSP., https://perma.cc/Z88V-S2VG (last visited Jan. 27, 2018).

281 MINN. DEP'T OF TRANSP. ET AL., *supra* note 277, at 16–17.

282 N.H. DEP'T OF TRANSP., WINTER MAINTENANCE SNOW REMOVAL AND ICE CONTROL POLICY 5, https://perma.cc/N5Y7-EMNE (last visited Jan. 27, 2018).

283 N.Y. STATE DEP'T OF TRANSP., HIGHWAY MAINTENANCE GUIDELINES: CHAPTER 5, at C-4 to C-8 (rev. 2012), https://perma.cc/3ZK2-C62X.

284 OHIO DEP'T OF TRANSP., MATERIALS APPLICATION GUIDELINES (2008), https://perma.cc/3F5K-F6QD.

285 VT. AGENCY OF TRANSP., SNOW AND ICE CONTROL PLAN FOR STATE AND INTERSTATE HIGHWAYS 9 (2013), https://perma.cc/JWH3-AWLZ.

286 WIS. DEP'T OF TRANSP., HIGHWAY MAINTENANCE MANUAL ch. 06, § 20, subject 20, at 1 (2012), https://perma.cc/E6ZF-GF6Y; WIS. DEP'T OF TRANSP., HIGHWAY MAINTENANCE MANUAL ch. 06, § 20, subject 25, at 2–3 (2008), https://perma.cc/4H25-N64K.

The wide disparity in suggested deicer application rates at the same weather conditions suggests a need for increased standardization for purposes of efficiency and sustainability. This could occur as a result of increased cooperation between and among states, facilitated by the Federal Highway Administration (FHA). In June 1996, FHA published its *Manual of Practice for an Effective Anti-icing Program*.[287] The *Manual* includes general programmatic guidance, equipment management advice, and even proposed application rates.[288] The FHA could help to standardize recommended rates by updating and publicizing this guidance to state and local agencies. A 2002 EPA bulletin focused on the management of highway deicing chemicals could also be of some use.[289]

At a minimum, even without federal involvement, states should decrease the span of recommended "ranges" at a single intersection point of temperature/pavement conditions. Standardization could also include requirements or guidelines for pre-wetting salt before application, or for anti-icing measures such as brine application to prevent bond formation between road surfaces and ice. Finally, it would be helpful for applicators if the guidance were incorporated in state-level documents or regulatory codes.

Other guides address non-roadway facilities such as parking lots, sidewalks, and building surroundings. These include Minnesota's *Winter Parking Lot and Sidewalk Maintenance Manual* and the University of Wisconsin-Madison's *Outdoor Salt Use Policy*. Both manuals offer insight into best management practices and effective ways to minimize salt use, while also balancing the concern for public safety.[290] Minnesota's manual offers anti-icing and deicing application rate guidelines specifically designed for parking lots and sidewalks.[291]

The University of Wisconsin-Madison's manual contains operational and design practices that achieve the same, or better, level of safety as current practices while also applying less salt.[292] These include keeping runoff from pooling in the first place to prevent ice, removing snow first to avoid salting the snow, avoiding the use of salt in below-zero temperatures, avoiding salt application in grass or planting beds, minimizing or eliminating salt use if there is a warming trend or sun exposure that will melt the ice quickly, and sweeping up any excess or spilled salt.[293] The manual also

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287 FED. HIGHWAY ADMIN., MANUAL OF PRACTICE FOR AN EFFECTIVE ANTI-ICING PROGRAM: A GUIDE FOR HIGHWAY WINTER MAINTENANCE PERSONNEL (1996), https://perma.cc/YTG2-C3UP.

288 *Id.* at app. C tbls.8–13.

289 *See generally* U.S. ENVTL. PROT. AGENCY, SOURCE WATER PROTECTION PRACTICES BULLETIN: MANAGING HIGHWAY DEICING TO PREVENT CONTAMINATION OF DRINKING WATER (2002).

290 *See* MINN. POLLUTION CONTROL AGENCY ET AL., WINTER PARKING LOT AND SIDEWALK MAINTENANCE MANUAL 6, 8, 11 (3d rev. 2015), http://perma.cc/283A-2KVT; UNIV. OF WIS.-MADISON ENV'T, HEALTH & SAFETY DEP'T, OUTDOOR SALT USE POLICY 3, 6 (2014), https://perma.cc/MD7W-MPEN.

291 MINN. POLLUTION CONTROL AGENCY ET AL., *supra* note 290, at 42.

292 *See generally* UNIV. OF WIS.-MADISON ENV'T, HEALTH & SAFETY DEP'T, *supra* note 290 (describing alternatives, minimization techniques, and best practices).

293 *Id.* at 3–4.

suggests that deicing be considered during the facility design phase using methods such as reducing impermeable areas.[294] It also promotes more environmentally efficient application techniques (e.g., applying salt by hand instead of using a sidewalk spreader, depending on the specific characteristics of the area).[295] All of these measures could be incorporated in state guidance or codes.

Several industry trade groups have also issued manuals that could prove useful in standardizing existing guidance on deicing best management practices. One example of this is the Western Transportation Institute's (WTI) 2015 *Manual of Environmental Best Practices for Snow and Ice Control*.[296] The WTI manual provides guidance in a variety of specific areas including training, monitoring, record keeping, material selection, facility management, operational and equipment strategies, and the use of RWISs.[297]

Best management practices could apply to salt storage as well as application. Such regulations already exist in some states. In Wisconsin, for example, requirements for salt storage facilities include a covered structure with an impermeable base that drains to a holding tank to prevent salt from reaching surface waters and groundwater, coupled with a site design that diverts runoff from contact with salt.[298] Regulations could also mandate the submittal of required records and a mandatory inspection at least once per year.

Other mandated best management practices relate to optimizing water softening operations, as previously discussed. Where optimization steps have been insufficient to meet water quality goals, however, some municipalities have taken direct steps to regulate or even prohibit water softener use.[299] For example, brine discharges from water softeners have played a primary role in a long-running dispute involving the Santa Clarita (California) Valley Sanitation District.[300] The District initially reached a compromise with residents to concentrate brine and ship it away from the area prior to discharge, but safety aspects of that plan have now also come under fire.[301] Several California communities have now banned or severely restricted the use of salt-based water softeners, including Los Angeles, San

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294 *Id.* at 6.

295 *Id.* at 2.

296 LAURA FAY ET AL., W. TRANSP. INST., MANUAL OF ENVIRONMENTAL BEST PRACTICES FOR SNOW AND ICE CONTROL (2015), https://perma.cc/ZQG8-V3AT.

297 *Id.* at 2–3, 89–90.

298 *See* WIS. ADMIN. CODE Trans § 277.04(3) (2017).

299 *See United States Ban Salt Water Softeners*, BIO-WATER TECH. (Sept. 12, 2016), https://perma.cc/7QH6-Q4XP.

300 Jim Holt, *Update: Both Sides Claim Victory in Split Decision on Chloride Plan*, SANTA CLARITA VALLEY SIGNAL (Feb. 25, 2016), https://perma.cc/K4YQ-8JSF.

301 Jim Holt, *Plan Would Truck Brine Out of SCV*, SANTA CLARITA VALLEY SIGNAL (May 13, 2015), https://perma.cc/KFX9-DWCM; Jim Holt, *SCV Sanitation District Hit with Second Lawsuit from Ratepayers Over Chloride Removal*, SANTA CLARITA VALLEY SIGNAL (July 18, 2016), https://perma.cc/L9W2-98YB.

Diego, Orange, San Bernardino, Riverside, Ventura, Santa Barbara, San Marco, and Tulare.[302]

*Sewer Use Ordinances*. Municipalities concerned about excess chlorides in residential, commercial, and industrial tributary discharges could also enact sewer use ordinances limiting chloride content in wastewater. The Madison, Wisconsin Metropolitan Sewerage District has taken this approach.[303] The Madison ordinance provides that:

> All Community Customers shall undertake efforts to reduce chlorides into the Community Sewers including . . . source reduction measures . . . , measures to reduce inflow of road salt laden water into Community Sewers and measures to reduce the direct drainage of road salt laden water from storage or truck loading into Community Sewers.[304]

Further, sewer users must "notify the District annually of measures taken" to decrease chloride transport to community sewers.[305] Customers must also evaluate sources of chloride contamination: "All Community Customers that own groundwater supply wells shall analyze at least one sample from each well annually for chloride and shall report the results to the District."[306] Municipal users are subject to additional requirements that specifically relate to deicing activities: "All Community Customers that hold a municipal separate storm sewer system (MS4) permit . . . and report on deicing activities as part of their MS4 reporting requirements, shall send a copy to the District at the same frequency and at the same time."[307]

*Direct regulation under the CWA*. Finally, and most aggressively, some commenters have suggested that salt application vehicles could be regulated as point sources under the CWA.[308] The CWA prohibits the addition of any pollutant from a point source to waters of the United States without a permit.[309] Theoretically, courts could interpret the statute to sweep salt trucks within the definition of a "point source." Under the statute, a point source is broadly defined as "any discernible, confined and discrete conveyance."[310] Courts have held, on occasion, that dump trucks, backhoes, and other equipment used for mechanized land clearing are point sources, likely because the material they discharge directly enters waters of the United States.[311]

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302 *Update: The California Ban on Salt-Based Water Softeners*, PELICAN WATER SYS. (Oct. 14, 2014), https://perma.cc/5VWG-MBJN (summarizing California ban ordinances).

303 *See* Madison, Wis., Madison Metropolitan Sewerage District, Sewer Use Ordinance § 4.7.2 (2017).

304 *Id.* § 4.7.2(a).

305 *Id.*

306 *Id.* § 4.7.2(b).

307 *Id.* § 4.7.2(c).

308 *See, e.g.*, Christine A. Fazio & Ethan I. Strell, *Environmental Impact of Road Salt and Deicers*, N.Y.L.J. (Feb. 24, 2011), https://perma.cc/7BFD-MKSB.

309 CWA, 33 U.S.C. §§ 1311(a), 1342(a)(1).

310 *Id.* § 1362(14).

311 *See* Stillwater of Crown Point Homeowner's Ass'n, Inc. v. Stiglich, 999 F. Supp. 2d 1111, 1129 (N.D. Ind. 2014) (citing numerous cases).

Even liquid manure spreading vehicles may be treated as point sources when the discharge is thereafter channeled or collected and "directly flows" to waters of the United States.[312] Similarly, some courts have held that a pesticide applicator is a point source if the pesticide falls on land and then is introduced to waters; other courts have interpreted the law to require that to qualify as a point source, the vehicle must spray directly over water.[313]

However, this type of statutory construction is unlikely because it would require an oversight agency, such as a state environmental agency or EPA, to interpret the statute in a way that could directly compromise public safety.

The next legal and policy strategy to address chloride impacts considers methodologies to promote the use of alternatives that avoid excess deployment of chloride in the first place.

### *D. Chloride Alternatives*

#### *1. Green Infrastructure*

*Description.* Green infrastructure is a diverse group of strategies that reduces and treats stormwater at its source, while delivering environmental, social, and economic benefits.[314] Stormwater runoff occurs when rain or snowmelt flows over hard surfaces such as roads, driveways, and parking lots, instead of soaking into the ground.[315] In addition to road salt, stormwater runoff also collects oil and other "toxic chemicals" such as heavy metals, nutrients, sediment, and pathogens as it flows to the storm sewer system and is discharged to local waterways.[316] Green infrastructure practices are intended to force precipitation to slowly percolate back into the ground, or capture it for later reuse, rather than quickly transporting it to surface waters as traditional infrastructure does.[317] To do so, vegetation, soils, and other elements and practices mimic and restore natural processes in urban environments.[318] Some of these practices, especially—as discussed

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312 Concerned Area Residents for the Env't v. Southview Farm, 34 F.3d 114, 118–19 (2d Cir. 1994).

313 *See* Peconic Baykeeper, Inc. v. Suffolk County, 600 F.3d 180, 188–89 (2d Cir. 2010) (finding that trucks and helicopters discharging pesticides into the air were point sources); *see also* Sierra Club v. BNSF Ry. Co., No. 1:13-cv-00272-LRS, 2014 WL 53309, at *4 (E.D. Wash. Jan. 2, 2014) (citing League of Wilderness Defs./Blue Mountains Biodiversity Project v. Forsgren, 309 F.3d 1181 (9th Cir. 2002); No Spray Coal., Inc. v. City of New York, No. 00 Civ. 5395(GBD), 2005 WL 1354041, at *5 (S.D.N.Y. June 8, 2005)).

314 *See* Roopika Subramanian, *Rained Out: Problems and Solutions for Managing Urban Stormwater Runoff*, 43 ECOLOGY L.Q. 421, 432 (2016) (describing how green infrastructure solves "[s]ome of the central problems related to urban stormwater runoff, such as flooding, increased flow, and velocity of flow"); *What is Green Infrastructure?*, U.S. ENVTL. PROTECTION AGENCY, https://perma.cc/M868-ZCBV (last updated Aug. 14, 2017).

315 *What is Green Infrastructure?*, *supra* note 314.

316 *See* Subramanian, *supra* note 314, at 424; *What is Green Infrastructure?*, *supra* note 314.

317 SIERRA CLUB, GREEN INFRASTRUCTURE: A STRATEGY FOR RESTORING THE GREAT LAKES AND GREAT COMMUNITIES, https://perma.cc/4H2L-VWA7 (last visited Jan. 27, 2018).

318 *What is Green Infrastructure?*, *supra* note 314.

below—permeable pavements and bioswales, are also likely effective in reducing chloride transport to waterways.[319]

*General Advantages and Challenges.* EPA estimates that green infrastructure creates long-term cost savings of 15%–80% over the life cycle of infrastructure through reduced life-cycle costs, reduced need for traditional or "grey" infrastructure, and reduced land acquisition requirements.[320] "Historically, municipalities have managed their stormwater utilizing 'grey' infrastructure practices made up of gutters, basins, and pipes that transport stormwater quickly to [waterways]. Many municipalities struggle to maintain this . . . infrastructure due to a lack of [proper] funding."[321] Grey infrastructure solutions cost millions and take many years to implement.[322]

Monitoring results from studies in the United States and Canada show that green infrastructure can have tremendous environmental advantages, including capturing beyond 90% of runoff from regular storm events, reducing pollutant loads by over 90%, and delaying peak flows during extreme events.[323] More generally, green infrastructure also slows the flow of water, leading to increased filtering time and less pollutants ending up in waterways.[324] Green infrastructure solutions are flexible because they can be constructed quickly and relatively easily.[325]

Green infrastructure advocates face challenges, however, including increased up-front capital costs and public resistance.[326] Further, there is environmental concern that green infrastructure simply transfers chlorides, and other pollutants, from a surface water issue to a groundwater issue, changing the timing of chloride release without reducing the mass entering the environment. However, as explained below, this is not likely correct. Ongoing operations and maintenance issues may also arise. Green

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319 *See infra* notes 329–340 and accompanying text.

320 U.S. ENVTL. PROT. AGENCY, REDUCING STORMWATER COSTS THROUGH LOW IMPACT DEVELOPMENT (LID) STRATEGIES AND PRACTICES 27 (2007), https://perma.cc/4K9D-FDCH; *Want to Know More About Green Infrastructure?*, RAIN COMMUNITY SOLUTIONS, https://perma.cc/AU88-YJYY (last visited Jan. 27, 2018).

321 Amy Rowe & Michele Bakacs, *An Introduction to Green Infrastructure Practices*, RUTGERS: N.J. AGRIC. EXPERIMENT STATION (Dec. 2012), https://perma.cc/T2YW-MGFK.

322 *See* U.S. ENVTL. PROT. AGENCY, THE ECONOMIC BENEFITS OF GREEN INFRASTRUCTURE: A CASE STUDY OF LANCASTER, PA 3 (2014), https://perma.cc/Q6S4-H464; *Want to Know More About Green Infrastructure?*, *supra* note 320.

323 BARR ENG'G CO., BURSVILLE STORMWATER RETROFIT STUDY 12 (2006), https://perma.cc/DL7Q-WSY8; *Want to Know More About Green Infrastructure?*, *supra* note 320.

324 CREDIT VALLEY CONSERVATION, ADVANCING LOW IMPACT DEVELOPMENT AS A SMART SOLUTION FOR STORMWATER MANAGEMENT 12, https://perma.cc/6LR8-U8E3 (last visited Jan. 27, 2018).

325 *See* MELISSA G. KRAMER, U.S. ENVTL. PROT. AGENCY, ENHANCING SUSTAINABLE COMMUNITIES WITH GREEN INFRASTRUCTURE 2–3 (2014), https://perma.cc/ZHR6-8RK9; *Green Infrastructure Toolkit: Models for Starting Pilots*, GEO. CLIMATE CTR., https://perma.cc/J9KE-W6U3 (last visited Jan. 27, 2018).

326 *See generally* CLEAN WATER AM. ALL., BARRIERS AND GATEWAYS TO GREEN INFRASTRUCTURE, https://perma.cc/L85M-JSPG (last visited Jan. 27, 2018) (describing the various reasons that communities resist the implementation of green infrastructure and summarizing the financial barriers to such projects).

infrastructure practices, like permeable pavements, may require additional equipment such as a rubber snowplow blade to avoid damaging permeable pavements, or a regenerative air vacuum rather than a traditional street sweeper.[327] They are sometimes thought to be harder to plow or cleanup for road crews.[328]

*Chloride-specific aspects of green infrastructure use.* Expanded use of two specific green infrastructure practices—permeable pavement and bioswales—would substantially reduce road salt application levels and costs, and corresponding loads of chlorides to waterways. Once salt is applied, it is difficult to prevent its movement to waterways; green infrastructure is valuable because it reduces the application requirement in the first place. When water quickly infiltrates, it does not pool (and then ice) on the surface.

Some green infrastructure techniques replace impervious surfaces or surfaces where water is unable to penetrate, such as roads, driveways, and parking lots.[329] Replacing these impervious surfaces with permeable surfaces leads to reduced stormwater runoff because the permeable surfaces infiltrate, treat, and store rainwater where it falls.[330] The rainwater and runoff eventually seep into the underlying soil.[331]

Specifically, one study estimates that road salt application levels can be reduced up to 77% via the use of permeable pavements.[332] Permeable pavements are effective to prevent winter icing because water infiltrates the soil rather than pooling on the surface, which eventually forms ice requiring treatment.[333] Additionally, there is no evidence of increased damage from frost heave for permeable pavement compared with regular pavement.[334] Permeable pavements are used primarily on low-speed roads, parking lots, driveways, bike paths, and in parking lanes, and could be a viable option for reducing chlorides because they attempt to minimize the amount of salt that is initially applied.[335] In addition, green infrastructure designed to reduce chloride discharges will likely also address pollutants that cause other runoff problems such as oil, grease, and nutrients.

Bioswales may also yield chloride reductions in waterways. Bioswales are sloped drainage areas that may contain salt-tolerant native plants and

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327 MONTGOMERY CTY., MD., DEP'T OF ENVTL. PROT., HOW TO MAINTAIN YOUR POROUS PAVEMENT 1 (2013), https://perma.cc/35EU-W8KU.

328 MARIA CAHILL ET AL., POROUS PAVEMENT 6 (2011), https://perma.cc/JYB8-V5JD.

329 CAHILL ET AL., *supra* note 328, at 1.

330 CLEAN WATER AM. ALL., *supra* note 326, at 7.

331 CAHILL ET AL., *supra* note 328, at 1.

332 Roseen et al., *supra* note 79, at 7.

333 *Want to Know More About Green Infrastructure?*, *supra* note 320.

334 *See* PETER T. WEISS ET AL., MINN. DEP'T OF TRANSP., PERMEABLE PAVEMENTS IN COLD CLIMATES: STATE OF THE ART AND COLD CLIMATE CASE STUDIES 41–42 (2015), https://perma.cc/JPJ2-ANXU.

335 *See* CAHILL ET AL., *supra* note 328, at 1, 8; *Permeable Pavement*, MINN. STORMWATER MANUAL, https://perma.cc/N7QM-SZBJ (last modified Nov. 13, 2017); *see also supra* notes 77–82 and accompanying text.

vegetation.[336] These plants and vegetation capture and treat water as it slowly drains into the ground, which increases filtering time and allows the water to seep back into the soil.[337] The effectiveness of bioswales depends upon the retention time of storm water in the bioswale—the longer the retention time, the higher the removal efficiency.[338] Bioswales can remove and immobilize or break down a large portion of pollutants.[339] Bioswales are most commonly installed in road medians and in parking lot perimeters.[340]

*Other community-based efforts*. In addition to these two specific green infrastructure practices, other community-based practices may also yield reductions in chloride transport to waterways and can be implemented at the neighborhood scale.[341] They include rain barrels, rain gardens, green roofs, and downspout disconnections.[342] Rain barrels are containers that capture water from a roof so that it can be used later on lawns, gardens, and indoor plants.[343] Rain gardens "are shallow, vegetated basins that collect and absorb runoff from rooftops, sidewalks, or streets."[344] Green roofs act as a layer of plant material that absorbs water and are especially effective in urban areas where space restraints limit the use of other practices.[345] Lastly, downspout disconnections involve rerouting rooftop drainage pipes from storm sewers to rain barrels or permeable areas.[346] All of these practices are simple to install at the residential or neighborhood level.

Green infrastructure helps to prevent the need for chloride application. Another category of chloride alternatives involves the use of different materials altogether for anti-icing and deicing.

### *2. Alternative Deicers*

Some communities have taken to using alternative substances to reduce the application of ordinary road salt in the form of sodium chloride. These alternatives may include calcium chloride, magnesium chloride, calcium magnesium acetate, potassium acetate, agricultural byproducts,

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336 *Green Infrastructure: Low-Impact Development and Green Infrastructure in the Semi-Arid West*, U.S. ENVTL. PROTECTION AGENCY, https://perma.cc/6HL2-3G7E (last updated Sept. 14, 2016).

337 *See* DENNIS JURRIES, STATE OF OR. DEP'T OF ENVTL. QUALITY, BIOFILTERS (BIOSWALES, VEGETATIVE BUFFERS, & CONSTRUCTED WETLANDS) FOR STORM WATER DISCHARGE POLLUTION REMOVAL 14–15 (2003), https://perma.cc/U2WN-LPGA; *Green Infrastructure: Low-Impact Development and Green Infrastructure in the Semi-Arid West*, *supra* note 336.

338 JURRIES, *supra* note 337, at 14–15.

339 *Id.* at 15.

340 *What is Green Infrastructure?*, *supra* note 314; *see also* BILL HENDRICKS, PLANTS TOLERANT OF DEICING SALT IN SOILS (2009), https://perma.cc/7GV7-CMWH (providing a catalog of salt-tolerant plants).

341 *What is Green Infrastructure?*, *supra* note 314.

342 *Id.*

343 *Soak Up the Rain: Rain Barrels*, U.S. ENVTL. PROTECTION AGENCY, https://perma.cc/RKN2-G692 (last updated Nov. 6, 2017).

344 *What is Green Infrastructure?*, *supra* note 314.

345 *Id.*

346 *Id.*

gravel, beet juice, and cheese brine.[347] While alternative deicers may reduce chloride stresses on waterways, some come with countervailing risks;[348] for example, use of organic deicers such as calcium magnesium acetate or beet juice can raise the biochemical oxygen demand[349] (BOD) in waters.[350] As such, these alternatives must be evaluated on a number of metrics including cost, effectiveness, corrosion potential, and associated risks.

Integrated watershed management is the next policy strategy considered to reduce chloride discharges to waterways. It is of more general applicability than the approaches discussed so far, and its benefits (while indirect) may be more holistic.

### *E. Integrated Watershed Management*

Recent studies have advocated management of water resources using an integrated approach at the watershed level, necessarily crossing traditional geopolitical and agency boundaries.[351] Generally, this "integrated watershed management" or "one water" methodology aims to coordinate development and management of water and related resources so as to maximize economic and social welfare without compromising environmental sustainability.[352] Although its precise scope and content remains unclear, implementation of the approach requires innovative and cooperative governance mechanisms. It may play a role in the implementation of innovative technologies such as green infrastructure. Effective intergovernmental cooperation in these areas could lead to both environmental and technological advances, including improvements related to chloride management.

Integrated water resources management approaches have been known by many names, and differ in scope and content along a spectrum of potential structures including information sharing, informal planning, and

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347 *See generally* Barbara M. Gerbino-Bevins, Performance Rating of De-icing Chemicals for Winter Operations (Aug. 2011) (unpublished M.S thesis, University of Nebraska-Lincoln), https://perma.cc/Q238-LMFH; Bill Chappell, *Cheese to the Rescue: Surprising Spray Melts Road Ice*, NAT'L PUB. RADIO (Jan. 21, 2014), https://perma.cc/B7V4-2K2P.

348 Corsi et al., *A Fresh Look at Road Salt*, *supra* note 2, at 7382 ("Alternative chemicals each have unique environmental and/or economic impacts as well.").

349 Biochemical oxygen demand, or BOD, is a measure of the oxygen level needed for biological organisms to break down organic material present in the water at a particular temperature. William L. Andreen, *Water Quality Today—Has the Clean Water Act Been a Success?*, 55 ALA. L. REV. 537, 556 (2004).

350 Corsi et al., *A Fresh Look at Road Salt*, *supra* note 2, at 7382.

351 *See, e.g.*, Keith S. Porter, *Good Alliances Make Good Neighbors: The Case for Tribal-State-Federal Watershed Partnerships*, 16 CORNELL J.L. & PUB. POL'Y 495, 502, 504–05 (2007); A. Dan Tarlock, *Putting Rivers Back in the Landscape: The Revival of Watershed Management in the United States*, 14 HASTINGS W.-NW. J. ENVTL. L. & POL'Y 1059, 1061 (2008) (referring to "ideal of integrated watershed management" and explaining the importance of the watershed as a planning and regulatory tool).

352 This definition is closely modeled on that adopted by the Global Water Partnership. *See* JAN HASSING ET AL., U.N. EDUC., SCI. & CULTURAL ORG., INTEGRATED WATER RESOURCES MANAGEMENT (IWRM) IN ACTION 3 (2009), https://perma.cc/SQ4M-TDQD.

even shared management.[353] It may also include informal or non-traditional watershed groups (as often form in connection with the agricultural sector).[354] Proponents may create groups to facilitate watershed-based decision making, such as watershed planning councils or interagency working groups. In any format, however, the approach is intended to address the interlinked nature of water resources—surface water and ground water, point and nonpoint sources, storm water and wastewater management, water quality and water quantity, all may be considered under the integrated approach.[355]

In concept, multiple agencies or agencies from multiple jurisdictions (local, state, and federal) work together within a utility footprint—at city scale, in a watershed, or even regionally—to address a broad range of water-related issues such as water supply, water quality, and land use.[356] Such an approach promotes the coordinated development and management of water and related resources to maximize economic and social welfare without compromising environmental sustainability.[357] In 2016, a group of water management agencies and organizations, including EPA and the American Water Works Association, recommended "explicit integration" of water, stormwater, and wastewater needs and priorities as part of an effective utility management strategy.[358]

An integrated approach often has several advantages. It is flexible and allows for adaptive management as a core principle of its use. It can be a broad, inclusive process that involves diverse stakeholders and can complement or supplement traditional regulatory approaches. In some forms, it can provide incentives for regulated entities to meet environmental goals as an alternative to enforcement strategies. Integrated approaches also address two interlinked difficulties created by conventional approaches: fragmentation and under-regulation. Fragmentation occurs when separate agencies are responsible for different but closely related issues, and when a single watershed is crossed by multiple geographic and political boundaries, leading to management by multiple agencies and jurisdiction at various levels of government.[359] Under-regulation occurs when some sources, such as nonpoint agricultural discharges, are unregulated by traditional "command and control" regulatory approaches.[360]

Yet the integrated approach also faces certain difficulties. The most direct involve lack of funding and administrative inertia or reluctance to

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353 *See, e.g.*, Neil S. Grigg, *Integrated Water Resources Management*, WATER ENCYCLOPEDIA, https://perma.cc/7VSK-PV7N (last visited Jan. 27, 2018) (noting "functional integration" and "conjunctive use").

354 *Id.*; EFFECTIVE UTIL. MGMT. STEERING GRP., TAKING THE NEXT STEP: FINDINGS OF THE EFFECTIVE UTILITY MANAGEMENT REVIEW STEERING GROUP 11, 15 (2016), https://perma.cc/T7M7-YCPS.

355 *See* Grigg, *supra* note 353.

356 *Id.*

357 HASSING ET AL., *supra* note 352, at 3.

358 EFFECTIVE UTIL. MGMT. STEERING GRP., *supra* note 354, at 11.

359 Tarlock, *supra* note 351, at 1082–83.

360 *See* Porter, *supra* note 351, at 500.

cooperate. Partly for these reasons, the concept's precise application or structure in a particular context is often poorly defined. When efforts bog down, partial integration can lead to increased fragmentation through the creation of additional entities without full control, but holding some stake in regulatory outcomes.

The integrated approach may bear on several aspects of chloride reduction efforts, including the general control of nonpoint source pollution and the implementation of green infrastructure approaches. Chloride control efforts need to evaluate, understand, and optimize discharges from a wide ranges of sources; as discussed above, chloride emanates from both nonpoint and point sources, and from many different industries.[361] In these contexts, while it may be difficult to suggest an aggressive integrated management approach to deal only with the chloride issue, chloride should be part of the portfolio to be addressed where integrated management is pursued. At a minimum, informational sharing strategies should be pursued within agencies.

The Chicago Area Waterway System (CAWS) Chloride Initiative (CAWS Initiative) is one of the few integrated management efforts to have addressed chloride pollution. In July 2015, the Illinois Pollution Control Board set a water quality standard of 500 mg/L chloride in most CAWS waterways, effective July 2018.[362] Led by the Metropolitan Water Reclamation District of Greater Chicago (MWRD), the CAWS Initiative participant organizations also include municipal, industrial, highway, wastewater treatment, and regulatory groups.[363] The overall work has been divided into several sectors, including legal, best management practices, water quality, data acquisition, and evaluation of social and economic impacts.[364] Ultimately, the results are intended to further the goal of meeting the new standards by "assessing current water conditions, documenting current road deicing activities, developing a pollutant minimization plan, identifying opportunities to reduce road salt runoff while maintaining public safety, and then implementing the plan and documenting progress."[365] The results will likely be used in preparing technical reports to be used for discharger variance petitions.[366]

The final policy approach discussed involves direct market interventions to artificially increase the cost of salt and therefore decrease its use. Admittedly, these face difficult sociopolitical obstacles.

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361 *See supra* Part I.A.

362 *See generally* Salt Inst. v. Ill. Pollution Control Bd., No 1–15–2003, 2016 WL 5853625 (Ill. App. Ct. Sept. 30, 2016) (affirming the Illinois Pollution Control Board's 500 mg/L chloride standard); *Chicago Area Waterways Chloride Initiative Work Group*, METROPOLITAN WATER RECLAMATION DISTRICT GREATER CHI., https://perma.cc/6Y9U-4G73 (last visited Jan. 27, 2018).

363 FRIENDS CHI. RIVER, HOLD THE ROAD SALT!, https://perma.cc/4RTL-PN75 (last visited Jan. 27, 2018).

364 *See Chicago Area Waterways Chloride Initiative Work Group*, *supra* note 362.

365 *Id.*

366 *See Salt Inst.*, 2016 WL 5853625, at *3–6 (discussing potential availability of variances from chloride water quality standard).

### *F. Direct Economic Measures*

Because the cost of salt is a driving factor in use rates, a "salt tax" would be expected to drive down those rates. A straight tax is likely to be politically unpalatable. However, alternative proposals to fund environmental improvements are relatively commonplace. For example, a proposed measure in Iowa would extend a 1% increase in the sales tax that had previously been allocated to other uses, with a portion of the proceeds applied to water infrastructure and related water quality protection measures.[367] A related alternative would have funded water quality programs out of a water-metering tax.[368] Both measures are supported by a broad coalition of groups, including public health advocates.[369]

## III. CONCLUSION

Without question, the foregoing menu of policy options will not all be appropriate in every context. After evaluating community-specific considerations, policy makers may choose one or more to reduce the problem of chloride transport to surface waters and groundwater. This work is not intended to suggest the elimination of chloride use in its most visible forms (deicing and water softeners). Rather, it suggests that such use be optimized. Optimization carries "triple bottom line" benefits for the environment (in chloride reductions); for the economy (in cost savings on chloride expenditures and personnel hours); and for society (in improved public health).

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367 William Petroski, *Coalition Backing Iowa Sales Tax Hike for Water Quality Cites Support*, DES MOINES REG. (Oct. 18, 2016), https://perma.cc/AR4J-HUU2.

368 Rod Boshart, *Branstad Offers Water Quality Compromise*, GAZETTE (July 27, 2016), https://perma.cc/YX7C-VJSZ.

369 Erin Murphy, *Health Groups Back Iowa Sales Tax for Natural Resources*, COURIER (Dec. 8, 2016), https://perma.cc/HSA7-HB7A.