EPS 2/TS/13
October 2000

Transportation Systems Branch
Air Pollution Prevention Directorate
Environment Canada

ENVIRONMENTAL PROTECTION SERIES

Locomotive Emissions

Monitoring Programme 1998

Environment Canada
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Locomotive Emissions Monitoring Programme

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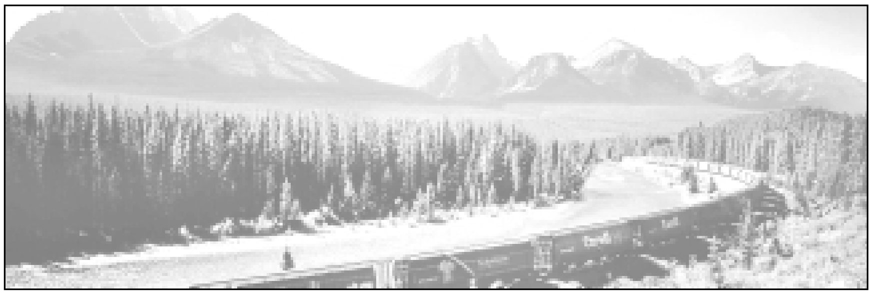

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Executive Summary

The Railway Association of Canada has gathered the data required to report under the Locomotive Emissions Monitoring Programme for the period 1975 to 1998.

The information covers:

- annual traffic volume in gross ton-miles and in net ton-miles;
- annual diesel fuel consumption for mainline and branchline service, for yard switching service and for passenger service;
- annual emissions of oxides of nitrogen (NO_X), hydrocarbons (HC), oxides of sulphur (SO_X), particulate matter (PM), carbon monoxide (CO) and carbon dioxide (CO_2);
- fuel consumption and emissions in the three designated Tropospheric Ozone Management Areas (TOMAs) for 1998 (the data are also segregated for the winter and summer periods); and
- measures being undertaken to reduce fuel consumption and consequent emissions.

The data show that:

- fuel consumption and emissions per unit of freight traffic volume continue to decline as predicted;
- the rate of traffic growth in the last several years was greater than predicted;
- the voluntary cap on emissions of NO_X was achieved in 1998 and since 1990 has exceeded it on average by only 0.2%;
- emissions of the greenhouse gas CO_2 per unit of traffic volume continued to decline at a rate of over 1% per annum.

Traffic levels will be monitored to determine whether the recent accelerated increase in rail traffic is short term or represents a higher rate of growth. If the latter case prevails, then consideration should be given to recognizing and taking into account that traffic diverted from the highway mode results in a reduced national level of emissions.

Sommaire

L'Association des chemins de fer du Canada a rassemblé les données nécessaires pour la période de rapport 1975 à 1998 prévue par le Programme de surveillance des émissions des locomotives.

Les renseignements portent sur :

- le volume de trafic annuel en tonnes-mille brutes et en tonnes-mille nettes;
- la consommation de carburant diesel annuelle pour le service de ligne principale et de ligne secondaire, le service de manoeuvre et le service voyageurs;
- les émissions annuelles d'oxydes d'azote (NO_X), d'hydrocarbures (HC), d'oxydes de soufre (SO_X), de particules (P), de monoxyde de carbone (CO) et de dioxyde de carbone (CO_2);
- la consommation de carburant et les émissions dans les trois Zones de gestion de l'ozone troposphérique (ZGOT) désignées pour 1998 (les données étant également partagées entre les périodes d’hiver et d’été);
- les mesures en train d’être adoptées pour la réduction de la consommation de carburant et des émissions qui en résultent.

Les données révèlent que :

- la consommation de carburant et les émissions, par unité de volume de trafic de marchandises, continuent de diminuer selon les prédictions;
- le taux de croissance du trafic au cours des quelques dernières années a été supérieur au taux prédit;
- le plafond volontaire touchant les émissions de NO_X a été atteint en 1998 et, depuis 1990, ne l'a dépassé en moyenne que d'environ 0,2 %;
- les émissions du gaz à effet de serre CO_2 par unité de volume de circulation ont continué à décroître à un taux supérieur à 1 % par année.

Les niveaux de trafic seront contrôlés pour déterminer si la hausse accélérée de la circulation ferroviaire enregistrée récemment n'est que passagère ou si elle représente un taux de croissance plus élevé. Dans ce dernier cas, il faudra reconnaître et prendre en considération les effets de la réduction du transport par autoroute sur le taux d'émissions global au pays.

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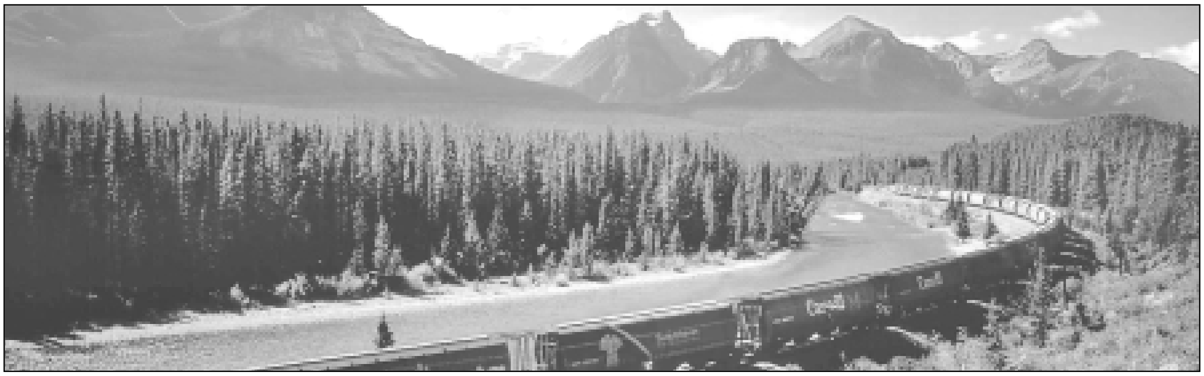


1.0 Introduction

The Memorandum of Understanding between Environment Canada and The Railway Association of Canada (RAC) of December 27, 1995, requires the RAC to attempt to make an annual report to Environment Canada on the emissions of exhaust gases from locomotives used in rail service. The report should include data on the traffic moved, the fuel consumed, estimates of the consequent emissions of certain exhaust gases, and information on any improvements in equipment or operating practices that will lead to reduced emissions.

2.0 Data for 1975 to 1998

2.1 Traffic Data

The volume of traffic, measured in gross ton-miles (GTM) and in net ton-miles (NTM), for the years 1975 to 1998 is shown in Tables 1a to 1d. Estimates are also given in Table 1d for the years 2000 and 2005. Data for the years up to and including 1996 are taken from *Rail in Canada,*[1] whereas those for 1997 and 1998 are from information supplied to the RAC by its member railways. Traffic data are plotted in Figure 1.

The term "gross ton-miles" refers to the aggregate of the ton-miles handled, calculated using the total weight of the trailing tonnage of the trains moved. It excludes the contribution of the weight of the locomotives pulling the trains.

The term "net ton-miles" refers to the aggregate of the ton-miles handled, calculated using the total weight of the commodities in the cars of the trains moved. It includes the ton-miles involved in the movement of railway materials.

When the Locomotive Emissions Monitoring Programme was established, it was decided that the projection of future traffic and fuel consumption data would be based on 1990 levels.

The following assumptions were made for the total traffic volume to be handled by the railways in Canada after that date:

a) Gross ton-miles would increase at an average annual rate of 1.2% of the 1990 volume.

b) Net ton-miles would increase at an average annual rate of 1.5% of the 1990 volume.

c) The ratio of net ton-miles to gross ton-miles would therefore increase at an average annual rate of 0.3%, reflecting the ongoing improvements in the effectiveness of freight cars.

[1] Statistics Canada Catalogue 52-216 Annual.

Table 1a: Annual Traffic and Fuel Consumption Statistics, 1975-1981

			1975	1976	1977	1978	1979	1980	1981
TRAFFIC DATA									
GROSS TON-MILES	ALL FREIGHT	million gtm	266,941.9	273,360.4	282,114.8	285,196.6	307,917.7	308,474.5	309,174.6
NET TON-MILES	ALL FREIGHT	million ntm	138,576.6	142,178.5	148,900.3	151,036.8	163,660.8	164,347.3	163,925.8
RATIO of NTM / GTM			0.519	0.520	0.528	0.530	0.532	0.533	0.530
FUEL CONSUMPTION DATA									
FREIGHT SERVICE	SUB TOTAL - Existing Locomotive Fleet	Imp gal	407,052,164	419,203,247	436,291,345	440,024,087	459,310,810	455,812,403	443,860,816
	SUB TOTAL - CNR & CPR New Low Emissions Locos	Imp gal							
MAINLINE & BRANCHLINE									
	TOTAL MAINLINE & BRANCHLINE SERVICE	Imp gal	407,052,164	419,203,247	436,291,345	440,024,087	459,310,810	455,812,403	443,860,816
YARD SWITCHING SERVICE.		Imp gal	33,676,252	36,409,975	36,784,996	36,986,113	39,794,091	37,338,811	32,560,311
WORK TRAIN SERVICE		Imp gal	8,311,573	8,975,287	10,010,070	8,870,030	10,387,399	8,894,352	9,946,747
	TOTAL YARD & WORK TRAIN SERVICE	Imp gal	41,987,825	45,385,262	46,795,066	45,856,143	50,181,490	46,233,163	42,507,058
TOTAL FREIGHT OPERATIONS		Imp gal	449,039,989	464,588,509	483,086,411	485,880,230	509,492,300	502,045,566	486,367,874
PASSENGER FUEL		Imp gal	n/a	n/a	n/a	n/a	n/a	n/a	n/a
TOTAL FUEL - ALL OPERATIONS		Imp gal	449,039,989	464,588,509	483,086,411	485,880,230	509,492,300	502,045,566	486,367,874
TOTAL FREIGHT FUEL / GTM		Imp gal per 1000 GTM	1.6822	1.6995	1.7124	1.7037	1.6546	1.6275	1.5731
TOTAL FREIGHT FUEL / NTM		Imp gal per 1000 NTM	3.2404	3.2676	3.2444	3.2170	3.1131	3.0548	2.9670

Table 1b: Annual Traffic and Fuel Consumption Statistics, 1982-1988

			1982	1983	1984	1985	1986	1987	1988
TRAFFIC DATA									
GROSS TON-MILES	ALL FREIGHT	million gtm	275,560.4	298,510.0	329,577.2	314,688.0	319,685.7	342,010.5	346,386.6
NET TON-MILES	ALL FREIGHT	million ntm	147,380.4	158,815.9	176,411.9	168,080.4	168,987.9	186,344.5	188,020.8
RATIO of NTM / GTM			0.535	0.532	0.535	0.534	0.529	0.545	0.543
FUEL CONSUMPTION DATA									
FREIGHT SERVICE	SUB TOTAL - Existing Locomotive Fleet	Imp gal	391,445,966	411,156,794	437,852,458	427,680,176	430,613,225	439,597,337	448,134,752
	SUB TOTAL - CNR & CPR New Low Emissions Locos	Imp gal							
MAINLINE & BRANCHLINE									
	TOTAL MAINLINE & BRANCHLINE SERVICE	Imp gal	391,445,966	411,156,794	437,852,458	427,680,176	430,613,225	439,597,337	448,134,752
YARD SWITCHING SERVICE.		Imp gal	29,261,667	26,029,182	26,732,542	26,613,387	25,877,445	25,531,119	26,666,102
WORK TRAIN SERVICE		Imp gal	8,607,211	8,110,350	8,822,318	8,486,384	6,419,695	5,648,588	5,463,752
	TOTAL YARD & WORK TRAIN SERVICE	Imp gal	37,868,879	34,139,532	35,554,860	35,099,770	32,297,140	31,179,707	32,129,854
TOTAL FREIGHT OPERATIONS		Imp gal	429,314,845	445,296,325	473,407,319	462,779,947	462,910,365	470,777,044	480,264,606
PASSENGER FUEL		Imp gal	n/a	n/a	n/a	n/a	n/a	n/a	31,996,890
TOTAL FUEL - ALL OPERATIONS		Imp gal	429,314,845	445,296,325	473,407,319	462,779,947	462,910,365	470,777,044	512,261,496
TOTAL FREIGHT FUEL / GTM		Imp gal per 1000 GTM	1.5580	1.4917	1.4364	1.4706	1.4480	1.3765	1.3865
TOTAL FREIGHT FUEL / NTM		Imp gal per 1000 NTM	2.9130	2.8039	2.6835	2.7533	2.7393	2.5264	2.5543

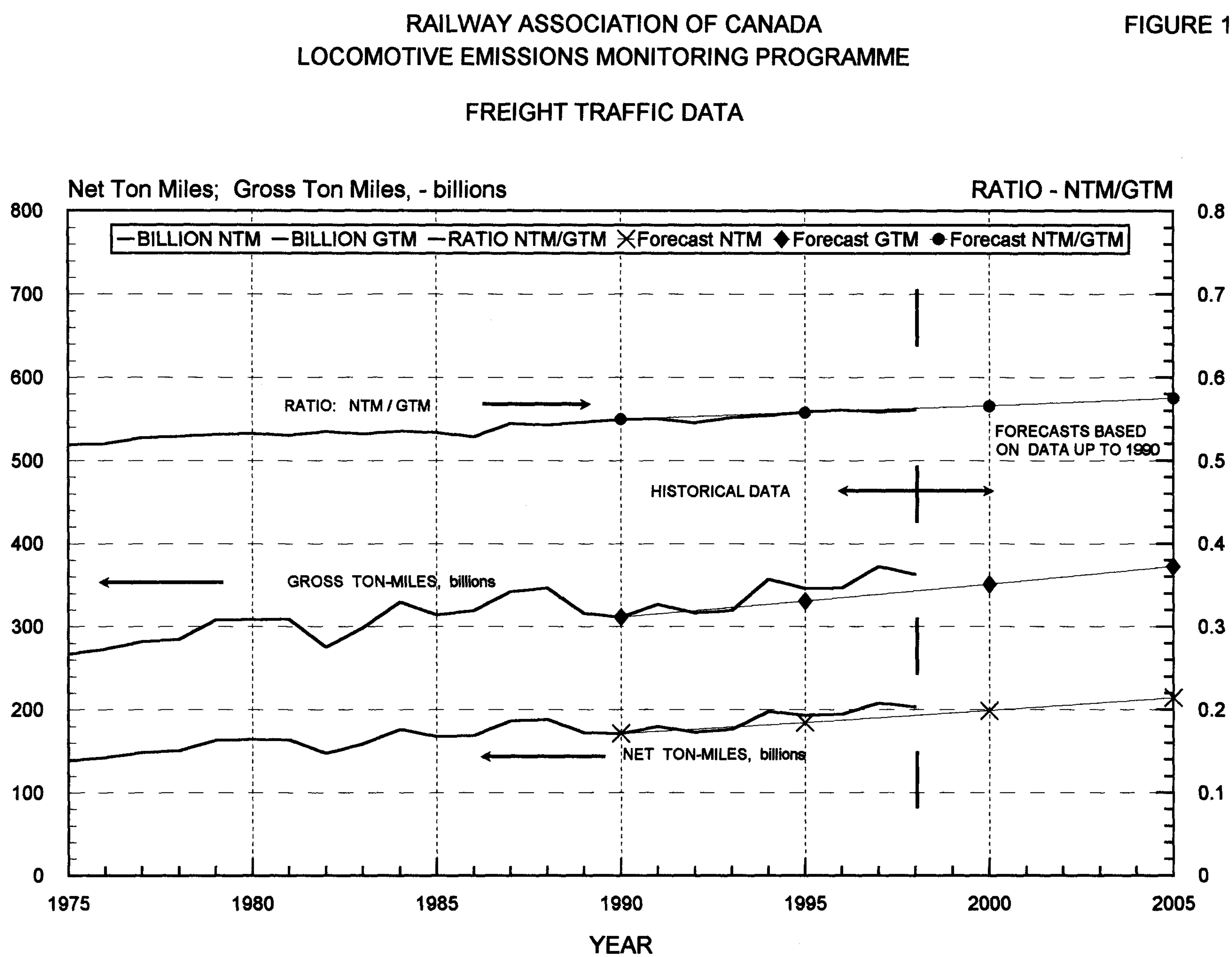
Table 1c: Annual Traffic and Fuel Consumption Statistics, 1989-1994

			1989	1990	1991	1992	1993	1994
TRAFFIC DATA								
GROSS TON-MILES	ALL FREIGHT	million gtm	316,193.2	311,605.6	326,623.9	316,598.2	319,633.0	357,407.3
NET TON-MILES	ALL FREIGHT	million ntm	172,662.4	171,321.8	179,752.7	172,922.6	176,587.7	197,853.0
RATIO of NTM / GTM			0.546	0.550	0.550	0.546	0.552	0.554
FUEL CONSUMPTION DATA								
FREIGHT SERVICE	SUB TOTAL - Existing Locomotive Fleet	Imp gal	413,537,710	401,454,041	413,727,374	401,827,787	399,367,750	425,960,693
	SUB TOTAL - CNR & CPR New Low Emissions Locos	Imp gal						
MAINLINE & BRANCHLINE								
	TOTAL MAINLINE & BRANCHLINE SERVICE	Imp gal	413,537,710	401,454,041	413,727,374	401,827,787	399,367,750	425,960,693
YARD SWITCHING SERVICE.		Imp gal	25,399,966	26,425,932	26,425,476	26,649,476	27,209,986	30,157,938
WORK TRAIN SERVICE		Imp gal	4,084,975	3,447,258	2,966,169	3,231,506	2,605,223	2,589,165
	TOTAL YARD & WORK TRAIN SERVICE	Imp gal	29,484,941	29,873,190	29,391,645	29,880,982	29,815,209	32,747,103
TOTAL FREIGHT OPERATIONS		Imp gal	443,022,651	431,327,231	443,119,019	431,708,769	429,182,960	458,707,796
PASSENGER FUEL		Imp gal	33,656,118	22,620,559	15,802,221	14,175,071	15,295,429	13,220,138
TOTAL FUEL - ALL OPERATIONS		Imp gal	476,678,769	453,947,790	458,921,240	445,883,840	444,478,389	471,927,934
TOTAL FREIGHT FUEL / GTM		Imp gal per 1000 GTM	1.4011	1.3842	1.3567	1.3636	1.3427	1.2834
TOTAL FREIGHT FUEL / NTM		Imp gal per 1000 NTM	2.5658	2.5176	2.4652	2.4965	2.4304	2.3184

Table 1d: Annual Traffic and Fuel Consumption Statistics, 1995-1998, and Projections for 2000 and 2005

			1995	1996	1997	1998	2000	2005
TRAFFIC DATA								
GROSS TON-MILES	ALL FREIGHT	million gtm	346,357.1	346,513.5	372,696.1	362,831.3	351,083.4	372,660.1
NET TON-MILES	ALL FREIGHT	million ntm	193,456.3	194,444.2	208,347.7	203,403.6	198,826.0	214,192.0
RATIO of NTM / GTM			0.559	0.561	0.559	0.561	0.566	0.575
FUEL CONSUMPTION DATA								
FREIGHT SERVICE	SUB TOTAL - Existing Locomotive Fleet	Imp gal	426,629,212	412,290,696	447,260,000	414,419,000	326,005,129	260,152,041
	SUB TOTAL - CNR & CPR New Low Emissions Locos	Imp gal					84,000,000	154,000,000
MAINLINE & BRANCHLINE								
	TOTAL MAINLINE & BRANCHLINE SERVICE	Imp gal	426,629,212	412,290,696	447,260,000	414,419,000	410,005,129	414,152,041
YARD SWITCHING SERVICE.		Imp gal	30,846,036	29,989,213	24,953,000	25,961,000	27,000,000	27,000,000
WORK TRAIN SERVICE		Imp gal	2,153,384	1,442,189	1,326,000	1,650,000	2,500,000	2,500,000
	TOTAL YARD & WORK TRAIN SERVICE	Imp gal	32,999,420	31,431,402	26,279,000	27,611,000	29,500,000	29,500,000
TOTAL FREIGHT OPERATIONS		Imp gal	459,628,632	443,722,098	473,539,000	442,030,000	439,505,129	443,652,041
PASSENGER FUEL		Imp gal	12,406,652	12,939,884	13,435,498	12,888,000	14,000,000	14,000,000
TOTAL FUEL - ALL OPERATIONS		Imp gal	472,035,284	456,661,982	486,974,498	454,918,000	453,505,129	457,652,041
TOTAL FREIGHT FUEL / GTM		Imp gal per 1000 GTM	1.3270	1.2805	1.2706	1.2183	1.2519	1.1905
TOTAL FREIGHT FUEL / NTM		Imp gal per 1000 NTM	2.3759	2.2820	2.2728	2.1732	2.2105	2.0713

Figure 1: Freight Traffic Data



2.2 Fuel Consumption Data

The fuel consumed by railway locomotives in Canada for the years 1975 to 1998 is also shown in Tables 1a to 1d. Estimates are given in Table 1d for the years 2000 and 2005. Data for the years up to and including 1996 are taken from *Rail in Canada,*[2] whereas those for 1997 and 1998 are from information supplied to the RAC by its member railways.

Fuel consumption is broken down into the quantities used for:

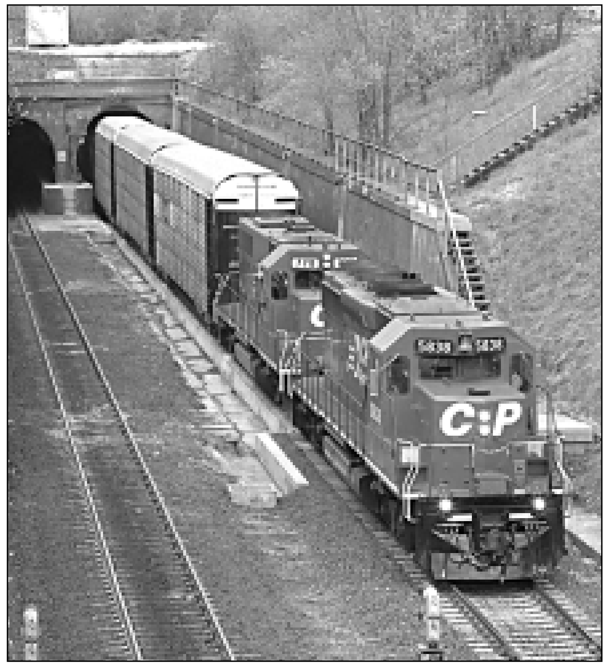
- mainline and branchline freight movement;
- yard switching and work train service; and
- passenger train service. (Information for this category was available only for the period since 1988.)

The data are plotted in Figure 2.

A measure of the efficiency with which freight traffic is handled is the fuel consumption per unit of traffic volume. These data, in units of gallons per 1,000 gross ton-miles and gallons per 1,000 net ton-miles, are shown in Tables 1a to 1d and plotted in Figure 3.

The curves in Figure 3 show the overall improvement in specific fuel consumption for the movement of freight by Canadian railways in the period 1975 to 1998. Operational factors result in year-to-year variations from the long-term trend line. The reduction in specific fuel consumption is the result of many factors. These include:

- the use of locomotives with more efficient engines and transmissions;
- improved train handling practices;
- the use of improved wheel tread profiles;
- the use of freight car trucks with lower rolling and curving resistance;
- the use of locomotive-mounted and wayside rail gauge face lubricators; and
- an increase in average load per car.



Estimates of future fuel consumption were made as follows:

a) The fuel consumption rate in gallons per 1,000 gross ton-miles up to 1990 was examined to determine the annual decrement prior to that date. The annual decrement was found to be 1.9% of the 1990 level. It was assumed that the various improvements being implemented and planned would cause the fuel consumption rate to continue to decrease at about one-half of this historical pace, or at an annual rate of 1% of the 1990 level, through to 2005. The projected values are shown in Figure 3.

b) The fuel consumption rate values were then applied to the projected traffic levels to obtain the estimated total freight fuel consumption to 2005.

c) The estimated passenger service fuel consumption was based on values predicted in 1990.

[2] Statistics Canada Catalogue 52-216 Annual.

Figure 2: Fuel Data

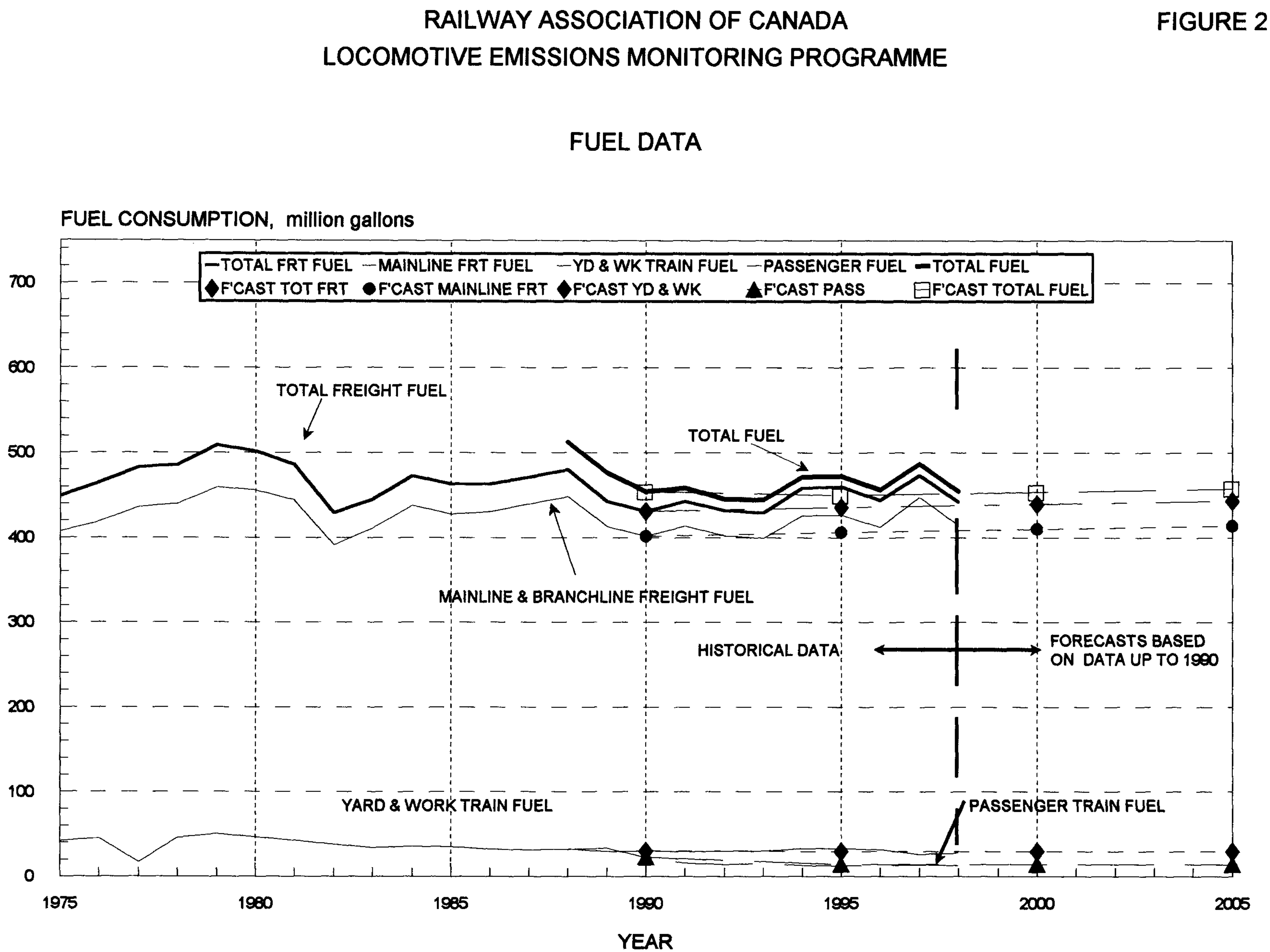
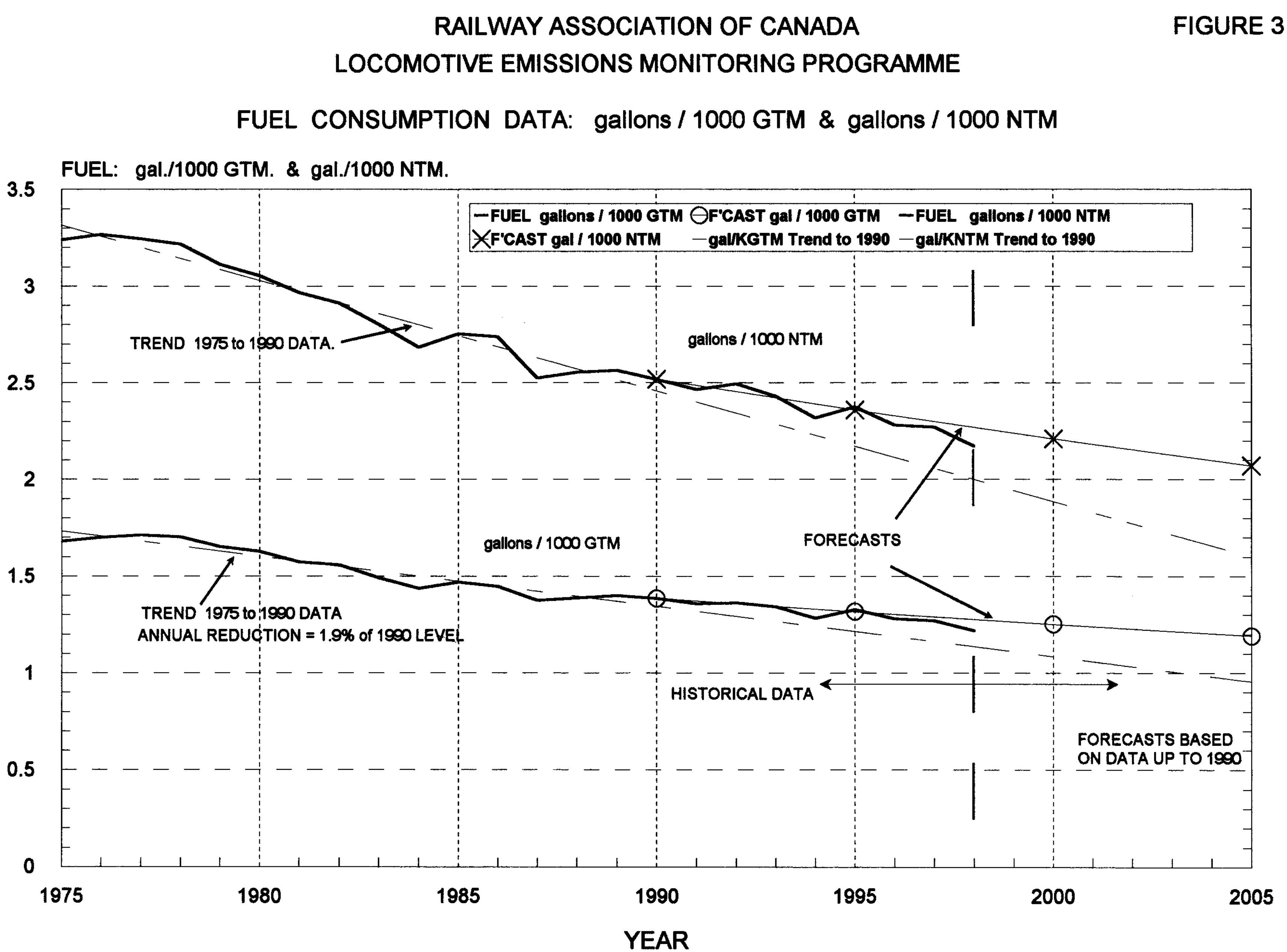


Figure 3: Fuel Consumption Data: gallons/1000 GTM and gallons/1000 NTM



2.3 Locomotive Emissions Data

The gaseous emissions from locomotive operation were calculated using factors giving quantities of selected exhaust gases per gallon of fuel consumed. These factors were derived from extensive testing by the Association of American Railroads and the locomotive manufacturers. They are shown in Tables 10 and 12 of an Environment Canada report entitled Recommended Reporting Requirements for the Locomotive Emissions Monitoring (LEM) Program.3 The factors are based on emissions data for engines in the various throttle notch settings applied to the duty cycle for locomotive operation considered to be applicable to Canadian service conditions.

The emissions data are shown in Tables 2a to 2d of this report. Values are shown for:

- oxides of nitrogen (NO_X);
- carbon monoxide (CO);
- hydrocarbons (HC);
- oxides of sulphur (SO_X);
- particulate matter (PM); and
- carbon dioxide (CO_2).

Values are presented for the several types of service and for the total locomotive emissions for all railway operations. The historical and forecast quantities of NO_X emissions are also plotted in Figure 4.

The projected values for locomotive emissions shown in Figure 4 are based on the forecast traffic levels and on the forecast efficiency of locomotive and train operation.

The proposed cap of 115 kilotonnes per annum on emissions of NO_X is also shown in Figure 4.

Emissions of NO_X and CO_2 per unit of traffic volume are calculated in Tables 2a to 2d. Emission rates are plotted in Figure 5 in kilograms per 1,000 net ton-miles.

2.4 Observations on Data

The efficiency with which freight traffic was handled continued to improve at a rate slightly better than that forecast, as shown by "Fuel Consumption per Traffic Unit" in Figure 3, and by "Emissions per Traffic Unit" in Figure 5.

Emissions of NO_X were below the cap of 115 kilotonnes in 1998 (by 1.1%), having exceeded it in 1997 (by 5.8%). Average emissions since 1990 have been slightly above the cap level (by 0.2%). This recent performance was achieved in spite of the significant increase in traffic levels since 1994 over the forecast volumes, see Figure 1. For further discussion, see Section 9.

Emissions of NO_X and of the greenhouse gas CO_2, measured in kilograms per 1,000 net ton-miles, have continued to decrease slightly faster than forecast with only small variations. The curves in Figure 5 show clearly the steady progress made since the late 1970s in reducing such emissions from rail freight transportation.

[3] Environment Canada, Environmental Protection Series, Report EPS 2/TS/8, September 1994.

Table 2a: Annual Emission Statistics, 1975-1981

		EMISSIONS FACTORS STD. FRGT. & PASS.	YARD & WORK	1975	1976	1977	1978	1979	1980	1981
		gm/IG	gm/IG	kilotonnes						
FREIGHT - MAIN & BRANCH LN	NOx	248.3		101.07	104.09	108.33	109.26	114.05	113.18	110.21
	CO	47.7		19.42	20.00	20.81	20.99	21.91	21.74	21.17
	HC	12.4		5.05	5.20	5.41	5.46	5.70	5.65	5.50
Adj'd to 0.15% Sulphur Fuel	SOx	11.5		4.69	4.83	5.02	5.07	5.29	5.25	5.11
	PM	5.9		2.40	2.47	2.57	2.60	2.71	2.69	2.62
Based on 86.5% Carbon Fuel	CO2	12300		5006.74	5156.20	5366.38	5412.30	5649.52	5606.49	5459.49
YD. SW.+WK.TRN. SERV.	NOx		277	11.63	12.57	12.96	12.70	13.90	12.81	11.77
	CO		47.3	1.99	2.15	2.21	2.17	2.37	2.19	2.01
	HC		16.4	0.69	0.74	0.77	0.75	0.82	0.76	0.70
Adj'd to 0.15% Sulphur Fuel	SOx		11.5	0.48	0.52	0.54	0.53	0.58	0.53	0.49
	PM		6.7	0.28	0.30	0.31	0.31	0.34	0.31	0.28
Based on 86.5% Carbon Fuel	CO2		12300	516.45	558.24	575.58	564.03	617.23	568.67	522.84
PASSENGER	NOx	248.3		n/a	n/a	n/a	n/a	n/a	n/a	n/a
	CO	47.7		n/a	n/a	n/a	n/a	n/a	n/a	n/a
	HC	12.4		n/a	n/a	n/a	n/a	n/a	n/a	n/a
Adj'd to 0.15% Sulphur Fuel	SOx	11.5		n/a	n/a	n/a	n/a	n/a	n/a	n/a
	PM	5.9		n/a	n/a	n/a	n/a	n/a	n/a	n/a
Based on 86.5% Carbon Fuel	CO2	12300		n/a	n/a	n/a	n/a	n/a	n/a	n/a
TOTAL - RAIL OPERATIONS.	NOx	248.3	277	112.70	116.66	121.29	121.96	127.95	125.98	121.99
	CO	47.7	47.3	21.40	22.14	23.02	23.16	24.28	23.93	23.18
	HC	12.4	16.4	5.74	5.94	6.18	6.21	6.52	6.41	6.20
Adj'd to 0.15% Sulphur Fuel	SOx	11.5	11.5	5.17	5.35	5.56	5.59	5.87	5.78	5.60
	PM	5.9	6.7	2.68	2.78	2.89	2.90	3.05	3.00	2.90
Based on 86.5% Carbon Fuel	CO2	12300	12300	5523.19	5714.44	5941.96	5976.33	6266.76	6175.16	5982.32
EMISSIONS per FREIGHT TRAFFIC UNIT				kg / 1000 NTM						
NOx				0.813	0.821	0.815	0.807	0.782	0.767	0.744
CO				0.154	0.156	0.155	0.153	0.148	0.146	0.141
HC				0.041	0.042	0.041	0.041	0.040	0.039	0.038
SOx				0.037	0.038	0.037	0.037	0.036	0.035	0.034
PM				0.019	0.020	0.019	0.019	0.019	0.018	0.018
CO2				39.857	40.192	39.906	39.569	38.291	37.574	36.494

Table 2b: Annual Emission Statistics, 1982-1988

		EMISSIONS FACTORS STD. FRGT. & PASS.	YARD & WORK	1982	1983	1984	1985	1986	1987	1988
		gm/IG	gm/IG	kilotonnes						
FREIGHT - MAIN & BRANCH LN	NOx	248.3		97.20	102.09	108.72	106.19	106.92	109.15	111.27
	CO	47.7		18.67	19.61	20.89	20.40	20.54	20.97	21.38
	HC	12.4		4.85	5.10	5.43	5.30	5.34	5.45	5.56
Adj'd to 0.15% Sulphur Fuel	SOx	11.5		4.51	4.73	5.04	4.93	4.96	5.06	5.16
	PM	5.9		2.31	2.43	2.58	2.52	2.54	2.59	2.64
Based on 86.5% Carbon Fuel	CO2	12300		4814.79	5057.23	5385.59	5260.47	5296.54	5407.05	5512.06
YD. SW.+WK.TRN. SERV.	NOx		277	10.49	9.46	9.85	9.72	8.95	8.64	8.90
	CO		47.3	1.79	1.61	1.68	1.66	1.53	1.47	1.52
	HC		16.4	0.62	0.56	0.58	0.58	0.53	0.51	0.53
Adj'd to 0.15% Sulphur Fuel	SOx		11.5	0.44	0.39	0.41	0.40	0.37	0.36	0.37
	PM		6.7		0.23	0.24	0.24	0.22	0.21	0.22
Based on 86.5% Carbon Fuel	CO2		12300	465.79	419.92	437.32	431.73	397.25	383.51	395.20
PASSENGER	NOx	248.3		n/a	n/a	n/a	n/a	n/a	n/a	7.94
	CO	47.7		n/a	n/a	n/a	n/a	n/a	n/a	1.53
	HC	12.4		n/a	n/a	n/a	n/a	n/a	n/a	0.40
Adj'd to 0.15% Sulphur Fuel	SOx	11.5		n/a	n/a	n/a	n/a	n/a	n/a	0.37
	PM	5.9		n/a	n/a	n/a	n/a	n/a	n/a	0.19
Based on 86.5% Carbon Fuel	CO2	12300		n/a	n/a	n/a	n/a	n/a	n/a	393.56
TOTAL - RAIL OPERATIONS.	NOx	248.3	277	107.69	111.55	118.57	115.92	115.87	117.79	128.12
	CO	47.7	47.3	20.46	21.23	22.57	22.06	22.07	22.44	24.42
	HC	12.4	16.4	5.47	5.66	6.01	5.88	5.87	5.96	6.48
Adj'd to 0.15% Sulphur Fuel	SOx	11.5	11.5	4.94	5.13	5.45	5.33	5.33	5.42	5.90
	PM	5.9	6.7	2.56	2.65	2.82	2.76	2.76	2.80	3.05
Based on 86.5% Carbon Fuel	CO2	12300	12300	5280.57	5477.14	5822.91	5692.19	5693.80	5790.56	6300.82
EMISSIONS per FREIGHT TRAFFIC UNIT				kg / 1000 NTM						
NOx				0.731	0.702	0.672	0.690	0.686	0.632	0.639
CO				0.139	0.134	0.128	0.131	0.131	0.120	0.122
HC				0.037	0.036	0.034	0.035	0.035	0.032	0.032
SOx				0.034	0.032	0.031	0.032	0.032	0.029	0.029
PM				0.017	0.017	0.016	0.016	0.016	0.015	0.015
CO2				35.830	34.487	33.007	33.866	33.694	31.074	31.418

Table 2c: Annual Emissions Statistics, 1989-1994

		EMISSIONS FACTORS STD. FRGT. & PASS.	YARD & WORK	1989	1990	1991	1992	1993	1994
		gm/IG	gm/IG	kilotonnes					
FREIGHT - MAIN & BRANCH LN	NOx	248.3		102.68	99.68	102.73	99.77	99.16	105.77
	CO	47.7		19.73	19.15	19.73	19.17	19.05	20.32
	HC	12.4		5.13	4.98	5.13	4.98	4.95	5.28
Adj'd to 0.15% Sulphur Fuel	SOx	11.5		4.76	4.62	4.76	4.63	4.60	4.91
	PM	5.9		2.44	2.37	2.44	2.37	2.36	2.51
Based on 86.5% Carbon Fuel	CO2	12300		5086.51	4937.88	5088.85	4942.48	4912.22	5239.32
YD. SW.+WK.TRN. SERV.	NOx		277	8.17	8.27	8.14	8.28	8.26	9.07
	CO		47.3	1.39	1.41	1.39	1.41	1.41	1.55
	HC		16.4	0.48	0.49	0.48	0.49	0.49	0.54
Adj'd to 0.15% Sulphur Fuel	SOx		11.5	0.34	0.34	0.34	0.34	0.34	0.38
	PM		6.7	0.20	0.20	0.20	0.20	0.20	0.22
Based on 86.5% Carbon Fuel	CO2		12300	362.66	367.44	361.52	367.54	366.73	402.79
PASSENGER	NOx	248.3		8.36	5.62	3.92	3.52	3.80	3.28
	CO	47.7		1.61	1.08	0.75	0.68	0.73	0.63
	HC	12.4		0.42	0.28	0.20	0.18	0.19	0.16
Adj'd to 0.15% Sulphur Fuel	SOx	11.5		0.39	0.26	0.18	0.16	0.18	0.15
	PM	5.9		0.20	0.13	0.09	0.08	0.09	0.08
Based on 86.5% Carbon Fuel	CO2	12300		413.97	278.23	194.37	174.35	188.13	162.61
TOTAL - RAIL OPERATIONS.	NOx	248.3	277	119.21	113.57	114.79	111.57	111.22	118.12
	CO	47.7	47.3	22.73	21.64	21.88	21.26	21.19	22.50
	HC	12.4	16.4	6.03	5.75	5.81	5.65	5.63	5.98
Adj'd to 0.15% Sulphur Fuel	SOx	11.5	11.5	5.49	5.23	5.28	5.13	5.12	5.43
	PM	5.9	6.7	2.84	2.70	2.73	2.65	2.65	2.81
Based on 86.5% Carbon Fuel	CO2	12300	12300	5863.15	5583.56	5644.73	5484.37	5467.08	5804.71
EMISSIONS per FREIGHT TRAFFIC UNIT				kg / 1000 NTM					
NOx				0.642	0.630	0.617	0.625	0.608	0.580
CO				0.122	0.120	0.118	0.119	0.116	0.111
HC				0.032	0.032	0.031	0.032	0.031	0.029
SOx				0.030	0.029	0.028	0.029	0.028	0.027
PM				0.015	0.015	0.015	0.015	0.014	0.014
CO2				31.560	30.967	30.321	30.707	29.894	28.517

Table 2d: Annual Emissions Statistics, 1995-1998, and Projections for 2000 and 2005

		EMISSIONS FACTORS STD. FRGT. & PASS.	YARD & WORK	1995	1996	1997	1998	2000	2005
		gm/IG	gm/IG	kilotonnes					
FREIGHT - MAIN & BRANCH LN	NOx	248.3		105.93	102.37	111.05	102.90	99.72	99.01
	CO	47.7		20.35	19.67	21.33	19.77	19.56	19.76
	HC	12.4		5.29	5.11	5.55	5.14	5.08	5.14
Adj'd to 0.15% Sulphur Fuel	SOx	11.5		4.91	4.75	5.15	4.77	4.72	4.77
	PM	5.9		2.52	2.43	2.64	2.45	2.42	2.44
Based on 86.5% Carbon Fuel	CO2	12300		5247.54	5071.18	5501.30	5097.35	5043.06	5094.07
YD. SW.+WK.TRN. SERV.	NOx		277	9.14	8.71	7.28	7.65	8.17	8.17
	CO		47.3	1.56	1.49	1.24	1.31	1.40	1.40
	HC		16.4	0.54	0.52	0.43	0.45	0.48	0.48
Adj'd to 0.15% Sulphur Fuel	SOx		11.5	0.38	0.36	0.30	0.32	0.34	0.34
	PM		6.7	0.22	0.21	0.18	0.18	0.20	0.20
Based on 86.5% Carbon Fuel	CO2		12300	405.89	386.61	323.23	339.62	362.85	362.85
PASSENGER	NOx	248.3		3.08	3.21	3.34	3.20	3.48	3.48
	CO	47.7		0.59	0.62	0.64	0.61	0.67	0.67
	HC	12.4		0.15	0.16	0.17	0.16	0.17	0.17
Adj'd to 0.15% Sulphur Fuel	SOx	11.5		0.14	0.15	0.15	0.15	0.16	0.16
	PM	5.9		0.07	0.08	0.08	0.08	0.08	0.08
Based on 86.5% Carbon Fuel	CO2	12300		152.60	159.16	165.26	158.52	172.20	172.20
TOTAL - RAIL OPERATIONS.	NOx	248.3	277	118.15	114.29	121.67	113.75	111.37	110.66
	CO	47.7	47.3	22.50	21.77	23.22	21.69	21.62	21.82
	HC	12.4	16.4	5.99	5.79	6.14	5.75	5.74	5.79
Adj'd to 0.15% Sulphur Fuel	SOx	11.5	11.5	5.44	5.26	5.61	5.24	5.22	5.27
	PM	5.9	6.7	2.81	2.72	2.89	2.71	2.70	2.72
Based on 86.5% Carbon Fuel	CO2	12300	12300	5806.03	5616.94	5989.79	5595.49	5578.11	5629.12
EMISSIONS per FREIGHT TRAFFIC UNIT				kg / 1000 NTM					
NOx				0.595	0.571	0.568	0.543	0.543	0.500
CO				0.113	0.109	0.108	0.104	0.105	0.099
HC				0.030	0.029	0.029	0.027	0.028	0.026
SOx				0.027	0.026	0.026	0.025	0.025	0.024
PM				0.014	0.014	0.014	0.013	0.013	0.012
CO2				29.223	28.069	27.956	26.730	27.189	25.477

Figure 4: Locomotive Emissions Data: NO_X kilotonnes

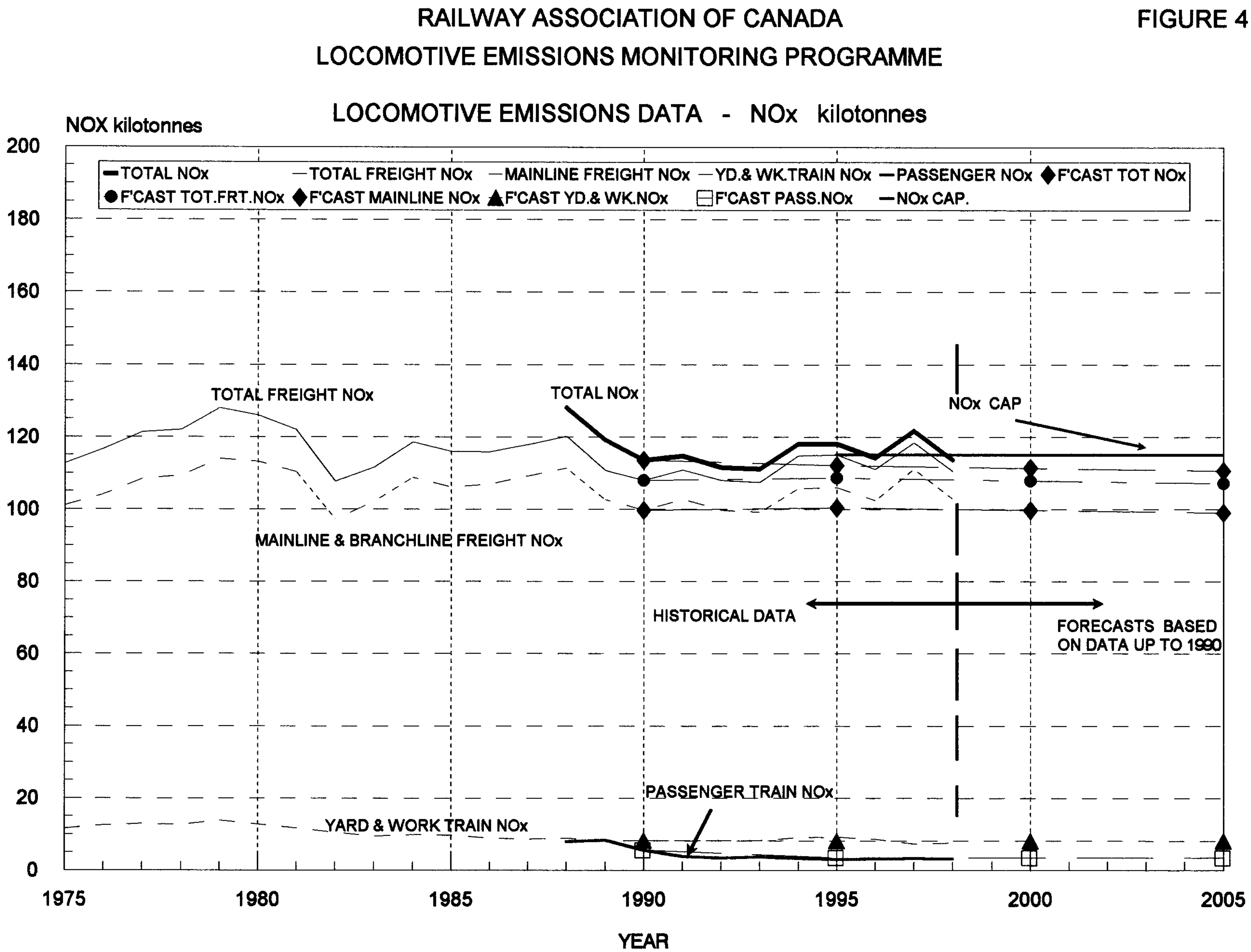
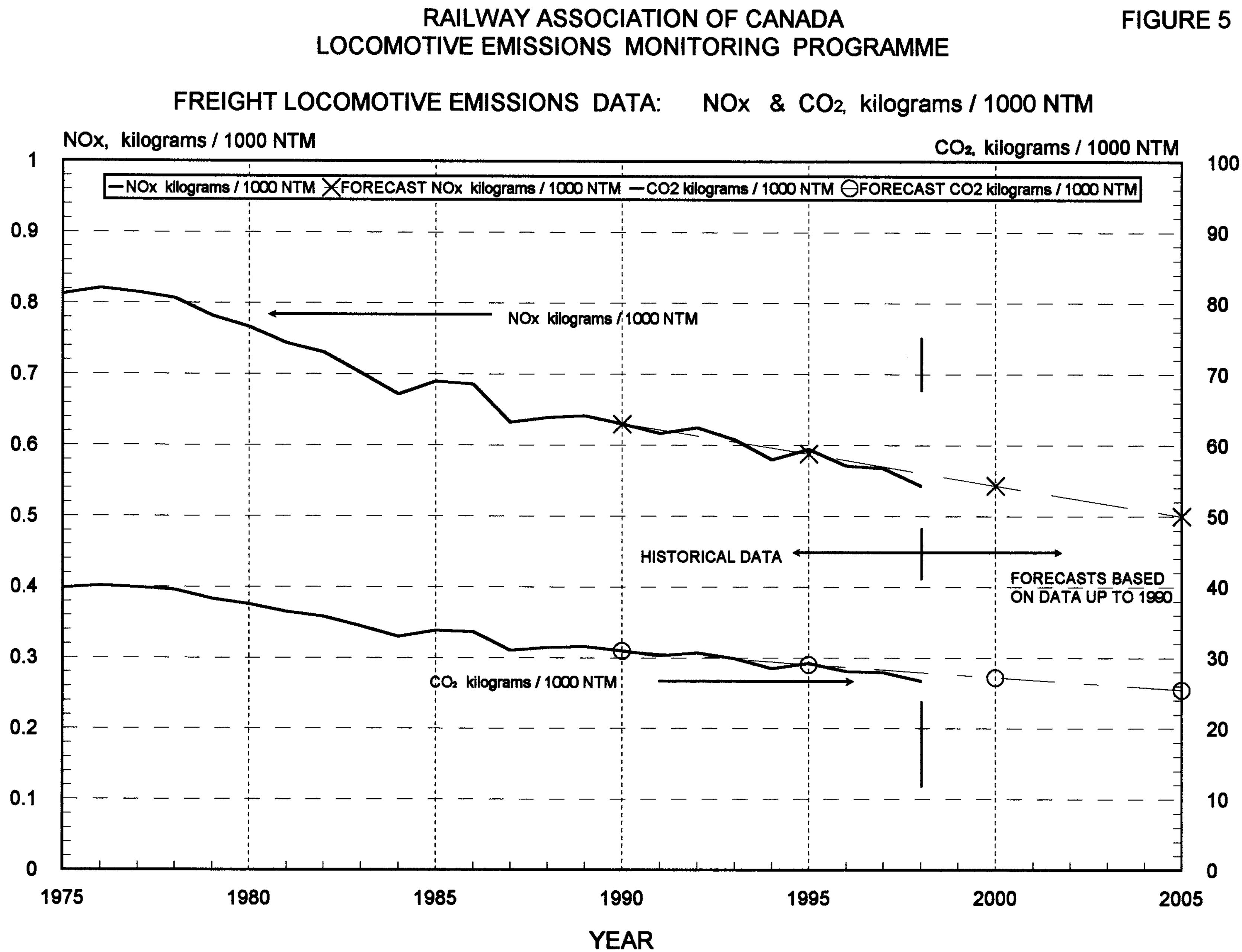


Figure 5: Freight Locomotive Emissions Data: NO_x and CO_2 kilograms/1000 NTM



3.0 Fuel Consumption and Emissions in Tropospheric Ozone Management Areas (TOMAs) during 1998

3.1 Annual Data

Three Tropospheric Ozone Management Areas have been designated as being of particular interest for gaseous emissions. These areas and the sections of the several railways that operate within them are shown in Appendix I.

Fuel consumption in these areas is derived from knowledge of the total traffic in the areas, expressed in gross ton-miles, as a proportion of the total rail traffic in Canada. The emissions are then calculated using established factors for the various gases.

The results for the three TOMAs are shown in Table 3. The fuel used in the TOMAs is also shown as a percentage of the total fuel consumption of all Canadian rail operations. It is noteworthy that this percentage is relatively low as shown below.

The balance of the total fuel consumption (i.e., 80.84%, 80.12%, 80.91% and 79.35%) took place outside the three TOMAs across the rest of the country. The resulting emissions were therefore spread widely over areas with a relatively low population density.

3.2 Seasonal Data

Emissions in the TOMAs have been divided into two seasonal periods as specified in the initiating Memorandum of Understanding:

- winter (seven months)—January to April and October to December inclusively; and
- summer (five months)—May to September inclusively.

The distribution of traffic between winter and summer periods was provided by the major railways for their entire systems. The distribution of traffic between winter and summer periods in the TOMAs was assumed to be similar to that for the whole system for each railway. Smaller railways were not always able to provide seasonal traffic distribution. In these cases, seasonal traffic distribution was based on the ratio of days in winter to days in summer, since seasonal traffic distribution corresponded closely to this ratio for the major railways.

Seasonal fuel consumption in each TOMA was then estimated according to the ratio of summer to winter traffic for each railway, except in the case of GO Transit in TOMA No. 2. Here, the actual seasonal fuel consumption data were available. The emissions in the seasonal periods were then calculated as before, and the results are shown in Table 3.

Fuel Used in the TOMAs as a Percentage of Total Fuel Used by Railways in Canada

Year		**1995**	**1996**	**1997**	**1998**
TOMA No. 1	Lower Fraser Valley, B.C.	4.27%	4.42%	4.17%	4.26%
TOMA No. 2	Windsor–Quebec City Corridor	14.78%	15.33%	14.83%	16.29%
TOMA No. 3	Saint John Area, N.B.	0.11%	0.13%	0.09%	0.10%

Table 3: Tropospheric Ozone Management Areas — Traffic, Fuel and Emissions Data, 1998

TOMA					No:1 LOWER FRASER VALLEY B.C.			No:2 WINDSOR-QUEBEC CITY			No:3 SAINT JOHN N.B. AREA		
						SEASONAL SPLIT			SEASONAL SPLIT			SEASONAL SPLIT	
GROSS TON-MILES						Winter	Summer		Winter	Summer		Winter	Summer
CN				million gtm	6,530.124	59.73%	40.27%	35128.928	59.73%	40.27%	276.436	59.73%	40.27%
CP				million gtm	8,538.949	58.63%	41.37%	16,687.552	58.63%	41.37%			
B.C. RAIL *				million gtm	275.870	58.08%	41.92%						
BURLINGTON NORTHERN SANTA FE RAILROAD				million gtm	300.000	58.08%	41.92%						
SOUTHERN RAILWAY OF B. C.				million gtm	116.000	58.08%	41.92%						
GO TRANSIT				million gtm					58.13%	41.87%			
ESSEX TERMINAL RAILWAY				million gtm				20.127	58.08%	41.92%			
GODERICH - EXETER RLY.				million gtm				57.700	58.08%	41.92%			
CSX				million gtm				140.675	58.08%	41.92%			
CONRAIL				million gtm				45.383	58.08%	41.92%			
So.Ont,-RAILINK				million gtm				139.136	58.08%	41.92%			
NORFOLK SOUTHERN				million gtm				528.962	58.08%	41.92%			
N. B. SOUTHERN RAILWAY				million gtm							80.000	58.08%	41.92%
TOTAL FREIGHT				million gtm	15,760.943			52,748.463			356.436		
VIA				million gtm	49.921	58.08%	41.92%	1,481.937	58.08%	41.92%			
FUEL CONSUMPTION													
FUEL RATE - FREIGHT SERVICE				imp gal per 1000 GTM	1.2183			1.2183			1.2183		
FUEL RATE - PASSENGER SERVICE				imp gal per 1000 GTM	3.65			3.65			3.65		
FREIGHT FUEL CONSUMPTION IN TOMA				million Imp gal	19.202	11.341	7.861	64.263	38.142	26.121	0.434	0.258	0.176
VIA FUEL CONSUMPTION IN TOMA				million Imp gal	0.182	0.106	0.076	5.409	3.142	2.267	0.000	0.000	0.000
GO TRANSIT				million Imp gal				4.428	2.574	1.854			
TOTAL FUEL CONSUMPTION IN TOMA				million Imp gal	19.384	11.447	7.937	74.101	43.858	30.243	0.434	0.258	0.176
CANADIAN TOTAL FUEL CONSUMPTION				million Imp gal	454.918			454.918			454.918		
TOMA FUEL CONSUMPTION AS % CANADIAN TOTAL					4.26%			16.29%			0.10%		
EMISSIONS	EMISSIONS FACTORS												
	STD.	YARD	COMB **										
	gm/Imp gal	gm/Imp gal	gm/Imp gal										
OXIDES of NITROGEN (NOx)	248.3	277	250.0	kilotonnes	4.85	2.86	1.98	18.53	10.97	7.56	0.11	0.06	0.04
CARBON MONOXIDE (CO)	47.7	47.3	47.7	kilotonnes	0.92	0.55	0.38	3.53	2.09	1.44	0.02	0.01	0.01
HYDROCARBONS (HC)	12.4	16.4	12.6	kilotonnes	0.25	0.14	0.10	0.94	0.55	0.38	0.01	0.00	0.00
SULPHUR OXIDES (SOx)	11.5	11.5	11.5	kilotonnes	0.22	0.13	0.09	0.85	0.50	0.35	0.00	0.00	0.00
PARTICULATE MATTER (PM)	5.9	6.7	5.9	kilotonnes	0.12	0.07	0.05	0.44	0.26	0.18	0.00	0.00	0.00
CARBON DIOXIDE (CO2)	12300	12300	12300.0	kilotonnes	238.42	140.79	97.63	911.44	539.45	371.99	5.34	3.17	2.17

Notes: * B.C. RAIL gtm for TOMA No: 1 derived as % length of line in TOMA No: 1 of total line length.

** Combined Emission Factors derived from Standard & Yard Factors with Fuel Consumption Data from Table 1d).

4.0 Locomotive Fleet Composition

The composition of the Canadian locomotive fleet as of the end of 1998 is shown in Tables 4 and 5.

Table 4: Canadian Locomotive Fleet — Mainline and Branchline, 1998

BUILDER	ENGINE MODEL	HP	YEAR	TOTAL	CN	CP	VIA	BC RAIL	GO TRNST	OTHER
GM/EMD	20V-645E3	3600		6						6
	16V-710G3B	4300	'96	167	139	28				
	16V-710G3B	4000	'95	26	26					
	16V-710G3	3800	'85-89	63	63					
	12V-710G3 or 710G3A	3000	'88-'95	45					45	
	16V-645F3B	3600	'85-'94	66	60					6
	16V-645E3B	3000	'85-'87	23				23		
	16V-645E3C	3000		58			58			
	16V-645E3M	3000	'88							
	16V-645E3	3000	'66-'80	1140	523	569				48
	16V-645D3A	2250	'64-'66	18		2				16
	16V-645D3	2250	'63							
	CAT 3516	2075	'94	3						3
SUB-TOTAL				1615	811	599	58	23	45	79
MLW	16V-251F	3700	'70-'84	7			7			
	16V-251F	3600	'69-'82	24						24
	16V-251E	3000	'67-'76	9						9
	16V-251B	2400	'63-'66	1		1				
SUB-TOTAL				41	0	1	7	0	0	33
GE	16V-7FDL-16	4400	'94-'95	317	103	184		30		
	16V-7FDL-16	4000	'90-'94	58	55					3
	16V-FDL16	3900	'88	3				3		
	16V-FDL16	3600	'80	5				5		
	16V-FDL16	3200		13				10		3
SUB-TOTAL				396	158	184	0	48	0	6
BUDD-RDC	DD 6-110	550	'55-'58	21			6	9		6
TOTAL MAINLINE & BRANCHLINE				2073	969	784	71	80	45	124

Table 5: Canadian Locomotive Fleet — Yard and Switching, 1998

BUILDER	ENGINE MODEL	HP	YEAR	TOTAL	CN	CP	VIA	BC RAIL	GO TRNST	OTHER
GM/EMD	16V-645E	2000	'71-'75,'86	288	110	129				49
	16V-645C	1800	'54-'67	175	162		7			6
	16V-645C	1750	'75-'81	202		202				0
	16V-645C	1500	'81-'94	10		10				0
	16V-645D	1500	'52	0						0
	16V-567C	1750	'51-'63	59		3				56
	16V-567B	1500	'51-'52,'78	9						9
	12V-645E	1500	'71-'80	4						4
	12V-645C	1350	'87-'89	117	117					0
	12V-645C	1200	'81-'85	24		24				0
	12V-567C	1200	'55-'60	103	61	33				9
	8V-645E	1000	'66-'67	2			2			0
	8V-645C	1000	'67-'69	0						0
	8V-567C	900	'51-'64	13		1				12
	8V-567B	800	'51-'54	1						1
										0
	CAT3512	2000	'90-'91	6		6				0
SUB-TOTAL				1013	450	408	9	0	0	146
MLW	12V-251C3	2000	'73-'81	2						2
	12V-251C	2000	'64-'76	24				4		20
	12V-251C	1800	'66	2				2		0
	12V-251B	1800	'56-'65	52						52
	12V-251B	1400	'59-'60	2						2
	6I-251B/C	1000	'59-'60	18						18
										0
	CAT 12V-3512	2000		27				27		0
SUB-TOTAL				127	0	0	0	33	0	94
TOTAL - YARD & SWITCHING:				1140	450	408	9	33	0	240
GRAND TOTAL - MAIN-LINE, BRANCH-LINE, YARD and SWITCHING:				3213	1419	1192	80	113	45	364

5.0 Operational Improvements

5.1 Locomotive Fleet Upgrade

The new locomotives that are being introduced by Canadian railways to replace older units have improved emission characteristics. The concentration of NO_x in the exhaust gases of diesel engines will be slightly reduced, while fuel consumption will be significantly reduced. This means that less fuel will be used to move trains, leading to significant reductions in NO_x emissions.

The effects of this progressive change can be seen in the continued downward trend in the curves for fuel consumption per 1,000 gross ton-miles and per 1,000 net ton-miles plotted in Figure 3. Exhaust emissions are also expected to follow a continued downward trend.

5.2 Train Handling Practices

The proportion of mainline locomotives fitted with dynamic brakes will continue to increase, with benefits for fuel consumption. This will allow the increased use of the dynamic brake for control of train speed, rather than the use of the air brake system. The air brake does not allow the locomotive engineer to reduce the severity of a brake application already in force, and it is frequently necessary to apply power at the same time as the brakes to maintain speed over variable track grades. This procedure significantly increases fuel consumption. When the dynamic brake is used to control speed, the severity of the application can be varied as needed, and fuel consumption is not significantly increased.

5.3 Rail Gauge Face Lubrication

The railways have continuing programs to ensure that the system of track-mounted rail lubricators is maintained in good operating condition. Railways that have applied on-board locomotive wheel flange lubricators also have programs to keep these in working order. Efficient rail gauge face lubrication has been shown in many tests to reduce fuel consumption.

5.4 Freight Car Productivity Improvement

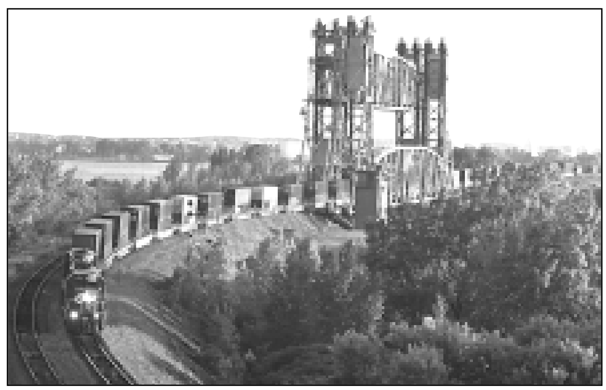
The maximum allowable axle load is being increased on many lines in Canada. This enables the railways to use certain cars with a gross weight on rail of up to 286,000 pounds instead of 263,000 pounds. The gross-to-tare ratio of such freight cars is increased so that the quantity of gross ton-miles accumulated to move a given amount of freight is reduced. This contributes to the improvement in the ratio of net ton-miles to gross ton-miles forecast in section 2.1c above and confirmed in Figure 1. The associated emissions will therefore continue to be reduced.

6.0 Improvements to Existing Locomotives

6.1 Low Idle Applications

The railways are extending the application of the "low idle" feature to more mainline locomotives. This feature allows the diesel engine to idle at a reduced speed with a consequently reduced load from fans and internal windage losses. The reduction in fuel consumption can be as much as two gallons per hour and, on the accepted duty cycles, can be as much as 3% of annual fuel consumption. The use of the low-idle feature is limited in some cases by the ability of the auxiliary power system to generate sufficient power for battery charging. However, a continued reduction in overall fuel consumption is expected from this feature.

6.2 Automatic Start/Stop Systems



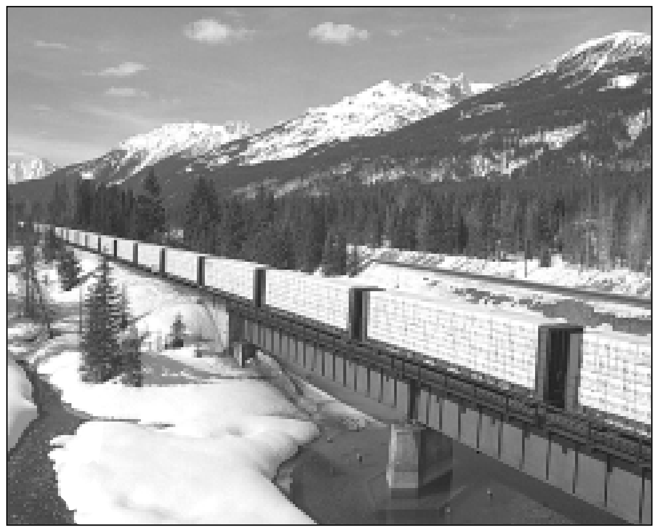
The railways are installing devices on switching locomotives that will automatically shut down and restart the diesel engine when the locomotive is not in use. The device is regulated by several locomotive system parameters such as water temperature and battery condition. It will restart the engine and enable it to idle for a time to prevent freezing and to charge the batteries. The railways now have a policy of shutting down unused engines when ambient temperatures permit; the so-called smart-start systems will enable this practice to be extended all year.

7.0 Emissions Performance Data

No new emissions data have been made available to the industry by the Association of American Railroads or the manufacturers that will significantly change the calculations and projections in this report.

8.0 Diesel Fuel Properties

Canadian railways have since the mid-1970s made use of a significant amount of fuel from an extraction plant in the Alberta Tar Sands region. This fuel was tested by the Association of American Railroads at the Southwest Research Institute and found to have emission characteristics at least as good as those of conventional diesel fuel.



9.0 Observations and Conclusions

It was observed, and shown in Figure 4, that emissions of NO_x in 1998 were slightly below the voluntary cap of 115 kilotonnes per year, and that average emission levels since 1990 were only marginally above that level. It was shown that, because emissions of NO_x per gross and net ton-mile were reduced at a rate slightly better than forecast (see Tables 2a to 2d and Figure 5), the higher values from 1994 to 1997 were due to traffic increases significantly greater than forecast. The continued improvement in 1998 shows the effect of the introduction of new, more efficient locomotives into the fleet.

Emissions of NO_x and CO_2 in kilograms per 1,000 net ton-miles, shown in Figure 5, have continued to decrease since the late 1970s. The rate of decrease since 1990 has closely followed the forecast, showing the effects of the continual improvement in the efficiency of rail transportation.

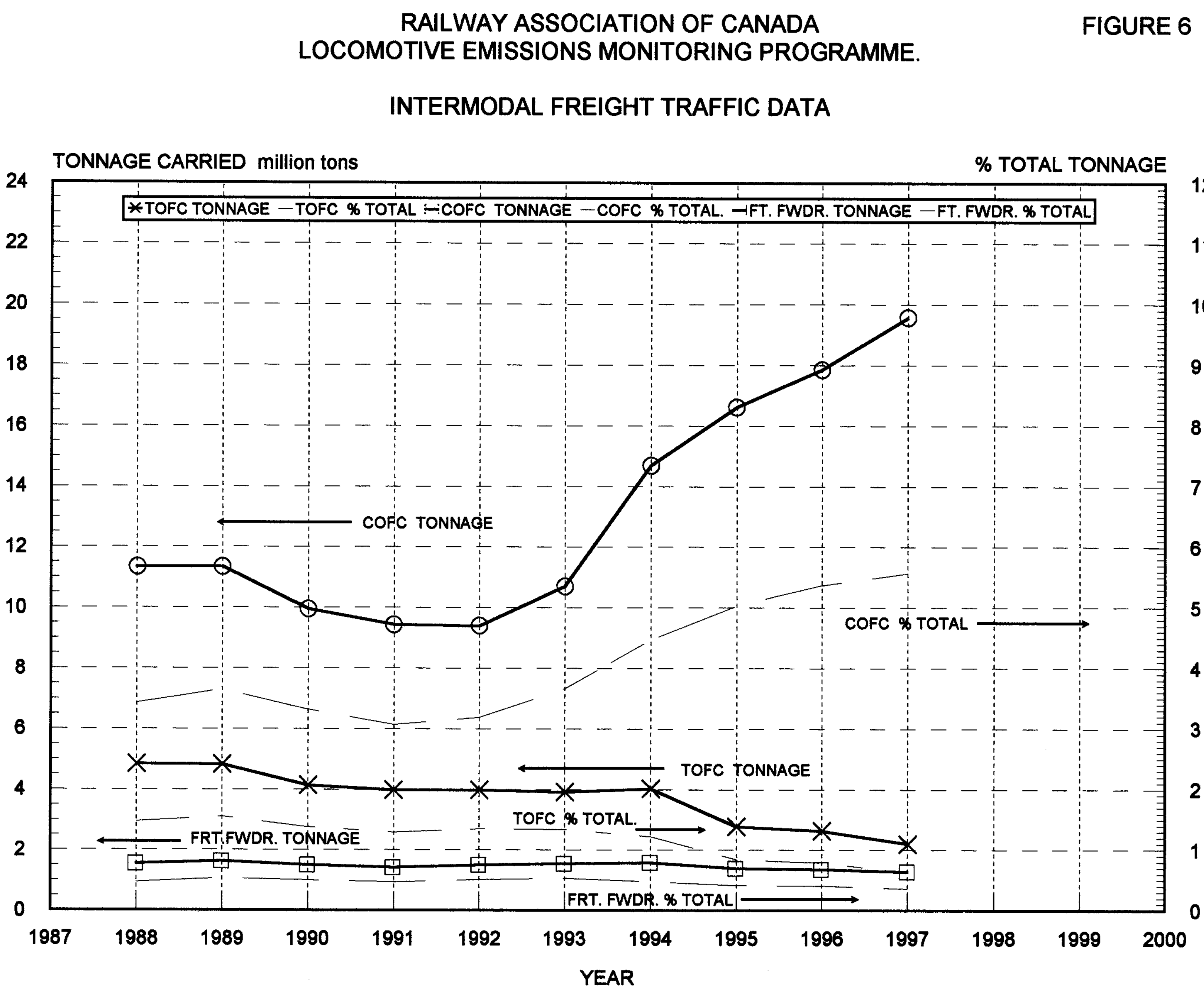
One area of traffic growth has been the movement of containers. Figure 6 shows the tonnage of intermodal traffic on Canadian railways from 1988 to 1997. (Data for 1998 are as yet unavailable from Statistics Canada.) The recent increase in container handling is clear, both in absolute terms and as a percentage of total tonnage moved.

This portion of the traffic increase is considered to be extremely sensitive to highway competition. If the increase in container freight were to be moved over the highway, the associated emissions of the contaminants under examination would be two to three times greater.

Traffic levels will continue to be followed to determine whether the recent accelerated increase in rail traffic is short term or represents a higher rate of growth. If the latter case prevails, consideration should be given to revising the measure for monitoring improvements. This concept was recognized in an Environment Canada report entitled *Recommended Reporting Requirements for the Locomotive Emissions Monitoring (LEM) Program*.[4] The revision would be based on the distribution of traffic between modes of transport. It would give credit for the net reduction in emissions resulting from diverting traffic from the highway to the railways, or from not adding traffic to the highway mode.

[4] Environment Canada, Environmental Protection Series, Report EPS 2/TS/8, September 1994, p. 21, Section 4.6.

Figure 6: Intermodal Freight Traffic Data



10.0 Summary

The railway industry in Canada continues its long-term trend of improved operating efficiency, including reduced fuel consumption and emissions. The railway mode should be viewed as an integral part of the solution to Canada's transportation needs. Such a solution should put a premium on modes with net benefits in environmental health, safety, land use and cost-effectiveness.

Appendix I:
Railway Lines Included in Tropospheric Ozone Management Areas

TOMA No. 1. Lower Fraser Valley, British Columbia

CP Rail System

Division	Subdivisions
Vancouver	Cascade
	Mission
	Page

Canadian National Railways

District	Subdivisions
Pacific	B.C. Harbour
	B.C. Hydro
	Rawlison
	Yale

Burlington Northern Railroad — All

Southern Railway of British Columbia Ltd. — All

TOMA No. 2. Windsor–Quebec City Corridor, Ontario and Quebec

CP Rail System

Divisions	Subdivisions	Remarks
Quebec	All except: Lacolle	
Toronto	All except:	
	Mactier	Medonte–Mactier
	Owen Sound	Shelburn–Owen Sound
Algoma	Chalk River	Smiths Falls–Arnprior

Canadian National Railways

Note: The ownership of some subdivisions was in the process of being transferred to other railway operators. Traffic, in gross ton-miles, on such lines was included in the CN total for the TOMA.

District Champlain

Subdivisions

Bécancour	Joliette	St. Hyacinthe
Bridge	Montfort	St. Laurent
Champlain	Montréal	St. Malo
Diamond	Mount Royal	St. Rémi
Drummondville	Rouses Point	Valleyfield
Freight Con.	Sorel	

District Great Lakes

Subdivisions

Alexandria	Halton	Stamford
Canal	Humberstone	Strathroy
Caso	Kingston	Talbot
Cayuga	Leamington	Thorold
Chatham	Marmora	Toronto Term.
Dundas	Meaford	Uxbridge
Fergus	Newton	Vankleek
Grimsby	Oakville	Walkley
Guelph	Paynes	Weston
Hagersville	Smiths Falls	York

Essex Terminal Railway — All

Goderich–Exeter Railway — All

CSX — All

TOMA No. 3. Saint John Area, New Brunswick

Canadian National Railways

District	Subdivision
Champlain	Denison
	Sussex

New Brunswick Southern

Division	Subdivision	Remarks
	McAdam	Saint John–Welsford