Reducing Road Salt at Kent State University 2020-21

University Facilities Management

Grounds

1) **Sustainability within the winter maintenance programming of the Kent State University Grounds department considers more than just the physical environment. Sustainability practices encompass**
   a) Societal Needs (safe passage for people and goods)
   b) Economic Constraints
   c) Environmental Stewardship

2) **Setting Levels of Service for KSU**
   a) Snowfall triggers
      i) Road
         (1) Grounds Manager sets trigger during work shift
            (a) Zero tolerance in-school session
            (b) ½" out of school session
         (2) KSUPD/Safety Services sets roadway triggers in off-hours/weekends
      ii) Parking Lots
         (1) KSUPD/Parking Services sets trigger for lots
      iii) Sidewalks/Entrances/Ramps/Steps
         (1) Grounds Manager makes the call when in-session during work shift
         (2) Events and Res Hall numbers dictate services provided off-hours

3) **Prior to a weather event**
   a) Monitor forecast
   b) Tear-down and set-up equipment
   c) Identify schedule and staffing for storm
   d) Anti-icing/pre-treatment of pavement

4) **Pre-treatment**
   a) Proactive measure to prevent the bond between ice/snow to pavement using a liquid
      i) Roads return to normal more quickly
      ii) Reduction in airborne dust and salt
      iii) Brine sticks to surface unlike rock salt
      iv) Salt needs moisture in order to be effective, brine kick starts this
      v) Brine will work if snow event is delayed
      vi) Reduction in labor hours, material usage, equipment usage
      vii) KSU has a 3000-gallon storage tank for sodium chloride brine
         (1) NaCl brine is procured from ODOT for free
         (2) NaCl brine is applied directly to pavement and concrete
            (a) Blades system for roads
            (b) Snow Ex system on compact tractor for walks, ramps, Esplanade
            (c) Backpack and hand sprayers for steps and entrances

viii) Sodium chloride brine
(1) Works to temps down to 15 degrees F
(2) Should be a 23% solution with a freezing point of -6F
(3) 23% is what we are continually seeking on the road surface
(a) 22% and icing occurs
(b) 24% and crystallization occurs
(4) We need to consider the pavement temperature when applying
(a) This would be an excellent opportunity to work with academics to apply for a grant to pay for a weather station that could monitor pavement temps and moisture levels
(b) It is not safe to apply brine in drifting, blowing situations, as blowing snow may stick to the brine and dilute it causing ice to form
(5) Typical Anti-ice or pavement pre-treatment chemicals:
(a) NaCl brine (free)
(b) Mag Chloride (expensive)
(c) Potassium Acetate (more expensive)
(d) Calcium Chloride (cost prohibitive

5) Pre-Wetting

a) Applying liquid brine to rock salt prior to placing on the road to reduce scatter and initiate action
i) Apply to stockpile
ii) Apply to load prior to dumping in hopper
iii) Apply directly to salt spinner
b) KSU employs all three techniques of pre-wetting
c) Up to 30% of rock salt is lost in drains and ditches of vehicles traveling 30mph if salt is not pre-wet
d) Pre-wet salt is ready for immediate action due to presence of moisture
e) Studies are showing that 50 gallons of pre-wet to a ton of road salt has dramatic effect on highly trafficked roads-KSU doesn't have highway conditions such as that.

6) De-icing

a) Process in which a snow/ice to pavement bond has occurred and needs to be broken by applying material from the top layer of snow down to the pavement.
b) NE Ohio is typically in this stance due to the types of weather systems that have rain and wind prior to the snowfall, prohibiting the pre-treatment of the pavement surfaces
c) NaCl Rock Salt
i) Several standard operating procedures can be employed to reduce the harmful environmental effects and amount of rock salt used per weather event:
(1) Utilizing mechanical means of snow clearance over chemical
(a) Brooms, blowers, shovels, plows vs rock salt
(2) Calibration of spreaders on a regular schedule
(3) Not using BLAST feature on automatic controls to override spreaders while stopped
(4) Applying salt to crown of road and upper portion of ramps to create brine and allow gravity to move it across the surfaces

(5) Close control of dumping the bed of trucks when moving salt supply to auger. Physically checking for piles after dumping.
(6) Not spreading on drifting snow
(7) Cleaning up any spills from trucks, and hand applications
(8) Teaching staff that more is not more
  (a) Getting into the chemistry of salt applications
  (b) Noting effects of salt damage to vegetation and water quality
(9) Ensuring that staff is aware of and familiar with responsibilities, their equipment and products they are using
  (a) Not spreading over snow melt systems
  (b) Not using pricey materials
  (c) Not double treating with co-workers

d) Three biggest deicing materials outside of sodium chloride (NaCl) rock salt
  i) Calcium chloride ($CaCl_2$)
  ii) Magnesium chloride ($MgCl_2$)
  iii) Potassium acetate—we use this

e) Chlorides (a compound of chlorine with another element) versus acetates (a salt or ester of acetic acid)
  i) Advantage of chlorides-
    (1) The ease in sourcing
    (2) They are relatively inexpensive
  ii) Disadvantages of chlorides
    (1) Corrosive to ferrous metals and shorten the lifespan of steel structures
    (2) With a high freezing point, can contribute to concrete damage to freeze and thaw cycles
    (3) Pollutants that can accumulate in water sources
    (4) Chlorides are a problem for NaCl, $MgCl_2$, and $CaCl_2$ – anything that has the chlorine atom in it. In the case of NaCl, the chlorides can accumulate in ground and surfaces waters and raise levels past EPA's potable water levels
    (5) NaCl is more of a problem than $MgCl_2$ or $CaCl_2$, because Mg and Ca are more significant plant nutrients than Na
  iii) Advantages of acetates
    (1) Not very corrosive to steel
    (2) Work at lower pavement temps than sodium chloride
    (3) Acetate don't persist long term in water sources.
  iv) Disadvantages of acetates
    (1) They are most harmful to wildlife when they first enter the water system as they begin to biodegrade and remove oxygen from the system
    (2) They don't work on pavement temps below -20 degrees
    (3) They corrode zinc (galvanized metals)

f) Other non-chloride deicers
  i) Formates- a salt or ester of formic acid
    (1) limited quantity and high prices
    (2) Pose the smallest need for oxygen when they break down out of all the non-chloride deicers

(3) Minimal effect on steel

ii) Urea-an inexpensive form of nitrogen with an NPK of 46-0-0, naturally produced by animals. Synthetic urea is manufactured with anhydrous ammonia
   (1) No degradation on steel
   (2) Uses largest amount of oxygen when breaking down in water system
   (3) Nitrogen pollution in ground and surface water can cause deadly algae blooms
   (4) Can cause human health problems
   (5) Nitrogen pollution is the leading cause of the anoxic dead zone in the Gulf of Mexico

iii) Glycol/Glycerin- any class of organic compounds belonging to the alcohol family
   (1) Used mostly at airports
   (2) Can work at very low temps
   (3) Ethylene glycol is considered a hazardous air pollutant by the EPA
   (4) Glycerol can be toxic to fish

iv) Abrasives-grit like particles or granules, as of sand or other small, coarse particles
   (1) Do not melt snow/ice
   (2) Only product that works when deicing chemical don't and only provide traction
   (3) Can be recovered from use on the road in storm drain grit chambers, but if left in system can cause high turbidity and cause harm to aquatic life.
   (4) WE use far less sand on campus for several reason
      (a) Kent State University infrastructure could not currently support the clean-up from using sand
      (b) Stormwater BMPs and compliance regulations would literally be blown out of the water
      (c) We do not have filters on our catch basins that could collect the debris
      (d) We do not have adequate equipment to perform clean up on a regular basis
      (e) Street sweeper needs replaced at a current cost of $180,000-$280,000
      (f) This would require a full-time position of just street sweeping
      (g) Our current salt spreaders would need to be completed recalibrated
      (h) Sand requires re-applications about every two hours, again a staffing issue
   (5) KSU weather patterns typically don't include the amount of snow and ice that would be enough to make a long term hardpack scenario
      (a) The ecological impact on macroinvertebrates would be detrimental to our aquatic ecosystems
      (b) The sand fills in the crevices between gravel that provide habitat for these insects
      (c) If we lose the insects the whole food chain is ruined and there are severe repercussions ecologically

v) Additives-organic byproducts, such as beet, corn, molasses
   (1) Must be used in combination with other deicers
   (2) Do not melt snow
   (3) Use oxygen to breakdown and may serve as a fertilizer to some algae and plants which can be harmful to aquatic life.
   (4) Some studies show that additives may decrease amount of rock salt needed-but may be the scatter effect.

Table 1: Deicer environmentally harmful and ice melt capability

Deicer Category	Material	Environmentally Harmful (Yes/No)	Melts Ice (Yes/No)
Acetates	Potassium Acetate	Yes	Yes
	Sodium Acetate	Yes	Yes
	Calcium Magnesium Acetate	Yes	Yes
Formates	Sodium Formate	Yes	Yes
	Potassium Formate	Yes	Yes
Urea	Urea, Urea/ammonium nitrate	Yes	Yes
Glycerol/Glycol	Glycerol	Yes	Yes
	Ethylene Glycol	Yes	Yes
	Propylene Glycol	Yes	Yes
Succinate	Potassium Succinate	Yes	Yes
Additives	"Beet Juice"	Yes	No
	Molasses	Yes	No
	Distiller's Solubles	Yes	No
	Corn Syrup	Yes	No
Abrasives	Sand	Yes	No
Chlorides	Sodium Chloride	Yes	Yes
	Sodium Chloride liquid	Yes	Yes
	Calcium Chloride	Yes	Yes
	Magnesium Chloride	Yes	Yes
Explanation of Column		Which products are harmful to surface or groundwater. May include high turbidity, loss of habitat, high conductivity, high dissolved oxygen demand, toxicity or nutrient loading.	Which products melt snow and ice?
References		[4], [13], [16], [17], [18], [23], [34]	[4], [13], [14], [16], [17], [23], [29], [30], [33], [37], [40]

Table 2: Common form of deicers and waste factor

Deicer Category	Material	Common Form Used (Liquid/Solid)	Low Waste (Yes/No)
Acetates	Potassium Acetate	Liquid	Yes
	Sodium Acetate	Solid	No
	Calcium Magnesium Acetate	Solid	No
Formates	Sodium Formate	Solid	No
	Potassium Formate	Liquid	Yes
Urea	Urea	Solid	No
Glycerol/Glycol	Glycerol	Liquid	Yes
	Ethylene Glycol	Liquid	Yes
	Propylene Glycol	Liquid	Yes
Succinate	Potassium Succinate	Liquid	Yes
Additives	"Beet Juice"	Liquid	Yes
	Molasses	Liquid	Yes
	Distiller's Solubles	Liquid	Yes
	Corn Syrup	Liquid	Yes
Abrasives	Sand	Solid	No
Chlorides	Sodium Chloride	Solid	No
	Sodium Chloride	Liquid	Yes
	Calcium Chloride	Liquid	Yes
	Magnesium Chloride	Liquid	Yes
Explanation of Column	List of non-chloride products for winter	The physical form of the product commonly used.	When applied to the road, does this product "stay put", melt the target area, and not bounce or blow off the road.
References		[4], [13], [14], [16], [17], [23], [29], [30], [33], [37], [40]	[4], [13], [14], [16], [17], [23], [29], [30], [33], [37], [40]

Table 3: Deicers performance in average, cold, and very cold melting ranges

Deicer Category	Material	Effective Ice Melting at Average Temperatures (15 °F to 32 °F ± 5 °F) (Yes/No)	Effective Ice Melting at Cold Temperatures (-20 °F to 15 °F ± 5 °F) (Yes/No)	Effective Ice Melting at Very Cold Temperatures (Below -20 °F ± 5 °F) (Yes/No)
Acetates	Potassium Acetate	Yes	Yes	No
	Sodium Acetate	Yes	No	No
	Calcium Magnesium Acetate	Yes	No	No
Formates	Sodium Formate	Yes	Yes	No
	Potassium Formate	Yes	Yes	No
Urea	Urea	Yes	No	No
Glycerol/Glycol	Glycerol	Yes	Yes	No
	Ethylene Glycol	Yes	Yes	No
	Propylene Glycol	Yes	Yes	No
Succinate	Potassium Succinate	Yes	Yes	No
Additives	"Beet Juice"	No	No	No
	Molasses	No	No	No
	Distiller's Solubles	No	No	No
	Corn Syrup	No	No	No
Abrasives	Sand	No	No	No
Chlorides	Sodium Chloride	Yes	No	No
	Sodium Chloride liquid	Yes	No	No
	Calcium Chloride	Yes	Yes	No
	Magnesium Chloride	Yes	Yes	No
Explanation of Column		Refers to pavement temperatures at which significant ice melting will likely occur. For all deicers, as temperature drops, ice melting will decrease and while two deicers may work at the same temperature range, they may not be equally effective at a given temperature		
References		[4], [13], [14], [16], [17], [23], [29], [30], [33], [37], [40]	[4], [13], [14], [16], [17], [23], [29], [30], [33], [37], [40]	[4], [13], [14], [16], [17], [23], [29], [30], [33], [37], [40]

Table 4: Price ranges in per gallon, ton, and lane mile and deicer availability

Deicer Category	Material	Price Estimates		Large Scale Availability
			(per lane mile)	(Yes/No)
Acetates	Potassium Acetate	~ $4.50/gallon	~ $135	Yes
	Sodium Acetate	~ $1,900/ton	~ $190	Yes
	Calcium Magnesium Acetate	~ $1900/ton	~ $190	Yes
Formates	Sodium Formate	~ $400/ton	~ $40	No
	Potassium Formate	~ $70/gallon	~ $2,100	No
Urea	Urea	~ $490/ton	~ $49	Yes
Glycerol/Glycol	Glycerol	~ $50/gallon	~ $1,500	Yes
	Ethylene Glycol	~ $40/gallon	~ $1,200	No
	Propylene Glycol	~ $40/gallon	~ $1,200	Yes
Succinate	Potassium Succinate	~ $2.50/gallon	~ $75	Yes
Additives	"Beet Juice"	NA	N/A	NA
	Molasses	NA	N/A	NA
	Distiller's Solubles	NA	N/A	NA
	Corn Syrup	NA	N/A	NA
Abrasives	Sand	~ $10/ton	~ $1	Yes
Chlorides	Sodium Chloride	~ $70/ton	~ $7	Yes
	Sodium Chloride liquid	~ 15 cents/gallon	~ $5	Yes
	Calcium Chloride	~ $1.40/gallon	~ $42	Yes
	Magnesium Chloride	~ $1.20/gallon	~ $36	Yes
Explanation of Column		Rough estimates of product pricing. Prices vary with availability, shipping costs, and competing markets for the same products, volume purchased and other variables. Additives are not included in pricing since they are used in much smaller amounts. The estimate per lane mile is based off the rates of 200 pounds/lane mile and 30 gallons/lane mile. These are not suggested application rates. Rates should be chosen based on road conditions, weather conditions, pavement temperature, and other contributing factors. These rates are only for cost comparison purposes.		Is the product available today in large commercial quantities such that if MnDOT switched to this product instead of salt there would be enough available
References		[4], [7], [13], [16], [17], [23], [26], [32], [33], [37]		[3], [7], [8], [13], [26], [32], [33]

Table 5: Deicer breaks down or accumulates in water, dissolved oxygen demand and aquatic plant growth

Deicer Category	Material	Breaks down in water (Yes/No)	Accumulates in Water (Yes/No)	Uses up oxygen in the water (Yes/No)	Accelerates algae and aquatic plant growth (Yes/No)
Acetates	Potassium Acetate	Yes	No	Yes	No
	Sodium Acetate	Yes	No	Yes	No
	Calcium Magnesium Acetate	Yes	No	Yes	No
Formates	Sodium Formate	Yes	No	Yes	No
	Potassium Formate	Yes	No	Yes	No
Urea	Urea	Yes	No	Yes Highest of all	Yes
Glycerol/Glycol	Glycerol	Yes	No	Yes	No
	Ethylene Glycol	Yes	No	Yes	No
	Propylene Glycol	Yes	No	Yes	No
Succinate	Potassium Succinate	Yes	No	Yes	No
Additives	"Beet Juice"	Yes	No	Yes	Yes
	Molasses	Yes	No	Yes	Yes
	Distiller's Solubles	Yes	No	Yes	Yes
	Corn Syrup	Yes	No	Yes	Yes
Abrasives	Sand	No	Yes	No	No
Chlorides	Sodium Chloride	No	Yes	No	No
	Sodium Chloride liquid	No	Yes	No	No
	Calcium Chloride	No	Yes	No	No
	Magnesium Chloride	No	Yes	No	No
Explanation of Column		When a chemical breaks down into other chemicals over time (biodegrades or decomposes)	If we stop using this chemical today, will it still be in our water in 5 years?	(BOD/COD) When chemicals breakdown in the water, they often use dissolved oxygen. This creates a hardship for aquatic life since oxygen is also needed by aquatic species (i.e. fish) in order to live.	Some products contain nutrients such as nitrogen & phosphorus. When in the water, nutrients speed up the growth of algae and aquatic plants
References		[4], [13], [16], [19], [23], [34]	[4], [13], [16], [19], [23], [34]	[4], [13], [16], [19], [23], [34]	[4], [13], [19], [23]

Table 6: Deicer pollutant removal, corrosive to steel

Deicer Category	Material	Easily removed from water (Yes/No)	Ponds remove this pollutant (Yes/No)	Corrosive to Steel (Yes/No)
Acetates	Potassium Acetate	No	No	No
	Sodium Acetate	No	No	No
	Calcium Magnesium Acetate	No	No	No
Formates	Sodium Formate	No	No	No
	Potassium Formate	No	No	No
Urea	Urea, Urea/ammonium nitrate	No	No	No
Glycerol/Glycol	Glycerol	No	No	No
	Ethylene Glycol	No	No	No
	Propylene Glycol	No	No	No
Succinate	Potassium Succinate	No	No	No
Additives	"Beet Juice"	No	No	No
	Molasses	No	No	No
	Distiller's Solubles	No	No	No
	Corn Syrup	No	No	No
Abrasives	Sand	Yes	Yes	No
Chlorides	Sodium Chloride	No	No	Yes
	Sodium Chloride liquid	No	No	Yes
	Calcium Chloride	No	No	Yes
	Magnesium Chloride	No	No	Yes
Explanation of Column		Can be removed by a known process and using a straight-forward, affordable procedure	Can stormwater ponds or rain gardens effectively remove this product before it reaches the lakes, rivers, or wetlands?	Will this product by itself be corrosive to steel?
References		[4], [13], [16], [19], [23], [34]	[38]	[4], [13], [14], [16], [17], [39]

Note. From “Chloride Free Snow and Ice Control Material”, Minnesota Department of Transportation Office of Transportation System Management Research Services and Library, Fortin, Connie, Tjaden, Lauren, Mulhem, Nancy (Fortin Consulting Inc)., October 2014, TRS1411, p. 6-11, lrrb.org/media/reports/TRS1411.pdf ,Transportation Research Synthesis.

Key take aways from Rock Salt Reduction discussions:

Current proactive measures taken by the Grounds department such as the education of staff on areas of responsibilities, proper equipment and material usage and clean-ups are essential. The pretreatment of surfaces with brine is imperative to sustainable snowfighting, as it will prevent the bond from forming between the pavement surface and the ice. The pretreatment application of brine allows for more efficient snow removal with less labor, less stress on equipment and fewer materials resulting in a more sustainable process with quicker clean up periods. The Grounds fleet is currently stocked with equipment that can apply the NaCl brine to major passages throughout campus prior to a winter storm event. ODOT District 4 provides the brine solution to KSU at no charge. NaCl brine has been determined to be the most effective, affordable product for these purposes.

Other procedures to further reduce the amount of rock salt damage to the environment and structures will also be employed by the Grounds department. One such procedure is monitoring the calibration of application equipment. A particular area of emphasis on the department will post-storm clean-up. Rock salt will be swept up by staff if a vehicle spill occurred or if over application occurred, this will be done by the street sweeper and manually. Past practices in the department, such as pre-salting before storms will be adjusted to pre-treating with brine solutions. Equipment Operators will be asked to pre-wet road salt in capable vehicles at all times so that we reduce the scatter of the salt grains when applied to the road surface which reduces the amount of salt that ends up in the ditches and soil and kickstarts the chemical burn of the ice/snow melt. Grounds will continue to utilize potassium acetate when temperatures of the pavement are below 15 degrees. Potassium acetate is a much more environmentally friendly product than chloride as noted in the earlier outline section of Chlorides vs. Acetates. During the pandemic, Grounds is going against past practices that have called for the dispatch of sidewalk clearance vehicles during off-hours storms and will only bring in road trucks unless accumulations top 4". Grounds will continue to work with the Office of the University Architects to ensure that new building projects include the addition of snow-melt systems. Management can try to identify areas on campus that abrasives may work for us and not pollute our stormwater or surface water. However, research shows that sand/salt mixtures reduce the effectiveness of the salt component. Management staff will provide more education regarding sustainable salting to staff, delving into which materials should be used in different scenarios and the science behind the decisions, with an emphasis on what the build up of chloride does to our environment and infrastructures. **The key to a successful sustainable winter weather management program is knowledge, and creation of good habits by the entire Grounds maintenance staff.**

The Grounds department will work with the faculty advisory group in regard to product additions to department's arsenal. Grounds will work with academics to secure a grant for the purchase of a weather station that could provide pavement temperatures and moisture levels on campus in conjunction with student projects. Grounds will also work with the public safety to secure camera access to certain high traveled routes on campus. Grounds will audit salt usage electronically for the first year this season and will be able to share that information with faculty and students. The faculty advisory group will continue to monitor salinity levels in stormwater ponds and provide the current data and data from past years to the Grounds department. While Grounds is on the right track, we will continue to push staff to control what they can control in regard to serving as good stewards to the environment.