Chemical Impacts on Water and Vegetation


www.ci.bellevue.wa.us


Photo courtesy of M. Mills


www.miissoulanews.bigskypress.com

Laura Fay

PNS

June 5, 2018

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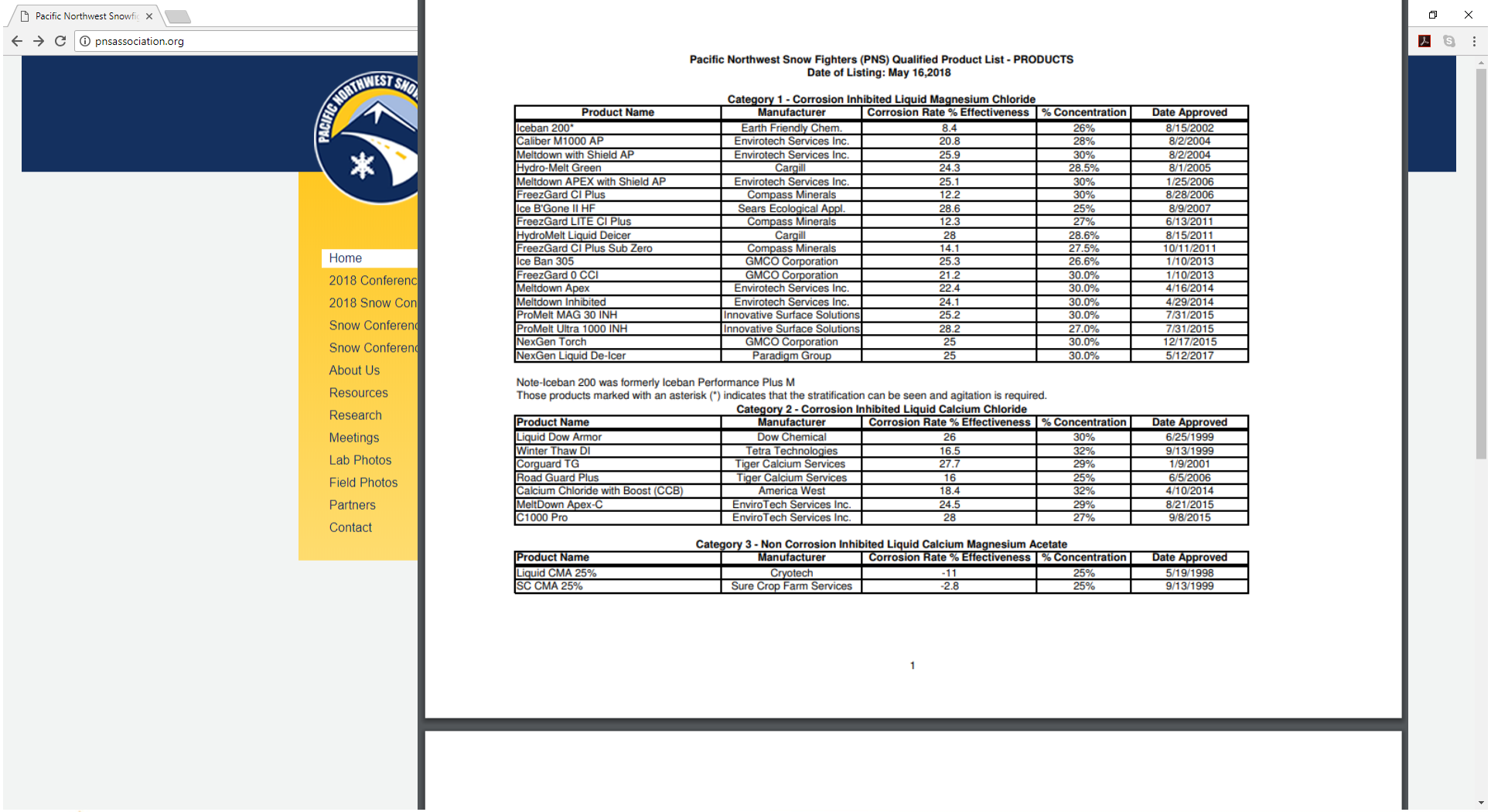
PNS QPL



Pacific Northwest Snow Fighters (PNS) Qualified Product List - PRODUCTS
Date of Listing: May 16,2018

Category 1 - Corrosion Inhibited Liquid Magnesium Chloride

Product Name	Manufacturer	Corrosion Rate % Effectiveness	% Concentration	Date Approved
Iceban 200*	Earth Friendly Chem.	8.4	26%	8/15/2002
Caliber M1000 AP	Envirotech Services Inc.	20.8	28%	8/2/2004
Meltdown with Shield AP	Envirotech Services Inc.	25.9	30%	8/2/2004
Hydro-Melt Green	Cargill	24.3	28.5%	8/1/2005
Meltdown APEX with Shield AP	Envirotech Services Inc.	25.1	30%	1/25/2006
FreezGard CI Plus	Compass Minerals	12.2	30%	8/28/2006
Ice B'Gone II HF	Sears Ecological Appl.	28.6	25%	8/9/2007
FreezGard LITE CI Plus	Compass Minerals	12.3	27%	6/13/2011
HydroMelt Liquid Deicer	Cargill	28	28.6%	8/15/2011
FreezGard CI Plus Sub Zero	Compass Minerals	14.1	27.5%	10/11/2011
Ice Ban 305	GMCO Corporation	25.3	26.6%	1/10/2013
FreezGard 0 CCI	GMCO Corporation	21.2	30.0%	1/10/2013
Meltdown Apex	Envirotech Services Inc.	22.4	30.0%	4/16/2014
Meltdown Inhibited	Envirotech Services Inc.	24.1	30.0%	4/29/2014
ProMelt MAG 30 INH	Innovative Surface Solutions	25.2	30.0%	7/31/2015
ProMelt Ultra 1000 INH	Innovative Surface Solutions	28.2	27.0%	7/31/2015
NexGen Torch	GMCO Corporation	25	30.0%	12/17/2015
NexGen Liquid De-Icer	Paradigm Group	25	30.0%	5/12/2017

Note-Iceban 200 was formerly Iceban Performance Plus M
Those products marked with an asterisk (*) indicates that the stratification can be seen and agitation is required.

Category 2 - Corrosion Inhibited Liquid Calcium Chloride

Product Name	Manufacturer	Corrosion Rate % Effectiveness	% Concentration	Date Approved
Liquid Dow Armor	Dow Chemical	26	30%	6/25/1999
Winter Thaw DI	Tetra Technologies	16.5	32%	9/13/1999
Corguard TG	Tiger Calcium Services	27.7	29%	1/9/2001
Road Guard Plus	Tiger Calcium Services	16	25%	6/5/2006
Calcium Chloride with Boost (CCB)	America West	18.4	32%	4/10/2014
MeltDown Apex-C	EnviroTech Services Inc.	24.5	29%	8/21/2015
C1000 Pro	EnviroTech Services Inc.	28	27%	9/8/2015

Category 3 - Non Corrosion Inhibited Liquid Calcium Magnesium Acetate

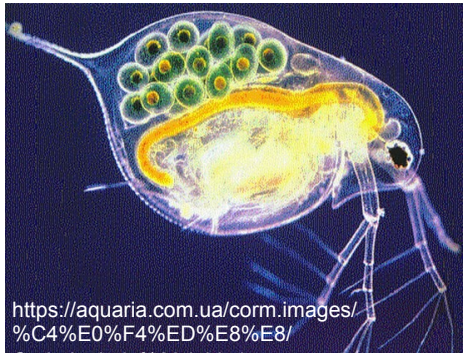
Product Name	Manufacturer	Corrosion Rate % Effectiveness	% Concentration	Date Approved
Liquid CMA 25%	Cryotech	-11	25%	5/19/1998
SC CMA 25%	Sure Crop Farm Services	-2.8	25%	9/13/1999

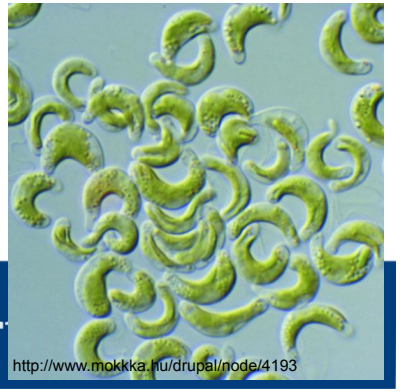
1

What does it take to be on PNS QPL?

https://www.gettyimages.com/detail/photo/underwater-rainbow-trout-oncorhynchus-mykiss-royalty-free-image/157420493


http://wildlife.ohiodnr.gov/species-and-habitats/species-guide-index/fish/fathead-minnow


https://aquaria.com.ua/corm.images/%C4%E0%F4%ED%E8%E8/


http://www.mokkka.hu/drupal/node/4193

- Elemental Analysis

Arsenic	5.0
Barium	100.0
Cadmium	0.20
Chromium	1.0
Copper	1.0
Lead	1.0
Mercury	0.05
Selenium	5.0
Zinc	10.00
Phosphorus	2500.
Cyanide	0.20

- Other Testing Required

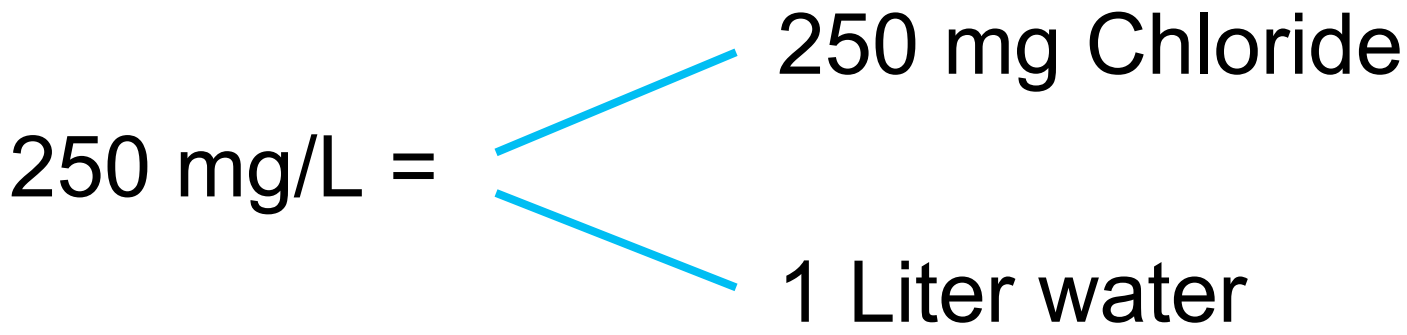
Ammonia - Nitrogen
Total Kjeldahl Nitrogen
Nitrate and Nitrite - Nitrogen
Biological Oxygen Demand
Chemical Oxygen Demand
Frictional Analysis
Toxicity Testing
    Rainbow Trout or Fathead Minnow Toxicity Test
    Ceriodaphnia Dubia Reproductive and Survival Bioassay
    Selenastrum Capricornutum Algal Growth

Where do these numbers come from?

- Your State
- The Environmental Protection Agency (EPA)
  - https://www.epa.gov/wqc/national-recommended-water-quality-criteria-aquatic-life-criteria-table
  - https://www.epa.gov/wqc/national-recommended-water-quality-criteria-human-health-criteria-table

Let's talk salt

- EPA water quality standard (*secondary drinking water standard)



*Maximum contaminant level, causes undesirable taste or odor, undesirable effects to the body, damage to equipment….

This is what 250 mg/L of salt looks like!

2500 mg NaCl

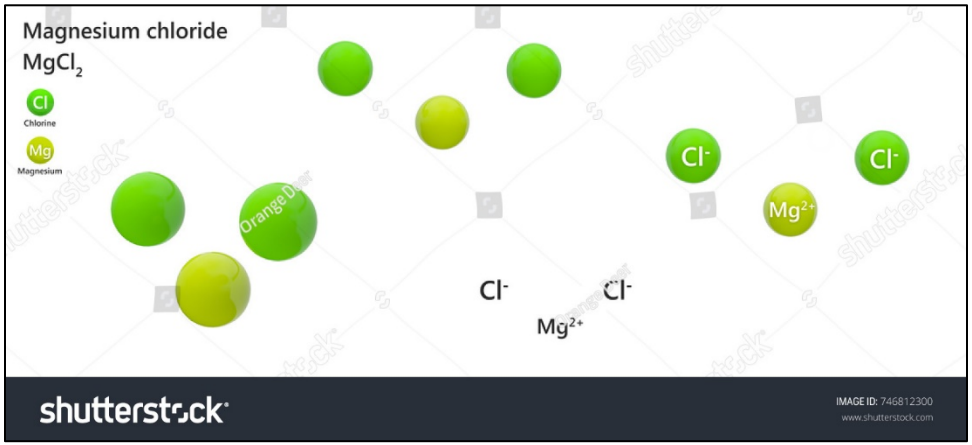
https://pespropt.wordpress.com/2014/10/13/dietary-guideline-10-restrict-salt-intake-to-minimum/

A little chemistry

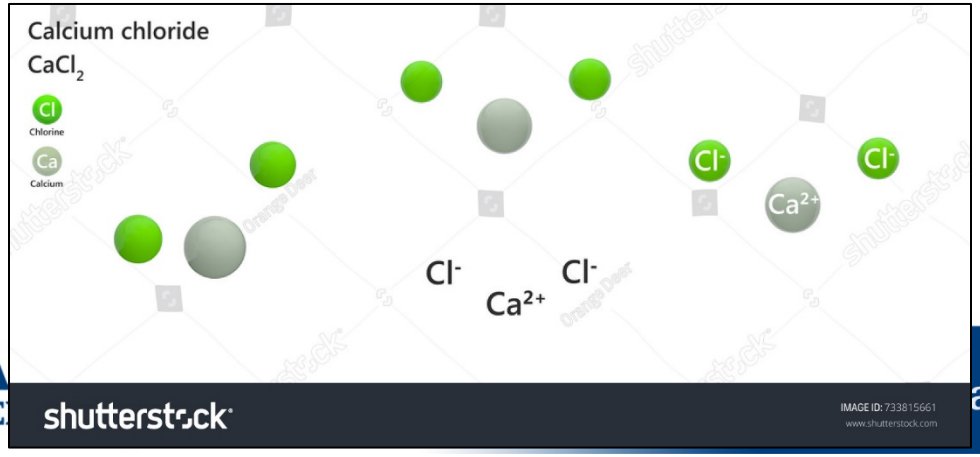
NaCl

[100 g of NaCl = 39.34 g Na + 60.66 g Cl.]

$MgCl_2$



$CaCl_2$



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What does this have to do with winter maintenance?

- Chloride (drinking water standard):
  - 250 mg/L
- Chloride (aquatic life standards):
  - 230 mg/L Chronic (longer term exposure)
  - 860 mg/L Acute (1 time exposure)

Product Application Rates

- **Sand** – 100 to 1000 lbs/l-m (32°F and colder)
- **Salt/sand** – 400 to 1000 lbs/l-m (32 to 0°F)
- **NaCl** (32 to 15°F)
  - Solid – 100 to 800 lbs/l-m
  - Liquid – 10 to 40 gal/l-m
  - Pre-wet – 8 to 20 gal/l-m
- **$MgCl_2$** (32 to -5°F) and **$CaCl_2$** (32 to -15°F)
  - Solid – 100 to 500 lbs/l-m
  - Liquid – 10 to 40 gal/l-m
  - Pre-wet – 8 to 20 gal/l-m
- **Ag-based by products** – typically an additive

Let's play a game

Pounds (lbs)	Milligrams (mg)	%*
• 50	• 22,680,000	0.002
• 100	• 45,360,000	0.0009
• 250	• 113,400,000	0.0004
• 500	• 226,800,000	0.0002
• 1000	• 453,600,000	0.00009

*Percent needed from application to reach the 250 mg/L water quality standard for chloride.

Chloride numbers from the field

- USGS (Corsi et al., 2014)
  - 29% of the sites exceeded the EPA (230 mg/L)
    - by an average of more than 100 days per year from 2006 - 2011, almost double the amount of days from 1990 -1994.
  - The lowest chloride concentrations were in watersheds that had little urban land use or cities without much snowfall.

https://www.usgs.gov/news/urban-stream-contamination-increasing-rapidly-due-road-salt

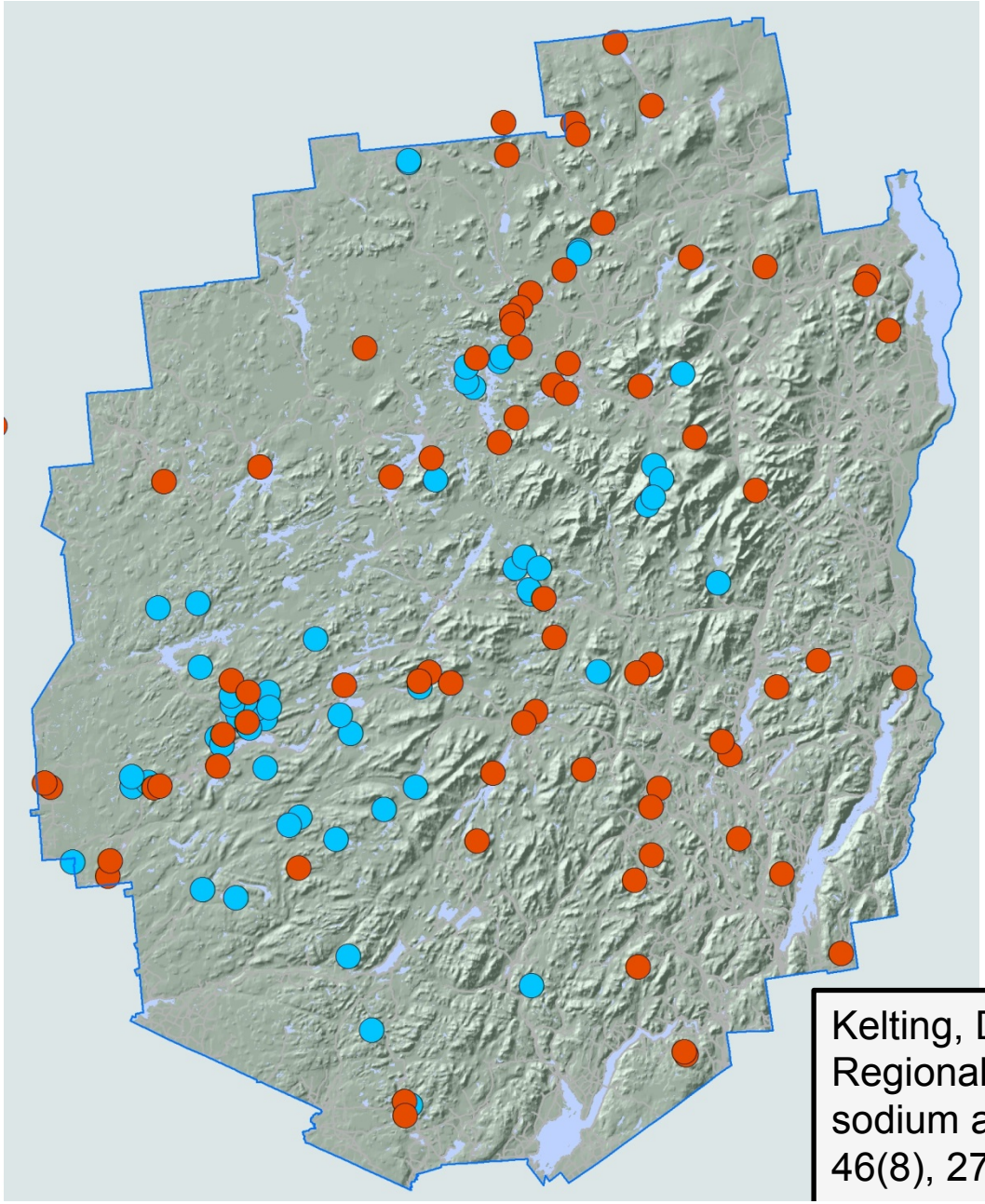
USGS (Corsi et al., 2014)

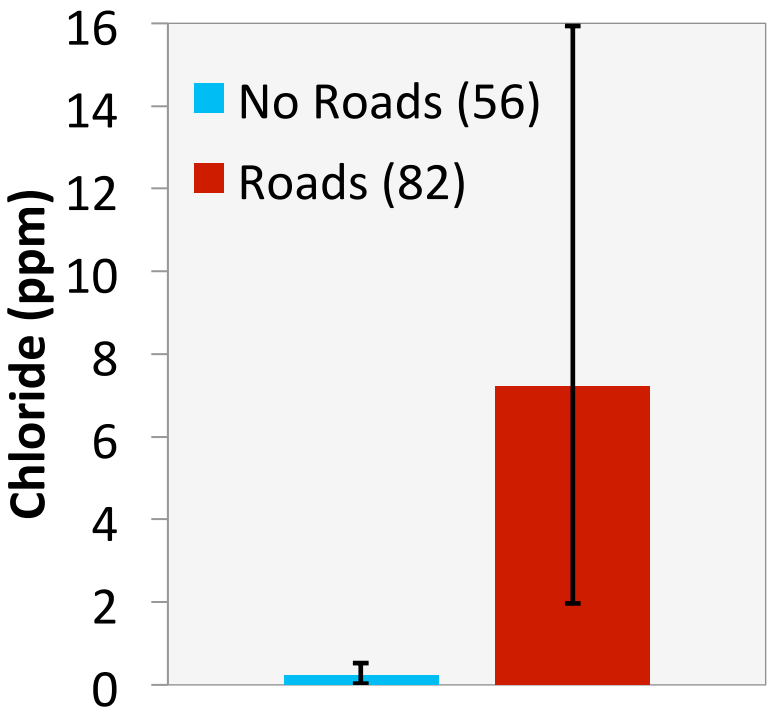
- In 16 of the streams, winter chloride concentrations increased over the study period.
- In 13 of the streams, chloride concentrations increased over the study period during non-deicing periods such as summer.
  - chloride infiltrating the groundwater system during the winter, then slowly released to the streams throughout the year.

USGS (Corsi et al., 2014)

- Chloride levels increased more rapidly than development of urban land near the study sites.
- The rapid chloride increases were likely caused by **increased salt application rates**, increased baseline conditions (the concentrations during summer low-flow periods) and greater snowfall in the Midwest during the latter part of the study.

Median Lake Chloride





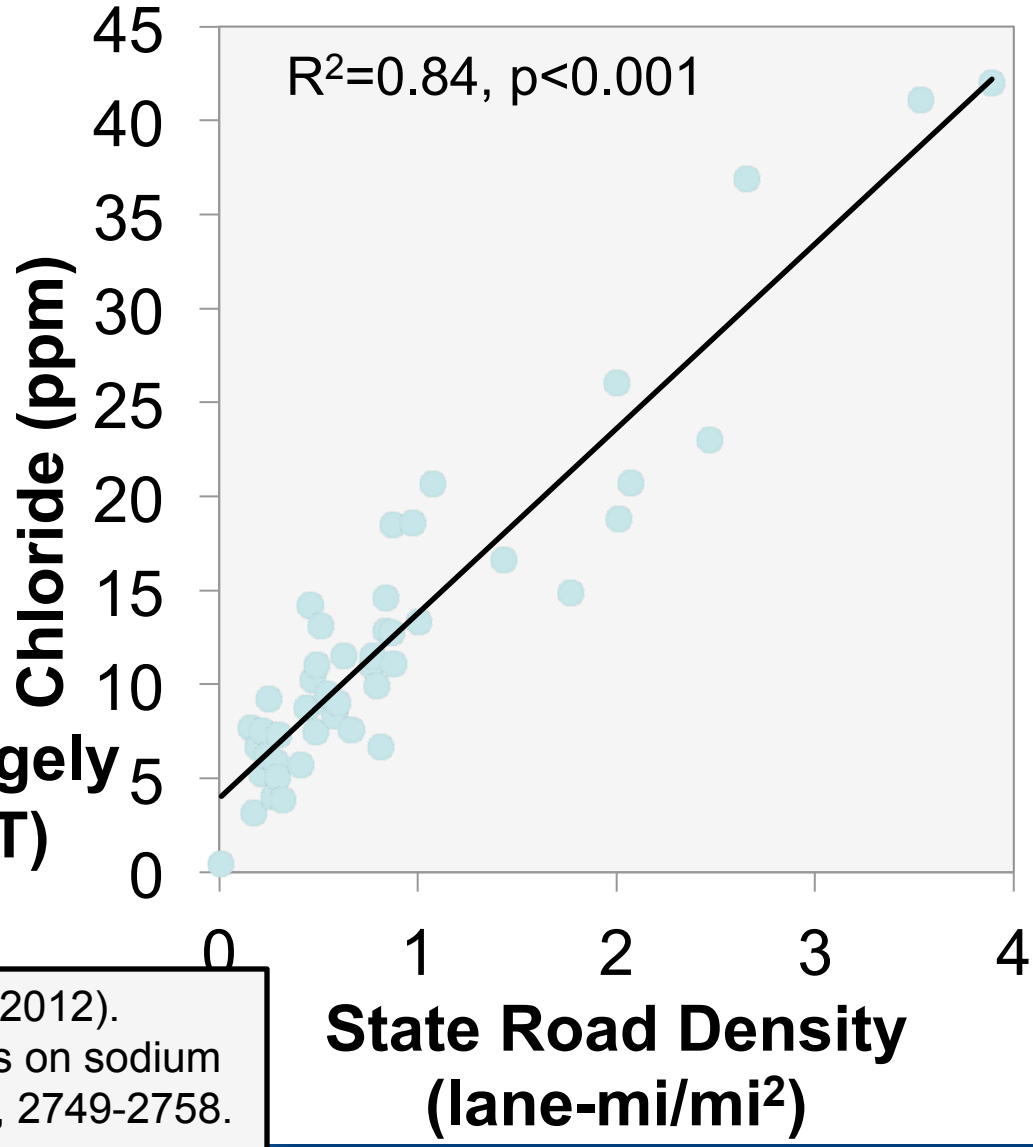
- <0.5ppm w/no roads
- 14X higher w/**roads**

Regional Salinization

Kelting, D. L., Laxson, C. L., & Yerger, E. C. (2012). Regional analysis of the effect of paved roads on sodium and chloride in lakes. *Water Research*, 46(8), 2749-2758.

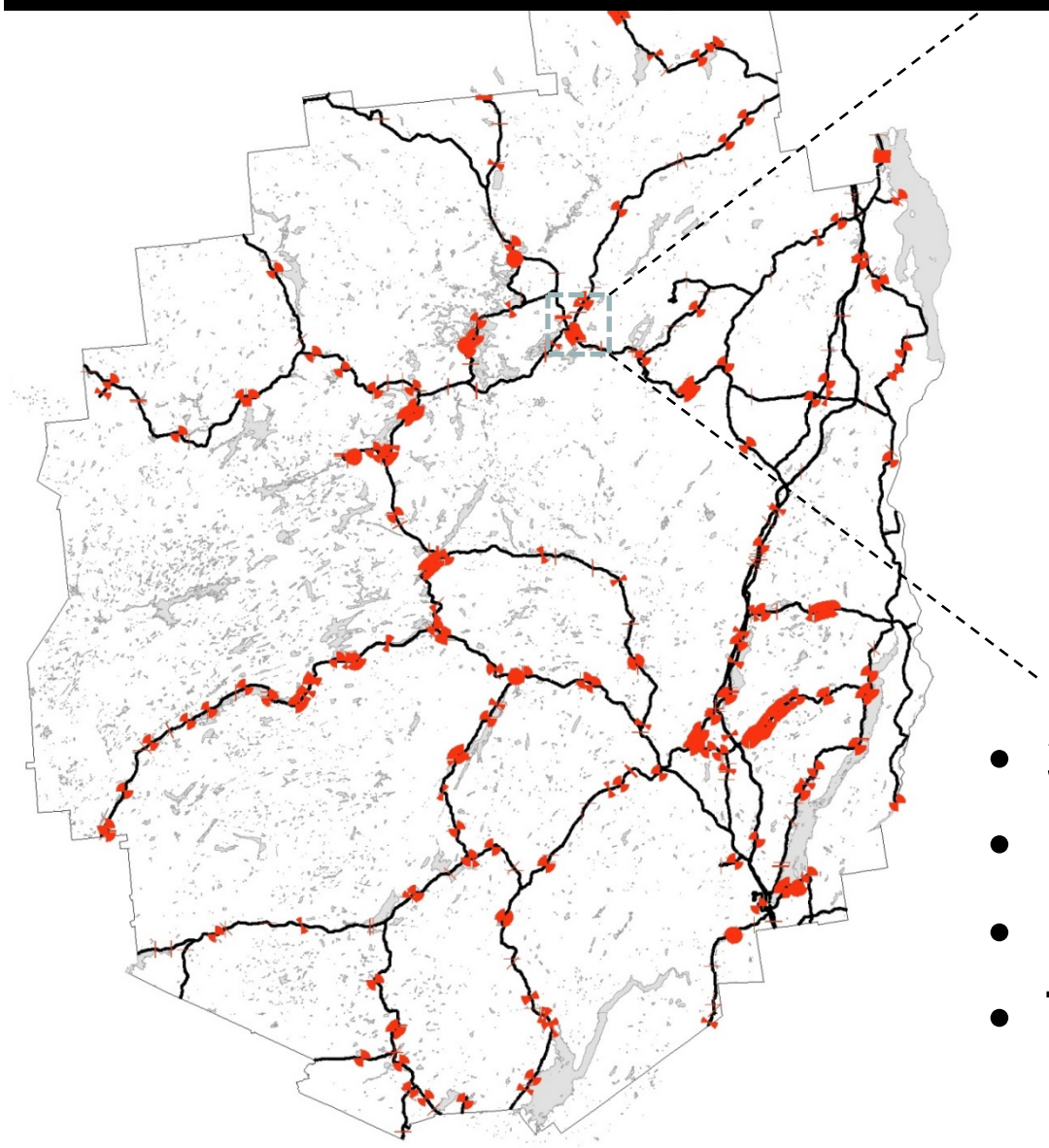
Lake Chloride and State Road Density

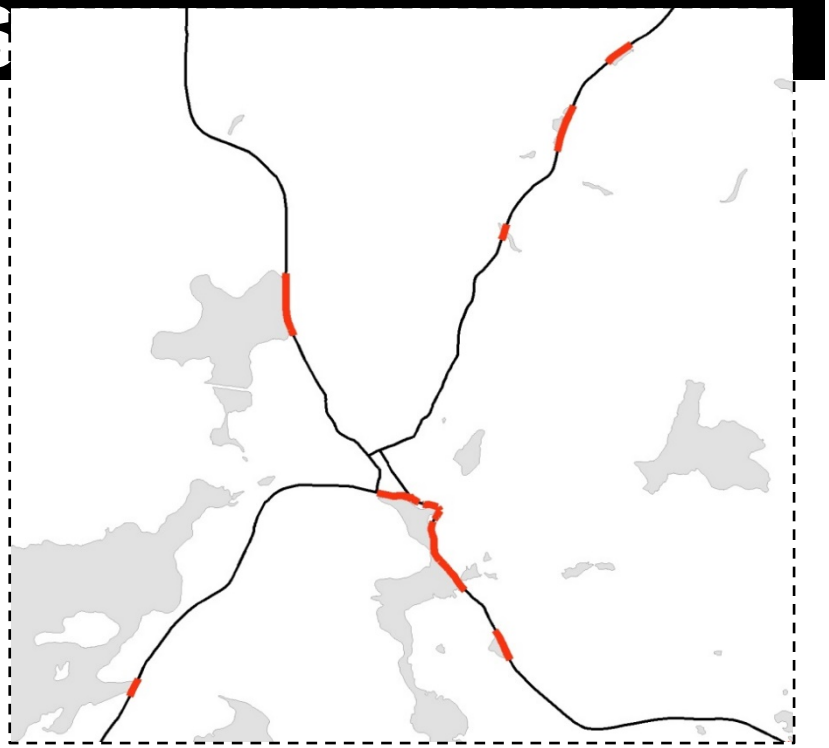
- State road density explained 84% of the variation in Cl
- Higher state road density equals higher salt load
- No relationship between local road density and Cl
- **Regional salinization is largely from state roads (NYS DOT)**



Kelting, D. L., Laxson, C. L., & Yerger, E. C. (2012). Regional analysis of the effect of paved roads on sodium and chloride in lakes. *Water Research*, 46(8), 2749-2758.

Reduce/Eliminate Salt Use in CSAs





- 362 road segments
- Minimum = 70 feet
- Maximum = 4.7 lane-miles
- Total = 141 lane-miles
  (5% of total)

The outcomes

- Identified No Salt Zones

Stuart Findlay and Vicky Kelly (Cary Institute, 2018)

- Background < 10 mg/L
- Environmental effects (sub lethal) ~ 100 mg/L
- Lethal > 1000 mg/L

- EPA Drinking Water Std. 250 mg/L
- EPA chronic 230 mg/L
- EPA acute 860 mg/L

Stuart Findlay and Vicky Kelly (Cary Institute, 2018)

- Surface water [Cl-] = 10 – 300 mg/L
  - Dutchess County, New York

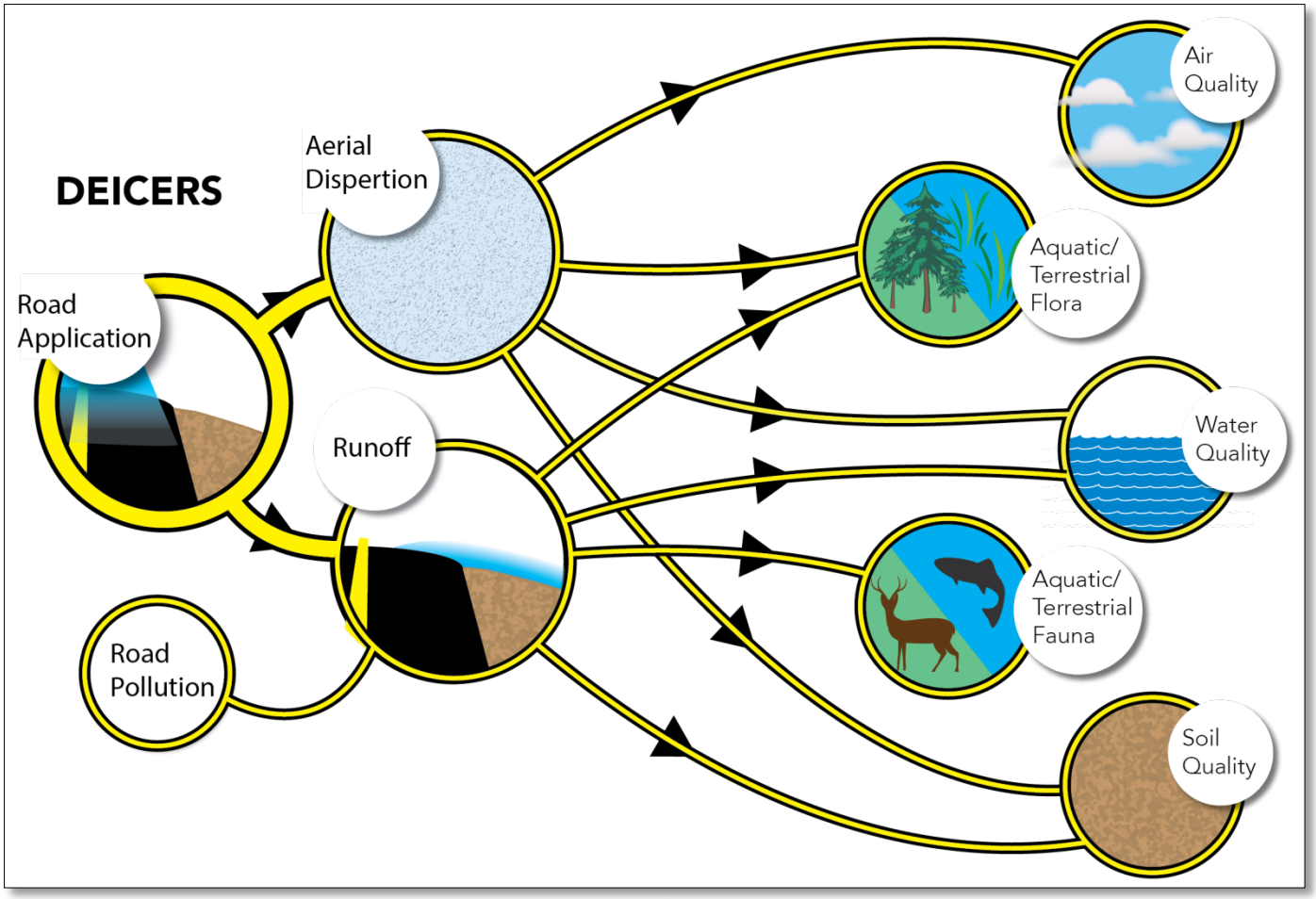
- Sources of chloride
  - 80% from deicing (DOT, local, private)
  - 5-10% from water softeners

Stuart Findlay and Vicky Kelly (Cary Institute, 2018)

- They found the UNEXPECTED
  - Think slow, glacial..

1. Long term increases in concentration
2. High [Cl-] in summer
3. Higher [Cl-] downstream in summer

Pathways of Deicer Migration off the Roadway



Impacts of Salt and Chloride Based Deicers


www.witnerservices.net


www.modot.org


Photo courtesy of M. Mills


www.miissoulanews.bigskypress.co


www.clf.org


www.syracuse.com


www.ci.bellevue.wa.us

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The science shows…

- Deicers can cause…
  - Mobilizations of heavy metals
  - Impacts to or death of aquatic & terrestrial species
  - Loss of native species => increase in invasive species (aquatic & terrestrial)
  - Wildlife-vehicle collisions

Reducing Wildlife Vehicle Collisions with Odor Repellents

- Wildlife Vehicle Collisions can be reduced by **26 – 43%**.
  - Results are up to 3 times lower than claims made by the product producers.
  - Less expensive than fencing.
  - Results dependent on type of odor used and species.

Bil, et al. An evaluation of odor repellent effectiveness in prevention of wildlife vehicle collisions. Journal of Environmental Management, 205 (2018) 209-214.

Impacts of Sand and Abrasives

BOD
(Biological/Biochemical Oxygen Demand)

- "The amount of dissolved oxygen needed by aerobic biological organisms to break down material in water at a specific temperature or a specific time."

https://en.wikipedia.org/wiki/Biochemical_oxygen_demand

BOD Level in mg/liter	Water Quality
1 - 2	**Very Good:** There will not be much organic matter present in the water supply.
3 - 5	**Fair:** Moderately Clean
6 - 9	**Poor:** Somewhat Polluted - Usually indicates that organic matter present and microorganisms are decomposing that waste.
100 or more	**Very Poor:** Very Polluted - Contains organic matter.

https://www.pharmaguideline.com/2013/06/determination-of-biological-oxygen.html

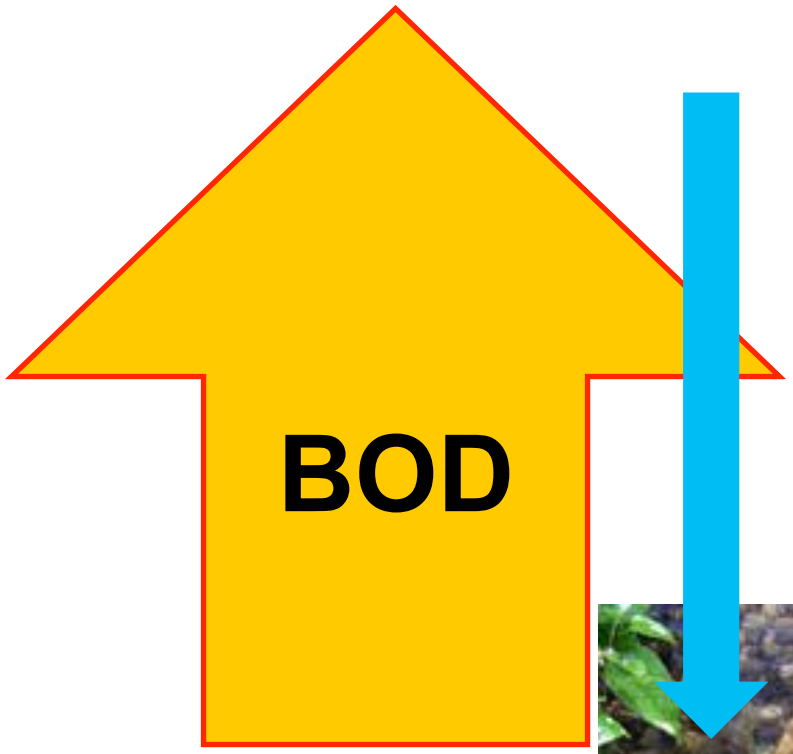
Ag-based, Acetate, Formates & Glycols

Benefits

- Break down in the environ.
- Less corrosive than chlorides

Not so good

- Higher costs
- Exert a higher BOD



Reduces available oxygen for organism in the soil and aquatic environments.

BOD data

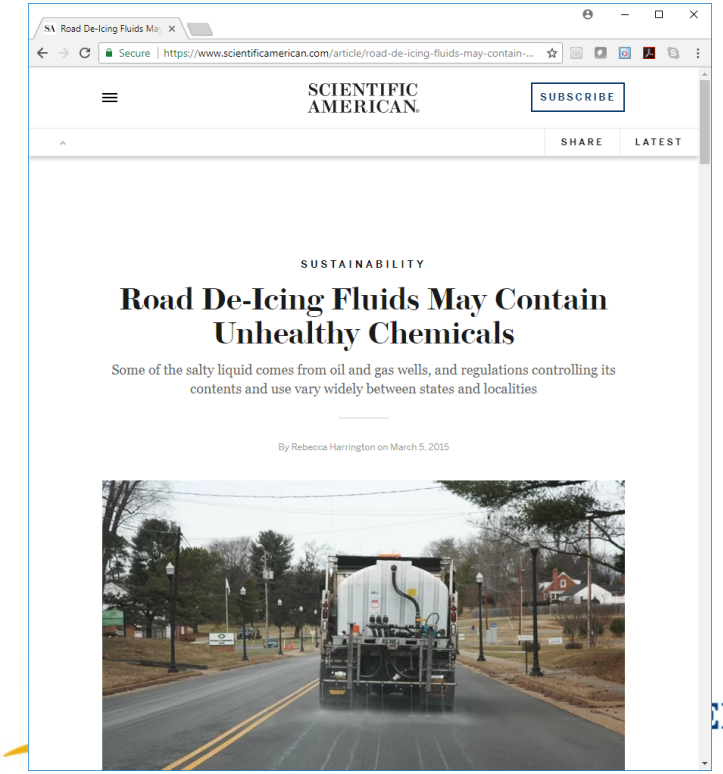
Table 1. Biological oxygen demand (BOD) imparted by deicers, reported by BioAmber.

Deicer	BOD (g O_2/g fluid)
Succinate Formula	0.15
Potassium Acetate	0.14[2]
Potassium Formate	0.12
Ethylene Glycol	1.0[2]

So what does this mean? How do I use this information?

Natural/Waste Brines

- Where is it from?
- Did they do toxicity testing?
- Show me the data!



Let's remove the chlorides with..

- Bioswales
  - Store chlorides
  - can serve as reservoirs,
  - can recharge shallow aquifers with chloride laden water.


https://bwengr.com/blog/bioswale-in-action-during-storm


https://www.soils.org/discover-soils/soils-in-the-city/green-infrastructure/important-terms/rain-gardens-bioswales


https://lacreekfreak.wordpress.com/tag/bioswales/

Water Treatment with Wetlands

- Salinization of wetlands ⇨ halophilic species to move in, non-native species.
- Halophilic plants can take up salts, but then when they die it ends up back in the aquatic systems unless you remove the plants.

https://www.davisenterprise.com/local-news/new-wastewater-treatment-plant-is-good-news-for-citys-wetlands/

http://constructed-wetlands.com/ecotechnologies-stormwater-treatment-wetlands.html

Porous and Permeable Pavements

- Applied solid material get trapped
- Liquid anti-icers flow down into the matrix
- Appear snowy longer, snow gets keyed into the matrix
- Provide higher friction = overall less deicer applied in black ice conditions

https:///geotechnology.com/porous-pavement/

https://weston.e9projects.com/porous-asphalt-pavements/

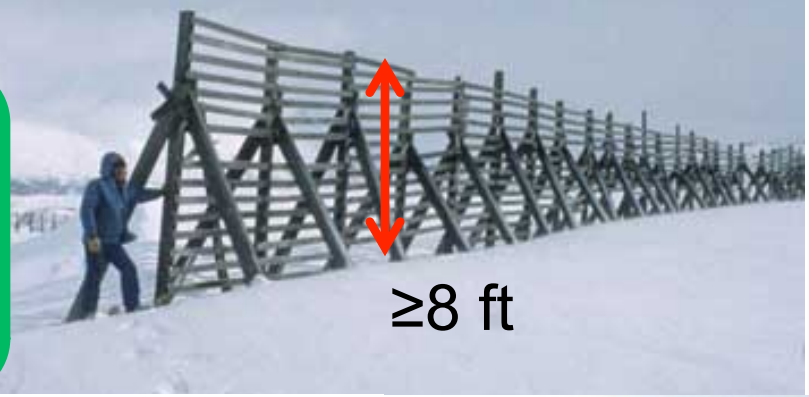
Removing Chlorides

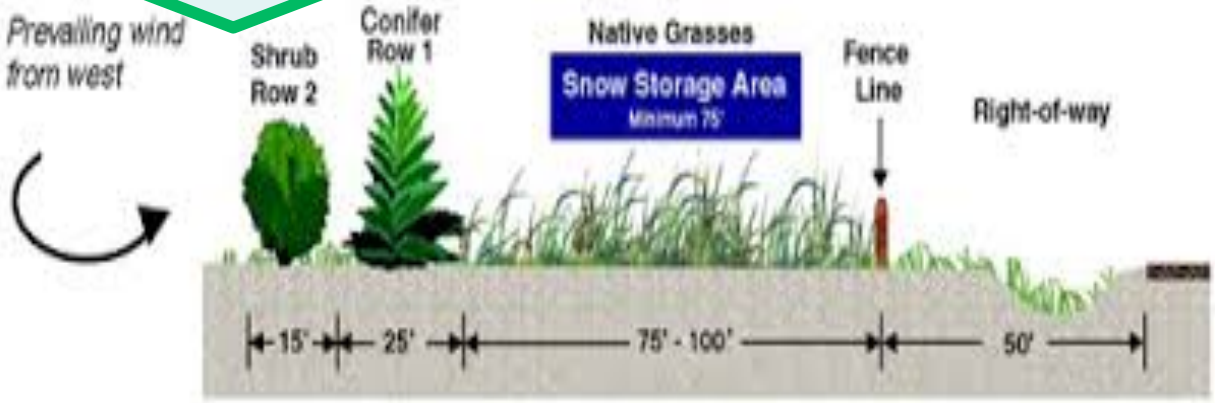
- Reverse osmosis
  - It works, but its expensive.
  - $1,500 → $18,000 → $30,000
    - cost increases as you scale up.

Drift Control and Snow Fences

- Reduce blowing and drifting snow
- Low cost snow storage
- Increased safety
- Reduce need for snow & ice control product
- 25 year lifespan at $1.40 per ft^2

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





Where does this leave us…

- BMPs
- Invent a better deicer
- Invent a different deicing system
  - heated pavement
  - ??

Necessity is the Mother of invention!
-Plato made of Play-doh

https://imgur.com/gallery/CN8we

Facility Management

- The design and operation of maintenance facilities can have a direct influence on potential contamination issues and loss of materials.
- “Good housekeeping” – clean, organized, and well maintained.

Facility Management – Material Storage

- Snow and ice control product storage facilities have the **greatest potential to impact the environment**, because they are a single source that can release high concentration runoff into the environment.

- Solids – Covered, impermeable surface.
- Liquids – Secondary containment, impermeable surface.

Equipment Calibration

- Is a must
- Why: to realize savings gained from investment in new technology
- 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

Equipment Calibration

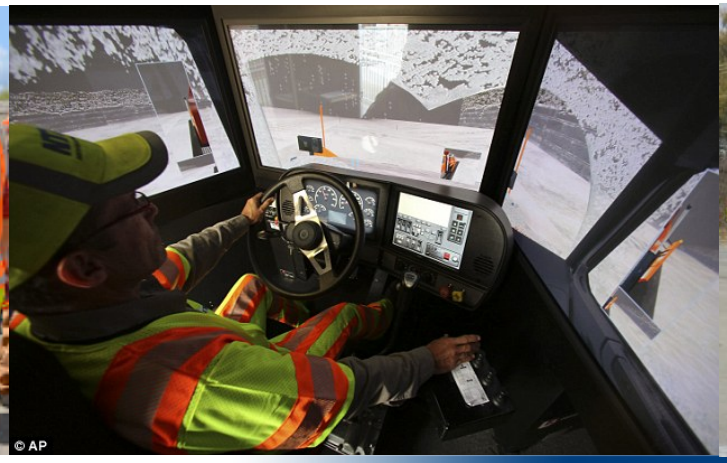
$avings of $75,000 from calibrating in the first year.

1. Ask the driver where they set the knob (500-1200lbs/l-m)
2. Recommend an application rate (e.g., 250 lbs/l-m), test use once calibrated.

Changing the culture of the operators.

Training

- The importance of training cannot be overstated as the success of any best practice (management system, strategy, technology, or product) hinges on the appropriate implementation by knowledgeable personnel.



Training……

- Assess the needs of your staff
- Consider who is being trained and how to best convey that information
- Design training based on learning goals
- Training methods:
  - Classroom, field, post-storm debriefing, simulator, etc.

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)

Training…..

- Benefits of improved or target training of winter maintenance personnel:
  - Reduction in the amount of snow and ice control products used while maintaining or increase LOS provided through:
    - Calibration training
    - Salt Smart Principles
    - Application rate
    - Impacts of over applications


(www.nps.gov)

Summary of Environmental BMPs for Snow and Ice Control

- Cover and store snow and ice control materials on an impermeable surface, secondary containment for liquids.
- Regulate the application of snow and ice control materials to prevent over application.
- Use specialized equipment to apply the right amount, in the right place, at the right time.

Summary of Environmental BMPs for Snow and Ice Control

- Use the appropriate snow and ice control materials for the given conditions.
- Calibrate equipment.
- Train operators in proper application, calibration, and cleaning procedures.
- “Good housekeeping” – clean, organized and well maintained.

Summary of Environmental BMPs for Snow and Ice Control

- Set Goals, Have performance expectations
- Implementing existing knowledge
- Project champions
- Culture change, operational change
  - Long term system wide approaches
  - Each success is a stepping stone,

Resources/References

EVALUATION OF ALTERNATIVE ANTI-ICING AND DEICING COMPOUNDS USING SODIUM CHLORIDE AND MAGNESIUM CHLORIDE AS BASELINE DEICERS (Report)

http://www.westerntransportationinstitute.org/documents/reports/4w1095_final_report.pdf

Manual of Environmental Best Practices for Snow and Ice Control (Manual and webinar)

http://clearroads.org/project/snow-and-ice-control-environmental-best-management-practices-manual/

Strategies to Mitigate the Impacts of Chloride Roadway Deicers on the Natural Environment (Report)

http://www.trb.org/Publications/Blurbs/169520.aspx

Manual of Best Management Practices for Roads Salt in Winter Maintenance (Manual and webinar)

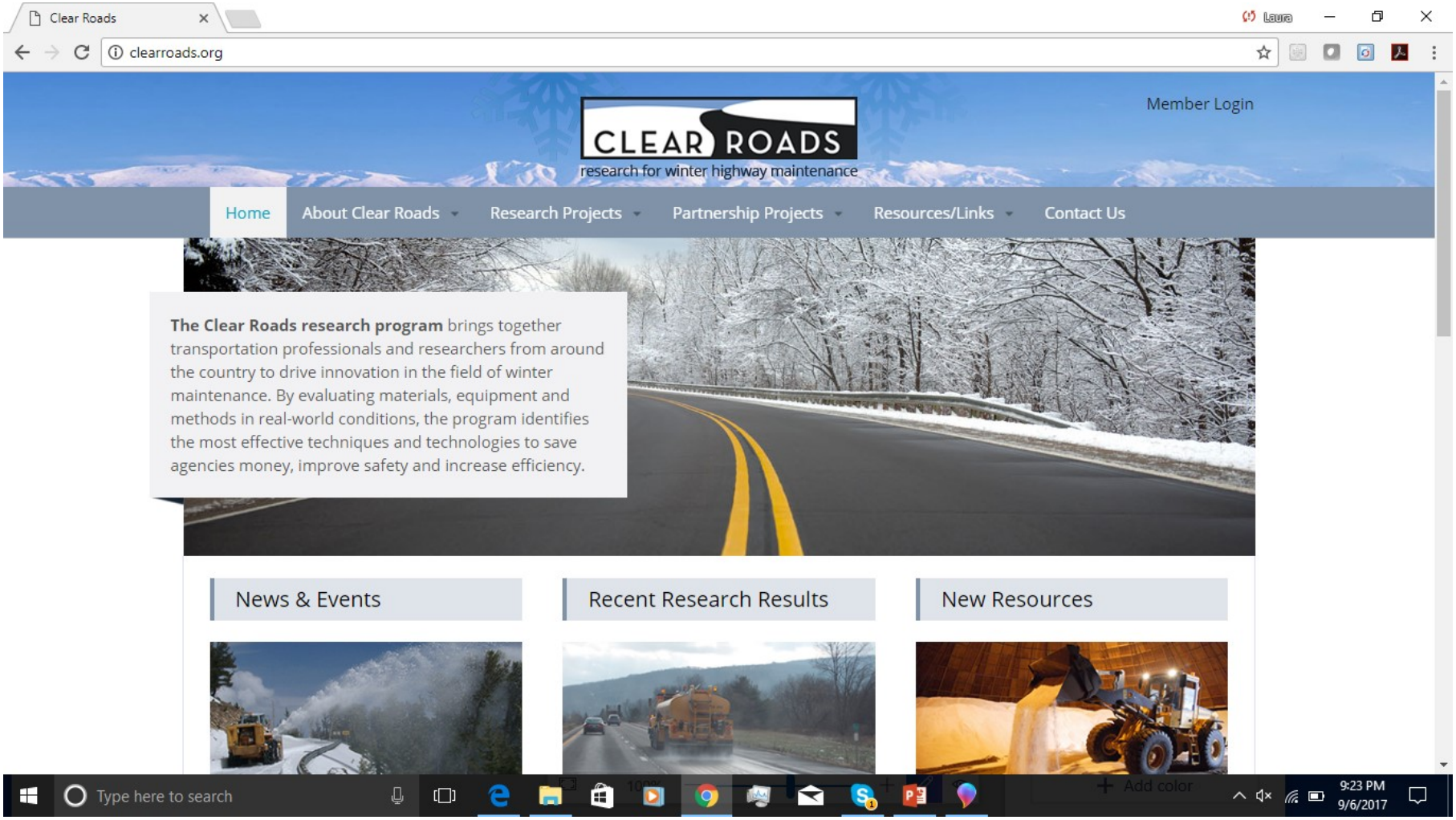
http://clearroads.org/wp-content/uploads/dlm_uploads/0537_2015-Clear-Roads-Best-Practice-Guide-WEB.pdf

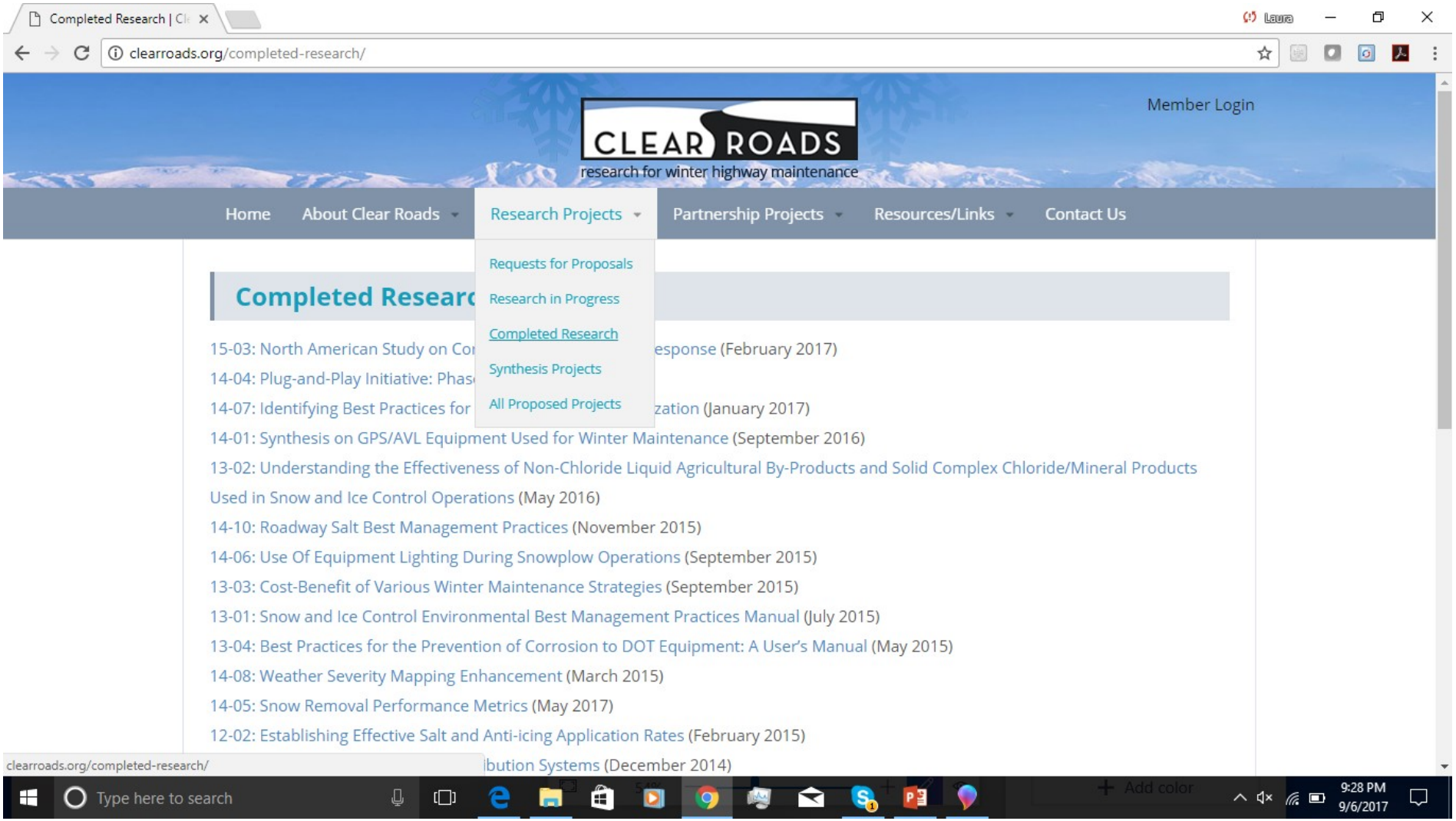
Understanding the Effectiveness of Non-Chloride Liquid Agricultural By-Products and Solid Complex Chloride/Mineral Products Used in Snow and Ice Control Operations

http://clearroads.org/project/13-02/

Resources/References

Resources/References





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Questions?

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2019 International Low Volume Roads Conference

- NW Montana – near Glacier National Park
- Meet, share with, and learn from your counterparts in foreign countries, across the country, and from federal and state land agencies on all things low volume roads (construction, maintenance, stabilization, safety, dust control, you name it, we'll have it!)

https://sites.google.com/site/trbcommitteeafb30/