FINAL REPORT

Multi-pollutant Emission Reduction Analysis Foundation (MERAF) for the Hot-Mix Asphalt Sector

Prepared for:

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and
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The Hot-Mix Asphalt Sector TAN members are listed in Appendix A.

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While members of the Technical Advisory Network (TAN) participated in draft report reviews, the text of this report does not necessarily incorporate all comments suggested by the TAN members and therefore does not necessarily reflect the views of all TAN members.

Abstract

This report provides background technical information on the Canadian Hot-Mix Asphalt Sector. The contents include a profile of the industry, sector emissions (current and projected), domestic and international emission standards, best available pollution prevention and control techniques, possible emission reduction options and identification of areas for further analysis.

Summary

S.1 Introduction

Air pollution affects the health of all Canadians, especially children and the elderly. A major air pollution concern is 'smog'.

'Smog' refers to a noxious mixture of air pollutants that can often be seen as a haze in the air. The two main ingredients in smog that are known to affect human health are ground-level ozone and fine airborne particles. Other smog pollutants of concern are nitrogen oxides, sulphur dioxide and carbon monoxide.

Studies from the Toronto Public Health Department, Government of Canada and Ontario Medical Association all demonstrate the potential impacts of air pollution on health. Research studies worldwide, including from Health Canada, have demonstrated that air pollution can lead to premature death, increased hospital admissions, more emergency room visits and higher rates of absenteeism. Exposure to smog can lead to irritation of the eyes, nose and throat, it can worsen existing heart and lung problems, and in extreme cases it can result in an early death.

Environment Canada and the Canadian Council of Ministers of the Environment (CCME) are committed to addressing particulate matter and ground-level ozone.

In June 2000, CCME Ministers, with the exception of Quebec, endorsed Canada-wide Standards (CWS) for Particulate Matter (PM) and Ground-level Ozone. These standards set ambient limits for PM less than 2.5 microns ($PM_{2.5}$) and ozone to be obtained by the year 2010. The standards are as follows:

$PM_{2.5}$: 30 micrograms/m^3, 24 hour averaging time, by year 2010
(Achievement to be based on the 98th percentile ambient measurement annually, averaged over 3 consecutive years.)

Ozone: 65 parts per billion, 8 hour averaging time, by year 2010
(Achievement to be based on the 4th highest measurement annually, averaged over 3 consecutive years.)

When these CWS were endorsed, CCME Ministers also agreed to a list of Joint Initial Actions aimed at reducing pollutant emissions contributing to PM and ozone. The Joint Initial Actions include the development of comprehensive Multi-pollutant Emission Reduction Strategies (MERS) for key industrial sectors. The MERS approach is an effort to pursue integrated solutions to problems of smog, acid rain, toxic releases, and climate change.

A MERS is considered to be a national picture of sector emission reduction plans, to be built from jurisdictional PM and ozone plans and national multi-pollutant emissions reduction analysis. Jurisdictional implementation plans on PM and ozone, which will be prepared by individual jurisdictions, will outline emission reduction initiatives to achieve these CWS.

The MERS are developed in partnership with provinces, territories and stakeholders and will focus on three general activities:

- *National Multi-pollutant Emission Reduction Analysis Foundation (MERAF)*: Technical feasibility studies of emission reduction options and costs, and economic profiles, as input into development of sector actions in jurisdictional plans. Work contributing to the MERAF may be conducted by industry, other stakeholders, and the federal government.

- *Forum for Information Sharing & Coordination:* Jurisdictions and stakeholders to share information on how a particular sector is being dealt with in different parts of the country.

- *National Sector Roll-up*: The national picture of the sector is to be assembled by 2003 based on actions in jurisdictional plans and national multi-pollutant analysis.

The MERAF Report for the Hot-Mix Asphalt (HMA) Sector represents the first phase in the MERS process. It is intended as a source of information on technically feasible emission reduction options for the Hot-Mix Asphalt sector for consideration in the development of jurisdictional implementation plans under the CWS. The report draws upon readily available information. It is not intended as a policy document.

More specifically, the report provides:

- A profile of Canada's hot-mix asphalt industry;
- A multi-pollutant inventory of emissions from this industry;
- A review of emission standards, programs and policies in Canada and abroad;
- A set of available techniques (control technologies and management practices) to reduce emissions;
- An evaluation of the potential emission reductions associated with the available techniques;
- An analysis of data constraints; and
- An assessment of areas for possible further analysis.

S.2 Industry Profile

This report addresses the Canadian hot-mix asphalt (HMA) industry sector defined as producers of asphalt concrete for road paving. This report does not address the upstream refining of asphalt or the process known as "hot-in-place asphalt recycling". Asphalt concrete (or hot-mix asphalt) is manufactured by mixing asphalt cement with aggregates to produce hot-mix asphalt. There are approximately 520 plants located across Canada in rural and urban locations.

The majority of plants in Canada are owned and operated by privately-held Canadian corporations ranging in size from small, single plant owner-operators to large road building contractors and paving companies. An exception is Lafarge Corporation that owns and operates 90 plants. Other major producers include The Miller Group with 27 plants, K.J. Beamish Construction Co. Ltd. with 9 plants and Sintra with 13 plants.

The hot-mix asphalt industry in Canada is represented at the provincial level by regional road builder and heavy construction associations and at the national level by the Canadian Construction Association. The industry is also represented by hot-mix asphalt producer associations in Ontario, Quebec and British Columbia. Of these, the Ontario Hot-Mix Producers Association (OHMPA) is the most active. Bitume Québec is operated by volunteers from member firms in the Quebec industry. The B.C. Hot-Mix Producers Association is operated as an affiliated association of the BC Road Builders and Heavy Construction Association.

Economic data indicates that, in 2000, the hot-mix asphalt sector directly employed an estimated 5,000 people and produced about 32 million tonnes of asphalt concrete for road paving. The sector contributed $1.12 billion to the Canadian economy, or about 0.15% to the national Gross Domestic Product.

S.3 Emission Sources and Data

The air pollutants examined in this report included:

Criteria air contaminants (CAC):
- Particulate matter (Total, <10μm, and <2.5μm)
- Nitrogen oxides (NOx)
- Sulphur oxides (SOx)
- Carbon monoxide (CO)
- Volatile organic compounds (VOC);

Toxic substances:
- Polycyclic aromatic hydrocarbons (PAH)

Greenhouse gases:
- Carbon dioxide (CO_2)

National and regional emissions for the hot-mix asphalt sector were calculated for base year 2000 for the pollutants of interest. Emissions were determined from best estimates of HMA production and assumptions on the types of processes, fuels and control equipment, and whether plant road surfaces are paved or unpaved. The emission factors used were those published in AP-42 (2001) by the U.S. Environmental Protection Agency. These emission factors were developed from a database of over 300 tests at representative U.S. plants.

Table T.1 shows the main sources within an HMA facility and the associated pollutants of interest. Air pollutants from this sector are characterized by particulate matter (PM) as the pollutant of most concern. Fuel burning generates the typical products of combustion associated with fuel oil, natural gas and at some facilities, waste oil.

The regional distribution of emissions shown in Table T.2 were determined in this study and include both process and fuel combustion emissions.

Polycyclic aromatic hydrocarbons (PAH) were included in this study because these substances have been assessed as toxic pursuant to the *Canadian Environmental Protection Act*. Both heated asphalt cement and combustion of fuels may release trace quantities within HMA plants. Since PAH emissions are associated with the group of organic compounds referred to as VOC – pollutants for which emission limits are typically prescribed in regulatory instruments - minimizing VOC emissions also reduces PAH, odour and smog-forming pollutants.

CO_2 is of interest since new, more efficient fuel burners have the collateral benefit of reducing CO_2 emissions. CO_2, on the other hand, may also increase if existing, uncontrolled plants were retro-fitted with add-on pollution control systems that use incrementally more energy to operate.

Table T.1: Sources and Types of Air Pollutants

Source	Pollutant
Batch Mix - Dryer and Mixing Tower	PM, PM_{10}, $PM_{2.5}$, CO, SO_2, NO_X, CO_2, VOCs, PAHs
Drum Mix – Drum Mixer	PM, PM_{10}, $PM_{2.5}$, CO, SO_2, NO_X, CO_2, VOCs, PAHs
Asphalt Storage Tanks	VOCs, CO, PAHs
Silo Filling and Truck Load-Out	$PM_{2.5}$, CO, VOCs, PAHs
Aggregate Handling	PM, PM_{10}, $PM_{2.5}$
Road Dust	PM, PM_{10}, $PM_{2.5}$

Table T.2: Hot-Mix Asphalt Sector Emissions for Year 2000 (tonnes)

Province	PM	PM_{10}	$PM_{2.5}$	SO_2	NO_X	VOC	CO	PAH	CO_2
Newfoundland	130	60	10	9	18	7	53	0.2	7,700
Nova Scotia	290	120	20	24	42	14	130	0.3	16,800
New Brunswick	490	210	30	43	73	23	230	0.5	28,400
PEI	70	30	5	5	9	3	27	0.1	3,500
Quebec	1,800	790	150	110	210	86	1,000	1.3	120,000
Ontario	3,200	1,420	270	160	320	140	2,000	1.9	216,000
Manitoba	5,570	1,130	183	10	24	14	132	0.2	17,320
Saskatchewan	280	120	20	12	27	16	140	0.2	18,700
Alberta	1,100	480	90	50	100	53	630	1.0	73,200
British Columbia	1,000	450	80	63	120	49	590	1.0	68,400
Yukon & NWT(1)	0	0	0	0	0	0	0	0	0
Canada	14,000	4810	868	487	938	404	4,970	6.5	569,980

(1) Information on plants was not available

Table T.3 shows the emissions from the HMA sector in context of the emissions from all industrial sectors. The HMA sector emissions for year 2000 were determined in this study. They are compared to the total industrial sector emissions for year 1995, as published in Environment Canada's *1995 Criteria Air Contaminant Emissions for Canada* except for CO_2. The CO_2 emissions for the industrial sector are for year 1997 as published in *Canada's Greenhouse Gas Inventory -1997 Emissions and Removals with Trends*.

It is apparent that the contribution from the HMA sector is relatively small, accounting for about 2.2%, 1.6% and 0.5% respectively of total filterable PM, PM_{10} and $PM_{2.5}$. Most of the PM within a facility originates as airborne road dust generated from on-site vehicle traffic providing the process operations are controlled.

The contribution of the other pollutants to national emissions is negligible from this sector.

Table T.3: Contribution of Emissions from the Hot-Mix Asphalt Sector to all Industry Sectors - HMA Annual Production 32 million tonnes/year)

Pollutant	Total Industrial Emissions(1) (ktonnes/y)	Hot-Mix Asphalt Emissions(2) (ktonnes/y)	Hot-Mix Asphalt Contribution to Industrial Emissions (%)
PM	621	14.0	2.2
PM_{10}	287	4.8	1.6
$PM_{2.5}$	172	0.9	0.5
SO_x	1,950	0.5	<0.1
NO_X	620	0.9	0.1
VOC	940	0.4	<0.1
CO	2,177	5.0	0.2
CO_2(3)	123,000	570	1.5

Notes:

1. Except for CO_2, emissions are from Environment Canada's Criteria Air Contaminants Inventory for 1995 (Residual Discharge Information System, 1999) which reflect "process" emissions.
2. Emissions are for year 2000 as determined in this study for the HMA Sector and include both process and fuel combustion emissions.
3. Emissions are for year 1997 from Canada's Greenhouse Gas Inventory and include both "process" and "fuel combustion" emissions. Note that industry sectors in the Greenhouse Gas Inventory are not the same as those in the Criteria Air Contaminants Inventory.

S.4 Current Emission Management Practices

A review was conducted of regulations, guidelines and operating permits of Canadian jurisdictions. The review also included requirements of U.S. federal and selected state and local air management authorities and of selected countries. In Canada, requirements have been established by most jurisdictions but vary with respect to the maximum allowable emissions and requirements pertaining to the operation and maintenance of control equipment, fugitive dust control, record-keeping, emission testing, and reporting.

Information from international standards and discussions with asphalt plant operators and control technology manufacturers were also relevant to identifying best available control technologies and fugitive dust control practices.

The Ontario Hot-Mix Producers Association, in addition to the Ontario government's regulatory programs, encourages continuous environmental improvement by promoting the adoption of operating practices set out in the environmental practices guide developed by the Association.

The identified best available techniques (BAT) may be helpful to jurisdictions when considering provincial, territorial or regional air management planning priorities. Small plants operating in small markets in remote areas, sometimes for limited durations, may not require the stringency of control that might be needed for plants in urban areas where air quality levels periodically exceed the ambient air quality objectives of the Canada-wide Standards. In other cases, stringent controls may be appropriate in non-urban areas where plants may impact parks and wilderness and where pristine air quality is to be protected. In addition, jurisdictions typically require better emission performance for new plants than for existing plants. The applicability of the BATs depends highly on these and other factors, and therefore should be considered in light of their practicality.

The possible environmental and human health benefits by further reducing source emissions and the consequent improvement in ambient air quality in the vicinity of plants have not been considered. This type of analysis was beyond the scope of this study.

Recognizing the need for flexibility, Table T.4 summarizes the range of available techniques for pollution prevention and control for each stage in the HMA production process. The comments in the table provide contextual information on the control options. The measures identified herein to minimize emissions of pollutants and odour are comparable to the *Environmental Practices Guide* of the Ontario Hot-Mix Producers Association.

Table T.4: Best Available Techniques

Pollutant / Source	Control Option	Control Target	Basis of Target
Particulate Matter/ Captured and Controlled Sources			
Stationary Batch Dryers & Drum Mixers	Fabric Filter	Outlet loading of 20 mg/Rm^3	Requirement of Bay Area Air Quality Management District (Bay Area AQMD); Germany; Sweden
	or Wet Scrubber as an alternative to fabric filters for rural plants	Outlet loading 90 mg/Rm^3	OHMPA *Environmental Practices Guide* identifies fabric filter or wet scrubber technologies but with no recommended emission concentration.
		Opacity 20% Annual testing	B.C.'s regulation specifies opacity rather than a maximum allowable PM concentration
Mobile Batch Dryers & Drum Mixers	Fabric Filter	Outlet loading of 20 mg/Rm^3	Requirement of Bay Area Air Quality Management District; Germany; Sweden OHMPA *Environmental Practices Guide* identifies fabric filter or wet scrubber efficiencies although no emission concentration is specified.
	or Wet Scrubber	Opacity 20% Annual testing Outlet loading 90 mg/Rm^3	B.C.'s regulation specifies opacity rather than a maximum allowable PM concentration
Mixing Tower & screens	Capture and duct to Fabric Filter	Outlet loading of 20 mg/Rm^3	Requirement of Bay Area Air Quality Management District; Germany; Sweden
		Opacity 20% Annual testing	B.C.'s regulation specifies opacity rather than a maximum allowable PM concentration
	or Wet Scrubber	Outlet loading 90 mg/Rm^3	OHMPA *Environmental Practices Guide* identifies fabric filter or wet scrubber technologies.

Note: Rm^3 is reference cubic metre

Table T.4: Best Available Techniques (Continued)

Pollutant / Source	Control Option	Control Target	Basis of Target
Particulate Matter/Fugitive Sources			
Aggregate Storage Piles	Moisture control **or**	Apply water to at least 80% of the surface area of all open storage piles on a daily basis or when there is evidence of wind driven dust	Requirement of Quebec, South Coast Air Quality Management District (South Coast AQMD), Bay Area Air Quality Management District (Bay Area AQMD)
	Temporary covering **or**		Requirement of South Coast Air Quality Management District
	Chemical stabilizer **or**		South Coast AQMD, Bay Area AQMD
	3-sided enclosures	3-sided enclosures with walls with no more than 50% porosity which extend, at a minimum, to the top of the pile	Requirement of South Coast Air Quality Management District, Germany
Conveyors & Transfer points	Water sprays or mists		Requirement of Quebec, South Coast AQMD
Unpaved Roads	Control vehicle speed **and**	< 15 kph	Requirement of South Coast AQMD
	Water spray w/ chemical suppressants	Water all roads for any vehicular traffic once daily or more frequently if dusting occurs.	Requirement of New Brunswick, Quebec, South Coast AQMD, Bay Area AQMD
Paved Roads	Control vehicle speed **and** Wet down or vacuum sweep	< 15 kph Water flush and vacuum sweep all roads for any vehicular traffic once daily or as required if dusting occurs	Requirement of New Brunswick, Quebec, South Coast AQMD, Bay Area AQMD

Table T.4: Best Available Techniques (Continued)

Pollutant / Source	Control Option	Control Target	Basis of Target
Odour			
Drums/Dryers	Temperature control for burner and dryer/drum operation. Annual burner calibration by a competent individual to verify operation.	Minimize odour complaints through an Odour Abatement Program	Ontario permitting requirement for critical receptors OHMPA *Environmental Practices Guide* identifies odour control techniques for sources within a plant.
Load-Out	Truck equipped with tarpaulin **and** clean up spillage **or** Enclose truck load- out and duct to dryer/drum mixer	Minimize odour complaints through an Odour Abatement Program	Ontario permitting requirement for critical receptors
Storage Silos	Enclose silo openings **or** Vent storage silos to dryer/drum mixer	Minimize odour complaints through an Odour Abatement Program	Ontario permitting requirement for critical receptors.
Asphalt Cement Tank	Tank vent filters (condensers)	Minimize odour complaints through an Odour Abatement Program	Ontario permitting requirement for critical receptors

Table T.4: Best Available Techniques (Continued)

Pollutant / Source	Control Option	Control Target	Basis of Target
Combustion Gases			
Carbon Monoxide	Good Combustion Practices for burner and dryer/drum mixer operation. Annual burner calibration by a competent individual to verify operation.	Exhaust gas limits: Batch - 265 ppmv @ 15% O_2 Dry Drum - 133 ppmv @ 15% O_2 Dry Annual calibration	Requirement of Bay Area AQMD, B.C. New Plants OHMPA *Environmental Practices Guide* identifies operating checks to minimize emissions and conserve fuel. Emission testing required by B.C.
Nitrogen Dioxide	Natural Gas & Low NO_X Combustion System for burner and dryer / drum mixer operation Annual burner calibration by a competent individual to verify operation	Exhaust Gas limits: Batch - 12 ppmv @15% O_2 Dry Drum - 12 ppmv @ 15% O_2 Dry Annual calibration	Requirement of Bay Area AQMD
Sulphur Dioxide	Natural Gas or Low Sulphur Fuel for burner and dryer / drum mixer operation. Annual burner calibration by a competent individual to verify operation.	Natural Gas or Fuel Oil <0.5% S by wt Annual calibration	Requirement of Bay Area AQMD
Volatile Organics	Temperature Control for burner and dryer / drum mixer operation. Annual burner calibration by a competent individual to verify operation	Exhaust Gas Limits: 60 mg/m^3 @16% O2 Dry **or** 100 ppmv @ exhaust conditions Annual calibration	Requirements of B.C., Bay Area AQMD Testing of total organics required by B.C.

Notes: (1) The threshold of predicted odour detection, which is based on odour measurements and dispersion modeling, is considered to be in the range of 2 to 5 odour units (ou), taking into account the accuracy of the odour measurement and atmospheric dispersion modeling.

S.5 Emission Reduction Opportunities

In order assess the long term trend in emissions from year 2000 to 2020, industry representatives were asked their opinions about the growth of Canadian HMA production that resulted in two scenarios being considered. An annual increase of 2% in production would represent an optimistic scenario while nominal, or no growth of HMA production in the foreseeable future, is generally expected because annual production has not varied significantly over the past decade.

Scenario 1: In this scenario, it was assumed that current emission controls and practices remain unchanged over the 20-year time horizon. Emissions under this business as usual scenario would increase in direct correspondence with the 2% annual growth in HMA production. As shown in Figure F.1, the PM emissions would increase about 45% from the emissions in year 2000.

Scenario 2: This scenario assumes that there would be no growth in HMA production to 2010 and best available control technologies would be uniformly applied to the dryer and drum mixer processes and fuel burners, while for fugitive sources, management practices would be implemented to minimize dust generation. As shown in Figure F.2, Total PM emissions would decrease up to 81% relative to the emissions in year 2000.

Figure F.1: HMA Emissions Projection to 2020 based on 2% Annual Growth in Production without Best Available Techniques Applied

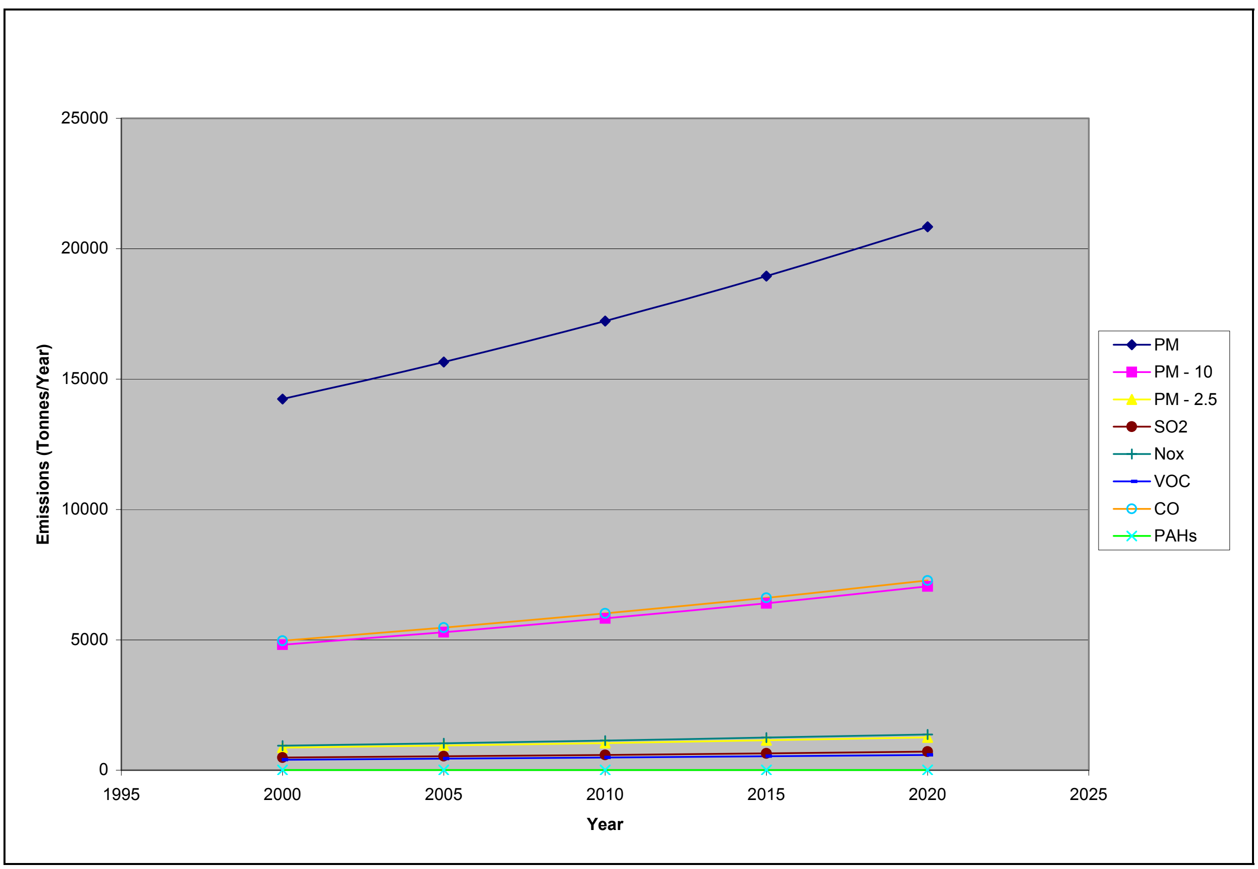
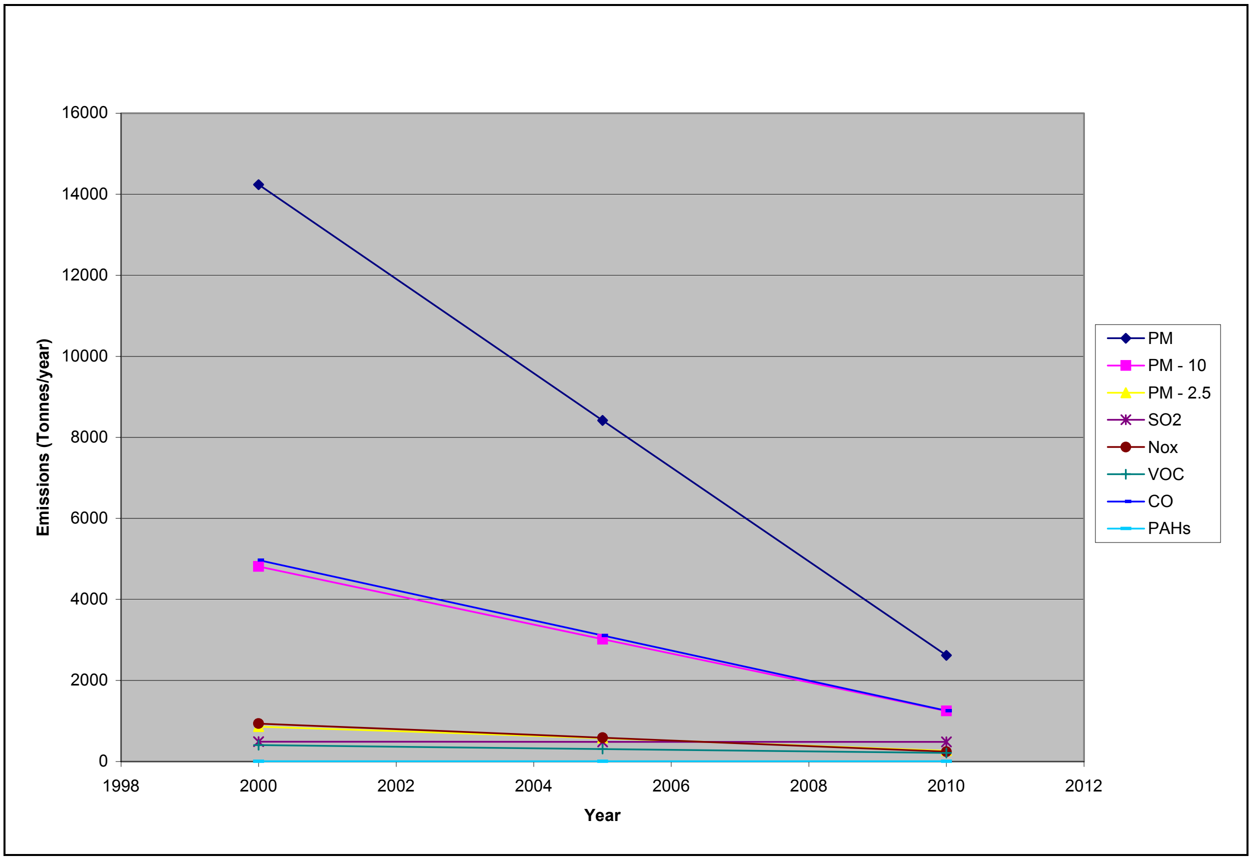


Figure F.2: HMA Emissions Projection 2000-2010 based on No Growth in Production and Best Available Techniques Applied



The impacts on operating costs, energy utilization, and possible affects on product prices could not be determined within the scope of this study. Industry was consulted to obtain data on costs of their environmental control programs. However, the responses from companies to a limited questionnaire survey were insufficient to estimate costs of retro-fitting existing facilities with new, add-on control technologies or to determine operating costs of emission control systems or costs of fugitive dust management practices. These data deficiencies are noted and form the basis for the recommendations presented in the ensuing section.

Capital costs for new fabric filters and fuel burners are documented in the main body of this report.

S.6 Conclusions and Recommendations

S.6.1 Conclusions

The principle findings of this study can be summarized as follows:

1. Particulate matter is the pollutant of most concern from hot-mix asphalt facilities. The contribution of PM from this sector is small in comparison with national emissions.
2. The hot-mix asphalt sector contributes an estimated 2.2%, 1.6%, and 0.5% respectively to the total quantities of PM, PM_{10} and $PM_{2.5}$ emitted from all industrial sources in Canada.
3. Airborne road dust is the principle source of PM within a facility, providing the emissions from the main process sources are captured and controlled.
4. The hot-mix asphalt industry in Canada is characterized by a wide range of ownership ranging from single plant owner-operators to one international-based, integrated company.
5. Most jurisdictions in Canada have established emission requirements in legislation, regulations, or operating permits that apply either general or specific terms to hot-mix asphalt plant operations. Emission requirements for this sector vary widely across jurisdictions in Canada.
6. Best available control technology and dust management practices have been identified. When sector-wide PM emissions are estimated by the application of uniformly applied best available techniques, a reduction up to about 81% relative to the emissions in year 2000 would appear possible.

S.6.2 Recommendations

Emissions Data

Some information and data deficiencies became apparent during the course of this study. In the absence of more detailed information, broad assumptions were made about the type of plants, type of fuel, control equipment, and paved and unpaved road surfaces at sites.

While best available emission information was used for this study, it was realized that there are opportunities to improve some data. Source testing of a large number of facilities helped EPA develop the emission factors for the main criteria air contaminants. The tested facilities mainly used fabric filter control systems. A generally high confidence level is associated with the emission factors for these pollutants.

A large number of plants in Canada, however, use venturi or wet scrubbers for which EPA emission factors are lacking, even for the criteria air contaminants. Source testing of Canadian plants would improve this data gap. In addition, a Canadian test program for PM_{10} and $PM_{2.5}$ and PAH would establish emission factors that are not available in the EPA data.

The areas of data uncertainties could be addressed through further research as follows:

1. Develop improved data on source emissions and emission factors for the criteria air contaminants associated with plants equipped with wet scrubbing control systems.
2. Develop data on total PM, PM_{10} and $PM_{2.5}$ and PAH source emissions and emission factors for plants equipped with fabric filter and wet scrubbing control systems.

Emission Controls and Management Practices

Although a limited questionnaire survey gathered some information on emission control techniques and management practices at Canadian hot-mix asphalt plants, the responses were insufficient to define current practices and to profile the more than 500 facilities in the HMA sector more accurately than presented in this report.

A more comprehensive understanding of current practices could improve the precision of the emission estimates and reduce the uncertainty in any future analysis of the expected benefits and costs of emissions management strategies that jurisdictions may wish to pursue, should such analysis be desired in future.

A representative and statistically significant number of hot-mix asphalt facilities across Canada could be surveyed to identify:

1. Current emission control and management practices,
2. Fuel types and quantities,
3. Specific plans to enhance emission control and management practices,
4. Operating costs associated with emission controls and management practices, and
5. Costs for retro-fitting existing plants with new emission controls and fuel burners.

The preceding information would enable a more accurate profile to be developed that would establish a baseline against which future changes could be measured and improve the analysis of sector-wide cost impacts if best available techniques were applied. The analysis would generate cost-effectiveness information that would be useful for comparing the cost per tonne of pollutant reductions in the hot-mix asphalt sector to the control costs for the same pollutants in other industry sectors. The impact of control technologies and practices on product costs and profitability would be other important elements in such analyses.

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1 Introduction

1.1 Background

Air pollution affects the health of all Canadians, especially children and the elderly. A major air pollution concern is 'smog'.

'Smog' refers to a noxious mixture of air pollutants that can often be seen as a haze in the air[1]. The two main ingredients in smog that are known to affect human health are ground-level ozone and fine airborne particles. Other smog pollutants of concern are nitrogen oxides, sulphur dioxide and carbon monoxide.

The source of these pollutants include fossil fuel burning, industrial and vehicle emissions, road dust, agriculture, construction, and wood burning, among others[2].

Studies from the Toronto Public Health Department, Government of Canada and Ontario Medical Association all demonstrate the potential impacts of air pollution on health[3]. Research studies worldwide, including from Health Canada, have demonstrated that air pollution can lead to premature death, increased hospital admissions, more emergency room visits and higher rates of absenteeism[4]. Exposure to smog can lead to irritation of the eyes, nose and throat, it can worsen existing heart and lung problems, and in extreme cases it can result in an early death[5].

Environment Canada and the Canadian Council of Ministers of the Environment (CCME) are committed to addressing particulate matter and ground-level ozone. The implementation of the Canada-US Air Quality Agreement Ozone Annex and Canada-wide Standards for Particulate Matter and Ozone, among other initiatives, will contribute toward reducing ambient levels of particulate matter and ground-level ozone.

1.1.1 Particulate Matter and Ground-level Ozone

The primary drivers for reducing ambient levels of particulate matter and ground-level ozone are the effects these pollutants have on human health and the environment.

Particulate (PM) matter refers to microscopic solid and liquid particles that remain suspended in the air for some time. Particles give smog its colour and affect visibility. Ground-level ozone is a colourless gas that forms just above the earth's surface.

[1] Environment Canada. *What is Smog?*. Last updated 2001/08/01. URL: http://www.ec.gc.ca/air/smog_e.shtml
[2] Health Canada. *It's Your Health - Smog*. Last updated 2001/11/30. URL: http://www.hc-sc.gc.ca/english/iyh/smog.htm
[3] Environment Canada. *Health (Air Pollution)*. Last updated 2001/08/01. URL: http://www.ec.gc.ca/air/health_e.shtml
[4] Health Canada. *Air Health Effects*. URL: http://ww.hc-sc.gc.ca/air
[5] Health Canada. *It's Your Health - Smog*. Last updated 2001/11/30. URL: http://www.hc-sc.gc.ca/english/iyh/smog.htm

Ground-level ozone is considered a secondary pollutant because it is produced through chemical reactions of two primary precursor pollutants: nitrogen oxides (NO_X) and volatile organic compounds (VOCs). Particulate matter can be both primary pollutants and secondary pollutants. Primary particles are emitted directly into the atmosphere (e.g., windblown dust and soil, pollen, automobile and industrial exhausts or emissions). Secondary particles are formed through chemical reactions involving the precursors NO_X, VOCs, sulphur oxides (SO_X), and ammonia (NH_3)[6].

$PM_{2.5}$ (the fine fraction of PM) is mainly a secondary pollutant. PM is a problem throughout all seasons and in all regions of Canada, while ozone can be characterized as a summer regional problem. These pollutants and their precursors (such as NO_X, VOCs, SO_X) can be transported long distances by air currents. Therefore, the air quality at a given site results from a mixture of local, regional, and/or distant sources[7].

Extensive scientific studies have shown significant health and environmental effects associated with these pollutants. Particulate matter and ozone are linked to serious health impacts including chronic bronchitis, asthma, and premature deaths. $PM_{2.5}$ has been recognized to have the potential for the greatest health impact on a larger segment of the general population[8].

The 1998 Science Assessment Document on National Ambient Air Quality Objectives for Particulate Matter (PM) reports that exposure to particulate matter is strongly linked to daily mortality, increased hospitalizations, and cardiovascular and respiratory diseases. It also reports that $PM_{2.5}$ is linked to an increase in respiratory hospitalizations and visits to emergency rooms. Fine particles (i.e., $PM_{2.5}$) are shown to have a stronger and more significant association with mortality than coarse particles, as either the coarse fraction of PM_{10} (i.e. $PM_{10-2.5}$), PM_{10} and/or total suspended particulate (TSP). Sulphate, considered a strong surrogate for fine particles from combustion sources, appears to have as strong or stronger association than $PM_{2.5}$ with increased mortality and hospitalizations[9].

The 1999 Science Assessment Document on National Ambient Air Quality Objectives for Ground-Level Ozone reports that exposure to ground-level ozone is strongly linked to mortality, respiratory hospitalizations and visits to emergency departments. The controlled human exposure studies reviewed, identified a dose-response relationship between ozone and lung function changes, symptoms and inflammation. Other studies identified that patients with pre-existing lung diseases (e.g., asthma, chronic obstructive pulmonary diseases (COPD), etc.) are more susceptible to ozone-induced health

[6] Canadian Council of Ministers of the Environment. *Backgrounder - Particulate Matter and Ozone Canada-wide Standards*. June 2000. URL: http://www.ccme.ca/pdfs/backgrounders_060600/PM_Ozone_Backgrounder_E.pdf
[7] Ibid.
[8] Ibid.
[9] CEPA/FPAC Working Group on Air Quality Objectives. *National Ambient Air Quality Objectives for Particulate Matter - Executive Summary. Part 1: Science Assessment Document*. Minister of Public Works and Government Services. Cat. No. H46-2/98-220. 1998.

effects than healthy people. Emerging evidence suggests that long term exposure to ambient ozone could be of public health and economic concern[10].

Environment Canada's Green Lane provides a synopsis of the health effects of PM and ozone as follows:

> "Airborne particles that are small enough to be inhaled can also have a significant effect on health. Those sensitive to ozone are also sensitive to airborne particles – people who already suffer from heart or lung disease, children and the elderly. Of greatest health concern are very fine particles that can penetrate deeply into the lungs and interfere with the functioning of the respiratory system. These fine particles have been linked to increases in asthma symptoms, hospital admissions and even premature mortality.
>
> Ground-level ozone affects the body's respiratory system and causes inflammation of the airways that can persist for up to 18 hours after exposure ceases. It can cause coughing, wheezing and chest tightness. It can also aggravate existing heart and lung conditions. There is evidence that exposure heightens the sensitivity of asthmatics to allergens[11].

Other effects of these pollutants include reduced visibility in the case of PM, and crop damage and greater vulnerability to disease in some tree species in the case of ozone[12].

More information on the health effects of air pollution is available at Health Canada's website: www.hc-sc.gc.ca

1.2 Canada-wide Standards for Particulate Matter and Ground-level Ozone

In June 2000, CCME Ministers, with the exception of Québec, endorsed Canada-wide Standards (CWS) for Particulate Matter (PM) and Ground-level Ozone[13]. These standards set ambient limits for PM less than 2.5 microns ($PM_{2.5}$) and ozone to be obtained by the year 2010. The standards are as follows:

$PM_{2.5}$: 30 micrograms/m^3, 24 hour averaging time, by year 2010

[10] Federal-Provincial Working Group on Air Quality Objectives and Guidelines. *National Ambient Air Quality Objectives for Ground-Level Ozone - Summary Science Assessment Document*. Cat. No. En42-17/7-2-1999. July 1999.
[11] Environment Canada. *Smog and Your Health*. Last updated 2001/08/01. URL: http://www.ec.gc.ca/air/health_e.shtml
[12] Canadian Council of Ministers of the Environment. *Backgrounder - Particulate Matter and Ozone Canada-wide Standards*. June 2000. URL: http://www.ccme.ca/pdfs/backgrounders_060600/PM_Ozone_Backgrounder_E.pdf
[13] Canadian Council of Ministers of the Environment (CCME). *Canada-wide Standards for Particulate Matter (PM) and Ozone*. June 5-6, 2000. Quebec City. URL: http://www.ccme.ca/pdfs/backgrounders_060600/PMOzone_Standard_E.pdf

(Achievement to be based on the 98th percentile ambient measurement annually, averaged over 3 consecutive years.)

Ozone: 65 parts per billion, 8 hour averaging time, by year 2010. (Achievement to be based on the 4th highest measurement annually, averaged over 3 consecutive years.)

PM and ground-level ozone are two of the six substances selected as priorities for development of CWS. Other substances being addressed through the CWS process include benzene, mercury, dioxins and furans, and petroleum hydrocarbons in soil.

1.2.1 Multi-pollutant Emission Reduction Strategies (MERS)

At the time of endorsing the CWS for PM and Ozone, CCME Ministers also agreed to a list of Joint Initial Actions aimed at reducing pollutant emissions contributing to PM and ozone[14]. The Joint Initial Actions include the development of comprehensive Multi-pollutant Emission Reduction Strategies (MERS) for key industrial sectors. The MERS approach is an effort to pursue integrated solutions to problems of smog, acid rain, toxic releases, and climate change.

The sectors identified for the development of a MERS include the electric power generation, base metals smelting, iron and steel, pulp and paper, lumber and allied wood products, concrete ready-mix, and asphalt hot-mix sectors. The selection of these sectors was based on several factors including the following:

- These sectors are significant sources of direct emissions of PM and of the precursor pollutants that form PM and ozone, as based on best available information;
- These sectors are common to most jurisdictions and affect many communities across Canada;
- Effective action requires a multi-jurisdictional approach; and
- Effective action can be initiated in the near-term.

A MERS is considered to be a national picture of sectoral emission reduction plans, to be built from jurisdictional PM and ozone plans and national multi-pollutant emissions reduction analysis. Jurisdictional implementation plans on PM and Ozone will be prepared by individual jurisdictions, will outline actions to achieve the Canada-wide Standards (CWS) for PM and Ozone by 2010 and will set out emission reduction initiatives.

The development of MERS will be done in partnership with provinces, territories and stakeholders and will focus on three general activities:

[14] Canadian Council of Ministers of the Environment. *Joint Initial Actions to Reduce Pollutant Emissions That Contribute to Particulate Matter and Ground-level Ozone*. June 6, 2000. URL: http://www.ccme.ca/pdfs/backgrounders_060600/PMOzone_Joint_Actions_E.pdf

- *National Multi-pollutant Emission Reduction Analysis Foundation (MERAF)*: Technical feasibility studies of emission reduction options and costs, and economic profiles, as input into development of sectoral actions in jurisdictional plans. Work contributing to the MERAF may be conducted by industry, other stakeholders, and the federal government.
- *Forum for Information Sharing & Coordination:* Jurisdictions and stakeholders to share information on how a particular sector is being dealt with in different parts of the country.
- *National Sector Roll-up*: The national picture of the sector is to be assembled by 2003 based on actions in jurisdictional plans and national multi-pollutant analysis.

At the time of writing, the development of a MERS for the electric power generation is underway. For the remaining non-energy, industrial sectors, a common approach for the first phase of MERS development has been undertaken, as described in the following section.

1.3 Multi-pollutant Emission Reduction Analysis Foundations (MERAFs) for the Industrial MERS Sectors

A common approach for Phase 1 of MERS development for the non-energy, industrial sectors was accepted in October 2001 by the Joint Actions Implementation Coordinating Committee (JAICC) of the CWS for PM and Ozone. The affected industrial sectors include base metals smelting, iron and steel, pulp and paper, lumber and allied wood products, concrete ready-mix, and asphalt hot-mix. The outlined approach calls for the development of Multi-pollutant Emission Reduction Analysis Foundation (MERAF) Reports for each of the identified sectors.

What follows is a MERAF Report for the Hot-Mix Asphalt sector. This MERAF report is intended as a source of information on technically feasible emission reduction options for the Hot-Mix Asphalt sector for consideration in the development of jurisdictional implementation plans under the CWS for PM and Ozone. The report draws upon readily available information. It is not intended as a policy document.

To formulate a “National Multi-pollutant Emission Reduction Analysis Foundation”, this report:

- Provides a profile of the sector;
- Examines the processes employed by facilities included in the sector and sources of emissions;
- Determines the types and quantities of emissions by process, as well as on a facility basis, and provincial/territorial basis;
- Reviews current national and international standards and best available pollution prevention and control techniques as applicable to the sector and the emissions being examined;

- Examines and quantify emission reductions through the application of best available techniques and best environmental management practices and associated constraints, by process, facility (where practicable) and jurisdiction;
- Identifies gaps in information and uncertainties where they exist; and
- Provides recommendations on achievable emission reduction options for the sector on a national and jurisdictional basis.

1.3.1 Scope of Pollutants

The analysis in this report is intended to examine pollutants which contribute to the problems of smog, acid rain, toxic releases and climate change. As such, the scope of pollutants addressed will cover those that contribute to particulate matter and ozone, as well as toxics released to air and greenhouse gases.

For the purposes of this report, toxic substances those substances scheduled as toxic under the *Canadian Environmental Protection Act*'s (CEPA)[15] List of Toxic Substances (Schedule 1) that are associated with air releases from the Hot-Mix Asphalt sector. These substances have been assessed by the federal Ministers of the Environment and of Health to be toxic as they are entering or may enter the environment in a quantity or concentration or under conditions that;

(a) have or may have an immediate or long-term harmful effect on the environment or its biological diversity;
(b) constitute or may constitute a danger to the environment on which life depends; or
(c) constitute or may constitute a danger in Canada to human life or health.

The air pollutants examined in this report included:

Criteria air contaminants (CAC):
- Particulate matter (Total, <10μm, and <2.5μm)
- Nitrogen oxides (NOx)
- Sulphur oxides (SOx)
- Carbon monoxide (CO)
- Volatile organic compounds (VOC);

Toxic substances:
- Polycyclic aromatic hydrocarbons (PAH)

Greenhouse gases:
- Carbon dioxide (CO_2)

[15] Government of Canada. *Canadian Environmental Protection Act, 1999*. Canada Gazette Part III. Vol.22, No.3. Ottawa, Thursday, November 4, 1999. URL: http://www.ec.gc.ca/CEPARegistry/the_act/

1.4 Methodology

The MERAF report was prepared largely from publicaly available information from a variety of sources, in-house knowledge and information solicited from personal communications. The purpose of the report, as listed in Section 1.3, generally determined the project tasks and contents of this MERAF.

Input into the development of the MERAF report was provided by the Hot-Mix Asphalt Technical Advisory Network (TAN). The TAN was a selected group of stakeholders who provided technical expertise and advice. It's members represent industry, public interest groups, and federal and provincial governments. A list of the Hot-Mix Asphalt TAN members is provided in Appendix A.

A scoping study[16] prepared for the CCME on the Hot-Mix Asphalt (HMA) sector was used as a starting point for information and knowledge on the industry, associated emissions, and control management practices. Other published reports and information were obtained from personal communications with members of the TAN and other industry, government, and equipment supplier contacts. Industry representatives in the Atlantic Provinces, Ontario, Alberta and British Columbia were contacted by telephone to aid in the development of province-specific information for the sector.

In order to gather further information not publicly available, three documents were developed and shared with selected individuals for review, comment and data gathering:

- a questionnaire of technical and cost information
- a draft outline of best available control techniques, and
- an inventory of typical HMA plant emissions.

Provincial and territorial emissions from the sector were developed from process descriptions, applicable emission factors and technical and production information of the Canadian industry sector.

Although completion of the questionnaire was requested of a number of industry representatives, the response was not sufficient to develop a comprehensive and representative profile of the HMA sector with respect to environmental control technologies and practices, emissions and capital and operating costs. Consequently, to estimate the emissions from this sector, broad assumptions about emission controls and practices based on general knowledge of this industry were necessary.

2. Industry Profile

2.1 Sector Definition

This study addresses the processes whereby asphalt cement is mixed with aggregate to produce hot-mix asphalt (HMA). The process starts with the receipt of the asphalt cement and the raw aggregate at the facility. The process, therefore, does not include the upstream refining of asphalt cement. The process covered by this study concludes with the transfer of HMA into transport trucks and the movement of these trucks to the HMA plant boundary. The study does not address the transport of the HMA to the road site. The study also does not address other asphalt paving processes referred to as 'hot-in-place asphalt recycling', 'cold in-place recycling', or expanded (foamed) asphalt paving'..

2.2 Industry Associations

2.2.1 Canada

The hot-mix asphalt industry in Canada is currently represented by only a few associations. The Ontario Hot-Mix Producers Association (OHMPA; www.ohmpa.org), located in Mississauga, Ontario, is the most active, and is presently the only hot-mix asphalt industry association in Canada that operates on a full-time, fully-staffed basis. Formed in 1974, the Ontario Hot-Mix Producers Association currently has approximately 47 member companies operating about 145 hot-mix asphalt plants across Ontario. Through an agreement with The Asphalt Institute, a U.S.-based international asphalt industry association, OHMPA's Technical Director is also a part-time Canadian representative of The Asphalt Institute (AI) and through OHMPA provides technical support to the asphalt industry across Canada. Bitume Quebec, representing the Quebec hot-mix asphalt producers, does not maintain its own offices and is operated by volunteers from member firms in the Quebec hot-mix asphalt industry. Similarly, the British Columbia Hot-Mix Producers Association is operated as an affiliated association of the BC Road Builders and Heavy Construction Association. In other provinces, the hot-mix asphalt producers and paving industry is largely represented by the provincial roadbuilder and heavy construction associations. For example, hot-mix asphalt producers in Newfoundland are represented as members of the Newfoundland and Labrador Road Builders/Heavy Civil Association. The construction industry across Canada is also represented by the Canadian Construction Association (CCA; www.cca-acc.com), which works closely with and on behalf of all of the provincial road builder and hot-mix industry associations.

The Canadian Technical Asphalt Association (CTAA; www.ctaa.ca) is a national association formed in about 1955 to encourage the exchange of information on the characteristics and uses of asphalt materials and related topics; assemble, correlate and disseminate technical information and conduct annual conferences to promote the exchange of information. CTAA publishes the proceedings of its annual conference each year.

The Canadian User Producer Group for Asphalt (CUPGA) was formed in 1990 by the Canadian Strategic Highway Research Program (C-SHRP) and CTAA for the purpose of disseminating information in Canada on the research and findings of the asphalt portion of the Strategic Highway Research Program (SHRP). In 1993, CTAA expanded the role for CUPGA to include many of the other research and technology activities currently operating formally or informally under the CTAA umbrella. However, SHRP related issues continue to dominate the agenda of CUPGA.

2.2.2 United States and International

There are two main asphalt industry associations in the United States, both of which are long-established and internationally known. The Asphalt Institute (AI; www.asphaltinstitute.org), based in Lexington, Kentucky, represents the international asphalt cement/bitumen producers, manufacturers and affiliated businesses including hot-mix asphalt producers and paving contractors. The Asphalt Institute’s mission is to promote the use, benefits, and quality performance of petroleum asphalt through environmental, marketing, research, engineering and technical development. It maintains a full-time staff of technical experts, researchers and support personnel, with affiliations and representatives in key geographic centres and in Canada through an agreement with OHMPA.

The National Asphalt Pavement Association (NAPA; www.hotmix.org) is located in Lanham, Maryland and specifically represents the hot-mix asphalt producers/paving contractors and equipment manufacturers, and produces technical publications on hot-mix asphalt and asphalt paving technology. The National Center for Asphalt Technology (NCAT) was formed through a joint agreement between NAPA and Auburn University as a vehicle to conduct research and development in asphalt technology. The International Society of Asphalt Pavements (ISAP; www.asphalt.org) and the Association of Asphalt Paving Technologists (AAPT; www.asphalttechnology.org) are also U.S.-based asphalt industry technical associations that disseminate technical information and publications on asphalt technology.

Additionally, approximately 35 states currently have asphalt pavement associations that have been established to represent the state asphalt producers and paving contractors. A complete list of the state associations is provided in the Links section of the NAPA web site (www.hotmix.org).

Significant international asphalt industry associations include:

- Eurobitume (European equivalent of The Asphalt Institute, based in Brussels, Belgium and representing bitumen producers; www.eurobitume.org)
- European Asphalt Pavement Association (EAPA; www.eapa.org)
- Australian Asphalt Pavement Association (AAPA; www.aapa.asan.au)
- South African Bitumen Association (SABITA; sabita.co.za)
- New Zealand Pavement and Bitumen Contractor’s Association (bitumen.org.nz).

2.3 Canadian Hot-Mix Asphalt Industry

2.3.1 Canadian Operations

The vast majority of hot-mix asphalt plants in Canada are owned and operated by privately-held Canadian corporations ranging in size from small single plant owner-operators to large road building contractors and paving companies. The most notable exception is Lafarge Canada Inc., which is 54 percent owned by Lafarge Corporation, a Paris-based multi-national construction materials and construction firm having total sales internationally in excess of $12 billion in 2000. Lafarge Canada Inc. is a subsidiary of Lafarge North America and recently acquired the Warren Paving & Materials Group. As a consequence, Lafarge Canada Inc. owns and operates 90 hot-mix plants across Canada, with 45 in Ontario alone. Other major hot-mix asphalt producers include The Miller Group (25 plants in Ontario and 2 in New Brunswick); K. J. Beamish Construction Co., Ltd. (9 plants in Ontario); Sintra (13 plants in Quebec). There are a number of other operators having 3 or more plants.

In order to determine the number of HMA plants nationally and provide estimates of national HMA production various sources of information were accessed to develop Table 2.1. The May 2001 HMA industry MERAF scoping report by JAN Consultants and Venta, Glaser & Associates[16] provided a relatively current general overview of the asphalt industry in Canada and information from this report was used for 6 of the provinces or regions. Additional information was supplied by OHMPA for Ontario, communications with Atlantic Canada hot-mix asphalt producers for the Atlantic Provinces and communications with provincial agency staff for New Brunswick and Manitoba.

Table 2.1 presents information on the distribution of plants across Canada and the annual production for the year 2001. Figure 2.1 presents the distribution of HMA plants across Canada.

Table 2.1 Annual HMA Production 2001

Province	No. of Plants [drum/batch]	No. of Owners	Estimated Annual Production (t)
Nunavut[1.]	ND	ND	ND
Yukon[1.]	ND	ND	ND
British Columbia[1.]	80	43	3,844,000
Alberta[1.]	30	15	4,113,700
Saskatchewan[1.]	30	18	1,069,500
Manitoba[2.]	18	ND	989,600
Ontario[3.]	145	45	12,000,000
Quebec[1.]	130	ND	6,745,600
Newfoundland[4.]	23 [10/7]	23	442,500
New Brunswick[5.]	37 [11/17]	24	1,615,000*[,4.]
PEI[4.]	4 [2/2]	4	>200,000
Nova Scotia[4.]	19 [9/9]	10	962,000
Totals	516	> 182	31,981,900

* 2001 was an exceptionally high production year for New Brunswick due to placement of a substantial tonnage (~ 1 million t) of asphalt concrete on the Fredericton to Moncton Highway project that was completed in fall 2001.

Data Sources:

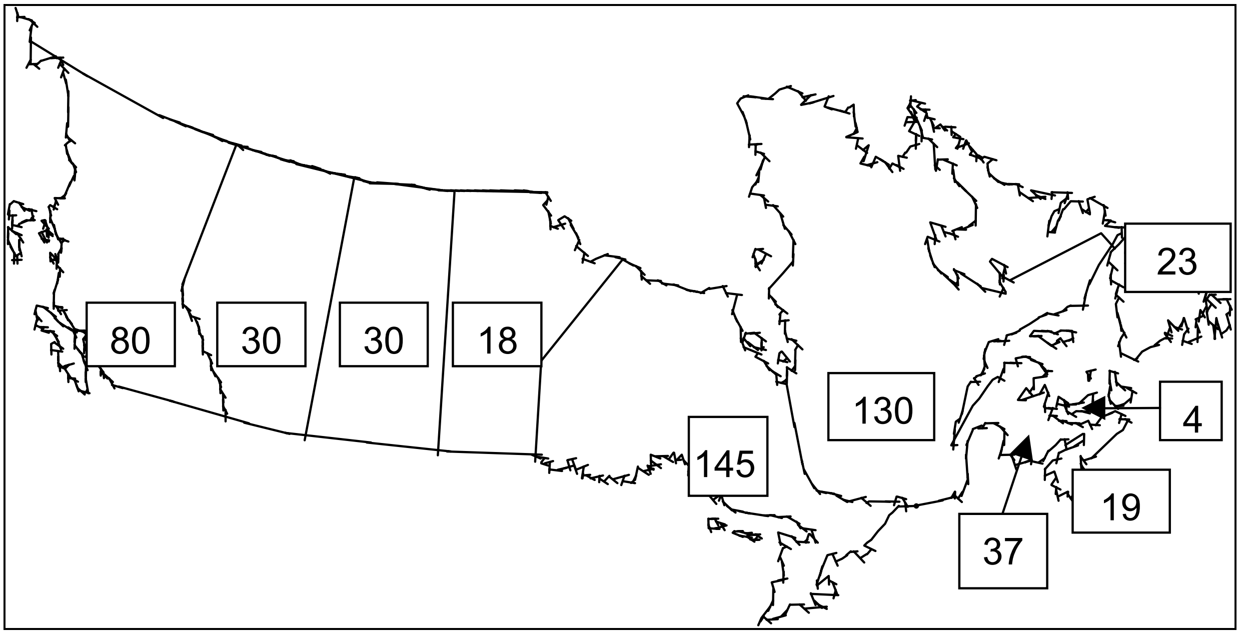
1. JAN Consultants and Venta, Glaser & Associates, Scoping Study to Characterize the Asphalt Hot-Mix Industry in Canada, and Its Associated Emissions and Emissions Controls, CCME Contract No. 156-2001, May 7, 2001.
2. Manitoba Conservation Memo, From: Jean Van Dusen To: Dave Bezak, Subject: Multi-pollutant Emission Reduction Analysis Foundation (MERAF) for the Hot-Mix Asphalt Sector, May 31, 2002
3. OHMPA, ohmpa.org Web Site, March 16, 2002.
4. JEGEL, Personal Communications (Telecommunication) between M. Corbett, JEGEL, and various Atlantic Canada hot-mix asphalt producers, February 2002.
5. Department of the Environment & Local Government, to P. Piersol, Canadian ORTECH Environmental, March 8, 2002 NB DOE&LG, Electronic Communication from M. Glynn, Air Quality Engineer, Approvals Branch, New Brunswick.

2.3.2 Canadian Hot-Mix Asphalt Production

As previously indicated, the scoping study estimated that the annual production of hot-mix asphalt in Canada was approximately 31 million tonnes in 1999[16]. This estimated production value has been separately corroborated by ORTECH-JEGEL through direct discussions with asphalt paving industry associations and provincial highway department representatives for the year 2001, see Table 2.1. Based on discussion with the industry and assessment of production over the last 10 years, annual production has remained relatively constant. It is anticipated that this no-growth situation will continue for the foreseeable future.

[16] JAN Consultants and Venta, Glaser & Associates, Scoping Study to Characterize the Asphalt Hot-Mix Industry in Canada, and Its Associated Emissions and Emissions Controls, CCME Contract No. 156-2001, May 7, 2001.

Figure 2.1 Distribution of Hot-Mix Asphalt Plants Across Canada (refer to Table 2.1)



2.3.3 Canadian HMA Industry Economic Profile

The industry economic profile is somewhat more difficult to characterize. Hot-mix asphalt is typically sold on a per tonne basis, and in many instances this includes delivery and placement at the project paving site. Further, regional economies and competition have a significant impact on the pricing of this commodity.

Industry Canada maintains trade statistics for all Canadian industries by North America Industrial Classification System (NAICS) codes, which can be accessed (Trade Data On-Line – www.strategis.gc.ca) to assess the Canadian industry economic profile. However, the reported figures for hot-mix asphalt are not given individually. Hot-mix asphalt paving falls within North America Industrial Classification System (NAICS) Code 324121 - Asphalt Paving Mixture and Block Manufacturing, which is defined as "…establishments primarily engaged in manufacturing asphalt paving mixtures and blocks, from purchased asphalt, bituminous materials or coal tar." This sector is part of the larger sector described under NAICS Code 32412 – Asphalt Paving, Roofing and Saturated Materials Manufacturing. This sector is defined as "…establishments primarily engaged in manufacturing asphalt paving materials, manufacturing roofing rolls, sheets and shingles, by saturating mats and felts with purchased asphalt or bituminous materials; and manufactured roofing cements and coatings".

ORTECH-JEGEL accessed the Trade Data On-Line database to generate a report of Canadian Manufacturing Shipments filed under NAICS 324121 – Asphalt Paving Mixture and Block Manufacturing for the 5-year period commencing 1995 and ending 1999:

Table 2.2 Asphalt Paving Mixture and Block Manufacturing, 1995-1999

	Value in Thousands of Canadian Dollars				
	1995	**1996**	**1997**	**1998**	**1999**
NAICS 324121	354,390	361,302	415,777	407,955	453,756
Others	380,669,723	389,921,950	417,410,745	440,734,282	488,180,146
Total (Manufacturing Industries)	381,024,113	390,283,252	417,826,522	441,142,237	488,633,902

The amount of hot-mix asphalt that has been estimated to be produced annually for use in roads, highways, airports and the private sector across Canada approaches 32 million tonnes. This would suggest the Industry Canada statistics are somewhat high. Regardless, this order of magnitude in the manufactured shipment of asphalt paving mixtures represents less than 0.1 percent of the total manufactured shipment of all major manufacturing industries.

The total Canadian Gross Domestic Product (GDP) for 1999 was $722.3 billion ($774.7 billion in 2000), which represented 1.8 percent of the total world GDP. Assuming that the total production of hot-mix asphalt in Canada was 32 million tonnes in either of these two years, and HMA sold at a unit cost of $ 35/tonne, then hot-mix asphalt production ($1.12 billion) conservatively represents only 0.15 percent of the Canadian GDP.

Employment statistics for this sector are also not directly reported by Industry Canada. The hot-mix asphalt industry sector employment numbers can be estimated based on the number of employees working at a typical plant and extrapolating this number to the number of plants nation wide. A typical plant ‘standard’ staff complement would consist of a supervisor, a plant operator (usually 1 plus a back-up), scale staff (2), a mechanic and perhaps a quality control laboratory (2), for a total of a maximum of 10 staff. This estimate would not include sales, administrative and senior management staff, which would vary from company to company. Based on this ‘standard’ staff complement per plant, nation wide employment for approximately 480 plants would be in the order of 4,600 to 5,000.

3 Emission Sources and Data

3.1 Hot-Mix Asphalt Processes

3.1.1 General Process Description

The basic manufacturing processes of hot-mix asphalt (HMA) involve removing free moisture from the raw aggregate materials, heating the aggregate materials, and coating this aggregate with hot asphalt cement to produce asphalt concrete paving material. These processes can be accomplished in either a dryer and tower combination (batch mix plant) or a drum mixer. These aggregate materials are a mixture of size graded, high quality aggregate, which can include reclaimed asphalt pavement (RAP). The aggregate material constitutes typically 95% (by weight) of the total asphalt concrete mixture.

Supporting processes of the dryer or drum mixer include aggregate storage piles and feed bins, asphalt cement tanks and heaters, asphalt concrete paving material storage silos and air pollution control equipment. Aggregate material may be trucked to the plant or the plant will be located near an aggregate pit. The asphalt paving material is loaded into transport trucks and taken to the road paving sites.

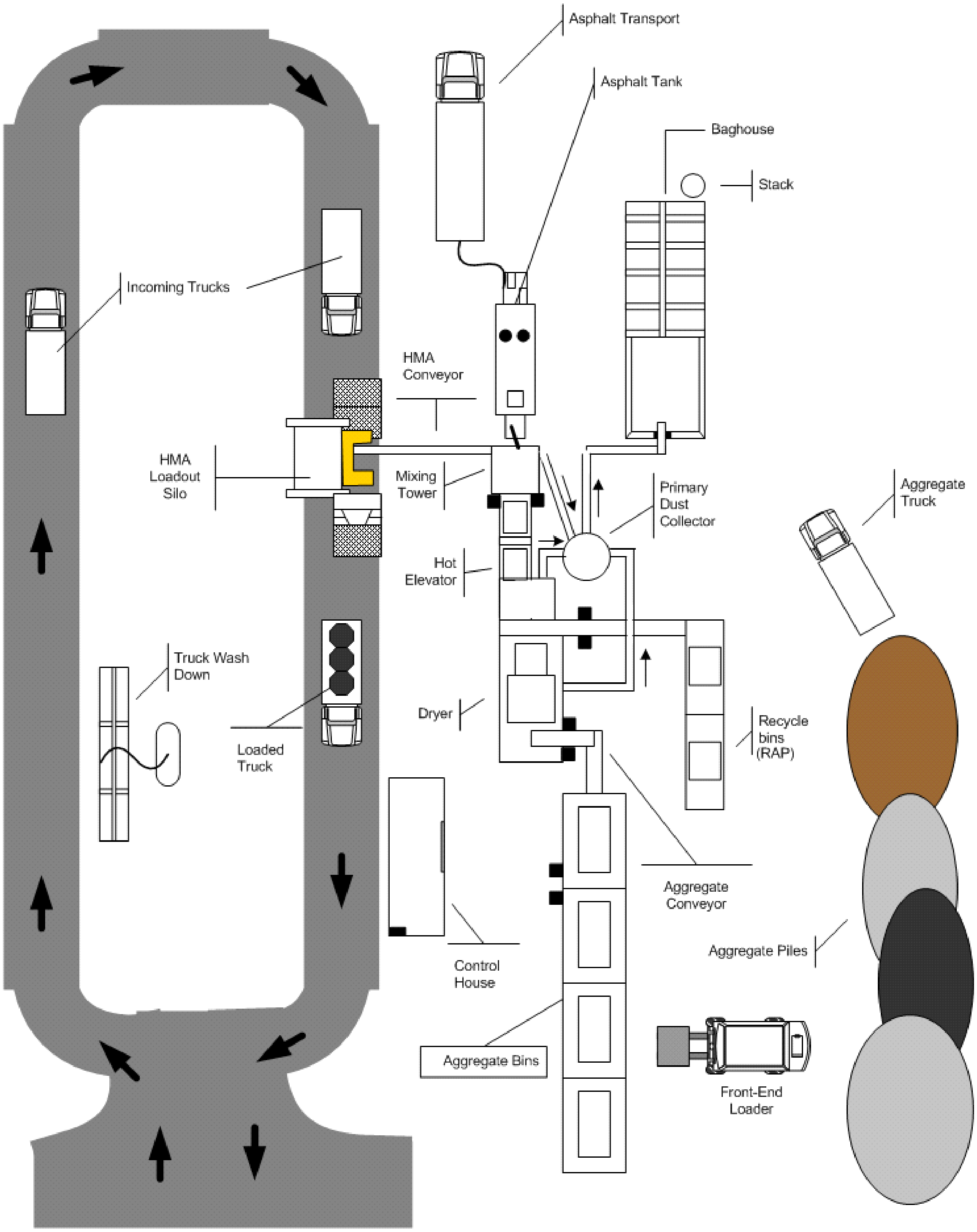
A typical plant layout is presented in Figure 3.1. An HMA plant can be constructed as a permanent plant, a skid-mounted plant or a portable plant. Most Canadian plants use either natural gas or fuel oil. Some plants have the capability to process RAP.

Emissions at hot-mix asphalt plants may be fugitive or ducted (uncontrolled or controlled, respectively). Fugitive or open sources of emissions typically include traffic areas (roadways and storage yards), stockpiles, bins and conveyors, as well as any holes or gaps in ductwork. Ducted sources mainly involve the aggregate heating and drying as well as any 'scavenged' emissions (batch tower/mixer for instance). 'Blue smoke' refers to a haze of hydrocarbon droplets that can develop at certain spots in the drying and mixing process.

3.1.2 Batch Mix Plants

The batch mixing process manufactures the asphalt paving material in two separate operations, Figure 3.2, which also illustrates the typical fugitive and ducted emission points of concern. In the dryer, the free moisture is removed from the aggregate and the heating takes place. The dryer is set on a slight incline with a burner at the lower end. The aggregate is fed to the top end of the dryer and moves down to the lower burner end where it leaves as hot dry aggregate. The dryer rotates and tumbles the aggregate as it passes through the hot gases, which exit at the top end. A bucket elevator transfers the hot aggregate from the dryer to the second operation, the mixing tower. The hot gases from the dryer pass to particulate control equipment.

Figure 3.1 Typical Hot-Mix Asphalt Plant (Batch) Site Layout



In the tower the hot aggregate is separated into various sizes by the vibrating screens at the top of the tower and then drop into hot storage silo bins. From these storage silo bins the hot aggregate is dropped into a weigh hopper and hot asphalt cement is also pumped into a weigh bucket. Together the hot aggregate and the hot asphalt cement are dropped into a twin shaft pugmill where the aggregate is coated with the asphalt cement to produce the finished product. Material transfer points at the dryer and mixing tower are enclosed and dust is collected controlled by the particulate control equipment.

3.1.3 Drum Mix Plants

In the continuous drum mixing process the aggregate is coated with the asphalt cement while still in the drum. There are 2 types of drum mixing plants; parallel flow drum mix plants and counterflow drum mix plants.

In **parallel flow drum mix plants,** sized aggregate is introduced into the drum at the burner end, Figure 3.3. As the drum rotates, the aggregates as well as the hot gases from the burner, move towards the lower other end of the drum in parallel. Liquid asphalt cement is introduced in the mixing zone midway down the drum in a lower temperature zone, along with any RAP or particulate matter from the dust collectors. As the liquid asphalt cement and hot, dry aggregate travels the remaining distance to the lower end of the drum the aggregate is coated with the asphalt cement. The mixture is discharged from the drum and is conveyed to either a surge bin or HMA storage silos, where it is then loaded into transport trucks. The hot combustion exhaust gases exit the lower end of the drum and pass to the particulate control equipment.

In **counterflow drum mix plants**, sized aggregate is introduced into the drum at the upper end and travels down to the lower burner end, Figure 3.4. The aggregate travels down and the hot combustion gases pass up the drum in the opposite direction or counterflow. The liquid asphalt cement is introduced behind the burner flame so as to avoid direct contact with the hot gases and flame. Any RAP and recovered dust from the control equipment is introduced at a lower temperature point midway along the drum. As the liquid asphalt cement and hot, dry aggregate travels the remaining distance to the lower end of the drum the aggregate is coated with the asphalt cement. The mixture is discharged from the drum and is conveyed to either a surge bin or HMA storage silos, where it is then loaded into transport trucks. The hot combustion exhaust gases exit the upper end of the drum and pass to the particulate control equipment.

Combination drum/batch plants (‘dratch’ plants) are a hybrid of the two. These hybrids usually consist of a continuous drum dryer-mixer that can be used either as a continuous mixing unit for high or continuous rates of production, or as a dryer feeding the dried heated aggregate to a small batch mixer where the aggregate is screened and the asphalt cement is added and mixed for smaller production runs.

Figure 3.2 Hot-Mix Asphalt Batch Plant Processes

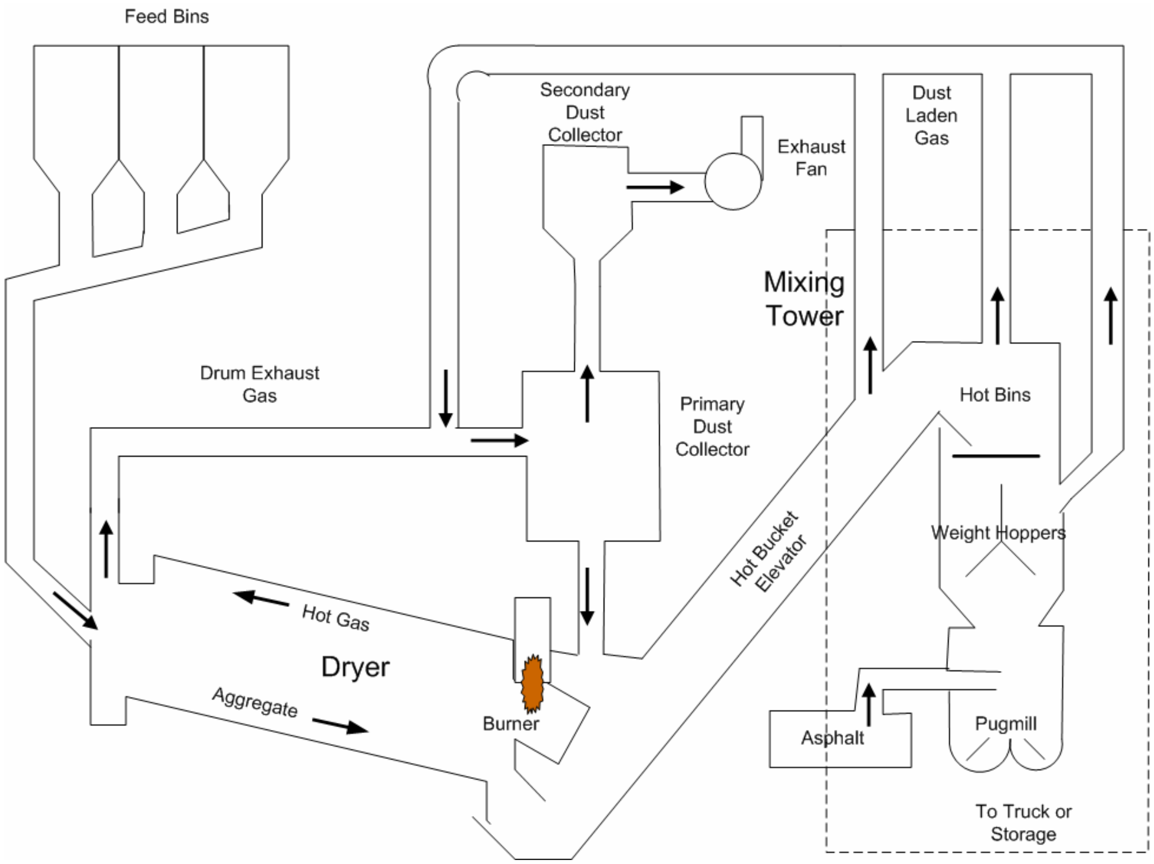


Figure 3.3 Hot-Mix Asphalt Drum Plant Processes, Parallel Flow

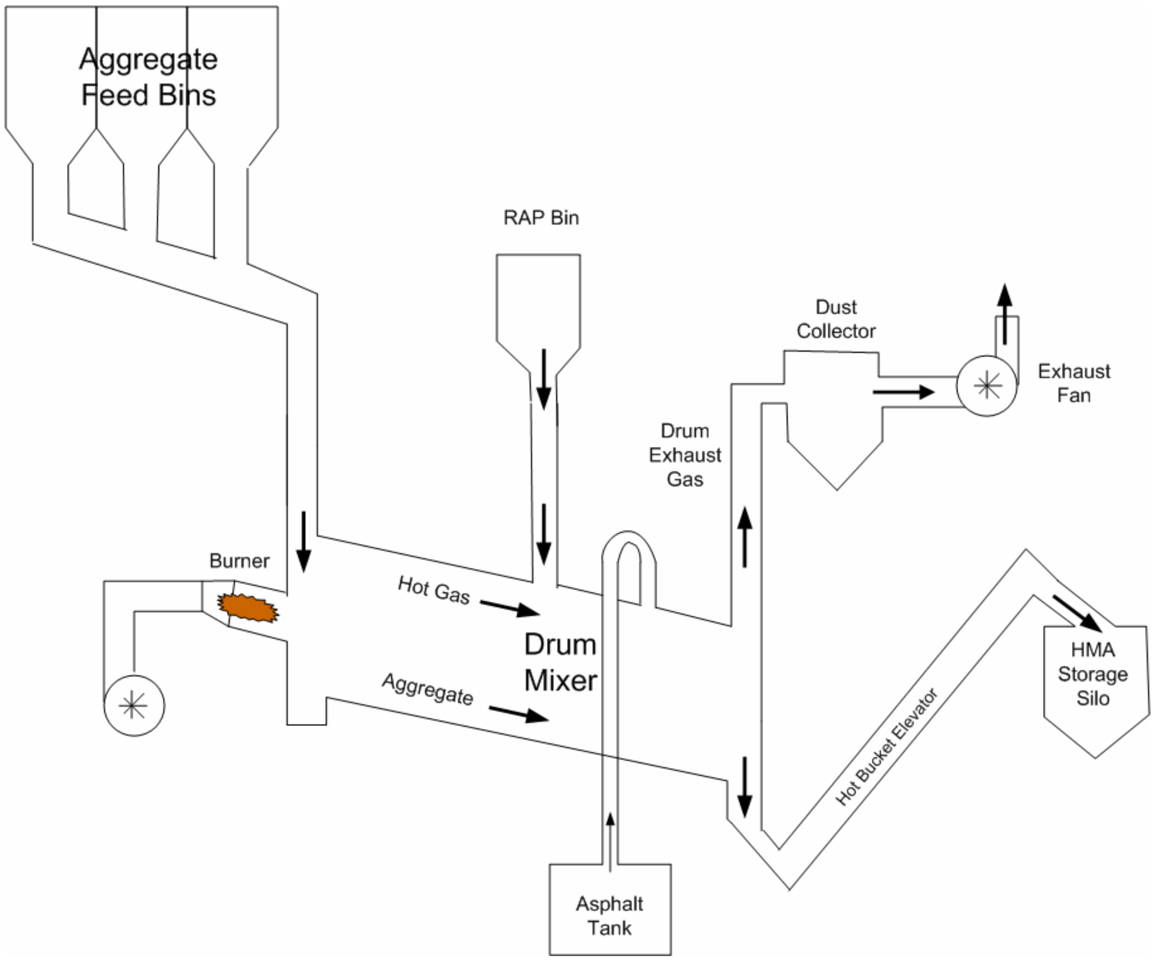
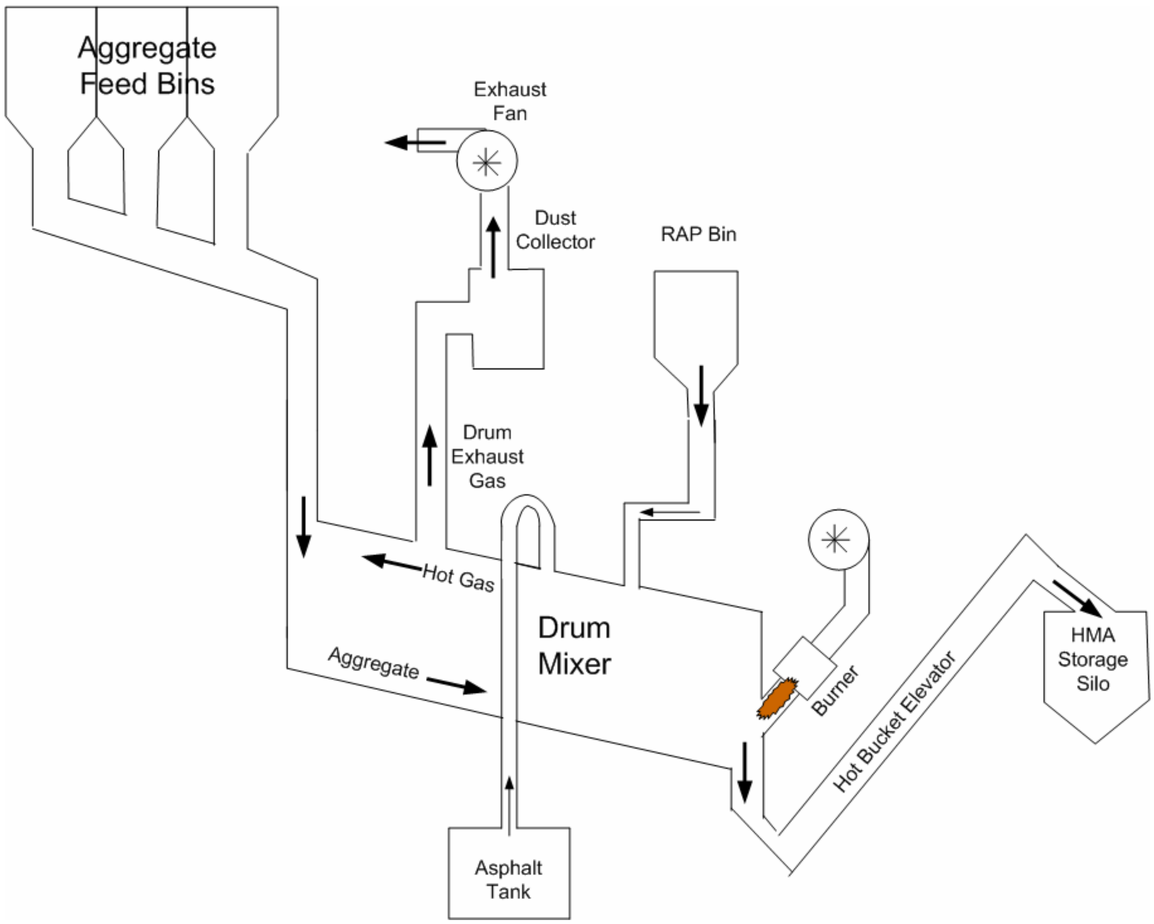


Figure 3.4 Hot-Mix Asphalt Drum Plant Processes, Counter Flow



3.1.4 Materials Handling

The raw aggregate can be transported to the plant site and placed in storage piles or, if the plant is located in an aggregate pit, then the aggregate is transported directly to the storage piles from the pit. The aggregate storage piles can be located on paved surfaces and the plant road surfaces may also be paved in order to minimize vehicle road dust. Front-end loaders manage the storage piles and transfer the aggregate to the appropriate cold feed hoppers. Conveyor belts transport the aggregate from the feed hoppers to the dryers or drum mixers. Transfer points are covered and dust is extracted by the dust control equipment.

Liquid asphalt cement is transported to the plants in heated tanker trucks and stored in heated tanks from which vapour is captured and piped to the dryers or drum mixers.

3.1.5 Pollution Control Equipment

For **batch mix plants** the particulate laden dryer exhaust gases are controlled by a combination of primary dust collectors such as a knock-out box or a simple cyclone, followed by secondary dust collectors such as a wet scrubber or a baghouse. The particulate removed from the primary dust collector is returned to the process with the hot, dry aggregate exiting the dryer and is then transferred to the mixing tower. This particulate collection system also collects dust from transfer points of the mixing tower. To control combustion products from the dryer burner, the design, operation, and maintenance of the burner provide opportunities to minimize emissions of NO_X, CO, and organic compounds. Sulphur emissions are minimized by the use of low sulphur fuel oils or natural gas or propane.

For **drum mix plants** primary dust collection systems are usually also integral components of the emissions control system, usually consisting of horizontally or vertically mounted cyclones that greatly reduce the load on the baghouse or wet scrubber. A secondary dust collector such as a venturi wet scrubber or a fabric filter baghouse mainly controls the fine particulate laden drum mixer exhaust gases. Up until about the late-1970s, most parallel flow drum mixers incorporated an integral wet scrubber. Since the heating of the aggregate and the mixing of the aggregate with the liquid asphalt cement occurs in the drum, the generation of dust emissions is lower than that of a batch dryer. To control combustion products from the drum mixer burner, the design, operation, and maintenance of the burner provides opportunities to minimize emissions of NO_X, CO, and organic compounds. Sulphur emissions are minimized by the use of low sulphur fuel oils or the natural gas or propane.

Newer asphalt plants incorporate ‘blue smoke’ reduction units. Such units typically involve capturing and disposal of the ‘blue smoke’ either by pulling the haze back through the burner where any residual hydrocarbon products can be consumed, or to hydrostatic precipitators.

Material handling fugitive emissions at the storage piles are controlled by wetting, and surface treatments. Paving, wetting the roadways and reduced vehicle speed control roadway vehicle dust emissions.

Emission Sources

The air pollutants examined in this report include:

Criteria air contaminants (CAC):
- Particulate matter (Total, <10μm, and <2.5 μm)
- Nitrogen oxides (NO_X)
- Sulphur oxides (SO_X)
- Carbon monoxide (CO)
- Volatile organic compounds (VOC);

Toxic substances;
- Polycyclic aromatic hydrocarbons (PAH)

Greenhouse gases;
Carbon dioxide (CO_2)

Since the hot-mix asphalt industry involves the handling and processing of large quantities of aggregate, the main pollutant emitted is particulate matter (PM, PM_{10} and $PM_{2.5}$). Particulate is emitted from captured and controlled sources such as the dryer and drum mixers and from fugitive material handling sources such as raw aggregate conveyor transfer points and hot-mix asphalt paving material transferring. The amount of dust handled by the emissions control system can vary substantially depending on the quality and fines content of the aggregates (especially fine aggregates) used, and the hot-mix asphalt mixtures being produced.

Gaseous products of combustion are generated from the dryer and mixing drum burner. These pollutants include carbon dioxide, carbon monoxide, nitrogen oxides, sulphur oxides and unburned hydrocarbons or volatile organic compounds (VOCs). PAH compounds in very low concentrations are also formed during the combustion of fuels.

Emissions of dioxins and furans from HMA dryers and drum mixers have been studied[17][18], however, the data does not definitively indicate that dioxins and furans are associated with the HMA plant processes. Many of the individual components have not been detected and the U.S. EPA AP-42 emission factors are assigned E ratings because they are based on a limited number of tests.

[17] U.S. EPA. *Compilation of Air Pollution Emission Factors, Volume I: Stationary Point and Area Sources,* AP-42, 1995 with updates to 12/00.
[18] U.S. EPA. *Hot-Mix Asphalt Plants Emission Assessment Report,* Office of Air Quality Planning and Standards, Research Triangle Park, EPA-454/R-00-019, December 2000.

The liquid asphalt cement can also be a source of organic compound emissions that contain polycyclic aromatic hydrocarbons (PAH), some of which are semi-volatile. In addition to the PAHs present in combustion gases, PAH compounds can be emitted from dryers, drum mixers, HMA silos and load-out, and from the displaced saturated vapour when asphalt cement storage tanks are filled.

Asphalt is essentially the material that remains after distillation of crude oil at petroleum refineries. Consequently, asphalt consists primarily of heavy organic compounds with low boiling points. After the vacuum distillation step, there is processing associated with much of the road asphalt produced in Canada. While the addition of distillates to create Rapid, Medium and Slow Cure Asphalts stopped more 10 years ago (but water/polymer addition for emulsion asphalts continues and in most cases after the product has left the refinery), today's asphalts are often oxidized and polymers are added at the point of production (i.e. the refinery) to create more versatile materials for road paving. Asphalt that receives no further processing after the vacuum distillation step is called straight-run asphalt.

Seventeen, among the large number of compounds in the PAH class are of primary interest. This group of 17 PAHs became reportable to the National Pollutant Release Inventory (NPRI) for calendar year 2000 providing more than 50 kilograms, as the combined total quantity of all 17 compounds, are released to all environmental media, and providing a facility meets other reporting criteria as well.

Industry information provided to Environment Canada by the Canadian Petroleum Products Institute indicated that five PAH compounds were detected in a sampling program of 17 samples of both oxidized and straight-run asphalt streams from three refineries. The detectable compounds included: naphthalene, flourene, phenanthrene, pyrene, and chrysene. Naphthalene has been a reportable substance to the NPRI since 1993, subject to a facility meeting the NPRI reporting criteria. Naphthalene and methylnaphthalene dominate the PAH emissions associated with heated asphalt.

HMA transport trucks and the aggregate front-end loaders emit combustion pollutants. Vehicle engine emissions are not included in this study because vehicles, engines and fuels are subject to existing regulatory programs of Environment Canada under the *Canadian Environmental Protection Act, 1999*.

Table 3.1 summarizes the sources and pollutants released from hot-mix asphalt plants.

Table 3.1 Pollutant Emissions from Hot-Mix Asphalt Plants

Source	Criteria Pollutants
Batch Mix - Dryer and Mixing Tower	PM, PM_{10}, $PM_{2.5}$, CO, SO_2, NO_X, CO_2, VOCs, PAHs
Drum Mix – Drum Mixer	PM, PM_{10}, $PM_{2.5}$, CO, SO_2, NO_X, CO_2, VOCs, PAHs
Asphalt Storage Tanks	VOCs, CO, PAHs
Silo Filling and Truck Load-Out	$PM_{2.5}$, CO, VOCs, PAHs
Aggregate Handling	PM, PM_{10}, $PM_{2.5}$
Road Dust	PM, PM_{10}, $PM_{2.5}$

3.2 Emission Calculation Methodology and Information

3.3.1 Emission Factors

The United States Environmental Protection Agency (EPA), Office of Air Quality Planning, and Standards released a final report entitled, Hot-Mix Asphalt Plants - Emissions Assessment Report, in December 2000. This EPA report updates the Asphalt Section in AP-42 published in 1995. The Assessment Report included an analysis of over 300 emissions tests collected from State and local air pollution control agency files in order to improve on the AP-42 emission factors of the 1995 Hot-Mix Asphalt Section of AP-42. Additional test data on kiln stack emissions and fugitive emissions from silo filling or transport truck loading were incorporated into the report. These AP-42 emission factors typically are used to estimate area-wide emissions for a large number of facilities and emissions for specific facilities where source-specific emissions data are not available or where source testing data would be cost prohibitive to obtain.

3.3.1.1 Dryer and Drum Mixer Emissions

For **batch plants**, emission factors are presented for PM emissions from the dryer and mixing tower. The wet scrubber controlled and the fabric filter controlled emission factors have quality ratings of “A” excellent, “B” above average and “C” average. The emission factors were developed by EPA by averaging test data that covered a large range of emission tests. For example, the intermediate fabric filter controlled batch plant filterable particulate emission factor (0.0125 kg/tonne) is the average of test data from 89 plants. The range of emissions from these plants varied widely, from 0.0012 to 0.09 kg/tonne, with a median of 0.006 kg/tonne.

Emission factors for particle size distributions are also presented. These emissions factors have a quality rating of “E” poor. They were determined using data published in 1986 and particle size distribution test data from one plant together with the total particulate emission factors mentioned above.

Particulate emission factors for batch plant dryers and mixing towers are presented in Table 3.2. These emissions factors are in units of kg of particulate (PM) emitted per tonne of HMA produced and represent emission concentrations typically in the range of 70 mg/m^3 to 110 mg/m^3.

**Table 3.2 Particulate Matter Emission Factors, (kg/tonne)
Batch and Drum Hot-Mix Asphalt Plants**

Process	Total Particulate	PM_{10}	$PM_{2.5}$
Batch Plants			
Uncontrolled	16.0	2.35	0.135
Venturi or Wet Scrubber	0.07	0.0446	0.0137
Fabric filter	0.021	0.0135	0.00415
Drum Plants			
Uncontrolled	14.0	3.25	0.15
Venturi or Wet Scrubber	0.0225	0.0150	0.00189
Fabric filter	0.0165	0.0115	0.00145

For **drum mix plants** emission factors are presented for PM emissions from the drum mixing process. It is assumed that emissions from parallel and counterflow drum mixers are similar. The uncontrolled emissions have quality ratings of “D” or below average and “E” or poor. The wet scrubber controlled and the fabric filter controlled emission factors have quality ratings of “A” excellent and “C” average. The emission factors were also determined by averaging test data that covered a large range of emissions. For example, the intermediate fabric filter controlled drum mix plant filterable particulate emission factor (0.007 kg/tonne) is the average of test data from 155 plants which covered a large range, 0.00044 to 0.07 kg/tonne, with a median of 0.005 kg/tonne.

Emission factors for particle size distributions are also presented. These emission factors have a quality rating of “E”, or poor, and were determined using data published in 1986 and particle size distribution test data from one plant, together with the main total particulate emission factors mentioned above.

Particulate emission factors for the drum mixers of drum mix plants are presented in Table 3.2. These emissions factors are in units of kg of particulate (PM) emitted per tonne of HMA produced and represent emission concentrations typically in the range of 70 mg/m^3 to 110 mg/m^3.

In addition to the particulate emissions, combustion products are emitted from the natural gas or fuel oil combustion of the batch dryer and drum mixer burners. AP-42 presents emission factors for these pollutants. The CO emission factors represent normal plant operations without scrutiny to the burner design, operation and maintenance. Attention to burner design, periodic evaluation of burner operation and appropriate maintenance can reduce CO emissions. Emissions data for dryers and drums mixers using natural gas and No. 2 fuel oil were combined to develop a single emission factor as the magnitude of emissions was similar for dryers and drum mixers using the two types of fuels.

The carbon dioxide emission factors are an average of all available data, regardless of the dryer and drum mixer fuels, as emissions were similar regardless of fuel type. Based on data from drum mix facilities, 50% of the fuel-bound sulphur, up to a maximum (as SO_2) of 0.05 kg/tonne, is expected to be retained in the product, with the remainder emitted as SO_2. Carbon dioxide and sulphur dioxide emissions can also be estimated based on fuel usage and the fuel combustion emission factors in AP-42 Chapter 1. This fuel consumption emission estimation technique was not used as fuel consumption data was not available and a survey would be needed to obtain this data.

Table 3.3 Gaseous Emission Factors, (kg/tonne)
Batch and Drum Hot-Mix Asphalt Plants

Process	CO	CO_2	NOx	SOx	VOC	PAH
Natural Gas Fired Dryer & Mixing Tower	0.2	18.5	0.0125	0.0023	0.0041	5.5×10^{-5}
No. 2 Fuel Oil Fired Dryer & Mixing Tower	0.2	18.5	0.06	0.044	0.041	5.5×10^{-5}
Natural Gas Drum Mixer	0.065	16.5	0.013	0.0017	0.016	9.5×10^{-5}
No. 2 Fuel Oil Drum Mixer	0.065	16.5	0.0275	0.0055	0.016	4.4×10^{-4}

In addition to the combustion product emissions, AP-42 also presents emission factors for organic pollutants (VOCs) and total PAHs from dryer mixers and drum mixers. The data for VOC in Table 3.3 represents total hydrocarbons expressed as propane plus formaldehyde, minus methane.

3.3.1.2 Truck Load–Out and Silo Filling Emissions

Predictive emission factor equations from AP-42 were used to estimate load-out and silo filling operations. Table 3.4 presents typical emission factors based on assumptions regarding asphalt loss-on-heating and temperature. PAH emissions are dependent on the HMA temperature. Increases or decreases in temperature will have a direct effect on PAH emissions. For the emission factor calculation a typical moderate temperature of 145°C was selected. Required HMA temperatures vary with asphalt cement grade, ambient temperature and haul time to the road sites. Recommended HMA temperatures will vary from 140°C to a maximum of 170°C. It is assumed that the truck load-out and silo filling particulate emissions are $PM_{2.5}$.

Table 3.4 Truck Load-Out and Silo Filling Emission Factors, (kg/tonne)

Source	Pollutant	Emission Factor	Assumptions
Truck Load-Out	$PM_{2.5}$ VOC CO PAHs	0.00018 0.0011 0.0004 5.93 % of VOCs	Percent loss-on-heating = 0.5% HMA mix temperature = 145°C
Silo Filling	$PM_{2.5}$ VOC CO PAHs	0.00017 0.0033 0.0003 11.4% of VOCs	Percent loss-on-heating = 0.5% HMA mix temperature = 145°C

3.3.1.3 Asphalt Cement Storage Tank Emissions

Emissions from asphalt cement storage tanks were estimated from the procedure outlined in AP-42 Section 7.1 Organic Liquid Storage Tanks and the TANKS software. In order to develop an average emission factor various assumptions were made. These assumptions were that a 100,000 tonne per year plant with a 68,000 L (18,000 US gal) tank had 65.6 turnovers or fillings per year and the average tank temperature was 145°C (290°F). With these inputs to the procedure, the TANKS software model predicted an emission factor of 0.000168 kg/tonne for VOCs. PAH emissions from asphalt cement storage tanks were assumed to contain 11.4% (by weight) of the total VOC emissions. PAH emissions are dependent on the asphalt tank temperature. Increases or decreases in temperature will have a direct effect on PAH emissions. For the emission factor calculation a typical moderate temperature of 145°C was selected.

3.3.1.4 Material Handling and Road Dust Emissions

Emission factors for estimating emissions from material handling and road dust are published in other sections of AP-42. For various emission factors only PM_{10} values are given by EPA as reliable. $PM_{2.5}$ emission factor data was not available and since EPA has moved to air quality standards only for PM_{10} and $PM_{2.5}$ and not total PM, there are no PM emission factors. Where only PM_{10} emission factors were given in AP-42, $PM_{2.5}$ emissions were not calculated and the PM emission was assumed to be the same as the PM_{10} emission.

Table 3.5 Material Handling and Road Dust Emission Factors

Source	Pollutant	Emission Factor	Assumptions	AP-42 Section
Receipt of New Aggregate	PM_{10} $PM_{2.5}$	0.0022 kg/tonne of new aggregate 0.00065 kg/tonne of new aggregate	Moisture = 1.5% Wind speed = 10 mph	13.2.4
Transfer of New Aggregate	PM_{10}	0.000024 kg/tonne of new aggregate	Controlled	11.19.2
Screening of New Aggregate	PM_{10}	0.00042 kg/tonne	Controlled	11.19.2
RAP Crushing Aggregate	PM_{10}	0.00003 kg/tonne	Controlled, tertiary crushing	11.19.2
Paved Road Dust	PM PM_{10} $PM_{2.5}$	2.27 kg/VKT 0.43 kg/VKT 0.10 kg/VKT	Vehicle wt = 22 tons Silt content = 3 g/m^2	13.2.1
Unpaved Road Dust	PM PM_{10} $PM_{2.5}$	5.47 kg/VKT 2.28 kg/VKT 0.35 kg/VKT	Vehicle wt = 6 tons Silt content = 8.4% Moisture = 3 %	13.2.2
	PM PM_{10} $PM_{2.5}$	20.0 kg/VKT 8.37 kg/VKT 1.28 kg/VKT	Vehicle wt = 22 tons Silt content = 8.4% Moisture = 3 %	13.2.2

3.3.2 Emissions Measurements

Limited emissions measurement data was available from various Canadian jurisdictions for hot-mix asphalt plants in their regions. These emissions measurements are examples of the potential emissions from plants and do not represent a sample size large enough to be considered typical average emissions from hot-mix asphalt plants.

An Ontario Ministry of Environment 1993 document presents test data on three Ontario hot-mix asphalt plants[19]. This Ontario test data is from a pilot study which evaluated the application of recycled tire crumb rubber as an additive to the asphalt mix. The plants were operated in a mode that would be typical of worst case operation and not representative of a well maintained operation. The three plants included one batch plant with a baghouse for control, a drum mix type with a venturi scrubber and another drum mix type with a spray tower for control. The emissions data varied significantly from plant to plant based on the type of operation, the air pollution control equipment,

[19] Ontario Ministry of the Environment and Energy. *Summary of Emission Factors from Asphalt Plants,* Air Resources Branch, May 1993

the type of asphalt and the operating practices. Particulate was the pollutant of concern and the Ontario in-stack limit of 230 mg/Rm^3 was exceeded at all three plants.

Hot-mix asphalt test data from New Brunswick was provided to the consultants for consideration. This data covered both batch and drum type plants using aggregate and a mixture of aggregate and RAP and using wet scrubbers and baghouses for control. HMA production rate information during the testing was not available for this emissions data. The New Brunswick limits for particulate (200 mg/m^3), carbon monoxide (100 mg/m^3), and sulphur dioxide (100 mg/m^3) were exceeded in some instances. The limits for nitrogen oxides (100 mg/m^3) and total non-methane hydrocarbon (100 mg/m^3) limits were not exceeded.

Hot-mix asphalt test data from the Greater Vancouver Region was also provided to the consultants for consideration. Details of the plant types, controls and production rates were not provided. The test data on the 7 plants indicates the limit for particulate (90 mg/m^3) was not exceeded, however, the limits for organics (60 mg/m^3) and carbon monoxide (200 mg/m^3) were exceeded.

Emissions test data was obtained for plants in Germany where about 400 asphalt mixing plants were tested between the years 1989 to 1992[20]. The test data covers plants with very different maintenance and operating conditions. The following table presents selected data from conventional plants fired with natural gas and light heating oil.

Table 3.6 Measured Emission Data from German Asphalt Mixing Plants

Emission Component	Natural Gas Median (mg/m^3)	Light Fuel Oil Median (mg/m^3)
Particulate	11.0	13.5
Carbon Monoxide	361	439
Sulphur Dioxide	<10	<10
Nitrogen Dioxide	29.2	38.5
Organics[1]	39.6	43.1

Notes: 1. Non-methane hydrocarbons, expressed as total carbon.
2. Concentration values are based on 17% oxygen.

[20] Emissionen luftverunreinigender Stoffe aus Asphalt-Mischanlagen beim Einsatz von Ausbauasphalt, Umweltplanung Arbeits-Und Umweltschultz Heft 190, April 1995

3.4 Hot-Mix Asphalt Sector Air Emissions

3.4.1 Emissions Determination Methodology

In order to predict emissions from the Canadian hot-mix asphalt sector, pollution control technologies and management practices were determined for the separate process operations. This technique of calculating pollutant emissions from the separate hot-mix asphalt process operations provides comparative data to assess how each unit process contributes to the overall plant emissions for the pollutants of interest. Other techniques have determined average emissions from the dryers and drum mixers, the raw aggregate handling operations and the HMA handling operations. This averaging emission technique apportions the emission estimates and enables comparing batch dryers versus drum mixers, the different fuels used, or the impact of paved versus unpaved roads, etc.

The following sections present information and specific process data that was used to calculate annual total Canada and provincial emissions.

3.4.2 Canadian Hot-Mix Asphalt Industry Sector Information

For the No-Growth emissions projection scenarios, the national annual production in year 2001 (Table 2.1) was used to determine emissions for the base year of 2000. This data was used with the emission factors to calculate provincial emissions for the different processes. Other information necessary to calculate the sector-wide emissions included the following parameters:

- Plant Type: Batch or Drum
- Fuel: Natural Gas or #2 Fuel Oil
- Particulate Control: Uncontrolled, Wet Scrubber or Fabric filter
- Location: Urban or Rural

The information on plant type, type of fuel and the particulate control equipment was used with the appropriate emission factor and HMA production to calculate the emissions.

Assumptions about physical site size were necessary to determine the length of paved and unpaved roads at facilities. Rural plant sites were assumed to be larger than urban sites and to have 500 m of HMA transport truck roadways with 300 m paved and 200 m unpaved. Urban plants were assumed to be located on smaller sites with 100 m of paved HMA transport truck roadways. This roadway information was used in determining the paved and unpaved road dust emissions. Both rural and urban sites were assumed to have unpaved surfaces for the front-end loader that handled the aggregate. Table 3.7 presents the information used as the basis for calculating HMA sector wide emissions.

Table 3.7 Canadian Industry Information

Province	Plant Type (%)		Fuel (%)		Control (%)		Location (%)	
	Batch	Drum	Gas	Oil	WS	FF	Rural	Urban
Newfoundland	40	60	0	100	50	50	50	50
Nova Scotia	50	50	0	100	50	50	50	50
New Brunswick	55	45	0	100	50	50	50	50
PEI	50	50	0	100	50	50	80	20
Quebec	65	35	50	50	50	50	35	65
Ontario	75	25	65	35	50	50	35	65
Manitoba	50	50	60	40	17	16	35	65
Saskatchewan	50	50	60	40	50	50	35	65
Alberta	65	35	65	35	50	50	35	65
British Columbia	65	35	50	50	50	50	35	65
Yukon & NWT	50	50	50	50	50	50	80	20

Notes: WS – Wet Scrubber
FF – Fabric Filter

Provincial and national air pollutant emissions are presented in Table 3.8 and Figures 3.5 and 3.6 for the year 2000. Since the provinces of Ontario, Quebec, Alberta, and British Columbia have the largest HMA production volumes, they also have the largest pollutant emission quantities, with the exception of Manitoba. In Manitoba, 37% of the provincial production is from uncontrolled plants.

Table 3.8 Hot-Mix Asphalt Provincial and National Air Pollutant Emissions Year 2000 – No Growth (tonnes/year)

Province	PM	PM_{10}	$PM_{2.5}$	CO_2	SO_2	NO_X	VOC	CO	PAH
Newfoundland	132	56	10	7,660	9	18	7	53	0.2
Nova Scotia	289	124	22	16,800	24	42	14	128	0.3
New Brunswick	487	209	32	28,400	43	73	23	226	0.5
PEI	75	32	5	3,500	5	9	3	27	0.1
Quebec	1,800	789	146	120,000	110	207	86	1,040	1.3
Ontario	3,240	1,420	269	216,000	161	316	139	2,000	1.9
Manitoba	5,570	1,130	183	17,320	10	24	14	132	0.2
Saskatchewan	282	123	22	18,700	12	27	16	142	0.2
Alberta	1,100	481	89	73,200	50	104	53	631	1.0
British Columbia	1,030	449	83	68,400	63	118	49	590	1.0
Yukon & NWT	0	0	0	0	0	0	0	0	0
Canada	14,005	4,814	862	569,980	487	938	404	4,970	6.5

Figure 3.5 Annual (2000) Provincial Hot-Mix Asphalt Particulate Emissions

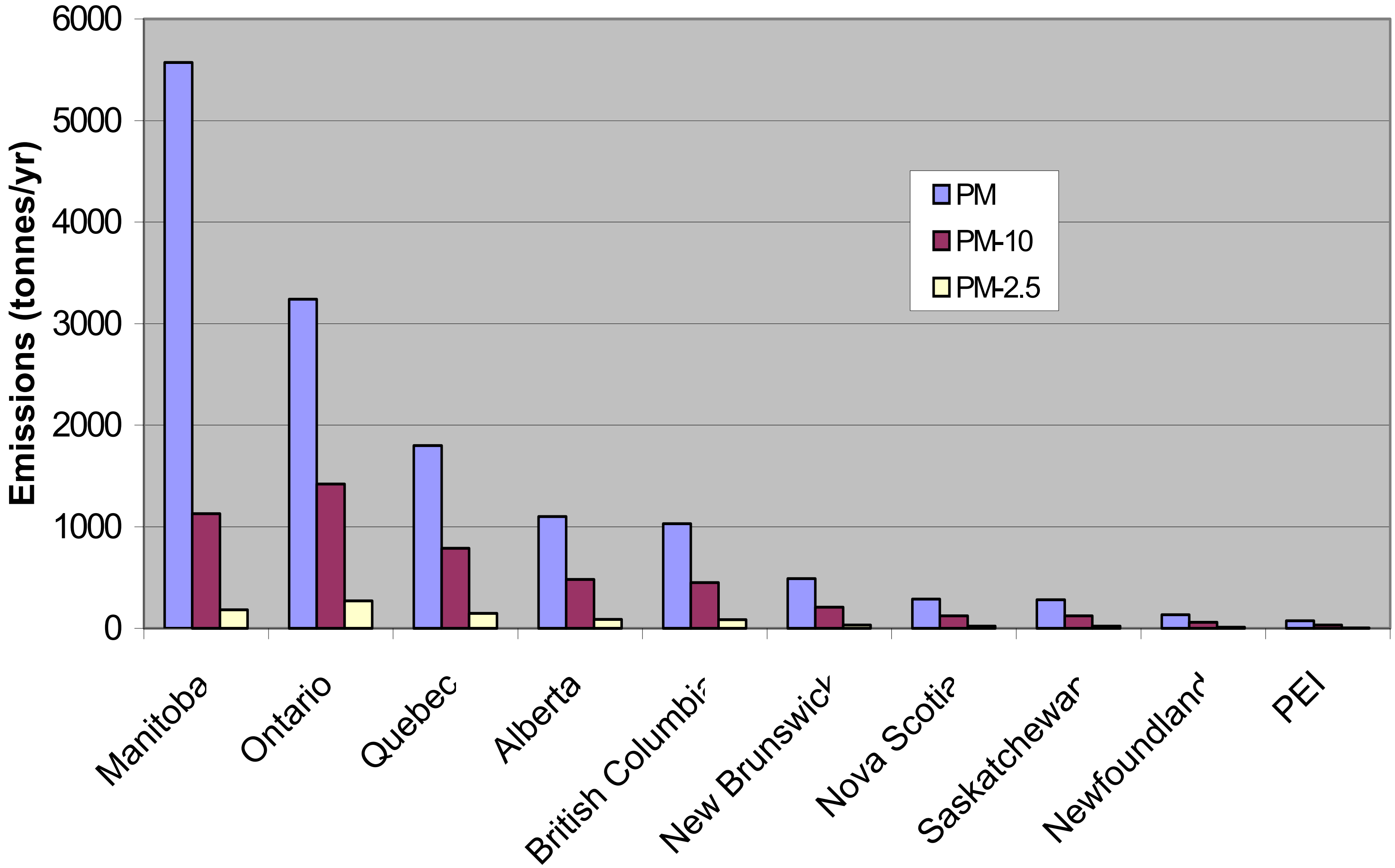
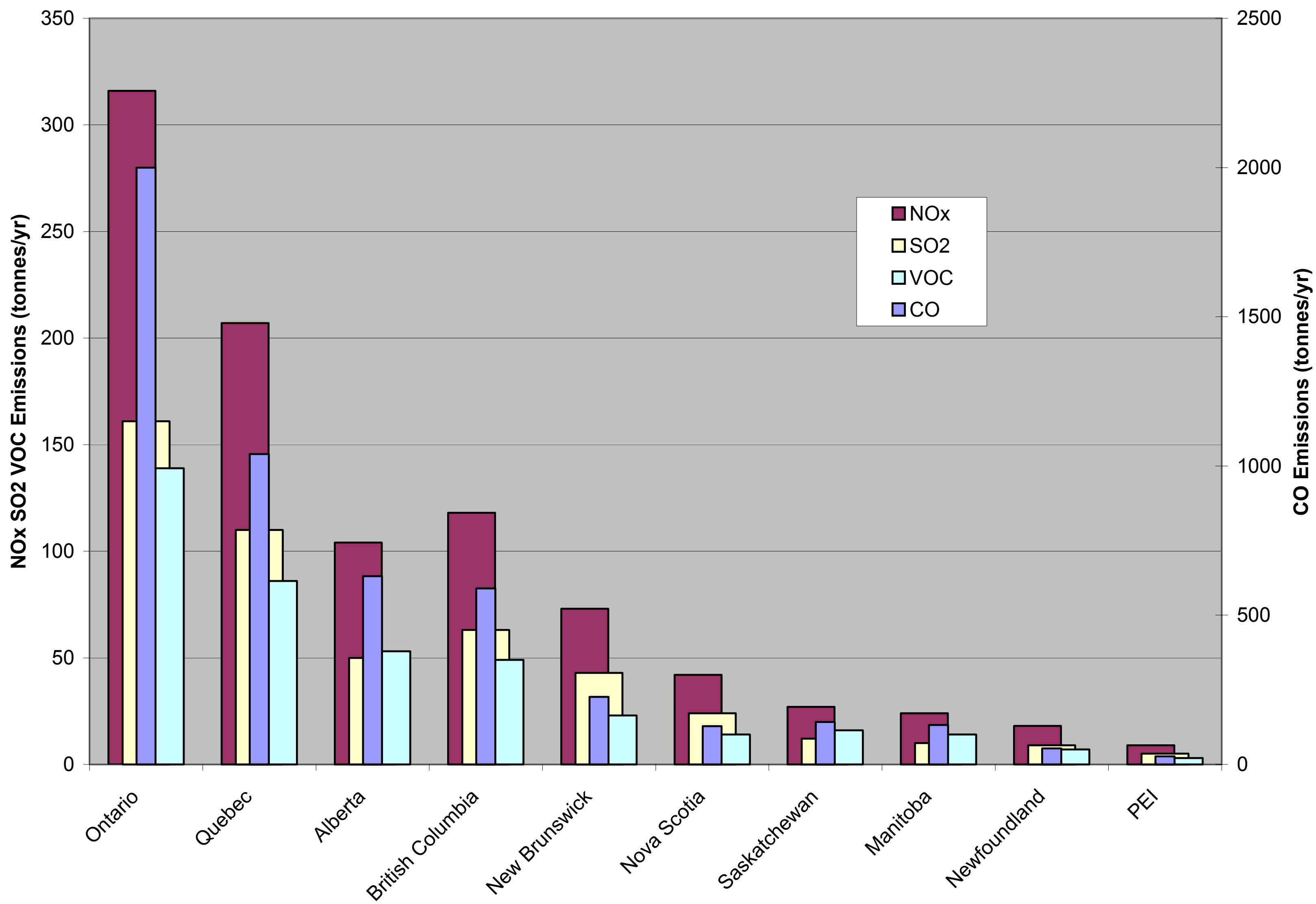


Figure 3.6 Annual (2000) Provincial Hot-Mix Asphalt Gaseous Emissions



Emissions were also calculated to illustrate the magnitude of emissions from a hypothetical batch plant and a hypothetical drum plant each with an annual HMA production of 100,000 tonnes. This data is shown in Tables 3.9, 3.10, 3.11 and 3.12 and Figures 3.7 and 3.8. These calculations showed that the main source of particulate is from the unpaved roads, followed by the batch plant dryers and mixing towers, paved roads, and the receipt of the raw aggregate.

The combustion gases of carbon dioxide, sulphur dioxide and nitrogen oxides are emitted from the batch plant dryers and the drum mixers. VOC emissions, in decreasing order of magnitude are the drum mixers, batch dryers, mixing towers, silo filling operations, and HMA truck load-out. Carbon monoxide is emitted primarily from the batch plant dryers. PAHs are emitted mainly by the storage silos and drum mixers that are fired by light fuel oil. The emissions example for a drum plant, Table 3.11, assumes the plant uses natural gas. If the drum plant were operated with fuel oil, the PAH emissions would nominally increase by 0.0062 tonnes/year. PAHs are dependent on the HMA temperature. Increasing or decreasing the HMA temperature will directly affect emissions, although only by a small amount.

Table 3.9 Emissions for a Hypothetical Batch HMA Plant - Particulate Emissions

Process	Information		Annual Emissions tonnes/y		
Plant Type	Batch				
Production:	100,000 tonnes/year HMA		PM	PM_{10}	$PM_{2.5}$
Aggregate:	95,000 tonnes/year				
	Receipt of aggregate to storage piles		2.09	2.09	0.06
	Transfer of aggregate from storage piles to bins and from bins to conveyors and between conveyors, 5 transfer points		0.01	0.01	
	Aggregate screening		0.042	0.042	
	Front-end	100m per trip, 4 tonnes transported per trip	13.00	5.42	0.83
	Loader	Silt content = 8.4%			
	Unpaved roads,	Weight = 6 tons			
		Moisture = 3%			
		Vehicle speed = <15 km/h			
Asphalt Cement:	5,000 tonnes/year				
	Tank temperature = 145 C (290 F)				
	One 68,000 L (18,000 US	Gal) tank			
Dryer and Mixing Tower	Fuel: Oil				
	Particulate Control: Wet Scrubber		7.00	4.46	1.37
Storage Silos & Load-out	HMA load-out temperature = 145 C (290 F)		0.02	0.02	0.02
	Asphalt loss on heating = 0.5%		0.02	0.02	0.02
On-Site HMA Trucking	Unpaved roads,	200m per trip, 20 tonnes transported per trip	22.00	9.20	1.40
	(Rural plants)	Silt content = 8.4%			
		Weight = 22 tons			
		Vehicle speed = <15 km/h			
	Paved Roads,	300 m per trip, 20 tonnes transported per trip	3.74	0.72	0.17
	(Rural plants)	Silt content = 3 gm/m^2			
		Moisture = 3%			
		Vehicle speed = <15 km/h			
	Paved Roads	100 m per trip, 20 tonnes transported per trip	1.25	0.24	0.06
	(Urban plants)	Silt content = 3 gm/m^2			
		Moisture = 3%			
		Vehicle speed = <15 km/h			

Total - Urban Plant	23.43	12.30	2.34
Total - Rural Plant	47.92	21.98	3.85

Table 3.10 Emissions for a Hypothetical Batch HMA Plant - Gaseous Emissions

Process	Information	Annual Emissions tonnes/y					
		CO	**NO_X**	**SO_2**	**CO_2**	**VOC**	**PAH**
Plant Type: Production:	Batch 100,000 tonnes/year HMA						
Asphalt Cement:	5,000 tonnes/year Tank temperature = 145°C (290°F) One 68,000 L (18,000 US Gal) tank					0.02	0.002
Dryer & Mixing Tower	Fuel: Oil	20.0	6.00	8.80	1850	0.41	0.0055
Storage Silos & Load-out	HMA load-out temperature = 145°C (290°F) Asphalt loss on heating = 0.5%	0.03 0.04				0.33 0.11	0.037 0.065
Total		20.07	6.00	8.80	1850	0.87	0.051

Figure 3.7 Hypothetical Batch Plant Emission Points

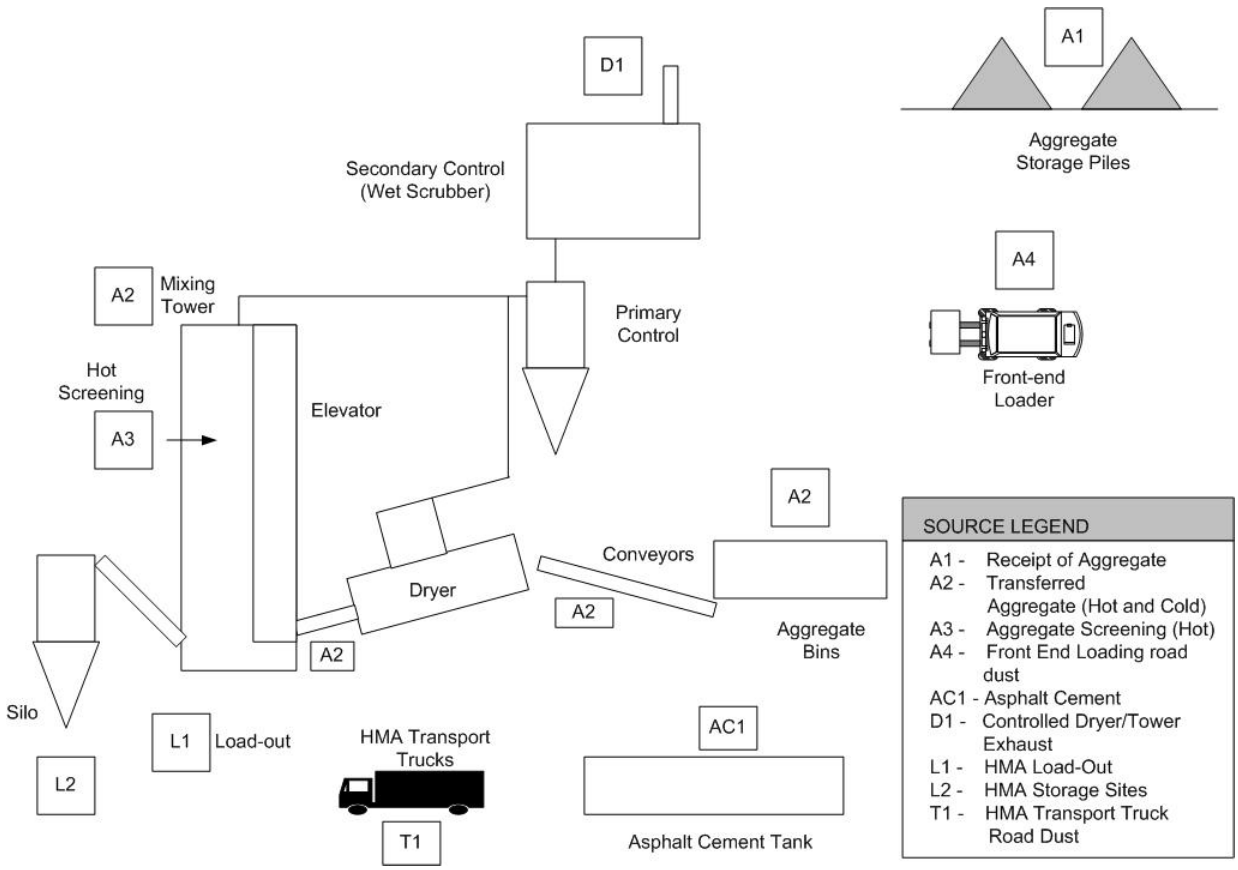


Table 3.11 Emissions for a Hypothetical HMA Drum Plant - Particulate Emissions

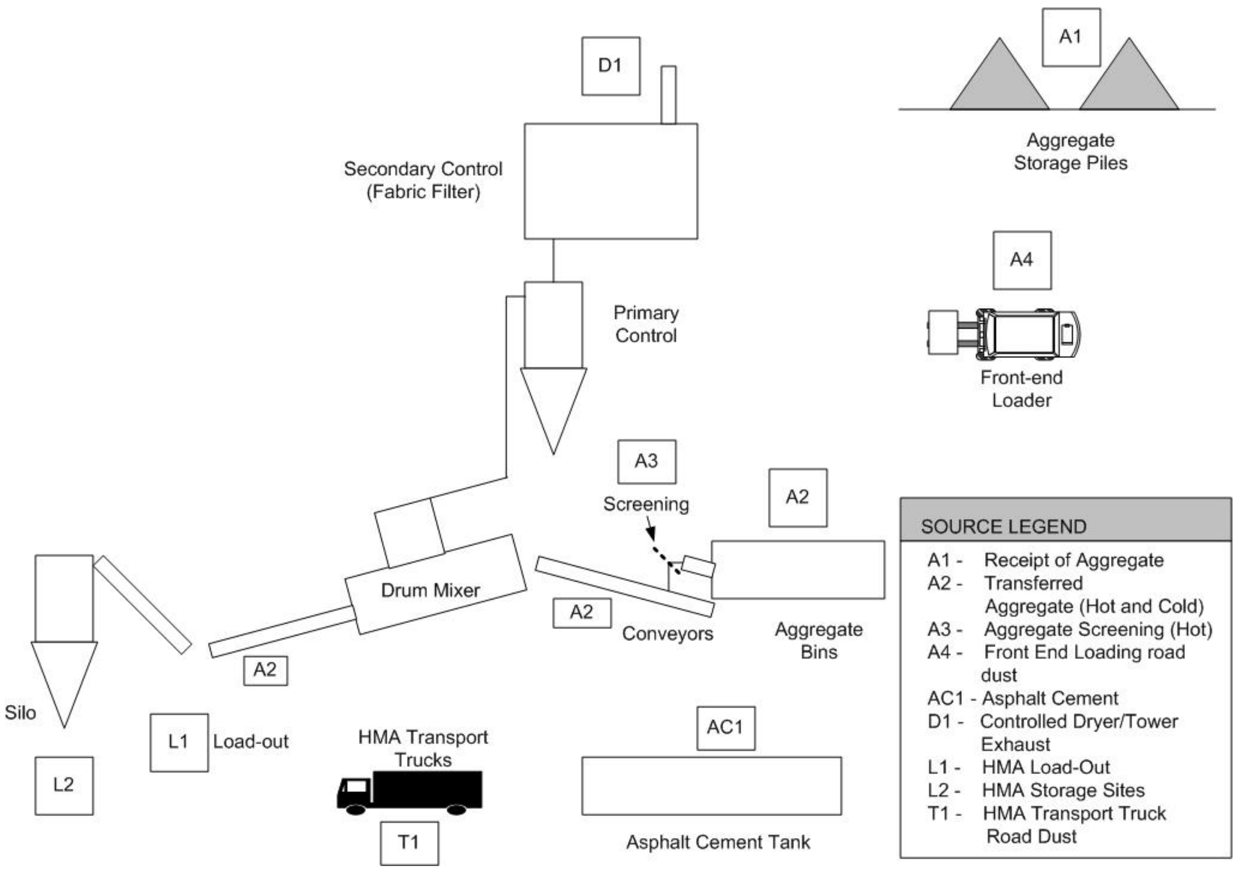
Process	Information		Annual Emissions tonnes/y PM	PM_{10}	$PM_{2.5}$
Plant Type:	Drum				
Production:	100,000 tonnes/year HMA				
Aggregate:	95,000 tonnes/year				
	Receipt of aggregate to storage piles		2.09	2.09	0.06
	Transfer of aggregate from storage piles to bins and from bins to conveyors and between conveyors, 5 transfer points		0.01	0.01	
	Aggregate screening		0.04	0.04	
	Front-end Loader	100m per trip, 4 tonnes transported per trip Silt content = 8.4%	13.00	5.42	0.83
	Unpaved roads,	Weight = 6 tons Moisture = 3% Vehicle speed = <15 km/h			
Asphalt Cement:	5,000 tonnes/year Tank temperature = 290°F One 18,000 US Gal tank				
Drum Mixer	Fuel: Natural Gas				
	Particulate Control: Fabric Filter		1.65	1.15	0.15
Storage Silos & Load-out	HMA load-out temperature = 290°F		0.02	0.02	0.02
	Asphalt loss on heating = 0.5%		0.02	0.02	0.02
On-Site HMA Trucking:	Unpaved roads,	200m per trip, 20 tonnes transported per trip	22.00	9.20	1.40
	(Rural plants)	Silt content = 8.4% Weight = 22 tons Vehicle speed = <15 km/h			
	Paved Roads,	300 m per trip, 20 tonnes transported per trip	3.74	0.72	0.17
	(Rural plants)	Silt content = 3 gm/m2 Moisture = 3% Vehicle speed = <15 km/h			
	Paved Roads	100 m per trip, 20 tonnes transported per trip Silt content = 3 gm/m2 Moisture = 3% Vehicle speed = <15 km/h	1.25	0.24	0.06

	PM	PM_{10}	$PM_{2.5}$
Total – Urban Plant	18.44	9.35	1.11
Total – Rural Plant	42.93	19.02	2.63

Table 3.12 Gaseous Emissions for a Hypothetical HMA Drum Plant

Process	Information	Annual Emissions tonnes/y					
		CO	NO_X	SO_2	CO_2	VOC	PAH
Plant Type: Production:	Drum 100,000 tonnes/year HMA						
Asphalt Cement:	5,000 tonnes/year Tank temperature = 145°C (290°F) One 18,000 US Gal tank					0.02	0.0019
Drum Mixer	Fuel: Natural Gas	6.50	1.30	0.17	1650	1.6	0.0095
Storage Silos &	HMA load-out temperature = 145°C (290°F)	0.03				0.33	0.037
Load-out	Asphalt loss on heating = 0.5%	0.04				0.11	0.0065
	Total	6.57	1.30	0.17	1650	2.06	0.055

Figure 3.8 Hypothetical Drum Mix Plant Emission Points



The total emissions from the hot-mix asphalt were compared to the total industrial sector emissions for the year 2000, as shown in Table 3.13.

Table 3.13 Contribution of Emissions from the Hot-Mix Asphalt Sector to all Industry Sectors - HMA Annual Production 33.3 million tonnes/year

Pollutant	Total Industrial Emissions(1) (ktonnes/y)	Hot-Mix Asphalt Emissions(2) (ktonnes/y)	Hot-Mix Asphalt Contribution to Industrial Emissions (%)
PM	621	14.0	2.2
PM_{10}	287	4.8	1.6
$PM_{2.5}$	172	0.9	0.5
SO_x	1,950	0.5	<0.1
NO_X	620	0.9	0.1
VOC	940	0.4	<0.1
CO	2,177	5.0	0.2
CO_2(3)	38,000	570	1.5

Notes:

1. Emissions are for year 1995 from Environment Canada's Criteria Air Contaminants Inventory (residual Discharge Information System)
2. Emissions are for year 2000 as determined in this study
3. Emissions are for year 1997 from Canada's Greenhouse Gas Inventory. Note that industry sectors in the Greenhouse Gas Inventory are not the same as those in the Criteria Air Contaminants Inventory.

Most of the PM, PM_{10} and $PM_{2.5}$ is emitted from paved and unpaved road fugitive sources rather than the HMA process sources when the processes are controlled. Table 3.14 shows the HMA sector pollutant emissions and the emissions from other industrial sectors and open sources. It is apparent that the HMA sector is very small in comparison. The same trend is apparent for the other pollutants.

Table 3.14 Hot-Mix Asphalt Sector, Other Industrial Sectors and Open Source Emissions (ktonnes/year, 2000)

Pollutant	Hot-Mix Asphalt Sector	Largest Industrial Sector	Other Industrial Sector	Open Sources
PM	14.0	160 (Wood Industry)	292 (Others)	15,716 (Total)
PM_{10}	4.8	88 (Wood Industry)	83 (Others)	4,610 (Total)
$PM_{2.5}$	0.9	52 (Wood Industry)	35 (Others)	580 (Total)
SO_2	0.5	670 (Non-Ferrous Mining & Smelting)	38 (Cement & Concrete)	
NO_X	0.9	339 (Upstream Oil & Gas)	40 (Cement & Concrete)	
VOC	0.4	774 (Upstream Oil & Gas)	10 (Chemical)	
CO	5.0	733 (Wood Industry)	28 (Cement & Concrete)	

3.4.3 Emissions Summary

The emissions in this report are a best estimate of national and regional emissions from the Canadian Hot-Mix Asphalt Sector. The emission factors used were based on the updated AP-42 emission factors, which were developed from a database of over 300 tests that were representative of this industry. These emission factors are most appropriately used to estimate emissions for a large population of facilities.

The estimates used assumptions based on best estimates of hot-mix asphalt production, the type of plants, the type of fuel, the control equipment and whether the plant road surfaces are paved or unpaved. Even though the actual hot-mix asphalt sector operations and emissions may differ from these best estimates, the predicted emission trends are considered valid.

When compared to national emissions of other industrial sectors and to open area sources, the emissions from the Hot-Mix Asphalt Sector are very small. Since the emissions are directly related to production, most of the emissions are released in the provinces of Ontario, Quebec, Alberta, and British Columbia.

On-site vehicle traffic on paved and unpaved roads is the main source of dust emissions, rather than the HMA process sources, when these are controlled. Controls on process dryers and mixers and material handling operations minimize these otherwise significant sources of particulate emissions.

4 Current Emission Standards and Management Practices

4.1 Emission Standards

4.1.1 Canadian Regulatory Requirements

Environmental protection legislation and regulations in most Canadian jurisdictions address hot-mix asphalt plants, either through general enabling legislation or by specific hot-mix asphalt requirements as shown in Table 4.1. Manitoba, Saskatchewan, and Alberta also have hot-mix asphalt guidelines or codes of practice which are referenced during asphalt plant permitting[21,22,23].

In Manitoba, permanent HMA plants, that remain at one location for more than one year, are listed as Class 1 development under the Manitoba Environment Act. These permanent plants are licensed under the Act for control of emissions. Air pollutants that specifically would be addressed are particulate matter and opacity, noise and odour nuisance, and on-site fugitive dust release. Temporary HMA plants, which are located at sites for fewer than 365 days, are not licensed but are subject to siting guidelines and generally do not have particulate emission controls.

The Saskatchewan guidelines determine the siting requirements of hot-mix asphalt plants based on emissions. Plants that meet emissions criteria for the dryer exhaust gas with concentration of less than 250 mg/Rm^3, and that have emissions with an opacity not exceeding 20% and have insignificant particulate fugitive emissions can be located in urban centres with populations of greater than 1,000. Plants that do not meet these criteria must be located at specified distances from cities, recreational parks, small towns and residences or businesses.

The Alberta Code of Practice outlines the minimum environmental requirements for asphalt plants operating under registered permits. The Code outlines owner/operator responsibilities, pollution control technology, operational requirements, record keeping and reporting. The dryer/drum mixer exhaust must meet particulate emission criteria of less than 40% opacity, averaged over 6 months. Stack gas particulate concentrations are limited to less than 0.20 grams per kg of exhaust stack gases, and the plant shall not cause an offensive odour. Fugitive emissions can not cause an adverse effect. If a baghouse is used for control, tracer leak tests have to be conducted at least once every 200 hours of operation.

[21] Saskatchewan, *Asphalt Plant Guidelines*
[22] Manitoba, *Temporary Asphalt Plant Siting Guidelines,* Union of Manitoba Municipalities, Dept. Of Conservation, Dept. of Highways and Transportation, Manitoba heavy Construction Association, July 1996
[23] Alberta Environmental Protection, *Code of Practice for Asphalt Paving Plants,* Substance Release Regulation (A.R. 124/93) under the Environmental Protection and Enhancement Act

Table 4.1 Summary of Canadian Hot-Mix Asphalt Production Regulations

Province/Region	Act/Regulation	Summary	Pollutants Specified
British Columbia	Waste Management Act B.C. Reg 217/97	Asphalt Plant Reg	CO, Organics, Opacity, PM
GVRD	Bylaw No. 937, 1999	Permitting of Asphalt Plants	CO, Organics, Opacity, PM
Alberta	Environmental Protection and Enhancement Act Substance Release Reg. AR 124/93	Code of Practice for Asphalt Paving Plants	PM, Opacity
Saskatchewan	Clean Air Regulations Chap. 12.1, Reg 1, 1989	Asphalt Plant Guideline	Opacity
Manitoba	Environment Act	Air Emissions Temporary Asphalt Plant Siting Guidelines	Opacity, PM
Ontario	Environmental Protection Act O. Reg 346, O. Reg. 349	Hot-Mix Asphalt Facilities	Opacity, PM
	O. Reg 127	Air Quality Emissions Reporting	
Quebec	Environmental Quality Act Q-2, r.25	Regulation respecting hot-mix asphalt plants	Opacity, PM
New Brunswick	Clean Air Act N.B. Reg 97-923	Permitting	PM, CO, SO_2,NO_x, TNMHC
Nova Scotia	Environment Act N.S. Reg 47/95 N.S. Reg 55/95	Permitting Permitting	Air Quality
PEI	Environmental Protection Act	Guidelines for Asphalt Plants	PM, CO, SO_2, NO_x
Newfoundland	Environment Act Air Pollution Control Regs. 957/96	Air Quality	
NWT	Environmental Protection Act R.R.N.W.T. c.E-23	Consolidation of Asphalt Paving Industry Regulations	PM, Opacity

For the permitting of hot-mix asphalt plants in New Brunswick, specific asphalt plant conditions have been established. These conditions govern fugitive particulate control and stack gas emission testing. Aggregate storage piles must be limited in size to minimize fugitive emissions, vehicle road dust must be controlled, and good housekeeping practices must be employed to minimize dust emissions from raw materials handling.

The stack emission limits in New Brunswick's regulation are: particulate matter – 200 mg/m^3, carbon monoxide – 1,000 mg/m^3, sulphur dioxide - 250 mg/m^3, nitrogen oxides - 150 mg/m^3 and total non-methane hydrocarbons – 100 mg/m^3.

The specific hot-mix asphalt regulations of Quebec, Ontario, British Columbia and NWT/Nunavut cover emissions limits, emissions testing, siting, particulate control, fugitive dust management, equipment operation and maintenance and noise limits[24,25,26,27]. The Ontario Ministry of the Environment has also published a Code of Practice for asphalt plants[28].

The Quebec regulation differentiates between existing and new plants and the emission limits are a function of the HMA production rate. The emission standards for PM ranges from 23-30 kg/hours for existing asphalt plants and 1.5-10.7 kg/hour for new asphalt plants. These standards refer to plants with a rate of production between 50-400 metric tons/hour.

B.C.'s regulation was published in June, 1997 and sets maximum allowable numerical emission limits for particulates, organics, opacity, and CO. Revisions to the 1997 Regulation, including proposed amendments, have been circulated to industry for comment, with the intent to publish the revised Regulation in late 2002. It is the most stringent among Canadian jurisdictions. The emission limits differ for existing and new plants and for plants located within the Lower Fraser Valley and those operating outside this geographical area. The maximum allowable PM concentration is 120 mg/m^3 for plants operating outside the Lower Fraser Valley up to January 1, 2003 when a 90 mg/m^3 limit becomes effective. Within the Greater Vancouver metropolitan area, the Greater Vancouver Regional District, the local air management authority, sets 90 mg/m^3 as the limit in permits for existing facilities.

B.C.'s regulation also covers hot-in-place asphalt recycling plants and cutback asphalt.

[24] Quebec, *Regulation respecting hot-mix asphalt plants,* (Quebec Reg. Q-2, r.25)
[25] Ontario, *Hot-Mix Asphalt Facilities,* R.R.O. 1990 Reg. 349 under the Environmental Protection Act.
[26] British Columbia, *Asphalt Plant Regulation,* B.C. Reg. 217/97 under the Waste Management Act, deposited June 27, 1997
[27] NWT, *Consolidation of Asphalt Paving Industry Regulations,* R.R.N.W.T. 1990,c.E-23 under the Environmental Protection Act
[28] Ontario Ministry of Environment and Energy, *Asphalt Plant Code of Practice,* Section 4.4 Air Pollution Control Technology, Science and Technology Branch, 1st Draft, September 20, 1993

In a report dated April, 2001 entitled, *Preliminary Review of the Asphalt Plant Regulatory Program*, prepared for the then B.C. Ministry of Environment, Lands and Parks (re-named in 2001 to B.C. Ministry of Water, Land and Air Protection), it was noted that testing requirements were not being adhered to. This resulted in industry concerns over possible inequities and the absence of a level playing field as it pertains to monitoring. An important consideration is that the industry is diverse in its make-up, comprising small to large operators, fixed and mobile plants, and locations that vary from urban centres to remote areas of the province. The report made the following recommendations:

- Consider amendments to the regulation that reflect noted areas for improvement;
- Promote industry-wide testing and establish benchmarks;
- Establish a central data base for monitoring results;
- Assess the state of the industry for a stewardship model;
- Establish guidelines for regional enforcement activities; and
- Explore a transition towards industry stewardship.

The pollutants covered by the emission limits include particulates, carbon monoxide, organics and opacity. Particulates in the exhaust gases are limited to 90 mg/m^3 in British Columbia (new plants) and 230 mg/m^3 in Ontario and NWT/Nunavut. Opacity of the stack exhaust gases must not exceed 20% in British Columbia, Ontario, Quebec, and NWT/Nunavut. The British Columbia regulation referred to existing and new plants at the time of introduction of the regulation with existing plants eventually being required to meet the new plant requirements. Since the regulation was introduced in 1997, the existing plants of 1997 will be required to meet the new plant emission limits as of January 1, 2003. The British Columbia organics and carbon monoxide new plant limits are 60 mg/m^3 and 200 mg/m^3, respectively.

The Quebec regulation also requires that process material transfer points be enclosed and ducted to the dust control equipment, that dust collector fines be handled so as not to generate airborne dust and that on-site roads be paved and cleaned or dust suppression products be used to minimize on-site dust generation. British Columbia's regulation also states that dust collector fines be handled so as not to generate airborne dust, that stack emissions tests be performed annually, and that daily inspections be performed on emission control equipment.

In addition to the Ontario air pollution regulation for hot-mix asphalt plants (ON Reg 349) and air quality (ON Reg 346) a new regulation was introduced in 2001 that requires mandatory emissions reporting (ON Reg. 127). The reporting regulation covers the same pollutants that plants have to report under Environment Canada's National Pollutant Release Inventory (NPRI) program starting with calendar year 2002. The pollutants that require reporting, providing they exceed the annual emission quantity thresholds, include PM, PM_{10}, $PM_{2.5}$ and PAH. Reporting threshold limits for these pollutants are 10,000 kg/y for PM, 500 kg/y for PM_{10}, 300 kg/y for $PM_{2.5}$, and 50 kg/y for total PAH.

In addition to these provincial and territorial regulations the Greater Vancouver Regional District (GVRD) has air management authority for permitting industrial sources including asphalt plants in their jurisdiction under a bylaw[29]. The permits of this bylaw authorize the operation of the process equipment and require emissions limits and annual testing similar to those required by the Province of British Columbia.

A summary of hot-mix asphalt regulations by source category is presented in Table 4.2.

4.1.2 US and International Standards

In 1986 the U. S. Environmental Protection Agency (EPA) published amendments to its 1977 *Standards of Performance Hot-Mix Asphalt Facilities*[30]. These standards limit particulate emissions to 90 mg/dm^3 and opacity to 20%. The state agencies implement these standards as required under the Clean Air Act.

The majority of the states have adopted these new sources performance standards. States may require more stringent controls that minimize emissions in non-attainment areas and to protect pristine air quality in certain attainment areas. In cases where plants are located in sensitive areas, Lowest Achievable Emission Reductions (LAER) may be applied. The Best Available Control Technology (BACT) for particulate matter is fabric filters that are capable of achieving emissions to less than 20 mg/dm^3. Permitting and operational requirements also include fugitive material handling controls. Approved design for dust control involves the enclosure of conveyors, transfer points, screening equipment with venting to a baghouse or wet scrubber. Water sprays with chemical suppressants for these emission points and also for aggregate storage piles and site roads are also acceptable dust suppression methods. Examples of two California air quality districts' (Bay Area, and South Coast) asphalt and fugitive dust control requirements are presented in Table 4.2.

Recently the US EPA announced changes in the list of categories of major sources emitting hazardous air pollutants (HAPs) and categories of area sources warranting regulation. After studying the emissions of HAPS from Asphalt Concrete Manufacture, it was decided that the emissions of an individual plant would be less than the EPA annual emission trigger for HAPs. The annual emission triggers for HAP are 10 tons per year for any individual HAP or 25 tons per year for three or more HAP. Based on this evaluation, the EPA Administrator decided to de-list Asphalt Concrete Manufacture from the national emission standards for hazardous air pollutants (NESHAP) program[31].

[29] GVRD, *Air Quality Management Bylaw No. 725*
[30] U.S CFR Title 40, Part 60, Subpart I –*Standards of Performance for Hot-Mix Asphalt Facilities.*
[31] U.S. Federal Register, February 12, 2002, http://www.epa.gov/ttncaaa1/t3/fr_notices/rsclu_2002.pdf

Requirements of the Swedish Environmental Protection Agency state that the stack exhaust limit for particulate matter is 20 mg/Rm^3, that aggregate storage piles should be protected from the wind, that road surfaces should be paved or watered and that fabric filters should be properly maintained[32].

In Germany, emission guidelines have been established for reducing emissions from hot-mix asphalt production[19]. These emissions guidelines address organic material, total dust, benzene, sulphur oxides, nitrogen oxides, and carbon monoxide.

[32] Swedish Environmental Protection Agency, *Asphalt and Oil-Gravel Plants Industry fact Sheet, Section 35.26C of the Environmental Protection Ordinance (1989.364) August 1991*

Table 4.2 Summary of Hot-Mix Asphalt Regulations by Source Category

Source	Pollutant Control Requirement		Jurisdiction
	PM (mg/m^3)	Gases	
Batch Dryer or Drum Mixer			
	120	CO - 120 mg/m^3	B.C. – Existing Plants
		Organics – 120 mg/m^3	B.C. – Existing Plants
	90	CO – 200 mg/m^3	B.C. – New Plants
		Organics – 60 mg/m^3	B.C. – New Plants
	250		Saskatchewan
	230		Ontario
	200	CO - 1,000 mg/m^3	New Brunswick
		TNMHC – 100 mg/m^3	New Brunswick
		NO_x – 150 mg/m^3	New Brunswick
		SO_2 – 250 mg/m^3	New Brunswick
	90		EPA NSPS
	20		Sweden
	20	CO – 500 mg/m^3	Germany
		NO_2 – 200 mg/m^3	Germany
		VOCs – 50 mg/m^3	Germany
		SO_2 – 500 mg/m^3	Germany
Batch Dryer			
	23 mg/m^3 PM_{10}	CO – 265 ppmv @ 15% O_2 dry	Bay Area AQMD, CA
		NO_2 – 12 ppmv @ 15% O_2 dry	Bay Area AQMD, CA
		VOCs – 60 mg/m^3 @ 16% O_2 dry	Bay Area AQMD, CA
Drum Mixer			
	23 mg/m^3 PM_{10}	CO – 133 ppmv @ 15% O_2 dry	Bay Area AQMD, CA
		NO_2 – 12 ppmv @ 15% O_2 dry	Bay Area AQMD, CA
		VOCs – 60 mg/m^3 @ 16% O_2 dry	Bay Area AQMD, CA
Enclosed or Ducted Dust Control at Material Transfer Points			
	120		B.C. – Existing Plants
	90		B.C. – New Plants
	250		Saskatchewan
	230		Ontario
	200		New Brunswick
	90		EPA NSPS
	23		Bay Area AQMD, CA
	20		Sweden
	20		Germany

Table 4.2 Summary of Hot-Mix Asphalt Regulations by Source Category, cont'd.

Source	Control Technique	Jurisdiction
Particulate Fugitive Sources:		
Aggregate Storage Piles		
	Minimize pile size, good housekeeping	New Brunswick
	Control of fugitive dust	Quebec
	Protect from the wind	Sweden
	Store in silos **or** 3-sided Enclosures	Germany
	Moisture Control **or** Temporary Coverings **or** Chemical Stabilizers **or** 3-sided Enclosures	South Coast AQMD, CA
	Water spray and chemical suppressants	Bay Area AQMD, CA
Conveyors and Transfer Points		
	Transfer points enclosed and controlled	Quebec
	Water spray or chemical suppressants	Bay Area AQMD, CA
Road Dust		
	Control of road dust	New Brunswick
	Minimize road dust	Quebec
	Control of road dust	Sweden
	Vehicle speed control **and** water sprays	South Coast AQMD, CA
	Water spray **or** chemical suppressants	Bay Area AQMD, CA

4.2 Emission Controls and Management Practices

4.2.2 General

The ensuing sections review and document control technologies and practices, and their performance.

In reviewing the legislation and regulatory and non-regulatory instruments of jurisdictions in Canada, it is apparent that a wide range of emission control practices prevails. In addition to government regulatory actions, several asphalt associations have developed guidelines on practices to promote continuing environmental improvements through voluntary actions of its industry members.

Some jurisdictions have established emission requirements that are more stringent for new plants than for existing facilities. Some jurisdictions require more stringent controls for plants located in urban areas than for plants located in rural areas.

This section presents options that jurisdictions may find helpful when considering provincial, territorial, or regional air management planning priorities and strategies. It is recognized that jurisdictions may consider different levels of environmental protection depending on site-specific circumstances. Small plants operating in small markets in remote areas, and often for limited duration, may not require the stringency of control as might be needed for industry in urban areas where air quality levels periodically exceed the ambient air quality objectives of the Canada-wide Standards. In other cases, stringent controls may be appropriate where plant emissions may impact parks and wilderness areas where pristine air quality is to be protected.

The principle of best available control technologies and practices is reflected throughout the documentation. This approach is consistent with the guidance provided by the CCME which, through the Canada-wide Standards process, seeks to minimize environmental releases of pollutants, toxic substances, and greenhouse gases. Data on capital costs of emission control technologies and fuel burners are provided for reference.

Existing emission requirements of Canadian jurisdictions as well as of international jurisdictions are reviewed. In jurisdictions where emission requirements have been established, these standards are noted for the reader’s reference.

An analysis of the emission reductions are presented to illustrate the sector-wide emissions trends under scenarios of uniformly applied controls.

4.2.3 Best Available Techniques

The management options have to be considered in the context of practical technical and cost considerations, particularly for older plants operating in small markets. The sources of emissions from HMA facilities and typical control methods were described in Section 3 and regulatory requirements were documented in Section 4.1. This section reviews the techniques and management practices in order to identify the best available techniques that are achieved in practice and recommended by various jurisdictions. Table 4.3 summarizes the technologies and practices. Consideration is given to the application of available techniques by presenting options. For example, fabric filters are the preferred technology and is commonly accepted as the best available technology for dryer and drum mixer particulate control. It is recognised, however, that efficient wet scrubbers may be more practical and feasible for rural, remote locations or mobile plants that operate for only short duration.

In addition to add-on control systems, recommendations are also presented for the operation and maintenance of the equipment. Environmental Codes of Practice are an important element of a successful environmental management system.

4.2.3.1 Batch Dryer and Drum Mixer

Emissions from batch dryers and drum mixers are controlled by either wet or venturi scrubbers or fabric filters. Fabric filters are the preferred control technology because they have high particulate removal efficiencies, consume less electrical energy than wet scrubbers, avoid the generation of wastewater requiring treatment, and recover dry dust that can be easily recycled within the process. Fabric filter manufacturers routinely guarantee equipment performance for particulate emissions to less than 0.04 gr/dscf (92 mg/m^3). It is also not uncommon for some fabric filter manufacturers to provide guarantees of less than 0.01 gr/dscf (23 mg/m^3) in order to comply with BACT limits established by some jurisdictions in the U.S. The Bay Area Air Quality Management District (BAAQMD), for example, mandates a requirement of 0.01 gr/dscf (23 mg/m^3). Emission test results from modern fabric filters are regularly reported achieving PM_{10} concentrations in the range from 0.005 to 0.02 gr/dscf (5 to 23 mg/m^3).

High efficiency wet scrubbers are considered best available control technology and may be an acceptable option under certain circumstances. While the comparative efficiency of alternative scrubber systems is somewhat lower than state-of-the-art fabric filters, properly designed, sized and maintained wet scrubbers can achieve emission performances comparable to fabric filters. Wet scrubber systems may be more applicable for the rural location or the mobile, short-duration, plant operation.

New Plants

In considering the best available control technology for batch driers and drum mixers, it is apparent that fabric filters are the control system of choice. Although they can be designed for a wide range of emission performances, modern fabric filters are capable of consistently achieving 20 mg/m^3 or better in practice, although equipment size and cost increase as performance improves. This particulate concentration is established in environmental standards of Germany, Sweden, and the Bay Area Air Quality Management District in California. This performance is applied to plants located in sensitive areas in the U.S. Data from 400 asphalt plants tested in Germany over the period 1989 to 1992 showed an average emission performance of 11 mg/m^3. Manufacturers in the U.S. guarantee emission performances to 20 mg/m^3 and lower. (Reference: personal communication with Astec Corporation, U.S.).

The 1986 U.S. EPA federal standards set an allowable limit of 90 mg/m^3 for plants that were considered “new” when built after June, 1973. This performance standard reflects out of date technology and data. Accordingly, these standards do not serve as an appropriate reference for purposes of establishing new standards today.

Among Canadian jurisdictions, the most stringent particulate standard for new plants built after 1997 is 90 mg/m^3 as established in B.C.’s 1997 regulation. The Provinces of Saskatchewan, Ontario, and New Brunswick established standards with limits of 250, 230 and 200 mg/m^{3,} respectively, although new plants are not distinguished from existing plants. The B.C. standard was based at the time on the U.S. EPA federal standard according to the information provided by B.C.’s representative on the Asphalt Technical Advisory Committee. The rationale on which B.C.’s regulation is based is not a sufficiently convincing argument to consider 90 mg/m^3 as a performance reflecting current technology.

Having regard to the preceding considerations, it is concluded that for new plants an emission performance of 20 mg/m^3 is proven technology.

Existing Plants

Existing control systems at Canadian HMA plants are predominantly fabric filters with performances that vary widely. Some plants in Canada have no controls.

In examining the emission standards of Canadian jurisdictions, B.C.’s 1997 standard is the most stringent and prescribes a maximum allowable particulate concentration of 120 mg/m^3 plants operating up to January 1, 2003 when the 90 mg/m^3 becomes effective. Within the greater Vancouver metropolitan area, the Greater Vancouver Regional District, the local air management authority, sets 90 mg/m^3 as the limit in permits for existing facilities.

Limited emission test date available from seven operating plants in the greater Vancouver metropolitan area in B.C. showed all plants met the 90 mg/m^3 PM standard.

Emission test data was provided by a B.C. operator for two plants located outside the greater Vancouver metropolitan area: one is equipped with a fabric filter and another has a wet scrubber. Recent stack test data showed particulate emissions were less than 40 and 70 mg/m^3 respectively from these two plants.

Test data from seven operating plants in New Brunswick, that process reclaimed asphalt pavement, ranged from 37 to 1,900 mg/m^3. Five of the seven plants were in compliance with the provincial PM standard of 200 mg/m^3. Data from 10 plants that do not process reclaimed asphalt pavement ranged from 13 to 540 mg/m^3 and seven plants were in compliance with the standard.

Emission standards in Germany and Sweden have established a particulate emission performance of 20 mg/m^3 for new as well as existing plants.

If improved emission controls were to be considered for existing plants, beyond maintaining the status quo, technology retro-fits are likely required in many cases. Information within the scope of this study is lacking to be able to determine the number of plants in Canada that may be affected. If emission reductions were desirable, the replacement control systems would be either new and reflect the performance of current technologies or be used fabric filters in order to upgrade from wet scrubber technology. Accordingly, best available control technology when applied to existing plants would apply to new fabric filters which also would be defined by an emission performance of 20 mg/m^3.

Since the preceding source control approach, which is based on best available techniques, does not consider emissions in relation to ambient air quality goals in the vicinity in which plants are located, it may be argued that an emission performance of 20 mg/m^3 would be inappropriate, and particularly not for remote, rural plants. Industry has expressed concerns over consequent increased product costs and competitiveness if environmental controls were made too stringent. Industry has also asserted that governments should justify controls in relation to environmental benefits and air quality particularly when the HMA sector's contribution is so small in relation to the particulate emissions from all industrial sources.

In conclusion, this report makes no recommendation on an emission performance goal for broad application at existing Canadian plants. The information provided herein provides technical information on best available control techniques that jurisdictions may find helpful when establishing allowable emission limits for existing plants.

4.2.3.2 Combustion Gases

The importance of fuel selection, where choices are available, and good combustion practices in minimizing gaseous emissions is well understood by plant operators. While natural gas is a 'cleaner' fuel, its availability is generally limited to larger urban areas, and is not available at most temporary asphalt plant sites or in rural areas. In these instances, the fuel choice is most often limited to fuel oil. Liquefied petroleum gas (LPG) is an option for burners equipped with the appropriate conversion kit. Increases in the price of natural gas in 2001 are also causing some operators to switch, and others are considering switching, from natural gas back to fuel oil, according to industry sources.

Good combustion practices, developed initially through selection of the appropriate burner, proper installation and set-up, and routine maintenance, are important. Optimum operation minimizes emissions, conserves fuel and contributes to economical plant operation and more consistent asphalt paving product quality. The importance of limiting the temperature of aggregate drying and asphalt mixing also cannot be over-emphasized as this can mitigate gaseous emissions and odours.

The HMA industry has developed best practices recommendations, including environmental codes of practice and environmental practices guides (OHMPA for instance[33]), that emphasize the importance of systematic, timely burner calibration and maintenance. This is widely considered to be the most important method of reducing gaseous emissions, and is a recurring topic in the asphalt industry technical literature [Asphalt Contractor, January 2002]. NAPA, in particular, has and continues to provide substantial technical support to the hot-mix asphalt industry, with the publication "The Fundamentals of the Operation and Maintenance of the Exhaust Gas System in a Hot-Mix Asphalt Facility"[34]. This NAPA document provides detailed technical information on gaseous and particulate emissions control and reduction through proper plant and equipment design, set-up, calibration and maintenance. Burner equipment manufacturers and combustion-engineering specialists are also valuable resources available to the plant operators.

The control options that are presented in Table 4.3 for combustion gases reflect prevailing practices of industry and do not add any new, extraordinary or "best" requirements. Adherence to these practices can not be over- emphasized.

[33] Ontario Hot-Mix Asphalt Producers Association, *Environmental Practices Guide for Ontario Hot-Mix Asphalt Plants,* Second Edition March 2000
[34] NAPA, *The Fundamentals of the Operation and Maintenance of the Exhaust Gas System in a Hot-Mix Asphalt Facility,* 2nd Edition, NAPA Information Series 52 (IS-52), revised 1987, reprinted 1995.

4.2.3.3 Particulate Fugitive Sources

There are a number of fugitive dust suppression systems that could be considered, ranging from 'garden hose' technology to water and surfactant sprays, foams and mist/fog generation systems. The simplest and most commonly used method of dust suppression is the application of water. Water may be applied to the top surface by sprayer trucks or sweepers to control dust on roads and storage yards. On unpaved roads, water can be supplemented by use of commercial dust palliatives such as calcium chloride, surfactants or foams. While paving or spreading of RAP millings on hauls roads can significantly reduce dust, some dust is generated regardless, and some form of dust control is still required. Significant reduction in the amount of dust on roads and in storage yards can also be achieved by maintaining vehicle and equipment speeds at less than 15 kph and maintaining the road/yard surface in a relatively smooth condition.

It is important that the aggregates be kept in a continuously moist condition during delivery, stockpiling and transferring to the hot-mix asphalt plant. Sprinklers or low-velocity sprayers are effective for dust control on stockpiles. Water sprays, misting or fogging units can be employed on conveyor belts and at transfer points. The overall objective is to keep the aggregates moist, not wet. Excessive moisture, can promote accumulation of wet, sticky fines on chutes and around transfer conveyors, or cause the aggregates to agglomerate. This impairs the flow characteristics of the material being conveyed; wet aggregates are also more difficult to dry, requiring longer retention time in the dryer that increases energy consumption, fuel costs and gaseous emissions.

Fogging or misting units are effective at optimizing the application of water, and can be used to create a curtain around transfer points so that any dust that becomes airborne becomes surrounded with water and removed from the air stream. Such systems are highly effective and have low installation and operating costs. It is important that the dust control systems be routinely and properly maintained, to ensure that the appropriate flow rates and coverage are consistently achieved.

The State of Texas requires permits that specify BACT for fugitive dust control. The State’s BACT requires that all aggregates be washed prior to delivery, at least 70% capture and control of fugitive dust emissions from aggregate handling, and at least 95% control of fugitive dust from all roads and traffic areas. Although fines are essential in making high quality paving mixtures, it is understood that washing is unique because of the particular characteristics of the aggregates of this region.

It is neither common nor necessary in Canada to require that all hot-mix aggregates be washed prior to delivery, noting that some fines are generally needed to produce a paving product having suitable physical properties.

The control options presented in Table 4.3 for particulate fugitive sources are widely practiced by the HMA industry. The fugitive dust control procedures listed in this table are referenced to jurisdictions where these requirements are specified and are proven to be practical and achievable.

4.2.3.4 PAH and Odour

PAH and odourous compounds are associated with VOC emissions. Although odourous compounds are not considered as smog precursor pollutants, odours associated with HMA activities can be a nuisance concern to neighbors in some areas when prevailing winds impact nearby residences and businesses. Controlling VOC emissions reduces both PAH and odourous compounds. Some jurisdictions take into account the odour issue by considering adjacent land use and population exposure. A unit of measurement for odour, much like a concentration unit of pollutants, also has been adopted by some jurisdictions, with maximum allowable limit of one odour unit set at, either the point of impingement, or the nearest sensitive receptor. This may present a very stringent emission restriction on odorous compounds which will require an odour abatement program.

The main sources of odour and PAH in HMA plants are fumes from asphalt storage tanks, and fumes resulting from overheating or incomplete combustion in the dryer and/or mixer. The heated liquid asphalt cement generates some fumes in the storage tank, which are displaced and vented to the atmosphere when the storage tanks are filled. While various ‘masking agents’ have been developed to alter the malodours, such agents do not eliminate the odour. The result is a generally more pleasant odour (cherry smell for instance), that may also be objectionable to some individuals. Asphalt cement producers are also working to develop low odour asphalt cements by producing asphalt with lower H_2S content.

PAH and odour resulting from refilling of the asphalt cement storage tanks can be mitigated to a significant extent by installation of filters on the storage tank vents. There are several similar vent filters systems available. The filters assist in reducing odours by forcing the fumes to pass through a condensing filter system where any petroleum hydrocarbons in the vapour in the tank are removed before discharging to air. Often, odour complaints can be addressed by simply scheduling storage tank refilling to times when near neighbours are not present (at work) or inside. Electrostatic precipitators have not proven to be effective in the mitigation of odour and are extremely costly.

In addition to the variety of technologies available to mitigate odorous emissions there a number of community and process-related techniques that are important for the on-going success of any odour abatement program. These techniques include controlling the process, a Code of Practice for facility operators, a program of complaint response and effective community relations and land use planning.

PAH and odour generated during the aggregate drying and asphalt cement mixing can be largely dealt with by ensuring that drum temperatures do not exceed the manufacturer's recommended mixing temperatures for the asphalt cement. The burner must be operating at maximum efficiency at all times to ensure complete combustion. Fuel selection is also important, and use of fuels that are observed to be excessively odorous should be avoided (natural gas is less odorous than fuel oil, and therefore where fuel oil must be used, consideration should be given to use of fuel oils that are low in sulphur content). In some cases, the use of liquid anti-stripping additives can generate additional objectionable odours; in such cases, it may be necessary to switch to liquid anti-stripping additives or use hydrated lime.

It is also important that HMA delivery trucks are properly and promptly covered with a tarp immediately upon loading and that spillages are cleaned-up immediately.

Process monitoring and control activities within an odour abatement program can be implemented with a code of practice for facility operators. These codes of practice or operation manuals can be developed and implemented by the facility or a HMA industry organization.

A "Complaint Response Plan" can be initiated by facility operators to improve communication and accountability between surrounding neighbours and the HMA facility. An effective complaint response plan is an extension of the operating procedures of the plant and may include a dedicated local telephone number, record-keeping, co-ordination with plant operating records, follow-up procedures and record keeping and on-going review and approval by the plant management.

In many instances, diligent implementation of a complaint response plan by facility operators can result in improved communication and understanding between the plant and the local community. Establishing a community-relations group may also be useful.

Although land-use planning is not a primary odour abatement technique, poor land-use planning can result in complaints of severe odour problems that even the most effective technology or techniques cannot overcome. Proper land-use planning, such as when siting a portable plant, can be the most effective technique to minimize odour complaints.

The control options presented in Table 4.3 for PAH and odour sources are presently practiced by the HMA industry. Adherence to these practices will minimize emissions and odour complaints

Table 4.3 Best Available Techniques

Pollutant / Source	Control Option	Description	Control Target	Basis of Target
Particulate Matter/ Captured and Controlled Sources				
Stationary Batch Dryers & Drum Mixers	Fabric Filter **Or** Wet Scrubber	Operated following an Environmental Code of Practice Rural locations	Outlet loading of 20 mg/Rm^3 Opacity 20% Annual testing Outlet loading 90 mg/Rm^3	Requirement of Bay Area Air Quality Management District (Bay Area AQMD); Germany; Sweden Opacity and testing required by B.C.
Mobile Batch Dryers & Drum Mixers	Fabric Filter **Or** Wet Scrubber	Operated following a an Environmental Code of Practice Rural locations	Outlet loading of 20 mg/Rm^3 Opacity 20% Annual testing Outlet loading 90 mg/Rm^3	Requirement of Bay Area Air Quality Management District; Germany; Sweden Opacity and testing required by B.C.
Mixing Tower & screens	Capture and duct to Fabric Filter **Or** Wet Scrubber	Operated following an Environmental Code of Practice Rural locations	Outlet loading of 20 mg/ Rm^3 Opacity 20% Annual testing Outlet loading 90 mg/Rm^3	Requirement of Bay Area Air Quality Management District; Germany; Sweden Opacity and testing required by B.C.

Note: Rm^3 is reference cubic metre

Table 4.3 Best Available Techniques (continued)

Pollutant / Source	Control Option	Description	Control Target	Basis of Target
Particulate Matter/Fugitive Sources				
Aggregate Storage Piles	Moisture control **or**	Administered with an Environmental Code of Practice	Apply water to at least 80% of the surface area of all open storage piles on a daily basis or when there is evidence of wind driven dust	Requirement Quebec, South Coast Air Quality Management District (South Coast AQMD) Requirement of Bay Area Air Quality Management District
	Temporary covering **or**	Administered with an Environmental Code of Practice		Requirement of South Coast Air Quality Management District
	Chemical stabilizer **or**	Administered with an Environmental Code of Practice		South Coast AQMD, Bay Area AQMD
	3-sided enclosures		3-sided enclosures with walls with no more than 50% porosity which extend, at a minimum, to the top of the pile.	Requirement of South Coast Air Quality Management District, Germany
Conveyors & Transfer points	Water sprays or mists	Administered with an Environmental Code of Practice		Requirement of Quebec, South Coast AQDM
Unpaved Roads	Control vehicle speed **and** Water spray w/ chemical suppressants	Administered with an Environmental Code of Practice	< 15 kph Water all roads for any vehicular traffic once daily or more frequently if dusting occurs.	Requirement of South Coast AQDM Requirement of New Brunswick, Quebec, South Coast AQDM, Bay Area AQDM
Paved Roads	Control vehicle speed **and** Wet down or vacuum sweep	Administered with an Environmental Code of Practice Municipal agencies will also require water flushing and vacuum sweeping of public roads to minimize track-out of material onto public paved roads	< 15 kph Water flush and vacuum sweep all roads for any vehicular traffic once daily or more frequently if dusting occurs.	Requirement of South Coast AQDM Requirement of New Brunswick, Quebec, South Coast AQDM, Bay Area AQDM

Table 4.3 Best Available Techniques (continued)

Pollutant / Source	Control Option	Description	Control Target	Basis of Target
Odour				
Drums/Dryers	Temperature control	Administered with an Environmental Code of Practice on burner and dryer / drum operation Annual burner calibration by a competent individual to verify operation	Minimize odour complaints through an Odour Abatement Program	Ontario permitting requirement for critical receptors
Load-Out	Truck equipped with tarpaulin **and** clean up spillage **or** Enclosure of truck load-out and duct to dryer/drum mixer	Administered with an Environmental Code of Practice	Minimize odour complaints through an Odour Abatement Program	Ontario permitting requirement for critical receptors
Storage Silos	Enclose silo openings **Or** Vent storage silos to dryer/drum mixer	Administered with an Environmental Code of Practice	Minimize odour complaints through an Odour Abatement Program	Ontario permitting requirement for critical receptors
Asphalt Cement Tank	Tank vent filters (condensers)	Administered with an Environmental Code of Practice	Minimize odour complaints through an Odour Abatement Program	Ontario permitting requirement for critical receptors

Table 4.3 Best Available Techniques (continued)

Pollutant / Source	Control Option	Description	Control Target	Basis of Target
Combustion Gases				
Carbon Monoxide	Good Combustion Practices	Administered with an Environmental Code of Practice Burner and dryer / drum mixer operation Annual burner calibration by a competent individual to verify operation	Exhaust gas limits: • Batch - 265 ppmv @ 15% O_2 Dry • Drum - 133 ppmv @ 15% O_2 Dry • Annual calibration	Requirement of Bay Area AQDM, B.C. New Plants Requirement of Bay Area AQDM, B.C. New Plants Testing required by B.C.
Nitrogen Dioxide	Natural Gas & Low NO_X Combustion System	Administered with an Environmental Code of Practice Burner and dryer / drum mixer operation Annual burner calibration by a competent individual to verify operation	Exhaust Gas limits: • Batch - 12 ppmv @15% O2 Dry • Drum - 12 ppmv @ 15% O2 Dry • Annual calibration	Requirement of Bay Area AQMD Requirement of Bay Area AQMD
Sulphur Dioxide	Natural Gas or Low Sulphur Fuel	Administered with an Environmental Code of Practice Burner and dryer / drum mixer operation Annual burner calibration by a competent individual to verify operation	Natural Gas or Fuel Oil <0.5% S by wt Annual calibration	Requirement of Bay Area AQMD
Volatile Organics	Temperature Control	Administered with an Environmental Code of Practice Burner and dryer / drum mixer operation Annual burner calibration by a competent individual to verify operation	Exhaust Gas Limits • 60 mg/m^3 @16% O_2 Dry **or** • 100 ppmv @ exhaust conditions Annual testing	Requirements of B.C., Bay Area AQMD Testing of total organics required by B.C.

Table 4.3 Best Available Techniques (continued)

Pollutant / Source	Control Option	Description	Control Target	Basis of Target
General				
All pollutant releases to all environmental media	Multi media Environmental Code of Practice	To be developed by through stakeholder consultations	Environmental Code of Practice should be extended beyond emissions to the atmosphere and include wastewater, solid wastes, spill prevention, odour complaints, and any other environmentally relevant considerations	Environmental Practices Guide of the Ontario Hot-Mix Producers Association, the Code of Practice of Alberta Environment, and several Environmental Codes of Practice developed by Environment Canada for other industry sectors would be useful references for content and format
		Regional industry associations have an opportunity to promote voluntary compliance with an Environmental Code of Practice	Training programs for key employees at facilities would be an important element in compliance promotion	Mechanisms need to be developed to measure progress in implementing environmental controls and measuring success of reducing emissions

4.2.4 Analysis of Emission Reductions and Projections

Annual emissions of the pollutants of interest were calculated based on the emissions data developed in Section 3.4. This provided the emission estimate for the Base Case emissions, referenced to year 2000. Industry representatives on the Technical Advisory Network were asked their opinion on possible growth of the HMA sector to year 2020. Industry members were consistent in their opinions that an assumption of an annual growth rate of 2% would be reasonable, but also felt that there may not be any growth over the foreseeable future. The no-growth scenario is consistent with the reasonably constant HMA production during the 10-year period to 2000.

The emission projections were based on two scenarios:

(1) An annual growth of 2 % in HMA production through to 2020 under the assumption that current emission practices remain unchanged at existing facilities and new facilities use the same technologies and practices as existing facilities (Growth with no BAT), and
(2) No growth in HMA production through to 2010 under the assumption that BAT is implemented at existing facilities and new facilities use BAT (No Growth with BAT).

Scenario 1: In this scenario, it was assumed that current emission controls and practices remain unchanged over the 20-year time horizon. Emissions under this business as usual scenario would increase in direct correspondence with the growth in HMA production. As shown in Figure 4.1, the PM emissions would increase about 45% from the emissions in year 2000.

Scenario 2: This scenario assumes that there would be no growth in HMA production to 2010 and best available control technologies would be uniformly applied to the dryer and drum mixer processes and fuel burners, while for fugitive sources management practices would be implemented to minimize dust generation. As shown in Figure 4.2, the PM emissions would decrease about 81% relative to the emissions in year 2000.

The reference year emissions in year 2000 were calculated using emission factors for the batch dryers and the drum mixers that are representative of plants with exhaust concentrations of particulate (PM) typically in the range of 70 mg/m^3 to 110 mg/m^3. The emission reduction scenario for these sources is for a potential decrease of 33% or a reduction of particulate concentrations to a range of 45 mg/m^3 to 75 mg/m^3. For the fugitive emissions and the gaseous emissions, it is assumed that the Base Case emissions represent the application of an 80% control practice. The reduction scenario assumes an increase in the control practice efficiency to 95% control. In order to project the impact of these reductions, it was assumed that these reductions would be applied to 50% of the plants by 2005 and to 100% of the plants by 2010. These emissions reduction projections, for a no-growth production situation, are presented in Figure 4.2 for the years 2000, 2005 and 2010. Emissions would continue after 2010 at the 2010 values for no growth in production.

Figure 4.1 Emissions Projection, 2000 to 2020

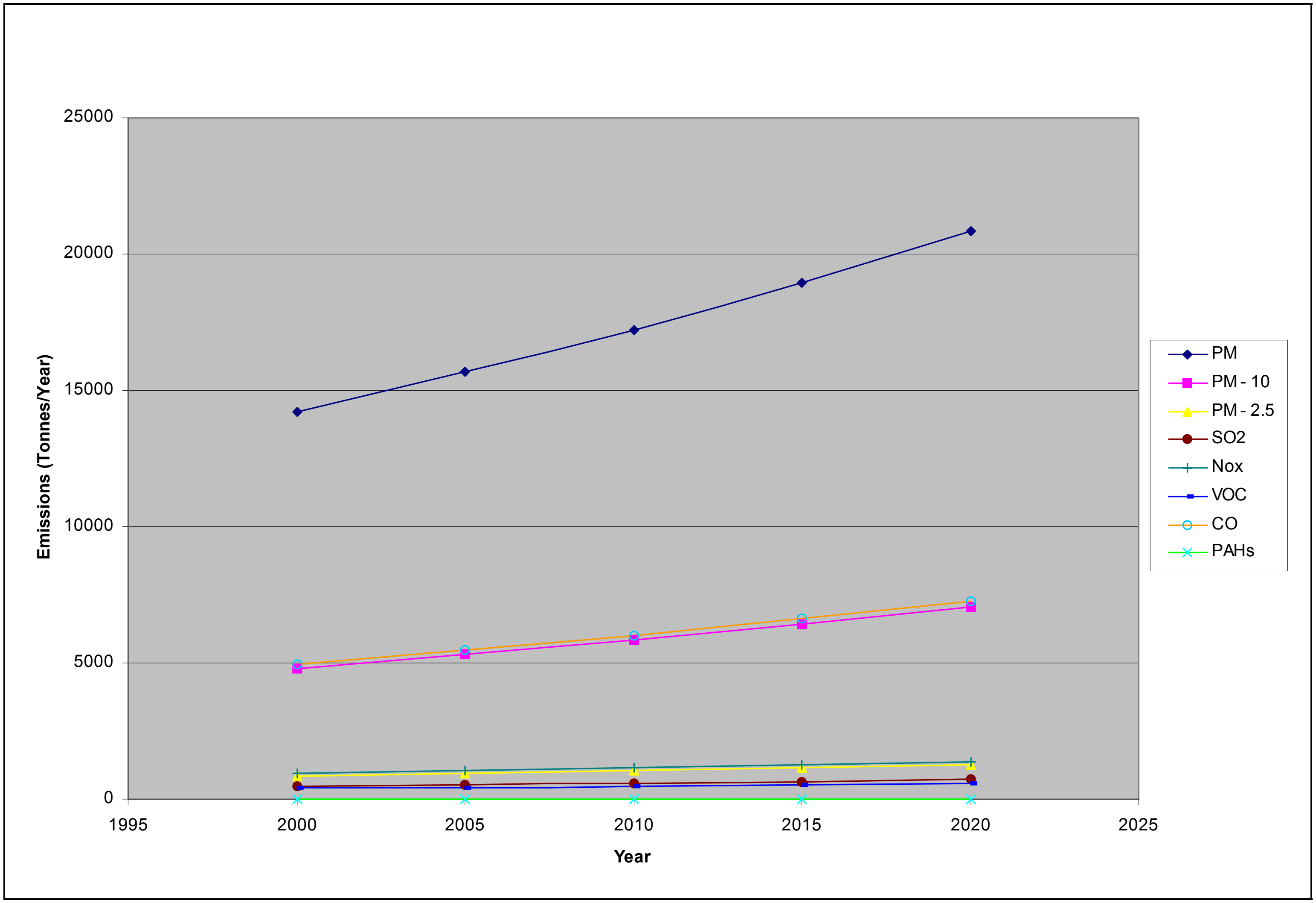
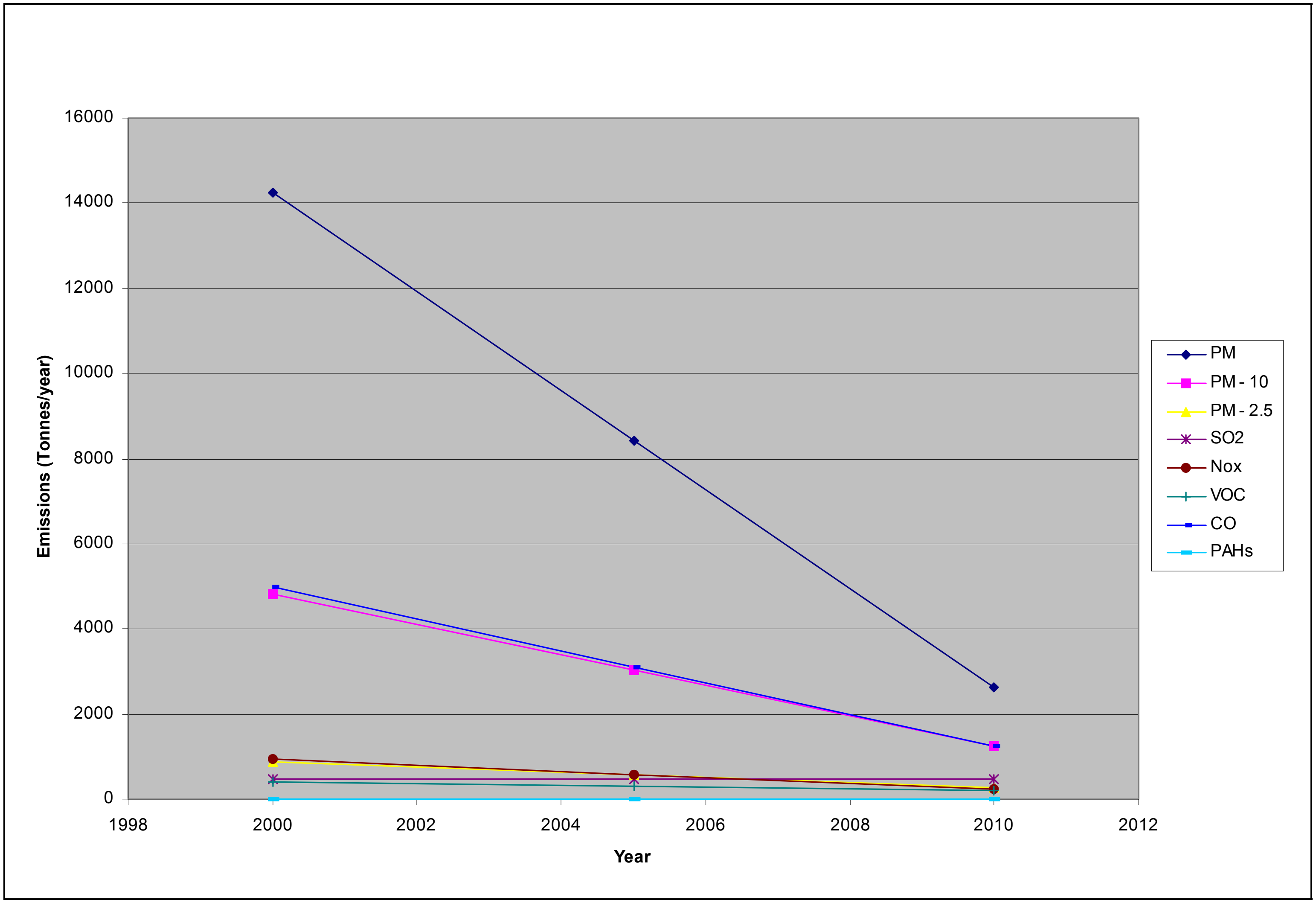


Figure 4.2 Emissions Projection, 2000 to 2010



4.2.5 Cost Analysis of the Recommended Best Available Techniques

The costing of emissions control systems and emissions control practices in the hot-mix asphalt industry is much like that of other industries and sectors. Capital costs associated with purchase and installation of emissions control systems vary substantially with the type of equipment purchased, plant details such as its type, age and size, location, etc. Operating costs include not only the direct cost of operation of the equipment but also on-going maintenance and replacement of any components. The control of fugitive particulate emissions (road dust for instance) also involves additional labour, equipment and materials costs that are not specifically tied to the emissions control system but rather to the plant's overall emission control practices. Costs associated with environmental approvals and regulatory requirements (permitting for instance) also vary substantially by jurisdiction/agency.

For this study, the costs of various emissions control equipment were to be obtained by contacting key asphalt plant producers and emissions control equipment manufacturers. It should be recognized that most emissions control equipment is purchased as 'add-ons' to existing asphalt plants, and the life of an asphalt plant itself can be extended for many years by retrofitting new components to replace worn equipment or in order to increase plant production or efficiency. Consequently, the installation costs can be significant and vary greatly with plant type, age, etc. and other improvements that may be carried out in conjunction with the emissions control equipment. For instance, replacement of an old asphalt plant burner is rarely carried out solely to reduce emissions, but to replace worn equipment, increase productivity and improve burner efficiency. However, there are substantial emissions reductions 'indirectly' achieved in moving to state-of-the-art equipment. It is therefore difficult to separate the costs related solely to emission control.

In an effort to address the range of costs associated with emissions control in Canadian hot-mix asphalt plants, the Study Team completed a review of its project files and developed a questionnaire for completion by several 'typical' hot-mix asphalt producers (Appendix B). Several hot-mix asphalt producers were selected by the Study Team across Canada, covering a range of plant types, age, size/production levels and locations. The hot-mix asphalt producer was first contacted by telephone and invited to participate, with the questionnaire then distributed by e-mail and/or facsimile. Follow-up telephone calls were made by the Study Team representatives to encourage timely response and answer any questions. By the time of writing of the Final Report, only two partially completed questionnaires had been received. Consequently with only two sets of questionnaire data, the information received was considered insufficient to conduct analysis of uniformly retro-fitting BAT to existing operating plants. In this regard, it is important to continue to work closely with the hot-mix asphalt industry to determine the costs associated with BAT in order to more fully assess the impact that implementation and scheduling of emission reductions may have on this diverse industry across Canada.

4.2.5.1 Capital Cost Considerations

Most existing HMA plants in Canada are over 30 years old, and are predominately batch plants producing 180 to 240 tonnes per hour (tph). The number of new asphalt plants sold in Canada each year is relatively small. The major manufacturers (Astec Industries, Gencor, Cedarapids/Standard Havens, CMI, ADM, etc.) offer a full range of plant types and sizes/production rates to meet the hot-mix asphalt sector needs, as well as a wide variety of emissions control components, that are sold as modules.

Most of the new asphalt plants for sale in Canada by Astec Industries Inc., U.S. are continuous mix plants in the 300 tph range for portable plants and 400 tph for stationary plants. Contractors appear to be showing an increased preference for larger portable plants, however, this does present some problems in transporting them due to the relatively high weights involved. A typical 400 tph Double Barrel plant is equipped with a 100 million BTU burner, 67,000 ACFM fabric filter baghouse, processes aggregate with a moisture content of 5 percent, and has a fuel consumption (based on No. 2 fuel oil) of approximately 7.4 litres per tonne (1.77 US gal/ton) of hot-mix asphalt.

Depending on size and features, the cost of a new asphalt plant, exclusive of property and ancillary equipment such as loaders, ranges from about $ 1.2 million to in excess of $ 3 million Canadian.

There has been a growing emphasis on environmental considerations in the design of state-of-the-art asphalt plants including reduced gaseous emissions (‘blue smoke’), lower noise, and odour mitigation. Most new plants incorporate fabric filter baghouses for control of particulate emissions, sealed-in, 100 percent total air burners, and ‘blue smoke’ reduction features.

While new plants may be purchased with open-fired burners, they are generally not considered as ‘standard equipment’. More fuel efficient, sealed-in 100 percent total air units are becoming the industry norm despite their significantly higher purchase cost. Some manufacturers (Astec for instance) have adopted low NO_X burners as standard equipment. Astec offers the Hauck Eco-Star II sealed-in, 100 percent total air models and has developed the new Astec WhisperJet burner that is being offered on some plants in 2002.

The cost difference between open-fired and sealed-in, 100 percent total air burners is reported to be in the order of about $30,000 (Astec data). However, this cost differential can be offset by the lower installation cost of the sealed-in units and the significantly lower fuel costs due to their higher combustion efficiency. Thermix Combustion Systems (the Canadian representative for Hauck Manufacturing Company) suggests that natural gas cost savings of 10 to 20% can be achieved by the sealed-in burner as compared to open-fired burners. For a ‘typical’ plant producing in the order of 300,000 to 400,000 tons/annum, a large plant in the Canadian market, Thermix has translated the reduced fuel consumption to annual fuel savings estimated in the range of $75,000 to $100,000/annum. Regional differences in the price of natural gas would modify these estimated average savings.

In order to develop a range of typical equipment and operating costs associated with the control technologies and dust management practices, the Study Team for this project contacted a Canadian representative of Astec Industries. Astec Industries of Atlanta, Georgia, provided some cost information for consideration (Table 4.4).

It has become common for a producer to purchase a 'second-hand' plant or specific components (usually from the US) rather than new equipment. For instance, the Astec Used Equipment Division recently advertised several used fabric filter baghouses: a 1985 56,000 ACFM Astec baghouse with new bags for US $ 80,000 (FOB Mobile, Alabama), a 1980 48,000 ACFM Astec baghouse for US $ 25,000, a 1985 46,000 ACFM for US $55,000 (FOB Cumming, Georgia), and a 1976 50,000 ACFM Barber-Greene baghouse for US $ 5,000 (FOB Quincy, Illinois). In comparison, a new 50,000 ACFM fabric filter baghouse costs about US $250,000 (not including installation). These equipment cost savings have to be balanced against the possible incremental costs of transportation and plant retro-fit modifications as compared to purchasing new units designed specifically for an owner's plant.

The life of an existing plant can be extended by many years by replacing key components such as the burner. Productivity can be increased by increasing the size of the burner, and the length of the dryer, etc. As such, there are many asphalt plants in Canada that despite being 25 to 30 years old (or more) have been retrofitted with relatively state-of-the-art components that can extend their life indefinitely. It should also be recognized that parallel flow drum mix drums manufactured prior to about the late-1970s, incorporated integral wet scrubbers, making retrofitting of fabric filter baghouses difficult. Again, the costs of such improvements vary greatly, and the functional life of the improvement is also variable. While most asphalt producers write down their capital equipment investments over a 10-year period, it is not unusual for such equipment to continue to operate well beyond this period. Astec, for instance, indicates that the life expectancy of most plant components is approximately 20 years. Because of this, hot-mix asphalt producers typically do not separately annualize the cost of emission control equipment. Investment decisions appear to be most often justified on the basis of the total cost of production, i.e. reduced total cost to produce a tonne of hot-mix asphalt. Individual hot-mix producers consider such information to be proprietary. Consequently, at this time, it is possible only to provide estimates of annualized capital costs of various emissions control equipment.

Table 4.4 Hot-Mix Asphalt Plant Capital Costs

Plant Component	Capital Cost Range	Life Expectancy
Burners		
Open-Fired	$40,000 to 98,000	20 years
100 Sealed-In (Total Air)	$78,000 to 108,000	20 years
Low NO_X	Doubles for flue gas recirculation	20 years
Fabric Filter Baghouses		
90 mg/m^3 Output	$325,000 to 845,000	20 years
20 mg/m^3 Output	$295,000 to 985,000	20 years
Replacement Bags	$25.70 to 44.00 each	5 years
Wet Scrubbers		
High Velocity Wet Venturi	Not available	
Wet Venturi Scrubber	$162,000 to $252,000	20 years
Storage Tank Vent Filters		
Passive	$3,940 to 5,280	20 years
Active	Not available	

This capital cost information merely indicates typical “order” of costs associated with adopting BAT (Best Available Technology) compared to RACT (Reasonably Available Control Technology) (for instance, 20 mg/m^3 versus 90 mg/m^3 for fabric filters). Fabric filter baghouse manufacturers regularly offer a performance ‘guarantee’ that the particulate matter will not exceed 90 mg/m^3 (0.04 gr/dscf) on new baghouses. However, because of due diligence considerations, the manufacturers’ guaranteed emission performance is necessarily conservative and, operational source testing consistently reports results that are much lower than this value.

There is a significant incremental cost for a fabric filter baghouse that is ‘guaranteed’ not to exceed the 20 mg/m^3 BAT limit. According to Astec, a typical 50,000 ACFM fabric filter baghouse requires 15 modules to achieve the manufacturer’s guaranteed value of 90 mg/m^3. To achieve a 20 mg/m^3 limit, the same baghouse requires 18 modules. In addition to the obvious increment in cost, there are practical considerations. The increase in the length of the baghouse due to the additional 3 modules effectively precludes it from being used for portable plants as the baghouse becomes too long to be conventionally transported on provincial highways. This essentially restricts their application to permanent/stationary plants.

4.2.5.2 Operating Costs

Since HMA plant producers consider information on their operating costs proprietary, operating costs are reported not in dollars, but rather in terms of units of energy, work, parts, etc. This allows consideration of differences in energy costs, wage structures, etc. Using this information, they are able to compare one plant in one part of the country with another plant in a different area. Operating costs vary greatly, depending on fuel type, fuel consumption, plant type, age, etc.

As previously stated, most existing HMA plants in Canada are over 30 years old, and are predominantly batch plants, producing an average of 180 to 240 tonnes per hour (tph). NAPA reports that the average US asphalt plant runs about 1380 hours per annum, producing 750 tons (about 680 tonnes) of hot-mix asphalt per day. Astec has indicated that these production rates are also generally appropriate for Canadian operations, and estimates the cost of plant and equipment maintenance for a typical plant to be in the order of $ 0.80 to $1.00 per tonne of hot-mix asphalt produced. Therefore, assuming an 8-hour per day operation (about 172 days per year), the annual plant maintenance cost is estimated to be in the order of $95,000 to $120,000/year for an annual production of 120,000 tonnes. The maintenance cost per tonne of hot-mix would obviously be somewhat higher at lower production rates.

While it is anticipated that adopting BAT would increase the maintenance costs, no analysis could be conducted to determine the impact on the sector in Canada.

5 Conclusions and Recommendations

Conclusions

The principle findings of this study can be summarized as follows:

1. Particulate matter is the pollutant of most concern from hot-mix asphalt facilities. The contribution of PM from this sector is small in comparison with national emissions.
2. The hot-mix asphalt sector contributes an estimated 2.2%, 1.6%, and 0.5% respectively to the total quantities of PM, PM_{10} and $PM_{2.5}$ emitted from all industrial sources in Canada.
3. Airborne road dust is the principle source of PM within a facility, providing the emissions from the main process sources are captured and controlled.
4. The hot-mix asphalt industry in Canada is characterized by a wide range of ownership ranging from single plant owner-operators to one international-based, integrated company.
5. Most jurisdictions in Canada have established emission requirements in legislation, regulations, or operating permits that apply either general or specific terms to hot-mix asphalt plant operations. Emission requirements for this sector vary widely across jurisdictions in Canada.
6. Best available control technology and dust management practices have been identified. When sector-wide PM emissions are estimated by the application of

uniformly applied best available techniques, a reduction up to about 81% relative to the emissions in year 2000 would appear possible.

Recommendations

Emissions Data

Some information and data deficiencies became apparent during the course of this study. In the absence of more detailed information, broad assumptions were made about the type of plants, type of fuel, control equipment, and paved and unpaved road surfaces at sites.

While best available emission information was used for this study, it was realized that there are opportunities to improve some data. Source testing of a large number of facilities helped EPA develop the emission factors for the main criteria air contaminants. The tested facilities mainly used fabric filter control systems. A generally high confidence level is associated with the emission factors for these pollutants.

A large number of plants in Canada, however, use venturi or wet scrubbers for which EPA emission factors are lacking, even for the criteria air contaminants. Source testing of Canadian plants would improve this data gap. In addition, a Canadian test program for PM_{10} and $PM_{2.5}$ and PAH would establish emission factors that are not available in the EPA data.

The areas of data uncertainties could be addressed through further research as follows:

1. Develop improved data on source emissions and emission factors for the criteria air contaminants associated with plants equipped with wet scrubbing control systems.
2. Develop data on total PM, PM_{10} and $PM_{2.5}$ and PAH source emissions and emission factors for plants equipped with fabric filter and wet scrubbing control systems.

Emission Controls and Management Practices

Although a limited questionnaire survey was conducted to gather information on emission control techniques and management practices at Canadian hot-mix asphalt plants, the responses were insufficient to define current practices and to profile the more than 500 facilities in HMA sector more accurately than presented in this report.

A more comprehensive understanding of current practices could improve the precision of the emission estimates and reduce the uncertainty in any future analysis of the expected benefits and costs of emissions management strategies that jurisdictions may wish to pursue, should such analysis be desired in future.

A representative and statistically significant number of hot-mix asphalt facilities across Canada could be surveyed to identify:

1. Current emission control and management practices,
2. Fuel types and quantities,
3. Specific plans to enhance emission control and management practices,
4. Operating costs associated with emission controls and management practices, and
5. Costs for retro-fitting existing plants with new emission controls and fuel burners.

The preceding information would enable a more accurate profile to be developed that would establish a baseline against which future changes could be measured and improve the analysis of sector-wide cost impacts if best available techniques were applied. The analysis would generate cost-effectiveness information that would be useful for comparing the cost per tonne of pollutant reductions in the hot-mix asphalt sector to the control costs for the same pollutants in other industry sectors. The impact of control technologies and practices on product costs and profitability would be other important elements in such analyses.

LIST OF ACRONYMS

AI	Asphalt Institute
BAAQMD	Bay Area Air Quality Management District
CCME	Canadian Council of Ministers of the Environment
CEPA	Canadian Environmental Protection Act
CFR	U.S. Code of Federal Register
C-SHRP	Canadian Strategic Highway Research Program
CTAA	Canadian Technical Asphalt Association
CUPGA	Canadian User Producer Group for Asphalt
CWS	Canada-wide Standards
dm^3	Dry cubic metre
EC	Environment Canada
EPA	Environmental Protection Agency
GDP	Gross Domestic Product
GVRD	Greater Vancouver Regional District
HAP	Hazardous air pollutants
HMA	Hot-mix asphalt
JAICC	Joint Actions Implementation Coordinating Committee
MERAF	Multi-pollutant Emission Reduction Analysis Foundation
MERS	Multi-pollutant Emission Reduction Strategies
NAICS	North America Industry Classification System
NAPA	National Asphalt Pavement Association
OHMPA	Ontario Hot-Mix Producers Association
RAP	Recycled Asphalt Pavement
SCAQMD	South Coast Air Quality Management District
scfm	Standard cubic feet per minute
TAN	Technical Advisory Network
TNMHC	Total non-methane hydrocarbons
tph	Tonnes per hour

Pollutants:

PM	particulate matter
PM_{10}	particulate matter equal to or less than 10 microns in size
$PM_{2.5}$	particulate matter equal to or less than 5 microns in size
SO_2	sulphur dioxide
NO_X	nitrogen oxides
VOC	volatile organic compounds
CO	carbon monoxide
PAH	polycyclic aromatic compounds
CO_2	carbon dioxide

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APPENDIX B: Questionnaire on Equipment and Operating Costs

QUESTIONNAIRE

EQUIPMENT AND OPERATING COSTS

INTRODUCTION:

Canadian ORTECH International, under Contract No. K2219-1-0006 with Environment Canada, is conducting a study to determine Best Environmental Techniques for minimizing emissions from the Canadian hot-mix asphalt industry sector. A determination of costs of the identified Best Available Techniques is an important aspect of this Study.

As part of this Study, Canadian ORTECH is conducting a survey of selected, volunteer hot-mix asphalt plant owners/operators in Canada to obtain certain information associated primarily with air pollutant emissions and the costs associated with their control. This information will help to:

- determine current environmental practices among plants in Canada,
- the costs associated with controlling air pollutant emissions, and
- improve the profile of information on the Canadian hot-mix asphalt sector as a whole.

Information obtained in this survey will not be published in a manner that will associate the data to a specific company and facility.

Check and/or provide details as appropriate:

Company: ____

Plant: ________________ Location: ______________________________

1.5 PLANT AND EMISSIONS CONTROL EQUIPMENT DETAILS

1. Plant type:

   Batch ☐ Drum ☐ Combined Drum/Batch ☐

   Stationary Plant ☐ Mobile/Portable Plant ☐

2. Plant Model and Age in years (*please specify*): ______________________

3. Approximate Production Capacity, in tonnes/hr:

< 150 tph ☐ 150 – 200 tph ☐ 200 – 300 tph ☐

300 – 400 tph ☐ > 400 tph ☐

4. Approximate Annual Production: ________________ t/annum

5. Typical number of full-time equivalent plant employees: ________

6. Burner Make and Model: ________________________________

Rating: ______________________ BTU/hr

7. Fuel type:
   - Natural gas ☐
   - LPG ☐
   - No. 2 Fuel Oil ☐
   - No. 4 Fuel Oil ☐
   - Bunker Fuel ☐
   - Other (*please specify)*: __________________

7. Fuel Consumption: ___________ litres/hour?
   ___________ litres/month? (m^3/month for natural gas)
   ___________ litres/annum? (m^3/year for natural gas)

8. Hot-Oil Heater Make and Model: __________________________

   Fuel type:
   - Natural gas ☐
   - LPG ☐
   - No. 2 Fuel Oil ☐
   - No. 4 Fuel Oil ☐
   - Bunker Fuel ☐
   - Other (*please specify)*: __________________

9. Please describe the principal components of the emissions control system:

   Primary collector:
   - Knock-out box ☐
   - Horizontal cyclone ☐
   - Vertical cyclone ☐
   - No primary ☐

Secondary collector: Wet scrubber ☐
Wet venturi/scrubber ☐
Pressure drop: ______ inches
High velocity venturi ☐
Fabric filter baghouse ☐

10. Have you made any significant changes to the plant emissions control system in the past 5 years. If so, please describe the changes that were made and their approximate cost including equipment, installation/ construction costs, plant/system calibration and permit/approvals costs.

____
____
____
____
____

11. Do you have any current plans to replace or upgrade your emissions control equipment in the next 5 years? If so, what upgrades are you proposing, what year would this work be carried out, and how long has it been between upgrades?

____
____
____
____
____

PARTICULATE EMISSIONS CONTROL

1.5.1

1.5.2 12. Enclosed or Ducted Sources

Wet collector system
Dimensions of discharge pond ____ m L x ____ m W x____ m D
Frequency for clean-out (*please specify*) ______________________
Estimated Annual Maintenance Cost ______________________

Does pond have an effluent discharge? Yes ☐ No ☐

Is the effluent quality specified by government regulations?
Yes ☐ No ☐
If Yes, please specify:
____
____

Dry collector system (baghouse)
Frequency for checking filter bags Weekly ☐

Monthly ☐
Annually ☐
Other ☐ __________

Frequency of filter bag replacement
Annually ☐
As required ☐

Estimated Annual Maintenance Cost ________________________

Ducting

Frequency of duct inspections
On-going ☐
Weekly ☐
Monthly ☐
Annually ☐
Other ☐ __________

Frequency of duct cleaning/replacement
Annually ☐
Other ☐ __________

Estimated Annual Maintenance Cost ________________________

1.5.3 13. Fugitive or Open Sources

Plant yard/haul roads:
gravel-surface ☐
paved-surface ☐
RAP-surface ☐

Length of site roadways
____________ m paved
____________ m unpaved

Number and type of vehicles/day
____________ trucks
____________ loaders
____________ other

Posted speed in yard and haul roads: ________ km/hr

Dust control method:
Water trucks only ☐
Spray washers/sweepers ☐
Water + chemical dust suppressant ☐
Other (*please specify)* _______________

Frequency: Once a day ☐

	Twice a day	☐	
	Continuously	☐	
	As-required basis	☐	
Approximate annual cost:	Contracted	☐	$ ________/y
	In-house	☐	$ ________/y

Aggregate stockpiles:	No moisture control	☐	
	Water, as needed	☐	
	Installed sprinklers on piles	☐	
	3-sided enclosures	☐	
	Temporary covers	☐	
	Limits on fines content (washed)	☐	
	Wind screens	☐	
Approximate cost:	Capital	☐	$ ________
	Maintenance	☐	$ ________/y

Conveyors/transfer points	No moisture control	☐	
	Fogging/misting	☐	
	Wind screens	☐	
	Enclosed conveyors	☐	
Approximate cost:	Capital	☐	$ ________
	Maintenance	☐	$ ________/y

1.6 GASEOUS EMISSIONS

14. Asphalt Cement Storage Tanks:

Number of tanks and capacity: ____________________
____
____

Number of deliveries/day ____________________

Odour/Fumes Control:	None	☐	
	Vent filter	☐	
	Masking agents	☐	
	Limits on delivery time	☐	
Approximate cost:	Capital	☐	$ ________
	Maintenance	☐	$ ________/y

15.0 Dryer/Drum:

Burner type. model and rating ____________________
____
____

Maintenance/calibration schedule Annually ☐
As required ☐

In-house ☐
Specialist ☐

Emissions test completed to confirm set-up? Yes ☐
No ☐

Estimated Annual Maintenance Cost ________________________

Temperature control during hot-mix asphalt production:

In accordance with asphalt cement temperature charts?

Yes ☐ No ☐

If No, please provide additional details

Asphalt Cement Storage Tank Temperature Range _________ °C

Mixing Temperature Range _________ °C

.

1.7 ADMINISTRATIVE/REGULATORY REQUIREMENTS

16. Specify the environmental requirements that you follow in your day-to-day operations:

1.7.1.1 Government Regulations? ***Yes*** ☐ ***No*** ☐

If Yes, please list:

____
____
____
____
____
____

Government Environmental Code of Practice or Guideline?

Yes ☐ No ☐

If Yes, please specify:

____

____

Industry Environmental Code of Practice or Guideline (eg. OHMPA)?

Yes ☐ No ☐

If Yes, please specify:

____

____

Company Environmental Code of Practice or Guideline?

Yes ☐ No ☐

If Yes, please specify:

____

____

17. Do you have any recent emissions source testing results that you would be willing to provide?

Yes ☐ No ☐

If Yes, please attach.

18. Do you have costs information associated with Government Environmental Permit Application Fees and Annual Emission Fees?

Yes ☐ No ☐

Amount of one-time Permit Application Fee for Emissions: $________

Amount of one-time Permit Application Fee for Effluent: $________

Amount of the Annual Emission Fee: $________

Amount of the Annual Effluent Fee: $________

Other environmental fees:

19. Are fugitive pollutant emissions (e.g. on-site road dust emission) included in the calculation of your plant's annual tonnage of emissions and in the emission fee?

Yes ☐ No ☐

20. What was the annual tonnage of all air pollutants discharged from your plant in 2001, on which your annual emission fee was assessed?

____
____

THANK YOU!