North American Trade and Transportation Corridors:

Environmental Impacts and Mitigation Strategies

Final Report

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EXECUTIVE SUMMARY

Trade between Canada, the United States and Mexico has grown rapidly since the implementation of the North American Free Trade Agreement (NAFTA). Naturally, the increase in trade-related transport activity has influenced the environmental consequences in trade corridors. This study examines the environmental impacts of that trade on five binational segments of three primary NAFTA trade corridors, with a particular focus on air pollution emissions. The corridor segments selected for the analysis are Vancouver-Seattle, Winnipeg-Fargo, Toronto-Detroit, San Antonio-Monterrey and Tucson-Hermosillo. The study determines current and future commodity flows, freight vehicle traffic volumes and emissions in each of these corridor segments. The impacts of several mitigation strategies are also explored.

Currently, NAFTA trade contributes significantly to air pollution in all the corridors, particularly NO_x and PM_{10} emissions. Cross-border freight is responsible for 3 to 11 percent of all mobile source NO_x emissions in the corridors and 5 to 16 percent of all mobile source PM_{10} emissions. Trucking carries most of the freight in the corridors and currently contributes the bulk of trade-related emissions—typically three-quarters of NO_x and more than 90 percent of PM_{10}. Truck idling associated with border crossing delay contributes significantly to CO emissions, particularly in corridors where border delay is problematic. As much as six percent of all trade-related CO emissions in the corridors are caused by truck idling. Local inventories of CO_2 and other greenhouse gases are under development but not yet available. Nonetheless, it is known that ground freight overall accounts for nearly 20 percent of total North American mobile source greenhouse gas emissions, and it is likely that trade-related freight accounts for approximately this percentage in some corridors.

By 2020, due to the large expected reduction in emission rates, total trade-related emissions of NO_x and PM_{10} will decline or remain constant compared to current levels. This occurs despite trade volumes that grow by two to four times. In most US-Canada corridors, NAFTA freight emissions of NO_x and PM_{10} per ton-kilometer will drop to less than one-fifth their current levels. The gains in the US-Mexico corridors will not be quite as large under the assumption that low-sulfur diesel will not be widely available in Mexico, but NAFTA freight emissions of NO_x and PM_{10} per ton-kilometer are still expected to drop to about one-quarter of their current levels.

Trade-related emissions of CO_2 and other greenhouse gases and of CO will not be reduced under the new emission standards, and are therefore expected to rise substantially by 2020. Under the baseline 2020 growth scenario, CO_2 emissions from NAFTA trade will increase by 2.4 to 4 times over their current levels in the five corridors. Such increases are critical in light of national goals of stabilizing or reducing such emissions.

Changes to assumptions about trade growth rates or future mode share can have a major effect on estimations of future emissions. For example, if the growth in truck and rail traffic follows the trend over the past decade, NO_x and PM_{10} emissions from trade could be as much as 50 percent higher than the estimated 2020 Baseline levels. If this occurs, 2020 emissions of NO_x and PM_{10} could exceed 1999 levels in some corridors. Changes in the rail/truck mode share would also affect future emissions, though less significantly. For example, a shift from truck to rail would increase NO_x and PM_{10} emissions in most corridors, though it would simultaneously reduce emissions of VOC, CO and CO_2.

Opportunities exist to achieve lower trade-related emissions through implementation of mitigation strategies. The study explores five such strategies for truck freight:

- Use of natural gas for heavy-duty trucks is an effective strategy to reduce trade emissions (particularly PM_{10}) through the next decade. By 2020, the vast improvement in diesel engine emissions for certain pollutants means that natural gas will probably not offer an emission reduction in the Canada-US corridors. In US-Mexico corridors in 2020, under the assumption that low-sulfur diesel fuel is not widely available in Mexico, use of natural gas by 20 percent of Mexican trucks would reduce PM_{10} trade-related emissions by 10 percent.
- Commercial vehicles face an average delay of up to one hour to cross Canada-US and US-Mexico borders. Policy changes and investments could cut this delay in half, and would result in a reduction of 0.2 to 0.6 metric tons of CO per day at each crossing (1.5 to 2.4 percent of trade-related truck emissions in the corridor segments).
- The use of low-sulfur diesel fuel in Mexico would allow Mexican trucks to achieve the same dramatic emission reductions expected for US and Canadian trucks. If Mexican truck emission rates match those in the United States by 2020, trade-related emissions of NO_x, VOC and PM_{10} in the San Antonio-Monterrey corridor would be cut approximately in half.
- Improving the efficiency of freight transport by reducing empty vehicle mileage would increase efficiency and lower all pollutant emissions from trade. In the Toronto-Detroit corridor, reducing the fraction of empty trucks from 15 percent to 10 percent would eliminate over 0.5 metric tons of NO_x and 600 metric tons of CO_2 per day in 2020 (five percent of the trade-related truck total). The US-Mexico corridors have the potential for even larger reductions, but the data needed for such analysis are incomplete.
- Allowing the use of longer combination vehicles (LCVs) in NAFTA corridors would reduce truck volumes and associated emissions. Because LCVs lower the cost of shipping by truck, some freight would likely shift from rail to truck. Increasing the truck weight limits in five US midwestern states to 47,854 kilograms (105,500 pounds) and allowing Rocky Mountain Double configurations would reduce emissions of all pollutants by 4 to 7 percent compared to the 2020 baseline.

Some of the data needed to assess environmental impacts of trade and transportation corridors are unavailable or highly uncertain. A coordinated effort to collect and disseminate information is needed, particularly in the following areas:

- Cross-border traffic volumes, including number of empty versus full trucks and rail cars;
- Freight origin-destination patterns in the border regions;
- Data and methodology to estimate railroad emissions; and
- Measurements of average commercial vehicle delay at border crossing.

1 INTRODUCTION

The implementation of the North American Free Trade Agreement in 1994 strengthened the already healthy economic relationships between Canada, the United States and Mexico. Since the signing of NAFTA, US trade with Canada has nearly doubled and now totals $410 billion per year. US-Mexico trade has grown even more rapidly, more than tripling to $252 billion annually. Canada-Mexico trade, while still quite small at $7.5 billion, has increased more than two-fold over the same period. This trade has undoubtedly increased prosperity in all three nations. But there have also been environmental consequences in corridors that carry the trade.

The liberalization of North American trade can have a variety of both positive and negative environmental impacts. In a basic sense, trade can affect the environment through changes in the scale of production, through wider dissemination of products, and indirectly through altering the structure of production processes.[1] This paper considers environmental impacts associated with only one element of trade liberalization—the physical movement of goods between nations. And although North American goods movement occurs by a variety of means—highways, railways, waterways, air and pipeline—we focus primarily on trucking and rail freight, since these modes contribute most significantly to adverse environmental impacts.

A large body of research has explored the environmental effects of freight transportation, yet very little has tried to isolate the impacts of freight associated with international trade. This is a challenging task, since NAFTA trade occurs in the context of other freight and transportation activity in multiple local, state/provincial and national jurisdictions. Furthermore, the available information on North American goods movement is generally not structured to assess how trade affects the environment along freight corridors. A goal of this study is to highlight areas of incompatible or inadequate technical data and bring focus on the need for better coordination in trinational environmental planning

The primary purpose of this report is to identify the current and future air quality impacts that occur as a result of the development of North American trade and transportation corridors. Five binational corridor segments are selected for detailed analysis, as discussed in Section 2. In Section 3, current levels of trade, truck and railroad movements, and pollutant emissions are calculated for each corridor. Section 4 presents a similar analysis for the year 2020, based on trade growth scenarios. Section 5 evaluates the effectiveness of various mitigation strategies in reducing trade-related emissions. Other types of environmental impacts associated with truck and rail freight are briefly discussed in Section 6. Section 7 identifies areas where existing data are insufficient to properly evaluate environmental impacts. A summary of the findings is presented in Section 8.

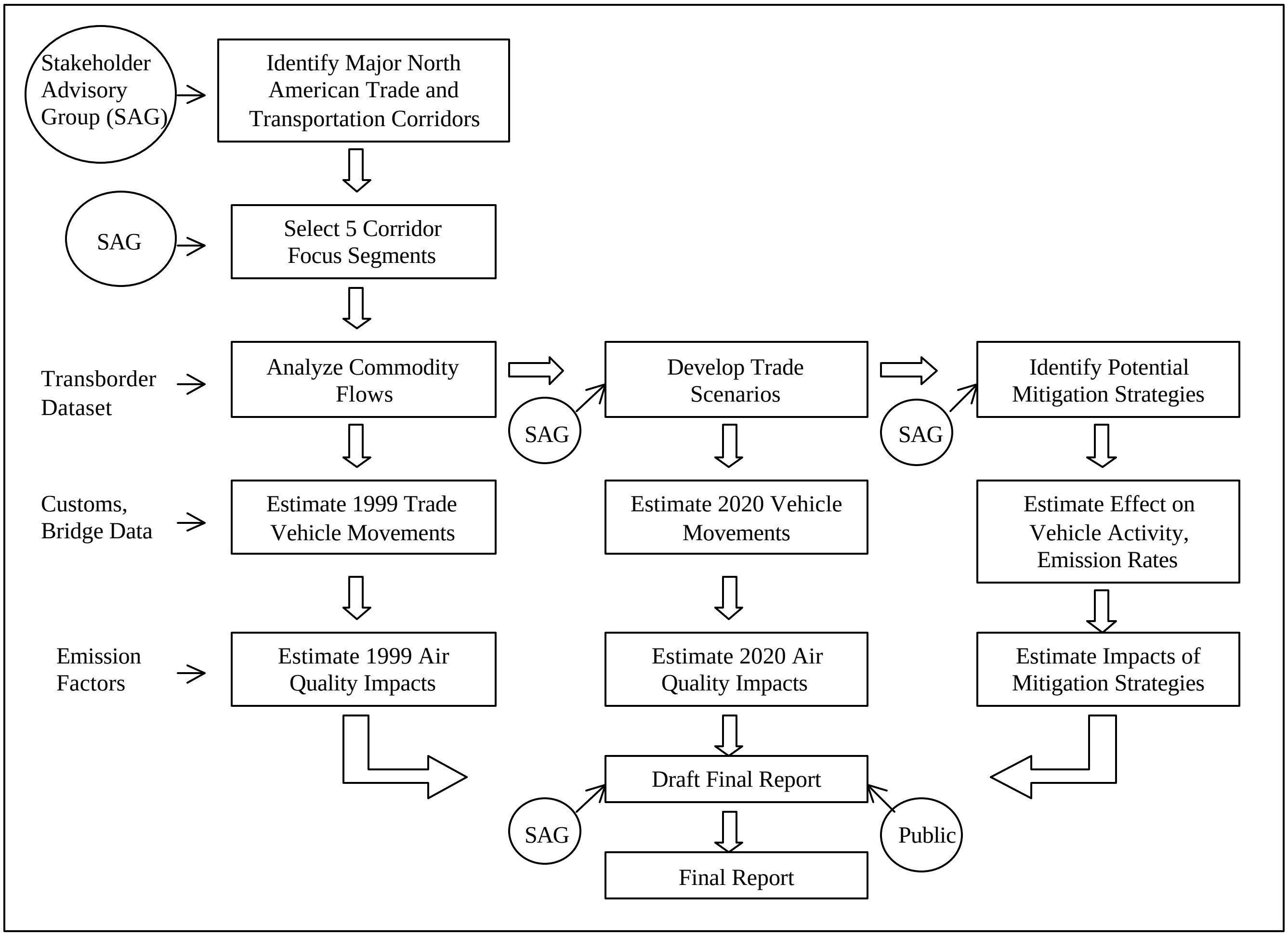
Three appendices are attached to this final report. Appendix A includes commodity flow summary tables for each corridor. Appendix B contains comments from reviewers of the draft report, and Appendix C contains responses to a selection of these comments.

[1] *NAFTA Effects—A Survey of Recent Attempts to Model the Environmental Effects of Trade*.

2 METHODOLOGY

The study methodology is illustrated by the roadmap shown in Exhibit 1. Each major element is described in greater detail below.

Exhibit 1: Study Methodology Roadmap

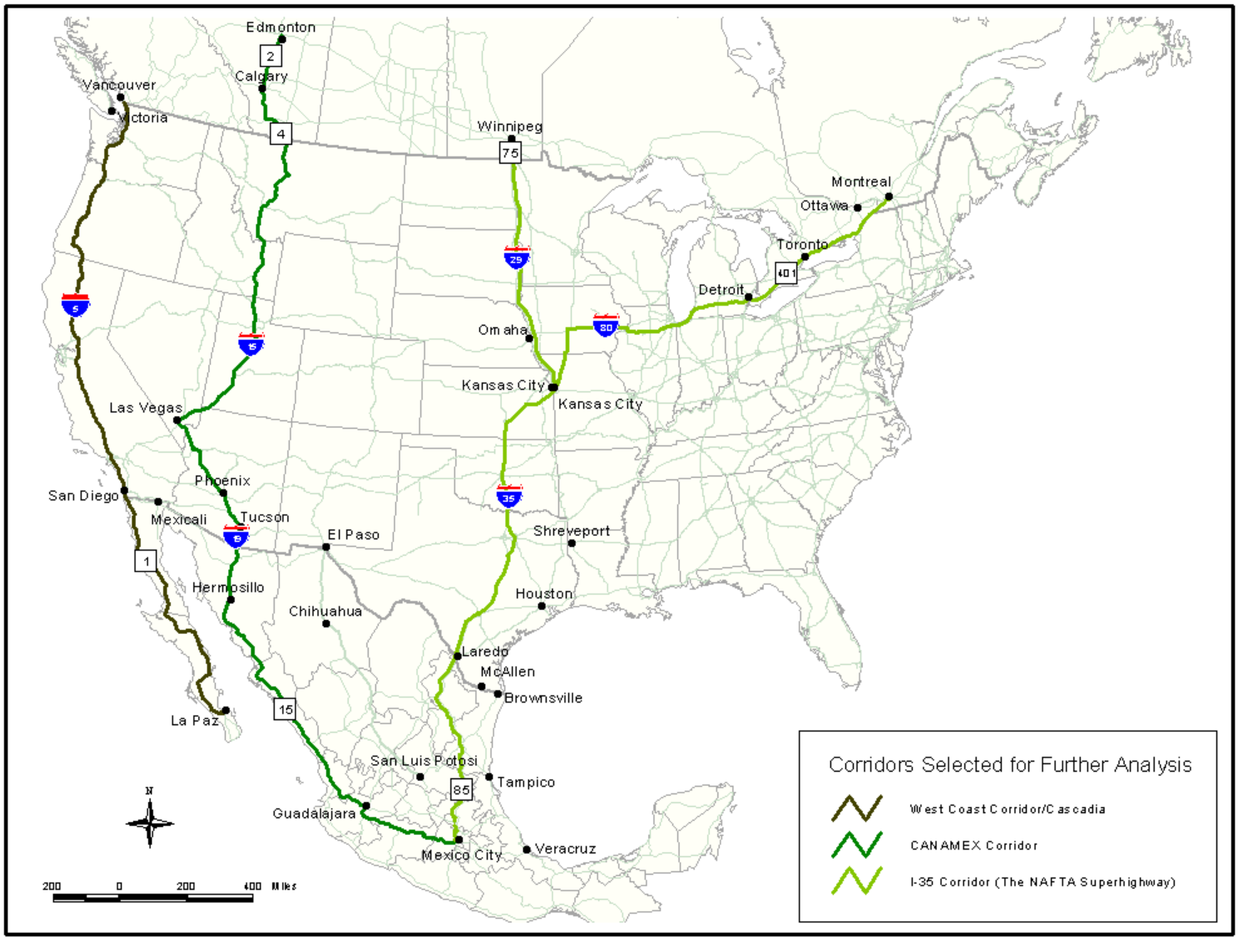


2.1 Corridor Selection

The first task was to select specific trade and transportation corridors for the analysis. This was accomplished by first identifying major North American trade corridors, crossing all three nations, and then selecting segments of these full corridors for detailed analysis. Most corridors are generally defined by highway routes, although all corridors selected for this analysis include freight rail service and possibly waterborne freight service.

Initially, seven major corridors were identified based on a review of previous studies. Three corridors stood out as being the most significant in terms of Canada-US-Mexico trade: the West Coast Corridor, the CANAMEX Corridor, and the North American Superhighway Corridor. We solicited feedback from the Stakeholder Advisory Group (SAG) to verify the appropriateness of these three corridors and to identify segments that should serve as the focus of the study. These corridors are shown in Exhibit 2 and described below.

Exhibit 2: Selected North American Trade and Transportation Corridors



- The West Coast Corridor runs from Vancouver, British Columbia, along the West Coast of the United States following Interstate 5, to Tijuana, Mexico and further south into Baja California. It is also sometimes known as the Cascadia Corridor, the I-5 Corridor, or the Pacific Highway. The US portion is federally designated as High Priority Corridor #30. Rail service runs parallel to the highway route throughout most of the corridor.
- The CANAMEX Corridor runs from Edmonton, Alberta through Calgary and into Montana, then to Salt Lake City, Las Vegas and Phoenix before crossing the Mexican border at Nogales and continuing to Hermosillo and Guadalajara. The US portion has been designated as High Priority Corridor #26. It is sometimes referred to as the I-15 Corridor. Parallel rail service runs south from Tucson.
- The North American Superhighway Corridor (NASCO) runs from Winnipeg, Manitoba through Fargo, Kansas City, Dallas and Laredo, Texas, then enters Mexico and runs through Monterrey to Mexico City. It is also called the Mid-Continent Corridor or the I-35 Corridor, while the northern portion is also called the Red River Trade Corridor. A

branch runs east from Kansas City through Chicago, Detroit, and on to Toronto and Montreal. Parallel rail service runs throughout the entire corridor.

These three corridors were characterized along the following dimensions: 1) the transportation system (highway and rail), 2) socioeconomic characteristics of the major urban areas, and 3) an identification of critical segments along the full corridors. Five of these critical segments were then selected for detailed analysis of trade, transportation and environmental impacts. The goal was to define segments that are long enough to allow the capture of trade impacts beyond the immediate border area but short enough so that corridor freight activity is still dominated by NAFTA trade. In selecting the segments, we chose those that were identified as most critical by SAG members, those that cross an international boundary, and those that offer both highway and rail alternatives. The five segments are listed below:

- West Coast Corridor North (Vancouver British Columbia to Seattle/Olympia, Washington)
- North American Superhighway Corridor Northwest (Winnipeg, Manitoba to Fargo, North Dakota)
- North American Superhighway Corridor Northeast (Toronto, Ontario to Detroit/Ann Arbor, Michigan)
- North American Superhighway Corridor South (San Antonio, Texas to Monterrey, Nuevo Leon)
- CANAMEX Corridor South (Tucson, Arizona to Hermosillo, Sonora)

2.2 Commodity Flows

Commodity flow data were used to analyze trade and transportation in each corridor segment. By building the analysis off a base of commodity flow data rather than simply vehicle counts, we can explore issues such as origin/destination patterns, changes in trade levels in particular industries, changes in vehicle size and weight, and shifts in mode share.

The commodity flow information was developed from analysis of the Transborder Surface Freight Dataset, maintained by the US Bureau of Transportation Statistics. This dataset is populated electronically from customs reports and is considered fairly accurate for border crossings by surface transportation modes. The dataset includes information on shipment weight and value, mode, commodity, port of entry (POE), and state/province of origin and destination. The dataset does not include a single file that contains all of this detail simultaneously, however. In particular, no file contains both commodity detail and POE detail. Therefore, we estimated commodity flows through particular POEs by multiplying the commodity mix between each state/province pair by the portion of flow between that pair that uses the particular POE. In addition, adjustments to the database were needed to account for the fact that US exports are reported only in terms of shipment value. To convert these values to weight, we used the US import files to estimate value to weight ratios for each commodity (and in the case of Canada-US flows, for each province).

Because the commodity flow analysis was conducted using a database built from US Customs Service records, shipments between Canada and Mexico are not represented. Canada-Mexico commodity flows are currently small compared to flows between these counties and the United States, and can be considered as having no significant impact when conducting a transportation and environmental analysis. Two-way Canada-Mexico merchandise trade totaled $7.5 billion in 1999, only two percent of the value of Canada-US merchandise trade and four percent of US-Mexico merchandise trade. These amounts are therefore likely within the margin of accuracy for the data and analysis in this report.

Table 1 summarizes truck and rail commodity flows through the five corridor segments.[2] The Toronto-Detroit Corridor (which includes both the Detroit-Windsor and Port Huron crossings) carries by far the highest freight tonnage—more than the other four corridors combined. All corridors have significant rail flows though only in one (Winnipeg-Fargo) does rail tonnage exceed truck tonnage.

Table 1: Summary of 1999 Cross-Border Commodity Flows (millions of kg)

Corridor Segment	By Truck			By Rail			By Truck and Rail		
	N-bound	S-bound	Sub-Total	N-bound	S-bound	Sub-Total	N-bound	S-bound	Total
Vancouver-Seattle	3,112	3,711	6,822	840	3,557	4,398	3,952	7,268	11,220
Winnipeg-Fargo	2,098	2,358	4,456	652	4,132	4,784	2,750	6,490	9,240
Toronto-Detroit *	22,355	21,677	44,032	5,466	12,104	17,569	27,821	33,780	61,601
San Antonio-Monterrey	7,281	10,345	17,626	2,994	5,950	8,944	10,275	16,295	26,571
Tucson-Hermosillo	2,385	1,390	3,775	981	579	1,560	3,366	1,969	5,335

* Northbound flows are United States to Canada, Southbound flows are Canada to United States

2.3 Freight Vehicle Movements

Determining environmental impacts requires information on freight vehicle movements, both full and empty, in a corridor. Commodity flows may not be proportional to freight vehicle traffic because many vehicles travel empty or carry less than their maximum capacity. We collected information on cross-border truck and rail movements from US Customs, Canada Customs, and private bridge and tunnel operating authorities.[3] These agencies report crossings for all commercial vehicles, including smaller two- and three-axle trucks that may not be engaged in international trade. Because the focus of this study is NAFTA-related trade, we calculated the number of larger trucks (four or more axles) at each crossing, and assumed that this represents the number of trade-related freight trucks. Smaller trucks are typically service-related vehicles that are not engaged in long-distance merchandise trade. Information on truck size at the border crossings is available from a variety of border crossing surveys, though it is not consistently

[2] Note that the full commodity flow tables include origin or destination information by 50 US states and 98 commodities (two-digit Harmonized Tariff System) and therefore cannot easily be displayed in a report format.
[3] Southbound truck volumes at Nogales were not available, and were assumed to equal northbound volumes.

reported.[4] In corridors where the border region is sparsely populated, such as Winnipeg-Fargo, nearly all freight traffic at the border is associated with longer-distance trade, and large trucks make up over 95 percent of all trucks. Where large population centers lie on each side of the border, a higher percentage of service trucks cross the border daily and tend to bias commercial vehicle counts.

Cross-border rail car volumes were available for some corridors but not for all. Some customs stations do not compile rail car traffic statistics at all, or do not distinguish between full and empty cars. At other crossings, like the rail tunnels between Ontario and Michigan, the information is considered proprietary. As described below, this lack of information did not preclude emissions calculations because rail emissions are determined from freight tonnage and fuel consumption.

We also used the commodity flows to estimate freight vehicle movements. Commodity flow tonnage was converted to the number of loaded freight vehicles (truck trailers or rail cars) using average payload information. For trucks, average payloads were derived from commodity densities by two-digit Harmonized Tariff System (HTS) code while for rail cars, average payloads were developed from the 1992 Rail Waybill Sample.[5] [6] These figures were then used to calculate the number of loaded freight vehicles. For truck freight, a scaling factor was derived for each corridor and direction that relates commodity flow tonnage to total vehicle counts. This scaling factor was used to estimate how future changes in commodity flows would affect vehicle movements.

Table 2 shows cross-border volumes of freight vehicles. Trade truck volumes are based on counts at border stations and include both full and empty vehicles. Rail volumes represent loaded cars only, calculated from commodity flow data.

Table 2: Cross-Border Freight Traffic Volumes, 1999

Corridor Segment	Trade Trucks (loaded and empty)			Rail Cars (loaded only)		
	N-bound	S-bound	Total	N-bound	S-bound	Total
Vancouver-Seattle	396,586	426,464	823,050	12,156	51,429	63,585
Winnipeg-Fargo	172,295	190,433	362,728	10,478	53,638	64,116
Toronto-Detroit *	2,337,266	2,340,007	4,677,273	78,869	202,947	281,816
San Antonio-Monterrey	1,189,209	1,045,324	2,234,533	56,451	87,200	143,651
Tucson-Hermosillo	219,471	219,471	438,942	13,792	8,831	22,623

* Northbound flows are United States to Canada, Southbound flows are Canada to United States

[4] See *1995 Commercial Vehicle Survey: Station Summary Report*; *Binational Border Transportation Planning and Programming Study*; Leidy 1995; *Lower Mainland Truck Freight Study;* and *Prairie Provinces Transportation System Study*.
[5] Figliozzi 2001.
[6] Hancock 2001.

2.4 Future Trade Scenarios

Trade growth scenarios were developed to investigate environmental impacts in 2020 under alternative conditions. A 2020 Baseline Scenario was developed for each binational corridor segment based on historic trends and forecasts from other studies. Because the past decade has been a period of historically high trade growth among NAFTA countries as well as a period of relatively strong economic growth overall, the Baseline Scenarios in all five cases envision somewhat slower growth than seen in recent years. The scenarios are not intended to be trade forecasts, but merely illustrate a range of possible future conditions. The impacts of each Baseline Scenario are then compared with one or more alternative scenarios, each of which assumes some change to the transportation industry or infrastructure in the corridor. In some cases, the alternatives include more rapid trade growth by either truck or rail. Other alternatives assume a change in shipping cost by one mode, resulting in mode shifts. The magnitude of the mode shifts was estimated using the cross elasticities shown in Table 3.[7] These figures describe the percentage of rail freight diverted given a change in the relative cost of shipping by truck versus rail. For example, a one-percent decrease in trucking cost would shift 3.6 percent of railroad's finished farm produce tonnage to trucking. These elasticities account for the fact that some products are more suited to one mode or another and are unlikely to experience diversion under any cost changes.

Table 3: Rail Ton-Mile Cross-Elasticity by Commodity

Commodity	Rail Ton-Mile Cross Elasticity
Bulk Farm Products	0.03
Finished Farm Products	3.60
Bulk Food Products	0.73
Finished Food Products	2.10
Lumber and Wood	0.65
Furniture	0.44
Pulp and Paper	0.82
Bulk Chemicals	0.58
Finished Chemicals	3.35
Primary Metals	1.35
Fabricated Metals	6.25
Machinery	4.25
Electrical Machinery	4.45
Motor Vehicles	0.25
Motor Vehicle Parts	1.25
Waste and Scrap	0.19
Bulk All Else	0.18
Finished All Else	4.20

[7] From *A Guidebook for Forecasting Freight Transportation Demand*.

2.5 Emission Factors

In each corridor, we calculated the impact of cross-border trade on emissions of oxides of nitrogen (NO_x), volatile organic compounds (VOC), carbon monoxide (CO), particulate matter less than 10 microns in diameter (PM_{10}), and carbon dioxide (CO_2). Air pollution emissions are generally calculated by applying freight vehicle activity data to emission factors. Properly determining these emission factors is critical to the analysis process and the resulting conclusions. Details of their development are provided below.

1999 Truck Emission Factors

Heavy-duty truck emission factors for NO_x, VOC and CO were estimated using the US EPA's MOBILE5 model. PM_{10} emission factors were estimated using EPA's PART5 model, and CO_2 factors were estimated from fuel combustion characteristics for diesel.[8] All trade trucks were assumed to be powered by diesel engines. Two sets of emission factors were developed—an on-highway emission rate based on a 55-mph average speed and an idle emission factor. Fuel economy data were based on annual average fuel economy statistics as published by the US Department of Energy.[9]

The emission factors are dependent upon the age of the fleet and mileage accumulation rates. The age distributions for US and Canadian trucks were based on line-haul truck registration data. The trucks were assumed to have national average levels of tampering and not subject to an Inspection/Maintenance program. PM_{10} factors only reflect exhaust emissions, not re-entrained road dust. The Mexican line-haul fleet was assumed to have the same age distribution as Canada and the United States. However, pre-1993 Mexican trucks are treated as unregulated emissions (pre-1988 US fleet with appropriate mileage accumulation), since Mexico had no diesel truck emission standards prior to that model year. We assumed the Mexican drayage fleet (for cross-border movements) was an average of five years older than the US and Canadian line-haul fleets, with the resulting net effect that only 10 percent of the fleet was post-1993 trucks. Diesel fuels in Mexico were assumed to be the same as the United States, with 500 parts per million (ppm) sulfur.

2020 Truck Emission Factors

Calculations of emissions in 2020 depend heavily on the assumptions about future-year truck emission factors. In December 2000, the US EPA approved very stringent emission standards for model year 2007 and later heavy-duty highway engines. NO_x emissions under the new standards will be 20 times lower than current standards, while VOC and PM_{10} emissions will be ten times lower. The standards will be phased in over three years, with all new engines meeting the standards by 2010. The dramatic emission reductions are made possible largely because of US EPA rules regarding the sulfur content of diesel fuel. Emissions control technologies for heavy-duty diesel engines, such as catalytic particulate filters and NO_x catalysts, are not able to function with high sulfur levels in diesel fuel. EPA's December 2000 rulemaking requires that by 2006,

[8] Stodolsky 2000
[9] *Annual Energy Outlook*.

the sulfur content of diesel be reduced to 15 ppm, down from the current standard of 500 ppm. Canada has published a notice of intent to adopt a similar standard. For this study, we assumed that the new heavy-duty truck emissions standards would take effect as scheduled in both the United States and Canada. However, it is possible that implementation of the new standards will be delayed, and this would result in considerably higher 2020 emission factors for US and Canadian trucks.

Emission factors for 2020 were determined in the same way as for 1999, but with the inclusion of the 2004 and the new US 2007 diesel regulations. We assumed that Canada will adopt the new US diesel standards and they will take effect concurrent with the US standards. A version of the MOBILE5 model was run which incorporates the 2004 emission standards (note that the 2004 standards do not affect PM emissions). Since the MOBILE5 and PART5 models do not currently include the 2007 emission standards, these were incorporated outside the model assuming no deterioration and a current conversion factor for brake-horsepower versus fuel consumption. In 2020 only 8.4 percent of the line haul fleet will be 2006 or earlier trucks.

Emission factors for the 2020 Mexican line-haul fleet assumed adoption of the US 2004 standards, but not the more stringent 2007 standards. The Mexican line-haul fleet was assumed to have the same age and fleet distribution as the US and Canadian line-haul fleets. Separate emission factors for the older drayage truck fleet were not used in 2020. We assume that use of these vehicles for cross-border movements will be phased out. Diesel fuels in Mexico were assumed to remain at the current level of 500 ppm sulfur. All truck emission factors are shown in Tables 4 and 5.

Table 4: Truck Emission Factors, Freeway

		Truck Emission Factors, Freeway (g/mile)				
		NO_x	VOC	CO	PM_{10}	CO_2
1999	US/Canada	12.8	1.06	6.50	0.75	1612
	Mexico Line Haul	19.3	1.50	7.28	1.13	1612
2020	US/Canada	1.38	0.32	6.21	0.051	1612
	Mexico	4.73	0.96	6.21	0.262	1612

Table 5: Truck Emission Factors, Idling

		Truck Emission Factors, Idling (g/minute)				
		NO_x	VOC	CO	PM_{10}	CO_2
1999	US/Canada	0.78	0.21	1.76	0.036	173
	Mexico Drayage	1.72	0.39	2.44	0.082	173
2020	US/Canada	0.08	0.05	1.68	0.003	173
	Mexico	0.32	0.19	1.95	0.017	173

One result of the new emissions standards is that by 2020, truck emissions of NO_x and PM_{10} per ton-kilometer are considerably lower than rail in the US-Canada corridors. In the three US-Canada corridors studied here, rail NO_x and PM_{10} emissions per ton-kilometer are 1.5 to 2.7 times higher than trucking. (The variation depends on the truck empty fraction and the amount of border delay.) In the US-Mexico corridors, rail NO_x and PM_{10} emissions per ton-kilometer remain slightly lower than those for trucks. In all corridors, rail enjoys a large advantage over trucking in terms of emissions of other pollutants and fuel consumption per ton-kilometer. Rail emissions of CO and CO_2 per ton-kilometer are only about one-tenth of the rate for trucks in 2020.

Rail Emission Factors

Rail locomotive emissions are typically calculated based on fuel use rather than miles of travel. In April 1998, the US EPA finalized emission standards for NO_x, hydrocarbons (HC), CO, PM_{10} and smoke for newly manufactured and rebuilt diesel-powered locomotives, which had been unregulated in the United States before this action. The standards call for a 45 percent reduction in NO_x emissions for locomotives built between 2002 and 2004 (Tier I), and a 59 percent reduction in NO_x for those built in 2005 and later (Tier II). Hydrocarbon and PM_{10} emissions for locomotives built in 2005 and later must be 40 percent lower. Because of the long life of locomotives, the benefits of these new standards will be only partially realized by 2020. We assume that both Canada and Mexico will adopt similar standards.

Locomotive emission factors were developed using EPA's *Locomotive Emission Standards: Regulatory Support Document* (April 1998), and reflect only Class I line-haul locomotives. The emission rates assume that all locomotives manufactured between 1973 and 2001 will be rebuilt to Tier 0 standards according to the 1997 EPA regulations. Locomotives built in 2002–2004 are assumed to meet Tier I standards at the time of manufacture and each subsequent remanufacture. Those built in 2005 and later are assumed to meet Tier II standards at the time of manufacture and each subsequent remanufacture. The small number of pre-1972 locomotives in service are not assumed to be in line-haul service.

We also anticipate that the United States and Canada will adopt low-sulfur standards for diesel fuel by 2020. Because sulfur in fuel contributes to particulate emissions, the introduction of low-sulfur diesel in the United States and Canada will likely reduce locomotive PM_{10} emissions even without new control technologies. There is very little information on this effect to date, but one study suggests that PM_{10} may be reduced approximately 19 percent.[10] We have incorporated this reduction to estimate 2020 US and Canadian locomotive emissions, shown in Table 6.

[10] *Diesel Fuel Effects on Locomotive Exhaust Emissions*.

Table 6: Locomotive Emission Factors

	Locomotive Emission Factors (g/gal)				
	NO_x	HC	CO	PM_{10}	CO_2
1999	269.4	10.0	26.5	6.69	9834
2020	127.1	7.0	26.5	3.69 (4.55)*	9834

* Mexican locomotives

To calculate 1999 railroad fuel use, we estimated an average fuel consumption rate per revenue-ton-mile of freight hauled.[11] This figure (386 ton-miles per gallon) reflects all Class 1 railroad operations in the United States. Railroads are becoming more fuel efficient for several reasons, including the introduction of more AC-generation locomotives, the development of more efficient diesel engines, and lower rail car tare weights. To estimate the fuel consumption rate for 2020, a curve was fit to historic data and projected to future years. Fuel efficiency is thus projected to reach 456 revenue ton-miles per gallon in 2020.[12] Fuel consumption rates were applied to corridor railroad ton-miles for 1999 and the 2020 scenarios. Fuel consumption was then multiplied by the emission factors to estimate locomotive emissions.

It is quite possible that the availability of low sulfur diesel will lead to future emissions standards for locomotives that are lower than the 2005 standards. In the United States, Argonne National Laboratory is beginning a research study of advanced emission controls for locomotives. However, there are currently no plans to reduce locomotive emission standards in the United States. If lower standards are implemented before 2020, the slow turnover of the locomotive fleet means that the average emission rates in 2020 will probably not be very different from those shown in Table 6.

2.6 Stakeholder Advisory Group

The study was guided by a Stakeholder Advisory Group (SAG). The role of the SAG was to assist the research team with: 1) the selection of trade and transportation corridors, 2) the identification of existing environmental initiatives in the corridors, and 3) the selection of environmental mitigation measures for analysis. The SAG also provided comments on the draft working paper, some of which are included in Appendix B. In addition, it is hoped that the SAG will play a role in increasing awareness of the project's results and thereby help to sustain the long-term goals of the effort. However, the report conclusions are the authors' alone and do not necessarily represent the views of SAG members.

The SAG is comprised of representatives from both government and non-government organizations (NGOs). Government representatives include staff from environmental agencies (Environment Canada, US Environmental Protection Agency, Instituto Nacional de Ecología de Mexico), trade/commerce agencies (Canadian Department of Foreign Affairs and International Trade, US Department of Commerce, Secretaría de Economía de Mexico) and transportation/energy agencies (Transport Canada, US Department of Energy, Secretaría de

[11] *Railroad Facts*.
[12] *Air Quality Issues in Intercity Freight.*

Comunicaciones y Transportes de Mexico). The SAG also includes a representative from at least one NGO in each country, including the Manitoba Clean Environment Commission, Environmental Defense, and the Foundation for Intermodal Research and Education. The latter organization also served to represent transportation stakeholders, as did a Mexican trucking company that was included on the SAG.

3 CURRENT TRADE AND AIR QUALITY IMPACTS

This section describes the current levels of trade-related transportation activity in each corridor and its impacts on air quality. Emissions are estimated for four criteria pollutants (NO_x, VOC, CO and PM_{10}) as well as CO_2, the leading greenhouse gas. From the freight transportation sector, NO_x and PM_{10} emissions present the biggest concern and the greatest potential for local air quality benefits. NO_x is a precursor to ground-level ozone (smog) and is chiefly produced by high-compression internal combustion engines. PM_{10} includes the fine soot particles produced in diesel engines. Most of the particulate matter from trucks and locomotives consists of the fine particles known as $PM_{2.5}$, which are most dangerous to human health. In the United States, heavy-duty trucks are responsible for approximately 20 percent of mobile source NO_x and PM_{10} emissions nationwide, while locomotives contribute approximately 5 percent. The freight sector is not a major contributor of CO nationally. But heavy-duty trucks can contribute significantly to localized concentrations (hot spots) of CO in urban areas.

In each corridor, we identify urban areas that do not meet national air quality standards for ozone, particulate matter or CO. Note that the US EPA recently announced its intention to revise the existing ozone and PM_{10} standards. For ozone, the one-hour standard will be replaced with an eight-hour standard to protect against longer exposure periods. The PM_{10} standard will be supplemented with a new $PM_{2.5}$ standard, based on the recognition that these fine particles contribute more to health effects than coarse particles. Implementation of these standards has been halted because of legal challenges. If they do take effect, they may result in some urban areas in the corridors being re-classified to non-attainment status. Canada is also ratifying a nationwide $PM_{2.5}$ standard

CO_2 is a common gas and does not pose a direct threat to human health. However, it is the primary component of the greenhouse gases (GHGs) that contribute to global warming. Transportation sources emit around 30 percent of total GHGs in North America, and CO_2 comprises about 95 percent of these transportation GHGs. Ground freight in North America represents about 20 percent of transportation GHG emissions, or therefore about 6 percent of total GHG emissions on the continent.

In general, the emissions calculations for all five pollutants involve multiplying truck and rail traffic volumes by the corridor length by the appropriate emission factor. Although they are similar, the five corridor segments are not exactly equal in length. In order to simplify the comparisons between corridor segments in terms of total trade-related emissions and the impacts of border delay, the lengths of the corridor segments have been standardized for the purpose of emissions calculations. Thus, each corridor segment is assumed to be 364 kilometers long (226 miles). This is the exact length of the Winnipeg-Fargo corridor and the Vancouver-Seattle/Olympia corridor. The other three corridors (Toronto-Detroit/Ann Arbor, San Antonio-Monterrey, and Tucson-Hermosillo) are slightly longer, so the emissions calculations reflect freight movement along only a portion of the full corridor segment.[13]

Truck idling emissions are also estimated based on border delay and presented separately. The impact of border idling generally looks quite small as compared to full corridor emissions. If shorter segments were chosen for analysis, the contribution of idling would appear greater.

To get a sense of the significance of corridor emissions associated with NAFTA trade, we compare them to an inventory of all mobile source emissions. The US EPA prepared a 1996 national inventory at the county level for REMSAD modeling that was based on the EPA's National Emission Trends inventory. We sum the emissions for all the counties in the corridor, including all counties traversed by the highway route(s) and those within 20 kilometers of the highway. The sum, the aggregate mobile source emissions for the corridor area, is compared against the trade-related emissions. A county-level inventory, although under development, was not available for CO_2.

It is important to note that the study estimates only the emissions from freight vehicles involved in international trade. Emissions from trucks and locomotives making purely domestic moves within the corridors are not estimated.

3.1 Vancouver-Seattle Corridor

Exhibit 3

The northern segment of the West Coast Corridor (Exhibit 3) starts in Vancouver, which has a population of approximately 1.8 million. Vancouver is home to major seaports and is the western terminus of both the Canadian Pacific (CP) and Canadian National (CN) railroads. Highway 99 runs south of Vancouver to the US border at Blaine, Washington. Commercial vehicles cross nearby to the east at BC Highway 15. In the United States the corridor follows Interstate 5 to the Seattle region, which has major seaports and a population of 3.4 million. CP and CN rail service runs from Vancouver to the US border, where they meet BNSF lines continuing to Seattle and farther south. The aggregate population of the corridor is 5,473,000. By 2020, this population is forecast to grow 36 percent to 7,451,000.

This segment carries the fifth highest volume of truck freight between the United States and Canada. Under the US Clean Air Act, the Seattle-Tacoma area (King

[13] Toronto-Detroit is 377 kilometers (234 miles); San Antonio-Monterrey is 496 kilometers (308 miles); Tucson-Hermosillo is 406 kilometers (252 miles).

and Pierce Counties) is designated as a Non-attainment Area for particulate matter (PM_{10}). It is also a Maintenance Area for ozone (under the one-hour standard) and carbon monoxide. The Lower Fraser Valley (Vancouver area) has had ozone problems in the past, though there have been no exceedances of Canadian national objectives in recent years.

Commodity flows in the corridor are dominated by wood and paper products, reflecting the concentration of these industries in the Pacific Northwest region. Southward flows of these products are much heavier than northward flows. Total surface commodity flows in 1999 were 11.1 million metric tons, with 61 percent carried by truck. The bulk of trade trucks move between British Columbia and Washington, Oregon and California. Most rail flows originate in BC or Alberta, and move to the US West Coast or Texas.

For emissions calculations, the corridor is assumed to extend from Vancouver to Olympia, Washington, a distance of 364 kilometers (226 miles). Average commercial vehicle border delay is assumed to be 37 minutes in both directions.[14] All freight flows are assumed to move the full length of the segment. Trade-related emissions for the corridor segment are shown in Table 7. Truck freight contributes the bulk of emissions, including 76 percent of NO_x, 88 percent of VOC and PM_{10}, and over 90 percent of CO and CO_2. Truck idling at the border is responsible for four percent of CO emissions. Comparing emissions with the mobile source inventory for the region that encompasses the US corridor segment, trade emissions make up 4.6 percent of PM_{10} and 2.8 percent of NO_x.

Table 7: Vancouver-Seattle Corridor Trade Emissions, 1999 (kg/day)

	NO_x	VOC	CO	PM_{10}	CO_2
Truck Line Haul	6,533	540	3,312	382	821,535
Truck Idling	65	18	147	3	14,459
Truck Subtotal	6,598	558	3,460	385	835,994
Rail	2,030	78	206	52	76,465
Total	8,628	635	3,666	437	912,459
Total in US Segment	6,946	534	3,090	366	765,441
% of Mobile Source Inventory	2.8	0.3	0.2	4.6	N/A

3.2 Winnipeg-Fargo Corridor

The northwest portion of the North American Superhighway Corridor (Exhibit 4) runs south on Highway 75 from Winnipeg, which has a population of 667,000. The highway route crosses the border at Emerson, Manitoba and Pembina, North Dakota, then continues on I-29 to Fargo, with a population of 170,000. The rest of the corridor is mostly rural and sparsely populated. The aggregate 1999 corridor population is 949,000. Population in the corridor is forecast to grow slowly, reaching 1,016,000 by 2020, a 7 percent increase. A rail line runs south from Winnipeg,

[14] *WTA and BCTA Trucking Survey Results Summary*

crossing the border just east of Pembina at Noyes, Minnesota, where it joins the extensive BNSF network. The Emerson-Pembina crossing is the seventh largest in terms of US-Canada truck freight by weight. The US portion of the corridor does not include any Non-attainment or Maintenance Areas under the US Clean Air Act. Similarly, Winnipeg has not had any recent violations of Canadian national air quality objectives.

Exhibit 4

Approximately 9.2 million metric tons of freight moved through the corridor in 1999, equally split between trucking and rail. The mix of commodities carried by truck is more diverse than in the other Canada-US corridors, and no single commodity group dominates the flow. There are large southbound flows of agricultural products (animals, oil seeds, processed plant products), wood and coal. Northbound shipments include large flows of agricultural supplies like animal feed and fertilizer, plus machinery and paper. Most truck flows through the corridor are between Manitoba and the upper midwestern states of Minnesota, North Dakota, Illinois and Wisconsin. Rail flows show a heavy imbalance (87 percent) in the southbound direction. They are dominated by fertilizer shipments (largely to Minnesota, Illinois and Indiana) and cereals shipments (largely to Minnesota and Illinois).

The length of the corridor is 364 kilometers (226 miles). No information is available on average border delay for trucks, but peak queues can reportedly have 30 to 40 vehicles.[15] We assume 15 minutes, given that many trucks at the crossing are pre-cleared for customs processing. All freight flows are assumed to move the full length of the segment. Table 8 shows emissions from NAFTA freight in the corridor. This corridor shows the highest contribution of rail to total trade emissions, including 44 percent NO_x and 25 percent of PM_{10}. Compared to the emissions inventory for the area of the US corridor segment, trade contributes 15.6 percent of mobile source PM_{10} emissions and 11.3 percent of mobile source NO_x, the highest portions of the five corridors examined. The high significance of trade-related emissions in this corridor is expected since the US portion is relatively sparsely populated and lacks a large industrial base.

[15] *Canada/US International Border Crossing Infrastructure Study*.

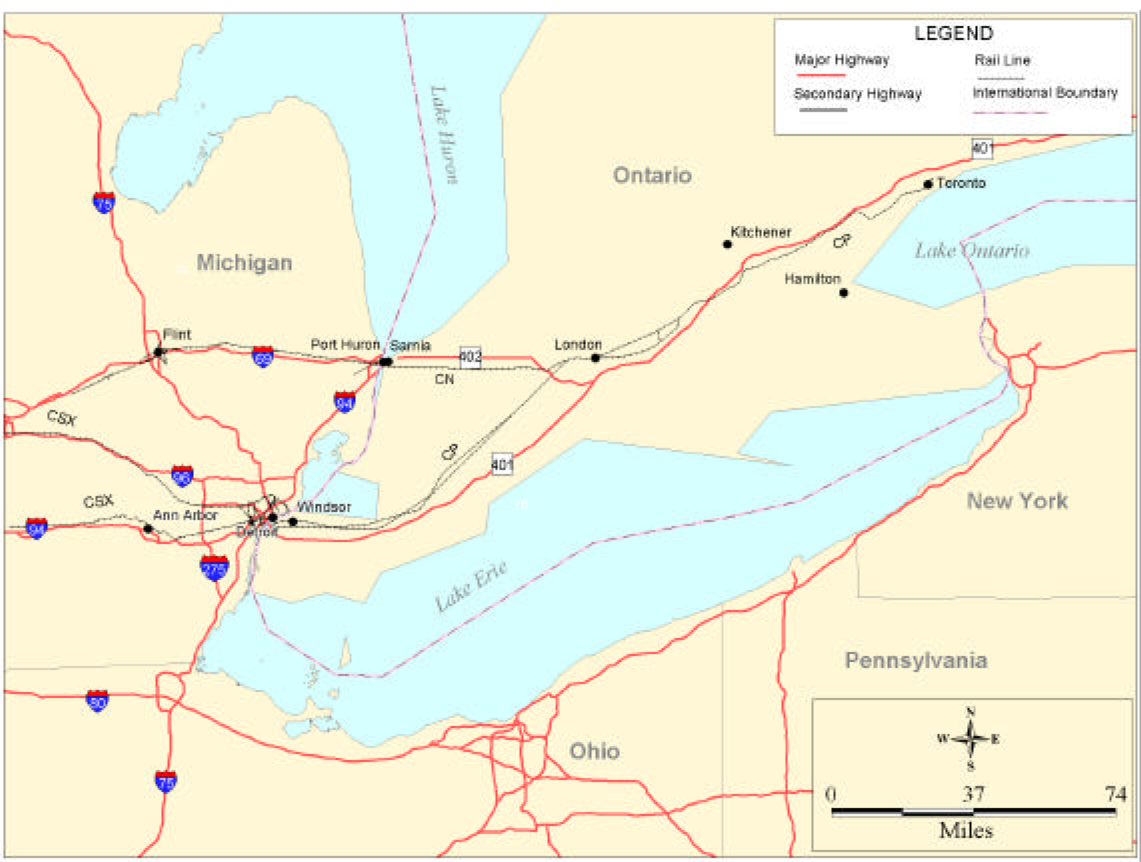
Table 8: Winnipeg-Fargo Corridor Trade Emissions, 1999 (kg/day)

	NO_x	VOC	CO	PM_{10}	CO_2
Truck Line Haul	2,879	238	1,460	168	362,061
Truck Idling	12	3	26	1	2,583
Truck Subtotal	2,891	241	1,486	169	364,644
Rail	2,279	84	225	57	83,176
Total	5,170	326	1,711	226	447,820
Total in US Segment	3,336	224	1,182	155	307,945
% of Mobile Source Inventory	11.3	1.0	0.5	15.6	N/A

3.3 Toronto-Detroit Corridor

The northeastern branch of the North American Superhighway Corridor (Exhibit 5) runs west from Toronto along Highway 401. It passes through the heavily populated regions of southwest Ontario before crossing the international border at Windsor-Detroit. Most commercial vehicles here use the Ambassador Bridge, though some also use the Detroit-Windsor Tunnel. The busiest border crossing in North America, the Ambassador Bridge carried 12.5 million vehicles in 1999, including 3.4 million trucks. From Detroit, I-94 runs west to Ann Arbor and, eventually,

Exhibit 5



Chicago. As an alternative route, trucks can drive due west from London, Ontario, using Highway 402 to cross at the Blue Water Bridge between Sarnia and Port Huron. The Blue Water Bridge was recently doubled to six lanes, and carried 4 million vehicles in 1999, including 1.5 million trucks. The Detroit-Windsor and Port Huron-Sarnia crossings rank first and third in terms of US-Canada truck freight by weight.

CN and CP rail lines largely parallel the highway routes. CP operates the Detroit-Windsor rail tunnel while CN operates the St. Clair River Tunnel at Sarnia. The St. Clair River Tunnel is a new facility handling modern double-stack cars and RoadRailer service. Norfolk Southern, Conrail and BNSF all provide service between Detroit and points west. The 1999 aggregate corridor population is approximately 10.7 million, including 2.3 million in the Toronto area and 4.3 million in the Detroit area. Population is forecast to grow by 24 percent by 2020, reaching 13.2 million. Most of this growth will occur in southwestern Ontario, as Detroit's population is expected to remain fairly stable. Under the current US EPA standards, the Detroit region is a Maintenance Area for ozone and carbon monoxide, while Wayne County (Detroit) is a Maintenance Area for PM_{10}. The Windsor-Toronto corridor has Canada's highest ozone and particulate matter levels, with an average of several violations of national ozone level objectives each year.

Two-way commodity flows through these border crossings (Windsor-Detroit and Sarnia-Port Huron) total over 61 million metric tons, more than the commodity flows through the other four corridor segments combined. Approximately 72 percent of the tonnage moves by truck. Approximately one-quarter of all truck shipments in the corridor are automobiles and related parts, though there are also large flows of steel, wood, paper products and machinery. Michigan is the dominant endpoint for truck shipments on the US side, with neighboring states of Ohio, Illinois and Indiana accounting for much of the rest. Rail flows are also large, with tonnage to the US more than twice that in the reverse direction. Rail flows of autos and auto parts are heavy into the United States, though they are not significant in the reverse direction. Chemicals are the largest commodity group shipped into Ontario, followed by plastics and cereals. Rail flows into Ontario originate largely in Texas.

For emissions calculations, a 364-kilometer (226 mile) highway route was assumed (roughly Kitchener, Ontario, to Ann Arbor, Michigan). The route through Port Huron-Sarnia is 21 kilometers longer than the route through Detroit. No information is available on average delay at any of the three crossings. Observations suggest that both the Ambassador and Blue Water Bridges do not experience significant commercial vehicle delays on average.[16] Thus, border delay was assumed to be 20 minutes, consistent with other crossings without large queues. All freight flows are assumed to move the full length of the segment.

Emissions from NAFTA trade are shown in Table 9. This corridor has the highest levels of both truck and rail emissions of the five corridors studied—nearly twice the levels of the next highest corridor, San Antonio-Monterrey. Truck freight contributes the bulk of emissions—81 percent of NO_x and over 90 percent of the other pollutants. Truck idling at the border contributes 2 percent of the trade-related CO emissions. Compared to the mobile source emissions inventory for the area of the US segment, trade-related emissions make up a significant portion of NO_x (4.8

[16] See *Canada/US International Border Crossing Infrastructure Study*; Giermanski 1999.

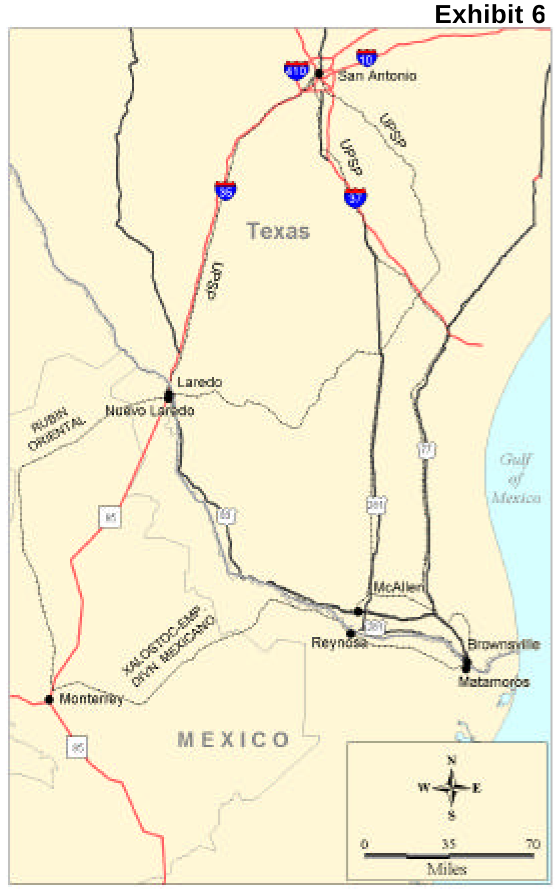
percent) and PM_{10} (7.4 percent). Given that the Detroit metropolitan area is home to over five million people and contains a major industrial presence, this high percentage is somewhat surprising, and it underscores tremendous trade volumes in the corridor.

Table 9: Toronto-Detroit Corridor Trade Emissions, 1999 (kg/day)

	NO_x	VOC	CO	PM_{10}	CO_2
Truck Line Haul	37,764	3,122	19,147	2,209	4,748,684
Truck Idling	199	54	452	9	44,415
Truck Subtotal	37,963	3,176	19,599	2,218	4,793,098
Rail	8,700	322	857	216	317,516
Total	46,663	3,498	20,456	2,434	5,110,615
Total in US Segment	13,315	996	5,829	671	1,415,665
% of Mobile Source Inventory	4.8	0.4	0.2	7.4	N/A

3.4 San Antonio-Monterrey Corridor

Exhibit 6



The southern segment of the North American Superhighway Corridor (Exhibit 6) runs south from San Antonio on I-35 to Laredo at the Mexican border. In Mexico, the route follows MX 085 (also toll road 85D) to Monterrey. Rail service to Laredo is provided by Union Pacific (UP), BNSF and the regional Texas Mexican Railway Company (Tex Mex). The UP lines provide direct connections with Mexico’s Ferrocarril del Noreste (FNE). The FNE line largely parallels MX-085, running from Laredo through Monterrey to Mexico City.

The aggregate corridor population in 1999 is 4.2 million, including 1.1 million in both San Antonio and Monterrey. Tremendous growth is forecast for this corridor, with 2020 corridor population expected to reach 6.4 million. The fastest growth is expected in the border area. Webb County, Texas, which includes Laredo, is expected to grow over 2.5 times by 2020, reaching 507,000. Nuevo Laredo’s population will be at least 440,000 by 2020. Air pollution from ozone and particulate matter is a serious problem in Monterrey. In 1997, Mexican air quality standards were exceeded on 36 days for ozone and nine days for PM_{10}. Air pollution levels in Laredo and Nuevo Laredo do not currently exceed the health-based ambient standards for the United States or Mexico, though there are few monitoring stations in the area.

Total 1999 commodity flows in the corridor were over 26 million metric tons, with 66 percent carried by truck. Southbound commodities by truck were led by coal, plastics, electrical equipment and auto parts. Much of this freight is component parts that are assembled in Mexico and trucked back to the United States as finished products. Thus, northbound truck flows are led by electrical equipment, machinery and automobiles. A large part of truck freight (44 percent) moves to and from Texas. After Texas, however, the common truck shipment endpoints are located far from the border, in states like Michigan, California and Illinois. This reflects the fact that the corridor serves US-Mexico trade relationships throughout the United States rather than just those between neighboring border states. Nearly two-thirds of rail commodity flows are southbound. Raw materials like wood pulp, cereals, cement and stone, and coal are the leading southbound rail commodities, originating in Texas, Georgia and midwestern farming states. Northbound rail flows are led by automobiles shipped to Michigan and beverages shipped to Texas.

Any analysis of US-Mexico trade flows must consider the impact of maquiladora factories. Begun in 1965, the maquiladora program consists primarily of manufacturing plants just south of the border that assemble finished products using US components, then ship the products back to the United States. As a percentage of total trade, maquiladoras have the greatest impact on the El Paso-Cuidad Juarez and San Ysidro-Tijuana crossings. Both Nuevo Laredo and Nogales have large numbers of maquiladoras as well. At Laredo-Nuevo Laredo, it is estimated that 13 percent of northbound trade and 12 percent of southbound trade is associated with maquiladoras.[17] Because this freight generally does not move the full length of the corridor segment, we adjusted the truck activity data accordingly.

For emissions calculations, we assumed a 364-kilometer (226 mile) corridor, which would extend as far north as roughly Pearsall, Texas. There are two major border crossings for trucks in the corridor. The Lincoln-Juarez Bridge connects the downtown areas of Laredo and Nuevo Laredo and lies at the end of I-35 and MX 085. The other crossing is the Columbia Bridge, located 35 kilometers (22 miles) northwest of the downtown areas. Use of this crossing adds approximately 64 kilometers to a border crossing trip, though border crossing delays are significantly less. Recent surveys indicate that 61 percent of trade trucks in this corridor use the Lincoln-Juarez Bridge, with the remainder using the Columbia Bridge. Our calculation of 1999 emissions impacts assumes this split.

Current regulations restrict the operation of Mexican trucks in the United States to only commercial zones around the border crossing.[18] Similarly, US carriers are generally not allowed to operate on Mexican federal highways. Because of these restrictions and customs processing requirements, the US-Mexico trade corridors have developed a unique system of transferring freight. In general, both northbound and southbound freight is carried to terminals in the border

[17] *Binational Border Transportation Planning and Programming Study*.

[18] A recent NAFTA arbitration panel ruled in favor of allowing full access to Mexican trucks, and the Bush Administration has indicated that it will comply. As described in Section 4, we assume that the restrictions will be lifted in analyses of future scenarios.

region using line-haul trucks. Trailers are then pulled across the border using drayage trucks that are largely Mexican-owned. Once across the border, line haul trucks carry the freight to its ultimate destination. Drayage trucks are generally older than line-haul trucks and produce higher emissions per mile. To account for this system in emissions calculations, we assume that all truck freight between San Antonio and Laredo moves by US line-haul trucks, and all freight between Nuevo Laredo and Monterrey moves by Mexican line-haul trucks. Cross-border moves, which include only a fraction of the full trip distance but all of the border delay idling, are assumed to be done by Mexican drayage trucks in both directions.

Table 10 shows emissions in the corridor in 1999. Truck freight contributes 84 percent of NO_x and over 90 percent of the other pollutants. Truck idling contributes 6.3 percent of trade-related CO emissions, the highest portion of the five corridors. Compared to the mobile source inventory for the region encompassing the US segment, NAFTA trade is responsible for 12.4 percent of PM_{10} emissions and 8.5 percent of NOx, second only to Winnipeg-Fargo in this regard.

Table 10: San Antonio-Monterrey Corridor Trade Emissions, 1999 (kg/day)

	NO_x	VOC	CO	PM_{10}	CO_2
Truck Line Haul	21,129	1,707	9,665	1,236	2,316,476
Truck Idling	480	110	682	23	38,925
Truck Subtotal	21,609	1,817	10,347	1,259	2,355,401
Rail	4,261	158	420	106	155,523
Total	25,871	1,975	10,767	1,364	2,510,924
Total in US Segment	15,566	1,303	7,615	863	1,794,510
% of Mobile Source Inventory	8.5	0.9	0.5	12.4	N/A

3.5 Tucson-Hermosillo Corridor

The southern segment of the CANAMEX Corridor (Exhibit 7) runs south from Tucson, Arizona, (pop. 804,000) on I-19 to the border. Nogales, Arizona, is a small city (pop. 20,000), but its counterpart in Sonora State is over eight times larger. From Nogales, Sonora, the corridor route follows MX 015 south to Santa Ana and Hermosillo (pop. 609,000). UP provides rail service from Tucson to Nogales, where the line connects with the Ferrocarril Del Norte Pacifico network, which runs down the west coast of Mexico. The 1999 aggregate population in the corridor is 1.7 million, with a 2020 forecast of over 2.4 million. Nogales, Arizona (Santa Cruz County) is a PM_{10} non-attainment area under the current US EPA standards, and Nogales, Sonora, is also believed to exceed PM_{10} standards.[19] Ambient PM_{10} levels in Hermosillo exceeded standards on multiple occasions in 2000, primarily during cooler months. Tucson is a Maintenance Area for carbon monoxide.

[19] *US-Mexico Border Environmental Indicators 1997*.

This corridor carries 5.3 million metric tons of commodities, 71 percent by truck. Unlike the Laredo-Nuevo Laredo crossing, the Nogales crossing serves primarily trade between the neighboring border states (Arizona and Sonora). Northbound truck freight consists of vegetables and fruits/nuts bound for Phoenix and other urban markets. Nogales is the only major US-Mexico border crossing that experiences significant seasonal fluctuations in trade, due to the high percentage of agricultural products. Southbound truck freight consists of plastics, iron and steel, coal, and electrical equipment. No significant tonnage of truck freight currently moves between Mexico and the northern parts of the CANAMEX corridor. Rail carries 1.5 million metric tons of freight in the corridor, led by northbound shipments of cement and stone to Arizona. Northbound automobile shipments by rail are also significant, originating at the Ford plant in Hermosillo. Southbound rail flows include ores and steel from Arizona and auto parts from Michigan.

Exhibit 7

For emissions calculation, the corridor was assumed to be 364 kilometers (226 miles) in length, running as far south as the town of Carbó in the state of Sonora. Trucks cross the border at the Mariposa crossing, approximately 2.5 kilometers west of downtown Nogales. Rail traffic crosses at the DeConcini gate in the downtown area. Border crossing delay for trucks averages 50 minutes northbound and 20 minutes southbound.[20] As with the San Antonio-Monterrey corridor, we assume that the line haul portion of truck trips are conducted by US and Mexican trucks in their respective countries, while cross-border movements (and all idling) are done by the Mexican drayage fleet. Maquiladora trade is a significant part of the total at this crossing, and was recently estimated to be 29 percent of northbound and 47 percent of southbound trade.[21] Truck activity data was adjusted to account for this in emission calculations.

NAFTA-trade emissions in the corridor are shown in Table 11. Trucking contributes 83 percent of NO_x and over 90 percent of the other pollutants. Truck idling at the border is responsible for 6.2 percent of CO emissions from trade, second only to the Laredo/Nuevo Laredo crossing in this percentage. Compared to the inventory of all mobile source emissions of the area encompassing the segment, NAFTA trade has a smaller impact than in the other corridors. Trade-related emissions for the US segment make up 4.3 percent of the PM_{10} inventory and 2.7 percent of the NO_x inventory.

[20] *Binational Border Transportation Planning and Programming Study*

[21] *Binational Border Transportation Planning and Programming Study*.

Table 11: Tucson-Hermosillo Corridor Trade Emissions, 1999 (kg/day)

	NO_x	VOC	CO	PM_{10}	CO_2
Truck Line Haul	3,515	279	1,480	205	344,028
Truck Idling	72	17	103	3	7,294
Truck Subtotal	3,587	296	1,583	209	351,323
Rail	743	28	73	18	27,125
Total	4,330	323	1,656	227	378,448
Total in US Segment	1,370	125	738	80	167,870
% of Mobile Source Inventory	2.7	0.3	0.2	4.3	N/A

3.6 Other Freight Transportation Modes

Waterborne Freight

Waterborne trade accounts for a substantial portion of freight flows in North America. Approximately 56 percent of Canada-Mexico trade tonnage moves by water. Major commodities include oil seeds and cereals southbound and petroleum northbound. Between Canada and the US, more than 20 percent of freight tonnage moves by water. Canadian maritime exports to the United States are led by coal, petroleum and paper products, while imports consist primarily of petroleum. (Figures for US—Mexico trade are less complete, but also show large amounts of maritime trade.)[22] While this trade has been growing steadily on an absolute basis, it has been losing market share. Ten years ago waterborne freight accounted for 63 percent of Canada-Mexico trade and 28 percent of Canada-US trade.

Much of the Canada-US waterborne trade moves between Atlantic Ocean ports and therefore does not have direct environmental impacts within the NAFTA corridors analyzed in this report. However, both the Great Lakes and West Coast ports also handle large volumes of NAFTA trade. Hamilton, Ontario, at the western end of Lake Ontario, is the largest Canadian port in terms of the value of maritime shipments from the United States. The port of Vancouver ranks second for US exports.

Nearly all US-Mexico waterborne trade moves through the Gulf of Mexico. The trade is dominated by United States oil imports originating on the coast of Campeche and Veracruz, moving to ports in Texas and Louisiana. There are also significant US-Mexico shipments from the port of Altamira, near Tampico. This route may provide an alternative to the land-borne route of San Antonio-Monterrey-Mexico City.

[22] *North American Transportation in Figures*.

Large freight ships are usually powered by residual fuel oil (bunker fuel), and most also have diesel motors for auxiliary on-board power. Emissions depend on several factors, including the distance traveled and the type and age of the vessel engines. The loading and unloading time spent in port may be an important factor in their impact on urban air quality. On the whole, maritime emissions are a small portion of total emissions. A 1997 emissions inventory for the US found that marine vessels contribute 1.0 percent of NO_x emissions nationwide and 0.1 percent of PM_{10}.

The large percentage shares of trade might suggest that maritime serves a broad variety of markets, and that there is as a result a possible opportunity to use it more extensively as an emissions reduction strategy. Certainly maritime does serve a wide variety of markets. Further, innovations such as feeder barges have shown the ability to carry traffic that would otherwise have gone to rail, and demonstrate the potential to increase their services. Overall, however, these large tonnage market shares reflect the fact that intra-North American maritime trade generally has the same commodity characteristics as other water-borne transit, and is best suited for bulk commodities.

Pipeline

There are also large commodity flows via pipeline from Canada to the United States, primarily petroleum and natural gas. Canada exported 52 million metric tons of fuels via pipeline in 1999, a larger tonnage than southbound truck and rail commodity flows in any single corridor. Nearly all of this originates in Alberta and flows to the midwestern and central plains states. The emissions impacts of pipelines generally depend on the stationary engines used to compress or pump the pipeline fluids.

4 FUTURE TRADE SCENARIOS AND AIR QUALITY IMPACTS

Trade and transportation in all five corridors will grow substantially in coming years. This section presents trade scenarios for 2020 and an estimate of their air quality impacts. A 2020 baseline scenario is developed for each corridor based on likely trade growth rates. Alternative scenarios are then used to compare changes in trade growth or changes to the transportation industry against the baseline. All air quality impacts are estimated using the 2020 emission factors described in Section 2.

It is difficult to predict border crossing delay 20 years into the future. All five corridor segments will experience a two- to four-fold increase in traffic under our baseline scenarios, which will undoubtedly overburden some existing border facilities. At the same time, the infrastructure at all border crossings is likely to be upgraded substantially. For example, there are currently plans to add a fourth crossing linking Laredo with Nuevo Laredo, and the Ambassador Bridge Authority has indicated it will twin that bridge when the need arises. Given these uncertainties, for the purposes of 2020 emissions calculations we assume the same border crossing delay through each port of entry system as exists currently. Also, we do not estimate the effects of increased freight traffic on the movement of non-freight vehicles and their emissions. For example, higher truck volumes in the corridors could cause greater passenger vehicle congestion and associated emissions.

4.1 Vancouver-Seattle Corridor

Baseline Scenario

The 2020 Baseline Scenario for the Vancouver-Seattle corridor envisions truck and rail commodity flows growing at 4.2 percent annually, resulting in total flows of 26.6 million metric tons by 2020. This is more than Transport Canada forecasts for growth in freight tonnage by for-hire trucking (2.3 percent annually through 2015), but less than recent growth in cross-border truck volumes (6.5 percent annually between 1986 and 1996).[23] [24]

Table 12 shows trade-related emissions in 2020 under the Baseline Scenario. Due to the dramatic improvement expected in truck emission rates, and to a lesser extent, rail emission rates, NO_x and PM_{10} emissions drop to less than half of the 1999 levels despite a more than doubling of freight tonnage. Emissions of CO and CO_2 more than double compared to 1999, similar to the growth in trade.

Table 12: Vancouver-Seattle Corridor Trade Emissions, 2020 Baseline Scenario

	Annual Commodity Flow (million kg)	Annual Vehicles*	Emissions (kg/day)				
			NO_x	VOC	CO	PM_{10}	CO_2
Truck	16,186	1,952,758	1,678	399	7,842	62	1,983,469
Rail	10,434	150,860	1,985	109	415	58	153,569
Total	26,620	N/A	3,664	508	8,257	119	2,137,038
Percent of 1999	237	237	42	80	225	27	234

* Loaded rail cars only

Alternative Scenario—Improved Rail Service

We explore the impact of an alternative scenario in which rail captures a larger mode share of future commodity flows. The Washington State Department of Transportation recently began a “Short-Haul Intermodal Initiative,” an effort to promote rail service improvements that would allow rail to capture a larger share of intermodal traffic between British Columbia and Washington. There are other opportunities to further improve rail service in the corridor. For example, the existing BNSF line north of Seattle includes several tunnels that do not allow modern double-stack container operations. And the proposed merger of CN and BNSF would reportedly cut transit times between Vancouver and California by 12 to 24 hours.

Trucking currently captures 61 percent of surface freight in the corridor, including 87 percent of the higher value products (over $1 per pound). Truck and rail mode share is almost evenly split

[23] *Freight Transport Trends & Forecasts to 2015*.
[24] *Transportation and North American Trade*.

for the lower value commodities (under $1 per pound), which indicates an opportunity for rail to capture a larger share.

To estimate the impact of rail service improvements, we assume a 10 percent rail shipping cost reduction and apply this to the cross-elasticities shown in Table 3. The result is a diversion of over 700,000 metric tons of freight from truck to rail, a 6.8 percent increase in rail tonnage over the 2020 baseline. Diverted commodities are led by wood, plastics, wood pulp and fertilizers. Truck traffic in the corridor drops by 84,000 vehicles annually. Because rail freight is more fuel efficient than trucking, the mode shift would reduce trade-related CO_2 emissions by over 3 percent, as shown in Table 13. Trade-related emissions of NO_x and PM_{10} would rise slightly as a result of trucking's relative advantage for emission of those pollutants in 2020.

Table 13: Vancouver-Seattle Corridor—Impact of Improved Rail Service (kg/day)

	Annual Commodity Flow (million kg)	Emissions (kg/day) NO_x	VOC	CO	PM_{10}	CO_2
1999	11,220	8,693	635	3,666	437	912,459
2020 Baseline	26,620	3,664	508	8,257	119	2,137,038
2020 Improved Rail Service	26,620	3,730	499	7,962	121	2,065,803
Percent Change (2020 Baseline vs. Alternative)	0	1.8	-1.8	-3.6	1.2	-3.3

4.2 Winnipeg-Fargo Corridor

Baseline Scenario

Under the 2020 Baseline Scenario, truck and rail freight tonnage in the Winnipeg-Fargo corridor grows by 6 percent annually, resulting in a total of 31.4 million metric tons. Table 14 shows 2020 emissions under the Baseline Scenario. Emissions of NO_x and PM_{10} fall to 80 percent and 57 percent of 1999 levels respectively. While this drop is striking in the face of tripling freight volumes, it is less than the reduction in the other two US-Canada corridors. This is due in part to the large mode share for rail, which is not expected to reduce emission rates as dramatically as trucks. CO_2 emissions from trade increase to more than three times 1999 levels.

Table 14: Winnipeg-Fargo Corridor Trade Emissions, 2020 Baseline Scenario

	Annual Commodity Flow (million kg)	Annual Vehicles*	Emissions (kg/day) NO_x	VOC	CO	PM_{10}	CO_2
Truck	15,150	1,233,117	1,054	248	4,827	39	1,239,630
Rail	16,262	217,966	3,094	170	647	90	239,357
Total	31,412	N/A	4,148	418	5,473	128	1,478,987
Percent of 1999	340	340	80	129	320	57	330

* Loaded rail cars only

Alternative Scenario—Higher Growth in Truck Traffic

Several indicators suggest that truck traffic could grow more rapidly than a six percent annual rate. Between 1986 and 1996, truck volumes at the Emerson-Pembina crossing have increased by an average of 9.4 percent per year. Exports to Canada from Minnesota, Manitoba's leading trade partner, increased by 9.9 percent annually over the past six years. Winnipeg's Mayor expects that trade in the corridor could grow by 12 percent annually in the short term.[25] While Winnipeg has long served as a transport hub for east-west movements across the Prairie Provinces, there is at least anecdotal evidence that future growth will be in north-south trade instead. Winnipeg is strategically positioned within 24 hours driving time of large US markets in Wisconsin, Minnesota and Illinois. Some industry representatives have predicted that Winnipeg-Minneapolis will become a strong trade corridor in future years.[26]

As an alternative to the 2020 Baseline Scenario, we calculate freight volume and emissions if truck freight were to grow at nine percent annually. Total commodity flow tonnage would be 38 percent higher than under the Baseline assumptions, shown in Table 15. Railroad freight still contributes more than half of NO_x and PM_{10} trade emissions, but trucking's share rises from only one-quarter to approximately 40 percent. Unlike the 2020 Baseline, NO_x emissions are slightly higher than in 1999. CO_2 and CO emissions rise nearly 70 percent compared to the Baseline levels, and are now over five times the levels in 1999.

Table 15: Winnipeg-Fargo Corridor—Impact of Greater Truck Traffic

	Annual Commodity Flow (million kg)	Emissions (kg/day)				
		NO_x	VOC	CO	PM_{10}	CO_2
1999	9,240	5,170	326	1,711	226	447,820
2020 Baseline	31,412	4,148	418	5,473	128	1,478,987
2020 Higher Truck Growth	43,486	4,988	616	9,320	159	2,466,896
Percent Change (2020 Baseline vs. Alternative)	38	20	47	70	24	67

4.3 Toronto-Detroit Corridor

Baseline Scenario

Because economic relationships between Ontario and the Midwestern states were already well-developed by the early 1990s, growth in freight traffic through this corridor has been less than total binational trade growth in recent years. Between 1986 and 1996, truck traffic through the three crossings grew by 5.7 percent per year.[27] Another study estimates that future trade through this corridor will grow by 5 percent annually.[28] This figure is used as the basis for the 2020 Baseline Scenario for both truck and rail commodity flows. Total cross-border tonnage reaches 172 million metric tons by 2020.

[25] Toulin, 1999
[26] *Prairie Provinces Transportation System Study*.
[27] *Transportation and North American Trade*.
[28] *Southwest Ontario Frontier International Gateway Study*.

Trade-related emissions for the 2020 Baseline Scenario are shown in Table 16. NO_x emissions fall to less than half of 1999 levels, and PM_{10} emissions fall to less than one-third of 1999 levels. Both CO and CO_2 emissions rise to 2.7 times their 1999 levels, in proportion to the growth in freight volume.

Table 16: Toronto-Detroit Corridor Trade Emissions, 2020 Baseline Scenario

	Annual Commodity Flow (million kg)	Annual Vehicles*	Emissions (kg/day)				
			NO_x	VOC	CO	PM_{10}	CO_2
Truck	122,672	13,030,708	11,342	2,674	52,165	416	13,353,393
Rail	48,947	785,129	9,680	533	2,023	281	748,796
Total	171,619	N/A	21,022	3,207	54,188	697	14,102,189
Percent of 1999	279	279	45	92	265	29	276

* Loaded rail cars only

Alternative Scenario—Improved Rail Service

Over the last decade, railroads have lost mode share for intermodal freight in this corridor.[29] Both CN and CP are now investing in new technologies in an attempt to recapture some of this traffic from trucking. Two prominent developments are the Iron Highway and RoadRailer service. The Iron Highway, originally developed by CSX, uses long, articulated platforms that are divided in the middle to form ramps. Truck trailers can be easily loaded and unloaded without the need for cranes. CP is marketing this service in southern Ontario and Quebec under the name "Expressway." RoadRailer technology, currently used by Norfolk Southern Railway in the United States, employs specialized truck trailers that can be converted to rail cars using detachable wheel/axle assemblies (bogies). Conventional locomotives can pull a train of up to 120 RoadRailer trailers. CN has introduced the service in the Toronto-Detroit corridor and plans to extend RoadRailer service to Chicago. There is also the potential to use VIA passenger trains to pull express freight using RoadRailer technology. These service improvements could significantly increase rail mode share, while additional rail service improvements could be achieved if the Detroit-Windsor tunnel is expanded to handle modern double-stack and auto carrier trains. In the Baseline Scenario, the trucking mode share is 71 percent of all freight in the corridor, including 60 percent of the lowest value commodities (under $1 per pound). This suggests significant opportunities for rail to capture a greater mode share.

We analyze the impact of an alternative growth scenario with improved rail service. A 10 percent reduction in rail shipping cost relative to trucking is assumed, and applied to the cross-elasticities in Table 3. The result is a 12 percent increase in rail tonnage compared to the Baseline (about 5.8 million metric tons), with plastics, iron and steel, and automobile parts making up the majority of diverted commodities. Nearly 600,000 trucks are removed from the corridor annually. Table 17 shows the emissions impacts of this modal diversion relative to the Baseline. By 2020, NO_x and PM_{10} rise by 3.3 percent and 2.4 percent in this scenario, while emissions of other pollutants fall, with CO and CO_2 emissions declining more than three percent due to the diversion to rail.

[29] *Assessment of Modal Integration & Modal Shift Opportunities*.

Table 17: Toronto-Detroit Corridor—Impact of Improved Rail Service (kg/day)

	Annual Commodity Flow (million kg)	Emissions (kg/day)				
		NO_x	VOC	CO	PM_{10}	CO_2
1999	61,601	46,663	3,498	20,456	2,434	5,110,615
2020 Baseline	171,619	21,022	3,207	54,188	697	14,102,189
2020 Improved Rail Service	171,619	21,720	3,165	52,383	714	13,667,435
Percent Change (2020 Baseline vs. Alternative)	0	3.3	-1.3	-3.3	2.4	-3.1

4.4 San Antonio-Monterrey Corridor

Baseline Scenario

The rate of trade growth in this corridor is expected to be the highest of the five included in the study. Recent trends show tremendous increases in both truck and rail traffic. While these rates reflect the early years of NAFTA and will likely slow somewhat, strong growth is still expected. Binational trade through the corridor differs from the other major US-Mexico corridors in that it is dominated by trade with Mexico's central industrial region rather than with border maquiladoras. Commodity flows consist of a variety of goods and are not significantly dependent on any one industry. The 2020 Baseline Scenario assumes 6.8 percent annual growth through 2020, resulting in nearly 106 million metric tons of freight by that year.

To estimate environmental impacts, the Baseline Scenario assumes a lifting of border operating restrictions for both US and Mexican trucks. A recent NAFTA arbitration panel ruled in favor of allowing full access to Mexican trucks, and the Bush Administration has indicated that it will comply. Half the trucks operating the full corridor are assumed to be US carriers, and half Mexican. As described in Section 2, the 2020 emission factors for Mexican line-haul trucks are significantly lower than in 1999, but still higher than US/Canada emission factors because they do not assume the use of low-sulfur diesel fuel. The use of older drayage trucks to pull trailers over the border is assumed to be phased out, so line haul trucks carry all freight between San Antonio and Monterrey. The fraction of maquiladora trade is assumed to remain constant. There are currently two bridges available for trucks crossing in the Laredo/Nuevo Laredo area. The Colombia Bridge opened in 1991 its use has been growing steadily. It offers less delay but adds 70 kilometers to a trip. Another crossing is planned for the downtown area. To estimate 2020 emissions, we assume that half of trade trucks will use the Columbia Bridge (up from 40 percent currently) and the other half will use existing and new downtown crossings.

Emissions under the 2020 Baseline Scenario are shown in Table 18. With respect to NO_x and PM_{10} emissions, all of the growth in trade activity in the corridor is offset by cleaner vehicles, resulting in a slight decline compared to 1999 levels. Trucking continues to contribute the bulk of these emissions—73 percent of NO_x and 81 percent of PM_{10}. CO and CO_2 emissions grow the most rapidly of the five corridors, increasing four-fold.

Table 18: San Antonio-Monterrey Corridor Trade Emissions, 2020 Baseline Scenario

	Annual Commodity Flow (million kg)	Annual Vehicles*	Emissions (kg/day) NO_x	VOC	CO	PM_{10}	CO_2
Truck	70,171	8,895,760	18,078	3,882	38,427	924	9,703,413
Rail	35,608	571,880	6,775	373	1,416	210	524,098
Total	105,779	N/A	24,854	4,255	39,843	1,134	10,227,511
Percent of 1999	398	398	96	215	370	83	407

* Loaded rail cars only

Alternative Scenario—Higher Growth in Truck Traffic

Several factors could lead to growth in freight movement by truck that exceeds the Baseline Scenario. Truck border crossings at Laredo grew by an astonishing 11.4 percent annually between 1990 and 1997.[30] While this period includes the early years of NAFTA, it also includes the US recession in the early 1990s and the Mexican financial crisis in 1995. The San Antonio-Monterrey corridor serves as the primary conduit for US-Mexico trade and will continue to do so. Not only does it link the United States with Monterrey, Mexico's third-largest city, but it also serves as the primary link between Mexico City and the United States. Thus, as the US-Mexico trade relationship continues to mature and broaden beyond maquiladoras, this corridor will undoubtedly maintain its prominence.

Lifting the operating restrictions that currently prevent US and Mexican trucks from operating in each other's territory will also likely boost truck freight. The United States limits the operation of Mexican trucks to commercial zones around the border municipality and, in response, Mexico bans US trucks from its federal highways. Due to these restrictions, truck shipments between the countries are carried by at least three different vehicles—a line-haul truck to the border area, a drayage truck across the border, and another line-haul truck to the final destination. Allowing full cross-border access for US and Mexican trucks could reduce shipment costs substantially.

To explore the impact of more rapid growth in truck traffic, we assume that truck freight in the corridor grows at 8.6 percent annually. This would result in 2020 commodity flows by truck that are 5.5 times 1999 levels. Truck volumes would increase at the same rate, if truck size and empty backhaul percentages remain constant. Rail freight volumes are assumed to grow at Baseline levels (6.8 percent annually). The environmental implications of this scenario are significant, as shown in Table 19. Pollutant emissions are 30 percent to 40 percent higher than under the 2020 Baseline Scenario. Unlike the Baseline, in which the lower emission factors for NO_x and PM_{10} more than offset the growth in traffic since 1999, this alternative scenario produces considerably higher NO_x and PM_{10} emissions compared to 1999. CO and CO_2 emissions rise to over five times their current levels.

[30] Because of a change in data reporting procedures at the Laredo customs station, counts for 1998–2000 cannot be compared to those for 1997 and earlier.

Table 19: San Antonio-Monterrey Alternative Scenario—Impact of Greater Truck Traffic (kg/day)

	Annual Commodity	Emissions (kg/day)				
	Flow (million kg)	NO_x	VOC	CO	PM_{10}	CO_2
1999	26,571	25,871	1,975	10,767	1,364	2,510,924
2020 Baseline	105,779	24,854	4,255	39,843	1,134	10,227,511
2020 Greater Truck Traffic	135,283	32,455	5,887	56,000	1,523	14,307,441
Percent Change (2020 Baseline vs. Alternative)	28	31	38	41	34	40

Alternative Scenario—Higher Growth in Rail Traffic

Another alternative scenario for the corridor involves a higher annual growth in rail traffic. Between 1990 and 1997, the average annual growth in Laredo-Nuevo Laredo rail car crossings was 11.7 percent, even higher than the growth in truck traffic. Several factors could ensure that strong growth in rail freight continues. Mexico's railroads were privatized in 1997, and after several years of investment, are now showing high levels of efficiency and profitability. Transportacion Ferroviaria Mexicana (TFM) is the principal trunk-line carrier between Mexico City, Monterrey and Nuevo Laredo. The railroad has recently made numerous infrastructure improvements in the corridor, including a new train control system between Monterrey and Nuevo Laredo, new switching yards near the border, and many expanded sidings. Transit times from Nuevo Laredo to Mexico City have been reduced from 60 hours to 34 hours for intermodal trains and 44 hours for merchandise trains.[31] TFM's partnership with the Kansas City Southern and Texas-Mexican Railroads are also succeeding in improving the efficiency of cross-border rail shipments. The greatest potential for rail in the corridor may lie with intermodal freight, and both US and Mexican railroads are investing in new or improved intermodal facilities.

As an alternative 2020 scenario, we assume nine percent annual growth in rail freight tonnage through the corridor. This results in 54.6 million metric tons of rail freight through the corridor in 2020, a six-fold increase over 1999 levels. Truck freight growth follows the Baseline Scenario. Table 20 shows the emissions impacts of this scenario. Pollutant emissions rise between 2 and 15 percent compared to the Baseline, with emissions of NO_x and PM_{10} showing the greatest increase. However, the emissions impacts are considerably less than the first alternative scenario of greater truck traffic.

Table 20: San Antonio-Monterrey Alternative Scenario—Impact of Greater Rail Traffic (kg/day)

	Annual Commodity	Emissions (kg/day)				
	Flow (million kg)	NO_x	VOC	CO	PM_{10}	CO_2
1999	26,571	25,871	1,975	10,767	1,364	2,510,924
2020 Baseline	105,779	24,854	4,255	39,843	1,134	10,227,511
2020 Greater Rail Traffic	124,811	28,475	4,454	40,600	1,246	10,507,629
Percent Change (2020 Baseline vs. Alternative)	18	15	5	2	10	3

[31] Vantuono, 1999.

4.5 Tucson-Hermosillo Corridor

Baseline Scenario

Commodity flows through this corridor reflect less diversity than those passing through other large US-Mexico corridors, and include more minerals and agricultural products. Thus, trade growth is not expected to match the high levels seen in the San Antonio-Monterrey corridor. The 2020 Baseline Scenario envisions an annual growth rate of 4.6 percent. Total freight reaches 13.7 million metric tons by 2020.

As with the San Antonio-Monterrey corridor, truck operating restrictions are expected to be lifted by 2020, so both US and Mexican carriers operate the full length of the segment without the use of drayage at the border. The fraction of maquiladora trade is assumed to remain constant. Table 21 shows emissions under the 2020 Baseline. Both NO_x and PM_{10} emissions fall to nearly half of 1999 levels due primarily to lower truck emission rates. Trucking is still responsible for most of these emissions—70 percent of NO_x and 78 percent of PM_{10}. As in the other corridors, emissions of CO and CO_2 increase in proportion with trade volumes.

Table 21: Tucson-Hermosillo Corridor Trade Emissions, 2020 Baseline Scenario

	Annual Commodity Flow (million kg)	Annual Vehicles*	Emissions (kg/day) NO_x	VOC	CO	PM_{10}	CO_2
Truck	9,706	1,128,684	1,798	389	4,056	91	1,024,372
Rail	4,011	58,172	763	42	160	26	59,042
Total	13,718	N/A	2,561	431	4,215	116	1,083,415
Percent of 1999	257	257	59	133	254	51	286

* Loaded rail cars only

Alternative Scenario—Mode Shift from Rail to Trucking

An alternative scenario for the Tucson-Hermosillo Corridor explores the impact of a mode shift from rail to trucking. In the Baseline Scenario, trucking carries 71 percent of all commodities and 64 percent of the lowest value goods (under $1 per pound), with little change in mode share for longer distances. There are several reasons to believe that as trade grows in this corridor, the rail mode share will decline. First, and most importantly, the freight movements in this corridor are fairly short in distance, which tends to favor trucking. Currently, 72 percent of truck freight and 75 percent of rail freight is moving to and from Arizona, and the major population centers of Arizona are within 24 hours driving distance of Nogales, Santa Ana and Hermosillo. Second, truck shipping costs will likely fall when Mexican vehicles are accorded full access to the US highway system. Third, trade growth between Sonora and California will not affect the corridor because it generally moves through Mexicali-Calexico. Fourth, double-stack rail operations are already in place from the United States to Hermosillo, so future rail service improvements may be less significant than in other corridors.

To explore the impact of a higher mode share for trucking, we assume a 10 percent decrease in truck shipping costs relative to rail. When this change is applied to the cross-elasticities shown in Table 3, the result is a 2.7 percent increase in bi-directional trucking tonnage, with approximately 260,000 metric tons of freight diverted from rail. Annual truck volumes increase by 32,000 vehicles. Table 22 shows the impact of this scenario on emissions. Compared to the 2020 Baseline, NO_x and PM_{10} emissions change very little. Emissions of other pollutants rise by 1.9 to 2.5 percent.

Table 22: Tucson-Hermosillo Corridor—Impact of Mode Shift to Trucking (kg/day)

	Annual Commodity Flow (million kg)	Emissions (kg/day)				
		NO_x	VOC	CO	PM_{10}	CO_2
1999	5,335	4,330	323	1,656	227	378,448
2020 Baseline	13,718	2,561	431	4,215	116	1,083,415
2020 Greater Truck Mode Share	13,718	2,562	439	4,319	117	1,108,381
Percent Change (2020 Baseline vs. Alternative)	0	0.0	1.9	2.5	0.8	2.3

5 MITIGATION STRATEGIES

The previous section illustrates how strict new standards will dramatically reduce NO_x and PM_{10} emissions from trucks. Yet rapid growth in freight transportation will offset much of the gains. In addition, if the new standards for ozone and particulate matter are implemented in the United States, there will likely be increased emphasis on reducing emissions from diesel engines. A variety of strategies can mitigate some of the air quality impacts associated with freight transportation in NAFTA trade corridors. This section explores five such strategies: alternative fuels, reducing border delay, lower truck emission standards in Mexico, reducing empty freight mileage, and use of longer combination vehicles. As mentioned previously, the SAG assisted in the selection of these mitigation strategies for analysis. While many other technical and operational strategies could reduce freight air quality impacts, the scope of this effort requires that we limit our analysis to only five.

5.1 Alternative Fuels

Description

The use of alternative fuels can play an important role in reducing pollutant emissions from the freight transportation sector. Alternative fuels include compressed natural gas (CNG), liquefied natural gas (LNG), propane, ethanol, methanol, as well as electric vehicles. Most alternative fuel programs to date have focused on lighter two- and three-axle vehicles, such as parcel delivery and service/utility fleets, but larger trucks can also use alternative fuels. Natural gas (LNG and CNG) and propane are the most viable fuels for the larger trucks involved in long distance freight. Because of the need for refueling and maintenance facilities, most use of alternative fuels has thus far been limited to urban areas. In an effort to promote their use for intercity freight, several regions are working to develop “clean corridors”—heavily traveled intercity routes with alternative fueling infrastructure.

The first clean corridor in the United States is being developed by a coalition known as the Interstate Clean Transportation Corridor (ICTC). The triangular corridor will link major cities in California and Nevada. The ICTC will provide LNG fuel at 10 locations along the route, servicing approximately 250 heavy-duty trucks and 500 local delivery trucks. Clean corridors are also being promoted as a strategy to mitigate environmental impacts from cross-border freight traffic. In Texas, a coalition of public agencies is working to create a clean corridor along I-35. Called the International Clean Transportation Corridor-3 (ICTC-3), the primary objective of the coalition at this point is education and outreach. The group includes Clean Cities coordinators and stakeholders from the Laredo, Houston, San Antonio, Austin, Dallas/Fort Worth, Oklahoma City, Kansas City, Omaha, Red River Valley, and Winnipeg coalitions. The ICTC-3 also serves as the alternative fuels working group of the North American Superhighway Coalition. The Laredo-San Antonio segment of the corridor is particularly promising because it passes through the two counties (Webb and Zapata) that are Texas’ largest natural gas producers. The ICTC-3 is also promoting alternative fuels in Monterrey, Mexico, and recently led a group of US alternative fuel vehicle manufacturers and equipment suppliers to meet with Mexican fleet managers and trade association staff there. Another clean corridor has been proposed for the northern portion of the West Coast Corridor, from Oregon to Vancouver.[32]

Impact on Emissions

Compared to today’s heavy-duty diesel trucks, CNG and LNG trucks offer lower emissions of NO_x, VOC, CO and PM_{10}, though the benefits are greatest for PM_{10}. Table 23 shows that PM_{10} emissions per mile from natural gas trucks are 12 times lower than the average US and Canadian truck, and 18 times lower than the average Mexican line-haul truck. If 10 percent of trucks in any corridor were running on natural gas today, truck PM_{10} emissions would be reduced by nine percent and NO_x emissions would be reduced by approximately four percent. The impact of heavy-duty natural gas vehicles on GHGs is uncertain, as it depends greatly on fuel efficiency assumptions. One recent study found slightly higher CO_2 emissions per mile from heavy-duty trucking using natural gas.[33]

Table 23: Truck Line-Haul Emission Factors, 1999

	Emission Factors in g/mile (1999)				
	NO_x	VOC	CO	PM_{10}	CO_2
Natural Gas	7.5	0.70	5.09	0.06	1709
US/Canada Diesel	12.8	1.06	6.50	0.75	1612
Mexico Diesel	19.3	1.50	7.28	1.13	1612

In future years, the emissions benefits of natural gas will decrease as diesel trucks become cleaner. As described in Section 2, the US emission standards beginning in 2007 are dramatically

[32] *Alternative Fuel News*.
[33] Chandler 2000.

lower than current standards, and would be lower than today's natural gas trucks as well. While natural gas trucks could also benefit somewhat from the control technologies (particulate filters and NO_x catalysts) that will be in place after 2007, it is not clear if they would actually have lower emissions than diesel after that point. Cummins Engine, one of the largest heavy-duty engine manufacturers in North America, is reportedly planning no further enhancements to their CNG engines because of the future availability of low emission diesel engines. Another large manufacturer, Detroit Diesel, will stop producing CNG engines completely. Staff at the US Department of Energy's Argonne National Laboratory estimate that natural gas will maintain an emissions advantage over diesel trucks only to about 2010.[34] For this reason, we have not explored the impact of alternative fuels on the US-Canada trade corridors in 2020. It should be noted, however, that if the introduction of low sulfur diesel is delayed, natural gas trucks may play an important role meeting air quality goals beyond 2010.

In the US-Mexico trade corridors, natural gas vehicles can provide benefits under the assumption that Mexico does not adopt the US/Canada low sulfur diesel fuel standards. To explore this mitigation strategy, we calculate emissions in the San Antonio-Monterrey corridor, where efforts to promote use of alternative fuels are already underway. We assume use of natural gas by 20 percent of Mexican line-haul trucks in the corridor (10 percent of the total). As under the 2020 Baseline scenario, operating restrictions are assumed to be lifted, allowing both Mexican and US trucks to drive the full corridor distance. The emission factors shown in Table 23 are used for the natural gas trucks, with the exception that NO_x emissions are assumed to equal the lower rates of the 2020 diesel fleet. As shown in Table 24, total trade-related PM_{10} emissions are reduced significantly (10 percent) under this scenario.

Table 24: Impact of Natural Gas Trucks on San Antonio-Monterrey Corridor, 2020 (kg/day)

	NO_x	VOC	CO	PM_{10}	CO_2
2020 Baseline	24,854	4,255	39,843	1,134	10,227,511
20% Mex. Nat. Gas Trucks	24,854	4,099	39,161	1,017	10,284,888
Percent Change	0	-3.7	-1.7	-10.4	0.6

Other types of alternative fuels and engine technologies could also lower trucking emissions, such as electric hybrid engines or fuel cells. While these options are not yet commercially available for heavy-duty trucks, they may provide a cleaner alternative to diesel by 2020. There has also been some effort to explore the use of alternative fuels in locomotives. Several demonstration projects have found that locomotives retrofitted to run on LNG achieved reduced NO_x emissions. This technology is still in its infancy, however, and cannot currently be considered as a viable mitigation strategy.[35]

[34] Saricks 2001
[35] *Air Quality Issues in Intercity Freight*.

5.2 Reducing Border Delay

Commercial vehicles can face considerable delay in crossing North America's international borders—delay during customs procedures and delay in queues to reach the customs station itself. Because trucks spend most of this delay time with engines idling, reducing border delay can reduce vehicle emissions. Options to reduce delay and its air quality impacts are discussed for the two corridors with the highest current levels of delay—San Antonio-Monterrey and Vancouver-Seattle.

San Antonio-Monterrey Corridor

The Laredo/Nuevo Laredo Port of Entry System consists of four border crossings. Three of the crossings link the two downtown areas—Convent Street, Lincoln-Juarez and the rail crossing, with Lincoln-Juarez currently handling most commercial truck traffic. The fourth is the Columbia crossing, located 35 kilometers northwest of Laredo, Texas. It opened in 1991 but has been underutilized, in part because its distance from the terminus of I-35 and MX-085 adds 64 kilometers to a border crossing trip, but also because roadway connections to the crossings had until recently been inadequate. A new four-lane roadway has just been completed linking the crossing with Monterrey, so usage will likely increase. A fourth vehicle crossing (Laredo IV) is being planned just west of Laredo, as is a new railroad bridge.

All three roadway bridges are privately-owned and charge a toll. On the US side, the US Customs Service handles inspection operations for all crossings. On the Mexican side, the City of Nuevo Laredo and the State of Tamaulipas operate the rail crossing and two downtown vehicle crossings. The Columbia Bridge, however, is located in and operated by the Municipio of Anahuac and the State of Nuevo Leon. This disjointed administrative structure makes it more difficult to coordinate management of the port of entry system.

Border Crossing Procedures

For northbound commercial traffic, the first control point is the Mexican export inspection booth. Processing time by Mexican export officials typically lasts only about one minute, but about two percent of trucks receive export inspections, which last 90 minutes on average. Northbound vehicles then proceed to manually-operated toll booths in order to cross the bridge. On the US side, all trucks (including empty trucks) enter the commercial processing area. Their first stop is the US primary inspection booths. Only document inspection occurs here, lasting about one minute on average, but long queues are common, particularly in the late afternoon. In a 1997 survey, a queue of over 100 trucks lasted from 3:30 to 6:30 pm, with waiting times exceeding two hours. After document inspection, approximately 13 percent of trucks are selected for secondary inspection, which lasts an average of 28 minutes but can take much longer. All trucks then undergo a final document inspection upon exiting, usually lasting less than one minute. The total average delay for northbound trucks to cross the border is estimated to be 55 minutes, with 31 minutes of this waiting in queues.[36]

[36] *Binational Border Transportation Planning and Programming Study*.

Southbound trucks do not receive US export inspection. They proceed directly to the toll booths, where tolls are manually collected. Backups at the toll booths can be extensive. In a survey conducted in 1997, the afternoon peak queue exceeded 200 vehicles and reached over 4.5 kilometers. This creates conflicts with cross traffic on Laredo local streets, and can lead to increased congestion (and emissions) within the City of Laredo. Once on the Mexican side, trucks proceed to the document inspection booths, where approximately 10 percent of trucks are selected for a primary inspection. Primary inspections at Nuevo Laredo last three to four hours on average. In the past, 10 percent of vehicles receiving primary inspections were selected for secondary inspection, equivalent to about one percent of total southbound trucks. The secondary inspection is a repetition of the primary inspection (lasting another three hours), performed for quality control purposes, and is reportedly being phased out. After completing inspection, Mexican exit processing reviews documents in a process that normally takes less than one minute. The total southbound truck border crossing process is estimated to average 60 minutes.[37]

Opportunities for Delay Reduction

There are significant opportunities to reduce delay at the US-Mexico border. For northbound movements, the US primary inspection booths are the largest capacity constraint. The existing bridge and approach roadway system does not significantly limit northbound vehicle flows, and will never reach saturation flow given the capacity of existing US inspection facilities. Previous studies of the Juarez-Lincoln Bridge have produced several recommendations to improve efficiency at the primary inspection booths, including:[38]

- Adding primary inspection booths;
- Encouraging use of the Columbia Bridge as an alternative crossing;
- Discouraging unnecessary crossing by bobtail trucks (tractors without trailers) by increasing their toll rates or implementing NAFTA provisions to permit more return loads; and
- Encouraging off-peak (late evening) crossing.

Southbound flows are constrained by the processing rate at the toll booths, the Laredo traffic control system, and Mexican customs processing. Recommended efficiency improvements include:

- Encouraging use of the Columbia Bridge as an alternative crossing;
- Improving traffic operations on the bridge approach in Laredo;
- Adding more southbound bridge toll booths;
- Use of electronic toll collection;
- Extending the operating hours of Mexican inspection facilities; and
- Implementing the North American Trade Automation Prototype System to expedite processing.

[37] *Binational Border Transportation Planning and Programming Study*.
[38] *Border Congestion Study: Study Findings and Methodology*.

Impact on Emissions

With traffic expected to increase substantially by 2020, future demands on the border crossing system will be great. Several additional crossings have been proposed for the Laredo area, and more will likely be considered in the coming years. Given these uncertainties, it is impossible to predict average truck delay in 2020. We calculate base case emissions under the assumption that capacity improvements are implemented such that average delay remains unchanged. To explore the impacts of reduced border delay, we assumed a lower average delay in 2020 both northbound and southbound.

A recent study of border congestion found that an average of 30 minutes of border crossing delay at Laredo/Nuevo Laredo (Juarez-Lincoln Bridge) is "avoidable".[39] If the current average delay were reduced by this amount, delay per truck would be 25 minutes northbound and 30 minutes southbound. The impact of this change on 2020 truck emissions is shown in Table 25. Emissions from truck idling would fall by 35 percent for the entire port of entry system. Compared to trade emissions along the entire corridor, the impact is much smaller (1.5 percent reduction in CO). Note, however, that this scenario only estimates the emission reduction from trade trucks. Any improvements at the Juarez-Lincoln Bridge would also reduce passenger vehicle delay and associated emissions at that crossing.

Table 25: Impact of Reduced Border Delay on San Antonio-Monterrey Corridor, 2020 (kg/day)

	NO_x	VOC	CO	PM_{10}	CO_2
Baseline Scenario 2020					
Truck Idling	189	124	1,737	10	178,826
Trade-Related Total	24,854	4,255	39,843	1,134	10,227,511
Reduced Border Delay 2020					
Truck Idling	122	80	1,121	6	115,471
Trade-Related Total	24,787	4,211	39,228	1,131	10,164,157
Percent Change					
Truck Idling	-35%	-35%	-35%	-35%	-35%
Trade-Related Total	-0.3%	-1.0%	-1.5%	-0.3%	-0.6%

Vancouver-Seattle Corridor

Border delay is also significant at the Pacific Highway/Blaine crossing in the Seattle-Vancouver corridor. Traffic volumes have grown rapidly in recent years, and current demand exceeds capacity during peak periods. In a recent survey of trucking companies, drivers reported average delay for loaded trucks in excess of 50 minutes. The situation is particularly bad in the northbound direction, where both commercial and passenger vehicles share a single approach lane. A US and Canadian coalition of business and government entities known as the International Mobility and Trade Corridor Project is currently leading efforts to improve cross-border mobility in the corridor.

The border crossing procedures are similar to those for northbound trucks at Laredo. Once they enter the customs facility, all commercial vehicles undergo a quick primary inspection. Certain

[39] *Border Congestion Study: Study Findings and Methodology*.

vehicles are then selected for secondary inspection, which takes much longer. When trucks enter secondary inspection, the driver typically visits a broker to complete the paperwork, then delivers it to the customs office. Customs inspectors review the manifests and determine whether or not the cargo should be manually inspected. If not, the truck is released to exit the facility. If an inspection is required, the driver moves the truck to the customs warehouse for manual inspection. Shipments that fail inspection are impounded.

Shortening average processing times at the border can be achieved by reducing the percentage of vehicles that require secondary inspection. Many commercial vehicles are "pre-cleared" for border crossing and rarely require secondary inspection.[40] These include:

- Vehicles that file customs paperwork on a monthly basis;
- Line release vehicles that are part of an expedited crossing program; and
- Vehicles that use advanced technology (ITS) to expedite border clearance.

The use of ITS to reduce the need for secondary inspections is particularly promising. One variation is known as the Pre-Arrival Processing System, or PAPS. PAPS was initially developed in Buffalo, and expanded by the North Border Leadership Group (consisting of US Customs representatives along the U.S-Canadian border). It relies on bar codes to provide pre-arrival information to customs, and was recently initiated at the Pacific Highway crossing. A recent study of the impacts of ITS for commercial vehicle border crossing found that high penetration of the technologies could reduce average processing times by roughly 40 percent.[41]

To determine the impact of reduced border delay on emissions, we assume that average commercial vehicle delay drops from 37 minutes to 15 minutes. As shown in Table 26, compared to the 2020 Baseline this reduces truck idling emissions at the border by nearly 60 percent. Trade emissions of NO_x and PM_{10} are cut by 0.3 percent across the entire corridor segment, while CO_2 emissions are cut by 1.0 percent.

Table 26: Impact of Reduced Border Delay on Vancouver-Seattle Corridor, 2020 (kg/day)

	NO_x	VOC	CO	PM_{10}	CO_2
Baseline Scenario 2020					
Truck Idling	16	10	333	1	34,305
Trade-Related Total	3,664	508	8,257	119	2,137,038
Reduced Border Delay 2020					
Truck Idling	6	4	135	0	13,907
Trade-Related Total	3,654	502	8,059	119	2,116,641
Percent Change					
Truck Idling	-59%	-59%	-59%	-59%	-59%
Trade-Related Total	-0.3%	-1.2%	-2.4%	-0.3%	-1.0%

Other corridors may present different opportunities to reduce delay. For example, the commercial vehicle facilities at Emerson-Pembina currently close at 11 pm and reopen at 8 am. Providing 24-hour customs service would allow truck shipments to be spread more evenly

[40] Nozick, 1998.
[41] Nozick, 1998.

throughout the day and may reduce delay somewhat. The actual magnitude of commercial vehicle border delay at Emerson-Pembina and most other crossings is not well understood.

5.3 Lower Truck Emission Standards in Mexico

In calculating 2020 emissions in the US-Mexico corridors, we assume that Mexican trucks would meet the 2004 emissions standards planned for the United States and Canada, but would not meet the 2007 standards that rely on the availability of low-sulfur (15 ppm) diesel fuel. It is possible that low sulfur fuel will be available in Mexico, at least in heavily traveled corridors such as Monterrey-Nuevo Laredo. There is some indication that PEMEX, the national oil company, is considering introducing cleaner diesel fuels in high-density corridors.[42]

We calculate the emissions benefits that could be gained from providing low sulfur diesel fuel, and associated emission control technologies, in the Monterrey-Nuevo Laredo Corridor. As a most optimistic scenario, we assume that all NAFTA trade trucks operating in the corridor would use the fuel and be equipped with NO_x catalysts and particulate traps, and would begin meeting the new US heavy-duty truck emissions standards starting in 2007 (the same schedule as the United States) As shown in Table 27, the emission benefits of this scenario are dramatic. Total NAFTA trade emissions of NO_x and VOC are reduced by over 40 percent, and PM_{10} emissions are reduced by over 55 percent.

Table 27: Impact of Low-Sulfur Diesel on San Antonio-Monterrey Corridor, 2020 (kg/day)

	NO_x	VOC	CO	PM_{10}	CO_2
2020 Baseline	24,854	4,255	39,843	1,134	10,227,511
Mexican Low Sulfur Diesel	14,982	2,325	39,843	511	10,227,511
Percent Change	-40	-45	0	-55	0

A more modest scenario, in which one-quarter of Mexican trade trucks in the corridor meet the 2007 US standards, still results in large emission reductions. Emission reductions compared to the Baseline would range from eight percent lower NO_x to 11 percent lower PM_{10}.

5.4 Reducing Empty Freight Mileage

Description

Improvements to freight operating efficiencies can reduce trade-related environmental impacts. One area of potential improvement is a reduction in empty mileage movements. When truck and rail carriers cannot arrange for a return shipment, trailers and rail cars travel empty. Reducing these inefficiencies can reduce freight vehicle movements and their associated emissions. Of course, given the keen competition in the industry, most carriers strive to maximize utilization of their equipment without government intervention. But some policy steps may help to reduce empty mileage. For example, the use of electronic data interchange (EDI) can reduce transaction

[42] *Binational Border Transportation Planning and Programming Study*.

costs in the truck-freight market and facilitate better load matching. Less restrictive cabotage rules could provide Canadian and US carriers making international trips with more flexibility in arranging for return loads. It is also believed that US operating restrictions on Mexican trucks leads to excessive deadheading at the US-Mexican border.

There may be less potential for a reduction in empty rail mileage in NAFTA corridors because rail commodity flows currently exhibit a much larger north-south imbalance. For example, southbound rail tonnage in the Vancouver-Seattle corridor is over four times northbound tonnage. Similarly, current rail flows from Ontario to eastern Michigan are more than twice those in the reverse direction. Commodity flows by truck, on the other hand, are fairly evenly balanced between northbound and southbound across all three of the US-Canada corridors.

Impact on Emissions

We explore the environmental impact of reducing empty backhauls in the Toronto-Detroit corridor. Commodity flows by truck through Detroit-Windsor and Port Huron-Sarnia are evenly split by direction. Based on surveys of commercial vehicles at Windsor and Sarnia, approximately 15 percent of large trucks in both directions are empty, and another 15 percent are a quarter to half full.[43] We calculate the impact of reducing the percentage of empty trucks to 10 percent. As shown in Table 28, total trade-related NO_x and PM_{10} emissions are reduced by about three percent compared to baseline levels. CO2 emissions drop by nearly five percent.

Table 28: Impact of Reducing Empty Mileage on Toronto-Detroit Corridor, 2020 (kg/day)

	NO_x	VOC	CO	PM_{10}	CO_2
2020 Baseline	21,022	3,207	54,188	697	14,102,189
Truck Backhauls Reduced	20,455	3,074	51,580	676	13,434,520
Percent Change	-2.7	-4.2	-4.8	-3.0	-4.7

The fraction of empty trucks between Ontario and Eastern Michigan is actually fairly low compared to many trade corridors. It is not uncommon to find 30 percent to 40 percent of trucks on major interurban highways traveling empty. Empty fractions appear to be much higher in the San Antonio-Monterrey corridor, though studies of the Laredo/Nuevo Laredo crossing are inconsistent. One study, based on customs data, suggests that 45 percent of northbound shipments at Laredo are empty.[44] Another, based on weigh-in-motion (WIM) data, found that only 22 percent of northbound five-axle trucks are empty.[45] The actual figure is probably somewhere between these two. There is no information on the empty truck fraction in the southbound direction, or at other points in the corridor north or south of the border.

In the San Antonio-Monterrey corridor, it is generally accepted that current operating restrictions are contributing to the high empty fraction. Northbound truck shipments are typically carried to Nuevo Laredo by Mexican line haul trucks, drayed across the border by another Mexican truck,

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[43] *1995 Commercial Vehicle Survey: Station Summary Report*.
[44] *Binational Border Transportation Planning and Programming Study*.
[45] Leidy, 1995.

then carried by a US truck in Texas. This system makes it difficult for trucks to find loads for their return trip, particularly the drayage fleet. Because the extent of empty mileage through the corridor is not known, it is difficult to calculate the potential emissions benefits of more efficient operations. Clearly there would be significant benefits to reducing empty mileage of drayage trucks at the border, as these trucks are generally older than the line haul trucks and have higher emission rates (though we expect use of drayage trucks for cross-border movements to be phased out by 2020). Reducing empty mileage would also cut border delay, particularly southbound queues at the Lincoln Bridge toll plaza, which would reduce emissions from all vehicles. It is likely that the percentage reduction in emissions would be much larger than in the Toronto-Detroit corridor.

On the other hand, the potential to reduce empty mileage is limited where large trade imbalances exist. Commodity flows between the United States and Mexico are not as evenly split by direction as in the US-Canada corridors. For example, southbound truck flows at Laredo/Nuevo Laredo exceed northbound flows by over 40 percent. As long as this continues, some level of empty backhauls will persist.

5.5 Longer Combination Vehicles

Description

Truck size and weight limits can affect the cost of freight movement by truck, and therefore the volume of truck traffic and related environmental impacts. These limits are determined by a variety of regulations at the federal and state/provincial level. In the United States, the federal government sets both “floors” and “ceilings” on state truck size and weight limits. All states are required to allow five-axle trucks with a gross vehicle weight of 36,287 kilograms (80,000 pounds) on Interstates.

The term longer combination vehicles (LCVs) generally refers to trucks that are both longer and heavier than this standard. LCVs can take many forms, but the most common are the Rocky Mountain Doubles (48-foot lead trailer followed by a 28-foot trailer), Turnpike Doubles (two 48-foot doubles) and triples (three 28-foot trailers). Before 1991, many US states had raised their limits to allow LCVs, but federal law in that year froze maximum size and weight limits in every state. “Grandfather” exemptions allow states to keep less restrictive limits if they were already in place in 1991.

In Canada, a memorandum of understanding (MOU) between the provinces, first signed in 1988, determines both size and weight limits. Weight limits are much higher than in the United States—up to 62,500 kilograms (130,790 pounds) for eight-axle combinations. Length limits allow trucks up to 25 meters (82 feet), though many fleets receive permits to operate longer vehicles. In Mexico, truck regulations applicable on national highways are established by the federal government, and the size and weight limits are generally similar to Canadian limits. A NAFTA provision calls for Canada, the United States and Mexico to develop a harmonized schedule of truck size and weight limits, but little progress has been made on this front.

Because they are the lowest common denominator, the US regulations tend to govern the size and weight of trucks involved in US/Canada trade. For any particular roadway, however, the actual truck operating restrictions may be subject to a myriad of unique state and provincial rules. For example, there is significant use of LCVs at the Alberta-Montana border crossings. A 1994 survey shows that 21 percent of trucks at Coutts-Sweetgrass pull double trailers, primarily because of Montana's policy to allow Canadian LCVs on I-15.[46]

Use of LCVs in the Winnipeg-Fargo corridor is much more limited. North Dakota allows trucks up to 47,854 kg (105,500 lbs) on Interstates with a permit, and also allows Rocky Mountain Doubles and Turnpike Doubles. However, many of the states south and east of North Dakota do not allow LCVs, primarily because of concerns about their impact on highway safety. This tends to limit their use in the corridor.[47] Analysis of commodity flow data suggests that only 10 percent of trucks crossing at Emerson/Pembina have a US trip end in North Dakota, while a much larger share (45 percent) of the trucks traveling in this corridor are moving between Manitoba and the states of Minnesota, Iowa, Illinois, Wisconsin and Missouri, which generally do not allow LCVs.

Impact on Emissions

We explore the impact of allowing LCVs throughout the upper midwestern states in a manner consistent with North Dakota's current policy. We assume all of the trucks moving between Canada and the states of Minnesota, Iowa, Wisconsin, Illinois and Missouri (45 percent of the corridor total) would be operating as either Rocky Mountain Doubles or six-axle single trailer combinations, with a maximum weight limit of 47,854 kg (105,500 lbs). This would allow roughly a 36 percent increase in average payload weight and, for the Rocky Mountain Doubles, a 62 percent increase in cargo volume. We apply these larger average payloads to the commodity flows to and from the upper midwestern states. The immediate impact would be an 11-percent reduction in trade truck traffic. However, an increase in truck size and weight would effectively reduce trucking costs, and thus divert some freight from rail to truck. This issue needs to be accounted when calculating environmental impacts.

Several studies have examined the impact of changes in truck size and weight limits on the US freight rail industry. One study estimated that eliminating the 36,287 kg (80,000 lbs) weight limit alone would divert 2.2 percent of railroad ton-miles to truck nationwide. A study for the American Trucking Association found that allowing nationwide operation of LCVs would divert 5 percent of rail ton-miles to truck. The American Association of Railroads estimates that nationwide use of LCVs would result in direct diversion of 11 percent of rail ton-miles, plus another 8 percent as a result of rail service cutbacks that would follow.[48]

Because our scenario for the Winnipeg-Fargo corridor envisions use of trucks only up to 47,854 kilograms (105,500 pounds) rather than heavier LCVs, we assume a five-percent diversion of rail tonnage to truck. Only rail freight moving to and from the midwestern states would be affected. We calculate a slight increase in emission factors for the larger trucks based on the relationship

[46] Nix, 1998.
[47] Only 3.2% of trucks in a 1996 survey had more than five axles (*Prairie Provinces Transportation System Study*).
[48] *A Guidebook for Forecasting Freight Transportation Demand*.

between energy use and GVW.[49] Table 29 shows the impact of the LCV scenario on freight traffic volumes and emissions in 2020, compared to the Baseline Scenario. The total impact is a reduction in emissions of all pollutants. CO and CO_2 show the greatest reduction (seven percent), while NO_x and PM_{10} emissions fall by approximately four percent. The mode shift to trucking has the effect of furthering the NO_x and PM_{10} reductions, while slightly offsetting the reductions in other pollutants.

Table 29: Impact of LCV Use on Winnipeg-Fargo Corridor, 2020

Scenario	Mode	Freight/year (million kg)	Annual Vehicles*	Emissions (kg/day) NO_x	VOC	CO	PM_{10}	CO_2
2020 Baseline	Truck	15,150	1,233,117	1,054	248	4,827	39	1,239,630
	Rail	16,262	217,966	3,094	170	647	90	239,357
	Total	31,412	N/A	4,148	418	5,473	128	1,478,987
LCV Scenario	Truck	15,150	1,093,820	945	222	4,326	35	1,111,110
-- Immediate Impact	Rail	16,262	217,966	3,094	170	647	90	239,357
	Total	31,412	N/A	4,039	393	4,973	124	1,350,467
LCV Scenario	Truck	15,598	1,125,650	972	229	4,452	36	1,143,444
-- Total Impact	Rail	15,814	207,068	3,009	166	629	87	232,765
(with mode shift)	Total	31,412	N/A	3,981	394	5,081	123	1,376,208
	Percent Change			-4.0	-5.7	-7.2	-4.3	-6.9

* Loaded rail cars only

It should be noted that any reduction in shipping cost (through use of LCVs or other means) may lead to some increase in total freight volumes due to induced demand. If the savings from lower transport costs are passed on to consumers, consumption (and aggregate demand) may increase, leading to more shipments. It is difficult to estimate the magnitude of these impacts, however. Since transport costs typically make up only a fraction of merchandise price, any increase in shipping volumes would likely be small. Also note that the increase in emission rates associated with larger trucks is not well understood. These calculations assume that fuel consumption and emission rates per mile would rise approximately three percent as GVW increases to 47,854 kilograms (105,000 pounds). If the fuel consumption increase for the heavier trucks is actually larger, the emission reductions would be smaller or might be eliminated altogether.

Several serious nonenvironmental concerns have been raised regarding greater use of LCVs, such as their impact on traffic safety and pavement damage. Although these issues are beyond the scope of this study, they must be included in any assessment of changes to LCV operating restrictions.

[49] Nix, 1991.

6 OTHER ENVIRONMENTAL IMPACTS

Increases in freight transportation can have adverse environmental impacts outside of air quality. These impacts occur through increased levels of truck and rail traffic in a corridor and also through construction activities associated with building new or expanded freight handling facilities, widening highways, double- or triple-tracking rail lines, or building new segments of highway or rail. Four areas of environmental impacts are discussed below—water resources, biological resources, noise and ground-borne vibration, and hazardous materials. No quantification of these impacts is attempted.

6.1 Water Resources

Increased truck traffic can contribute to higher levels of runoff pollution from highways, including particulates and heavy metals from vehicle exhaust fumes, copper from brake pads, tire and asphalt wear deposits, and drips of oil, grease, antifreeze, hydraulic fluids, and cleaning agents. Contamination of surface water beyond the corridor itself could occur in the event of a spill of material in transport. Spills can permeate the surrounding soil and contaminate the groundwater. Improperly disposed motor oil is an extremely concentrated water contaminant—one quart of motor oil can contaminate a million gallons of fresh water.

Construction impacts to water resources are often related to run-off from the impervious surfaces created by construction sites and erosion of barren rock and soil surfaces exposed during excavation. The use of vehicle washing effluents and oil and hazardous materials at the construction facility could also lead to surface water contamination. When construction involves work in surface water, like the dredging of a new tunnel alignment, there is a danger of disturbing contaminated sediments. Ground excavation in areas with a long history of industrial activity may disturb shallow groundwater containing elevated levels of heavy metals and hazardous organic compounds. The development of new railroad lines can contribute to leaching of creosote into soil and groundwater. Creosote is a hazardous material containing carcinogenic impurities, and is used to treat railroad ties to protect against decay and rot.

6.2 Biological Resources

Increases in freight traffic volumes can adversely impact sensitive species with habitat near the corridor. However, construction impacts on biological resources are a much bigger concern. Construction of a new right-of-way can lead to destruction or fragmentation of habitat. Construction can also impact biological resources when higher levels of run-off lead to a large physical disturbance of habitats, such as fish-spawning areas and water vegetation. High run-off volumes of water from hot paved surfaces can boost surface water temperatures, harming fish and other aquatic life. Open water disposal of dredged material can alter bottom habitats, decrease water quality, and adversely affect marine organisms.

6.3 Noise and Ground-Borne Vibration

Intrusive noise and vibration can degrade the quality of life for people in affected areas. In extreme cases, excessive noise can pose a threat to hearing. Sound above 65 dB(A) is enough to cause annoyance and sound above 125 dB(A) is considered painful.[50] In addition to the decibel level, the frequency, duration and time of day affect the extent of noise impacts. Noise can cause stress and other health problems and can affect the habitat of species living near the roadway or rail line.

Increased use of a transportation system generates greater noise impacts. Noise from road and rail transport comes primarily from engine operations, but also includes noise generated from pavement/rail-wheel contact, aerodynamic effects and the vibration of structures. Near a grade crossing, locomotive horns are typically the most significant contributor to noise. Typical noise levels for highway vehicles at a distance of 7.5 meters range from about 70 dB(A) for automobile traffic to 85 dB(A) for a heavy trucks. Noise levels for railroad operations are approximately 90dB(A) for an electric locomotive, 92dB(A) for a diesel locomotive, and 120 dB(A) for a locomotive horn. For safety reasons, locomotives typically sound a horn at a grade crossing, so increases in train frequency can significantly boost average noise levels for a population living near a crossing. A recent trend to mitigate these impacts is to ban locomotive horns in exchange for improvements to crossing protection.

Perceptible noise and vibration caused by construction equipment may cause annoyance to people in the vicinity. As a general rule, the total noise level during a typical 12-hour, daytime construction workday is about 90 dB(A) at 15 meters from the construction site. Impact pile driving can cause daytime annoyance out to a distance of approximately 76 meters and potential vibration damage to structures at distances less than about 12 meters from the pile driving. Tracked vehicles such as bulldozers as well as equipment used for vibratory compaction and excavation can create substantial noise and vibration during earth moving operations. Loaded trucks on construction surfaces can cause annoyance at distances up to 61 meters away. If exposed to sufficient high levels of ground vibration, a building may suffer structural damage, such as glass breaking or cracking plaster.

6.4 Hazardous Materials

Higher volumes of freight transport increase the likelihood of the accidental release of hazardous materials. Most reported incidents of hazardous waste spills occur in the highway sector, which transports over 60 percent of the hazardous materials in the United States, with rail reporting the next largest number of incidents. Spills may impose substantial costs for product loss, carrier damage, property damage, evacuations, and response personnel and equipment. The environmental impact depends on the type and quantity of material spilled, amount recovered in cleanup, chemical properties (such as toxicity and combustibility), and impact area characteristics (such as climatic conditions, flora and fauna density, and local topography). The hazardous materials most likely to be involved in a spill include corrosive and flammable liquids, gasoline, fuel oil, sulfuric acid, and compound cleaning liquids.

[50] Sound is most often measured on a nonlinear scale in units of decibels (dB). An adjusted scale, the A-weighted scale, emphasizes sound frequencies that people hear best. On this scale, a 10-dB(A) increase in sound level is generally perceived by humans as a doubling of sound.

During construction activity, the likelihood for encountering contaminated soils or groundwater is greater as the volume of the earth to be moved increases. The proximity of hazardous waste sites to the project will also affect the chance of encountering contaminated soils or groundwater. Petroleum-related contamination is the most commonly encountered problem but is one for which relatively well-developed procedures are available. Proximity of the project alignment to oil fields increases the possibility that associated hydrocarbon contaminants may be encountered, including hydrogen sulfide gas. Soil contamination is a common issue with construction projects, though it mainly affects project implementation and cost more than human health or ecology.

6.5 Summary of Other Environmental Impacts

The specific impacts of increased trade on environmental quality other than air depend greatly on local conditions. In general, increased freight activity within an existing corridor poses greater concerns for air quality impacts than non-air impacts. Noise is probably the most significant non-air impact resulting from higher traffic levels, particularly rail traffic, in places where the corridor passes through populated areas. The likelihood of a hazardous materials release may also increase with freight traffic levels. If increased trade leads to the expansion of facilities or construction of new facilities, non-air impacts can be much more significant, and water and biological resources then become a major concern.

7 DATA NEEDS AND OPPORTUNITIES FOR COOPERATION

The process of determining the environmental impacts of cross-border trade reveals a number of areas where necessary information is non-existent or highly uncertain. It is important that these deficiencies are addressed as trade-related environmental issues become more prominent. Four specific areas are mentioned below, followed by several examples of ways to improve information collection and environmental monitoring.

7.1 Data Needs

Cross-Border Traffic Volumes

At many border crossings, truck and rail traffic counts are not readily available. Obtaining the data usually requires contacting the individual customs stations, but many customs stations do not have records of rail traffic or do not release cross-border traffic information at all. It is also important to know the fraction of empty rail cars at a border crossing to properly estimate environmental impacts. Yet this information is rarely available, in part because customs offices do not compile it, and also because some rail crossings (e.g., tunnels) are privately operated and therefore the information is considered proprietary. One exception is the Texas-Mexico border crossings. Truck and rail traffic volumes for all POEs are regularly collected and published by Texas A&M International University.

Freight Origin-Destination Patterns

A variety of commercial vehicles cross the international borders, including service/utility trucks, short haul delivery trucks moving goods between the two border towns, intermodal drayage trucks, and long-haul trade trucks carrying goods to or from the interior of a country. Each affects air quality in a different way. To do a detailed environmental analysis, some information on goods movement patterns should be obtained from an origin-destination (O-D) survey of commercial vehicles at the border. A good example is Transport Canada's recently completed National Roadside Survey, which includes detailed interviews with truckers in border areas. In some cases, these interviews have been supplemented with additional surveys sponsored by local agencies or border trade alliances. In the United States, California performs periodic O-D surveys at its border with Mexico. No such program exists in Arizona, Texas, or Mexico.

Railroad Emissions Calculations

Because of limitations in the data and methodology, estimations of railroad emissions are subject to large uncertainties. As described in Section 2, rail emissions are calculated by applying average emission factors to estimated fuel use, which is based on freight ton-kilometers. The average fuel consumption rates inherently account for some movement of empty rail cars. But cross-border traffic could exhibit a percentage of empty cars that is quite different from the average. This is particularly true in corridors with large imbalances in rail freight, such as Vancouver-Seattle and Winnipeg-Fargo. It is likely that the standard emissions estimation methodology underestimates rail fuel use in these corridors because of a large number of empty cars. Correspondingly, these methods likely overestimate rail fuel use in corridors that are particularly well-balanced in their freight flows. Given these uncertainties and the increasing interest in corridor-specific emissions, better information is needed on freight railroad traffic and its fuel use.

Border Delay Measurements

With the high level of attention paid to border crossing delay, it is surprising that so little quantitative information is available on the actual magnitude of delay. Of the five corridor segments included in this study, a measurement of average border delay was available for only two crossings, and these were based on a single-day field survey in 1997.[51] Several other studies discuss maximum delay or maximum queue lengths, but this says little about the experience of an average trucker. Together with O-D surveys, border delay surveys should become part of a regular data collection scheme by the border trade alliances. In addition to environmental concerns, this would give the coalitions the ability to monitor border congestion and make a better case for new border infrastructure projects.

7.2 Data Collection and Sharing Opportunities

A variety of government, university and private sector organizations take an interest in border trade issues, and some of these could serve as a means to collect and distribute needed

[51] *Binational Border Transportation Planning and Programming Study*.

information on transportation and the environment in NAFTA corridors. Nearly all large border crossings have one or more public and private sector coalitions that exist to promote trade and regional development. These may be complemented by larger corridor coalitions, such as the CANAMEX Corridor Coalition or the North American Superhighway Corridor Coalition, that have more of a North American focus. Most of the corridor coalitions exist primarily to support highway modes, though some promote multi- modalism and environmental initiatives. In assessing environmental impacts, they can serve a useful role by monitoring traffic volumes and delay.

University research institutes can be an excellent source of border transportation and environmental information. For example, a consortium of Texas universities, including Texas A&M International University, the University of Texas at Austin, the University of Texas at El Paso, and Texas A&M, have contributed a substantial body of research on the effects of NAFTA implementation, with a focus on the Texas border area. Recent studies by this group have included examinations of border trade truck volumes, border truck size and weight issues, trade flow patterns, and border air pollution levels. The University of Manitoba Transport Information Group (UMTIG) is another example of a research institution involved study of NAFTA trade and transportation issues. Most institutes, however, do not appear to have taken much interest in border environmental issues.

State and provincial agencies should also play a role in monitoring the environmental impacts of trade and transportation at the corridor level. One example is the Oregon Department of Transportation’s “I-5 State of the Interstate Report—2000.” The report and data, delivered on CD ROM, provides an assessment of the existing and forecast safety, geometric, and operating conditions on Interstate 5 through Oregon. It also contains an inventory of environmental conditions in the corridor, including landscape conditions and sensitive species habitats. Truck and rail activity are discussed only in narrative form, but could be incorporated into such a system in more detail.

Finally, federal agencies support the collection, analysis and dissemination of information related to environmental impacts of trade and transportation. The US EPA has a program called the “US-Mexico Border Information Center On Air Pollution,” known by its Spanish acronym CICA. CICA provides technical support and assistance in evaluating air pollution problems along the Mexico-US border, including air pollutants and control strategies, pollution prevention and control technology applications, emission inventory, dispersion modeling and ambient monitoring. The program maintains a web site <http://www.epa.gov/ttn/catc/cica/> that includes detailed air quality data from monitoring sites in both the United States and Mexico. Most of the air quality information pertains to the areas that currently experience the most serious air pollution problems—San Diego-Tijuana, Calexico-Mexicali, Nogales-Nogales and El Paso-Ciudad Juarez, though some air quality monitoring data are available for Laredo and Hidalgo, Texas.

8 SUMMARY

This study examines the environmental impacts resulting from the development of North American trade and transportation corridors, with a primary focus on air pollution emissions. Five corridor segments are selected for analysis: Vancouver-Seattle, Winnipeg-Fargo, Toronto-Detroit, San Antonio-Monterrey and Tucson-Hermosillo. Current and future levels of trade, transportation and emissions are estimated for each corridor segment. Strategies to mitigate air quality impacts are discussed, and their effects are compared against a baseline scenario.

Current Trade and Air Quality Impacts

Currently, NAFTA trade contributes significantly to air pollution in the major north-south corridors, particularly NO_x and PM_{10} emissions. Cross-border freight is responsible for 3 to 11 percent of all mobile source NO_x emissions in the corridors and 5 to 16 percent of all mobile source PM_{10} emissions. Trucking carries the most freight in the corridors and contributes the bulk of trade-related emissions—typically three-quarters of NO_x and more than 90 percent of PM_{10}. The exception is the Winnipeg-Fargo corridor, where rail and truck volumes are roughly equal. Truck idling associated with border crossing delay contributes significantly to CO emissions, particularly in corridors where border delay is problematic. CO emissions from idling at the border are as high as six percent of all trade-related CO emissions in the corridor segment.

Trade-related emissions of CO_2 and other greenhouse gases are significant, but cannot yet be quantified relative to other sources at the corridor level. Development of county level GHG inventories will be necessary to further inform this issue.

Future Trade and Air Quality Impacts

By 2020, due to the expected reduction in emission rates for trucks and locomotives, total trade-related emissions of NO_x and PM_{10} will decline or remain constant compared to current levels. This occurs despite trade volumes that grow by two to four times. In the US-Canada corridors, truck emissions of NO_x and PM_{10} per ton-kilometer will drop to about one-tenth their current levels. The gains in the US-Mexico corridors will not be as large under the assumption that low-sulfur diesel will not be widely available in Mexico, but truck emissions of NO_x and PM_{10} per ton-kilometer are still expected to drop to about one-fifth their current levels.

The change in NO_x and PM_{10} emissions from rail freight alone depends on trade growth rates. In corridors that will experience relatively slow growth (Vancouver-Seattle), the lower expected emission rates for locomotives will nearly offset the growth in rail freight volume. Corridors with higher trade growth (Winnipeg-Fargo and San Antonio-Monterrey), NO_x and PM_{10} emissions from rail will increase by 50 percent to 100 percent.

Trade-related emissions of greenhouse gases and CO will not be reduced under the new emission standards, and are therefore expected to rise substantially by 2020. Under the baseline 2020 growth scenario, CO_2 emissions from NAFTA trade will increase by 2.4 to 4 times over their current levels in the five corridors. While international agreements and targets are still being negotiated, it is presumed that GHG emissions will need to be stabilized or even reduced; the large projected rate of increase for CO_2 is therefore an issue of significant importance.

The 2020 Baseline scenarios used to estimate future emissions rely on assumptions about trade growth rates and mode share. Changes to these assumptions will affect future emissions levels. For example, the growth in truck and rail traffic could be stronger than the rates assumed under the baseline. If the trade growth follows the trend over the past decade, NO_x and PM_{10} emissions from trade could be as much as 50 percent higher than the 2020 Baseline levels. If this occurs, 2020 emissions of NO_x and PM_{10} could exceed 1999 levels in some corridors. Changes to the rail/truck mode share would also affect future emissions, though less significantly. Because of the large reduction expected in truck emission rates for some pollutants, a shift to rail would increase NO_x and PM_{10} emissions in most corridors, though it would reduce emissions of CO and CO_2 substantially at the same time.

Mitigation Strategies

Natural gas powered trucks emit far lower amounts of PM_{10} compared to today's diesel trucks. PM_{10} emissions from trade could be cut by nine percent if just 10 percent of today's trucks were converted to natural gas. By 2020, the vast improvement in diesel engine emissions means that alternative fueled vehicles lose much of their advantage. In the US-Canada trade corridors, natural gas vehicles are not expected to offer a significant emissions improvement over the 2020 diesel fleet powered by low-sulfur fuel. In the US-Mexico corridors, natural gas is likely to provide air quality benefits through 2020. If 20 percent of Mexican trade trucks in the San Antonio-Monterrey corridor burn natural gas, PM_{10} emission levels would be reduced 10 percent from the 2020 baseline.

Commercial vehicles face large delays at some international borders, and reducing this delay will produce air quality benefits, particularly through reductions in CO emissions. Studies suggest that at the most congested crossings (Laredo-Nuevo Laredo, Nogales-Nogales, Blaine-Pacific Highway), policy changes and investments could cut average delay in half. At Laredo-Nuevo Laredo, reducing avoidable delay on the Lincoln Bridge would cut the CO idling emissions from trade trucks by 35 percent in 2020, or 1.5 percent of all CO emissions from trade. At Blaine-Pacific Highway, nearly 200 kilograms of CO per day could be eliminated by expanding the use of commercial vehicle pre-clearance, equivalent to 2.4 percent of trade-related CO emissions in the corridor.

The use of low-sulfur diesel fuel in the United States and Canada will allow heavy-duty trucks to cut NO_x and PM_{10} emission rates to only a fraction of current rates. While stricter emission standards are likely for Mexican trucks, the Mexican government currently has no plans to require low-sulfur fuels. Using low-sulfur diesel and advanced emission control technologies could have a major impact on truck emissions in the US-Mexico corridors. If Mexican truck emission rates match those in the United States by 2020, trade-related emissions of NO_x, VOC and PM_{10} in the San Antonio-Monterrey corridor will be cut by roughly half.

Improving the efficiency of freight transport by reducing empty vehicle mileage will lower all pollutant emissions from trade. In the Toronto-Detroit corridor, reducing the fraction of empty trucks from 15 percent to 10 percent would eliminate over 0.5 metric tons of NO_x and 600 metric tons of CO_2 per day in 2020 (5 percent of the trade total). The US-Mexico corridors have the potential for even larger reductions, but the data needed for such analysis is incomplete. Ports of entry with large trade imbalances will have less opportunity for reducing empty backhauls. Many north-south corridors currently have these imbalances in rail freight.

Allowing the use of longer combination vehicles (LCVs) in NAFTA corridors will reduce truck volumes and associated emissions. Because LCVs lower the cost of shipping by truck, some freight would shift from rail to truck. Use of longer and heavier trucks is allowed in several Canadian provinces, but because many US states restrict their use, the standard 5-axle single-trailer truck dominates most north-south corridors. By increasing the truck weight limits in five US midwestern states to 47,854 kilograms (105,500 pounds) and allowing Rocky Mountain Double configurations, emissions of all pollutants could be reduced by four to seven percent compared to the 2020 baseline. There are also safety and pavement damage issues associated with the greater use of LCVs, but they were not examined in this study.

Data Issues

Some of the data needed to assess environmental impacts of trade and transportation corridors are unavailable or highly uncertain. A coordinated effort to collect and disseminate information is needed, particularly in the following areas:

- Cross-border traffic volumes, including number of empty versus full trucks and rail cars;
- Freight origin-destination patterns in the border regions;
- Data and methodology to estimate railroad emissions; and
- Measurements of average commercial vehicle delay at border crossings.

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APPENDIX A COMMODITY FLOW SUMMARY TABLES

Truck Binational Commodity Flows, Vancouver-Seattle Corridor, 1999 (Metric tons)

Southbound (to US)

Destination	Wood and Wood Articles	Paper Products	Sulfur, Cement, Stone	Wood Pulp, Scrap Paper	Beverages	Other Commodities	Total
WA	702,159	114,245	178,255	69,302	23,437	491,632	1,579,030
CA	305,931	198,624	480	15,368	60,884	210,512	791,798
OR	360,337	41,238	11,688	25,022	18,014	102,968	559,266
IA	7,303	12,038	9	24	169	46,977	66,520
TX	36,752	11,404	39	486	2,950	14,719	66,350
Other States	342,565	100,684	11,129	25,821	15,116	152,296	647,611
Total	1,755,047	478,232	201,599	136,023	120,571	1,019,103	3,710,575

Northbound (to Canada)

Origin	Wood and Wood Articles	Coal, Mineral Oils	Paper Products	Iron and Steel	Sulfur, Cement, Stone	Other Commodities	Total
WA	155,949	215,486	98,987	75,526	41,607	439,693	1,027,248
CA	27,935	9,939	15,976	19,295	17,028	530,126	620,300
OR	105,109	53,075	32,040	28,672	5,518	127,399	351,815
OH	4,959	1,171	12,349	1,533	993	61,844	82,849
PA	3,567	5,807	15,459	2,818	1,478	51,294	80,423
Other States	55,117	27,613	80,791	29,967	87,460	668,101	949,050
Total	352,637	313,091	255,604	157,813	154,084	1,878,456	3,111,685

Rail Binational Commodity Flows, Vancouver-Seattle Corridor, 1999 (Metric tons)

Southbound (to US)

Destination	Wood and Wood Articles	Coal, Mineral Oils	Fertilizers	Wood Pulp, Scrap Paper	Organic Chemicals	Other Commodities	Total
WA	198,104	215,486	187,009	74,607	3,777	276,650	955,632
OR	270,824	52,301	70,474	54,686	133,422	137,436	719,142
CA	178,057	76,668	35,702	23,976	34,097	229,569	578,069
TX	91,304	22,098	68	7,456	34,383	24,748	180,057
MI	24,548	7,838	13,738	40,948	6,970	30,994	125,035
Other States	525,864	105,956	83,469	60,327	10,214	213,387	999,216
Total	1,288,701	480,347	390,460	261,998	222,862	912,784	3,557,151

Northbound (to Canada)

Origin	Sulfur, Cement, Stone	Coal, Mineral Oils	Organic Chemicals	Inorganic Chemicals	Iron and Steel	Other Commodities	Total
WA	85,037	37,491	-	51,889	476	4,927	179,820
PA	3,634	70,549	17,491	5,168	5,459	15,516	117,817
IL	2,779	2,816	29,456	3,582	1,212	39,704	79,550
GA	62,336	-	1,144	-	24	4,597	68,100
CA	563	25,765	1,881	14,389	44	23,373	66,014
Other States	11,562	16,109	48,445	17,291	61,643	174,120	329,170
Total	165,909	152,730	98,417	92,319	68,858	262,236	840,470

Truck Binational Commodity Flows, Winnipeg-Fargo Corridor, 1999 (Metric tons)

Southbound (to US)

Destination	Live Animals	Wood and Wood Articles	Coal, Mineral Oils	Processed Plant Products	Oil Seeds, Misc. Grains	Other Commodities	Total
MN	32,562	47,080	92,718	166	36174.83743	296,652	505,352
ND	2,387	6,357	44,114	3,016	103655.1098	123,407	282,936
WI	55,011	36,232	4,024	32,012	8968.888304	112,409	248,656
IL	3,342	26,401	7,820	65,921	3005.64048	91,416	197,905
IA	35,769	20,499	2,935	-	879.0295802	63,263	123,345
Other States	139,757	106,862	55,843	97,191	31,726	568,814	1,000,193
Total	268,828	243,430	207,453	198,305	184409.2586	1,255,960	2,358,386

Northbound (to Canada)

Origin	Machinery	Animal Feed	Paper Products	Oil Sees, Misc. Grains	Fertilizers	Other Commodities	Total
MN	13,792	71,716	13,491	29,521	12,633	159,072	300,225
IL	52,795	15,446	14,769	354	2,329	141,197	226,890
WI	26,193	4,523	45,643	1,785	61	70,185	148,391
ND	5,180	9,656	90	60,134	6,330	65,418	146,807
CA	5,258	4,782	518	1,301	241	77,502	89,602
Other States	173,164	119,619	91,376	18,948	83,887	699,164	1,186,158
Total	276,381	225,743	165,886	112,043	105,482	1,212,539	2,098,073

Rail Binational Commodity Flows, Winnipeg-Fargo Corridor, 1999 (Metric tons)

Southbound (to US)

Destination	Fertilizers	Cereals	Wood and Wood Articles	Fats and Oils	Coal, Mineral Oils	Other Commodities	Total
MN	550,269	396,082	22,077	7,167	30,044	116,189	1,121,829
IL	660,069	73,067	20,138	10,804	10,154	29,956	804,188
WI	103,994	104,241	16,693	2,841	23,389	40,566	291,724
ND	109,371	55,072	2,514	-	21,200	43,536	231,693
IN	161,398	21,684	4,406	219	950	10,817	199,475
Other States	495,691	424,944	197,670	101,025	32,974	230,824	1,483,127
Total	2,080,792	1,075,091	263,499	122,056	118,710	471,889	4,132,036

Northbound (to Canada)

Origin	Fertilizers	Ores, Slag, Ash	Plastics	Animal Feed	Rubber	Other Commodities	Total
FL	153,203	-	23	20,470	-	1,791	175,486
CT	-	85,616	382	-	-	685	86,684
TX	-	-	47,986	-	420	21,115	69,520
IL	-	-	407	535	2,190	55,962	59,095
MN	6,098	804	-	24,479	-	13,587	44,969
Other States	8,624	11,397	13,559	4,579	34,197	143,489	215,846
Total	167,925	97,818	62,357	50,064	36,807	236,629	651,599

Truck Binational Commodity Flows, Toronto-Detroit Corridor, 1999 (Metric tons)

Southbound (to US)

Destination	Autos, Parts	Iron, Steel	Wood and Wood Articles	Paper Products	Machinery	Other Commodities	Total
MI	2,885,707	1,240,151	771,983	182,165	631,301	2,651,449	8,362,755
OH	322,919	442,405	274,648	153,825	170,860	1,167,406	2,532,063
IL	247,324	167,426	119,534	289,145	89,272	952,379	1,865,080
IN	245,069	120,380	247,985	106,746	43,737	642,777	1,406,694
KY	229,261	78,541	32,384	36,978	51,041	288,229	716,433
Other States	1,111,572	215,294	455,008	851,893	265,112	3,894,984	6,793,863
Total	5,041,851	2,264,197	1,901,542	1,620,752	1,251,323	9,597,225	21,676,889

Northbound (to Canada)

Origin	Autos, Parts	Machinery	Iron, Steel	Paper Products	Plastics	Other Commodities	Total
MI	1,518,871	660,131	694,491	87,192	169,626	2,032,722	5,163,034
OH	552,852	276,372	583,799	193,033	154,945	1,291,543	3,052,544
IL	357,621	136,145	174,368	92,042	103,417	904,418	1,768,012
IN	480,101	150,223	220,835	43,319	68,626	630,246	1,593,350
CA	24,411	223,026	12,758	22,484	22,732	1,242,993	1,548,405
Other States	865,028	740,304	404,996	826,035	540,763	5,852,882	9,230,007
Total	3,798,884	2,186,201	2,091,247	1,264,105	1,060,109	11,954,805	22,355,351

Rail Binational Commodity Flows, Toronto-Detroit Corridor, 1999 (Metric tons)

Southbound (to US)

Destination	Autos, Parts	Wood and Wood Articles	Plastics	Iron, Steel	Paper Products	Other Commodities	Total
MI	1,340,543	82,804	448,384	132,311	84,846	749,371	2,838,259
IL	827	112,972	75,026	218,454	264,978	630,226	1,302,484
OH	44,603	72,411	169,563	234,535	115,498	352,663	989,274
IN	168,569	96,952	87,039	308,597	37,153	156,767	855,078
TX	998	96,059	116,432	61,145	82,832	428,290	785,756
Other States	628,514	966,760	392,443	305,896	604,307	2,434,755	5,332,674
Total	2,184,054	1,427,959	1,288,887	1,260,938	1,189,613	4,752,072	12,103,524

Northbound (to Canada)

Origin	Organic Chemicals	Plastics	Inorganic Chemicals	Cereals	Fertilizers	Other Commodities	Total
TX	385,444	354,467	52,324	3,960	389	362,512	1,159,096
KY	225,822	9,172	14,025	-	-	65,028	314,047
AR	-	-	-	248,325	112	38,968	287,405
PA	130,958	24,988	7,967	-	75	117,150	281,138
CA	723	887	40,680	85,201	1,595	141,343	270,429
Other States	382,871	287,907	488,332	112,980	327,352	1,553,945	3,153,387
Total	1,125,817	677,420	603,328	450,466	329,523	2,278,947	5,465,502

Truck Binational Commodity Flows, San Antonio-Monterrey Corridor, 1999 (Metric tons)

Northbound (to US)

Destination	Electrical Equipment	Autos, Parts	Machinery	Iron and Steel Products	Iron, Steel	Other Commodities	Total
TX	279,906	90,422	109,885	166,281	215,899	1,594,231	2,456,624
MI	31,835	117,020	91,014	125,730	21,495	93,961	481,055
CA	58,464	21,077	28,276	8,487	15,462	346,166	477,932
IL	38,281	25,116	74,479	6,879	5,917	172,434	323,106
OH	77,317	47,866	30,093	6,160	1,257	141,637	304,330
Other States	651,584	330,921	276,339	105,999	131,455	1,741,917	3,238,213
Total	1,137,386	632,421	610,086	419,537	391,484	4,090,347	7,281,261

Southbound (to Mexico)

Origin	Coal, Mineral Oils	Plastics	Autos, Parts	Electrical Equipment	Iron, Steel	Other Commodities	Total
TX	871,167	382,574	193,419	329,309	94,798	1,409,398	3,280,666
CA	45,136	50,271	9,258	50,258	24,465	301,823	481,211
MI	13,526	54,512	146,441	17,149	32,044	173,597	437,269
IL	28,883	57,773	17,733	19,600	36,876	251,293	412,158
PA	44,763	38,789	2,757	11,083	107,852	191,830	397,073
Other States	447,280	459,531	300,284	194,776	320,494	3,614,279	5,336,644
Total	1,450,756	1,043,450	669,891	622,176	616,529	5,942,220	10,345,022

Rail Binational Commodity Flows, San Antonio-Monterrey Corridor, 1999 (Metric tons)

Northbound (to US)

Destination	Autos, Parts	Beverages	Iron, Steel	Sulfur, Cement, Stone	Machinery	Other Commodities	Total
MI	1,201,087	-	30,600	7,246	95,231	3,307	1,337,471
TX	84,721	428,242	136,780	19,660	2,899	229,835	902,136
IL	69	160,707	609	99	60	15,275	176,819
PA	-	-	154	77,513	21	50,764	128,452
NJ	88	-	72,967	-	716	12,142	85,913
Other States	49,473	2,497	31,733	51,569	32,709	195,281	363,263
Total	1,335,438	591,446	272,843	156,087	131,637	506,604	2,994,055

Southbound (to Mexico)

Origin	Wood Pulp	Cereals	Sulfur, Cement, Stone	Coal, Mineral Oils	Animal Feed	Other Commodities	Total
TX	61,221	174,919	33,590	119,261	63,761	444,013	896,764
GA	316,316	182	90,318	2,768	708	15,092	425,384
IL	53,212	6,647	43,270	2,754	94,568	116,997	317,449
CA	20,372	11,480	4,726	142,830	11,698	59,715	250,823
IA	303	97,607	-	-	117,875	22,969	238,753
Other States	836,650	513,053	602,707	390,385	216,059	1,262,322	3,821,176
Total	1,288,075	803,888	774,611	657,997	504,669	1,921,109	5,950,349

Truck Binational Commodity Flows, Tucson-Hermosillo Corridor, 1999 (Metric tons)

Northbound (to US)

Destination	Vegetables	Fruit, Nuts	Copper and Products	Electrical Equipment	Machinery	Other Commodities	Total
AZ	856,678	436,697	116,311	43,184	66,290	355,907	1,875,066
CA	46,874	16,568	1,111	31,855	15,407	148,595	260,410
PA	6,960	5,349	99	4,903	4,213	41,634	63,157
IL	951	390	226	4,584	8,919	23,622	38,692
TX	1,190	1,740	135	2,425	952	14,840	21,282
Other States	3,752	5,248	621	23,629	12,931	80,310	126,490
Total	916,403	465,992	118,502	110,580	108,711	664,909	2,385,097

Southbound (to Mexico)

Origin	Plastics	Iron, Steel	Coal, Mineral Oils	Iron and Steel Products	Electrical Equipment	Other Commodities	Total
AZ	147,623	91,205	75,650	82,952	83,284	354,976	835,690
CA	7,582	3,690	6,808	3,954	7,580	42,965	72,579
TX	7,864	1,949	17,908	4,736	6,769	28,212	67,439
MI	6,597	3,878	1,637	5,367	2,075	33,366	52,920
IL	6,524	4,164	3,262	4,078	2,213	26,301	46,542
Other States	25,398	32,239	30,378	13,262	9,874	203,310	314,460
Total	201,588	137,124	135,643	114,350	111,797	689,130	1,389,632

Rail Binational Commodity Flows, Tucson-Hermosillo Corridor, 1999 (Metric tons)

Northbound (to US)

Destination	Sulfur, Cement, Stone	Autos, Parts	Inorganic Chemicals	Beverages	Copper and Products	Other Commodities	Total
AZ	685,481	112,727	67,957	460	15,960	8,243	890,827
CA	12,795	2,299	837	1,221	13	9,310	26,474
IL	12	8	179	19,304	-	1,736	21,240
MI	93	15,393	-	-	-	1,655	17,141
CT	1,383	-	458	-	899	6,434	9,174
Other States	1,263	845	977	4,240	1,046	7,834	16,206
Total	701,026	131,272	70,408	25,225	17,917	35,213	981,062

Southbound (to Mexico)

Origin	Ores, Slag, Ash	Iron, Steel	Cereals	Wood Pulp	Fertilizers	Other Commodities	Total
AZ	93,720	69,266	12,896	6,433	29,197	61,490	273,002
MI	-	5,487	187	9,408	-	96,083	111,166
MO	-	366	23,264	3,986	37	38,524	66,176
CA	-	830	1,441	2,558	626	26,033	31,488
KS	-	18	12,122	958	132	7,390	20,620
Other States	143	1,845	12,779	16,797	4,388	40,567	76,518
Total	93,863	77,812	62,690	40,139	34,379	270,088	578,970

APPENDIX B REVIEWER COMMENTS ON DRAFT REPORT

Mark Winfield
Pembina Institute for Appropriate Development

The paper provides a good overview of the issue. I have a few general comments on it.

1. I wonder if the paper is being a little overoptimistic in its assumptions re: emission reductions as a result of reductions in the sulfur content of diesel fuel and fuel switching in the trucking industry. In light of the change in administration in the US these may no longer be safe assumptions. It would be good to see emission projections without these types of assumptions re: the implementation of new requirements for mobile diesel sources.

2. I think the paper underestimates scope of the environmental impacts of the transportation corridor phenomena. This seems to be particularly true in the case of the Detroit-Toronto corridor, which is the one I am most familiar with. The trade related demand for highway capacity has been a major factor in the Ontario government's recent announcements for an enormous expansion of highway capacity in the Corridor (including the Niagara Mid-peninsula corridor, expansions of highways 401, 407 and 7 and a new highway north of the 407 passing north of the Greater Toronto Area). Highway expansions already underway in Southern Ontario are facilitating further urban sprawl, and further investments are likely to exacerbate this problem by appearing to make greater commuting distances feasible, and encouraging new developments further and further away from existing urban cores. This process has implications for air quality, climate change, land-use and infrastructure costs well beyond those associated with the new highway capacity per se.

3. The paper seems to assume that one of the solutions is larger and longer trucks. Presumably this carries with it some potentially significant costs in terms of safety and infrastructure maintenance costs which should be recognized within the paper.

4. In general the paper seems to assume that the increased in long-distance movement of freight in North America is inevitable and that nothing can be done to address this basic direction. As a result , its proposed responses tend to be rather weak, addressing the symptoms of this increased traffic, rather than considering the possibility of ways of dealing with its causes. Does increased trade necessarily require increased long-distance transportation of goods, particularly in the information age? Are there ways in which such transportation, and its associated direct and indirect environmental and infrastructure costs, can be discouraged, or to encourage shifts to less costly modes (e.g. full cost pricing of commercial road use including infrastructure capital and depreciation costs)? One possibility might be to take a wider comparative perspective in the paper, as I understand that some European governments have taken much more aggressive approaches to promoting modal shifts away from trucks.

These comments aside I think the paper is a good start on an important issue, and I would be pleased to chat with you further about these questions.

Harry Hirvonen
Science Advisor, Forest Health
Science Branch
Canadian Forest Service
Natural Resources Canada

From comments received within CFS, our concern lies predominantly in the area of entry of exotic pests (insects, plants, etc) harmful to our native forests. The whitepaper did not really address this issue. Two examples highlight the concern: the Asian longhorn beetle in New York and Illinois, where millions of dollars have been spent trying to eradicate this pest, and the brown spruce longhorn beetle, isolated near the Halifax port of entry (Nova Scotia). Over the past winter the Canadian Food Inspection Agency coordinated the cutting of a couple of thousand trees in and around Point Pleasant park to prevent its spread. If the beetle reaches our native forest, our commercial species are in peril—a real concern.

Food for thought:

- As long as NAFTA exists, trade will flourish among the three countries and, as a result, so will the environmental consequences.
- From an exotics standpoint, this will have a couple of effects:
  a) greater movement of species native to each country among the three countries, and
  b) greater movement of exotics entering one of the countries from offshore and being trans-shipped to the other two countries.
- Given that there is virtually free movement of goods within each country, transborder transportation corridors will function as foci for exotics and, therefore, the ecosystems near the crossings and in the areas where goods are warehoused for redistribution near the borders will be at higher risk.
- The relative proportions of trade goods moving by rail and by truck should be evaluated. Are the rail and road transportation corridors the same? What kinds of commodities move by the two methods? Is there a greater risk of exotics movement by one or the other?
- The concept of “Fortress North America” might be considered relative to offshore pests. Greater vigilance at initial ports of entry will protect the importing country and its NAFTA partners.
- Transportation corridors should be (and are) a priority of quarantine regulators in intercepting pest movement, but might also serve in modeling risk associated with pathways.

The CEC may want to take a close look at this “exotics” and trade issue among the three countries. I would be pleased to facilitate contact with our experts and the appropriate CEC contacts to discuss this issue.

Roger Cameron
Director, Public Affairs
The Railway Association of Canada

Summary of Comments

The purpose of this analysis is to review the critical assumptions and findings of the ICF report for the Commission on Environmental Cooperation concerning *North American Trade and Transportation Corridors: Environmental Impacts and Mitigation Strategies*, February 2001.

The report confirms the environmental advantage of railroads compared to trucks in terms of Greenhouse Gas (GHG) emissions and carbon monoxide. However, it projects that in the year 2020 trucks will have an environmental advantage in terms of nitrogen oxides and particulate matter, in assuming that truck emission technology improves much more rapidly. It also states that there would be environmental advantages to allowing longer or heavier trucks.

Following are summary comments on the report's key assumptions:

Implicit Assumptions	Comments
Truck NO_x and PM emissions situation will improve 900 percent faster than for trains	Past experience shows similar technical improvements for both modes
Significant reductions in truck NO_x levels despite doubling or quadrupling of truck traffic by 2020	Despite emission reduction regulations, on road diesel NO_x emissions up 60 percent since 1970 in the United States.
Proposed solutions are focused on technical improvements to one mode—trucks	Experience shows traffic growth overwhelms technical improvements
Truck traffic can double or even quadruple without increasing emissions due to congestion	OECD: expanding highway capacity is rarely a sustainable solution, but rather adds to the problem
New cleaner trucks *replace* older polluting trucks	Many used trucks continue polluting after sale at home or for export
Allowing bigger and heavier trucks will reduce emissions and the number of trucks on the road	Experience shows that bigger trucks expand trucking capacity and lead to more trucking demand and activity
No change in cabotage and immigration regulations for trucks and drivers	Dynamics of free trade under NAFTA can shift goods production and transport activity to areas of lower standards

The report did not assess the environmental benefits of implementing electronic tolling to eliminate highway subsidies to big trucks that distort the market to truck and induce additional transport demand. There was no assessment of an intermodal framework integrating policies across borders, jurisdictions and modes in the context of full user-pay for all freight modes.

1. Introduction

The North American Commission for Environmental Cooperation (CEC) commissioned the report from ICF Consulting. The CEC released the report on 9 March 2001. The status of the report is unclear. There is no obvious disclaimer on the report itself, but at page 11 it is called a "working paper." Comments to the CEC on the report are due 4 May 2001. Comments should be addressed to:

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The CEC has a Stakeholder Advisory Group (SAG) which helped shape the parameters of the study and is providing comments on the ICF report. The SAG is composed of representatives of government and nongovernmental organizations, as well as a Mexican trucking company.

The report confirms the environmental advantage of railroads compared to trucks in terms of greenhouse gas (GHG) emissions and carbon monoxide. However, it projects that in the year 2020 trucks will have an environmental advantage in terms of nitrogen oxides and particulate matter, by assuming that truck emission technology improves much more rapidly than rail technology. It also states that there would be environmental advantages to allowing longer or heavier trucks.

The purpose of this analysis is to review the critical assumptions and findings of the ICF report for the Commission on Environmental Cooperation concerning *North American Trade and Transportation Corridors: Environmental Impacts and Mitigation Strategies*, February 2001.

The ICF report measurements are usually in metric form. Since Environment Canada does not publish time series data on emissions, this analysis has drawn on Environmental Protection Agency (EPA) data from the United States, which are in imperial measurements and will surface in this analysis from time to time [ed.: conversion factors are given].

2. Main Points in the ICF Report

Freight traffic in five transportation corridors (Vancouver-Seattle, Winnipeg-Fargo, Toronto-Detroit, San Antonio-Monterrey and Tucson-Hermosillo) will double or even quadruple over the next 20 years.

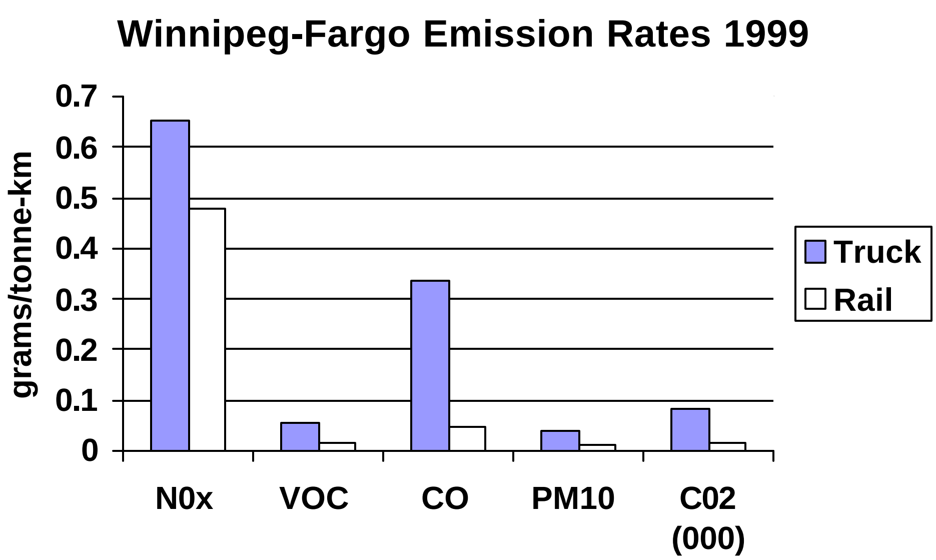
Trade related emissions of carbon dioxide (CO2), a greenhouse gas, will increase by two to four times over current levels in the study corridors. Trade related emissions of nitrogen oxides (NO_x)

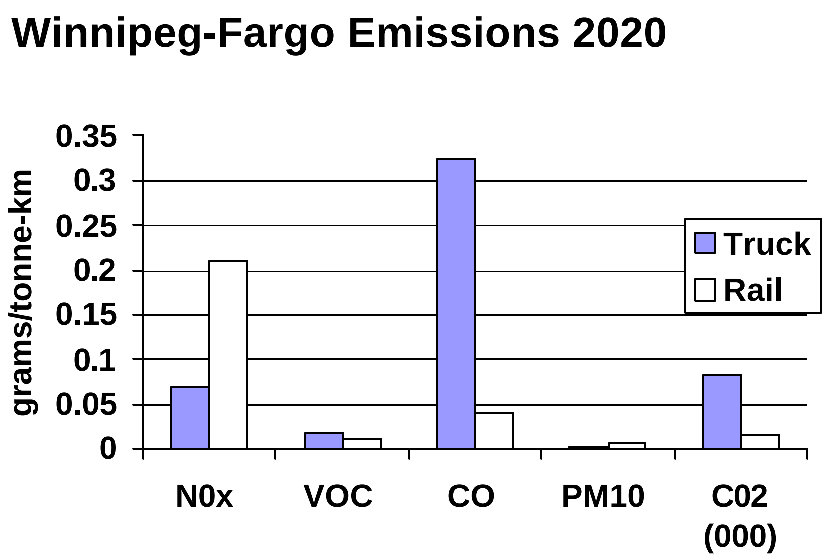
and particulates (PM) are expected to decline or stabilize. However, in some corridors rail emissions of NO_x and PM will increase 50 to 100 percent. This is because standards are less strict for locomotives and the replacement rate is slower for trains than for trucks.

The following table illustrates the reductions in NO_x emissions that the report forecasts for trucks in 2020. The report assumes drastic improvements in truck diesel technology. The example illustrated is for the Winnipeg-Fargo corridor. The data in the tables are derived from the output tables in the report.

Winnipeg-Fargo Emission Rates

		g/tonne-km	**g/tonne-km**	**g/tonne-km**	**g/tonne-km**	**g/tonne-km**
1999	billions tonne-km	NO_x	VOC	CO	PM_{10}	CO_2 (000)
Truck 1999	1.62	0.652	0.055	0.338	0.038	0.082
Rail 1999	1.74	0.478	0.018	0.047	0.012	0.017
		g/tonne-km	g/tonne-km	g/tonne-km	g/tonne-km	g/tonne-km
2020	billions tonne-km	NOx	VOC	CO	PM_{10}	CO_2 (000)
Truck 2020	5.51	0.070	0.017	0.323	0.003	0.082
Rail 2020	5.92	0.210	0.012	0.040	0.006	0.015





The data are also represented in the following table in terms of emission ratios truck/train. In 1999, trucks generate 1.4 times as much NO_x as rail per tonne-kilometer of freight movement; three times as much VOC, seven times as much CO, three times as much PM and five times as much CO_2. In 2020, trucks are forecast to generate 0.3 times as much NO_x as rail per tonne-kilometer, 1.4 times as much VOC, eight times as much CO, 0.4 times as much PM and six times as much CO_2. Truck emissions of NO_x and PM are forecast to improve by a quantum measure.

ICF Report: Emissions Ratios, Winnipeg-Fargo

	NO_x	VOC	CO	PM_{10}	CO_2
Truck/Rail 1999	1.36	3.10	7.16	3.18	4.72
Truck/Rail 2020	0.33	1.40	8.12	0.44	5.59

The ICF report states that increasing truck weights from 80,000 to 105,000 pounds and allowing Rocky Mountain Double longer combination vehicles would reduce pollution by four to seven percent compared to business as usual, even if freight shifts from rail.

3. Comments on Critical Assumptions in the Report

3.1 Relative Comparisons of Rail and Truck Emissions

The report assumes that truck emissions of NO_x and PM_{10} per tonne-kilometer will drop 900 percent faster than rail emissions. It assumes there will be little or no technology transfer between the modes and that governments make no changes to rail engine emission standards after those already set for 2005.

The US Environmental Protection Agency plans to reduce the allowable sulfur content in road diesel from the current limit of 500 parts per million (ppm) to 15 ppm in 2006. Canada will follow suit. The future limits of sulfur content in rail diesel in Canada are still to be determined. The report acknowledged that lower sulfur levels in rail diesel could reduce emissions below levels assumed in the report's calculations.

3.2 Historical Experience with Regulated Emission Reductions

The ICF report forecasts there will be significant reductions in absolute levels of truck NO_x levels despite significant increases in traffic. For example, it forecasts that Toronto-Detroit trucking activity will triple, but total truck NO_x emissions from the corridor will be cut by two-thirds.

It is important to test the assumption of future improvements to truck emissions against what has actually happened with rail and truck emission improvements over the past 30 years. For example, The Canadian Trucking Alliance states that a truck built in 1998 produces one-eighth as much pollution as a truck built in 1987. Cars are said to be ten times cleaner than they were ten years ago.

The Environmental Protection Agency reduced the NO_x limits on autos from three grams per mile in 1972 to one gram for the model years 1981–1991 and to 0.25 grams in 1994. Similarly, it reduced the NO_x limits for light duty trucks from 3 to 1.2 grams and 0.4 grams over the same period. The NO_x emissions for big trucks were said to be reduced from 52.35 grams per liter of diesel burned in 1985 models to 29.26 in 1990 and to 24.42 in 1995.

The appended tables illustrate the rail and truck NO_x and PM emission levels in the United States as reported by the Environmental Protection Agency (EPA) since 1970.

Despite talk about vehicles that are ten times cleaner, the total emissions of NO_x by on-road vehicles were slightly greater in 1998 than in 1970. Gasoline vehicle NO_x emissions were down slightly, but on-road diesel NO_x emissions were up 60 percent. Despite a more heavily regulated emission regime for trucks, truck and rail emissions followed the same path. The total truck NO_x emissions in 1998 were 2.6 times that of rail.

The emissions of PM for on-road vehicles in 1998 were one-third lower than in 1970. For on-road gas vehicles it is two-thirds lower. On-road diesel vehicle PM emissions were almost the same in 1998 as in 1970. Truck PM emissions were to have been cut by four-fifths by the 1995 model year. Rail PM emissions were also the same in 1998 compared to 1970.

Why is it that road vehicle emission reductions at the fleet level did not meet the expectation of improvements, particularly for NO_x?

1. The number of road vehicles and miles driven has overwhelmed individual engine improvements. The OECD concludes that sustainable transportation will not be achieved by a technical fix alone.

2. Emissions from new trucks under actual operating conditions are significantly higher than regulated limits for certification. The US EPA has found that the engines in as many as 1.3 million trucks built over 10 years had devices that defeated pollution controls. EPA: "Federal officials considered such engine control software ‘defeat devices’ which

are illegal under the federal laws." The defeat device shuts off emission control systems during steady-state operation at highway cruise speed.[52] The EPA has agreed to let six diesel engine makers install pollution control shut-off devices on their 2002 engines, three years after imposing more than $1 billion in penalties for using similar defeat devices in the past.[53]

3. In many cases the purchase of a new truck *adds* to the pollution of the existing fleet rather than eliminating the pollution from an old truck. For example, someone can buy the old truck for continued operation. Increasing the capacity of the truck fleet induces new demand and more emissions from more activity.

The report calculations assume that new standards are implemented without modification, even though it notes: “However, it is possible that implementation of the new standards will be delayed, and this would result in *considerably* higher 2020 emission factors for US and Canadian trucks” (emphasis added).

One major road diesel engine manufacturer is reported to have obtained an extension from the next emission hurdle in October 2002. Manufacturers may be able to use emissions trading to defer emission reductions.

The American Trucking Association questions the feasibility of the emission reductions for trucks assumed in the CEC report. A February 28 statement by Walter B. McCormick, Jr. of ATA stated: *“EPA has failed to address our concerns that the diesel fuel supply will be adequate and that proper distribution systems will be in place."* He also said: *"In addition, EPA’s rule is based on after-treatment technology and controls that do not have extensive track records. Questions about the feasibility of the technology create uncertainty in our industry, and are compounded by questions about the reliability of the technology.”*

Minute tire particles and road dust also contribute to PM emissions. The estimate of truck PM emissions in the report excludes the particles from truck tires. There is no estimate of minute tire particles in the US EPA inventory. But the PM_{10} due to dust from paved roads is 10 times greater than the emissions from road vehicle engines. In 1998 paved road dust was 2,618,000 tons (2,374,526 tonnes) compared to 257,000 tons (233,099 tonnes) from road vehicle engines. Unpaved road dust was another 12,668,000 tons (11,489,876 tonnes), but trade highways are paved.

“Particulate matter associated with motor vehicle use was responsible for approximately 33,300 deaths; between 17,700 and 41,600 cases of chronic respiratory illness; 1.12 million asthma attacks; and between 42.9 and 59.9 million respiratory restricted days in 1991. Of these impacts, road dust is responsible for the great majority, since road dust constitutes about 98 percent of particulate matter associated with motor vehicles.”[54]

[52] US Environmental Protection Agency (EPA), *National Air Pollutant Emission Trends 1900–1998*, p. 5-9, 5-10.
[53] “EPA to Let Engine makers Turn Off Pollution Controls,” *Transport Topics*, 27 Feb 2001.
[54] US EPA, *Indicators of the Environmental Impacts of Transportation*, 1996, p. 72.

3.3 Congestion

The ICF report assumes that truck traffic on trade routes can double or even quadruple without increasing emissions due to adding congestion. Adding this volume of truck traffic will create congestion problems. The trucking system is not isolated. It has an impact on the emissions of other vehicles by its presence in the traffic stream.

Adding more big trucks in the volumes projected will increase emissions from the volume of other cars and trucks already using the trade highways because they will experience more congestion. Switching the incremental load to rail instead reduces the emissions from other cars and trucks using the highway. It also reduces emissions at highway border crossings.

To contemplate a doubling or quadrupling of truck traffic, the report must therefore assume significant highway expansion to handle this growth, which in itself will induce more traffic, emissions and land use changes. Adding lanes induces substantial new traffic. For a 10 percent increase in lane miles, within five years the increase in new traffic induced is nine percent in metropolitan areas and five percent outside the metropolitan areas.[55] OECD research indicates that expanding highway capacity is rarely an environmental solution, but a problem.

A doubling to quadrupling of truck traffic would increase collisions and the related loss of life, injuries and spills of dangerous goods.

3.4 Inherent Physical and Organizational Characteristics

The rail mode has inherent physical attributes that make it more energy efficient than trucks for line-haul high-volume traffic. By burning less fuel per ton of load, it generates less exhaust emissions. Rolling resistance (per ton hauled) is lower for steel wheel on steel rail compared to tire on pavement. Aerodynamic drag or wind resistance is also lower because the trailing power and railcars draft behind the lead locomotive.

The following table compares the horsepower to weight ratios for some typical truck and train combinations carrying the same type of cargo. In the case of hauling a bulk commodity such as grain, the typical main line freight train has 0.8 horsepower per ton (hp/ton) of cargo. The typical bulk grain truck in Canada at the maximum legal weight requires 10 hp/ton. In the case of time-sensitive intermodal cargo, an intermodal train requires about four hp/ton. A tractor-trailer with a 53’ (16 m) trailer containing the same type of freight requires 23. This explains why fuel consumption by rail is less than by truck.

Horsepower to Weight Ratios Train & Truck

Grain Train	Grain Truck	Intermodal Train	Tractor-Trailer
2 locomotives	1 tractor	2 locomotives	1 tractor
6600-8000 hp	500 hp	8000 hp	350 hp
9000 net tons	49 net tons	2200 net tons	15 net tons
0.81 hp/net ton	10.2 hp/net ton	4 hp/net ton	23.3 hp/net ton

[55] Mark Hansen, “Do New Highways Generate Traffic?” *Access*, fall 1995.

Note: Grain train and grain truck are assumed to be running in the loaded direction. Intermodal train and tractor-trailer are both loaded at 15 tons per container (rail) or trailer (truck). This is not the maximum loading weight, but is the same for both modes. Assume loaded direction for both train and truck.

There is an implicit assumption in the report that the uptake of new emission control technology will be 900 percent faster for truck than train. As discussed previously, during the past 30 years the performance of the truck fleet in terms of emissions is no better than that of rail. Although replacement rates are slower for locomotives than trucks (due to longer lifespan and less generous tax treatment), the railways have a larger scale of organization to adopt nearly industry-wide coverage of best practices and new technology.

The trucking system is fragmented. There are 10,000 for-hire carriers in Canada and 50,000 independent owner-operators. There are more than 500,000 motor carriers in the United States. The use of best-practice and implementation of new technology varies widely from firm to firm. The Railway Association of Canada is able to monitor and report emissions under its MOU cap with Environment Canada. The trucking industry is unable to monitor or deliver a similar industry-wide coverage.

Railways are more advanced than the road mode in the application of information communications technology. Transport Canada's 1998 Annual Report notes that physical and ownership characteristics of the rail mode have enabled it to be more advanced than road transport in adopting information technology. This is one of the factors why productivity at Canadian railways grew twice as fast as for trucking between 1986 and 1997 (four percent annually for rail compared to 1.9 percent annually for trucking). For example, because railways control both infrastructure and rolling stock, they implemented equipment tracking more quickly and extensively.

The railways already employ information technology in signals, dispatch, traffic control, equipment tracking, electronic commerce, shipment management, and inter-line systems. Future applications include advanced train control and truly seamless interaction with all modes, customers, suppliers and customs agencies.

In the fall of 1997, Canadian railways began applying a system of instant clearance of goods entering Canada by rail in collaboration with Revenue Canada, Canada Customs and the Canadian Society of Customs Brokers. The system is available to all shippers.

Implementing this system gave rail customers a significant advantage. Ninety percent of the 550,000 rail cars entering Canada each year are cleared without inspection. The railways are in a good position to take advantage of this customs system because of the scale of organization and stability of their work force, which means fewer clearance problems at the border.

Fragmented trucking safety regulations are a barrier to using information technology in transborder trucking. The recent failed attempt to automate the Coutts AB / Sweetgrass MT border crossing for trucks is an example of why trucking should be harmonized by the federal levels of government. Differences between Montana and Alberta treatment of carrier safety compliance became a barrier.

3.5 Scrappage

The report assumes that 92 percent of the trucks in 2020 will have the new cleaner engines produced after 2007. This may be based on new truck purchase rates experienced in the late 1990s, but there is currently a glut of used trucks and a collapse in sales of new trucks.

The report assumes that nearly all of the trucks built before 2007 are scrapped and removed from service. Long-distance truck tractors often go through two or three owners. The third owner could be an owner-operator running high mileage on a low budget. There is a high demand to export used Canadian trucks to the United States and Mexico because of the exchange rate and heavier weight of the Canadian units.[56] Thus, a new truck often *adds* to the pollution that continues somewhere else from the old truck.

3.5 Bigger Trucks—Fewer Trucks?

The report projects that allowing heavier trucks (105,000 pounds instead of 80,000) and longer trucks [Rocky Mountain Doubles: 53' (16 m) + 28' (8.5 m) trailers] would reduce CO and CO_2 emissions by seven percent and NO_x and PM emissions by four percent for the Winnipeg-Fargo corridor. The assumptions behind this calculation are that:

- Truck weight can be increased 31 percent [from 80,000 to 105,000 pounds (36,240 to 47,565 kilograms)] while increasing fuel usage by only two percent.
- Heavier and longer trucks would result in reduced emissions by allowing fewer trucks to carry the same amount of freight.
- Heavier and longer trucks would not induce new shipping demand "since transport costs typically make up only a fraction of merchandise price."

The report assumes that allowing heavier and longer trucks could be limited to the upper midwestern states. Once the Congressional freeze on LCV expansion were violated, there would be many proposals to allow them elsewhere. This would lead to nationwide LCV operation. The US DOT estimates the following impacts: [57]

- Reduce rail traffic by 20 percent, reduce rail revenues by 19 percent and reduce contribution to overhead by 56 percent.
- Reductions in rail traffic would be even more dramatic in the east.
- Investment in railways would cease.
- Deplete capital invested in the railways during the previous ten years.

Rather than reducing emissions, allowing heavier and longer trucks *adds* pollution from the new configurations to the pollution that continues from the existing truck fleet. Allowing heavier and longer trucks in Canada in the late 1980s led to more, not fewer, trucks. The heavier trucks supplemented rather than supplanted existing trucks. The National Memorandum of Understanding Agreement on truck size and weight in Canada led to the widespread introduction

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[56] Gordon Taylor, Paterson/Hendry Chartered Accountants, Constable Associates, *The Potential for GHG Reductions from Scrappage Programs for Older Trucks and Engines*, 1999, section 4.7.1

[57] US DOT *Comprehensive Truck Size and Weight Study*, Vol III, 2000, Chapter 11. About one-third of the impact was due to heavier weights already allowed in Canada. About two-thirds related to the increased cargo volume.

of the six-axle tractor-trailer with a 53-foot trailer and a weight limit of 102,000 pounds. It also resulted in a heavier and longer double trailer combination, the so-called B-Train configuration.

Canada did some post-implementation analysis of impacts of these changes, which compared the trucking industry of 1987 (pre-agreement) to that of 1992 (post-agreement). The report contains a survey of trucking firms about the types of trucks they used on various routes in 1987 compared to 1992. The following table highlights some of the survey results taken of the larger carriers:

Percent Change in Trucking Equipment, 1987–1992 (Carrier Survey)

All semitrailers	+72.5%
2-axle trailer up to 48 feet	+88.0%
2-axle trailer > 48 feet	+127.3%
3-axle (fixed) trailer up to 48 feet	-0.6%
3-axle (fixed) trailer > 48 feet	+1281.8%
All tandem trailers	+27.6%
A -Train tandem trailers	-4.2%
B-Train tandem trailers	+166.7%
C-Train tandem trailers	-14.3%
Overall fleet inventory	+66.4%

This table indicates that firms expanded their capacity with the heavier and longer configurations, but continued to operate the old equipment. Indeed, the number of two-axle 48-foot trailers actually increased 88 percent. Firms added more capacity with B-Trains than they retired from A-Train and C-Train configurations.

The Canadian impact study notes that its carrier survey results illuminate general trends in the trucking industry, but cannot document the changes in the industry as a whole. Unfortunately, Statistics Canada's data on the overall truck fleet are not readily comparable between 1987 and 1992. The 1987 data include equipment of carriers with annual revenues greater than $250,000, but the 1992 data include equipment only of carriers with revenues greater than $1,000,000. Data can be compared for 1987 and 1989 before the change in Statistics Canada data collection in 1990. The number of semitrailers increased 4.7 percent between 1987 and 1989. Since the additions would include higher payload carrying tridem axle trailers and B Trains, the real increase in capacity was greater than 4.7 percent. The kilometers driven by road tractors increased 5.4 percent.

The recession in the early 1990s led to a shake out of truck carriers and excess capacity, as well as a general decline in both rail and truck tonnage. Since then, trucking has rebounded more strongly. Between 1992 and 1997, truck tonnage grew 49.4 percent and rail 20.8 percent.

The province of Saskatchewan allows some of the longest and heaviest trucks on the continent, up to 147 feet (44.8 m) long and containing 178,000 pounds (80,634 kg). The maximum allowable payload has more than doubled since the 1960s, yet the number of trucks has also doubled and the miles driven has tripled. Thus, trucking activity has grown six-fold.

The ICF report is a static, uni-dimensional analysis that does not factor in the long-term response of the production process to increased truck size and weight. Allowing heavier and longer trucks reduces haulage prices and this induces changes in the economy that create new shipping demand, the "rebound effect." Following are the mechanisms:

- Change in commodity mix and logistics patterns, creating a more complex and transport intensive supply chain and production process, leading to additional truck miles.

- Bigger trucks, lower transport prices, increases out-sourcing of component production, stimulating additional truck miles.

- Lower transportation costs for low-density products would shift the equilibrium even further toward virtual inventories and mobile warehousing on-board trucks.

- The regional distribution of investment and employment affected as firms respond to lowered trucking prices by consolidating and rationalizing industry structure, i.e., more intra-firm trade and long-distance sourcing.

The OECD finds that improving road transportation could make the traffic problem worse, and that technical fixes will not offset the growth in road traffic.[58] It is also studying the sustainability of different production and consumption solutions.[59]

The report is focused almost completely on technology solutions to one mode—truck. Research for the OECD indicates that growth of road traffic will overwhelm technical fixes. Additional road capacity (required to handle truck volumes projected) adds to the environmental problem. It also finds that about one-half of the sustainable solution for freight will happen on the demand side, for example, including mode shift.

Bigger trucks do not operate on exclusive rights of way, but share the road with smaller vehicles. There is a potential conflict between increasing mass and size of trucks on one hand and encouraging consumers to buy smaller more fuel-efficient passenger vehicles in order to reduce auto emissions. There is a safety issue in the divergence of truck and auto size and weight.

3.7 Road Pricing Option

The report does not simulate the environmental mitigation benefits of implementing an electronic tolling system to reduce or eliminate subsidies to big trucks. Electronic tolling technology is proven and reliable today on Ontario's highway 407. This toll road does not require trucks to stop at tollbooths. Transponders and electronic tolling systems are used to bill tractor-trailers 33 cents per kilometer driven on weekdays and 18 cents on weekends and at night.

Implementation of electronic truck tolling at the continental level would reduce distortions caused by subsidies to trucks and allow railways to operate at their natural economic advantage. Eliminating subsides to reflect the real costs of mobile warehousing on trucks would result in a more economical and environmentally sound production process.

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[58] OECD, Transport and Environment, Background and Synthesis Report, Policy Measures and Their Effects, undated, downloaded from OECD web site. Dec 1998.
[59] OECD, Sustainable Consumption and Production, undated, downloaded from web site, Dec 1998.

The US DOT Federal Highway Cost Allocation Study of 1997 found that heavy trucks are not paying for the costs they impose on the road system:

- Highway cost recovery declines as gross truck weight increased.
- Trucks with a registered GVW of 80,000 to 100,000 pounds (36,240 to 45,300 kg) pay just 60 percent of their road costs.
- Trucks with a registered GVW of over 100,000 pounds pay just 50 percent of their road costs.

User pay for trucks would reduce emissions by reducing highway congestion. It would level the playing field and stimulate private investment in railways, new rail locomotive technology, and faster introduction of new cleaner locomotives. It would also reduce GHG emissions by shifting freight to rail, which the report states generates one-tenth the emissions of truck per tonne in all corridors.

3.8 Intermodal Option

The report discussed mode shift from truck to rail on two corridors (Vancouver-Seattle and Toronto-Detroit). Although it found this would reduce GHG emissions, it also found there would be an increase in NO_x emissions because of the assumed 900 percent faster improvement in emissions technology for trucks.

However, there was no assessment of the benefits of a broader intermodal framework integrating policies across borders, jurisdictions and modes in the context of a user-pay system for trucks. An economically level playing field would stimulate investment in more rapid locomotive turnover for rail. Based on past experience, it would also be reasonable to assume that rail emissions technology keeps pace with truck technology.

The Sierra Club and Texas Citizen Fund have called for such a broad-based assessment.[60] Their report states:

> *"While most discussions of NAFTA trade corridors have been limited to the logistical challenges of accommodating increased traffic through highway upgrades and construction, rather than a broad-based investigation and analysis of the extent to which multimodal alternatives might provide relief. As a consequence, a broad-based comparative assessment of the environmental costs, impacts and benefits of the range of transport alternatives, is rare" (p.1).*

The CEC report does not provide the broad-based multimodal analysis required to achieve sustainable trade development. Instead, it takes the trucking system and trends of a doubling or quadrupling of corridor truck traffic in 20 years as a given. Yet, as the Sierra Club/Texas Citizen paper points out, there is a growing sense, particularly in the communities experiencing the

[60] Sierra Club and Shelia Holbrook-White, Texas Citizen Fund, WWF-US, *NAFTA Transportation Corridors: Approaches to Assessing Environmental Impacts and Alternatives*, October 2000.

heaviest flows of trade traffic, that NAFTA associated trade with its growing use of truck transport is veering down the path to environmental stress.

The Sierra Club/Texas Citizen paper asks why these highway expansion activities, rather than rail improvements, are being pursued first is not clear. It argues for gaining an understanding of the criteria by which public investments in highway infrastructure are made as well as the barriers (e.g., economic, regulatory, etc.) that limit the use of alternative modes such as rail. The ICF CEC report provides little insight to these important issues.

3.9 NAFTA Dynamics

The report assumes there will be no change in cabotage, which would increase the usage of Mexican trucks in the US and Canadian markets. The Canadian trucking industry is also requesting relaxation of immigration rules on drivers.

Although the report states it has allowed for the opening of the US border to Mexican trucks, it assumes these trucks will not operate into Canada.

The report assumes that trucks operating between Canada and the United States will radically improve their environment standards 10-fold. The dynamics of free trade with Mexico and the large amount of intrafirm trade within North America may shift goods production and transport activity to where truck pollution standards are less costly. Investment in new long haul trucks can be shifted to Mexico where standards are lower, yet they can operate continent wide. Old polluting ones could be exported to Mexico, yet continue to operate continent-wide under NAFTA.[61]

4. Choice of Words and Presentation

The report summary leaves the impression that all that really matters are exhaust gas emissions of NO_x and PM. Carbon monoxide from motor vehicles causes 850 million headaches annually in the United States. Rail is eight times cleaner per tonne-kilometer for CO. VOCs combine with NO_x to form ground-level ozone that has respiratory and other health impacts. VOCs are also are an ingredient to the formation of secondary particulates.

The report is correct in concluding that CO_2 does not kill people on contact, but there are significant indirect health impacts associated with global warming: injuries and loss of life during more extreme storms and floods, migration of tropical diseases to the northern hemisphere, problems with water quality, drought, and food supply.

The Executive Summary talks about truck emissions of NO_x and PM dropping to one-tenth of current levels, but does not bring forward into the summary the point from page nine that rail emissions of CO and CO_2 will be one-tenth that of truck emissions.

[61] Currently, there is a prohibition on the import of used trucks from the United States to Mexico. The American Trucking Association is requesting that this be relaxed.

There is sometimes a trade-off between reducing GHG emissions and NO_x emissions. For example, one of the reasons devices were installed on diesel trucks to defeat NO_x pollution controls was to improve fuel efficiency.

6. Impact of Government Policies on Equipment Replacement

The Canadian Trucking Alliance is lobbying for even more generous capital cost allowance measures for trucks (currently 40 percent compared to 15 percent for locomotives) as a way to reduce emissions.

There is a risk that the trucking industry could use the projections of the report to lobby for additional tax changes or truck size and weight increases that will shift freight away from more sustainable modes.

The Ontario Trucking Association states that in 1995 a locomotive generated 85 times as much PM and 43 times as much NO_x as a diesel truck. The PM levels include dust from coal in transit for rail, but excluded road dust from trucks. It lumped in urban delivery trucks carrying small loads to the per-truck calculation. The emissions from a 4,000 horsepower locomotive pulling 1,600 tonnes of cargo should be larger than even a large 500 horsepower tractor-trailer pulling 40 tonnes. But after factoring in the load carried, the locomotive is less polluting. A table of calculations taking into account the different levels of work performed by trucks and locomotives is appended.

The capital cost allowance (annual write-down for tax purposes) is 15 percent for locomotives compared to 40 percent for truck tractors. Increasing the rail CCA rate to 25 percent would move the Canadian railways closer to that of the US railroads and part way to the position of trucks.

Railways and rail equipment manufacturers may be able to adapt to emission limits on locomotives more strict than anticipated in the report if the depreciation rates were harmonized with trucks. Increased production of new equipment would stimulate additional investment in research and development.

Implementing user-pay cost recovery tolls for big trucks using trade highways would level the playing field of investment to encourage more rapid investment in new locomotives and locomotive technology.

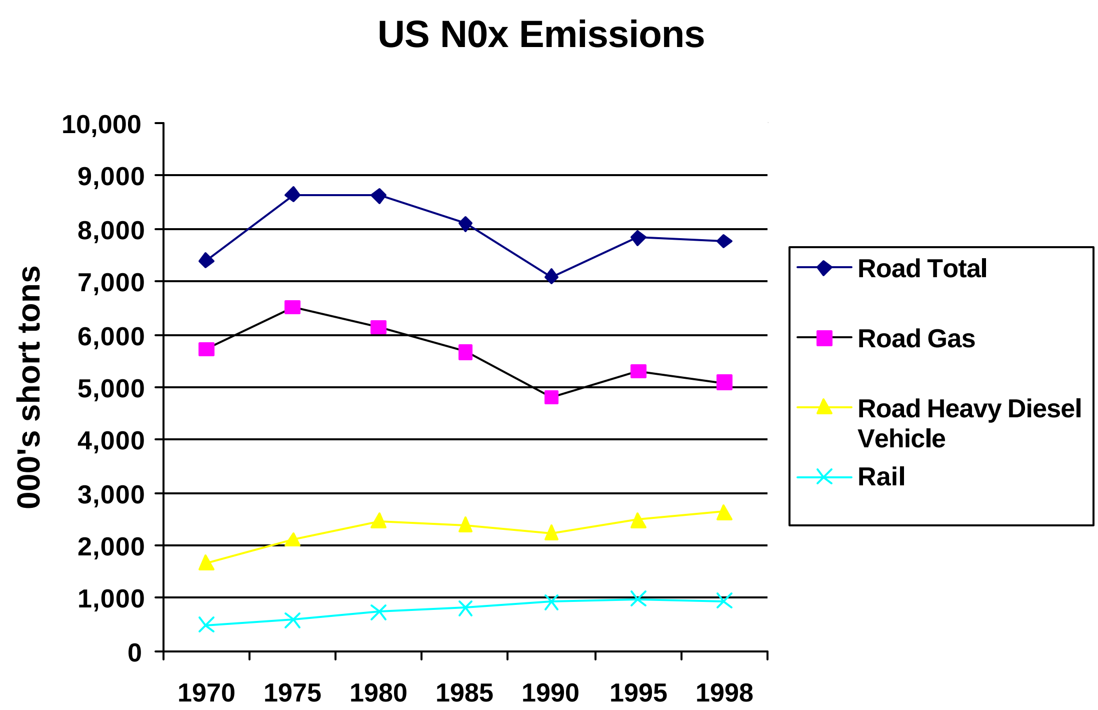
Glossary: Abreviations

CO	Carbon monoxide
NO_x	Nitrogen oxides
VOC	Volatile organic compounds
PM_{10}	Particulate matter 10 Microns
CO_2	Carbon dioxide equivalent
GHG	Greenhouse gas
EPA	(US) Environmental Protection Agency
CEC	(North American) Commission on Environmental Cooperation
ICF	ICF Consulting

Appendix: US NO_x Emissions (000s of short tons)

Source Category	1970	1975	1980	1985	1990	1995	1998
ON-ROAD VEHICLES	***7,390***	***8,645***	***8,621***	***8,089***	***7,089***	***7,826***	***7,765***
Light-Duty Gas Vehicles & Motorcycles	4,158	4,725	4,421	3,806	3,220	3,444	2,849
Light-Duty Gas Trucks	1,278	1,461	1,408	1,530	1,256	1,520	1,917
Light-Duty Gas Vehicles	5,436	6,186	5,829	5,336	4,476	4,963	4,766
Heavy-Duty Gas Vehicles	278	319	300	330	326	332	323
Total Gas Vehicles	5,714	6,505	6,128	5,666	4,802	5,295	5,089
Diesels	1,676	2,141	2,493	2,423	2,287	2,531	2,676
heavy-duty diesel vehicles	*1,676*	*2,118*	*2,463*	*2,389*	*2,240*	*2,482*	*2,630*
light-duty diesel trucks	*NA*	*NA*	*5*	*6*	*7*	*10*	*12*
light-duty diesel vehicles	*NA*	*23*	*25*	*28*	*39*	*39*	*34*
NON-ROAD ENGINES AND VEHICLES	***1,931***	***2,638***	***3,529***	***3,859***	***4,804***	***5,128***	***5,280***
Non-Road Gasoline	85	92	101	108	120	127	159
Non-Road Diesel (e.g., construction, farm)	1,109	1,666	2,125	2,155	2,513	2,739	2,809
Aircraft	72	85	106	119	158	165	168
Marine Vessels	171	207	467	557	943	936	1,008
Railroads	495	589	731	808	929	990	947
Non-Road Other	0	0	0	112	141	171	189
TOTAL ALL SOURCES ALL SECTORS	**20,928**	**22,632**	**24,384**	**23,198**	**24,049**	**24,921**	**24,454**

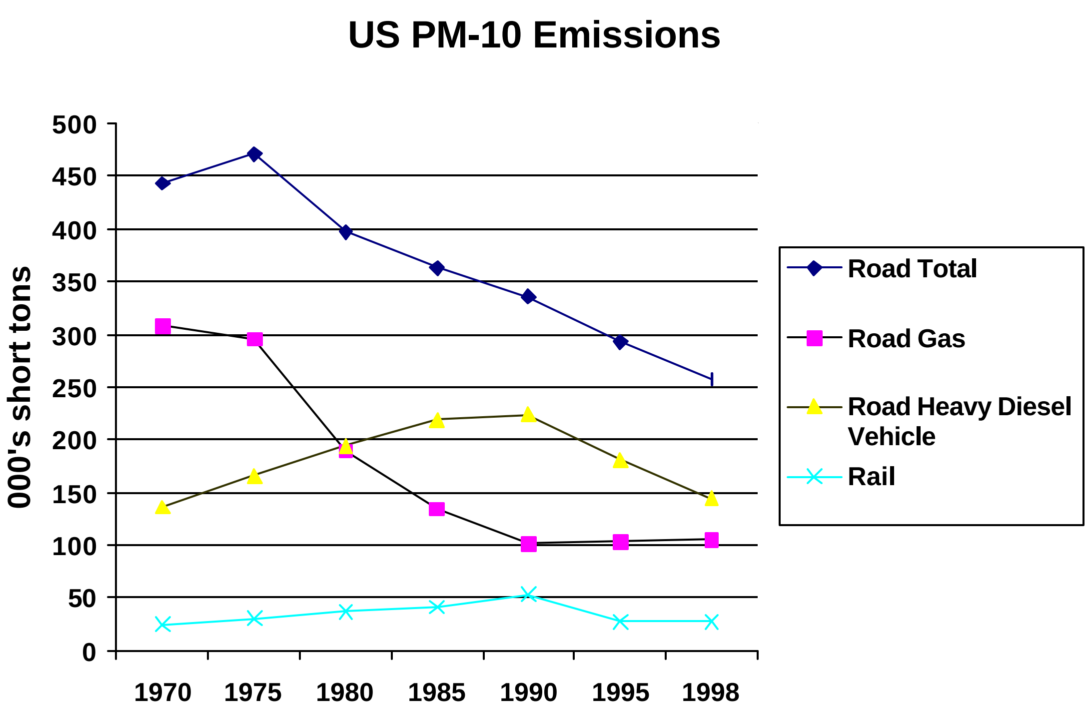
Note: 1 short ton equals 0.907 metric tons.
Source: US EPA, *National Air Pollutant Emission Trends*, 1900–1998, Appendix A



Appendix: US PM_{10} Emissions (000s of short tons)

Source Category			1970	1975	1980	1985	1990	1995	1998
ON-ROAD VEHICLES			***443***	***471***	***397***	***363***	***336***	***293***	***257***
	Light-Duty Gas Vehicles & Motorcycles		225	207	120	77	61	62	56
	Light-Duty Gas Trucks		70	72	55	43	30	32	40
	Light-Duty Gas Vehicles		294	279	174	120	91	94	97
	Heavy-Duty Gas Vehicles		13	15	15	14	10	9	8
	Total Gas Vehicles		308	295	189	134	101	103	105
	Diesels		136	177	208	229	235	190	152
		heavy-duty diesel vehicles	*136*	*166*	*194*	*219*	*224*	*181*	*144*
		light-duty diesel trucks	*NA*	*NA*	*2*	*1*	*1*	*2*	*2*
		light-duty diesel vehicles	*NA*	*10*	*12*	*8*	*9*	*8*	*6*
NON-ROAD ENGINES AND VEHICLES			**220**	**310**	**398**	**424**	**489**	**456**	**461**
	Non-Road Gasoline		12	39	42	44	47	49	48
	Non-Road Diesel (e.g. construction, farm)		154	204	263	272	301	296	301
	Aircraft		21	26	33	37	44	40	39
	Marine Vessels		9	10	23	28	44	43	44
	Railroads		25	30	37	41	53	27	27
	Non-Road Other		0	0	0	1	1	1	1
DUST	***unpaved roads***		***NA***	***NA***	***NA***	***11,644***	***11,234***	***10,362***	***12,668***
DUST	***paved roads***		***NA***	***NA***	***NA***	***5,080***	***2,248***	***2,409***	***2,618***
TOTAL ALL SOURCES ALL SECTORS			**13,042**	**7,671**	**7,119**	**45,445**	**29,962**	**27,070**	**34,741**

Note: 1 short ton equals 0.907 metric tons.
Source: US EPA, *National Air Pollutant Emission Trends*, 1900–1998, Appendix A



Appendix: Criteria Air Contaminants Emissions Canada 1995

	PM	SO_x	NO_x	VOC	CO
Road diesel emissions (tonnes)	32075	32807	378300	48540	224438
Truck diesel emissions (94.3%)	30247	30937	356737	45773	211645
Intercity trucks emissions (tonnes)	16938	17325	199773	25633	118521
Truck tonne-kms (billions)	180	180	180	180	180
Intercity trucks (billions of tonne-kms)	155	155	155	155	155
grams per truck tonne-km	0.17	0.17	1.98	0.25	1.18
grams per intercity truck tonne-km	0.11	0.11	1.29	0.17	0.76
Rail emissions (tonnes)	3000	7226	115604	5608	22022
Rail freight emissions (97.4%)	2922	7038	112598	5462	21449
Rail tonne-kms	282.4	282.4	282.4	282.4	282.4
grams per rail tonne-km	0.01	0.02	0.40	0.02	0.08
Intercity truck/rail	10.6	4.5	3.2	8.5	10.1

Source: 1995 PM, SO_x, NO_x, VOC, CO emissions, Environment Canada (posted Dec 1999), the most recent available, to be updated later this year.
Environment Canada listed rail emissions of PM as 19,492 tonnes, but this included 16,492 tonnes of dust from coal in transit and 3,000 tonnes from locomotive emissions.
Source: 1995 tonne-kms, Delcan et al. for Transportation Table
Intercity truck tonne-kms = 86% of total truck, Truck diesel is 94.3% of road diesel, Delcan et al.
Intercity truck emissions = 56% of total truck, Delcan et al.
Excludes emissions from gasoline trucks
Rail freight fuel use is 97.4% of total rail fuel use, RAC

Luis E. Gonzalez
Mexican Ministry of Economy

Comentarios de la Secretaría de Economía en Ottawa al estudio *"Efectos Ambientales y Estrategias de Mitigación en los Corredores de Comercio y Transporte de América del Norte"*.

Puntos principales del estudio e implicaciones para México:

El estudio examina los efectos ambientales del comercio entre Canadá, Estados Unidos y México en cinco segmentos binacionales de tres principales corredores de comercio del TLCAN, con especial atención en las emisiones de contaminantes de la atmósfera. Los segmentos de los corredores que se eligieron para el análisis son Vancouver-Seattle, Winnipeg-Fargo, Toronto-Detroit, San Antonio-Monterrey y Tucson- Hermosillo.

Para cada corredor se calculó el impacto del comercio transfronterizo en las emisiones de óxidos de nitrógeno (NO_x), compuestos orgánicos volátiles (COV), monóxido de carbono (CO), materia particulada de menos de 10 micras de diámetro (PM_{10}), y dióxido de carbono (CO_2). Las emisiones contaminantes atmosféricas se calcularon aplicando los datos de actividad de carga del vehículo a los factores de emisión.

Entre las oportunidades de reducción de emisiones de contaminantes en los corredores del TLCAN para 2020 propuestas por este estudio, las que beneficiarían de manera más considerable a México son:

a. El uso de gas natural comprimido.

En los corredores de comercio de Estados Unidos-México, los vehículos de gas natural pueden proporcionar beneficios bajo el supuesto de que México producirá factores de emisión más altos que EE.UU. y Canadá para 2020, en caso de que no adopte el combustible diesel con bajo porcentaje de azufre[62].

A diferencia de los corredores comerciales de EE.UU.-Canadá, en los que el uso de gas natural no tendría una gran ventaja debido a una mejoría significativa en las emisiones con la flotilla diesel de bajo azufre, en los corredores EE.UU.-México, el gas natural es probable que brinde

[62] "En diciembre del 2000 la EPA aprobó normas de emisiones muy estrictas para emisiones de motores dísel de servicio pesado en autopista modelo 2007 y posteriores. Con las nuevas normas, las emisiones de NO_X serán 20 veces menores que las actuales, las de COV y PM_{10} serán diez veces más bajas. Las normas entrarán en vigor por etapas en tres años, para permitir que los nuevos motores tengan cumplimiento pleno en 2010. Estas drásticas reducciones son posibles en buena medida gracias a las reglas de la EPA sobre contenido de azufre en el combustible dísel. Las tecnologías de control de emisiones para motores dísel de trabajo pesado no funcionan si el combustible tiene alto contenido de azufre. La decisión de la EPA de diciembre de 2000 requiere que, para 2006, el contenido de azufre en el dísel se reduzca a 15 ppm. A partir de su actual nivel de 500 ppm, norma similar a la de Canadá".

beneficios en la calidad del aire para 2020. Si 20% de los camiones mexicanos en el corredor San Antonio-Monterrey usan gas natural, los niveles de emisión de PM_{10} se reducirían 13% frente a la línea de base de 2020.

b. Cambios en los procedimientos e instalaciones de los cruces fronterizos.

Los vehículos comerciales padecen en algunas fronteras internacionales grandes esperas, cuya reducción se traduciría en beneficios en la calidad del aire, sobre todo en las emisiones de CO. En ciertos estudios se sugiere que en los cruces más congestionados (Laredo-Nuevo Laredo, Nogales-Nogales, Blaine-Pacific Highway), cambios de política e inversiones podrían reducir la espera a la mitad. En Laredo-Nuevo Laredo, la reducción de la espera evitable en el puente Lincoln reduciría las emisiones de CO de los camiones comerciales parados en más de 600 Kg por día en 2020.

c. Mejorar la eficiencia del transporte de carga mediante una reducción del kilometraje de vehículos vacíos permitiría disminuir la emisión de contaminantes.

d. El uso de una combinación de vehículos más largos (CVL) en los corredores del TLCAN podría reducir el volumen de vehículos y sus emisiones asociadas.

El permitir el uso de los CVL en los corredores del TLCAN reduciría los volúmenes de los camiones y las emisiones asociadas. Por el costo menor de embarque por camión de los CVL, algunas cargas dejarían el ferrocarril para optar por el camión. El uso de CVL es generalizado en Canadá.

Impactos en la calidad del aire

El sector de carga no es una importante fuente nacional de CO. Los camiones de servicio pesado, sin embargo, pueden contribuir de manera importante a concentraciones en áreas específicas de CO en zonas urbanas. El CO_2 es un gas común y no representa una amenaza directa a la salud humana. Es sin embargo, el principal componente de los gases de efecto invernadero que contribuyen al calentamiento global.

Cabe destacar que en este estudio se supuso que la flota mexicana de auto transporte de carga tenía la misma distribución de antigüedad que la de Canadá y EU. Sin embargo, los camiones mexicanos anteriores a 1993, se consideraron como sin regulación de emisiones (flota de EU anterior a 1988 con el kilometraje suficiente), puesto que México no tenía normas respecto de emisiones dísel antes de ese modelo. Se supuso también que la flota mexicana de trasbordo (para movimientos de cruce fronterizo) era en promedio cinco años más antigua que las flotas de auto transporte de EE.UU. y Canadá, con el resultado neto que sólo 10% de la flota resultó de camiones posteriores a 1993.

Para los factores de emisión de la flota mexicana de transporte de carga en 2020, se asumió la adopción de las normas estadounidenses de 2004, pero no las más estrictas de 2007. Se supuso también que la flota mexicana tendría la misma antigüedad y distribución que las flotas de EU y Canadá. No se usaron para el 2020 factores separados para la flota más antigua de tractocamiones de servicio fronterizo porque se supuso que estos vehículos que se usan para movimientos transfronterizos saldrán de circulación.

Se prevé que el ritmo de crecimiento en el corredor San Antonio-Monterrey sea el más alto de los cinco corredores incluidos en este estudio. Tendencias recientes muestran incrementos enormes en el tránsito camionero y ferrocarrilero en este corredor.

El comercio marítimo: Modo de transporte alternativo para México

Las fuentes marítimas representan una proporción menor del total de las emisiones. Los grandes barcos de carga por lo general utilizan petróleo residual y la mayoría cuenta con motores dísel como fuentes auxiliares de energía. Las emisiones dependen de varios factores, entre ellos la distancia del viaje y el tipo y antigüedad del motor del barco. El tiempo de carga y descarga en el puerto puede también influir de manera importante en la calidad atmosférica en las zonas urbanas.

Este tipo de comercio tiene una amplia participación porcentual en diferentes áreas del comercio, por lo que podría ser de utilidad en una gran variedad de mercados y de ahí se puede derivar una oportunidad de usarlo de manera más amplia como una estrategia de reducción de emisiones. Cabe destacar también, que este tipo de transporte es más adecuado para el movimiento de mercancías a granel.

El 56% de la carga comercial total entre Canadá-México se mueve por vías fluviales, incluidas algunas mercancías importantes, por ejemplo los aceites vegetales y los cereales hacia el sur (los cuales son la exportación canadiense más importante a México) y el petróleo hacia el norte.

Casi la totalidad del comercio marítimo entre EE.UU. y México se mueve a través del Golfo de México. El comercio está dominado por las importaciones estadounidenses de petróleo procedente de Campeche y Veracruz que se mueve a puertos de Texas y Louisiana. **También hay importantes embarques hacia EU en el puerto de Altamira. Esta ruta podría representar una alternativa a la vía terrestre San Antonio-Monterrey-Ciudad de México.**

Los países de América del Norte deberán de poner especial atención en fomentar el comercio por la vía marítima, ya que aun cuando ha seguido creciendo a ritmo sostenido en términos absolutos, éste ha perdido participación en el comercio total. Hace diez años la carga marítima representaba 63% del comercio Canadá-México y 28% del de Canadá con EE.UU en contraste con el 56% mencionado anteriormente.

Observaciones y comentarios finales

- Consideramos que este estudio es muy útil ya que identifica de manera detallada los impactos actuales y potenciales en la calidad del aire del comercio realizado en los corredores de transporte del TLCAN. Además de que nos permite obtener una visión más completa del efecto del incremento en el comercio y el transporte sobre el ambiente.

- En la medida en que tengamos identificadas los indicadores de contaminación que el transporte genera en determinados corredores, será posible proponer estrategias de mitigación viables. Por ejemplo, el hecho de que se haya concluído que el transporte marítimo es relativamente menos contaminante que los otros medios, nos sugiere que debemos explorar la manera de impulsar esta opción como alternativa para disminuir la carga de vehículos en los corredores México-EE.UU.

- Sugeriríamos revisar si las conclusiones obtenidas son sensibles al supuesto de mantener constante la distribución de antigüedad entre la flota mexicana de auto transporte de carga y la de Canadá y EE.UU empleado en el estudio.

- El estudio hace mención a la carencia de los siguientes datos:

    - Los volúmenes de tránsito transfronterizo, incluido el número de vagones vacíos frente a los cargados, tanto ferroviarios como camioneros.
    - Patrones de origen y destino de la carga en las regiones fronterizas.
    - Datos y metodología para calcular las emisiones ferroviarias.
    - Medición de la espera promedio de los vehículos comerciales en los cruces fronterizos

Por lo tanto, a fin de dar el debido seguimiento a este tipo de proyectos y de ir obteniendo la información de la cual se carece, recomendamos la creación de un grupo de trabajo gubernamental trilateral. Por parte de México, podrían participar las Secretarías de Economía, de Comunicaciones y Transportes y de Medio Ambiente y Recursos Naturales con sus respectivas contrapartes de EE.UU. y Canadá.

Sr. Manuel Sotelo Suarez
Presidente
Asoc.de Transportistas de Cd.Juarez A.C.

Através de la presente manifestamos nuestro deseo de que los cruces internacionales de intercambio comercial que se localizan en esta región, El Paso Texas, Sante Teresa Nuevo México y Cd.Juárez México, sean considerados integralmente como un “Corredor Fronterizo del TLCAN”, y esto obedece a varias razones de las cuales expondremos a continuación las más relevantes.

En primer término nuestra situación geográfica nos ubica en una posición central a los largo de la línea divisoria entre México y los Estados Unidos, lo cual representa contar con más alternativas de comunicación terrestre y áerea con todas las ciudades de ambos países, lo que representa ahorros de tiempo y dinero en el envío y traslado de mercancías.

Así mismo nos percatamos día a día que gran parte de las mercancías comerciales que ingresan a México provenientes de varios estados norteamericanos del lado Oeste, como son California, Colorado, Arizona, entre otros, pasan por los cruces internacionales de esta región debido a que los puntos de destino se encuentran más cerca por esta vía, evadiendo pasar por puntos fronterizos mas cercanos a su origen, Tijuana y/o Mexicali, lo cual representaría mayores recorridos y por ende mayores tiempos y costos.

Otro aspecto importante de mencionar es la infraestructura en materia ferroviaria comercial que se localiza en la ciudad vecina de El Paso Texas, en donde se localizan importantes empresas norteamericanas dedicadas a este servicio como son: Union Pacific y Southern Pacific.

En general, y analizando los diferentes cruces de intercambio comercial localizados a lo largo de la línea fronteriza entre México y Estados Unidos, podemos percibir claramente que nuestra región cuenta con la mejor infraestructura requerida para realizar este intercambio de mercancías comerciales entre los países del TLCAN.

Por lo mencionado anteriormente, agradecemos en principio el interés y disposición que se preste a nuestra solicitud, exponiéndose para su corrrespondiente análisis ante las instancias gubernamentales respectivas de nuestros países, esperando ser favorecidos con su formal aceptación como el “Corredor Fronterizo Central”, para contribuir así a un mayor y eficiente desarrollo del Tratado en mención.

Sin más por el momento agradezco la atención a la presente, suscribiéndome de Usted para cualquier información al respecto.

Bob Evans
Executive Director
CRASH, Canadians for Responsible and Safe Highways

I am writing to express our organization's concerns about the recent report prepared for the CEC by ICF Consulting on North American trade corridors that contains an uncritical endorsement of allowing giant multi-trailer trucks.

First we must correct two misleading and erroneous claims. At page 40 the report states that many fleets (in Canada) receive permits to operate vehicles longer than 25 meters. At page 49 it states "Use of LCVs is widespread in Canada." The reader is left with the impression these trucks operate across Canada and there is no concern. Actually, trucks longer than 25 meters (82 feet) are not allowed in most provinces. Ontario, the principal trucking market, rejected a proposal to allow these vehicles after they failed simple on-road manoevring tests. Nowhere does the CEC document reveal that these trucks do not meet Canada's national safety performance standards.

Canadians want nothing to do with LCVS. An Angus Reid poll, taken in September 2000, found that 86 percent opposed longer double trailer trucks.

The suggestion that allowing heavier and longer trucks would reduce truck traffic defies previous experiences in Canada. Bigger trucks have meant more trucks.

Please find enclosed a briefing paper opposing longer trucks from CRASH, Transport 2000 and Sierra Club.

Louis P. Warchot and Michael J. Rush
Counsel
Association of American Railroads

On behalf of its member railroads, the Association of American Railroads (AAR) submits the following comments on the report, *North American Trade and Transportation Corridors: Environmental Impacts and Mitigation Strategies* (Trade and Transportation Corridors).[63] AAR is a trade association whose member railroads include railroads operating in Canada, Mexico, and the United States. On a ton-mile basis, AAR's member freight railroads account for the vast majority of the freight transported by rail in North America. AAR's membership also includes passenger railroads in the United States that operate almost all of that country's intercity passenger trains and provide commuter rail service.

AAR takes sharp issue with Trade and Transportation Corridors' methodology and conclusions. Trade and Transportation Corridors conclusions about likely emissions levels from locomotives ignore a number of factors that will result in emissions levels substantially lower than the report indicates. Furthermore, there is a distinct difference in the way railroad and truck emissions are treated.

I. Locomotive Emissions will be Reduced Significantly

A fundamental problem is Trade and Transportation Corridors' assumption that locomotive emissions will not be substantially reduced beyond what is required by current US EPA standards. Trade and Transportation Corridors states that if

> lower standards are implemented before 2020, the slow turnover of the locomotive fleet means that the average emission rates in 2020 will probably not be very different from those shown in Table 6.[64]

This conclusion ignores a number of reasons that locomotive emissions will be substantially reduced.

- *Locomotive turnover is more rapid than the report indicates*

Contrary to the statements in Trade and Transportation Corridors, there will be significant turnover in the locomotive fleet.[65] During the 1990s, Class I (large freight) railroads in the United States bought 6678 new locomotives, which amounts to a third of the Class I railroads' current locomotive fleet.[66]

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[63] ICF Consulting, *North American Trade and Transportation Corridors: Environmental Impacts and Mitigation Strategies*, prepared for the North American Commission for Environmental Cooperation (Feb. 21, 2001).
[64] Trade and Transportation Corridors at 10.
[65] Trade and Transportation Corridors at ii, 10.
[66] Since the number of locomotives in service increased by approximately 1400 in that time period, most of the new locomotives purchased replaced older locomotives. *See* Association of American Railroads, Railroad Facts: 2000 Edition, p. 48 (October 2000).

- *Energy and emissions efficiencies will be obtained through high-horsepower locomotives*

New locomotives often are more powerful than the locomotives they replace. For example, two new 6,000 horsepower locomotives can do the work of three old 4,000 horsepower locomotives, so the effective replacement rate, and the energy and emissions benefits from substituting new locomotives for older locomotives, will be greater than the replacement rate alone will indicate.

Furthermore, locomotives are very heavy so the ability of railroads to use fewer, high horsepower locomotives to accomplish the same amount of work that can be accomplished by a greater number of lower-horsepower locomotives will automatically reduce train weight, thereby achieving reduced fuel usage and emissions. Trade and Transportation Corridors makes much of the potential for greater efficiencies from LCVS, but ignores the efficiencies that can be obtained from more powerful locomotives.

- *Locomotives are subject to retrofit requirements*

Trade and Transportation Corridors' discussion of turnover rates ignores retrofit benefits. Unlike the case with trucks, US EPA's locomotive emissions regulations include retrofit requirements.[67] When remanufactured, locomotives manufactured after 1973 must comply with US emissions standards. By 2020, all, or virtually all, locomotives used by Class I railroads in the United States will be subject to US EPA emissions standards.

Clearly, there is a substantial likelihood that significant technologies will be developed that can be applied when locomotives are rebuilt. For example, aftertreatment devices might be applied on a retrofit basis. Later this year, railroads will be testing particulate filters on an older engine. All locomotives used to transport freight along the corridors studied in the report will periodically be remanufactured, and emissions-reduction technologies may be applied during the remanufacturing process.

- *AAR is facilitating research to improve energy and emissions efficiency*

Regardless of regulatory activity, there should be substantial improvements in locomotive fuel and emissions efficiency. Industry and the US government together have initiated an industry-government partnership to research technologies for reducing fuel consumption and emissions. The US Department of Energy will spend $70.6 million in FY 2001 on ways to improve truck energy and emissions efficiency. The railroad industry supports a similar, extensive research program for locomotives.

Trade and Transportation Corridors estimates that locomotive fuel efficiency will achieve 456 revenue ton-miles per gallon by 2020.[68] The railroads and their locomotive manufacturers have agreed to work with the US government on the development of a locomotive that can achieve

[67] 40 C.F.R. Part 92. Whenever locomotives are remanufactured, which occurs when the power assemblies are replaced, they are considered "new" and must be brought into compliance with the current EPA emissions standards.
[68] Trade and Transportation Corridors at 10.

489 revenue ton-miles per gallon by 2010, representing a 25 percent improvement in fuel efficiency. Furthermore, the railroads have established a goal of a 50 percent improvement in fuel efficiency by 2020. The emissions benefits from such fuel-efficiency improvements would be far beyond what Trade and Transportation Corridors envisions.

II. Railroads are more certain to achieve Targeted Emissions Levels than Trucks

In assessing emissions from locomotives and trucks, Trade and Transportation Corridors never alludes to the greater certainty that locomotives will attain their targeted emissions because of the different regulatory requirements applicable to locomotives and trucks. US locomotive emissions standards are applicable for regulatory "useful lives" that closely mirror actual useful lives before rebuilding, and when rebuilt, or "remanufactured," locomotive engines must comply with the emissions standards then in effect. Furthermore, engine manufacturers and Class I railroads must test locomotives in use to verify that emissions levels are as intended.[69]

In contrast, the regulatory useful life for heavy-duty trucks does not closely relate to actual experience, and US EPA does not regulate the rebuilding process. The current regulatory useful life for trucks is 435,000 miles.[70] EPA has observed that some truck engines accumulate in excess of 600,000 miles before their first rebuild and truck engines are often rebuilt many times.[71] Furthermore, there is no in-use testing to verify compliance.

In addition, Trade and Transportation Corridors uses modeling numbers that overestimate railroad emissions in the corridors studied and may well underestimate truck emissions. For locomotives, the report uses EPA estimates of average emissions levels for the nationwide locomotive fleet. However, in the corridors studied, the emissions will be from line-haul locomotives. These locomotives, on average, will be newer and will emit significantly fewer pollutants than locomotives used for yard and local operations. Thus, fleet-wide average numbers will overstate the emissions from locomotives operating in these corridors.

In contrast, truck emissions may be understated. The truck emissions numbers used are based on 55 m.p.h. (88 kilometers/hour) operations, likely lower than the typical highway speed in the corridors studied. AAR understands that truck engines become less emissions-efficient at higher speeds.

III. The Report's Conclusions about the Contributions of Rails and Trucks to Emissions are Suspect

Trade and Transportation Corridors' conclusions about the Winnipeg-Fargo corridor are suspect. Trade and Transportation Corridors states that freight transported is split between trucking and rail. The report also states railroads are responsible for 44 percent of NO_x emissions on the corridor. This conclusion flies in the face of studies by US EPA and others concluding that rails have a 3-to-1 emissions advantage over trucks.[72]

[69] *See* 40 C.F.R. Part 92, Subpart G and 40 C.F.R. § 92.1003.
[70] 40 C.F.R. § 86.004-2(4)(iii).
[71] 60 Fed. Reg. 45580, 45600 (Aug. 31, 1995).
[72] *See, e.g.,* 62 Fed. Reg. 6368 (Feb. 11, 1997); C. Holloway, *The State of Canada's Railway Industry and*

IV. The Report ignores Ancillary Benefits of Rail

While Trade and Transportation Corridors discusses hazardous materials transportation, it ignores rail's advantages. Rail transportation is less likely to result in a release than truck transportation. According to US data, the number of railroad hazardous materials incidents is less than 8 percent of the number of highway hazardous materials incidents, even though both modes transport approximately the same amount of hazardous materials, on a ton-mile basis.[73]

Railroads are more energy efficient than trucks. A 1991 study for the United States Department of Transportation found that rail double-stack transportation of containers is approximately three times more fuel efficient than truck transportation.[74]

Many communities believe one of rail's significant advantages is that it takes goods off the highways, thereby reducing highway congestion and associated motor vehicle fuel consumption and emissions. A single "double-stack" train can remove as many as 280 trucks from the highways.[75]

V. Conclusion

Many of the flaws in Trade and Transportation Corridors could have been avoided had the authors of the report consulted those with expertise on railroad emissions. AAR has asked government and industry representatives who have worked on railroad emissions issues if they were given an opportunity to provide input prior to the release of the report and the answer from all has been no.

The North American Commission for Environmental Cooperation should not permit a report such as this to be published with its imprimatur. The report constitutes an attack on the railroad industry, with no effort prior to publication to obtain the railroad industry's perspective. Significant damage has been done. The report's conclusions have been quoted as gospel. The Commission would be well served to review its procedures to ensure fairness in the future.

Railway Industry and Environmental Implications: A Review, p. 35 (May 1994) (report for Environment Canada).

[73] The comparison was made by AAR using data from the United States Department of Transportation's Research and Special Programs Administration, "Hazardous Materials Incidents by Year & Mode," http://hazmat.dot.gov/files/hazmat/10vear/10yearfrm.html for 1990 through 1999; United States Department of Commerce Truck Inventory & Use Survey; Federal Highway Administration, "Highway Statistics;" Surface Transportation Board Waybill Sample. In 1997, combination trucks hauled an estimated 96 billion ton-miles of hazardous materials, while railroads hauled an estimated 95 billion ton-miles of hazardous materials.

[74] Abacus Technology Corp., *Rail vs. Truck Fuel Efficiency*, p. S-6 (DOT/FRA/RRP-91/2, April 1991) (comparison of rail and truck transportation of containers on a gallon per ton-mile basis). See also American Society of Mechanical Engineers, Task Force of the Internal Combustion Engine Division, "Statement on Surface Transportation of Intercity Freight," p. 6 (May 1992). A Canadian government study shows that overall, rail transportation has a 5 to I advantage over trucks when measuring ton-kilometers per liter of diesel fuel consumed. Transportation Table, National Climate Change Process, *Foundation Paper on Climate Change - Transportation Sector* --, http://www.nccp.ca/html/tables/pdf/trans_found.pdf, App. B., Table B1, (December 1998).

[75] A train consisting of twenty-eight cars, each consisting of five platforms which, in turn, can each hold two 40-foot containers, is capable of transporting 280 containers (such a train could carry more than 280 containers if it was transporting 20-foot, instead of 40-foot, containers).

Coralie Cooper
Mobile Source Analyst
Northeast States for Coordinated Air Use Management (NESCAUM)

The Northeast States for Coordinated Air Use Management MCAUM appreciates the opportunity to comment on the *North American Trade and Transportation Corridors Environmental Impacts and Mitigation* study prepared by ICF Consulting. NESSCAUM is an association of the air pollution control programs in the states of Connecticut, Maine, Massachusetts, New Jersey, New Hampshire, New York, Rhode bland, and Vermont. NESCAUM provides technical advice and policy guidance to our member states on air pollution issues.

Heavy-duty truck traffic and related emissions in the Northeast is a major concern to the state in our region. While heavy-duty diesel trucks represent approximately two percent of the vehicles registered in the region, emissions from this source comprise 26 percent of mobile source nitrogen oxides (NO_x) pollution. All of the states in the region with the exception of Vermont are in nonattainment for the National Ambient Air Quality Standards (NAAQS) for ozone. Reducing diesel pollution is a key element in state efforts to attain the NAAQS for ozone.

In addition to ozone precursors, diesel engines contribute to elevate levels of fine particles and other toxics such as formaldehyde, acetaldehyde, and acrolein. Ambient levels of diesel related air toxics such as formaldehyde exceed state health risk benchmarks in all areas of the Northeast. Diesel particulate had been labeled as a toxic air contaminant by the California Air Resources Board (CARB, 1998). Whole diesel exhaust has been labeled a probable human carcinogen by EPA (draft 2000), the National Institute for Occupational Safety and Health (1998), and the International Agency for Research of Cancer (1989).

NESCAUM supports the Commission for Environmental Cooperation’s effort to study the impact of emissions from increased trade due to the North American Free Trade Agreement (NAFTA). The goal of identifying current and future air quality impacts that occur as a result of the development of North American trade and transportation corridors is an important one. We ask that you consider several specific comments on the study, which are detailed below.

<u>Natural Gas Vehicle Emissions</u>

The study states “the use of natural gas for heavy-duty trucks is an effective strategy to reduce emissions through the next decade.” But by 2020, according to the study, “vast improvements in diesel engine emissions means that natural gas will probably not offer an emission reduction in the Canada-US corridors.” This could be the case if we assume (like the PART 5 and MOBILE models do) that diesel engine emissions do not deteriorate over time. However, studies have shown that diesel engine emissions do increase over time due to engine wear, mal maintenance, and tampering. A recent Colorado School of Mines study (1999) documented a 50 percent increase in diesel PM and HC emissions due to common maintenance problems. A study published by the Bureau of Mines (1988) on mechanically controlled diesel engines (which represent approximately 40 percent of the Northeast fleet) demonstrated that PM, HC, and CO emissions increase significantly over time with engine age. If deterioration-related emissions increases are included in an emissions comparison, diesel engines compare less favorably with natural gas engines.

In addition to criteria pollutants, toxics are important to consider when comparing diesel and natural gas vehicles. Given the designation of diesel particulates as a toxic air contaminant by the California Air Resources Board and diesel exhaust as a probable human carcinogen by the US EPA, it is important to reduce public exposure to particulate and other toxics from diesels. Natural gas vehicles can plan an important role in reducing exposure to diesel exhaust. Natural gas engines emit some of the same toxics that diesel engines do such as carbonyls, non-methane hydrocarbons, alkynes, aromatics and PAH but the emission rate from natural gas vehicles is typically musty lower than from diesels. Furthermore, controls available to reduce diesel engine toxic emissions can also be placed on natural gas engines to virtually eliminate natural gas toxic emissions.

<u>Truck versus Rail Emissions</u>

The ICF report authors estimated the increase in freight related travel over the next 20 years in five NAFTA corridors. From these estimates a projection of tons of emissions was then calculated using MOBILE5, PART5 and other methods. Once a comparison in emissions had been made, study authors then recommended a number of steps that could be taken by states, provinces, an the federal government to reduce NAFTA-related pollution. These recommendations include: reducing delays at border crossings; increasing the use of low sulfur diesel fuel in Mexico; reducing the fraction of empty trucks travelling on roads; allowing the use of longer combination vehicles in NAFTA corridors; and increasing allowed truck weight. The report states that some of these measures would shift the transportation of freight from rail to trucks. The report also states that given the dramatically reduced diesel engine emission standards (beginning in 2007) rail emissions will be greater than for trucks in 2020.

It is important to note the method used to calculate emissions from trucks and locomotives may provide an overly optimistic view of future truck emissions relative to locomotive emissions. ICF Consulting assumed that all new trucks (later than 2007) would be emitting at the 2007 standard. Similarly, study authors assumed that new locomotives (manufactured after the new emission standards are implemented) will be emitting at the new standards.

Trucks on the road in 2020 manufactured before 2007 (8.4 percent of the total truck fleet according to ICF) were assumed to meet the emission certification level for the given year they were manufactured. ICF assumed that pre-control locomotives operating in 2020 (and this fraction of the locomotive fleet is quite a bit larger than the 8.4 percent for trucks since locomotive engine are very slow to be replaced) would be rebuilt to new, cleaner standards. However, for the fraction of locomotive engines not assumed to be rebuilt, ICF used emission factors from EPA's document entitled "Criteria Pollutant Emissions for Locomotives" (1997 420-F-97-051). The emission factors in this document were gathered from older locomotive engines and have deterioration figures built into the base emission data.

Using these emission factors for even a small percentage of the locomotive fleet would increase the overall emission rate for locomotives significantly, since these emission factors are taken from older, high emitting locomotives and include deterioration factors. This could give trucks an unfair emission advantage since emission factors used for older trucks did not include any deterioration and are based on emission from brand new engines. In a final version of the report, ICF should clarify their method and either use deterioration factors for trucks as well as locomotives or use only emission factors without deterioration for both sources.

Thank you for the opportunity to provide comment on this report. We look forward to working with you as you develop recommendations on reducing NAFTA-related emissions.

Alan D. Hecht
Principal Deputy Assistant Administrator
US Environmental Protection Agency

Estimated emission factors for locomotives may be high. The estimates appear to be the fleet average emission factors from the 1998 Final Rulemaking (FRM) for locomotives. However, those estimates included switching and small railroad operation, both of which generally use older higher-emitting locomotives. Line-haul operations by Class I railroads are more likely to use the newer lower-emitting locomotives, and thus in the FRM we estimated that Class I line-haul emission rates would be about 10 [percent] lower (sic) than the nationwide average of all locomotives in 2020 (see attached spreadsheet). Line-haul emissions could be as much as 20 percent lower than the fleet average in 2020, if the fleet used a higher fraction of the lower-emitting 2005 and later locomotives.

Estimated emission factors for trucks may be low. The estimates are based on emissions for operation at 55 mph (88 km/h), which may be lower than the typical highway speed. Emissions for higher speeds would be higher. Also, our current understanding of the effects of malmaintenance, tampering and engine rebuilding on truck emissions is incomplete. This is especially true for the new aftertreatment technologies that are currently being developed to meet the new 2007 emission standards. It is possible that in-use emissions would be higher than current projections. This is not expected to be a problem for locomotives because maintenance and rebuilding are regulated.

It may be misleading to project impacts of modal shifts based solely on the standards that are currently on the books. In the 1998 FRM for locomotives, we intended to require similar emission controls for locomotives as we had for trucks. Assuming that the diesel aftertreatment technology becomes viable for trucks, it is likely that we will consider more stringent standards for locomotives before 2020, Because these controls are aftertreatment, it is likely that we would also consider requiring that they be retrofit to existing locomotives during rebuilds.

APPENDIX C RESPONSES TO SELECTED REVIEWER COMMENTS

Several reviewers of the draft report commented on our estimates of future trucking and locomotive emission rates and the relative contribution of trucking versus rail to trade-related emissions. We recognize that this is a critical portion of the analysis and deserves scrutiny. In this appendix we summarize these reviewer comments and respond to the general points raised.

Reviewers offered a number of reasons why they felt future locomotive emissions might be lower and/or truck emissions might be higher than assumed in the draft report, including the following:

- Locomotive turnover is more rapid than the draft report indicates.
- New locomotives are higher horsepower, and therefore will achieve greater emission and energy efficiencies than assumed in the draft report.
- Locomotives are subject to retrofit requirements, and the draft report does not account for the benefits of retrofits for upcoming standards and technologies. There is a substantial likelihood that emission control technologies will be developed that can be applied when locomotives are rebuilt.
- There will be substantial improvements in locomotive fuel and emissions efficiency, regardless of regulations, because of industry-government R&D partnerships.
- Other technological innovations will reduce railroad emissions, such as automatic shut down devices to reduce idling, track lubrication, and rail car tare weight reduction.
- Railroads are more certain to achieve targeted emission levels than trucks. The locomotive emission standards closely follow the actual useful life for locomotives in term of rebuilding intervals, in contrast to trucks. In addition, Class I railroads must test locomotives in use to verify emission levels, unlike heavy-duty trucks.
- The draft report locomotive emission rates are nationwide fleet averages (line-haul and yard locomotives) so they overstate the corridor emissions (which are produced only by line-haul locomotives).
- The draft report assumption of no deterioration for heavy-duty trucks is unrealistic, and inconsistent with the deterioration implicit in the locomotive emission factors.
- The draft report truck emission factors are too low because they assume 55 mph (88 km/h) highway speeds. Actual speeds will be higher in the trade corridors.

Locomotive Emission Rates

The locomotive emission factors used in the draft report were developed using EPA's *Locomotive Emission Standards: Regulatory Support Document* (April 1998) and *Handbook of Air Pollution Emission Factors, AP-42* (December 1997). The emission factors in these documents are recommended by EPA for developing emission inventories and are considered the standard for this type of analysis. The locomotive turnover rates used in these documents were developed by EPA using information from Class I railroads and are considered the most accurate available. The emission rates assume that all locomotives manufactured between 1973 and 2001 will be rebuilt to Tier 0 standards according to the 1997 EPA regulations. Locomotives built in

2002–2004 are assumed to meet Tier I standards at the time of manufacture and each subsequent remanufacture. Those built in 2005 and later are assumed to meet Tier II standards at the time of manufacture and each subsequent remanufacture. The small number of pre-1972 locomotives in service are not assumed to be in line-haul service.

The 1999 emission factors used in the analysis reflect Class I line-haul locomotives only. However, the 2020 emission factors used in the draft report were based on a Class I fleet average (line-haul and switch) rather than just line-haul. We acknowledge this error, and have corrected it in the Final Report. The corrected locomotive emission factors are lower than those used in the draft report by 11 percent (HC), 9 percent (NO_x) and 7 percent (PM).

The base (uncontrolled) locomotive emission factors for 1999 do implicitly include some deterioration. However, the 2020 emission factors assume that all line-haul locomotives manufactured between 1972 and 2001 will be brought into compliance with the Tier 0 standards by 2008. Therefore, the 2020 emission factors already assume no deterioration for locomotives.

The report assumes that low-sulfur off-road diesel will become available in the United States and Canada, and that this alone will reduce PM emission rates by 19 percent. The report also notes that future emission control technologies may facilitate locomotive emission rates that are lower than the 2005 (Tier II) standards. Because there is no information on what these emission factors might be, and because of the relatively slow turnover of locomotive fleets, we do not assume an improvement beyond the 2005 (Tier II) standards (except for the 19 percent PM reduction). In order to test the impact of possible lower locomotive emission standards or the widespread introduction of additional technologies, an alternative scenario is included at the end of this appendix.

Locomotive Fuel Efficiency

As stated in the report, locomotive fuel efficiency improvements are estimated by fitting a curve to historical data. The result is an approximately 18 percent improvement in revenue ton-kilometers per gallon by 2020. We acknowledge that public-private partnerships may result in greater efficiency gains. However, government and industry are also working together to improve the fuel efficiency of heavy-duty trucks, and no increase in truck fuel efficiency is assumed in the report. Further, we have no basis for determining the fuel efficiency gains through 2020 from locomotive or trucking partnerships. Therefore, an adhoc assumption of additional locomotive fuel efficiency gains cannot be supported.

Other Rail Technologies

We acknowledge that technological improvements to railroads, such as automatic shut down devices, track lubrication and tare weight reduction, have the potential to reduce fuel consumption and emissions per ton-kilometer. However, similar technological innovations are being explored for the trucking industry, including auxiliary power units to reduce idling, improved aerodynamics, lower rolling resistance tires and trailer tare weight reduction. Because of the uncertainties associated with the impact of these technologies and their future penetration levels, we do not assume any increase in their deployment for truck or rail freight.

Truck Speeds

Speed limits are now 65 to 75 mph (104 to 120 km/h) in most US states, and truck speeds on rural interstates are typically higher than 55 mph. However, speeds are often lower in urban areas and near border crossing facilities. Most of the five corridors encompass one or more large urban areas either at the border (such as Detroit/Windsor and Laredo/Nuevo Laredo) or elsewhere in the corridor (such as the Seattle metropolitan area). For this reason, we feel that an average speed of 55 mph for the entire corridor is a reasonable assumption.

Truck Deterioration

We assume that emission rates for heavy-duty line-haul trucks do not increase over time due to deterioration. This assumption is consistent with EPA's MOBILE5 and PART5 models, and consistent with the claims of engine manufacturers. The MOBILE6 model was not available at the time of the study. A preliminary report on MOBILE6 indicates that for NO_x and HC, the base emission rates (zero mileage level) have been reduced and very low deterioration rates have been introduced. We do not have any information at this time as to how this would affect 2020 emission factors for these pollutants. Consequently, given the lack of data, the assumption of zero deterioration is valid for line-haul heavy-duty trucks, especially given that these vehicles are typically newer and better-maintained than the fleet average.

Alternative Scenario—Lower Locomotive Emission Standards

The report notes that future emission control technologies may facilitate locomotive emission rates that are lower than the 2005 (Tier II) standards. We developed an alternative future scenario in order to test the impact of possible lower locomotive emission standards. This scenario assumes the following:

- Low-sulfur (15 ppm) off-road diesel is widely available in the United States and Canada by 2010.
- New locomotive emission standards (termed "Tier III") take effect beginning in 2010. All locomotives built in 2010 and later are assumed to meet Tier III standards at the time of manufacture and each subsequent remanufacture.
- The new "Tier III" locomotive emission standards reflect the same level of improvement seen in truck emission standards made possible by the use of advanced emission controls and low-sulfur diesel. Thus, they are equivalent to base locomotive emission factors (uncontrolled) times the ratio of 2007 heavy-duty truck emission factors to 1990 heavy-duty truck emission factors.
- Base emission factors, Tier I and II emission factors, fleet turnover and relative fuel consumption by tier are consistent with EPA's 1998 *Regulatory Support Document*.
- The resulting 2020 emission factors (in g/bhp-hr) are as follows: NO_x=4.57, CO=1.28, HC=0.27, PM=0.14. Compared to the 2020 Baseline, these emission factors are lower by 25, 0, 20 and 19 percent, respectively.

We applied these emission factors to the 2020 cross-border rail freight flows in the Toronto-Detroit corridor; results are shown in Table C-1. Rail emissions of NO_x and PM_{10} are 25 and 19 percent lower than in the 2020 Baseline Scenario for this corridor. Rail now accounts for 39% of total trade-related NO_x emissions and 35 percent of trade-related PM_{10} emissions, down from 46 and 40 percent under the Baseline Scenario. Rail accounts for only five percent of the trade-related CO_2 and four percent of the trade-related CO emissions, unchanged from the 2020 Baseline Scenario, and 14 percent of the trade-related VOC emissions, down from 17 percent in the 2020 Baseline Scenario.

Table C-1: Toronto-Detroit Corridor Trade Emissions, 2020 Low Emission Locomotive Scenario

	Annual Commodity Flow (million kg)	Annual Vehicles*	Emissions (kg/day)				
			NO_x	VOC	CO	PM_{10}	CO_2
Truck	122,672	13,030,708	11,342	2,674	52,165	416	13,353,393
Rail	48,947	785,129	7,244	426	2,027	228	748,796
Total	171,619	N/A	18,586	3,100	54,192	644	14,102,189
Percent of 1999	279%	279%	40%	89%	265%	26%	276%

* Loaded rail cars only

On a ton-kilometer basis, trucking still maintains an advantage over rail for NO_x and PM_{10} emissions. Rail emissions of NO_x and PM_{10} per ton-kilometer are 50 and 30 percent higher than for trucking, compared to 110 and 60 percent under the Baseline Scenario. Rail emissions of CO_2 per ton-kilometer remain approximately 86 percent *lower* than for trucking, illustrating the significant advantage for rail with respect to greenhouse gas emissions.