MEMORANDUM

To: Watershed Partners

From: Jim Tierney, Watershed Inspector General, AAG, (518) 474-4843
Charlie Silver, Ph.D., Watershed I.G. Scientist, (518) 473-6620

Re: Scientific Guidance on Lower-Phosphorus Roadway De-icers.

Date: April 2, 2002

As we all know, excess phosphorus impairs water quality in the NYC Watershed. Phosphorus gets into the water from many sources, including sewage treatment plants, animal wastes, lawn fertilizers, muddy construction sites, and runoff from paved surfaces. In many ways, the need to reduce phosphorus levels to protect drinking water quality has been a driving force behind many of our Watershed protection efforts.

Certain winter-time roadway de-icer products also have been identified as potentially significant sources of phosphorus pollution. That is why a team of public-sector scientists reviewed the phosphorus content of various roadway de-icers and assessed the probable impacts of their use.

Enclosed for your consideration please find the results of that science-based investigation. Importantly, this summary report contains useful, non-binding, advice on practices and products that will help limit phosphorus pollution. Though winter is over, we hope that you will employ this guidance in planning and purchasing de-icer products for next winter (an effort which often takes place over the summer).

Thank you for your time and consideration of these recommendations. Please feel free to call with any questions.

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Deicer Advisory Guidelines
The Importance of Considering the Phosphorus Content of Deicers in the Protection of Drinking Water Supplies in the NYC Watershed

April 2, 2002

INTRODUCTION

Phosphorus in Road Deicers Can Harm Reservoirs

Icy roads are a hazard to motorists and cause accidents. The traditional response to this problem has been the application of rock salt as a primary chemical deicer and sand as an abrasive for better traction.

Today, a variety of liquid deicing/anti-icing products are being marketed in addition to rock salt and sand. Some liquid deicers are a mixture of agricultural byproducts and salt solutions, others are synthetic or man-made. Depending on their constituents, the phosphorus content of liquid deicer products is quite variable and, in some cases, very high. Once spread onto roadways, the rock salt, sand or liquid deicer products are readily transported into water bodies by stormwater and snowmelt.

Excess phosphorus is a significant problem within the New York City water supply reservoirs. Heightened levels of phosphorus in these reservoirs accelerate eutrophic conditions (i.e., creates algae blooms), that, in turn, generate offensive taste, color and odor in drinking water and increase the potential for the formation of hazardous byproducts when the water is disinfected. Eutrophic conditions also can increase levels of certain heavy metals in reservoir waters. Algae blooms add suspended materials to the water that can, in turn, interfere with effective disinfection of drinking water. In fact, Federal and State environmental agencies have formally classified a significant number of New York City Watershed (Watershed) reservoirs as "impaired" or "stressed" due to high phosphorus levels in their waters. This concern is heightened because water from these reservoirs is not filtered before it is delivered to most consumers.

As a result, extensive efforts are underway to limit the introduction of phosphorus from all sources into New York City's drinking water reservoirs, including phosphorus from roadway deicers.

Study of Winter Road Maintenance

In response to this concern, scientists and engineers from the New York City Department of Environmental Protection (DEP), the New York State Department of Environmental Conservation (DEC), the New York State Department of Health (DOH), the New York State Department of Transportation (DOT), and the New York State Attorney General's Office, evaluated the potential phosphorus additions associated with the use of various winter roadway maintenance products within the Watershed.

The liquid deicer products selected for this evaluation were available for purchase by Departments of Public Works operating within the Watershed through the New York State Office of General Services. Samples of road salt, sand, and liquid deicer products were collected and analyzed for their total phosphorus content. The goal of this study was to determine how much phosphorus is contained in winter road maintenance deicing products and to provide non-binding guidance to state agencies and local municipalities concerning the selection and application of deicers within the Watershed.

ADVISORY GUIDELINES

At the outset, we stress that human safety is the primary goal of roadway deicing and winter-time highway maintenance. In order to balance safety and public health, the following guidelines are presented as advice to municipal, county, and state entities and are not meant to interfere with the primary duty to protect human life and safety. These guidelines are effective immediately.

1. Total Phosphorus Guidance: Winter Road Maintenance Deicers:

<u>Endorsed</u>: deicer products that contain 50 parts per million total phosphorus (ppm) or less;

<u>Discouraged</u>: deicer products that contain more than 100 ppm total phosphorus (particularly in Delaware, Putnam, and Westchester Counties);

<u>Avoid</u>: any deicer that contains greater than 250 ppm total phosphorus should not be used or applied within the Watershed.[1]

2. Reducing the use of sand as a treatment material should be a primary goal of environmentally responsible road maintenance because sand usage is responsible for much of the phosphorus introduced into the reservoirs from winter road maintenance. The use of sand also degrades aquatic habitat in streams, wetlands and rivers.

3. Changes in existing road maintenance practices should seek to decrease phosphorus input into the New York City reservoirs.

A "winter highway materials use" survey form is enclosed. This form is designed to gather information about deicer usage (e.g., amounts and types of liquid deicer purchased and used throughout the season, ratios of salt/sand mixture applied, and application amounts per lane mile). The information that you provide will be analyzed periodically and used to refine these guidelines.

Manufacturers or vendors of deicer products may request that new or improved deicer

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[1] The data presented in Table 1 were employed to arrive at these guideline values. A description of how these data were used is available from DEP by contacting Charles Cutietta-Olson at (914)773-4475 or olsonc@water.dep.nyc.ny.us.

products be analyzed for total phosphorus content by contacting the DEP staff person identified in footnote 1. Resources for these analyses are limited, therefore, no guarantee is made regarding the availability of DEP to undertake additional testing. Revisions to these guidelines will be considered periodically as new information and new products become available.

BRIEF SUMMARY OF BACKGROUND INFORMATION

Attributes and Deficiencies of Deicers

Most roadway treatments consist of salt, sand, liquid deicers or some combination of these products. Rock salt (sodium chloride, NaCl), magnesium chloride ($MgCl_2$) and calcium chloride ($CaCl_2$) are the most commonly used roadway deicer salts. In general, liquid deicer products presently on the market are comprised of liquid salts, agricultural byproduct/salt mixtures, or synthetic compounds. The agricultural byproducts employed in liquid deicers generally include: (1) sugar-based byproducts of the distilling process, (2) byproducts of corn steeping, (3) manufactured corn-based products, and (4) other carbohydrates. Liquid deicer products can be applied in combination with salt or sand.

* Salts: The total phosphorus content of most salts is low, generally making salts a preferred deicing agent in the phosphorus sensitive Watershed. However, salt usage can corrode vehicles, bridges, guardrails, damage concrete roadways and have other adverse environmental impacts (e.g., excess salt can contaminate wells and be toxic to certain roadside plants and animals).

* Sand: Problems associated with spreading sand on Watershed roadways include: (1) sand may contain substantial amounts of phosphorus, (2) sand may adversely affect aquatic habitat in streams, wetlands, and rivers by covering fish and insect reproductive substrates, (3) sand may create air quality or dust concerns, (4) sand often clogs drainage features along highways (e.g. catch basins, gutters, ditches, etc.), and (5) sand may pit or crack windshields.

* Liquid deicer products: One advantage of applying liquid deicers is the ability of these products to adhere to the road. Once applied, liquid deicers tend to stick to the road and are not as easily cast aside or worn away by traffic as salt or sand. Another advantage is that the liquid deicers may act faster than solid salt which must turn into a brine before it becomes an effective deicer. Salt treated with liquid deicers works at lower temperatures and keeps the road free of ice longer. These properties should translate into fewer applications of deicing agents over the course of a storm event. Some liquid deicers have proven anti-corrosion properties and, as such, reduce damage to vehicles, bridges, guide rails, and roadways.

Certain liquid deicer products, however, contain high concentrations of total phosphorus that can be washed into nearby watercourses and drinking water supply reservoirs, adversely affecting water quality and the aquatic environment. Hence, it is critical that liquid deicers are selected in a manner that takes into account their total phosphorus content and are applied with care. There are a number of low-phosphorus liquid deicer products on the market (see Table 1).

Phosphorus Testing of Various Deicers

Samples of salt, sand, and liquid deicers were collected from storage facilities by DEC and DEP personnel from October to November 2001 and analyzed for total phosphorus content (Table 1).

Total phosphorus analyses were performed by the Upstate Freshwater Institute in Syracuse, New York, which is an ELAP-approved (Environmental Laboratory Assessment Program) laboratory. Samples were analyzed for total phosphorus using US Environmental Protection Agency Method 365.2 (persulfate digestion/ascorbic acid colorimetric method).

Of the various liquid deicer products that were analyzed, the one with the lowest total phosphorus concentration (0.81 ppm) was the synthetic product, Ice B' Gone 2, manufactured by Sears Ecological Applications Co. Its total phosphorus concentration was less than the salt samples analyzed (1 ppm - 4 ppm). Two other liquid deicer products, Magic - 0 which is manufactured by Sears Ecological Applications Co. and Ultra M manufactured by Natural Solutions Liquid Deicers, contained total phosphorus concentrations that were 50.8 ppm or less. The total phosphorus content of NC-3000, which is manufactured by SWP Liquid Deicers, was measured at 50.5 ppm but it was also measured at 90.6 ppm. Replicate phosphorus analyses of NC-3000 were highly variable due to the presence of interfering substances, but it is likely that the total phosphorus content is approximately 100 ppm or less. The total phosphorus content of four liquid deicer products were between 100 ppm and 250 ppm (Magic-0 with Spanish Cane and Magic 0 with Sugar Beets which is manufactured by Sears Ecological Applications Co., and Caliber M1000 and Caliber M2000 manufactured by SWP Liquid Deicers). Five liquid deicers exceeded 250 ppm total phosphorus, with the three highest ranging from 1,500 ppm to 3,700 ppm.

The average total phosphorus content of salt was measured at only 2.3 ppm. For Westchester County the average total phosphorus content of two sand piles was 54.2 ppm. For Delaware County, the average total phosphorus content of sand was calculated from municipal salt/sand piles containing 10% salt to 90% sand. The average total phosphorus content of sand in Delaware County was 123 ppm (Delhi – 126 ppm, Walton Village – 61 ppm, and Bloomville – 181 ppm).

Table 1. Phosphorus Concentrations in Deicers

Company or Item	Product or Product Constituent Name	Description	Total Phosphorus (ppm*)
Sears Ecological Applications Co. Liquid Deicers	Ice B' Gone 1 (concentrate) **	Spanish cane sugar byproduct	323.4
	$MgCl_2$ (30% solution) **	From Dead Sea	6.2
	Magic-0: Estimate calculated from ratio of above two components	Ice B' Gone 1 (Spanish Cane) + $MgCl_2$ - 50:50***	164.8
	Magic-0: Laboratory measured value of product consisting of top two components	Ice B' Gone 1 (Spanish Cane) + $MgCl_2$ - 50:50	194.2
	Magic-0	Ice B' Gone 1 (Venezuelan Cane) + $MgCl_2$ - 50:50	50.8
	Magic-0	Ice B' Gone 1 (Sugar Beet) + $MgCl_2$ - 50:50	108.7
	Ice B' Gone 2	Synthetic product	0.81
Natural Solutions Liquid Deicers	Summit M	Corn steep residue + $MgCl_2$ - 50:50	2,281.9; 3,692.4#
	Performance Plus M	Corn steep residue + $MgCl_2$ - 16:84	1,556.1; 2,062.1#
	Performance Plus C	Corn steep residue + $CaCl_2$ - 50:50	2,133.4
	Performance Plus C	Corn steep residue + $CaCl_2$ - 16:84	863.2
	Ultra M	Corn-based product + $MgCl_2$	13.4; 16.7#
	$MgCl_2$ (30% solution) **	From Great Salt Lake	13.4; 12.1#
SWP Liquid Deicers	Caliber M1000	Manufactured corn product + $MgCl_2$ - 10:90	109.4
	Caliber M2000	Manufactured corn product + $MgCl_2$ - 20:80	249.6
	$MgCl_2$ w/ rust inhibitor		259.5
	NC-3000	Carbohydrate, potassium carboxylates mix	90.6; 50.5##
Salt	Westchester County salt		4.0
	Westchester County salt		1.0
	Delaware Co. NYSDOT salt		2.0
Sand	Westchester County sand		53.4
	Westchester County sand		55.0
Salt:Sand	Delhi (10:90)		113.5
	Walton Village (10:90)		55.0
	Bloomville salt/sand (10:90)		163.5

* ppm = parts per million (or milligrams per liter [mg/L])

** Product constituents = Ice B' Gone 1 concentrate and $MgCl_2$ or magnesium chloride salt (30% solution).

*** 50:50 = A ratio consisting of 50% Ice B' Gone 1 and 50% $MgCl_2$.

Sample re-analyzed.

Product was analyzed twice with a duplicate analysis each time. Agreement between duplicates was poor and outside quality control limits. Results of the four analyses ranged from 14.9 to 112.8 ppm. Lab concluded that there was interference with this sample and the method.

The Phosphorus Problem in the New York City Watershed

Phosphorus is an element that is required in virtually all biological systems for growth. Reservoirs are complex ecosystems containing plants, microorganisms, invertebrates (e.g., insects, clams, crayfish, etc.), and fish, which rely on nutrients from upstream sources. These organisms are highly interdependent, but ultimately their growth is directly related to the amount and availability of nutrients (received by the reservoirs). During most of the growing season, the "limiting" nutrient in the New York City Watershed reservoirs is phosphorus which, if allowed to increase, would generally support a corresponding increase in aquatic plant growth, particularly algae, and other nuisance organisms. In other words, phosphorus concentrations generally control the extent to which plants can grow in the New York City reservoirs, and contribute to the quality of the finished drinking water.

The New York City Watershed extends over 5% of the state, yet provides mostly unfiltered drinking water to approximately nine million people daily (including one million people living outside of the City). The introduction of excessive nutrients, primarily phosphorus, into the reservoirs promotes algae blooms which generate offensive tastes and odors in drinking water supplies, and increases water treatment costs. A visual cue that excessive phosphorus is present in an aquatic environment is that the water becomes green in color, and mats of colored plant and bacterial life appear on the surface, particularly in areas of stagnant water.

Over time, the individual algae die off, and while the bloom itself continues in the surface waters, the dead algae will fall to the bottom of the reservoir's water column. Decay of the dead algae leads to a decline in the levels of dissolved oxygen in the lower depths of the water. This low oxygen environment causes serious problems when the water is to be used as a drinking water supply. These low oxygen conditions cause contaminants such as iron, manganese, and even additional phosphorus to be released from reservoir bottom sediments into the water, deteriorating its quality for human consumption. Organic material in the water, such as dead algae and bacteria, interact with chlorine during water disinfection in a manner that can increase levels of chemicals known as "disinfection byproducts." A number of these disinfection byproducts are suspected carcinogens and have been identified in medical studies as a possible cause of miscarriage. Finally, the increase in materials suspended in the water has the potential to interfere with the effectiveness of drinking water chlorination.