ENGINEERING

Development of Smart Salt Truck Technology for Improved Road Safety and Protection of Salt Vulnerable Areas

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Ontario Smart Mobility Readiness Forum

Tuesday March 25th, 2025

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MUNICIPAL PARKING

Toronto Parking Authority

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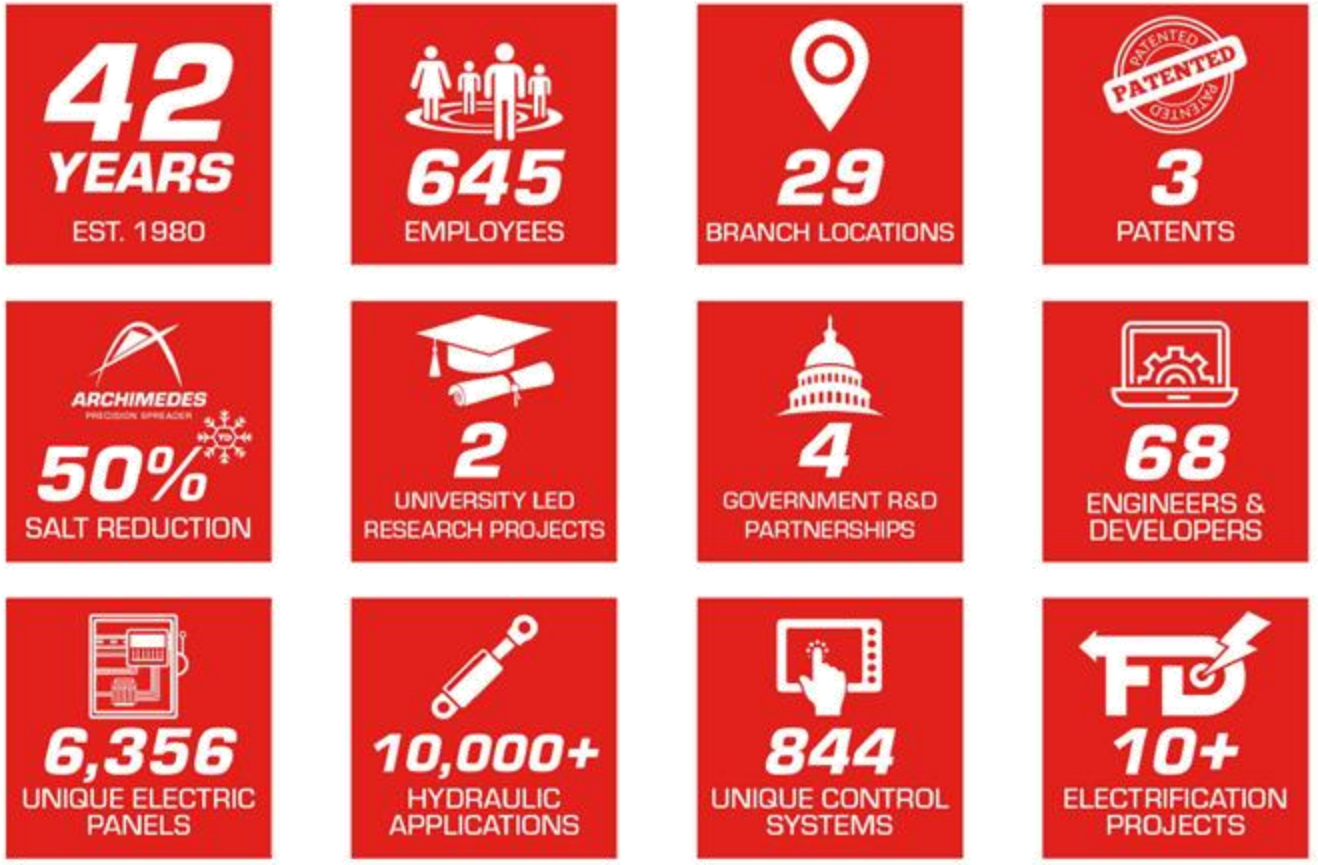
Introduction

The advancements in road surface monitoring sensors play an important role in implementation of real-time accurate mapping of road grip to issue warning using smart mobility technology, prioritize the deployment of the salt trucks, and optimize salt application rates based on the road surface conditions and road class.

FLODRAULIC Group



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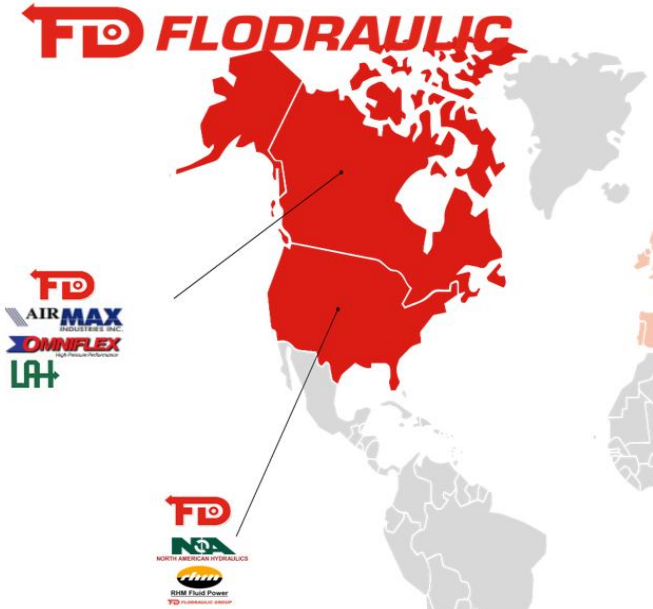

Our Mission is to become the leading system integrator in motion controls leveraging the knowledge and experience developed in 30+ years of applications in North America and Europe.

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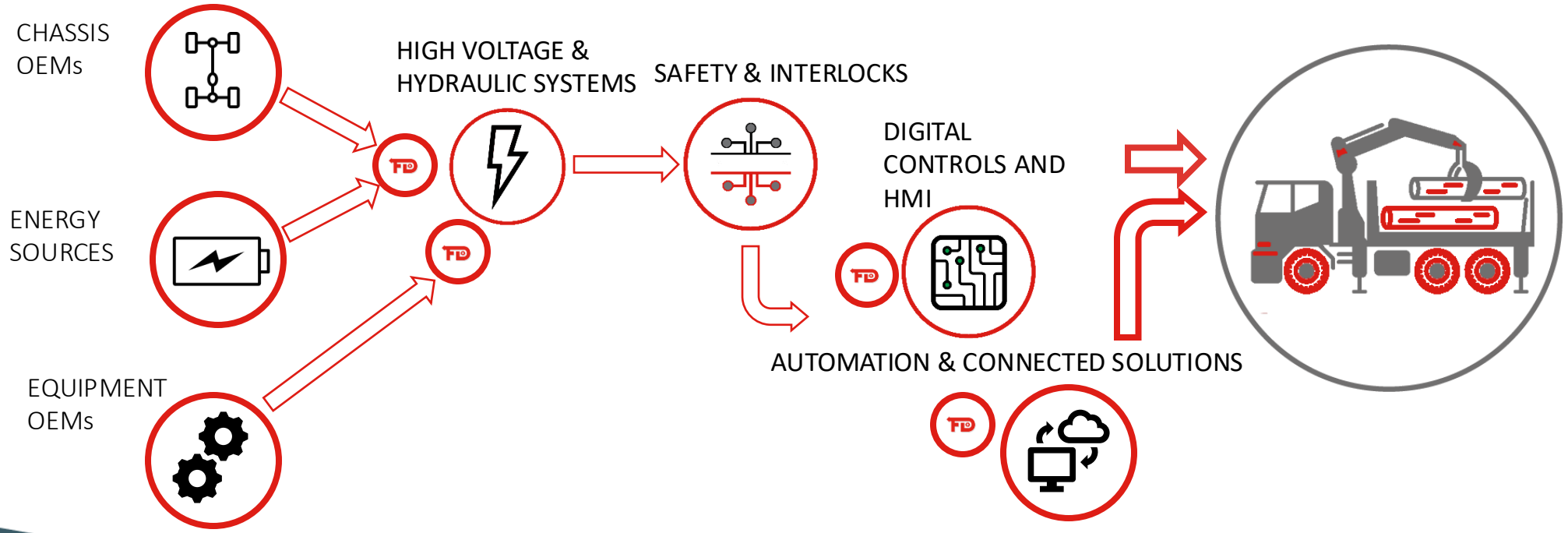
PARTNERS IN INTEGRATION

Flodraulic links Chassis and Equipment OEMs, Energy Sources, and Bodybuilder Equipment, with intelligent and efficient hydraulic and electrical control systems. Our experience as an Integrator and controls specialist make Flodraulic your ideal partner as you seek to develop electrified solutions.



STRATEGY & CORE SKILLS

FLODRAULIC will act as systems integrator, bringing together the solutions required to meet the diverse challenges of **ELECTRIFICATION**.

With a **STRONG POWER SOURCE PARTNER** we could adress most demanding application in different markets as well as semi-statonary or hybrid applications…

Coming from **ADVANCE HYDRAULICS**
Focus on **ELECTRIFICATION & HYBRID-SOLUTIONS**

FUNCTIONAL SAFETY

CONTROL SYSTEMS & HMI

HIGH VOLTAGE ELECTRIFICATION

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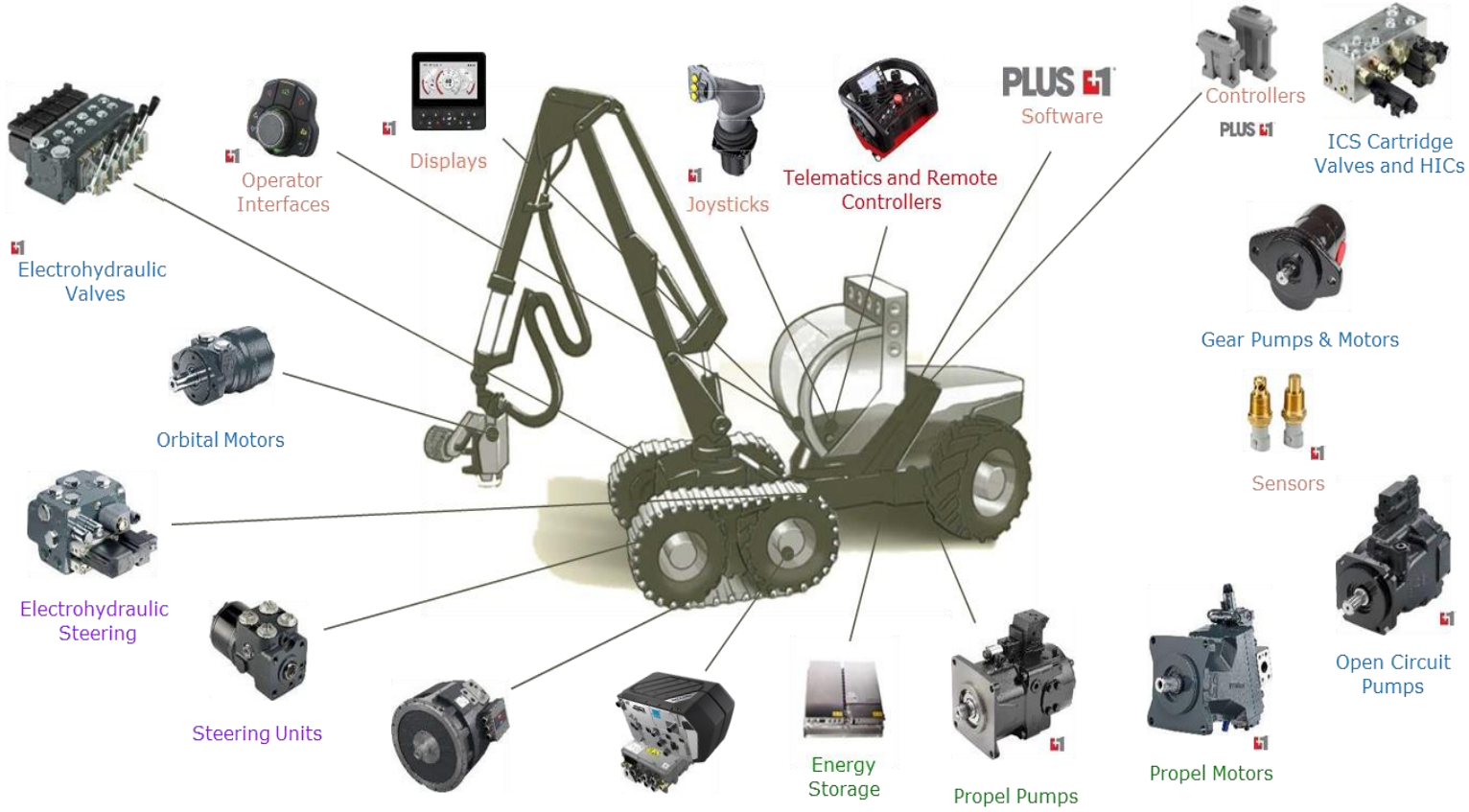
Digital Control Systems

CANbus

- Modern equipment is reliant on digital control systems for engine, chassis
- Digital control systems minimize complicated installation and preserve warranty
- Flodraulic has deep experience integrating ***bodybuilder equipment with the chassis***
- Our digital control solutions drive efficient operation
- Integrate with the customer's business through optional cloud connectivity, and software
- We work in many programing languages and integrate with CANbus or other networks in mobile, marine, and industrial applications

Electric/Hydraulic Control

Electrified machines require intelligent control systems integration of the many electro-mechanical systems. Operational efficiency is key when moving to energy sources with less reserve capacity when compared to conventional internal combustion systems.



Vocational Vehicles

- Typically See a use case that includes time in transit to and from work sites as well as time performing work functions
- Truck Mounted Mobile equipment includes: Cranes, Waste Handling, Specialized Material Transportation, Mobile Mixing, Recovery, Fire and Rescue, and many others
- Usable Payload Capacity is Often Critical
- Use Cases are Above Energy Requirement Limits for BEV only application

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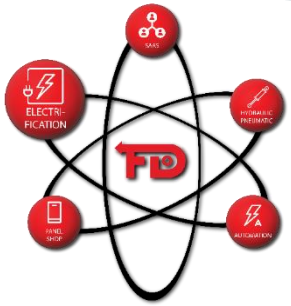
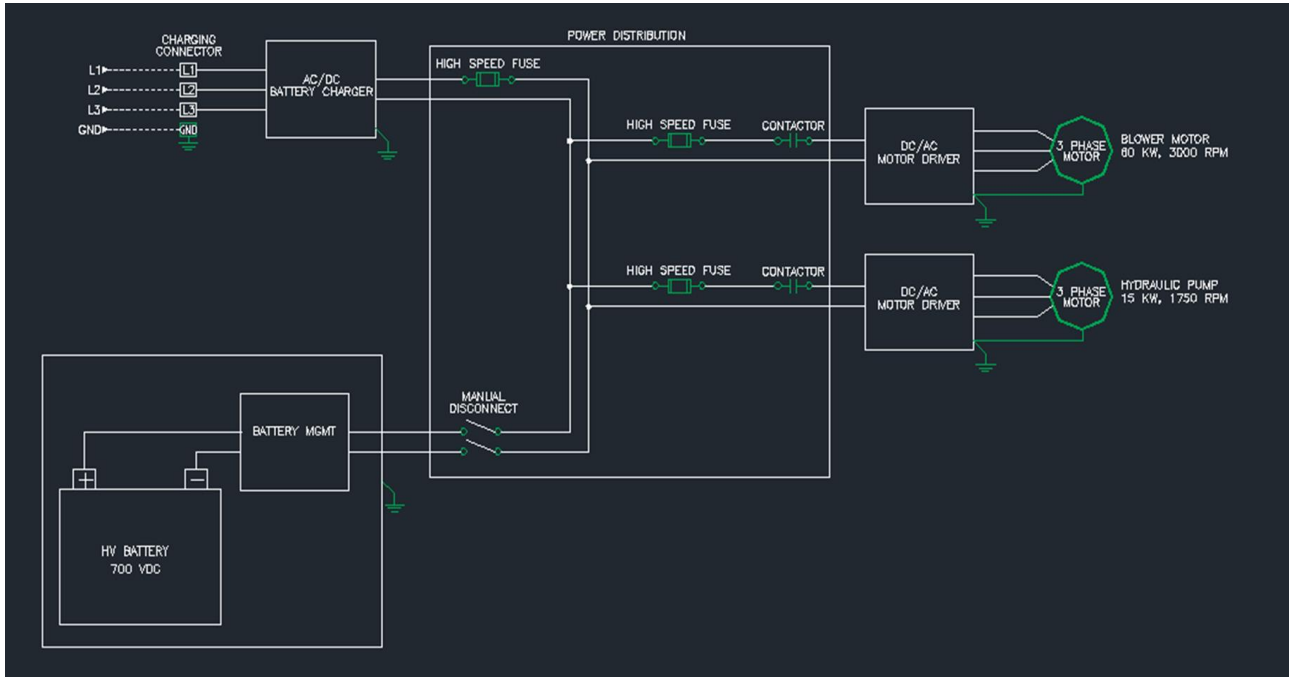
ELECTRIFICATION



Fuel Cells OR HV Battery to Supply the Power Required For Sophisticated Electrified Applications Require Specific and Specialized Knowledge.

Flodraulic Core Competencies Support:

- High Voltage Interlocking (HVIL)
- 24 VDC Low Voltage Controls
- 700+ VDC High Voltage Power Systems
- TM4, Editron motor/inverter interfacing
- Battery and Fuel Cell Management
- Fusing and bonding best practices
- Installation services
- Design and engineering services
- Service and Safety Training



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Connected Solutions

Software as a service (SaaS) is the most commonly used option for businesses in the cloud market, due to its easy accessibility and scalable environment. The Flodraulic team offers customers help with integration, customization and security– meaning customers don't need to lean on their in-house IT expertise.

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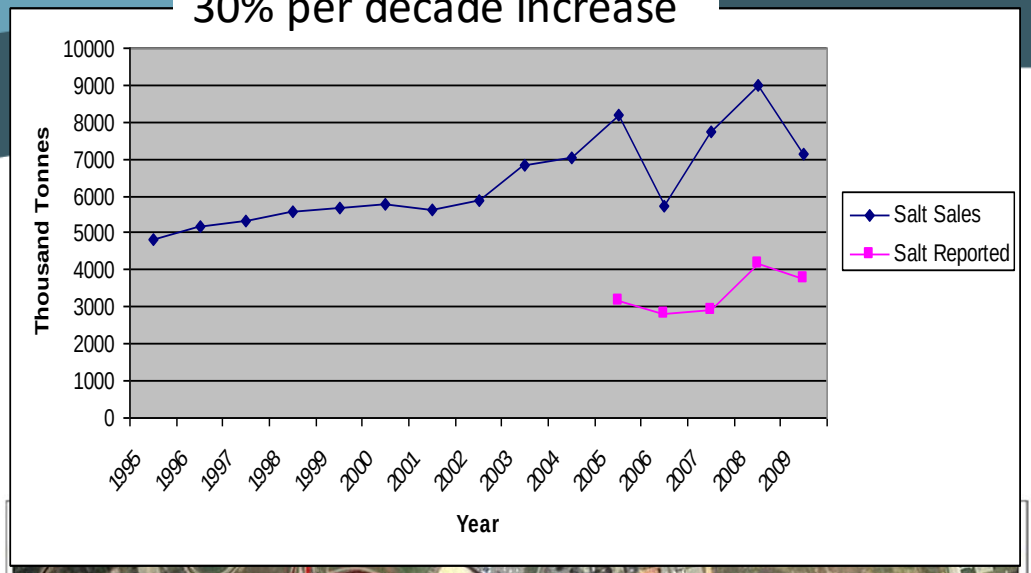
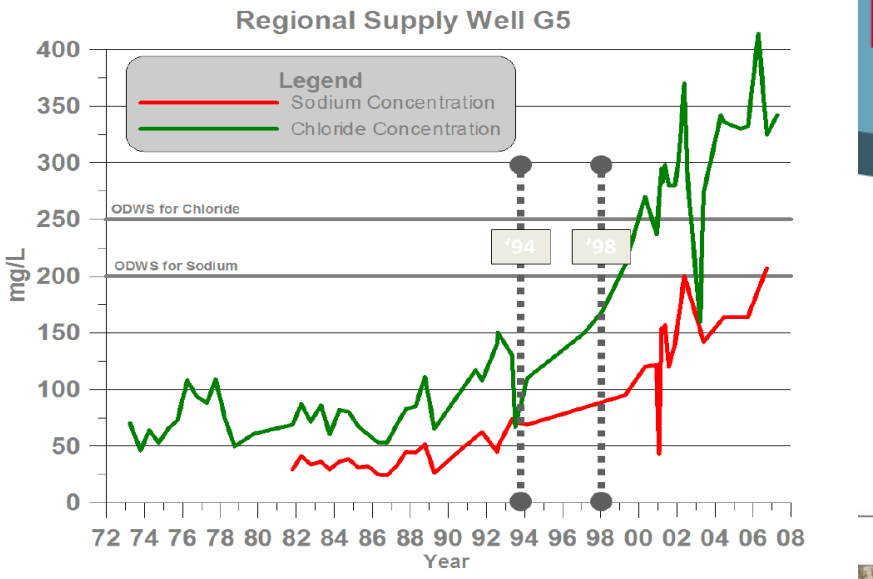
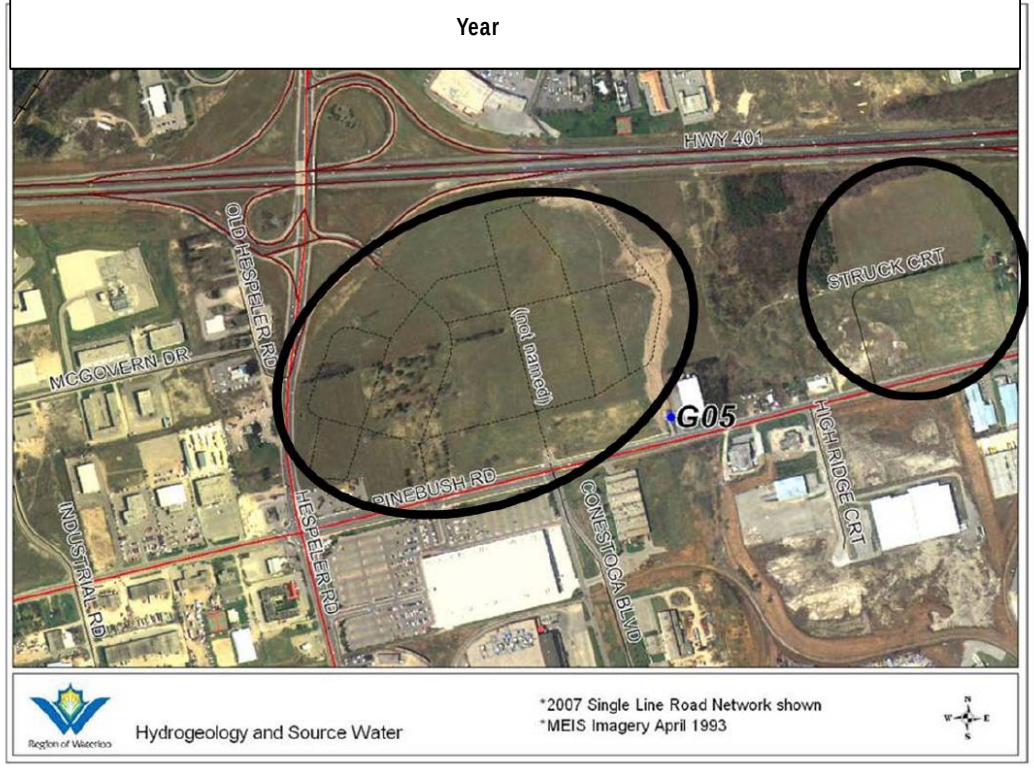
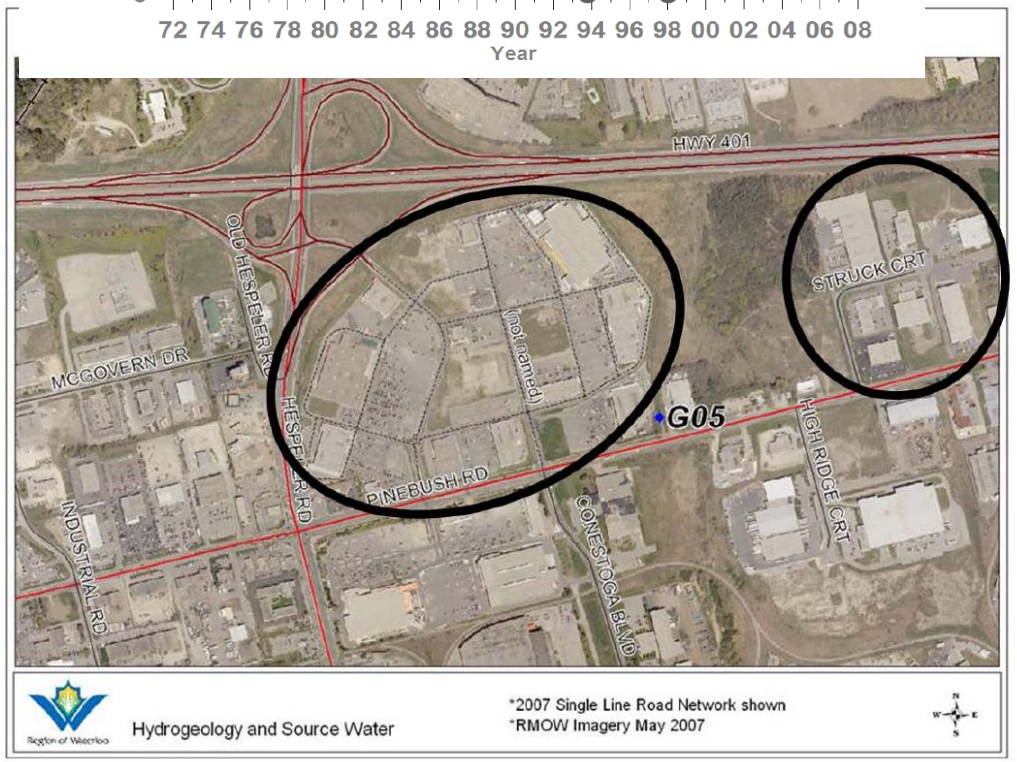
30% per decade increase









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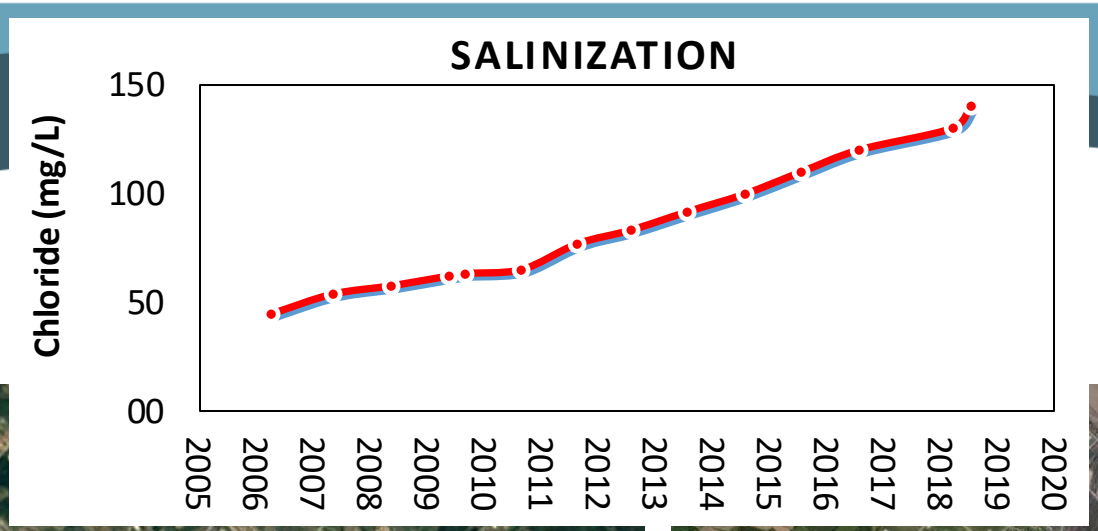
SALINIZATION
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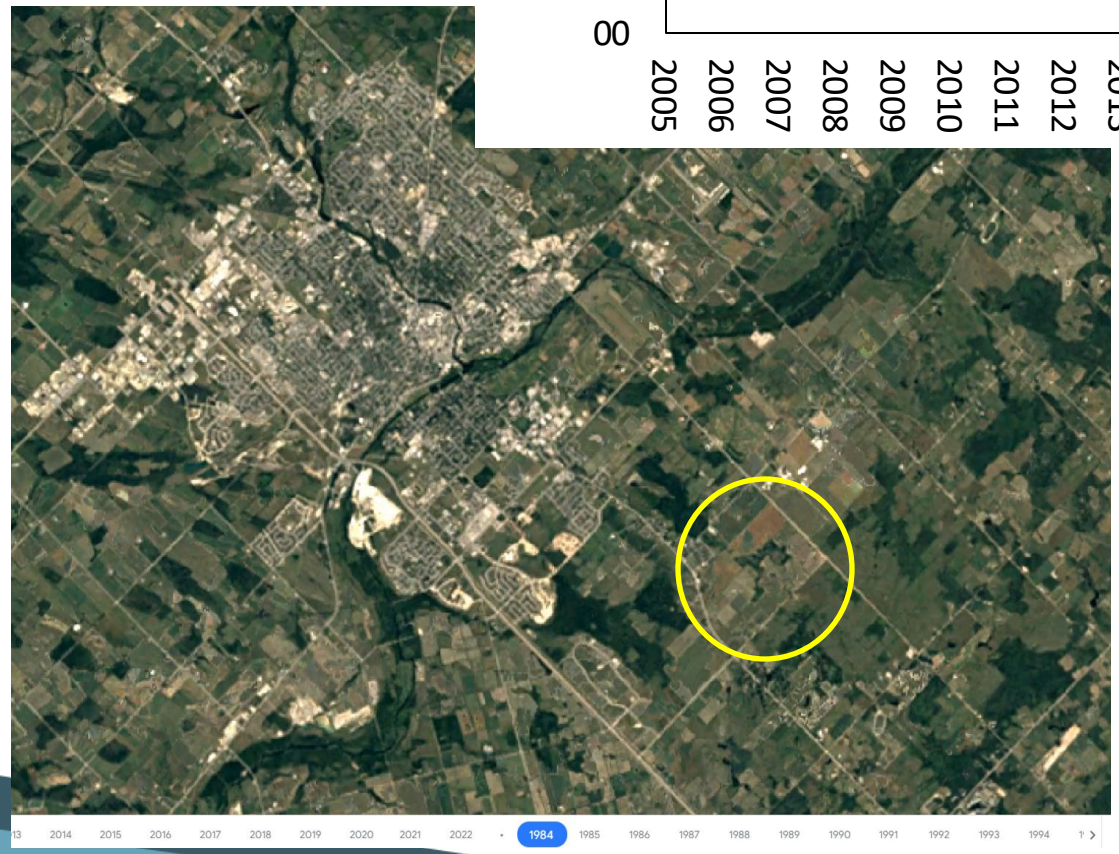
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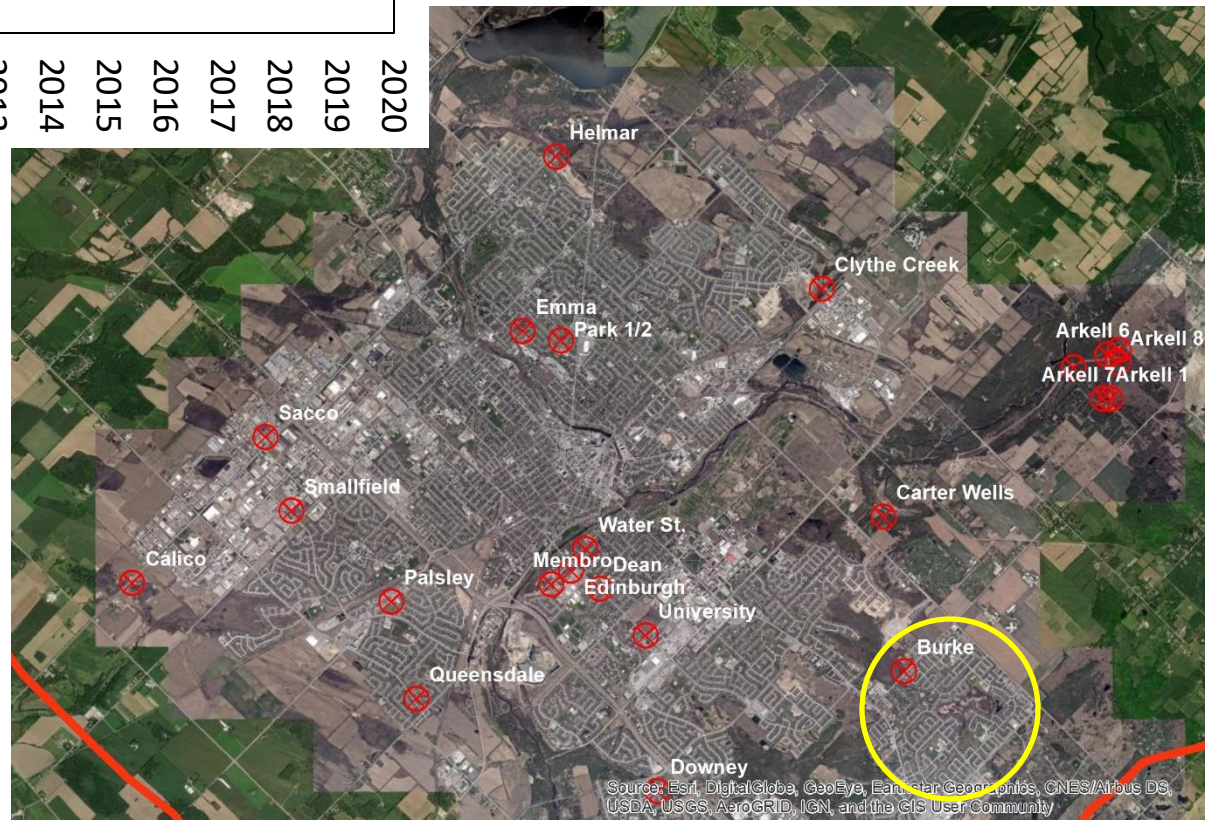
Helmar
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Emma
Park 1/2
Arkell 6
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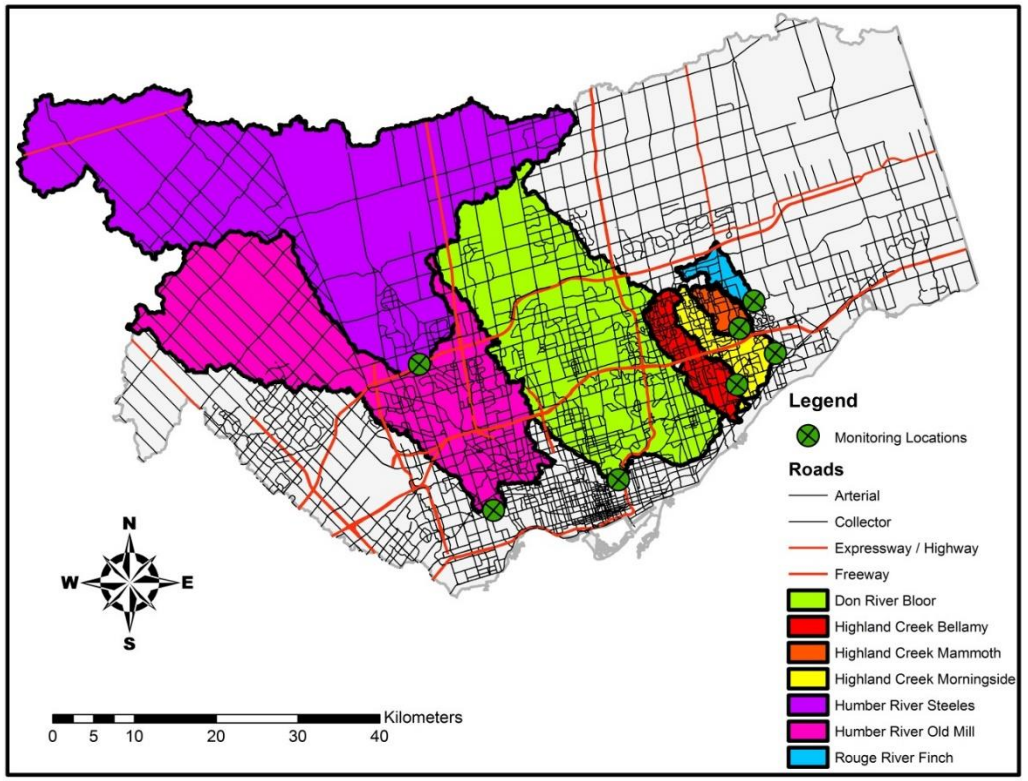
Smallfield
Carter Wells
Water St.
Calico
Membro
Dean
Edinburgh
University
Palsley
Burke
Queensdale
Downey
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

2024

Toronto Monitoring Stations



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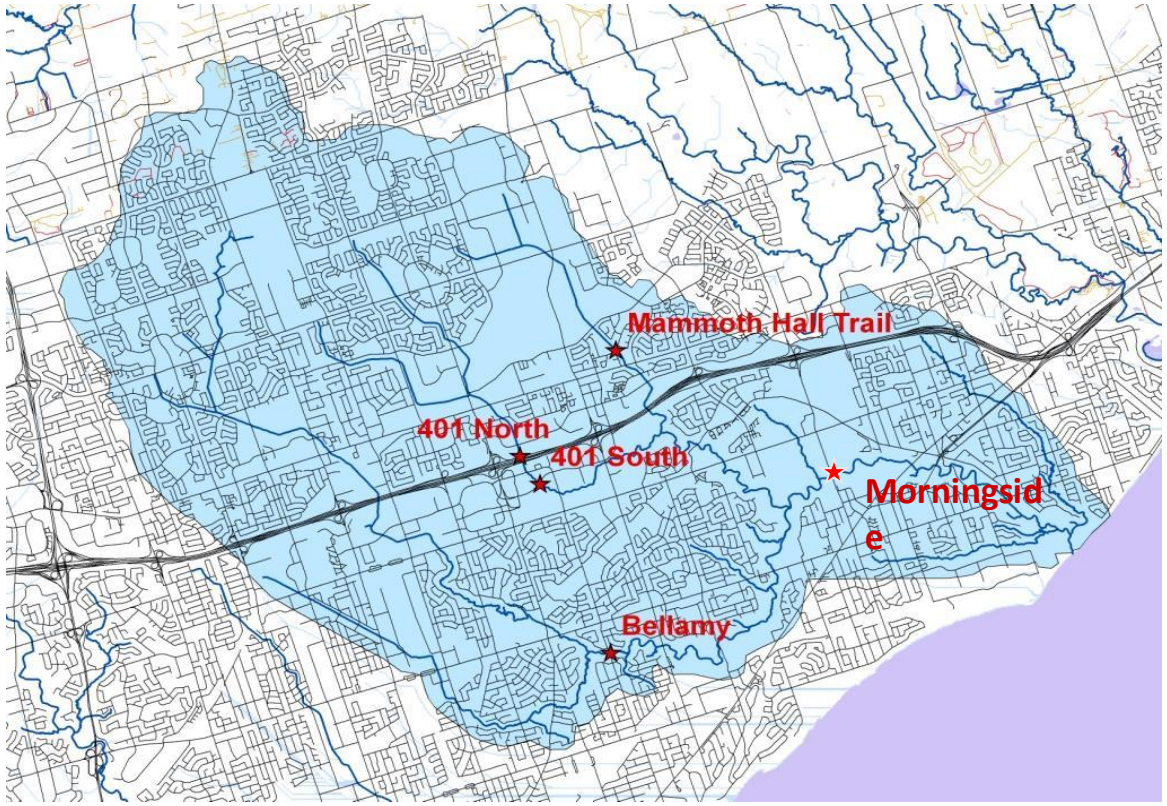
Highland Creek Monitoring Program



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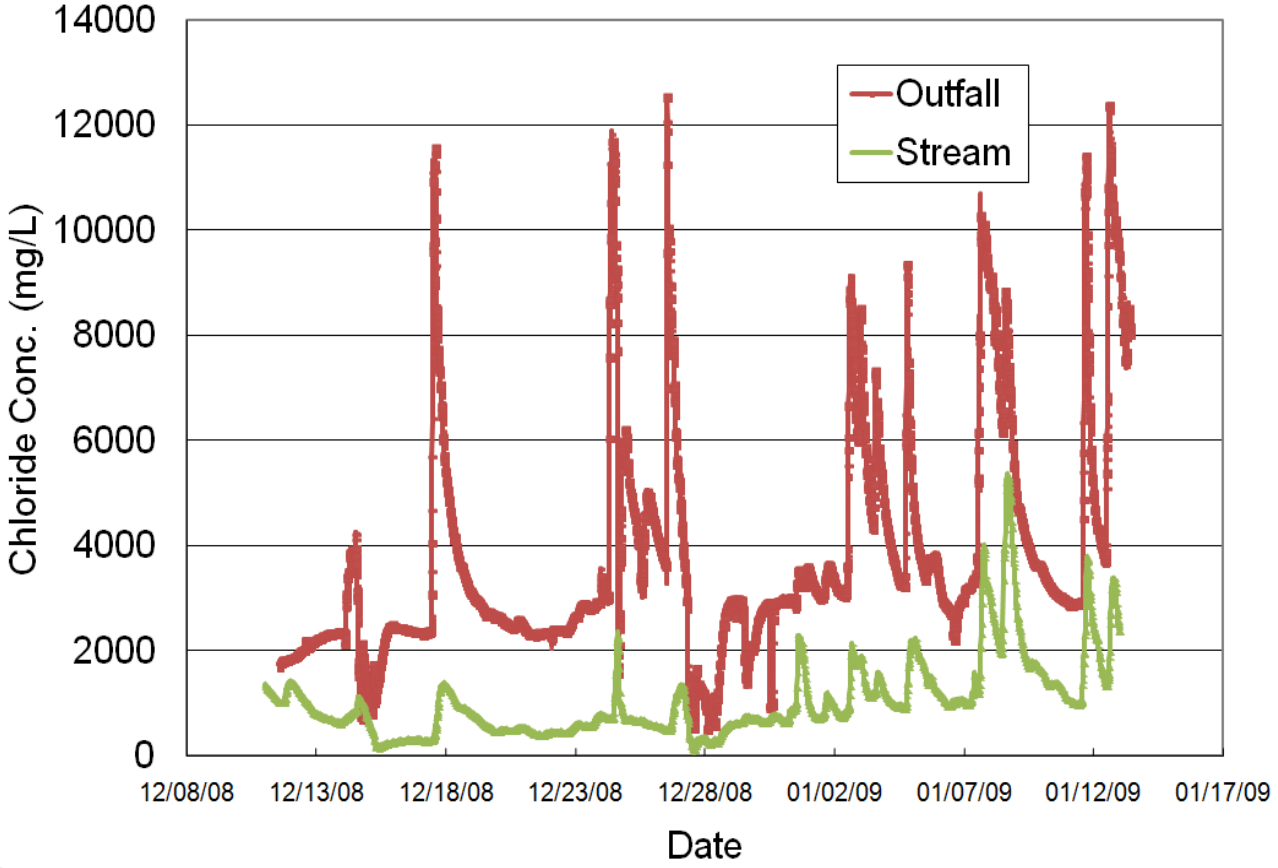
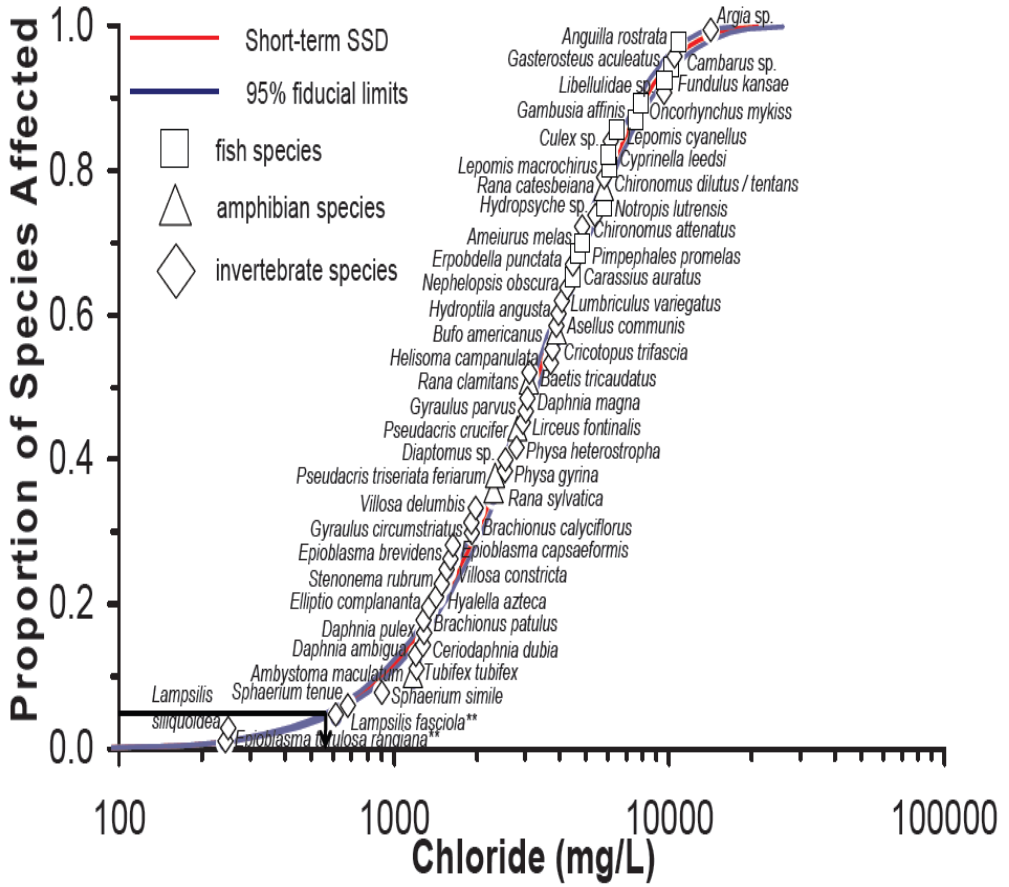
Protection of Salt Vulnerable Areas





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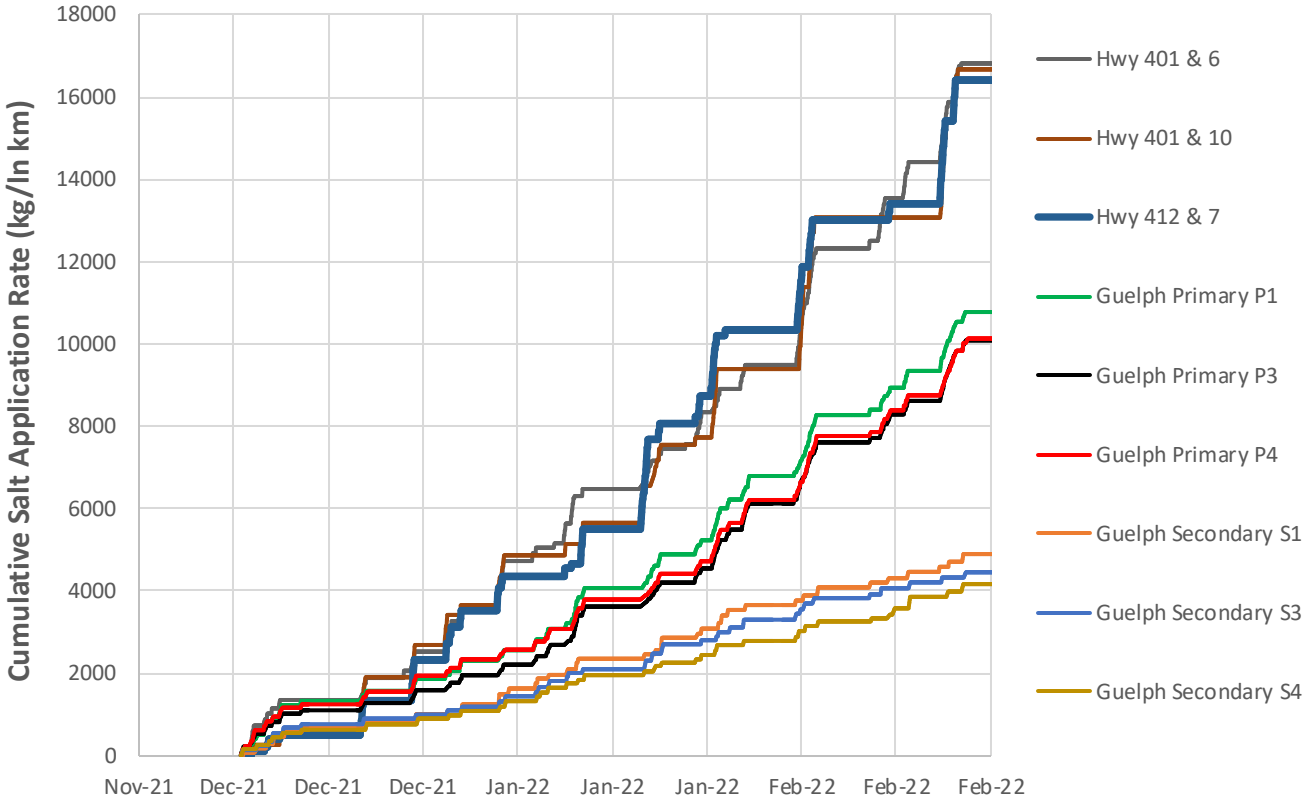
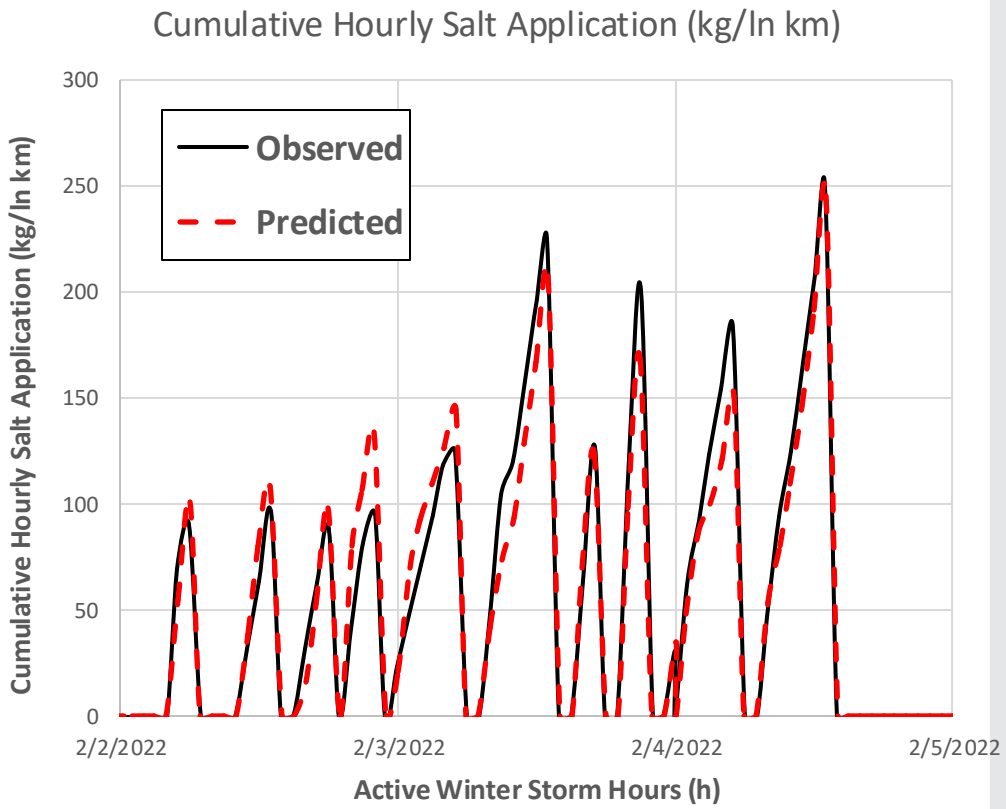
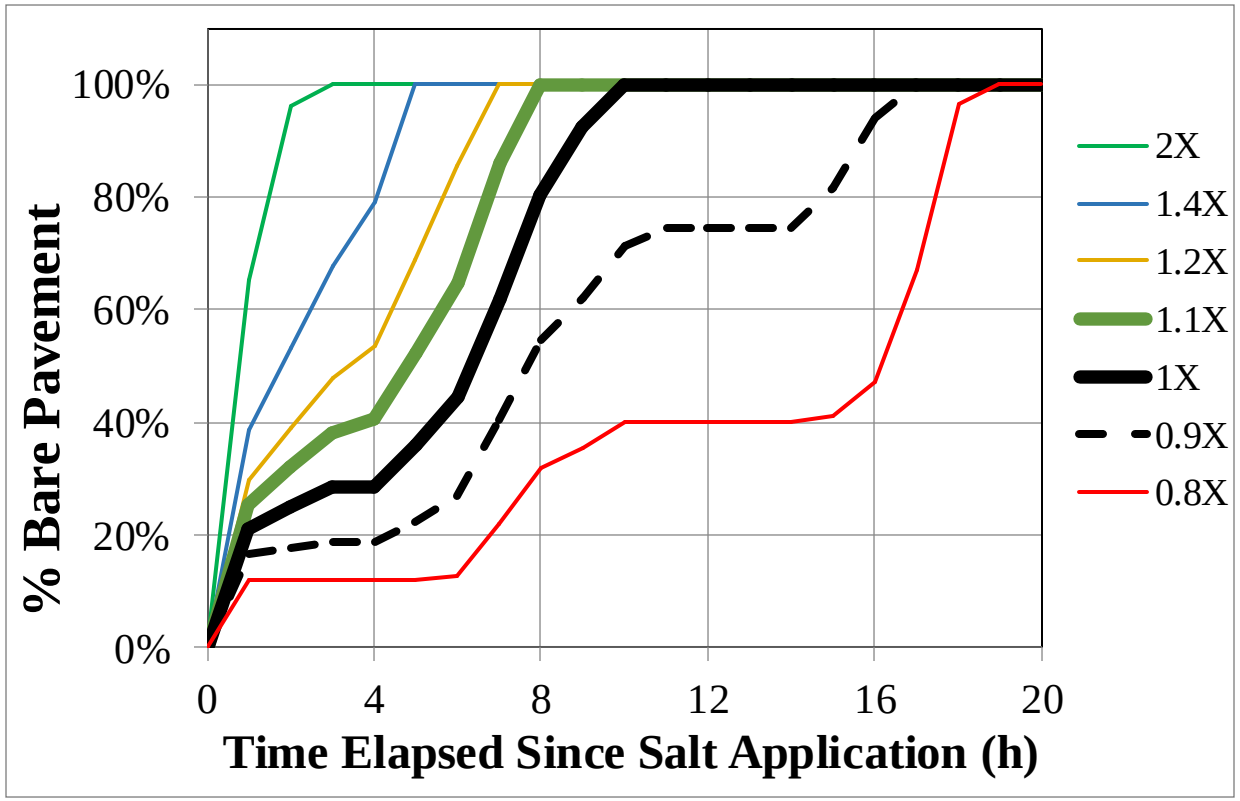
Cumulative Salt Application Rates





Bare Pavement Regain Time



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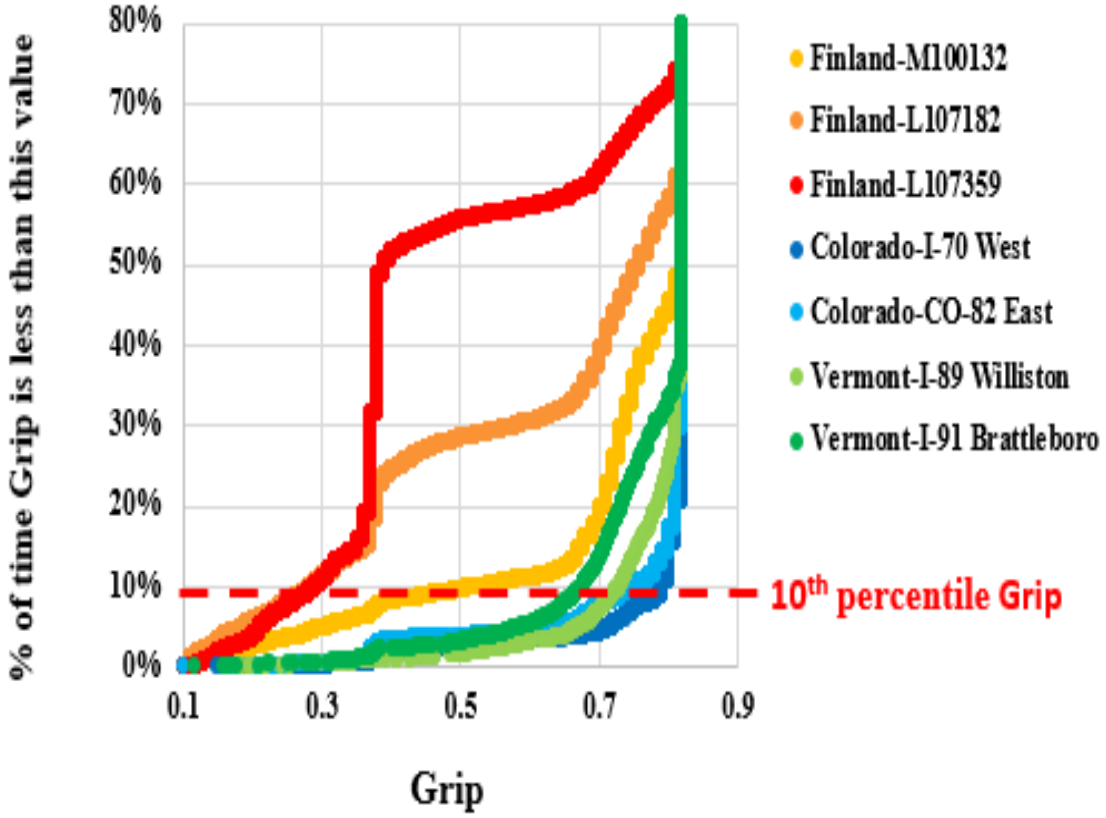
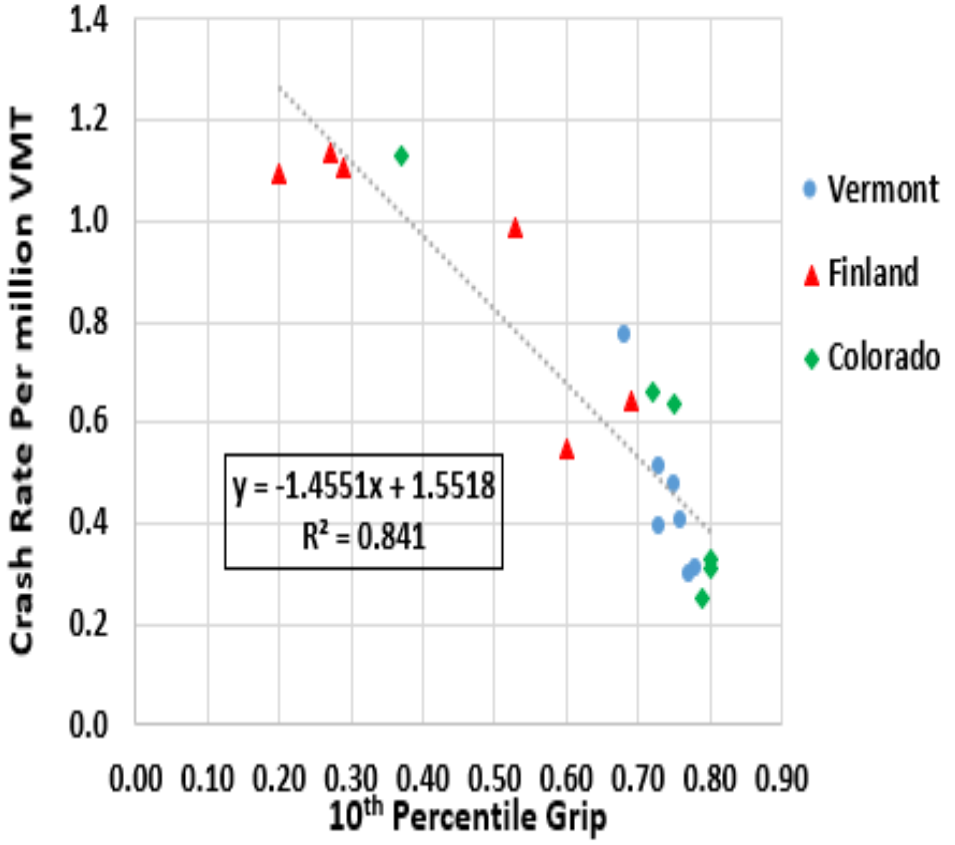
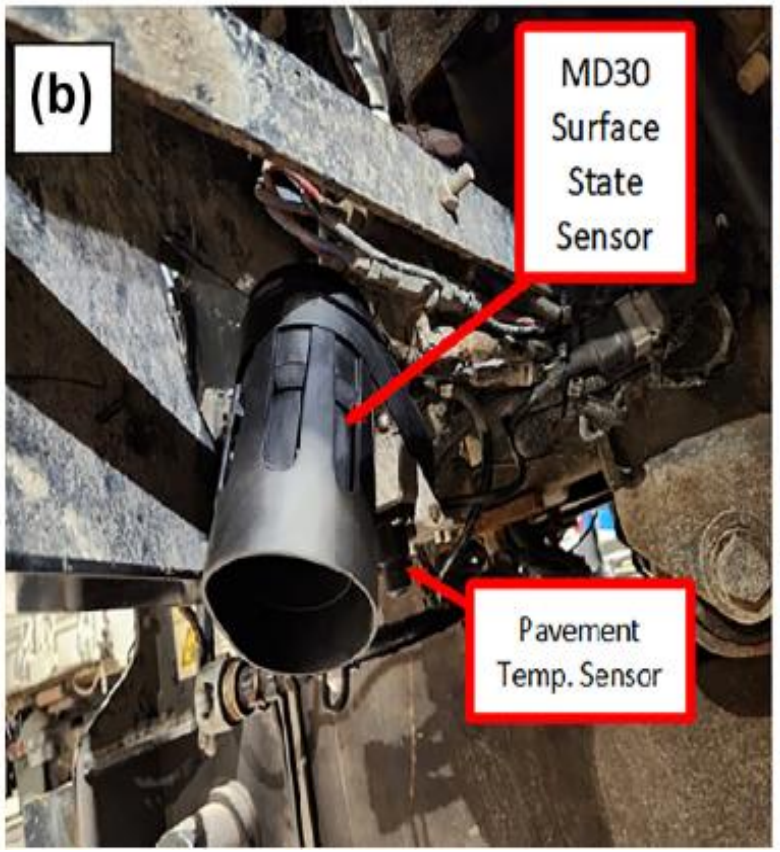
Effect of Grip Loss on Winter Crash Rates





Spatial & Temporal Variability of Grip

Mobile and Fixed Road Monitoring Stations



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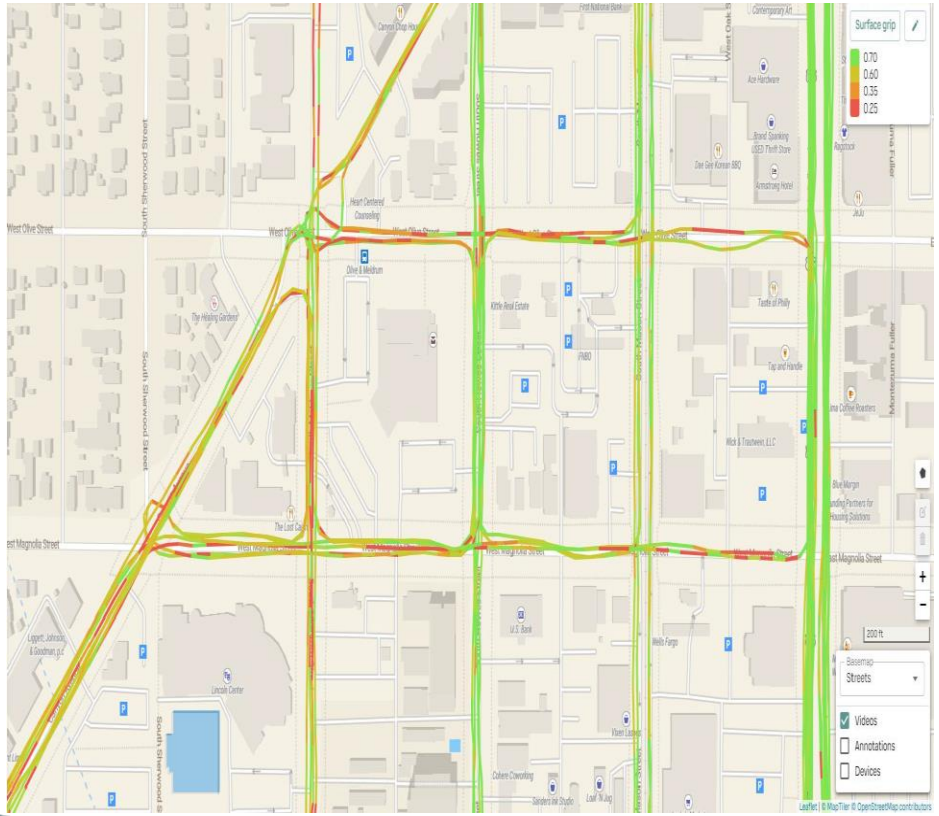
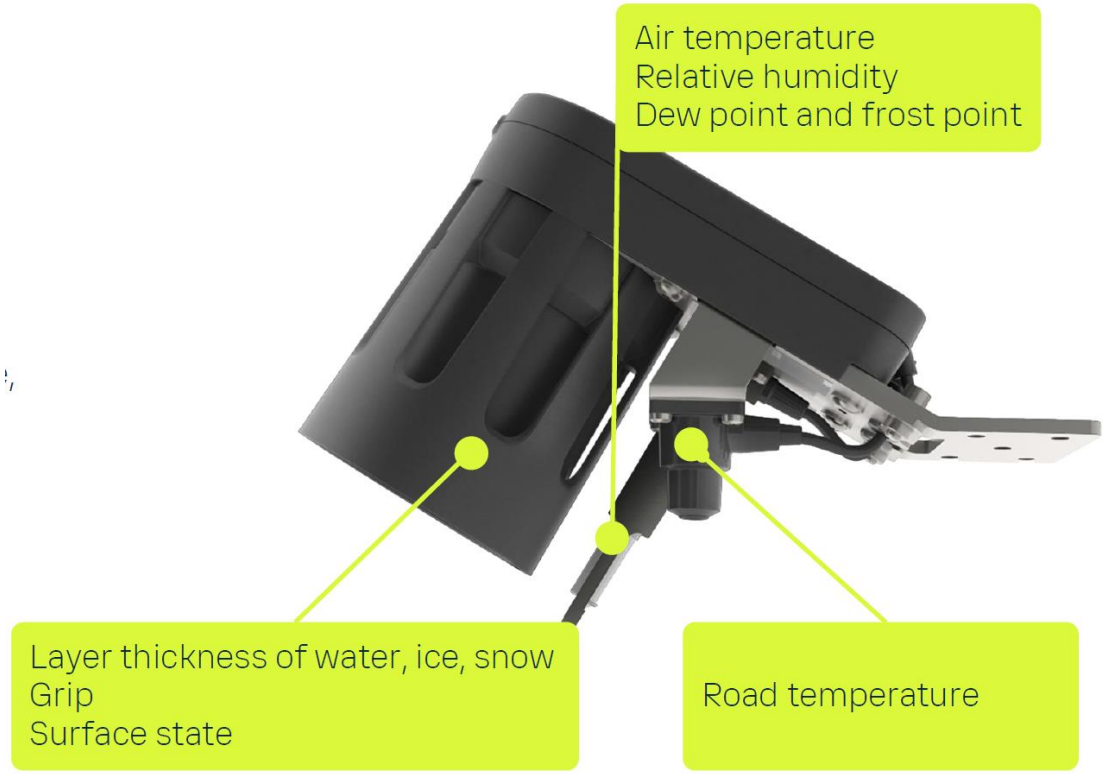
Vaisala MD30 Mobile Detector





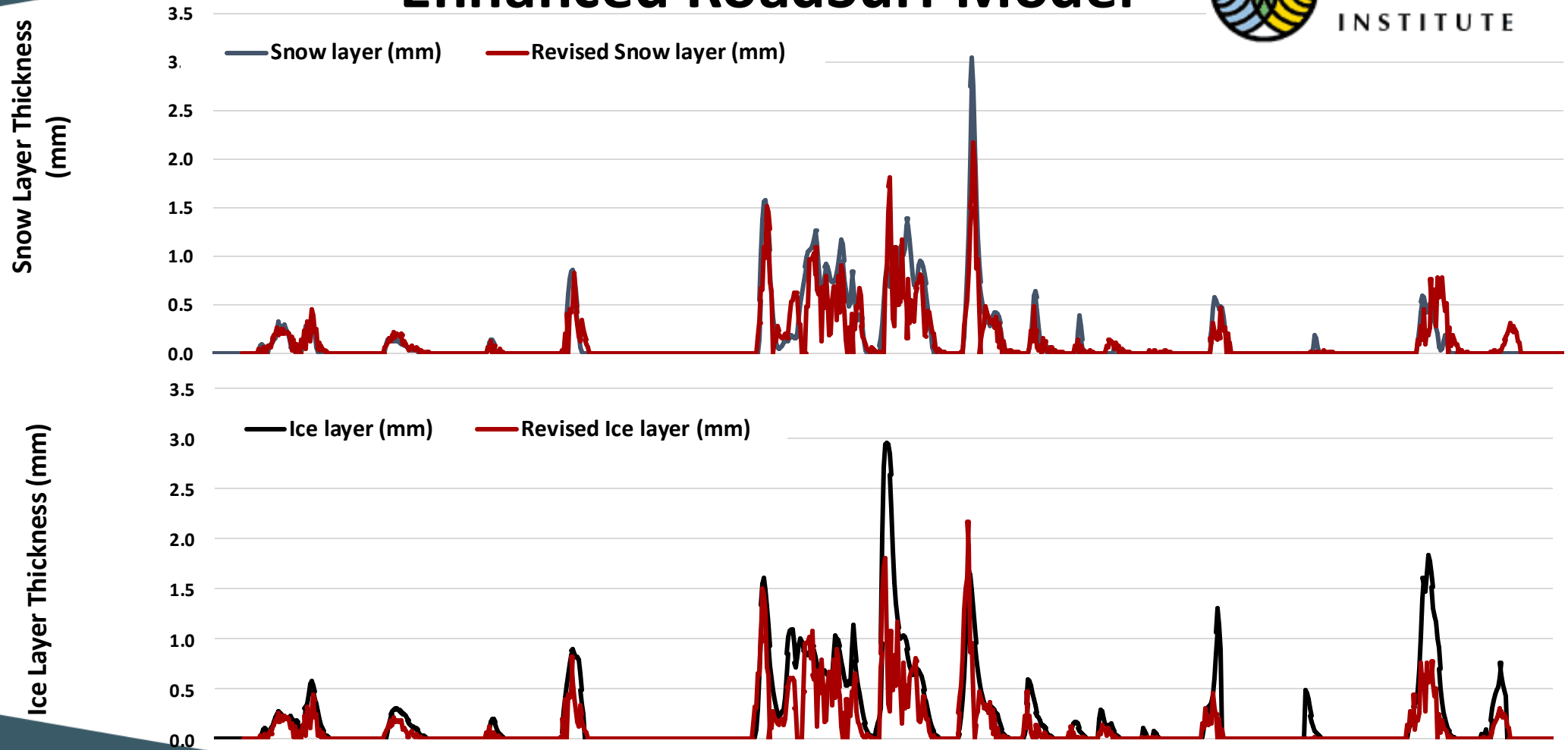
Colorado DOT Intelligent Transportation Systems

- **Results**
  - 80% reduction in accidents
  - Before system average of 15 accidents per year
  - After ~ 3 accidents
  - Approximately 12 accidents saved every year
  - Assuming 2 serious and 10 slight injury accidents
  - **Saving** of (2x$216k)+(10x$80k) = **$1.2M per annum**
- **Estimated 15:1 return of investment in 1 year**

https://www.codot.gov/programs/intelligent-transportation-systems/about

Enhanced RoadSurf Model

FINNISH METEOROLOGICAL INSTITUTE



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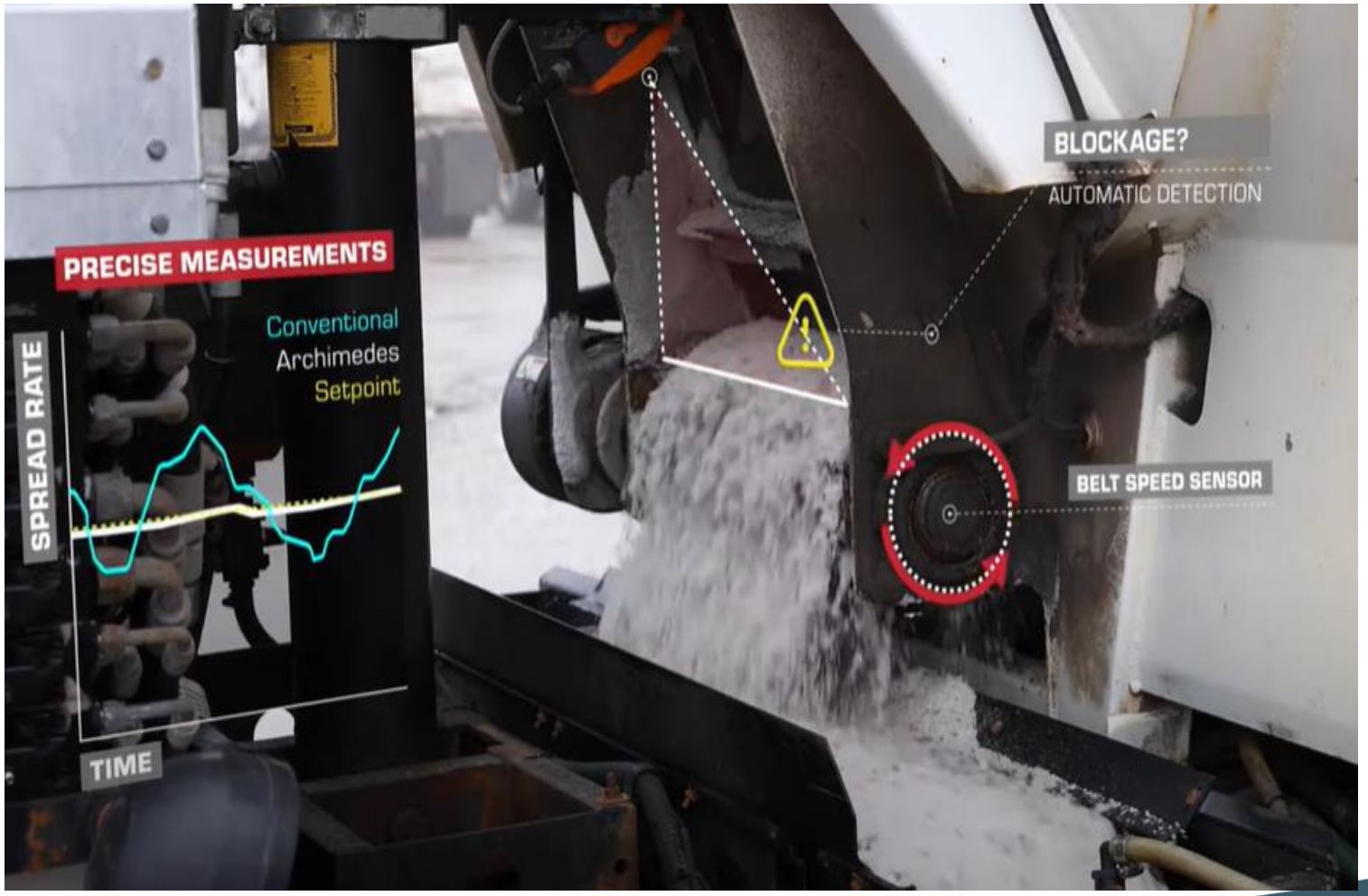
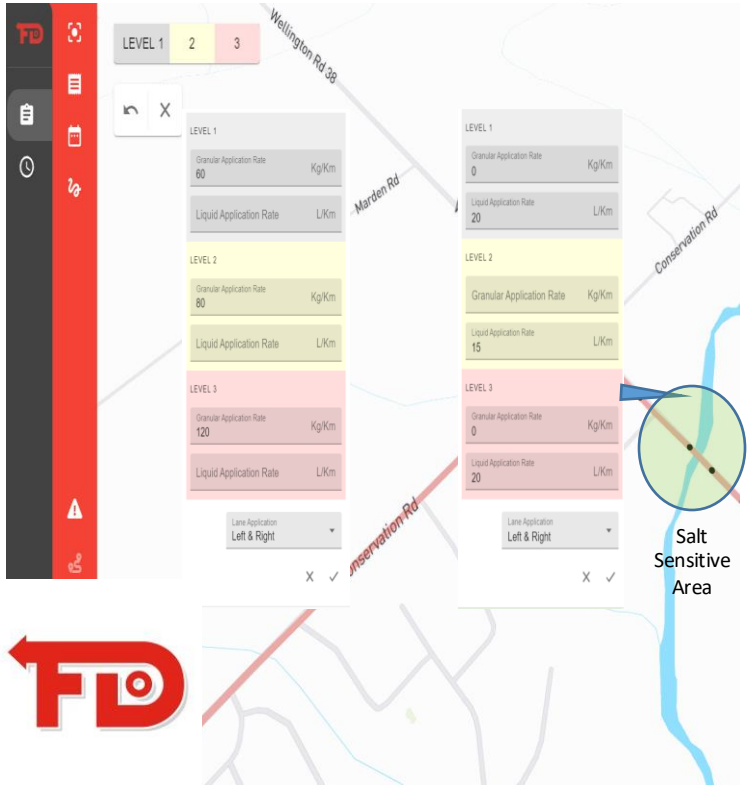
Closed-Loop Control

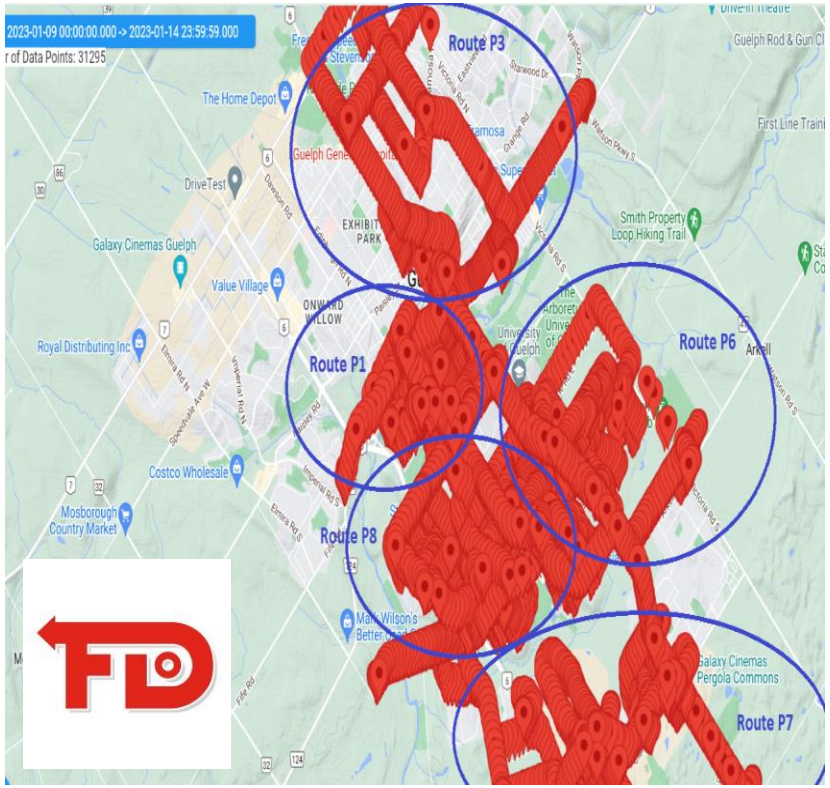
- The control system measures adapts and records salt payout in real-time
- Other approaches are only as accurate as the last calibration and lack proof of application



DLA & Salt Automated Switching

- User Friendly Web Platform to manage fleet and reporting
- Dynamically select application method and prescription on any road or specific location
- Raise or lower prescribed application based on storm severity across all road classes with one click
- **Switch between aggregate and liquid** applications at any time based on GPS locations
- Easy access to Reporting Data





Road Safety, Sustainability, and Cost Savings

Improved Road Safety: By optimizing salt truck deployment and salt application rates, Grip will be regained faster and more uniformly reducing the risk.

Environmental benefits: Dynamic spreading minimizes the environmental impact of road salt by using precise amounts tailored to current conditions.

Operational efficiency: With dynamic spreading, snowplow operators can focus on vehicle operation rather than constantly adjusting salt application rates.

Cost savings: By optimizing salt usage, dynamic spreading can lead to significant cost savings for transportation agencies.

Peer-reviewed Publications

1. Tabrizi, S.E., Elizarov, J., Farghaly, H., & Gharabaghi, B. (2025). Precision Salt Application Using Advanced Machine Learning Algorithms to Achieve Improved Road Safety and Reduced Environmental Impacts. Journal of Traffic and Transportation Engineering. https://jtte.chd.edu.cn/article/id/3a670221-e3ba-4214-83ef-08c661ebaa23

2. Tabrizi, S.E., Hippi, M., Sullivan, J., Farghaly, H., Gharabaghi, B. (2024). Real-Time Monitoring and Forecasting Ice Layer Thickness Growth Rate and Grip Loss on a Road Network During Winter Storm Events. Transportation Research Record (TRR) journal, 1-12. https://journals.sagepub.com/doi/10.1177/03611981241275580

3. Oliveira Santos, V., Costa Rocha, P.A., Scott, J., Van Griensven Thé, J., Gharabaghi B., (2023). Graph-Based Deep Learning Model for Forecasting Chloride Concentration in Urban Streams to Protect Salt-Vulnerable Areas. Environments, 10(9), 157. https://www.mdpi.com/2076-3298/10/9/157

4. Tabrizi, S. E.; Pringle, J.; Moosavi, Z.; Amouzadeh, A.; Farghaly, H.; Trenouth,W.R.; Gharabaghi, B. (2022). Protecting Salt Vulnerable Areas Using an Enhanced Roadside Drainage System (ERDS). Water 2022, 14, 3773. https://www.mdpi.com/2073-4441/14/22/3773

5. Tabrizi, S. E., Xiao, K., Thé, J. V. G., Saad, M., Farghaly, H., Yang, S. X., & Gharabaghi, B. (2021). Hourly road pavement surface temperature forecasting using deep learning models. Journal of Hydrology, 603, 126877. https://www.sciencedirect.com/science/article/pii/S0022169421009276?via%3Dihub

6. Salek, M., Levison, J., Parker, B., & Gharabaghi, B. (2018). CAD-DRASTIC: chloride application density combined with DRASTIC for assessing groundwater vulnerability to road salt application. Hydrogeology Journal, 26(7), 2379-2393. https://link.springer.com/article/10.1007/s10040-018-1801-7

7. Trenouth, W. R., Gharabaghi, B., & Perera, N. (2015). Road salt application planning tool for winter de-icing operations. Journal of Hydrology, 524, 401-410. https://www.sciencedirect.com/science/article/pii/S0022169415001675?via%3Dihub

8. Betts, A., Gharabaghi, B., McBean, E., & Parker, B. (2015). Salt vulnerability assessment methodology for municipal supply wells. Journal of Hydrology, 531, 523-533. https://www.sciencedirect.com/science/article/pii/S0022169415008720?via%3Dihub

9. Betts, A. R., Gharabaghi, B., & McBean, E. A. (2014). Salt vulnerability assessment methodology for urban streams. Journal of Hydrology, 517, 877–888. https://www.sciencedirect.com/science/article/pii/S002216941400465X?via%3Dihub

10. Perera, N., Gharabaghi, B., & Howard, K. (2013). Groundwater chloride response in the Highland Creek watershed due to road salt application: A re-assessment after 20 years. Journal of Hydrology, 479, 159-168. https://www.sciencedirect.com/science/article/pii/S0022169412010360

11. Perera, N., Gharabaghi, B., Noehammer, P., & Kilgour, B. (2010). Road salt application in Highland Creek watershed, Toronto, Ontario-chloride mass balance. Water Quality Research Journal, 45(4), 451-461. https://iwaponline.com/wqrj/article/45/4/451/39736/Road-Salt-Application-in-Highland-Creek-Watershed

12. Perera, N., Gharabaghi, B., & Noehammer, P. (2009). Stream chloride monitoring program of City of Toronto: implications of road salt application. Water Quality Research Journal, 44(2), 132-140. https://iwaponline.com/wqrj/article/44/2/132/39657/Stream-Chloride-Monitoring-Program-of-City-of

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Thank you

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