ALTO HSR CITIZEN RESEARCH INITIATIVE

Road Severance: Excess Lifecycle CO_2 Emissions

Quantification of Permanent Vehicle Detour Emissions — Model Input 3

Alto HSR Citizen Research Initiative — November 2026 Update — Second edition, revised. Supersedes the March 2026 edition prepared for the Alto HSR Public Consultation. — citizenresearch.ca

WHAT CHANGED IN THIS EDITION

- Masthead reissued as the November 2026 second edition.
- The electric-vehicle fleet trajectory is revised following the repeal of the federal Electric Vehicle Availability Standard — see Addendum A. Detour emissions rise as a result.
- The trajectory is now shared with the operational and consolidated notes; the March edition used two different trajectories across companion documents.
- Crossing counts, closure rates, detour distances and vehicle categories are unchanged. School buses and farm machinery are unchanged: the repealed standard applied to light-duty vehicles only.
- The §5.3 context table is restated against the consolidated output note's revised fifty-year lifecycle total of 17.56 Mt, replacing 21.3 Mt. Every previously uncosted category is a larger share of the total as a result.

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).

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

Table 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

Table 2. 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

Parameter	Low	Central	High
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

Table 3. 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 0.524, post-repeal)	100,423 t	172,132 t	267,761 t

> EV ADJUSTMENT NOTE — Light vehicles transition to EVs progressively over the 2040–2090 operating period. Assumptions: Following the repeal of the federal Electric Vehicle Availability Standard, the EV fraction is taken to rise from 15% (2040) to 70% (2080) and hold, averaging about 48% across the operating period — against the 20%-to-90% path assumed in March. The electric emission factor falls with the grid, from 12.3 g/km at today's 73.8 g/kWh to under 1 g/km on the IESO path. Integrating both effects year by year gives a fleet-weighted factor of 0.524 applied to the 50-year total, against 0.484 in March. The slower fleet transition dominates the cleaner grid, so detour emissions rise by about 8 per cent. 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

Table 4. 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

Table 5. Parameters and Annual Calculation — Parameter

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 CO_2 by Category (t CO_2e/yr)

Table 6. Annual Excess CO_2 by Category (t CO_2e/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 CO_2e)

Table 7. 50-Year Totals by Category and Scenario (t CO_2e)

	Low	Low		Central	Central		High	High					
Category	Low const.	Low EV-adj.	Low EV-adj.	Central const.	Central const.	Central EV-adj.	Central EV-adj.	High const.	High const.	High EV-adj.	High EV-adj.	Units	Units	Units
A. Light vehicles	191,650	100,423	100,423	328,500	328,500	172,132	172,132	511,000	511,000	267,761	267,761	t CO_2e	t CO_2e	t CO_2e
B. School buses	2,200	2,042	2,042	4,900	4,900	4,493	4,493	8,900	8,900	8,170	8,170	t CO_2e	t CO_2e	t CO_2e
C. Farm machinery	2,850	2,778	2,778	8,800	8,800	8,644	8,644	22,700	22,700	22,226	22,226	t CO_2e	t CO_2e	t CO_2e
TOTAL 50-YEAR	196,680	105,243	105,243	342,204	342,204	185,269	185,269	542,560	542,560	298,157	298,157	t CO_2e	t CO_2e	t CO_2e

5.3 Context: Relationship to 50-Year Lifecycle Budget

Table 8. 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.)	185,269	1.05%	This analysis, central scenario
Cold-climate operational premium (50-yr)	680,000	3.87%	7 HDPDL-derived categories; companion operational note
Leda clay ground treatment (construction, central)	800,000	4.55%	200 km Ottawa–Montréal segment; companion construction note
Cold-climate construction premium (central)	2,300,000	13.09%	Harbin–Dalian design requirements, full 1,000 km
50-yr lifecycle total (central)	17,560,000	100%	Construction 14.69 Mt + 50-yr operations of 2.87 Mt, integrated against the Modal Shift Note 3 central trajectory on the IESO grid path (consolidated output note, §5)

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.

Table 9. Sensitivity Analysis

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, citizenresearch.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

Addendum A (November 2026) Fleet electrification, after the repeal

The March edition assumed the light-vehicle fleet would electrify from 20 per cent in 2040 to 90 per cent in 2090, averaging approximately 55 per cent over the operating period, and applied an emission-factor adjustment of 0.484 to the fifty-year detour totals. That assumption rested on the federal Electric Vehicle Availability Standard.

The Standard has been repealed. The mandate was paused in September 2025, repeal was announced in February 2026, and the repealing amendment was posted in the Canada Gazette in August 2026 with a 75-day comment period and no replacement sales standard in force. Quebec has reduced its 2035 target to 80 per cent and British Columbia to 75 per cent. The proposed replacement greenhouse gas standard, targeting 75 per cent zero-emission sales by 2035, is not law.

This edition adopts a post-repeal trajectory rising from 15 per cent of the light fleet in 2040 to 70 per cent in 2080. The consequence for this note is that detour emissions are higher than the March edition estimated, because a larger share of the permanently displaced vehicle-kilometres continues to be driven by internal combustion vehicles.

Only the light-vehicle factor is revised. School buses and farm machinery were already assumed to electrify negligibly over the period — about 8 per cent and 3 per cent respectively — so a slower national transition moves them by less than the tables resolve, and their factors are carried forward unchanged. Light vehicles are the dominant category and the only one materially sensitive to the repeal.

The same change works against the Initiative's conclusion elsewhere. A dirtier displaced car fleet raises the modal-shift credit available to ALTO, and that effect is roughly an order of magnitude larger than the increase in detour emissions recorded here. Both effects are carried in the consolidated budget.

Road severance remains the one emission category in this analysis that cannot be reduced by grid decarbonisation, technology improvement or operational change. It is a direct consequence of the closure decision and persists for as long as the railway operates.