ENVIRONMENTAL SUSTAINABILITY IN WINTER ROADWAY OPERATIONS

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Supplemented by:

NCHRP Synthesis 449, Strategies to Mitigate the Impacts of Chloride Roadway Deicers on the Natural Environment

My coauthors:
Laura Fay, Jiang Huang
Outline

1. Impacts of Winter Highway Operations
2. Reducing Sand Usage
3. Strategic Planning to Reduce Salt Usage
4. Proactive Stewardship Practices
5. Precision Application
6. Monitoring & Keeping Records
7. WM Facility Management
8. Training
9. Concluding Remarks
1. Benefits of Winter Highway Operations

- Fewer accidents, improved mobility, reduced travel costs, reduced fuel use
- Sustained economic productivity, continued emergency services, ...
1a. WM in the U.S.

- > 70% roads, 70% population
- Hwys: 2.3 $bln/yr + 5 $bln/yr

**MnDOT Case Study:**

- (4,600 crashes) = 29% ↓
- $10.9M in travel time savings
- $48.4M in user fuel savings
- Total $227M saved, b/c of 6.2
- Intangible benefits

Ye, Z., ..., Shi, X. *Transportation Research Record*, 2014, in press.
## Multi-criteria Collaborative Decision Making

<table>
<thead>
<tr>
<th>Normalized Data</th>
<th>Cost per Lane Mile</th>
<th>Average Performance</th>
<th>Infrastructure /Vehicle Impacts</th>
<th>Environmental Impacts</th>
<th>Composite Index</th>
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<td></td>
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<td>Pocatello Brine</td>
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<tr>
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<td>2</td>
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1c. Impacts of Salt & Other Deicers
1d. Impacts of Salt & Other Deicers (cont’d)

Sustainability = economic growth + social progress + ecological balance

2. Reducing **Sand Usage & Managing Traction Materials**

- *More materials, lower LOS*
- Pre-wetting
  - *Liquid product*
  - *Hot water*
- Heating sand
- Using other materials
- Reduce bounce/scatter
- Apply in appropriate locations
  - *Low speed roads, hills, curves, intersections*
Pre-Wetting Solid Material

• Adding liquid to products or abrasives at stockpile or at the spreader

• Benefits
  o Eases product management and distribution
  o Accelerates breakup of snow/ice and enhances melting
  o Minimizes bounce and scatter, improves performance
  o Increases longevity on road = less frequent applications
3. Strategic Planning for Reduced Salt Usage
3a. Salt Management Plans

- A statement of policies & objectives
  - Identifies: road use, salt vulnerable areas, storage sites, snow disposal sites, training, ...
- Documentation
- Proposed approaches
- Training & Management Review
3b. Iowa DOT Salt Model

- Allocates salt to garages based on weather conditions & policy usage requirements.
- Creates a salt budget for each garage

### Garage Salt Use Summary

<table>
<thead>
<tr>
<th>CC</th>
<th>Garage</th>
<th>Allocation (Tons)</th>
<th>Salt Used (Tons)</th>
<th>Salt Target (Tons)</th>
<th>% Target Used</th>
<th>% Allocation Used</th>
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</table>
3c. Salt Matrix & Pre-set Spreader Application Rates

- **Goal**: Reduce application rates while maintaining same LOS
- **Considers**: pavement temp., heating/cooling trends, road condition at time of service, available maintenance strategies
- **Provides**: recommended application rates for liquid and solid for initial & subsequent treatments on reference sheets
  - 4 storm scenarios (light, moderate, & heavy snow, freezing rain)
  - Drivers use their judgment to make decisions
Performance Measures

– Mobility, accessibility, reliability, safety
– Example: *time to bare lane*
– Measured as: return to speed, friction, visual inspection, etc.
Operational Strategies

Toolbox approach

- Local needs
- Rd weather scenarios
- Local constraints

Proactive vs. Reactive

- Anti-icing
- Deicing (pre-wet salt, DLA, ...)
- Sanding (pre-wet sand)
- Mechanical (plowing/blowing)
“…prevent the formation or development of bonded snow & ice by timely applications of a chemical freezing-point depressant” (vs. DLA)

- ↑LOS, ↓product, abrasives & plowing
- 20 – 65 gal/l-m
- Cost savings +↑mobility & safety
- reducing impacts to the environment, infrastructure, vehicles

- Limitations:
  - Cold temps, rain/sleet, blowing snow, air temp above freezing & rising, high humidity
Real-time road condition information

- Used to time treatments & determine which treatments to use

- Benefits:
  - LOS
  - Cost savings
  - Aid in maintenance response
  - Efficiency

- Benefit/cost ratio: 1.4 to 11
4c. Pavement Sensors & Thermal Mapping

- Monitoring, planning, treatment strategies, forecasting
- Invasive and non-invasive
• Monitoring, planning, treatment strategy, prevent over-application

• *Colorado DOT*
  – Non-contract friction measurements
  – Provide good short/long-term assessment of product performance
Mobile RWIS Technologies

Integrated with AVL to provide improved real-time knowledge of road & environmental conditions throughout a network

- Surface temperature measurement devices
- On-board freezing point & ice presence detection sensors
- Salinity sensors

4e. Residual Chemical Measurement

*Salinity sensors have been used to make educated decisions about reapplication (Ye et al., 2012).*

- Monitor road surface product concentration
- On-vehicle, embedded, or non-contact
- Accurate/recalibrated application rates
- Link measurements with automatic spreader controls
- Benefits:
  - Prevents over-application, saves material & $$$
4f. Road Weather Management Decision Support

Tools that integrate road weather forecasts, coded maintenance rules of practice, resource data to provide recommended treatment strategies (FHWA 2011)

– Cost & material savings, benefit/cost: 1.33 to 8.67, less use of vehicles
– Lessons learned: time needed to refine forecast & get management on board, continued training & exposure
4g. MDSS
4h. Improved Weather Forecasts


Improved Weather Forecasts

Estimates of Labor and Materials Cost based on Level of Usage of UDOT Weather Operations Program

- **Worst Weather Info**
  - High Cost: $20
  - Low Cost: $30

- **Without UDOT Program**
  - High Cost: $15
  - Low Cost: $25

- **Actual**
  - High Cost: $10
  - Low Cost: $15

- **Full Use of Weather Program**
  - High Cost: $7
  - Low Cost: $10
• W.M. costs decrease as the use of weather information increases (Ye et al., 2009)

• Accurate and timely forecasts have been shown to save 11–25% (labor) and 4-10% (material), but using a bad forecast can cost you (Shi et al., 2007)

• Improved spatial resolution will provide greater expected benefits to service levels (Fu et al., 2009)
4i. **Drift Control & Snow Fences**

- Reduce blowing & drifting snow
- Low cost snow storage
- Increased safety
- Reduce need for ice control product
- 25 yr lifespan at $1.40 per ft²

Wildlife habitat, control erosion, improve water quality, reduce spring-time flooding, sequester carbon

≥8 ft
5. Precision Application to Manage & Reduce Chemical Applications

• Benefits
  – Improved material placement
  – Return on investment
  – Reduced chemical usage
  – Improved environmental stewardship

• Costs
  – Equipment
  – Training
  – Calibration
5a. Material Distribution Systems

- Tailgate Spreaders & Reverse dumping
- Multipurpose spreaders
- Rear Discharge Spreaders
- Zero velocity spreaders
- Dual spinners
- Spinner
- Modified spinners
- Homemade chutes

Challenges
- Mechanical failure
- Clogging & freezing
- Corrosion
- Frequent calibration
Case Study: Slurry Technology

• High volume liquid anti-icer to dry salt (30%:70%) ~ 60-90 gal/ton
• 200 lb/l-m = ~ 9 gal
• Oatmeal consistency, salt grains fully saturated
• Slurry auger & at spinner
Slurry Technology

• Lesson Learned
  – ¾ in salt allowed but smaller grains work better
  – Start with a heavier application, followed by smaller
  – Some equipment has worked better than others
    • Pumps, on board crushers, overall equipment design/functionality
• Material & cost savings (Maine DOT 2005)
• Anecdotal comments:
  – Goes into action quicker, acts immediately, lasts longer on road, out-perform traditional pre-wetting methods, minimizes bounce & scatter
5b. FAST Systems

- Reduced mobile operations
- Reduced crash frequency & delay
- Less material required

- Challenges
  - Activation frequency
  - System maintenance & training

- Appropriate only at a highly localized level, as a supplement to mobile operations

- Installation should be site specific

SAFETY ANALYSIS OF FAST

• FAST systems contributed to crash reductions of:
  o 2% on multilane rural highways
  o 16 – 70% on urban interstates
  o 31 – 57% on rural interstates
  o 19 – 40% on interchange ramps
  o Unclear for rural two-lane roads

• Changes to crash rates by severity provided safety benefits of $196,428 per winter
5c. Calibration

• Is a must
• Train how to calibrate & keep records
• **When to calibrate:**
  – when first acquired
  – points throughout a season
  – whenever a new material is used
  – after repairs
  – if there appears to be discrepancy in material usage
6. Monitoring & Keeping Records

• Determine your baseline
• Use collected data to find trends
• Consider tracking:
  – Total length of road
  – Winter severity rating
  – Number of events
  – Material used
  – Calibration dates
  – Treatment effectiveness
7. WM Facility Management

7a. Material Storage

• All products should be stored in a manner to minimize any loss of product
7b. Management of Snow Disposal Sites

The most effective way to dispose of snow is to let it melt where it accumulates.

- If moving snow to a melting location:
  - Minimize impacts (dust, litter, etc.)
  - Manage meltwater to comply with local water quality regulations
  - Routinely monitoring of site capacity, soil & water
8. Training for Salt Management & WM Operations

• Assess the needs of your staff
• Consider who is being trained & how to best convey that info
• Design training based on learning goals
• Training methods:
  – Classroom, field, post-storm debriefing, simulator, etc.
8a. Training Continued...

• Have experienced staff conduct the training
• Evaluate your training program
• Assess how much information was learned
• Common training methods:
  – Annual operator training, Snow University, Snow & Ice Rodeo, Computer Based Training (CBT)
9. Concluding Remarks

**WHAT:** deliver the right type & amount of materials in the right location at the right time

**WHY:**
- effectiveness & efficiency of winter operations
- material usage, $$$, environmental footprint

**HOW to balance** **LOS** vs. **sustainability:** best practice *in technology & management domains*

A Look to the Future

- Technological & institutional barriers remain
- Micro-scale road Wx forecasting & sensing
- ‘dynamic layer’ on the road surface: timing & freq.
- More integrated & automated onboard sensors + *Vehicle Infrastructure Integration*
- Performance measures + systematic approach to decision making in materials selection
- *Ultimate integration into the WM toolbox*: continued investment & efforts in R&D + user-needs driven product strategies
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• AASHTO Standing Committee on Highways
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• Annette Dunn
• Monty Mills
• Michael Williams
• Brian Burn
Questions?

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A “Supermix” (85% salt brine, 10% De-ice, and 5% CaCl$_2$): anti-icing above 15°F @ 40 gln/ln-mi pre-wetting above 2°F @ 10 gln/ton