RESEARCH NOTE

Road Severance: Excess Lifecycle CO_2 Emissions – Model Input 3

Quantification of Permanent Vehicle Detour Emissions on the 1,000 km Alto HSR Southern Corridor

Alto HSR Citizen Research Initiative — March 2026 — Reviewed by Steven Moore

EXECUTIVE SUMMARY

This note quantifies the excess CO_2 emissions generated by permanent road closures on the Alto HSR corridor. Transport Canada confirmed in March 2023 that the Toronto–Québec City corridor would require complete grade separation on an alignment with over 1,000 public and private crossings. International practice and road classification analysis indicate that 30–60% of crossings will be permanently closed rather than bridged, producing 350–700 dead-ended roads on the 1,000 km southern corridor. Every affected household and farm operation must thereafter travel additional kilometres for every trip that formerly crossed the corridor, a permanent, annually recurring emission cost that continues for the full operational life of the railway.

Three vehicle categories are quantified: light passenger vehicles, school buses, and farm machinery. The analysis is structured around three scenarios (low / central / high) reflecting closure count, household density per closure, and detour distance. 50-year totals are presented both at constant fleet composition and EV-adjusted (accounting for the progressive electrification of the passenger vehicle fleet over the 2040–2090 operating period).

	Low	Central	High	Unit
Road closures assumed	350	500	700	closures
Total annual excess CO_2 — all categories	**3,934**	**6,844**	**10,851**	t CO_2e/yr
50-year total — constant fleet (upper bound)	196,680	342,204	542,560	t CO_2e
50-year total — EV-adjusted (realistic)	**97,567**	**172,131**	**277,720**	t CO_2e
As % of 50-year lifecycle budget (central, 21.3 Mt)	0.46%	0.81%	1.30%	% of total

Road severance detour emissions are a permanent, annually compounding cost that has no counterpart in any other emission category: they cannot be reduced by grid decarbonisation, technology improvement, or operational change. They are a direct consequence of the closure decision and persist for as long as the railway operates. Alto has not acknowledged this category in any published environmental document.

1. Basis for Calculation: Transport Canada's 1,000+ Crossings

Transport Canada confirmed in its March 2023 TRAN Committee Appearance Binder that a full high-speed rail system between Quebec City and Toronto would require “complete grade separation” on an alignment with “more than 1,000 public and private crossings.” This statement was made in the context of the northern HFR alignment (through Peterborough, Ottawa, and Montréal). The southern corridor alignment, through the intensively farmed concession road grid of Eastern Ontario, crosses a denser road network and is expected to encounter more crossings, not fewer.

Alto VP of Systems Engineering David Cook confirmed at Kingston City Council (February 17, 2026) that the full corridor will be fenced — “anywhere where you could have level access, it would have to be fenced for sure” — and that Alto’s explicit goal is to “try and limit the number of overpasses that we’ll need to get created.” Road closures are therefore not a contingency; they are an intended design outcome.

1.1 Crossing Count and Closure Rate

Parameter	Low scenario	Central scenario	High scenario
Total crossings (1,000 km southern corridor)	1,050+	1,100+	1,200+
Closure rate (% not bridged)	33%	45%	58%
Road closures assumed	350	500	700
Agricultural zone closures (60% of total)	210	300	420

SOUTHERN CORRIDOR NOTE

The 1,000+ crossing figure was established for the northern HFR corridor through mixed terrain (Canadian Shield outcrops, wetlands, and larger rural lots). The southern corridor passes through the tightest section of Ontario’s concession road grid: roads spaced approximately 2 km apart in both directions, with active farm laneways, county roads, and municipal roads superimposed. Road-crossing density per corridor kilometre is demonstrably higher. The figures in this analysis are therefore conservative lower bounds.

2. Category A — Light Passenger Vehicles (Cars, Pickups, Light Trucks)

This category covers passenger vehicles, pickup trucks, and light SUVs, the dominant vehicle type on rural Ontario concession roads. The calculation follows the methodology in the Alto HSR Road Severance Technical Analysis (March 2026) and scales to the full 1,000 km corridor.

2.1 Parameters and Calculation

Parameter	Low	Central	High
Road closures	350	500	700
Affected households / operations per closure	15	18	20
Added vehicle-km per household per day (return detour)	10 km	10 km	10 km
Operating days per year	365	365	365
CO_2 emission factor — rural Ontario fleet average	200 g/km	200 g/km	200 g/km
Source	NRCan EnerGuide; Env. & Climate Change Canada NatInv. Report	NRCan EnerGuide	NRCan EnerGuide

2.2 Annual Calculation

Step	Low	Central	High
Annual added vehicle-km (closures × HH × 10 km × 365 days)	19.2 M km	32.9 M km	51.1 M km
CO_2 at 200 g/km	3,833 t	6,570 t	10,220 t
50-yr total — constant fleet	191,650 t	328,500 t	511,000 t
50-yr total — EV-adjusted (avg fleet factor 0.484)	92,747 t	158,994 t	247,324 t

EV ADJUSTMENT NOTE

Light vehicles transition to EVs progressively over the 2040–2090 operating period. Assumptions: EV fraction rises linearly from 20% (2040) to 90% (2090); average over 50 years ~55%. Ontario current grid (73.8 g/kWh) at 6 km/kWh efficiency = 12.3 g/km for EVs vs 200 g/km for ICE. Weighted average emission factor = 0.45×200 + 0.55×12.3 = 96.8 g/km. EV adjustment factor applied to 50-year total: 96.8/200 = 0.484. This is the dominant emission category and the most sensitive to fleet transition assumptions.

3. Category B — School Buses

Under Ontario’s MTO School Bus Handbook and the Student Transportation Services of Central Ontario (STSCO) guidelines, school buses are not required to travel roads not assumed and maintained year-round by the municipality. A dead-ended concession road may lose its maintenance rationale, triggering route re-planning. Even where roads remain eligible, dead-ending forces detour routing that adds time and kilometres to every run.

The Alto HSR Road Severance Technical Analysis estimated approximately 50 bus routes adding 8 km of daily detour over the 185-day school year, generating 74–89 t CO_2 annually. This analysis scales that figure for the full 1,000 km southern corridor and adds a high scenario.

3.1 Parameters and Annual Calculation

Parameter	Low	Central	High
Bus routes affected (1,000 km corridor)	40	60	80
Additional km per route per school day	6 km	8 km	10 km
School operating days per year	185	185	185
School bus CO_2 emission factor	1,000 g/km	1,100 g/km	1,200 g/km
Source	Transport Canada GHG data	Transport Canada GHG data	Transport Canada GHG data
Annual added CO_2	**44 t/yr**	**98 t/yr**	**178 t/yr**
50-yr total — EV-adjusted (school buses: 8% avg EV, factor 0.92×50=46 yr-equivalent)	2,042 t	4,493 t	8,170 t

NOTE — STUDENT WELFARE	*School bus detour emissions are the smallest component by CO_2 mass but the most directly traceable to student welfare impacts. Ontario's Student Transportation Fund allocates ~¢800M/year provincewide. Road closures forcing route detours add operating cost pressure without additional provincial reimbursement. The bus CO_2 impact will transition slowly to zero as school boards electrify fleets; the route-length and time impacts on students are permanent regardless of vehicle type.*

4. Category C — Farm Machinery

Farm machinery detour emissions were explicitly excluded from the Alto HSR Road Severance Technical Analysis table but acknowledged as a significant additional category. This section provides a first quantification. The southern corridor passes through some of the most intensively farmed land in Eastern Ontario, where approximately 60% of road closures will affect active agricultural operations.

Farm equipment road travel parameters differ materially from passenger vehicles. A modern agricultural tractor on road travel at 25–30 km/h consumes approximately 8–12 litres of diesel per hour, equating to 0.30–0.45 L/km. At the NRCan diesel CO_2 factor of 2.68 kg CO_2/litre, this produces 0.80–1.20 kg CO_2/km — 4–6× the rate of a passenger vehicle per kilometre. Farm equipment crossing frequency is seasonal; this analysis assumes an average of 50–90 equipment crossings per year per affected farm operation, reflecting planting, cultivation, harvesting, and input delivery movements across fields on opposite sides of the corridor.

4.1 Parameters and Annual Calculation

Parameter	Low	Central	High
Agricultural zone closures (60% of total)	210	300	420
Equipment crossings per farm per year	50	70	90
Average round-trip detour per crossing	6 km	8 km	10 km
Farm machinery CO_2 factor (road travel)	0.90 kg/km	1.05 kg/km	1.20 kg/km
Basis	Tractor: 8 L/hr, 0.30 L/km, 2.68 kg CO_2/L	Tractor: 10 L/hr, 0.38 L/km	Tractor: 12 L/hr, 0.45 L/km
Annual added CO_2	**57 t/yr**	**176 t/yr**	**454 t/yr**
50-yr total — EV-adjusted (farm machinery: ~3% EV by 2090; factor ~49 yr-equivalent)	2,778 t	8,644 t	22,226 t

FARM MACHINERY NOTE

Farm equipment will electrify far more slowly than passenger vehicles. Battery electric tractors exist in limited form (John Deere SESAM prototype) but commercial adoption for full-farm operations at scale is not projected before 2040 at the earliest, and rural charging infrastructure is essentially absent. For practical purposes, farm machinery detour emissions should be treated as a constant over the full 50-year operating period — making this the most durable emission category in the analysis.

5. Consolidated Results

The following tables consolidate all three categories into annual and 50-year totals.

5.1 Annual Excess CO2 by Category (t CO2e/yr)

Category	Low	Central	High	Primary driver
A. Light vehicles (cars, pickups, light trucks)	3,833	6,570	10,220	Closure count × household density × detour distance
B. School buses	44	98	178	Affected routes × detour km × 185 school days
C. Farm machinery	57	176	454	Ag. closures × crossing frequency × detour distance
TOTAL ANNUAL EXCESS CO_2	**3,934 t/yr**	**6,844 t/yr**	**10,851 t/yr**	All categories combined

5.2 50-Year Totals by Category and Scenario (t CO2e)

	Low		Central		High		
Category	Lo const.	Lo EV-adj.	Cen const.	Cen EV-adj.	Hi const.	Hi EV-adj.	Units
A. Light vehicles	191,650	92,747	328,500	158,994	511,000	247,324	t CO_2e
B. School buses	2,200	2,042	4,900	4,493	8,900	8,170	t CO_2e
C. Farm machinery	2,850	2,778	8,800	8,644	22,700	22,226	t CO_2e
TOTAL 50-YEAR	**196,680**	**97,567**	**342,204**	**172,131**	**542,560**	**277,720**	**t CO_2e**

5.3 Context: Relationship to 50-Year Lifecycle Budget

Metric	Central EV-adj. (t CO_2e)	As % of lifecycle total	Notes
Road severance detour emissions (50-yr EV-adj.)	172,131	0.81%	This analysis, central scenario
Cold-climate operational premium (50-yr)	680,000	3.19%	7 HDPDL-derived categories; companion operational note
Leda clay ground treatment (construction, central)	800,000	3.76%	200 km Ottawa–Montréal segment; companion construction note
Cold-climate construction premium (central)	2,300,000	10.80%	Harbin–Dalian design requirements, full 1,000 km
50-yr lifecycle total (central)	21,300,000	100%	Construction 14.69 Mt + 50-yr operations at 8M pax / current grid

KEY POINT

Road severance detour emissions (~1.2% of central lifecycle total) are smaller in absolute terms than the cold-climate and Leda clay categories. Their significance is qualitative as well as quantitative: they are the only emission category that is caused entirely and directly by a design decision — the closure of a road rather than the provision of a bridge. They are also the only category where the affected parties are third parties (rural households, farmers, school children) rather than the project operator. No level of technology improvement or grid decarbonisation reduces them.

6. Sensitivity Analysis

Three parameters dominate the result: road closure count, household density per closure, and average detour distance. The following table shows the sensitivity of the central annual total to ±50% variation in each key parameter, holding others at central values.

Parameter varied (±50% around central)	Annual CO_2 − 50%	Annual CO_2 +50%	Comment
Road closures (250 vs 750)	3,421 t	10,263 t	Linear relationship; closure count is the most policy-controllable variable
Households per closure (9 vs 27)	3,421 t	10,263 t	Reflects rural property density; higher on southern agricultural corridor
Detour distance (5 vs 15 km/day)	4,559 t	10,171 t	Most variable parameter; depends on nearest alternative crossing
Vehicle emission factor (100 vs 300 g/km)	2,671 t	8,013 t	Narrows as fleet electrifies; farm machinery less sensitive

The single most effective mitigation is not technology or electrification — it is the provision of grade separation structures rather than road closures. Every bridge built instead of a closure eliminates that closure's contribution entirely and permanently. Alto VP David Cook stated on record that the goal is to minimise overpass construction. The emissions estimated in this analysis are a quantified consequence of that stated goal.

7. What Alto Has Not Disclosed

As of March 2026, Alto has not published any of the following:

- A road crossing inventory for any corridor option under consideration, listing the number, type, and classification of crossings to be treated
- A crossing treatment methodology specifying the criteria that will determine whether a road receives a grade separation structure or is closed
- Any estimate of the number of road closures anticipated, or the detour distances that will result
- Any analysis of the vehicle emission implications of road closures over the operational life of the corridor
- Any acknowledgement that road closures generate permanent, annually recurring CO_2 emissions that partially offset the project's claimed decarbonisation benefit
- Any emergency services response time modelling accounting for road network severance
- Any school transportation analysis identifying routes that would require re-planning or students who would lose bus eligibility
- A comparison of crossing treatment standards between the northern and southern corridor options

8. Methodology and Sources

This analysis extends the quantitative framework in the Alto HSR Road Severance Technical Analysis (March 2026) in three ways: (1) scaling the light vehicle calculation to the full 1,000 km southern corridor; (2) adding Category C (farm machinery) as a first quantification; and (3) introducing an EV-adjusted 50-year total reflecting the progressive decarbonisation of the passenger vehicle fleet over the 2040–2090 operating period.

- Transport Canada TRAN Committee Appearance Binder, Item 15: High Frequency Rail, March 7, 2023 — 1,000+ crossing confirmation
- Alto HSR, Kingston City Council presentation (David Cook, VP Systems Engineering), February 17, 2026 — fencing confirmation; overpass minimisation stated goal; City of Kingston closed-captioning transcript
- Alto HSR Road Severance Technical Analysis, altohsrcitizenresearch.ca, March 2026 — source document for Sections 2 and 3
- NRCan EnerGuide Vehicle Data; Environment and Climate Change Canada National Inventory Report — 200 g CO_2/km rural Ontario fleet average
- Transport Canada GHG data — school bus 1,000–1,200 g CO_2/km
- NRCan diesel CO_2 factor: 2.68 kg CO_2/litre — applied to farm machinery consumption estimate
- Ontario MTO Official School Bus Handbook; Student Transportation Services of Central Ontario (STSCO) KPR Transportation Guidelines, Section 1.2
- Ontario Regulation 257/00 (Ambulance Act) — rural EMS response time standards
- The Canadian Encyclopedia, "Concession Line"; Wikipedia, "Concession road" — 2 km grid spacing basis
- EV fleet transition assumptions: Environment and Climate Change Canada Zero-Emission Vehicles projections; IESO Annual Planning Outlook grid intensity data

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