

CHEMICAL DE-ICING ON THE ALTO HIGH-SPEED RAIL SOUTHERN ROUTE

Impact of Glycol- and Saline-Based Solutions on the Frontenac Arch Biosphere and Karst Landscape Ecosystems

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Environmental and Hydrogeological Assessment

For Public Consultation and Environmental Assessment Processes

Executive Summary



A High-Speed Rail route located within ALTO's southern corridor would traverse approximately 220–260 kilometres of southeastern Ontario between Ottawa and Peterborough, passing through the Frontenac Arch Biosphere Reserve (UNESCO-designated), the Napanee Limestone Plain, and multiple ecologically significant watersheds draining to the Bay of Quinte Area of Concern. Operating through Ontario's severe winters (November–April), the railway would require systematic de-icing of track switches, overhead catenary systems, station platforms, drainage infrastructure, and train bogies.

This assessment evaluates the environmental risks of **glycol-based solutions** (propylene glycol and ethylene glycol) and **saline-based solutions** (sodium chloride brine, calcium chloride, potassium acetate, and calcium magnesium acetate) to the sensitive ecosystems of this corridor. It integrates data from the Salmon River Habitat Strategy (Green, 2005), the Ontario Geological Survey's karst mapping programme (Brunton and Dodge, 2008), Key Biodiversity Area designations (WCS Canada), amphibian and reptile toxicology research, and airport/railway de-icing environmental literature.

Principal finding: The southern corridor traverses a landscape uniquely vulnerable to chemical de-icing damage. The Frontenac Arch supports the highest density of reptile and amphibian species at risk in Canada — species with demonstrated acute sensitivity to both chloride salts and glycol compounds. The karst hydrogeology of the Napanee limestone plain provides no effective buffering: contaminants entering through sinkholes and enlarged fissures are transported rapidly through underground conduit networks to springs, wetlands, and municipal water supplies without natural filtration. The combination of extreme biological sensitivity and extreme hydrogeological vulnerability makes chemical de-icing along this corridor a risk of the highest order.

1. Background

In reply to ALTO's High Speed Rail 101 winter weather strategy, we present a research document with some serious reservations concerning glycol or saline based de-icers. We raise questions as to whether ALTO have adequately identified and considered all the relevant issues and are planning accordingly.



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High-Speed Rail 101

Winter weather presents real challenges, but it's nothing new for modern rail systems. Around the world, trains operate in conditions where snow, ice, and frigid temperatures are serious factors. Alto is planning with those realities in mind because that's the reality in Canada.

Staying on Top of It: Snow Clearance and Ice Prevention

To ensure uninterrupted service, teams will deploy well-established winter operations techniques, including:

- **Mechanical Snow Removal**
Specialized rail snowplows and blower-equipped machines will clear snow from the right-of-way, keeping the passage open.
- **Preventive Treatments**
Anti-icing products and sand can be applied to improve traction and reduce the likelihood of ice formation along the rail.

Keeping Things Moving: Switch Monitoring and Protection

To prevent switches from freezing and to ensure they continue to operate safely, a mix of heating and clearing technologies could be employed. For example:

- **Thermal Blowers** that direct warm air onto the switch points.
- **Electrical or Gas Burners** positioned beneath switches to melt accumulating frost.
- **Compressed Air Systems** designed to blast away snow or ice from moving components.
- **Chemical De-icing** applying glycol- or saline-based solutions, either manually or through automated nozzles.

2. The Southern Corridor: Ecological and Geological Context

2.1 The Frontenac Arch Biosphere

The Frontenac Arch is a southeastern extension of the Canadian Shield that bridges the St. Lawrence River between Kingston and Brockville, connecting the boreal forests of northern Ontario and Quebec to the Appalachian forests of the eastern United States. This narrow band of Precambrian granite — described by the Nature Conservancy of Canada as “a narrow pinch point” in the entire continental wildlife corridor — is one of the most biologically significant landscapes in Canada.

The Frontenac Arch Biosphere (FAB) Region now contains three formally designated Key Biodiversity Areas: the Thousand Islands KBA, Charleston Lake KBA, and Frontenac Forests KBA. The Napanee Limestone Plain, which partially overlaps the FAB Region, is currently being proposed as a fourth KBA (WCS Canada, 2024). The Thousand Islands area holds the highest diversity of reptiles, amphibians, and invertebrates of any national park in Canada (Parks Canada), and is a nationally designated Important Area for Reptiles and Amphibians (IMPARA).

Species at Risk in the Frontenac Arch

The FAB Region and its immediate environs support a remarkable concentration of species at risk, many of which are acutely sensitive to chemical contamination of their aquatic and wetland habitats:

Species	Status	Habitat	De-Icing Vulnerability
Gray Ratsnake (Frontenac Axis)	Threatened	Forests, forest edges, rocky outcrops; hibernacula in rock crevices	Habitat regulation protects areas within 1,000 m of occurrence; salt/glycol runoff degrades hibernacula and movement corridors; ethylene glycol sweet taste attracts wildlife ingestion
Blanding’s Turtle	Threatened	Shallow wetlands, marshes, ponds with muddy bottoms; 14–20 years to reproductive age	Chloride toxicity in breeding wetlands; only 8 eggs/year with very late maturity makes population recovery from chemical-induced mortality extremely slow
Eastern Whip-poor-will	Threatened	Open mixed forests with rock barrens	Insectivore dependent on invertebrate prey; chloride-induced invertebrate decline reduces food supply
Pugnose Shiner	Threatened	Clear, cool streams with aquatic vegetation; >10% of Canadian population in Thousand Islands	Highly sensitive to water quality changes; BOD from glycol depletes dissolved oxygen; chloride alters osmoregulation
Loggerhead Shrike	Endangered	Alvars and open grasslands of Napanee Plain; ~40 pairs in Ontario	Salt damage to alvar vegetation alters nesting habitat; insect prey declines from contaminated wetlands

King Rail	Endangered	Large freshwater marshes; <30 calling birds in 1999 survey	BOD-induced oxygen depletion in shallow marsh habitat; already at critical population levels
Bobolink / Eastern Meadowlark	Threatened	Grasslands, hayfields, meadows of Napanee Plain	Salt spray kills grassland vegetation within 30–50 m of track; de-icer runoff degrades habitat
Wood Thrush	Threatened	Interior forest along Moira River karst	Invertebrate prey dependent on clean forest floor; salt alters soil invertebrate communities

Table 1. Species at risk in the Frontenac Arch Biosphere and Napanee Plain corridor with de-icing chemical vulnerability.

2.2 The Karst Landscape of the Napanee Limestone Plain

The Napanee limestone plain is one of the Ontario Geological Survey’s seven representative hydrogeological terrains of southern Ontario (Canadian Journal of Earth Sciences, 2023). It is characterised by Ordovician Paleozoic limestone bedrock lying close to the surface, covered by thin glacial overburden of till and glaciolacustrine sand and clay — often less than one metre thick. The prevalence of karst topography, including sinkholes, solution-enlarged fissures, caves, disappearing streams, and springs, creates a unique hydrogeological regime in which 60–70% of total stream flow is derived from groundwater flowing through karst conduits (base flow index 0.6–0.7; Neff et al., 2005).

The Nature Conservancy of Canada has been working to protect the Napanee Plain since the early 1990s and has now conserved over 1,500 hectares of its significant natural features, including the Moira River Karst nature reserve (73 hectares of old-growth forest, karst formations, and wetlands) and the Stoco Karst Forest nature reserve (81 hectares near Stoco Fen Provincial Park). These investments reflect the landscape’s recognised ecological value and its vulnerability to alteration.

Critical hydrogeological characteristic: Research on fractured sedimentary bedrock aquifers in southern Ontario has demonstrated that contaminants can travel rapidly through fractures and karst conduits to groundwater, with variable and unpredictable travel times (Marshall and McBean, cited in ResearchGate). The thin overburden provides no effective filtration barrier. Any chemical applied at the surface — whether glycol or chloride salt — can reach the karst aquifer within hours to days, not the months to years expected in conventional porous-media hydrogeology.

Documented Karst Features in the Corridor

The Southern Route corridor intersects multiple documented karst systems:

- **Roblin Hell Holes ANSI:** Sinkholes, caves, underground streams, and a 20-metre escarpment directly in the corridor between Napanee and Belleville
- **Salmon River Alvar:** Flat limestone pavement with thin or absent soil; globally significant population of Juniper Sedge; the most vulnerable terrain type for chemical infiltration
- **Stoco Fen and Stoco Karst Forest:** Protected karst and wetland complex near Tweed providing water purification services for downstream Belleville

- **Moira River Karst:** Old-growth forest, wetlands, and rocky karst formations filtering water flowing to the Moira River and Belleville
- **Napanee Plain alvars:** A complex of limestone plain alvars, grasslands, forests, and wetlands identified as a priority for conservation and proposed as a Key Biodiversity Area³. Impact Assessment: Glycol-Based De-Icing Solutions

3.1 Biochemical Oxygen Demand — Severe Oxygen Depletion

Glycol compounds (propylene glycol and ethylene glycol) are organic alcohols that serve as a rich carbon source for aquatic microorganisms. When glycol-laden runoff enters surface waters, microbial decomposition consumes dissolved oxygen (DO) at rates that can be catastrophic for aquatic life. This biochemical oxygen demand (BOD) is the primary environmental threat from glycol-based de-icers.

The U.S. EPA's research on airport de-icing documented that glycol runoff can turn receiving streams orange and create "dead zones" where aquatic life cannot survive (EPA, 2009). Critically, propylene glycol — though less directly toxic to mammals than ethylene glycol — actually persists longer in the environment and consumes more oxygen during degradation (USGS). Research has shown that ethylene glycol can persist in cold water ecosystems for up to 60 days, causing prolonged stress to fish populations. This duration is particularly significant because HSR de-icing occurs during winter when water temperatures are lowest, microbial degradation rates are slowest, and the BOD from glycol persists the longest.

Application to the Frontenac Arch: The shallow wetlands, marshes, and ponds that provide breeding habitat for Blanding's Turtle, King Rail, and the corridor's amphibian species are precisely the low-flow, shallow, seasonally ice-covered water bodies most vulnerable to BOD-induced oxygen collapse. Under winter ice cover, these systems have no atmospheric re-aeration; any additional oxygen demand from glycol runoff pushes already-stressed dissolved oxygen levels toward lethal thresholds. Fish, amphibian eggs, and overwintering turtles cannot escape.

3.2 Direct Toxicity to Aquatic Organisms

Ethylene glycol is directly toxic to aquatic life, with lethal concentrations for fish ranging from 1,000 to 10,000 mg/L depending on species. Research on rainbow trout has documented sublethal effects including impaired swimming performance — a critical survival factor in flowing water. Field studies near airports have observed fish kills, oxalate crystal formation in fish kidneys, and reduced biodiversity in receiving streams (INCHEM/WHO). Formulated de-icing products containing proprietary additives (surfactants, corrosion inhibitors, dyes) are often significantly more toxic than pure glycol.

Application to the Frontenac Arch: The Pugnose Shiner, of which over 10% of Canada's population inhabits the Thousand Islands waterways, is a small minnow highly sensitive to water quality changes. Brook Trout spawning in the Salmon River's Pennell's Creek and Otter Creek wetlands require cold, well-oxygenated water. Even sub-lethal glycol concentrations depress oxygen levels enough to impair spawning success and egg survival.

3.3 Ethylene Glycol: The Sweet-Taste Wildlife Hazard

Ethylene glycol has a characteristic sweet taste that actively attracts wildlife. It is documented to be lethal to mammals at very small doses — a few tablespoons can kill a medium-sized dog. The Gray Ratsnake, Ontario's largest snake (up to 2.5 metres), uses rock crevices, building foundations, and ground-level features for hibernation, basking, and nesting. Pooled glycol runoff

near track infrastructure would create an attractive nuisance for ratsnakes, turtles, and small mammals emerging from hibernation in spring. The Ontario habitat regulation for Gray Ratsnake protects areas within 1,000 metres of any occurrence site; glycol contamination within this zone would constitute habitat degradation under the Endangered Species Act.

3.4 Karst Transport of Glycol

Unlike airport environments where glycol runoff can be collected through engineered drainage systems, the karst landscape of the Napanee limestone plain makes containment fundamentally impractical along open track corridors. Glycol applied to track surfaces, switches, and drainage infrastructure would infiltrate through sinkholes, solution-enlarged joints, and thin overburden into the karst conduit system. Once underground, glycol would be transported unpredictably to springs, stream baseflow discharge points, and wetlands across multiple watersheds — creating oxygen demand in locations remote from the point of application and impossible to predict or mitigate.

The high base flow index (0.6–0.7) means that contaminated karst groundwater directly becomes contaminated stream water. The Moira River Karst nature reserve, Stoco Fen Provincial Park, and the protected NCC lands along the Napanee Plain all depend on the karst system for the water purification services that justify their conservation investment. Glycol contamination of this system would undermine decades of conservation work.

4. Impact Assessment: Saline-Based De-Icing Solutions

4.1 Chloride Toxicity: Amphibians and Reptiles

Road salt research has produced a substantial and alarming body of evidence on chloride toxicity to the very species groups for which the Frontenac Arch is most significant — amphibians and reptiles.

Amphibians: Research by Collins and Russell (2009) found that spotted salamanders and wood frogs were the most sensitive amphibian species to chloride, and did not occupy ponds with high chloride concentrations. Chloride concentrations altered amphibian community structure by excluding salt-intolerant species. All amphibian life stages can experience reduced activity, lower growth rates, and death from elevated chloride, but eggs and tadpoles are generally more sensitive than adults (Ottawa Riverkeeper, Perron et al., 2022). Amphibians are particularly vulnerable because their permeable skin readily absorbs dissolved salts. Road salt can alter the male-to-female sex ratio of wood frogs, endanger their long-term reproductive rate, and cause delayed hatching, deformities, reduced size, and shorter lifespans in spotted salamanders (Chesapeake Bay Foundation).

Canada's guideline for the protection of aquatic life: 120 mg/L chloride (Environment Canada). The acute standard is 640 mg/L. Research across Ottawa found that 70% of stormwater ponds sampled had chloride levels exceeding the 120 mg/L guideline even during summer and fall months (Perron et al., University of Ottawa), demonstrating that chloride accumulates year-round and is not simply a seasonal pulse. Minnesota has set its chronic standard at 230 mg/L, with levels above this deemed harmful to aquatic life and concentrations above 860 mg/L lethal or sub-lethal to aquatic plants and invertebrates.

4.2 Freshwater Salinization: A Permanent, Cumulative Threat

Unlike glycol, which eventually biodegrades (albeit slowly and with destructive oxygen demand), chloride ions never degrade, volatilise, or disappear. Every gram of salt applied to HSR infrastructure would remain permanently in the environment, cycling between soils, groundwater, and surface waters. Research has documented “secondary salinisation” — a progressive, year-over-year increase in baseline chloride concentrations as salt accumulates in soils and aquifers and is slowly released back into surface waters even during seasons when no salt is being applied (Findlay and Kelly, 2011; Dugan et al., 2023, WIREs Water).

WWF-Canada has identified road salt as one of the most significant threats to freshwater biodiversity in the Great Lakes watershed, stating that *salty water kills eggs and larvae of wildlife such as mussels, and frogs and turtles die when there’s too much salt in lakes and rivers*. Natural background chloride concentrations in most freshwater systems should be below 10–20 mg/L, and in many cases below 5 mg/L (Hintz and Relyea, 2019). The gap between natural background and toxicity thresholds is dangerously narrow, and cumulative loading from HSR operations over decades would progressively close this gap.

4.3 Vegetation and Soil Degradation

The UK Rail Delivery Group’s research on railway de-icing agents found that vegetation and tree damage is the most serious impact of chloride-based de-icers. Salt spray from passing trains, combined with runoff from treated track surfaces, damages vegetation within 30–50 metres of the track corridor. In the Salmon River watershed’s limestone portion, only 38.1% of adjacent lands within 30 metres of streams currently have forest cover — far below the Environment Canada guideline of 100% (Green, 2005). Salt damage to the limited remaining riparian vegetation would directly undermine the watershed’s highest-priority restoration objective: stream bank reforestation.

Chloride salts also degrade soil structure by displacing calcium and magnesium ions from soil particles, causing clay dispersal and reduced infiltration capacity. On the Napanee Plain, where thin soils over limestone are already marginal for vegetation, additional salt stress would push alvar and grassland plant communities — including the globally significant Juniper Sedge population and habitat for the endangered Loggerhead Shrike — toward ecological collapse.

4.4 Karst Aquifer Contamination

The Ontario Geological Survey has confirmed that *shallow and, in some cases, even deeper groundwater aquifers in karst terrains are more susceptible to biological and chemical contamination* (Worthington et al., 2012; Hamilton et al., 2017). The Canadian Journal of Earth Sciences’ 2023 analysis of the Napanee limestone plain hydrogeological terrain identified karst conduit transport as a defining characteristic: contaminants travel rapidly through solution-enlarged fissures without natural filtration.

Chloride entering the karst system through track drainage would contaminate the aquifer that supplies municipal drinking water for communities including Napanee, Deseronto, and others. Unlike surface contamination that can be intercepted by constructed wetlands or stormwater management systems, subsurface karst transport is essentially uncontrollable once contaminants enter the system. The precedent of research on a First Nations reserve on fractured sedimentary bedrock in southern Ontario demonstrated that wastewater contaminants travelled through fractures with variable and unpredictable timing (Marshall and McBean), confirming that the karst system cannot be treated as a predictable flow path.

4.5 Invertebrate Community Collapse and Trophic Cascades

Chloride toxicity research has documented differential sensitivity among aquatic invertebrate groups. Mussels, snails, worms, mayflies, caddisflies, and stoneflies are among the most vulnerable, while crustaceans and some insect groups show higher tolerance (Perron et al., University of Ottawa). This differential sensitivity restructures aquatic communities, favouring tolerant species and eliminating sensitive ones. The loss of mayflies and stoneflies — important food sources for fish, amphibians, and insectivorous birds — triggers trophic cascades that ripple through the entire food web.

For the Frontenac Arch's insectivorous species at risk — Eastern Whip-poor-will, Chimney Swift, and the numerous bat species dependent on aquatic insect emergence — chloride-driven invertebrate community change would compound existing population pressures from habitat loss and climate change.

5. Comparative Risk Assessment: Glycol vs. Saline by Ecosystem

Ecosystem	Glycol Risk	Saline Risk	Combined	Rationale
Frontenac Arch Shield wetlands	HIGH	HIGH	VERY HIGH	IMPARA reptile/amphibian concentration; Blanding’s Turtle breeding habitat; Gray Ratsnake hibernacula
Napanee limestone alvars	MODERATE	VERY HIGH	VERY HIGH	Thin/absent soil; no buffering; Loggerhead Shrike habitat; globally rare Juniper Sedge; salt destroys alvar vegetation
Karst conduit aquifer system	HIGH	VERY HIGH	VERY HIGH	Rapid unfiltered contaminant transport; municipal water supplies; irreversible chloride accumulation
Salmon River watershed (limestone portion)	HIGH	HIGH	VERY HIGH	Only 38.1% riparian cover; 6 endangered species; Roblin Hell Holes karst; Bay of Quinte discharge
Napanee River / Wilton Creek	HIGH	VERY HIGH	VERY HIGH	Core of karst plain; BFI 0.6–0.7; >70% of phosphorus load is particulate; Bay of Quinte TP targets
Moira River (southern karst portion)	MODERATE	HIGH	HIGH	NCC Moira River Karst reserve; old-growth forest; Belleville drinking water downstream
Bay of Quinte (receiving waters)	HIGH	HIGH	VERY HIGH	Area of Concern; decades of RAP investment; cumulative loading from all tributaries; Big Marsh coastal wetland

Table 2. Comparative risk assessment of glycol- and saline-based de-icers by ecosystem along the Southern Alto Route.

6. Synergistic and Cumulative Effects

6.1 Chemical Interactions

Recent research has demonstrated that road salt contamination does not act in isolation. Elevated chloride concentrations alter the bioavailability and toxicity of other contaminants, including pesticides from adjacent agricultural lands. In the Napanee limestone plain, where the surrounding landscape includes active farmland contributing both nutrient and pesticide loading, the addition of HSR de-icing chemicals would create synergistic stress on aquatic ecosystems (ScienceDirect, 2025). Sodium and chloride ions modify soil chemistry in ways that mobilise heavy metals and increase their bioavailability to organisms.

6.2 Cumulative Loading to the Bay of Quinte

All watersheds crossed by the Southern Route drain to the Bay of Quinte, which has been designated an Area of Concern under the Canada-U.S. Great Lakes Water Quality Agreement since 1985. Decades of Remedial Action Plan (RAP) work have focused on reducing phosphorus loading and restoring impaired beneficial uses. Research on the Napanee River and Wilton Creek watersheds has shown that particulate phosphorus comprises over 70% of in-stream total phosphorus, and that hotspot analysis identifies cropland, pasture, and urban areas as primary sources.

Adding HSR de-icing chemical loading to every watershed crossing — whether glycol (increasing BOD and nutrient loading) or chloride (increasing salinization and mobilising phosphorus from soils) — would compound existing stressors and could reverse progress toward the Bay of Quinte’s targeted total phosphorus concentration of less than 0.02 mg/L. The RAP investment spanning four decades would be undermined.

6.3 Climate Change Amplification

Climate projections for southeastern Ontario include increased frequency of freeze-thaw cycles and more extreme precipitation events. Both trends would increase de-icing chemical demand (more frequent icing events requiring treatment) and increase contaminant transport (more intense runoff flushing chemicals into waterways during rain-on-snow events). The karst system’s rapid response to surface inputs means that climate-amplified chemical pulses would arrive in receiving waters with minimal attenuation.

7. Alternatives and Mitigation Measures

7.1 Electric Heating Systems (Preferred)

Japan's Shinkansen, Finland's railways, and most European HSR systems use electric resistance heating in switches, catenary systems, and platform surfaces as the primary de-icing method, supplemented by snow fences, heated water sprays in enclosed maintenance facilities, and aerodynamic train design. Electric heating eliminates chemical runoff entirely. Given that the Alto HSR will be electrified using Ontario's grid (approximately 69% non-emitting generation), electric heating aligns with the project's stated climate objectives and eliminates the most serious environmental risk identified in this assessment.

Costs include increased power consumption and reduced lifespan of concrete slab track. These are engineering and economic challenges, not ecological threats. In a landscape with the concentration of species at risk and hydrogeological vulnerability documented in this assessment, the additional cost of electric heating is a reasonable price for environmental protection.

7.2 Calcium Magnesium Acetate (CMA)

CMA is widely considered the most environmentally benign chemical de-icer. It is non-toxic, biodegradable, and less corrosive than chloride salts. However, it costs approximately 20 times more than sodium chloride and still exerts some biochemical oxygen demand as it degrades. CMA would be appropriate for localised application at stations and maintenance depots where runoff collection is feasible, but not for open corridor use over the karst landscape.

7.3 Potassium Acetate (KAc)

Potassium acetate is the leading liquid runway de-icer at airports and is used in automated bridge de-icing systems. It is effective to very low temperatures and less corrosive than chloride salts. The Minnesota Department of Transportation is conducting ongoing environmental studies. KAc could serve as a transitional option while electric heating systems are commissioned, but long-term environmental effects on karst aquifers remain under investigation.

7.4 Runoff Collection and Treatment

The U.S. EPA's 2009 proposed regulations required major airports to capture at least 60% of glycol runoff. Similar engineered collection systems could be designed for station areas and maintenance depots. However, along open track corridors over karst terrain, subsurface infiltration through sinkholes and fissures makes surface runoff collection fundamentally inadequate — contaminants enter the karst system before they reach collection points. This limitation is specific to the Napanee limestone plain and does not apply to track sections on Shield bedrock or thick overburden.

7.5 Mandatory Karst-Specific Measures

If any chemical de-icing is authorised for the Southern Route corridor, the following karst-specific measures would be essential:

1. Comprehensive dye-tracing study of the karst conduit network beneath the proposed alignment before any chemical use is authorised

2. Identification and mapping of all sinkholes, enlarged fissures, and karst springs within 2 km of the track alignment
3. Impermeable track bed lining over all identified karst zones to prevent direct infiltration
4. Real-time chloride, BOD, and dissolved oxygen monitoring at all karst springs and stream baseflow discharge points in the corridor
5. Annual chemical volume reporting with publicly accessible data and adaptive management triggers
6. Engagement of Quinte Conservation, Cataraqui Conservation, and the Mohawk Council of Tyendinaga as monitoring partners

8. Regulatory and Legal Framework

Chemical de-icing on the Alto HSR would engage multiple overlapping regulatory obligations:

Instrument	Relevance to De-Icing
Canadian Environmental Protection Act (CEPA)	Road salts declared toxic to the environment in 2001 under CEPA; Environment Canada Code of Practice for road salt management applies by analogy to railway operations
Fisheries Act (Canada)	Section 36(3) prohibits deposit of deleterious substances in waters frequented by fish; both glycol and concentrated chloride solutions meet this threshold; Frontenac Arch waters support fish species at risk
Species at Risk Act (SARA)	Prohibits destruction of critical habitat for listed species; Gray Ratsnake habitat regulation protects 1,000 m radius; Blanding’s Turtle wetland habitat; chemical contamination constitutes habitat degradation
Ontario Endangered Species Act	Provincial parallel to SARA; habitat regulation for Gray Ratsnake (Frontenac Axis population) explicitly protects hibernacula, nesting sites, and movement corridors; glycol/salt contamination would degrade protected habitat
Ontario Water Resources Act	Prohibits discharge of materials that may impair water quality; karst aquifer contamination threatens municipal drinking water supplies
Bay of Quinte Remedial Action Plan	Federal-provincial commitment to restore impaired beneficial uses; additional chemical loading from HSR contradicts RAP objectives and four decades of investment
UNESCO Biosphere Reserve designation	Frontenac Arch Biosphere designation implies commitment to sustainable development compatible with biodiversity conservation; chemical de-icing damage to species at risk habitats would conflict with biosphere reserve principles

Table 3. Regulatory framework applicable to chemical de-icing on the Alto HSR Southern Route.

9. Recommendations

1. Prohibit chemical de-icing along open track corridors over the Napanee limestone plain and within the Frontenac Arch Biosphere. The combination of extreme biological sensitivity (IMPARA designation, three Key Biodiversity Areas, federally and provincially protected species habitat) and extreme hydrogeological vulnerability (karst conduit transport, thin overburden, municipal aquifer contamination risk) makes chemical de-icing unacceptable in this landscape. Electric heating must be the primary de-icing technology.

2. Prohibit ethylene glycol use anywhere on the Alto HSR corridor. Its sweet taste actively attracts wildlife, its direct toxicity to aquatic organisms is well documented, and its persistence in cold water (up to 60 days) means winter application creates spring-thaw oxygen crises in receiving waters.

3. Prohibit sodium chloride and calcium chloride use within 2 km of any karst feature, Provincially Significant Wetland, ANSI, or watercourse. Chloride is permanent and cumulative; once it enters the karst aquifer, it cannot be removed. The narrow gap between natural background chloride levels (less than 5–20 mg/L) and toxicity thresholds (120 mg/L chronic, 640 mg/L acute under Canadian guidelines) provides almost no margin for error in a landscape with rapid, unfiltered contaminant transport.

4. Restrict any chemical de-icing to CMA or potassium acetate at enclosed stations and maintenance depots only, with engineered runoff collection systems and treatment before discharge. Annual chemical volumes must be publicly reported.

5. Require a comprehensive karst hydrogeological investigation using dye tracing, borehole surveys, ground-penetrating radar, and electrical resistivity tomography to map the subsurface conduit network beneath the proposed alignment before any operational permits are issued. This investigation should take 2–3 years and must be completed before construction begins.

6. Establish baseline water quality monitoring for chloride, BOD, dissolved oxygen, and glycol concentrations at all karst springs, stream baseflow points, and municipal wells within 5 km of the proposed alignment, with continuous monitoring throughout construction and the life of the railway.

7. Engage Indigenous partners, conservation authorities, and community stakeholders including the Mohawk Council of Akwesasne, Quinte Conservation, Cataraqi Conservation, the Nature Conservancy of Canada, WCS Canada, and the Friends of the Salmon River in the design, implementation, and oversight of any de-icing management plan.

8. Require that any Environmental Assessment for the Alto HSR include a dedicated De-Icing Management Plan as a condition of approval, with legally binding adaptive management triggers linked to water quality monitoring results. If monitoring detects chloride concentrations exceeding 50% of the Canadian guideline (60 mg/L) at any monitoring point, chemical de-icing operations must be immediately curtailed.

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This assessment draws on data from The Salmon River Habitat Strategy (Green, 2005), Ontario Geological Survey karst mapping, Key Biodiversity Area designations, amphibian and reptile toxicology research, airport and railway de-icing environmental literature, and current Alto HSR consultation materials. It is intended to inform public consultation and environmental assessment processes for the Alto HSR project.