EXECUTIVE SUMMARY: DEICER EFFECTS AND MITIGATING MEASURES

This report analyzes the performance, environmental effects, and economic costs of seven deicing materials: sodium chloride (road salt), CMA (calcium magnesium acetate), CMS-B (a patented product, Motech, containing principally potassium chloride), CG-90 Surface Saver (a patented corrosion-inhibiting salt), calcium chloride, Verglimit (a patented concrete road surface containing calcium chloride pellets), and sand (an abrasive). The data for the analysis of deicer performance are derived from current literature. The environmental effects are derived from literature and from a special Great Lakes chloride loading model constructed for this study. The economic costs are derived from actual and estimated costs and the application of depreciation rates tailored to Michigan.

Each deicing material has benefits, costs, and effects, and the selection of which material(s) to use depends on the situation. For instance, sodium chloride is an effective deicer, it can be used at low temperatures, its cost is relatively low, but it is more corrosive than the other deicers evaluated and therefore is most appropriate where corrosion is not the major concern; although the various deicers cause differing levels of corrosion, effects can be minimized through design and material modifications to both road structures and vehicles. Chapter 5 of this report includes a grid displaying the relative performance (including protection against corrosion), effectiveness, and costs of each.

Current deicing use in Michigan has not resulted in any documented widespread adverse effects on the state's natural environment. Undesirable effects are most likely to occur adjacent to heavily traveled roads (where deicers are applied in the highest quantities). The design of a roadway's drainage system affects the dispersal of a deicing material; for example, impervious storm drains can transport concentrated deicers directly to sensitive environments.

The deicer market constantly is changing. Prices rise and fall, new products are developed, and more is learned about the application and effects of products currently in use. To meet winter maintenance needs as efficiently, effectively, and with as little adverse impact as possible, the Michigan Department of Transportation (MDOT)—and other deicer users-should constantly monitor the market. If substantial changes in the types and quantities of deicing materials are contemplated, the environmental and economic effects of the changes must be evaluated.

CORROSION

As the use of deicers, particularly road salt, increased in the 1950s and 1960s, their corrosive effects on automobiles and the highway infrastructure escalated. To combat this vulnerability to corrosion, significant changes have been made in design, manufacturing processes, and materials used in the production of vehicles and in the construction of bridges and roads. Corrosion of cars has been reduced substantially in recent years; industry wide, the manufacturers' goal is to prevent surface rust for at least five years and perforations for at least ten years on new vehicles.

While older and low-maintenance bridges are very susceptible to the effects of corrosion, newer bridges and roadways are better protected. Thicker, denser concrete overlays, waterproof membranes, coated reinforcing steel, and cathodic protection are used to reduce maintenance costs and to slow corrosion.

Despite their being more expensive to purchase and apply than the road salt needed to achieve the same deicing results, in some situations the use of less-corrosive materials may be a cost-effective way to reduce corrosion. Since vehicle manufacturers now build corrosion inhibitors-and their cost-into the price of each vehicle, the general use by the MDOT of the higher-cost but less-corrosive deicers cannot be justified on the basis of reduced vehicle corrosion alone, but their selective use-on bridges and/or certain stretches of roadway-may be very practical.

ENVIRONMENT

None of the deicers evaluated in this report poses widespread adverse environmental threats; their potential impacts are very site specific. For example, the effects of deicers containing chloride salts (sodium chloride, calcium chloride, CG-90 Surface Saver, Verglimit, and CMS-B) are similar, but the extent of a deicer's impact depends on its concentration when it reaches the environment. Calcium magnesium acetate can have negative impacts different from those of chloride salts. Although sand, which is not a chemical, has few adverse environmental effects, in certain situations it too can cause problems. A grid directing the reader to discussion in the text of the various environmental effects of each deicer is included in chapter 5.

In Michigan lakes, streams, rivers, and even in the Great Lakes, current chloride levels are in part attributable to the use of road salt as a deicing material. However, the fact that there are measurable increases in the chloride concentrations in these bodies, at least on a seasonal basis, does not necessarily mean there are widespread negative environmental impacts. Literature and other information on chlorides indicate that except for isolated instances in creeks, streams, and relatively small lakes, the application of road salt as a deicer is not likely to result in significant direct impacts on aquatic biota. A model constructed for this study (described in chapter 4) finds that even under a "worst case scenario," chloride concentrations in the Great Lakes will reach *equilibrium* (uniform distribution) at levels far below that toxic to aquatic organisms. Deicing components other than chloride are not found to be increasing in lakes and streams, and any adverse impacts from their increased use most likely will occur near the place of application, where concentration is highest.

In small water bodies, the biochemical oxygen demand associated with the decomposition of CMA has the potential to deplete dissolved oxygen to levels that impair the survival ofbeneficial organisms. In small lakes with low water exchange, deicers containing chlorides can cause density stratification; if severe, this can prevent normal lake overturn, required to maintain dissolved oxygen levels. In streams, during spring thaw levels of chlorides may surge temporarily and reach levels toxic to aquatic biota; such surges are difficult to document because they are only temporary. These impacts of CMA and chloride compounds are most likely to occur in areas of high deicer use, where roadway runoff is channeled directly to small water bodies. Modifying drainage design and diverting runoff to less sensitive areas can minimize these effects on small water bodies.

Insofar as soils are concerned, laboratory tests find that many deicing components have the potential to release heavy metals from soils, which then migrate to surface and groundwater. No field evidence is found indicating that heavy metals in either groundwater or surface water bodies have increased because of the application of deicers. The potential for such contamination is highest where the soil already contains high levels of heavy metals and where the concentration of deicers is the greatest. Further study is needed.

Terrestrial vegetation is relatively tolerant of deicers. Grasses and shrubs generally are more tolerant than trees to the chlorides contained in many deicing materials. Certain salt-intolerant tree species within 50 feet of roadways show damage attributable to road salt spray/splash or root uptake; individual trees are threatened, but not forests. Damage to individual trees represents an economic loss to landowners when valuable, salt-sensitive native species (i.e., sugar maple) and commercially cultivated trees adjacent to roadways are affected. Vegetation damage, in general, is observed most frequently in urban areas where deicer use is heaviest, trees are closer to the roadway, and plants also are exposed to other environmental stresses. The selection of salt-tolerant tree and shrub species for roadside plantings will minimize the deicing effects on roadside vegetation.

Other sensitive vegetation areas are valuable natural or managed plant communities, i.e., arboretums, horticultural gardens, and natural areas, which may contain species sensitive to chloride. If such areas are affected, alternative deicing materials may need to be used on adjacent roadways.

Endangered and threatened species and the habitat on which they depend for survival can be adversely affected by the use of certain deicers. The Michigan Department of Natural Resources (MDNR) Natural Features Inventory can provide information on known critical habitat for endangered and threatened species within 50 feet of state roadways. The likelihood of significant deicer impacts is great for endangered and threatened species: Many already are under significant stress and/or have very limited habitat available. Alternative road deicing materials can be applied where the potential for impacts to specific endangered or threatened species is high.

Groundwater and vulnerable aquifers can be affected by any material applied or spilled on the land, including deicing materials. Generally, the deicing materials are diluted by the time they reach groundwater, or they are diluted by the groundwater to the point that concentrations do not exceed chloride drinking water standards. However, sodium is a primary component of road salt, and relatively small increases of sodium in drinking water may affect people with hypertension; therefore, wells that are recharged by rainfall or snowmelt and are close to roadways subject to heavy deicer application can be affected.

In the last 30 years, other states-including Maine, New Hampshire, and Massachusetts-have had specific problems with elevated sodium and chloride levels in private and public wells, attributed to road deicing practices. In areas where problems have been identified, road salt application has been reduced and alternative deicers such as CMA used to minimize the impacts of sodium and chloride on groundwater.

A significant amount of groundwater contamination attributable to deicers has been due to road salt storage practices: Large quantities of uncovered and uncontained road salt can lead to high concentrations of sodium and chloride running off and infiltrating groundwater and surface waters. Most MDOT road salt now is stored in covered storage sheds, and the material is loaded into trucks in contained areas. Loading areas are bermed, and effluent is collected and directed to sanitary systems or collection lagoons, which are periodically pumped. The MDOT is striving continually to reach 100 percent compliance with the salt storage requirements of the MDNR.

Although high levels of salt contamination from roadway application have been documented in only a few cases in Michigan, the vulnerability of certain individual, industrial, and municipal water supplies to potential contamination warrants systematic monitoring at representative locations.