Ontario

Background and Rationale Document for the Asphalt Mix Industry Standard under Ontario's Local Air Quality Regulation

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1.0 Introduction

1.1. Background

Ontario’s local air quality regulation (O. Reg. 419/05: Air Pollution – Local Air Quality) made under the Environmental Protection Act (EPA) works within the province’s air management framework by regulating air contaminants released into communities by various sources including local industrial and commercial facilities. The regulation aims to limit exposure to substances released into air that can affect human health and the environment while allowing industry to operate responsibly under a set of rules that are publicly transparent.

The regulation includes three compliance approaches for industry to demonstrate environmental performance and make improvements when required. Industry can meet the air standard, request and meet a site-specific standard or register and meet the requirements of a sector-based technical standard (if available). All three approaches are allowable under the regulation.

Provincial air standards are set based solely on science and therefore, may not be achievable by a facility or a sector due to unique technical or economic limitations. Instead of making the air standard less stringent, the regulation allows facilities or sectors to exceed the air standard as long as they are working to reduce their air emissions as much as possible with technology-based solutions and best practices. The Ministry of the Environment, Conservation and Parks (Ministry) closely oversees their progress using a framework to manage risk that was developed in cooperation with Public Health Units in Ontario and other stakeholders. Some facilities may never meet the air standard and instead will be regulated under one of the other compliance approaches. There are two types of technical standards:

- **Industry Standards** regulate all sources of a specified contaminant(s) within an industry sector.
- **Equipment Standards** address a source of contaminant, but may apply to one or multiple industry sectors.

Facilities in a sector that are operating under a technical standard may not meet one or more air standards; however, the focus is on best practices and lower emissions that reduce risks to local communities. In developing the Asphalt Mix Industry Standard, key sources of contaminants were identified and prescribed steps and timelines were considered to address them.

Facilities may also choose to register under the technical standard for contaminants where they meet the air standards. This allows them to be excluded from the modelling requirements of the regulation and reduce regulatory burden.

A technical standard is a technology-based solution designed for two or more facilities in a sector that may not be able to meet an air standard due to technical or economic limitations. This approach can include technology, operation, monitoring and reporting requirements. Once the technical standard is published, any facility in the sector (that may or may not meet the air standard) may apply to be registered under this compliance approach. Such registration would involve a posting on the Environmental Registry and may involve other forms of public outreach. The goal is to have a more efficient tool to better manage air emissions in the sector and overall exposure from various industrial and commercial facilities. The technical standards are published under the authority of section 38 of the regulation. This publication specifies the classes of facilities and the contaminants the technical standard applies to and the steps and time periods for compliance. A facility may be registered for an industry standard, an equipment standard or a combination of industry standards and equipment standards. A facility that meets its obligations under a technical standard is in compliance with the Regulation for the registered contaminants.

In general, a person is exempt from Part II of the Regulation for a contaminant if the person is registered with respect to a sufficient number of industry standards, equipment standards or a combination of industry standards and equipment standards to address all sources of that contaminant at their facility. In this case, registering for and meeting the requirements of a technical standard(s) is the compliance approach under the Regulation as opposed to the air standards compliance approach that is based on contaminant concentrations and associated ESDM requirements. In this case, no ESDM report is required to be prepared or submitted for the relevant contaminants (e.g. Technical Standard registration(s) covers all contaminants emitted from all sources at the facility).

If a person is registered to an industry standard(s), equipment standard(s) or combination of industry standard(s) and equipment standard(s) in respect of a facility and a contaminant, but all sources of the contaminant at the facility are not addressed by theses technical standard(s) (i.e. there are sources of contaminant at the facility that are part of other NAICS codes), the person may only exclude the sources of contaminant(s) that are associated with the NAICS code addressed in the technical standard(s). An ESDM report would be required for the remaining contaminants that were not registered and/or sources that emitted these contaminants that are associated with a different NAICS code. Note: Under the Regulation, the Director may still issue a notice under section 24 to request a facility registered to one or more technical standard(s) to submit an ESDM report for assessment purposes only.

A facility can also choose which contaminants it registers for. In the development of a technical standard, the Ministry assesses all sources of a contaminant related to specific industry processes within a North American Industry Classification System (NAICS) code, and makes a decision as to whether or not that source needs to be better controlled, monitored or managed. Development of a technical standard includes a better understanding of sources of the contaminant for that sector, benchmarking technology to address the sources of a contaminant, and consideration of economic issues. Specific requirements are included in the technical standard for those major sources that are determined to need better management or control. Timeframes are specified for implementation of the requirements.

In Ontario's Local Air Quality Regulation, the impact of the facility's point of impingement (POI) concentration on the local community and environment is the driver to reduce emissions. The driver is not necessarily the mass rate of emission of a contaminant. For development of a technical standard, the significant sources contributing to the exceedance of the POI are identified, and technical solutions are determined that are appropriate for those sources.

The requirements of a technical standard are designed to promote pollution reduction through the use of technology at the facility, the operation of the facility, the monitoring and reporting of information, and any other related matter.

1.2. **Purpose and Scope of Asphalt Mix Industry Standard**

The Asphalt Mix Industry Standard applies to:

- all facilities which produce road paving asphalt.
- designated by North American Industry Classification System (NAICS) codes in class 324121 which includes asphalt paving mixture except block manufacturing,
- warm, cold and hot mix operations,
- all substances that are anticipated to be released from the operations,
- certain portable operations.

This industry standard applies to the hot mix asphalt production sites in Ontario. In 2013, at the time the Ontario Hot Mix Producers Association (OHMPA) and now Ontario Road Builders' Association (ORBA) expressed interest in developing an industry standard, Appendix A. Since a new air standard for Benzo(a)pyrene (CAS No. 50-32-8) was introduced in 2011 (and took in effect in 2016), the association has identified more than one asphalt producing facility for which it will not be technically feasible to comply with the POI limit for this contaminant.

The proposal was later expanded to include all substances emitted from asphalt mix operations, Appendix B. A facility may wish to register to one, or more or all substances in the Technical Standard and follow corresponding rules.

1.3. **Organization of the Report**

Chapter 1.0 provides the background to Ontario's local air quality regulation including the three compliance pathways available to facilities along with the underpinning authority through which the Ministry administers technical standards. The overall organization of the report is also presented in this chapter.

Chapter 2.0 provides an overview of the hot mix asphalt sector in Ontario.

Chapter 3.0 summarizes the processes and equipment utilized in the hot mix asphalt sector, identifies key contaminants associated with those processes/equipment and identifies the sources of air emissions.

Chapter 4.0 is the scoping analysis for the air emissions.

Chapter 5.0 summarizes the technical requirements associated with hot mix asphalt operations across a number of jurisdictions including Environment Canada, the United States of America and the European Union.

Chapter 6.0 summarises of current methods to minimize emissions from dominant source.

Chapter 7.0 discusses the public consultation efforts conducted in support of a technical standard for this sector and the planned path forward taking into account stakeholder comments.

Chapter 8.0 takes into consideration the first seven chapters of this report, and presents an outline of the structure of the Asphalt Mix Industry Standard.

1.4. **Authority**

The Regulation (see sections 38 thru 44) provides authority to the Minister of the Environment, Conservation and Parks to publish and amend the Technical Standards publication entitled “Technical Standards to Manage Air Pollution”. The Technical Standard publication is available through the Ministry website and the Ministry’s Public Information Centre and version 6.0 was last amended March 22, 2018.

2.0 Overview of the Hot Mix Asphalt Industry

2.1. Hot Mix Asphalt Industry in Ontario

Hot mix asphalt (HMA) plants combine aggregates with liquid asphalt cement (AC) and reclaimed asphalt pavement (RAP) to produce asphalt for road construction. Asphalt plants fall under the 324121 NAICS code for Asphalt Paving Mixture and Block Manufacturing.

In recent years, the use of RAP has been initiated in the HMA industry. Reclaimed asphalt pavement significantly reduces the amount of virgin rock and asphalt cement needed to produce HMA.

Hot mix asphalt paving materials can be manufactured by:

- batch mix plants;
- parallel flow drum mix plants; and
- counterflow drum mix plants.

This order of listing generally reflects the chronological order of development and use within the HMA industry. A detailed description of the different types of plants can be found in the following sub-section titled “General Description of the Hot Mix Asphalt Manufacturing Process”.

Based on 2011 data, Ontario’s HMA plants contributed approximately $1.3 billion of GDP to the provincial economy. In 2017, approximately 13 million tonnes of HMA were produced at the 155 (estimated) active asphalt plants in Ontario. Of these 155 plants, approximately 20 plants only operate in batch mode, 10 plants operate in either batch or drum mode, and the rest of the plants operate in only drum mode (either counterflow or parallel flow). About 95% of plants being manufactured today are of the counterflow drum mix design, while batch plants only account for 5%.

Approximately 55% of the asphalt producers operate a single asphalt plant in Ontario. The remaining asphalt producers operate multiple asphalt plants, totalling approximately 130.

An HMA plant can be constructed as a permanent plant, or as a portable plant. Approximately 15% of asphalt plants are operated as portable plants. The raw materials, production process, equipment and emission controls are the same for both permanent and portable plants. A permanent asphalt plant does not change sites and operates at one location under a regular air permit. A portable asphalt plant is mobile and can be moved to potentially operate at various locations during the year. Prior to this Technical Standard portable asphalt plants received air permits for portable equipment under compliance with air standard. Once the Technical Standard is posted and available to the industry, the asphalt mix plants will have both compliance options available under the Local Air Quality Regulation.

A majority of plants operate in urban areas. Most portable asphalt plants operate in rural areas close to the paving project. HMA plants need to be located within 30-60 minutes of travel to the paving site. As a result, they are distributed across Ontario.

Most asphalt plants have the capability to use either natural gas or No. 2 fuel oil. Between 70 and 90% of the HMA is produced using natural gas as the fuel to dry and heat the aggregate.

Asphalt plants can vary greatly in size having typical annual production values between 50,000 tonnes and 400,000 tonnes.

Most asphalt plants in Ontario utilize a baghouse for fine particulate emission control from the mixing process. Only a small number of plants use a wet scrubber.

Most asphalt plants do not operate during the winter (i.e. December to April). A few plants in the Greater Toronto Area operate year round in order to provide asphalt for smaller construction projects such as pothole repair.

Asphalt plants are an integral part of the growth of a region. HMA plants need to be located close to the construction and paving job site because asphalt needs to remain hot enough to achieve compaction (required to be 150°C). Job sites that are further away (i.e. more than 30 to 45 minutes from time of truck loading) require the HMA to be heated to higher temperatures which increases construction costs and potential air emissions.

Historically, most HMA plants were built outside of urban centres, but within reach of the job sites. However, as a result of urban growth, many HMA plants are now surrounded by urban development, including residential development.

Figure 1 shows locations of a portion of Hot Mix plants in Ontario based on 2015 OHMPA membership. The figure does not contain locations of non-member plants or portable plants.

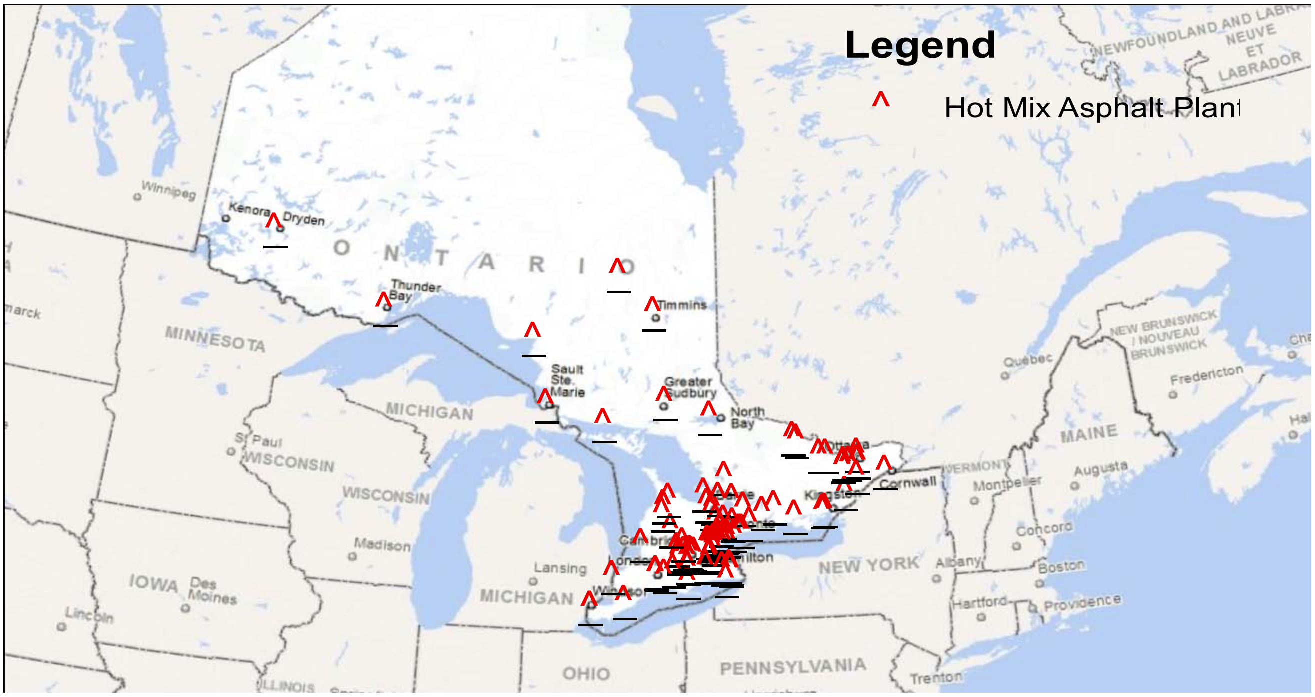

Figure 1 Location of Hot Mix Plants in Ontario based on the 2015 OHMPA membership.

2.2. General Description of the Various Asphalt Mix Manufacturing Processes

There are three (3) general ways of producing asphalt for the road paving purpose. The differences between these are in equipment and how materials are mixed. They are:

- hot mix,
- warm mix, and
- cold mix.

The most common one used in Ontario is the hot mix asphalt. A brief description of each will follow this chapter.

2.2.1. Hot Mix Asphalt Operations

HMA paving materials are a mixture of size-graded, high quality aggregate (i.e. sand, stone, and often RAP), and liquid asphalt cement, which is heated and mixed in measured quantities to produce HMA. Aggregate and RAP (if used) constitute over 92% by weight of the total mixture. Asphalt product characteristics are determined by the amount and grade of asphalt cement, types and quantity of aggregate and RAP used in the mix, and the mix temperature. All types of plants have the ability to produce different types of asphalt mixes. However, by their nature, batch plants are better suited to making small quantities of specialty mixes, and drum plants are better suited to making large quantities of specific mixes. Note, not all plant sites make all asphalt mixes.

It is important to note that asphalt cement and RAP quantities are usually clearly defined for most Ontario contracts in Ontario Provincial Standard Specifications and contract specific Special Provisions. Specifications in most cases provide “total” mix asphalt cement content (%) and allowable recycled asphalt content (RAP %). Higher allowed RAP content mixes contain less virgin asphalt cement.

Heated AC is delivered to the asphalt plant by tanker truck and unloaded into heated storage tanks. AC storage tanks may be horizontal or vertical. The AC storage tanks are heated using hot oil which circulates in a closed loop system. This oil is kept hot by a fuel-fired hot oil heater.

Virgin aggregate material is stockpiled near the cold feed bins. The bulk aggregate moisture content typically stabilizes between 3% to 5% by weight.

A certain percentage of fine aggregate is required for the production of good quality HMA. This fine aggregate can be obtained from the asphalt plant’s particulate matter collection system (i.e. baghouse).

As indicated in the industry overview, there are 3 different types of asphalt plants:

- namely batch mix plants,
- parallel flow drum mix plants, and
- counterflow drum mix plants.

The primary difference between the plants is the aggregate/RAP and AC mixing stage, which are discussed below.

Appendix C contains detailed description of each type of plant along with general material flow diagram.

2.2.2. **Warm Mix Asphalt Operations**

Warm-mix asphalt (WMA) constitute the set of technologies that allow for the production of asphalt to occur at temperatures between 20 to 55°C lower than those used in HMA [1]. Creating asphalt at lower temperatures reduces the amount of pollutants emitted into the atmosphere [2]. This is made possible by:

a) technologies, with aid of

b) additives, [3].

Appendix D provides general description of difference between technology and aid of additives as well as brief overview of how the technology has been evolving in Ontario and USA. Warm mix is considered to be an emerging way of making asphalt mix material for paving purposes.

According to a report by the Centre for Pavement and Transportation Technology (CPATT), the use of warm mix technologies is increasing across Canada. Warm mix technology was initially used in Canada in 2006, but has picked up considerably since a wider number of transportation agencies began using it in 2009. As of 2015, the majority of Canadian provinces reported routine use of warm mix asphalt, with Alberta, Manitoba, Quebec, and New Brunswick having placed in excess of 250,000 tons of warm mix by 2015. British Columbia and Yukon each have used between 50,000 and 250,000 tons. Some agencies have even begun to require the use of warm mix in their projects. As the technology continues to develop and is further tested and improved, the use of warm mix asphalt on Canadian roads should continue to increase (Appendix G).

2.2.3. **Cold Mix Asphalt Operations**

Cold mix asphalt (CMA) constitutes the last type of asphalt mixing process used by industry. In most cases, CMA is used for lightly trafficked roads, rehabilitation projects, or when the ambient air temperature is too low for the use of hot and warm mix asphalts [4, 5,6]. The biggest concerns with using CMA involve the high air-void content once compacted, the weak early-life strength, and the long curing times required for maximum performance [7].

Cold mix asphalt is a mix of aggregates, asphalt emulsions and reclaimed asphalt pavement (RAP)[5]. It is produced without heating the aggregate, and instead uses an asphalt emulsion (with water and soap) that breaks apart during mixing or compaction to coat the aggregate and gradually increase the strength of the mixture [4]. The process works at low temperatures which reduces the amount pollutants emitted considerably [6] [6]. Like HMA and WMA, the mixture quality of CMA varies between manufacturers, based on aggregate gradation, binder properties, and additive types [8]. There are two types of cold mix processes: open graded (OG) and dense/well graded (DG) [5].

Performance guidelines regarding the design and use of open graded and dense graded emulsion mixes have been published by the Asphalt Emulsion Manufacturers Association. These guidelines outline the materials, design, and workmanship required for using emulsion mixes in asphalt paving applications, and are a useful guide for facilities considering the use of cold mix asphalt [9, 10].

3.0 Summary of the Hot Mix Asphalt Process, Equipment and Key Contaminants Emitted to Air

The TS was developed for all reasonably, anticipated emissions to air, except noise, from operations associated with asphalt mix industry. Followed by, a discussion of anticipated process emissions.

This chapter describes production of hot mix asphalt as those can be assumed to release higher emissions into atmosphere due to warm nature of the process. Warm mix is considered to be an emerging way of making asphalt mix material for paving purposes and it normally occurs at much lower, than hot mix, temperatures.

The hot mix process can be divided into three groups, see Figure 2. Each group has specific emissions associated based on the type of material or equipment used.

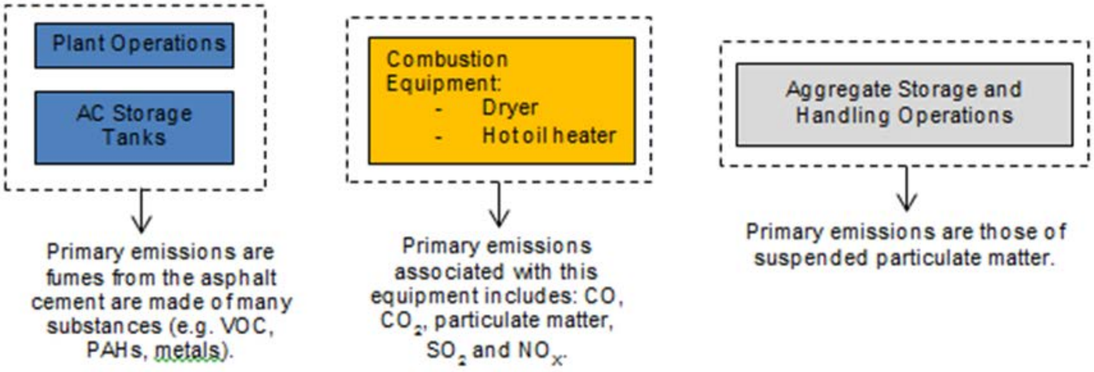

Figure 2 Production of hot mix asphalt and identification of primary emissions.

The plant operations include equipment that handles asphalt cement: asphalt cement storage tanks, hot mix asphalt dyer or batcher, hot mix asphalt storage silos when applicable. These sources emit fumes of asphalt cement and suspended particulate matter.

There also exists auxiliary equipment that provides heat, dyer and hot oil heater, release combustion gases.

Finally, a typical plant has aggregate storage piles as well as material handling operations that release suspended particulate matter.

This chapter will provide a short description of the operations followed by anticipated emissions.

3.1. Hot Mix Asphalt Production, Equipment and Emissions

As shown in figure 2, the primary emissions from the plant operations and asphalt cement tanks are those of volatile organic compounds, PAHs, metals and other various contaminants. These are part of the fumes that are released from the asphalt cement.

3.1.1. Asphalt Cement Delivery and Storage

The asphalt cement (AC) fumes are released from the asphalt cement tanks due to working loss and breathing loss. The working loss is a release during AC transfer from the delivery tanker into the AC storage tanks. The breathing loss occurs due to fluctuations of ambient temperatures and fact that the material must be mixed continuously and maintained at elevated temperature to maintain it in fluid state. These emissions are released through the storage tank vents as fumes.

Asphalt plants receive AC deliveries periodically, during day-time hours. AC tankers typically deliver from one to five loads a day, depending on production needs for that day. Breathing losses from AC storage tanks are minimal as AC has a low vapour pressure at the storage temperatures.

Mixing

Fumes of asphalt cement are generated and emitted at the drum mixer/pug mill. These emissions are ducted to the particulate matter collection system (e.g. baghouse) and are released through an exhaust stack.

Due to the high level of particulate in the exhaust stream B(a)P will preferentially condense on the particulate. The rate of condensation is a function of temperature. As a result, B(a)P released from the exhaust stack is expected to be found in both the vapour and particulate phases.

HMA Silo Filling

If HMA storage silos are used at the facility, asphalt cement fume are generated as HMA is loaded into HMA storage silos via enclosed transfer systems. These emissions are released as fugitive vapours from the top of the HMA storage silos.

Hot Mix Asphalt Loadout

Asphalt cement fumes are released as HMA is loaded into shipping trucks from the HMA storage silo(s) and/or batch tower pug mill. These emissions are released in two distinct events as fugitive vapours from the loadout area. Initially vapours are released from the hot asphalt product as it is released into the shipping truck. Additional vapours are released when the hot asphalt contacts the cool/cold truck bed.

HMA is typically loaded into shipping trucks in 2-3 loads. The first batch load of HMA is placed near the front of the truck bed. Then the truck moves forward to allow HMA to be loaded into the rear of the truck centre bed. The centre of the truck box is filled last as a best practice to prevent segregation of the HMA material.

For asphalt plants utilizing HMA storage silos, the HMA loadout occurs beneath/beside the HMA storage silos. Generally, drum plants utilize HMA storage silos, although they are also used by some batch plants.

For asphalt plants that do not have HMA storage silos, the HMA loadout occurs beneath the batch tower or directly from the slat conveyor (i.e. for small portable drum plants).

3.1.2. Emissions of Metals from the Production of Hot Mix Asphalt

In the industry of asphalt mix the aggregate is not purchased for metal content. The US EPA AP-42 contains a list of metals emitted from the dryer, including: manganese, zinc, nickel, copper, barium, and phosphorus. In addition to these, trace amounts of lead, cadmium, and mercury, among others, have been reported [11, 12]. The dominant source of metal emissions at Asphalt Mix facilities is, by and large, the dryer [11].

It should be noted that the majority of the AP-42 emissions factors for metals are of the “Poor” rating. Thus, the quality of the data is very low and there has not been a significant amount of research around the emissions of metals at Asphalt Mix facilities.

For the purpose of this Technical Standard the main source of metals was assumed to be fumes of asphalt cement.

3.1.3. Emissions of Volatile Organic Compounds (VOCs) from the Production of Hot Mix Asphalt

Volatile organic compounds, or VOCs, represent a class of organic compounds that are characterized by a high vapour pressure, and as such, these compounds are readily converted into vapours or gases. Since VOCs represent such a wide class of compounds, the health effects also vary broadly, ranging from having no health effect to being highly toxic [13].

At Asphalt Mix facilities, there are a variety of sources that result in the emission of VOCs—many of these sources are the same as for B(a)P. For instance, there are considerable VOC emissions during HMA storage silo filling and the loadout process, as described above, respectively. According to the U.S. Environmental Protection Agency, these sources make up over a third of the total VOC emissions at Asphalt Mix facilities. The major source of VOC emissions, however, is from the dryer, as described above. This source alone can produce over 60% of the total VOC emissions from the entire facility. Additionally, minor emissions of VOCs are produced during the delivery of the hot asphalt to the job site, but these constitute only a slight portion of the total emissions [11, 12].

3.2. Combustion Equipment Associated with a Typical Hot Mix Asphalt Plant

The dyer and the hot-oil heater are the two pieces of equipment that are part of the HMA plant. The dryer is used to drive moisture off the aggregates. The hot-oil heater is a closed system with oil, used as a blanket to heat AC storage tanks or the HMA silos when it is necessary to warm up the stored materials.

Not all HMA plants have hot-oil heater on the HMA silos but all plants have a hot-oil heater heating the AC tanks. The AC can solidify in the storage tanks and the hot-oil heater maintains the temperature so that the AC flows and can be pumped. Many plants have the hot-oil system controlled automatically to prevent overheating of the AC.

Both the dryer and the hot-oil heater tend to be fired with the same fuel that is accessible at the site. The fuel typically ranges from natural gas, liquid petroleum, liquid fuels.

The use of combustion equipment at HMA plants to enable the high temperature operation required for asphalt production leads to the release of considerable amounts of combustion gases, including carbon dioxide, carbon monoxide, sulphur oxides (SO_2), and nitrogen oxides (NO_x), among other minor products [11]. There are potentially, small amounts of benzo(a)pyrene, VOCs and metals that could be emitted due to combustion of liquid fuels. However, these were not considered to be significant sources that contribute to the overall site operations.

There are trances of Benzo(a)pyrene and other contaminants emitted from combustion of fuels. For this technical standard, the main contaminants of concerns were assumed to be CO,CO_2, SO_2, NOx and SPM.

3.2.1. **Dryer**

The dryer provides essential functionality at HMA facilities. Cold aggregate from the stockpile is loaded into the cold feed bins and metered out proportionately onto a conveyor belt, as required. The conveyor belt transports the cold aggregate into the dryer. At both batch mix and drum mix (continuous) plants, the dryer heats the aggregate and removes moisture by combusting a fuel in a burner. At drum mix plants, the dryer also acts to mix the dried aggregates with liquid AC, RAP, and baghouse fines, according to the mix design [11,12].

While burners can be designed to handle many fuels (natural gas, fuel oils, liquefied petroleum gas, coal, etc.), the majority of burners in Ontario operate using either natural gas or fuel oils (mainly No. 2, 4, or 5) [11, 12].

At HMA facilities in Ontario, dryers range in size anywhere from 8 MW of heat input up to 45 MW of heat input, depending on the production rate of the facility.

The majority of dryers used at HMA facilities in Ontario are produced by three main companies: Astec, Gencor, and Honeywell`s HAUCK line. Each of these companies offer a number of burners with different heat outputs and features, depending on a facility`s specific requirements [14, 15, 16].

The combustion of fuel within the dryer produces the heat necessary to promote the evaporation of water from the aggregate. In doing so, steam is evolved from the dryer [15]. In addition to steam, the dryer burner emits combustion gases, as well as particulate matter, methane, metals, and other organic compounds [11]

The emissions from dryers are typically ducted via an industrial ventilation system before being emitted to the atmosphere. Ducted emissions are often sent through a baghouse or similar form of pollution control technology before being released via a stack [11]. The combination of a dust collection system and tall stack means that emissions from the dryer are generally not major contributors to POI concentrations.

3.2.2. **Hot-Oil Heater**

The hot-oil heater serves as the primary method for maintaining the fluidity of the AC while it is being stored in the AC storage tank [17]. A thermal fluid (often oil) is heated by combusting fuel in a burner and is then circulated through the AC storage tank via heat transfer piping to keep the AC from hardening within the storage tank [17-19]. In some cases, hot oil may also be piped through the HMA silo in order to keep the asphalt from congealing while it is being stored for load-out [17].

In Ontario, hot oil heaters are almost exclusively fired using natural gas as the main fuel source, but they can also be designed to operate using fuel oils [17-19].

Hot oil heaters at HMA facilities in Ontario represent much smaller combustion sources than dryers with heat inputs generally lower than 1 MW, ranging anywhere from about 0.25 MW up to 0.9 MW.

The main source of emissions from the hot-oil heater is the burner where combustion of fuel occurs. The emissions from the hot-oil heater are primarily composed of combustion gases, along with trace amounts of formaldehyde [11].

The main difference between the hot-oil heater and the dryer is that the emissions from the hot-oil heater are generally directed through a much shorter stack than the dryer’s, and thus the heater’s emissions have a more significant effect on the POI concentrations of the combustion gases.

3.3. **Aggregates Materials Storage and Handling Operations**

The emissions of suspended particulate matter (SPM) occur from:

a) dryer which exhausts through baghouse or scrubber;

b) coarse aggregate materials bought, stored and handled on site;

c) roads; and

d) crushing/screening, only if equipment is brought in.

The emissions from the dryer are controlled by baghouse or scrubber. There are no further requirements imposed on this source.

Aggregate materials are derived to site and are stored on site in storage piles. The asphalt mix industry accepts materials with low to no silt content, washed materials. Coarse aggregate, sand and recycled asphalt pavement (RAP) can be incorporated into the asphalt mix.

With regards to production of hot mix asphalt, the mix design will often call for a certain percentage of fines to be included in the product. This can be achieved by addition of (i) mineral filler or (ii) baghouse dust.

i) The mineral filler must meet specifications provided by the Ontario Provincial Standards Specifications for province or municipality, 1003.

ii) The baghouse dust is associated with the baghouse which services the dryer.

For the purpose of this Technical Standard a number of standard dust management practices have been accepted based on sample Dust Management Plans that industry voluntarily submitted. The rules include stockpile control, maintaining paved areas and areas near storage piles either clear of accumulated materials or wet to prevent fugitive emissions. General housekeeping rules around the storage piles, conveyor belts and transfer points where emissions can occur are to be maintained in such a way as not to generate fugitive dust emissions. There are dust suppressants that can be applied to control emissions from the roads along with sweeping.

Crushing and screening operations are not regular part of production of asphalt mix. This equipment can be brought on site to process aggregate. When crushing and screening is brought onto a site the emissions can be controlled with water. Recycled asphalt cement cannot be watered as it will combine and bind again into larger pieces which again will have to be crushed.

It must be noted that the more water is applied onto aggregates to control emissions the more fuel must be used in the dyer to dry the materials.

3.4. Analysis of the Air Emissions from Asphalt Mix Plants from Various Reporting Programs

There are a number of reporting programs, regulations that exist on federal, provincial and municipal level. They include:

Federal level: National Pollutant Release Inventory

The reporting requirements exclude most of asphalt plants from the program. This makes difficult to draw conclusions from NPRI about this sector.

Provincial level:

- Quantification, Reporting, and Verification of Greenhouse Gas Emissions Regulation O.Reg. 413/16; and
- Airborne Contaminant Discharge, Monitoring and Reporting Regulation O.Reg. 127/01

Municipal level:

- Environmental Reporting and Disclosure bylaw with the City of Toronto, Chapter 423
- Health Protection Air Quality By-Law Number 2010-035 town of Oakville

All of the programs mentioned above have requirements that exclude most of asphalt plants from reporting. This makes difficult to draw conclusions about this sector based on the reporting programs.

The details including review of the programs against the asphalt mix industry is provided in Appendix E.

4.0 Scoping Analysis for Air Emissions

The purpose of the scoping analysis is to review all contaminants to be included in the technical. Identification of the key contaminants expanded the work to identify dominant sources.

They key contaminants were identified as:

- fume emissions from the asphalt cement which represent PAHs, VOCs, metals, non-VOCs;
- combustion gases from the fuel fired equipment; and
- suspended particulate matter.

The above represents a list of all contaminants that are reasonably anticipated to be emitted from asphalt mix operations. The list does not include silica oxide as virgin aggregate is not crushed on site.

The purpose of a dominant source analysis is to identify the most significant source emission contributors to point of impingement concentrations of a contaminant. The results of the analysis can be a key factor in the prioritization of air pollution control efforts; can be used to eliminate lower priority sources from further review; and, correspondingly, minimize capital and operating costs.

4.1. Significance Analysis Methodology

The original significant analysis was completed for benzo(a)pyrene contaminant alone. The benzo(a)pyrene is a contaminant that is released from the asphalt cement in the form of fumes. With time the list of contaminants expanded to include other substances in the fumes.

Benzo(a)pyrene is the contaminant the sector is interested including in the technical standard, (Appendix A). Benzo(a)pyrene is a surrogate of total Polycyclic Aromatic Hydrocarbons (PAHs)

In 2013 OAPC conducted a small study to determine if the HMA industry would require a technical standard for B(a)P emissions. The study modelled the B(a)P emissions from 7 large and 1 small production plants, mostly located in urban areas. The study identified that at least two HMA plants in Ontario would be unable to meet the new B(a)P POI standard and requested the MECP develop a Technical Standard.

OHMPA noted that the sample facilities which exceeded the B(a)P POI standard in the modelling exercise had the following parameters in common:

a) annual production value over 300,000 tonnes;

b) a majority of the asphalt produced was stored in a silo before it was loaded into trucks for shipment;

c) the HMA silos were located within approximately 20m of the property line.

OHMPA also noted that B(a)P emissions from asphalt cement storage tank filling and storage operations were insignificant, making AC storage tanks a non-dominant source.

An analysis showed that the point of impingement concentrations of B(a)P for a portion of Ontario facilities exceeds the new standards which took effect in 2016.

In the production of HMA the emissions of PAHs occur from the asphalt cement only. The maximum HMA production temperatures are not high enough to destroy the PAHs, [20]. The release of PAHs from the asphalt cement starts at temperatures as low as 140 ^{0}C and approximately doubles every 10 degrees Celsius. [20, 21]

4.2. Dominant Source Analysis for Benzo(a)Pyrene Air Emissions

The purpose of dominant source analysis is to determine which of the emission sources of the contaminant of interest contribute most to the POI standard. In general, there are two steps involved:

i) Estimating emissions of the contaminant of interest from the known sources;

ii) Completing air dispersion modelling to determine maximum, ground level concentration, from each source. This step is called source apportionment.

At the end of the exercise, the sources which contribute most to the ground level concentration can be identified and therefore, means of controlling them to reduce the overall emissions can recommended.

In the case of HMA operations, there are challenges that exist in both of the steps mentioned above:

i) The fugitive emissions associated with material drop cannot be easily tested for [11]

ii) Second challenge is in the approach to modelling the operations that emit the contaminant.

Knowing the challenges, it is still possible to complete the exercise understanding the data is not ideal. As describe below, it is difficult to estimate emissions from asphalt cement tanks as well as model the source in AERMOD. Furthermore, in field it was determined that during the delivery of the asphalt cement the fumes often can cause off site odour which results in complaints.

Keeping this in mind, the ministry kept the source in the technical standard and imposed rules around the sources as preventative measure.

4.2.1. Uncertainty of the Emissions Estimates

Since the fugitive emissions associated with the HMA operations are not easily tested for the US EPA emission factors published under AP-42 can be used, as per *"Procedure for Preparing an Emission Summary and Dispersion Modelling Report*", [22]. The US EPA AP42 emission factors are based on test data completed on a number of various plant types and materials used [11]. It is impossible to reproduce the exact conditions at all HMA plants since source of materials and operating conditions do vary based on the supplier and specifications of the final product.

These emissions should be taken in a general manner and as an indicator only. The actual emissions are dependent on the type of asphalt cement and how it was processed, and modified [11, 21]. The exact process associated in making specific asphalt cement is not known to the HMA plant that wishes to purchase it. Asphalt cement is purchased based on Performance Grade (PG) specified by the supplier.

US EPA AP42 chapter 11, Hot Mix Asphalt Plants, which provides emission factors for a number of operations at a typical hot mix asphalt plant.

It is important to note that the chapter 11 does not have emission factors associated with the asphalt cement storage tank. These emissions can be estimated using two approaches:

a) TANKS software

b) Owen Corning publication

Appendix F reviews both approaches to estimating emissions from asphalt cement tanks. In conclusion the resulting emission rates are not equal or close and significantly different.

4.2.2. Uncertainty of the Modelling

The source characterization was completed in accordance with the *"Air Dispersion Modelling Guideline for Ontario",* [23]. AERMOD was used as the preferred dispersion model for the purpose of this exercise.

The emissions associated with the mixing operations are controlled by a baghouse. The baghouse has known physical parameters and can be readily modelled in AERMOD. Since the baghouse has a tall stack, high velocity and temperature this source disperses well. The baghouse emissions were identified to not be dominant.

The challenge arises when considering the remaining sources of emissions which are in general fugitive type emissions, with intermittent puffs. They are not associated with a stack or known physical parameters such as temperature or velocity. Those types of sources are more difficult to model. In this case, volume sources were used as per Air Dispersion Modelling Guideline for Ontario, [13].

4.2.3. **Predicting Ground Level Concentrations**

Following emission source analysis was completed using the ministry approved US EPA AERMOD dispersion model.

Emissions of B(a)P were estimated for these facilities and modelled using AERMOD v. 12345 and regional meteorological data sets, all in accordance with the ministry's modelling guidance document [23].

4.2.4. **Dominant Source Analysis Methodology**

The dominant source analysis approach used to assist in the development of the technical standard for HMA manufacturers involved the following basic approach:

- The use of the latest emission summary and dispersion modelling reports for each facility (including atmospheric dispersion modelling on an annual average basis for B(a)P as a basis for the analysis).
- The US EPA AP-42 emission factors for each of the B(a)P source. B(a)P emissions from the HMA storage silo filling were conservatively based on the emissions of PAHs from silo filling, AC storage tank filling, and HMA loadout, and the B(a)P emissions from HMA loadout operations.
- The results from the above-noted modelling components of the dominant source analysis were used to identify the most dominant sources for further analysis within the development of the technical standard for the hot mix asphalt industry.

The dominant sources of benzo(a) pyrene contributing to off-site point of impingement are silo elevator/silo loading, and Truck Load Out – represented 90% of POI - Silo Elevator/Silo Loading – represented 8% of POI

- Mixing – represented <1% of POI
- Asphalt cement delivery and storage represented <0.1% of POI.

5.0 **Jurisdictional Review**

A review was conducted of regulatory requirements and codes of practice for emissions of benzo(a)pyrene, particulates, fuel combustion gases and volatile organic compounds (VOCs) from hot mix asphalt plants. This review covers requirements and codes of practice from jurisdictions in Canada, the United States and United Kingdom.

Various instruments from these jurisdictions were identified. Their description includes emission limits and, where available, control technologies required to achieve the requirements.

5.1. **Canada**

5.1.1. **Federal**

No Federal regulations or guidelines controlling emissions of air pollutants from hot mix asphalt plants have been identified.

A Multi-Pollutant Emission Reduction Analysis Foundation (MERAF) for the Hot Mix Asphalt Sector was developed for Environment Canada and the Canadian Council of Ministers of the Environment [24]. The subsequent report was published in September 2002 on the status of the hot mix asphalt industry sector with respect to its emissions sources and control methods. The report identified six primary conclusions relating to the Hot Mix industry:

1. Particulate matter is the primary pollutant of concern
2. The Hot Mix industry contributes just over 2% of the total particulate matter within Canada
3. Airborne road dust is the primary source of non-ducted particulate matter
4. The Hot Mix industry represents a wide range of ownership styles, from large, multi-national companies to single plant owner-operators
5. The emissions requirements for the sector vary widely across Canada, but most jurisdictions have established requirements that relate either directly or indirectly to the Hot Mix industry
6. Many of the best available control technologies are already known by the industry. Application of BACT could reduce PM emissions by as much as 80%

With regards to BACT examples include:

- there is the requirement of a fabric filter on to control emissions from the dryer. The fabric filter achieving emissions to less than 20 mg/dm3.
- Requirement to wash all aggregates prior to delivery.
- At least 70% capture and control fugitive dust emissions from aggregate handling
- At least 95% control of fugitive dust from all roads and traffic areas.

In addition to these six conclusions, the report identified OHMPA (now OAPC) as the most active producer association in Canada, and highlighted their *Environmental Practices Guide* extensively throughout the report as being one of the premier sources of best practices within the industry [25].

5.1.2. **Provincial**

5.1.2.1. **Ontario**

Ontario protects air quality through a comprehensive air management framework that includes regulations, targeted programs and partnerships with other jurisdictions to address sources of air pollution. This framework addresses emissions from the electricity sector (including coal-fired generation stations), vehicles, cross-border sources, as well as commercial and industrial facilities.

Ontario has several tools for managing air quality in Ontario. Below are some regulatory requirements that likely pertain to this sector:

- R.R.O. 1990, Regulation 349: Hot Mix Asphalt Facilities
- Environmental Compliance Approval, and Environmental Activity and Sector Registry
- O.Reg. 419/05: Air Pollution - Local Air Quality

R.R.O. 1990, Regulation 349: Hot Mix Asphalt Facilities

Under the Environmental Protection Act, Reg. 349 requires that any hot mix asphalt facility, except for the period of 15 minutes immediately following start-up, shall not operate, in such a manner as to emit suspended particulate matter into the air at a concentration in excess of 230 milligrams per cubic metre, or so that visible material including a water plume and fallout of water droplets emitted from the facility impinges on any point beyond the limits of the property.

O.Reg. 419/05: Air Pollution—Local Air Quality

Ontario's local air quality regulation (O. Reg. 419/05: Air Pollution – Local Air Quality) works within the province's air management framework by regulating air contaminants released into communities by various sources, including local industrial and commercial facilities. The regulation aims to limit exposure to substances released into air that can affect human health and the environment, while allowing industry to operate responsibly under a set of rules that are publicly transparent.

The regulation includes three compliance approaches for industry to demonstrate environmental performance, and make improvements when required. Industry can meet an air standard, request and meet a site-specific standard or register and meet the requirements under a technical standard (if available). All three approaches are allowable under the regulation.

The regulation sets out air standards as POI limits for contaminants. Standards for 139 contaminants in Schedule 2 of the regulation are set for half-hour averaging periods. Standards for 126 substances in Schedule 3 of the regulation are set for variable times, including 1-hour, 24-hour, annual, 30-day, 10-minute and half-hour averaging periods.

The facility identifies all sources of all contaminants and, using air dispersion modelling, determines the POI concentrations surrounding the facility. Hot mix asphalt facilities are required to meet air standards in Schedule 3, using the more advanced air dispersion models, by February 1, 2020.

Significant progress has been made in recent years to update or set new air standards. Since 2005, 68 new and/or updated air standards have been introduced into the regulation. A new air standard for benzo(a)pyrene took effect on July 1, 2016.

The site-specific standard and technical standard compliance approaches provide for specific mandatory requirements and allow facilities the time needed to develop and implement actions required to improve their environmental performance.

Environmental Compliance Approval

Under the Environmental Protection Act, any facility that releases emissions to the atmosphere, and manages or disposes of waste must obtain an Environmental Compliance Approval (ECA). Facilities that alter any equipment that may discharge a contaminant into the air also require an ECA.

Approvals generally do not contain stack limits for air emissions. However, based on site specific conditions approvals may include in-stack limits that are potentially associated with other requirements such as stack emission monitoring. Air Dispersion Models are used to assess point of impingement (POI) concentrations for various contaminants. Modelling or monitoring values are assessed against legal limits established in O. Reg. 419/05.

In addition, the Environmental Activity and Sector Registry (EASR) allows businesses to register certain activities with the Ministry, rather than apply for an approval. The registry is available for common systems and processes, to which pre-set rules of operation can be applied.

Currently, asphalt paving facilities (NAICS 32412) cannot register under O. Reg. 1/17.

Site-Specific Standard

When a facility cannot meet an air standard, it may be eligible to request a site-specific standard. Facilities eligible to request a site-specific standard are those facing technical or economic challenges in meeting a provincial air standard.

A site-specific standard is an approved air concentration based on technology considerations. It is approved by an appointed director of the ministry for an individual facility.

This approach focuses on actions to reduce emissions to air as much as possible considering the technology that is available and best operational practices. Economic factors may also be considered. A facility that meets its site-specific standard is in compliance with the regulation.

Site-specific standards can be approved for a period of five years to 10 years, upon which a facility may make a subsequent request.

Technical Standards

Sometimes, two or more facilities in a sector may not be able to meet an air standard due to technical or economic issues. In this case, the regulation allows for sector-based technical standards to be developed.

Sector-based technical standards set out technical and operational requirements for major sources of air emissions identified in a sector.

A technical standard can be an industry standard applied to multiple facilities within one sector, or an equipment standard that addresses a source of contaminant in one or more industry sectors.

A facility that meets its obligations under a technical standard is in compliance with the regulation.

Technical standards do not expire, but can be updated based on the availability of newer technologies, updated science on a contaminant that suggests more controls are needed, or at the request of the industry sector.

Relevant guidelines and guidance

The following guidelines and guidance are relevant to the local air quality regulation:

- Summary of Standards and Guidelines to support Ontario Regulation 419/05: Air Pollution — Local Air Quality
- Procedure for Preparing an Emission Summary and Dispersion Modelling Report: This document provides guidance regarding the preparation of an ESDM report as required by O. Reg. 419/05.
- Air Dispersion Modelling Guideline for Ontario: This guideline provides an overview of the approved dispersion models and discusses the type of data and approach needed to assess compliance with O. Reg. 419/05.
- Guideline for the Implementation of Air Standards in Ontario: This document provides guidance on the information needed to support a request for a site-specific air standard.

In February 2017, the ministry published a technical bulletin on the *Management Approaches for Industrial Fugitive Sources* intended to provide an overview of the best practices for managing fugitive dust emissions from industrial sources. This bulletin provides information on the typical sources of industrial fugitive emissions, their impacts, and common technologies and practices used in abating these emissions. The bulletin outlines the importance of creating and maintaining a Best Management Practices Plan, which is often included as a requirement in a facility's ECA.

The ministry, as of the time of writing, is in the process of developing an Odour Framework that will be used to outline the ministry's approach to controlling odorous emissions. This framework is being developed in conjunction with a series of tools and guidelines that will assist in implementing the framework, specifically as it relates to the ECA application process or ESDM reporting. A draft of the proposal is expected to be completed early in 2019.

Environmental Practices Guide

The OAPC formerly OHMPA publishes “Environmental Practices Guide for Ontario Hot Mix Asphalt Plants”. From time to time the OAPC updates the guide. The most recent version of the guide is the fifth edition which was published in 2015.

This document includes information on sources of air emissions including particulate and volatile organic compounds (VOCs) as well as odour and noise; best practices to control and minimize air emissions and documentation requirements. The guide assists plant operators in understanding the regulations that a plant must be assessed for and potentially comply with.

5.1.2.2. **Alberta**

The Environmental Protection and Enhancement Act (EPEA) prohibits the carrying out of activities that may impact the environment in Alberta unless an approval is obtained. The Activities Designation Regulation, under the EPEA, details which activities require approvals.

The EPEA also allows the Alberta Ministry of Environment to develop ambient environmental quality objectives, standards, and practices, codes of practice, guidelines or methods to protect Alberta’s ambient quality. For air in particular, all industrial facilities are required to be designed and operated such that ambient air quality objectives are respected. These objectives are used to establish required stack heights and end-of-stack limits or to assess compliance and evaluate facility performance. For instance, when facilities apply for an approval they must determine maximum ground level concentrations of SO_2, NO_2 or any other air contaminant that is significant and provide a dispersion modeling report.

This regulation limits the concentration of particulate matter across the province for all manufacturing or production. As well, the Regulation states that any facility manufacturing asphalt must follow the “Code of Practice for Asphalt Paving Plants” [27].

This Code of Practice (CP) limits emission as listed below:

- The opacity from all air emission sources at the asphalt paving plant shall not exceed 40 percent, averaged over a period of 6 consecutive minutes.
- The concentration of particulates in each effluent stream from the asphalt paving plant’s dryer stack to the ambient air shall not exceed 0.20 grams per kilogram of effluent.
- Emissions from the asphalt paving plant shall not cause an offensive odour.
- Fugitive dust emissions from the asphalt paving plant shall not cause an adverse effect

As well, the CP mandates certain housekeeping standards for emission control technologies as noted below:

- Wet Scrubbers
    - Must be operated to ensure sufficient retention time to settle out dust and sediment
    - Outlet scrubber water must be inspected on a daily basis, noting clarity (either Clear, Cloudy or Muddy) and any sediment in the Environmental Log (EL)
    - Scrubber water pump should be of sufficient size to provide the circulation capacity required for proper operation. The pump capacity should be tested annually and recorded in the EL
    - Hoses and couplings connecting the pump to the return water pit or tank and scrubber should be inspected daily and the results are recorded in the EL
    - A pressure gauge reading to the nearest 50 kPa or 5 psi is installed and maintained on the outlet of the scrubber water pump. Pressure should be recorded in the EL at least once per day while under normal operation. Any significant deviations from normal operating pressures should be investigated and corrected.
- Baghouse systems
    - The integrity of the baghouse is inspected daily and results included in the EL. Inspection shall include checking the outlet duct to verify no dust is passing.
    - A fluorescent trace dust test is performed the first week of every calendar year, and then once every 200 hours. Results are recorded in the EL
- Other requirements include:
    - Plume from the main stack is checked and recorded in the EL as either clear, white, dark, or dusty
    - Dust from collection equipment must be properly handled to ensure no release to atmosphere
    - Liquid burner fuel other than virgin fuel grade product must come from an Alberta Environmental Protection approved facility
    - EL is filled out when replacements or repairs are made to the control technology

This Code of practice will be reviewed every 10 years beginning in 2006.

As mentioned, the EPEA permits the development of ambient air quality guidelines that are used to address the emissions of specific pollutants from industrial sources. To understand the necessity of a guideline for B[a]P, a report was developed to provide a review of the scientific and technical information available. This report highlighted the physical and chemical properties of B[a]P, the emissions sources of B[a]P, the health effects of B[a]P, a review of B[a]P regulations in similar jurisdictions, and an overview of the monitoring techniques used for B[a]P [26].

5.1.2.3. **Quebec**

The Environmental Quality Act grants the Ministère du Développement durable, de l'Environnement et des Parcs (MDDEP) the power to prohibit the construction and alteration of an industry, or the starting of an activity that will result in a release of contaminants into the environment, unless a Certificate of Authorization is first obtained.

Clean Air Regulation under the *Environment Quality Act*

The *Clean Air Regulation* came into force on June 30, 2011 and replaced the *Regulation Respecting the Quality of the Atmosphere*. It updates ambient air quality standards for conventional contaminants (e.g., particulate matter, NO_x, SO_2), and introduces new ambient air quality standards and stricter emission standards. The regulation also has provisions on emissions monitoring and control, particularly regarding continuous monitoring and periodic source testing.

The following, Table 1, is taken from Division 5—Air Pollution Control Equipment

- Emissions for particulate matter are as noted in the table below:

Production Rate metric tonnes / hour	Standards (kg/h) Existing	Standards (kg/h) New
≤ 50	23	1.5
100	24	2.5
150	25	3.5
200	26	4.7
250	27	6.2
300	28	7.7
350	29	9.2
≥400	30	10.7

Table 1 Tabulated emissions of particulate matter and production rate.

- Opacity for any plant must not exceed 20%
- Dryer, bucket-elevator, screens, mixing and weigh hoppers and all transport points of aggregate will be enclosed and exhaust through dust collectors
- The height of the stack where sampling will be performed must be equal to 10 times its inner diameter, beginning from any bend or other disturbance
- Existing Plants are those in operation before Nov 28, 1979, however, they were expected by Jan 1, 1980 to comply with the “new” emission standards
- Dust from Dust Collector systems must be handled so that there will be no emissions to the atmosphere

5.1.2.4. **British Columbia**

The Environmental Management Act is the primary legislation for environmental issues. It prohibits the discharge of waste from specified industries, trades, businesses, operations or activities to the environment unless appropriate authorization is obtained. There are two types of environmental authorizations: permits and approvals. The approvals are authorizations issued for a short period, no more than 15 months. When the operation period is longer than 15 months, a permit is required. A single permit is used both for site construction and operation. Permits do not have a period of validity, but must be amended when there is a change in production rate, installation of new equipment, modification of process or at the discretion of the regional manager. There are three types of permits: air permit, effluent permit, and solid waste (refuse) permit.

Air permits cover all significant sources of air emissions and their emission control equipment. A typical air permit for the hot mix asphalt industry can contain an end-of-stack concentration limit and an emission rate limit for particulate matter. Ambient air limits, monitoring, or dispersion modeling requirements may be established in the air permit. The limits contained within a permit are based on provincial objectives and policy, regional considerations, negotiations and best available technology.

The following, Table 2, is a summary of some requirements outlined in Regulation 217/97 (Asphalt Plant regulation), last amended in 2018:

1. Emission Limitations:

Column 1	Column 2	Column 3
Parameter	Concentration Limit: • Lower Fraser Valley • Prince George Area • New Plants • Modified Plants	Concentration Limit: • Other Plants
Particulates	90 mg/m^3	120 mg/m^3
Organics (VOC including alkanes, alkenes and arenes)	60 mg/m^3 (1 hr average)	120 mg/m^3 (1 hr average)
Opacity	20%	20%
Carbon Monoxide	200 mg/m^3	400 mg/m^3

- Concentrations in mg/m^3 on a dry basis corrected to 16% oxygen, 20^0C and 101.325 kPa
- Column 3 refers to all plants located outside the Lower Fraser Valley (excluding Prince George area) built before June 27, 1997
- “New plants” refers to all plants built after June 27, 1997
- “Modified plants” refers to all plants built before June 27, 1997, but have been modified so their new maximum production is 10% or greater than before the modification.

Table 2 Tabulated emission limitations for plants located in Lower Fraser Valley, Prince George Area, new plants and modified plants as well as other plants.

2. Handling of material collected by emission controls

Any particulates captured by the control must be contained so as to not release them to the atmosphere. If water is used to remove contaminants, the effluent must be sent to a settling pond or an approved treatment works. When draining a settling pond, the effluent must not enter a stream (either directly or indirectly); the settled material in the pond is handled correctly to not release them to the atmosphere.

3. Monitoring and Testing

Stack testing at each aggregate dryer discharge is required every two years for the following:

a) Facilities which produce more than 10,000 tonnes of hot mix asphalt (HMA) per year and their three most recent emission tests comply with the standards
b) Facilities that produce less than 10,000 tonnes per year

Testing must occur at 80% of the plants maximum production.

Stack testing must collect the following information and be reported within 60 days of the test:

- Flue gas discharge flow rate in cubic metres per minute, corrected to 20°C and 1 atm;
- Carbon dioxide and oxygen concentrations in flue gas in percent by volume;
- Moisture content of flue gas;
- Amount of recycled asphalt pavement used, if any, as a percentage of total hot mix asphalt production;
- Temperature of the final hot mix asphalt product leaving the plant;
- Plant production rate measured over the duration of stack monitoring expressed in tonnes per hour;

If a source test shows emissions exceed the standard, another test must be performed within 90 days. A plan for the actions a plant decides to undertake to reduce these emissions must be delivered within 120 days of the original test. The director can accept, amend or reject the plan. If their plan is rejected or they did not submit one within the 120 days, they are prohibited from discharging emissions, except for subsequent stack tests to demonstrate they are back within range.

The regulation in addition has:

- requirement to develop maintenance of plant and emergency procedures.

- Offence and penalty for false information, commits knowingly an offence and is liable on conviction to a fine not exceeding $100, 000 otherwise, if not knowingly commits an offence and is liable on conviction to a fine not exceeding $200, 000.

In 2012, the BC Ministry of Environment planned to institute a Code of Practice for the Asphalt Industry. This Code of Practice implements the more stringent standards for all Asphalt plants across the province, eliminating the distinction between mobile and stationary plants, but still allowing the GVRD to apply its own standards if they are more stringent than the provincial ones. This Code also requires an oxygen combustion level between 12% and 16%. A facility permitted to operate outside this range must correct emissions to 14% oxygen.

The following are also included:

- Removal of mandatory testing at 80% capacity; testing will occur at the average production rate based on a rolling average between the months of June and August.
- Explicit prohibition of fuel switching for testing purposes. That is, the company must use their regular fuel supply when testing and not switch to a low sulphur content one
- Inclusion of both hot mix and/or warm mix asphalt operations
- Daily records of fuel types and volumes used
- For plants with <10,000 tonnes per year of production, if they are unable to meet the production durations needed for a stack test, the following will be required:
  - Logging of the date, duration and total production during each production event
  - Logging of annual production rate
  - Performance of an opacity test by a certified reader
- Records must be kept for at least 7 years
- The BC Ministry of Environment must be notified within 24 hours of an emergency condition, providing subsequent information on the emergency and remedial actions within 30 days.

Greater Vancouver Region District (GVRD)

GVRD had its own Bylaw (Bylaw No. 937, 1999), which has since been revoked and is now superseded with “Air Quality Management Bylaw No. 1082, 2008”. This new Bylaw replaces several other bylaws enacted. This bylaw contains no specific information for the regulation of HMA plants. Instead, it speaks in generalities, stating that no facility is allowed to emit pollutants without an approved permit obtained from the district director.

5.1.2.5. **Saskatchewan**

In 2015, the Saskatchewan Ministry of Environment published an environmental guideline for Saskatchewan asphalt plants which applies to all stationary and mobile asphalt plants located in the province, and replaces the 2003 Asphalt Plant Policy/Guideline**.**

- Permits to operate are no longer issued by the Clean Air Act and The Clean Air Regulations
- The Saskatchewan Environmental Code published in 2015 does not regulate asphalt plants directly due to the lower environmental risks associated with HMA plants when management practices, such as those outlined in the Best Practices Guide for Hot Mix Asphalt Plants published by the Canadian Construction Association (CCA83-2004)
- While neither stationary nor mobile HMA plants are considered an “industrial activity” within the 2010 Environmental Management and Protection Act (EMPA), the EMPA does have the authority to conduct compliance investigations and, if necessary, issue a Control Order (as per Section 54 of EMPA 2010) for HMA facilities in the case of an adverse effect to the environment.
- The 2015 Guideline eliminates the need for stationary or mobile HMA facilities to obtain permits/approvals for construction and operation, and clarifies the operational requirements for both types of facilities. Some requirements that asphalt owners and operators are required to meet include:
    - Ensuring that their air pollution control system is regularly serviced, and if necessary, is upgraded to meet particulate emission criteria levels; the air pollution control system is operating to its normal efficiency rating, and the proper operational procedures are carried out;
    - Ensuring that substances that may cause adverse effects as defined in Sections 2(1)(b) or 51(a) of EMPA 2010 are not (either directly, or indirectly) are not discharged into the environment ;
    - Maintaining operational logs which may include hours of operation, air pollution control system operation and maintenance records, plant and process upsets, amount and type of fuel(s) burned, control of on-site fugitive emissions, stack testing results, among others, as well as stack testing results, air dispersion modeling results, and membership in an air zone, if applicable.
    - Maintaining the operational logs for at least 3 years
    - For mobile asphalt plants specifically:
        - Must choose locations that are remote from villages, towns, cities, water courses, and businesses or residences. The Guideline provides specific separation distances from villages, towns and cities, recreational parks, residence or business and water course.

        - Must be equipped with, at minimum, cyclones to capture particulate emissions
    - For stationary plants specifically:
        - Are recommended to review the Self-Assessment Checklist in the Technical Proposal Guidelines if located in sensitive areas such as native grasslands, near wetlands, etc.
        - The particulate emission control technology includes baghouses, wet scrubbers and cyclones.
        - Must meet the minimum operating criteria for stationary HMA plants:
            - Ensure that total particulate matter emitted from dry exhaust stacks do not exceed 0.25 grams per standard cubic meter, measured on a dry and undiluted basis
            - Minimize fugitive emissions of particulate matter
        - Must perform annual stack testing while operating under normal operating conditions to ensure that total particulate matter emitted from dry exhaust stacks does not exceed 0.25 grams per standard cubic meter.
        - Must conduct stack tests in accordance with Environment Canada or U.S. EPA reference methodologies, or by other ministry approved methods. Stack sampling surveys must consist of three separate tests.
        - In the case of an exceedence of the 0.25 grams of particulate matter per standard cubic meter, results and a plan to reduce emission to meet the requirement are to be submitted to the ministry within 10 working days.

5.1.2.6. **Manitoba**

Under the Manitoba Environment Act (Act), there are no specific requirements for hot mix asphalt plants. Any industrial activity that emits a pollutant as defined in the Act that remain at one location for more than one year are listed as Class 1 development. Air pollutants that are addressed include particulate matter and opacity, noise and odour nuisance, and on-site fugitive dust release. Sites that exist for fewer than 365 days, are not licensed but are subject to siting guidelines and generally do not have particulate emission controls.

5.1.2.7. **New Brunswick**

Asphalt plants are not specifically identified in the Clean Air Act N.B. Regulation 97-923. Controlled emissions include CO, H_2S, NO_x, SO_x, and TSP. 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.

5.1.2.8. **Nova Scotia**

Asphalt plants are not specifically identified in the regulation under the Environment Act N.S. Regulation 47/95 and N.S. Regulation 55/95. Only general statements are made on procedures for air quality. Site specific emissions are defined in individual permits.

- Maximum permissible ground level concentrations of CO, H_2S, NO_s, O_3, SO_2, and TSP are governed by Schedule A of N.S. Reg. 28/2005 (Sections 25 and 112 of the Environmental Act)
- An approval issued by the Minister or an Administrator must contain provisions to ensure that the maximum permissible ground level concentrations prescribed in Schedule A are not exceeded.
    - https://www.novascotia.ca/just/regulations/regs/envairqt.htm
- As per N.S. Reg. 47/95, the Minister or an Administrator may issue one approval that will cover all activities and comprises all required approvals for a given facility, including HMA plants.

5.1.2.9. Prince Edward Island

Asphalt plants are identified in the PEI Environmental Protection Act https://www.princeedwardisland.ca/sites/default/files/legislation/e-09.pdf (may make regulations respecting the design, location, configuration, construction,

operation, installation and testing of, and the restricting and reporting of emissions in respect of asphalt plants);

https://www.princeedwardisland.ca/sites/default/files/legislation/e09-02.pdf (fee structure for permits). This province also makes reference to the Canadian Construction Association document CCA 83-2004: Environmental Best practices Guide for Hot Mix Asphalt Plants.

5.1.2.10. Newfoundland and Labrador

Asphalt plants are not specifically identified in the Air Pollution Control Act Regs.957/96.

The following limits are imposed on emissions:

- Visible emissions are limited by their Visible Emission Chart located in the Reg.
- Ambient Air quality are limited to the following:
    - 24 hour averages for PM
        - Total PM 120 ug/m^3
        - PM10 50 ug/m^3
        - PM2.5 25 ug/m^3
    - Annual average for PM
        - 60 ug/m^3
    - 24 hour average for BaP
        - 0.0015 ug/m^3
    - Annual average for BaP
        - 0.0003 ug/m^3

- Established limits for air contaminants emitted into the atmosphere are proscribed in Schedule A of the Air Pollution control Act Reg. 957/96 are set at a 24-hour averaging period for 249 contaminants, and at 1-year, 1-hour, and 10-minute averaging periods for a select number of contaminants.
- As per Service NL, a certificate of approval is required once per season to allow for the operation and/or construction of an HMA plant. Additional approvals may be required if any changes to the plant are made during the paving season, or if changing the location of the plant.

http://www.servicenl.gov.nl.ca/licenses/env_protection/asphalt/index.html

5.2. **United States**

The climate in which the asphalt is to be used on roads does play role in mix design. States that boarder with Ontario were considered for codes of practice/imposed technologies on asphalt mix plant. During the development of this technical standard only Michigan has actively imposed controls on the emissions associated with storage and loadout of the hot mix asphalt. Details of the lessons learned can be found below after discussion on New Source Performance Standards and National Emission Standards for Hazardous Air Pollutants Regulations.

New Source Performance Standards (NSPS)

New source performance standards (NSPS) are established to control the emissions of criteria and welfare-related pollutants from industrial sources. These regulations apply to new sources or sources that undergo major modifications or reconstruction after the date of promulgation and are reviewed periodically as pollution control technologies change to ensure that facilities are using control technologies which represent the capabilities of the currently available equipment.

The NSPS for a source category can include emission limits for one or more of the criteria pollutants, surrogates for criteria pollutants, e.g., opacity for PM, other pollutants related to criteria pollutants, e.g., VOCs because of their direct impact on ambient ozone, and “welfare-related” pollutants.

Under the New Source Performance Standards (NSPS) 40 CFR Part 60, Part I 60.90-60.93 Standards of Performance for Hot Mix Asphalt Facilities, the standard for particulate matter is outlined below:

60.92 Standard for particulate matter.

(a) On and after the date on which the performance test required to be conducted by 60.8 is completed, no owner or operator subject to the provisions of this subpart shall discharge or because the discharge into the atmosphere from any affected facility any gases which:

1. Contain particulate matter in excess of 90 mg/dscm (0.04 gr/dscf).
2. Exhibit 20 percent opacity, or greater.

National Emission Standards for Hazardous Air Pollutants (NESHAP) Regulations

The Clean Air Act Amendments required the United States Environmental Protection Agency (USEPA) specifically listed 189 pollutants as ‘hazardous air pollutants’ (HAPs) and required USEPA to develop rules to reduce emissions of these pollutants from industrial sources over a period of 10 years. In particular, USEPA had to address all sources having the potential to emit over 10 tons/year of one HAP or 25 tons/year of total HAPs. In addition, emission limits were set based on Maximum Achievable Control Technology (MACT) for these ‘major’ sources.

For existing sources, MACT is defined as the emission limit being achieved by the “best performing” 12% of all similar sources in the industrial subcategory. For new sources, the standards have to be set at a level being achieved by the single best performing source in the subcategory. Hot Mix Asphalt Mills are currently not subject to any MACT standards.

5.2.1. **Michigan**

The state of Michigan was contacted to describe their experience with Hot Mix Asphalt plants to the ministry - OHMPA technical working group (March 8, 2016 technical working group meeting).

A permit engineer and an inspector with the Michigan Department of Environmental Quality (MDEQ) – Air Quality Department informed via teleconference, how Michigan HMA plants are permitted. In Michigan, there are approximately 113 HMA plants with active Permits, of which 46 are portable.

Michigan Air Pollution Control Rule R336.1289 (Rule 289) exempts an asphalt production facility from the requirement to obtain a permit if certain controls are installed: AC storage tank with vapour condensation and recovery (or equivalent) and a storage silo with all emissions vented back into the burning zone of the kiln (or equivalent).

Current permanent plants require control on top of the silo and the loadout. The fumes forced out of the top of the silo, when hot-mix is added, are ducted back to the drum for burning. The loadout control, also known as “blue smoke” control, is an enclosure around the loadout, with air drawn from the loadout and surrounding area and passes through a filter before being exhausted. This stream cannot be passed to the drum burner because of the amount of air drawn and the challenge of maintaining the air balance.

The control on the loadout has safety issues related to visibility of staff, and safety of the driver in the tunnel area.

AC storage tank controls include a passive system (long vertical pipe; vapour condenses and drips back to tank), or a 2-stage condensing filter (condenses on steel wool filter, and drips back to tank).

In 2002 USEPA delisted HMA facilities from MACT requirements, but MDEQ continued the state requirements to control odour. In 2009, the Director banned permitting new parallel-flow drums. Around half of the existing plants, and all new plants have counter-flow drums. MEDQ noticed that number of complaints has dropped significantly for plants with such controls.

The MDEQ permits required facility emission testing for eight 8 years ending in 2012 (included benzene, xylene, toluene, naphthalene, formaldehyde, acrolein, and some metals – but did not include PAH testing). This data is publicly available, and MDEQ feels it is more representative than the USEPA AP-42 factors.

5.3. **United Kingdom**

The UK Expert Panel on Air Quality (EPAQS) set an air quality standard for B(a)P at 0.25 ng/m^3. This concentration has been adopted as a provisional national air quality strategy objective for England, Wales and Scotland, to be achieved by 31 December 2010.

Process Guidance Note 3/15a (04): “Secretary of State’s Guidance for Roadstone Coating Processes” was issued by the Secretary of State, the Welsh Assembly Government and the Scottish Ministers to provide guidance on the conditions appropriate for the control of emissions into the air from roadstone coating processes as defined in the Environmental Protection Act 1990.

This guidance note includes the best available techniques (BAT) and emission limit values achievable using BAT. For instance, the emission limit for total particulate matter is 50 mg/m^3 for a new or retrofitted road stone coating plant with new arrestment equipment. Other provisions with respect to monitoring, recordkeeping and notification are also included.

In 2014, Public Health England published the second version of a public report focused on polycyclic aromatic hydrocarbons (PAHs), with a specific focus on B[a]P. The report provided background on the major sources of B[a]P, its health effects, and other chemical and physiological properties. There was a considerable emphasis placed on incident management procedures in the case of exposure to B[a]P [28].

5.4. Netherlands

The Netherland Emission Guidelines for Air (NeR) a Federal document published in 2007 sets emission limits for most substances emitted to air and special provisions for specific activities and branches of industry for example asphalt mix industry. It does not have a legally binding status but it serves important guideline for permitting authorities. The NeR was developed by provinces, municipalities, the national government and the representatives for trade and industry.

The specific provisions for asphalt mix industry include requirements for: emissions of polycyclic aromatic hydrocarbons (PAHs), particulates and odour.

For emissions of particulate the existing fabric filters must meet a minimum emission requirement of 30 mg/m3. For a new particulate cleaning equipment the baghouse is considered to be Best Available Technology for controlling the emissions of fine particulates.

In the case of emissions of PAHs the rules are very specific to recycling of asphalt using a parallel drum. The waste gases must be recycled to the burner of the main drum or incinerated.

With respect to odour the document identifies following sources: asphalt cement tanks, drum containing the mineral charge, the mixer, finished product conveyor and the discharge points, emissions resulting from loading and unloading of the hot mix asphalt. The emissions from the parallel drum must be discharged through a stack. The NeR in addition covers odour abatement measures.

1. Limit emissions from the asphalt cement tanks using water lock.
2. The vehicles that transport final product off site must be covered.
3. Stack height must be at least 20 m or 30 m where old asphalt is recycled at high temperatures.
4. Placing enclosures and designing the loading bay in such a way as to allow collect emissions and vent via an elevated emission point.

The zoning requirements are based mainly on considerations of limiting noise pollution, 200 to 500 m from residential areas.

5.5. **European Union**

Under Article 16(2) of Council Directive 96/61/EC, the European Union conducted an investigation of the best available techniques for pollution control in the Large Volume Organic Chemical (LVOC) Industry. The initial report was published in February 2003, with a second version of the report being published in 2017. The report provides a broad outline of the major sources of VOC, PM, combustion gas, acid gas, and dioxin emissions from the LVOC industry, as well as sources of water pollutants and wastes. It offers an indication of the processes that generally produce emissions, and an extensive overview of techniques used to control the emissions from the identified sources.

In the control of VOCs, the report suggests that toxic VOCs should be replaced with less harmful substances, and that volatile compounds should be substituted with non-volatile compounds, where possible. Since this is not always possible, the report offers a number of additional techniques to control these emissions, including the following:

- Capture and reuse VOCs within the process
- Thermally/catalytically decompose VOCs
- Tank modifications (i.e. use of an external floating roof, storage under pressure, etc.)
- Store at lowest possible temperature
- Installation of leak detection devices

To control combustion gases, the report suggests switching to fuels with lower concentrations of carbon, nitrogen, and sulphur, utilizing low NO_x burners, the installation of selective catalytic or non-catalytic reduction technology (SCR/SNCR), and installing in-furnace of flue gas injection systems.

Particulate matter can be controlled by containing dust-prone materials in covered areas or storage vessels, making use of dust-suppression equipment (i.e. water sprays), installing scavenging systems near handling areas, and the use of technology for cleaning air (cyclones, filters, ESPs, etc.).

The report also offers a number of specific recommendations for the control of different equipment, including process heaters and furnaces [29].

6.0 Summary of Current Methods to Minimize Emissions from Dominant Sources

In this chapter various controls applied to reduce emissions of:

- asphalt cement fumes;
- suspended particulate matter; and
- combustion gases.

6.1. Control of Emissions of Asphalt Cement Fumes

This chapter describes methods and controls currently and commonly employed at hot mix asphalt (HMA) plants to minimize emissions of asphalt cement fumes. The asphalt cement fumes are defined in this document to represent a mixture of PAHs, VOCs, metals and non-VOCs. Basic assumption was made that any reduction or treatment of fumes would reduce emissions of any of the contaminants that make up the asphalt cement fume.

Asphalt cement fume emissions at HMA plants are created from the delivery, storage and use of AC. There are potentially four areas in the HMA production process where emissions of fumes can be generated from AC during the asphalt plant operating season:

i) asphalt cement (AC) delivery and storage;

ii) mixing after the addition of AC (i.e. mixing drum or batch pugmill);

iii) HMA storage silo filling; and

iv) HMA loadout.

The fumes are a mixture of various contaminants found in asphalt cement that would volatilize along with vapour.

6.1.1. Asphalt Cement Delivery and Storage

6.1.1.1. Optimizing Asphalt Cement Usage

Since AC delivery, storage and use is the source of asphalt cement fumes emissions, if HMA plants were able to further reduce the total quantity of AC required for production this would reduce asphalt cement fume emissions at all four stages of production. This must be balanced by ensuring enough AC to coat the aggregate for pavement quality standards.

HMA plants currently optimize the quantity of AC used in production because AC, along with fuel, is the most significant operating costs in a highly competitive industry.

Further reductions in AC usage are not technically feasible because AC quantities are clearly defined for most Ontario contracts in Ontario Provincial Standard Specifications and contract specific Special Provisions. Specifications, in most cases provide “total” mix AC content (%) and allowable recycled asphalt content (RAP %).

6.1.1.2. **Optimizing RAP Usage**

Since RAP is a source of AC, which has a lower B(a)P content (because the B(a)P has previously been released), increasing the quantity of RAP used in asphalt production would decrease the quantity of AC required in the mix.

HMA plants currently optimize the quantity of RAP used in production.

Further increases in RAP usage are not technically feasible because RAP content is clearly defined for most Ontario contracts in Ontario Provincial Standard Specifications and contract specific Special Provisions.

The 2016 Ontario Provincial Standard Specification for municipalities states that up to 15% of RAP by mass can be incorporated in the new hot mix asphalt.

6.1.1.3. **Minimizing Asphalt Cement Delivery and Storage Temperatures**

The emissions of asphalt cement fumes occur from following operations:

i. during delivery, as vapour when transferring AC from the delivery tanker trucks into the AC storage tanks, and

ii. storage tank breathing loses.

Minimizing AC delivery and storage temperatures would reduce the total quantity of vapours released. Below, Table 3, are typical AC delivery and storage temperatures recommended for Performance Graded Asphalt Cement (PGAC), [25], as suggested by OHMPA for their members.

Performance Graded Asphalt Cement (PGAC)	**AC Delivery Temperature Min.**	**AC Delivery Temperature Max.**	**AC Storage Temperature Min.**	**AC Storage Temperature Max.**
PG 52-34	120ºC	150ºC	130ºC	160ºC
PG 52-40	120ºC	150ºC	130ºC	160ºC
PG 58-22	130ºC	160ºC	140ºC	165ºC
PG 58-28	130ºC	160ºC	140ºC	165ºC
PG 58-34	135ºC	160ºC	140ºC	165ºC
PG 64-28	140ºC	165ºC	150ºC	170ºC
PG 64-34	145ºC	170ºC	150ºC	170ºC
PG 70-28	145ºC	170ºC	150ºC	170ºC
PG 70-34	150ºC	170ºC	150ºC	170ºC

Table 3 Generic temperatures for delivery and storage of various performance graded asphalt cement.

Note, the actual recommended AC storage temperatures are set by the suppliers according to characteristics of individual grades and can differ from those suggested by OAPC.

This important control is a current best practice across the industry.

6.1.2. Mixing of Asphalt Cement with Aggregates

6.1.2.1. Reducing Mixing Temperatures

Since asphalt cement fumes emissions are released from the mixing process after AC has been added, minimizing the mixing temperature after the addition of AC would reduce the total quantity of fumes emissions released.

HMA plants actively minimize mixing temperatures to minimize fuel usage and costs. The mixing temperature is dictated by the mix design which must meet customer and performance specifications. It is worth noting that the mix design is a set of instructions on how to produce specific asphalt mix for a particular job, it is designed in ideal, laboratory, environment. The mix design contains information about the types of aggregates, RAP, which PG grade of asphalt cement to be used to produce asphalt mix.

There are a number of software available out there that assist with estimating adjusted temperature to account for travel time and fact that asphalt mix cools during transportation. This adjustment is necessary as mixing temperature must remain hot enough to drive off water vapour.

From the Environmental Guide published by OAPC, plants are allowed to increase the temperature of the mix up to a maximum of 175 degrees Celsius. The asphalt mix temperature can exceed 175 degrees Celsius when:

- material requires to be transported long distance during cooler period;
- the mix was designed for overpass or bridge; and
- most recently the use of superpave.

The superpave itself does not call for high mix temperature. In order to meet the performance requirements the asphalt supplier designs specific asphalt mix which recently involves addition of various additives that reduce viscosity of the asphalt cement. Problem arises at the hot mix plant when the specialty asphalt cement has to be stored and pumped in line. In order for the highly modified asphalt cement to pump, current solution is to bring its temperature up.

In 2018 the industry noticed that municipality of Toronto begun to use superpave in all jobs. Currently the industry is trying to work on a better solution to the problem by working with the municipality on educating on the use of superpave consequences of having to produce asphalt mix at higher temperatures.

6.1.2.2. **First (Primary) Particulate Matter Collection System**

It is standard industry practice in Ontario to operate a primary particulate matter collection system (i.e. cyclone, multiclone and/or knockout box) through which mixing gases are exhausted prior to the secondary particulate matter collection system (i.e. baghouse or wet scrubber).

The primary particulate matter collection system is referred to as a “precleaner” because it is used to remove larger, abrasive particles before the air stream reaches the secondary particulate matter collection system. A cyclone is configured to produce a cyclonic air flow pattern inside. As the air spirals through the cyclone, the centrifugal force causes the dust, which is heavier than the exhaust gases, to move to the outside of the flow toward the plate walls. The gas flow is then turned inward away from the walls leaving the dust to slide down into the cone or hopper.

Cyclones remove particulate by centrifugal or inertial forces, induced by forcing particulate-laden gas to change direction. In applications where many small cyclones are operating in parallel, the entire system is called a multicyclone or multiclone.

A knock-out box is simply an enlarged section of ductwork with a hopper underneath. A knock-out box slows the exhaust gas stream and allows some of the dust to settle.

While this is highly effective at reducing total particulate emissions the effect on B(a)P emissions will be limited because B(a)P preferentially condenses onto fine particulate, which is not removed by the primary particulate matter collection system.

6.1.2.3. **Second (Secondary) Particulate Matter Collection System**

It is a standard industry practice for hot mix asphalt plants in Ontario to operate primary and secondary particulate matter collection systems through which mixing gases are exhausted. The secondary particulate matter collection system captures particulate matter containing B(a)P, thereby reducing B(a)P emissions. Most plants utilize a baghouse for fine particulate emission control from the mixing process. Only a small number of plants use a wet scrubber.

In 2018 during the time this technical standard was being developed the industry has indicated that wet scrubbers are slowly phased out. They are considered cumbersome and when one reaches its expiry the company moves to use of a baghouse.

6.1.3. Hot Mix Asphalt Storage Silo Filling

6.1.3.1. Minimizing Hot Mix Asphalt Storage Temperature

Since asphalt cement fume emissions are released from HMA silo filling, minimizing the HMA storage temperature would reduce the total quantity of asphalt cement fume emissions released.

HMA plants actively reduce HMA storage temperatures to minimize fuel usage and costs. The HMA storage temperature is dictated by the mix design which must meet customer and performance specifications.

6.1.3.2. Enclose Conveyors and Transfer Points for the Handling of Hot Mix Asphalt

Typically conveyors and transfer points where HMA is moved from the mixer/pug mill to the HMA storage silos are enclosed to prevent heat loss. This also reduces the release of fugitive asphalt cement fume emissions prior to reaching the HMA storage silo.

This is a current best practice across the industry.

6.1.4. Hot Mix Asphalt Loadout

6.1.4.1. Minimizing Hot Mix Asphalt Loadout Temperature

Since asphalt cement fume emissions are released from HMA loadout, minimizing the HMA loadout temperature would reduce the total quantity of asphalt cement fume emissions released.

HMA loadout temperature is the same as the HMA storage temperature in HMA storage silos or the same temperature as the mixing temperature for batch plants without HMA storage silos.

HMA plants actively reduce HMA mixing and storage temperatures to minimize fuel usage and costs.

6.1.4.2. Minimizing Hot Mix Asphalt Loadout Drop Height

Since asphalt cement fume emissions are released from the exposed surface of asphalt during HMA loadout, minimizing the drop height will minimize the exposed surface area of the asphalt will therefore reduce the total quantity of asphalt cement fume emissions released during HMA loadout.

Minimizing the loadout drop height is limited to potential required truck clearance heights. In addition, HMA plants are designed to limit the drop height into HMA trucks where practicable to maintain product temperature, reduce loading time and maintain product quality (i.e. prevent potential segregation of fine and coarse aggregate).

This is the current best practice across the industry.

6.1.4.3. **Asphalt Mix Loadout Vapour Recovery System**

The asphalt mix loadout vapour recovery system is also known as blue smoke control system. The blue smoke is a visible emissions with blue colour, it is a visible aerosol emission associated with the hot mix asphalt. Figure 3 below shows an example of such system which in this case has enclosure around the hot mix asphalt loadout, Vulcan company.

Figure 3 Example of a vapour recovery system which includes enclosure of the loadout point.

The system can comprise of enclosure around the loadout point and capture of the emissions in order to then divert them through pollution control equipment. In order to capture the emissions the material transfer points have to be sealed, a scavenging fan pulls the emissions and through ductwork.

The collected emissions can then diverted to one of following options:

- To the dryer, specifically the burner, and ultimately passed through the baghouse servicing the dryer and the stack;
- own dedicated three stage filter.

The dedicated three stage filter can cost up to 80,000$ information shared by the supplier. The asphalt mix industry in Ontario expressed as cost being a significant one. The system has own challenges as it takes space to install and best is to have it designed and installed as the plant design is considered. The filter and each stage has own lifetimes. A mix of water with liquid asphalt cement is by product of the system that has to be disposed of. During the process of development of this technical standard the supplier of this particular technology has indicated that lifespan of the system is 10 years and there so far has not been a system that reached the mark of 10 years. 10 years marks time when the main filter has to be replaced at a significant cost.

The asphalt mix plants that operated in Ontario and have been involved in the development of this technical standard expressed their concern over safety around the loadout enclosure. As the air is being pulled and collected to increase efficiency of the collection the area should be enclosed. The enclosure puts the driver in danger where he/she cannot be reached in case of emergency nor rescued. The same concerns were shared with the state of Michigan where approximately 10 of such systems have been put in place.

At the present time, there is a single plant in Ontario that has installed a vapour recovery system. For the purpose of this technical standard the ministry chose not to impose requirement of vapour recovery system. When the technical standard is updated the ministry will consider the vapour recovery system again. Note, the technical standard does allow for the scavenged air to be directed to general air pollution control technology which allows the plant to decide which equipment to install and opens the opportunity for innovation.

6.2. Control of Emissions of Suspended Particulate Matter

The suspended particulate matter was considered to be mainly emitted from the aggregate storage and handling operations. In this case sample Dust Management Plans that were volunteered by the working group were considered and requirements included in the technical standard.

6.3. Control of Emissions of Various Combustion Gases

The primary concerns from the combustion gases are centred on the emissions and control of sulphur and nitrogen oxides—SO_x and NO_x, respectively.

This chapter outlines the current technologies available to control the emissions of these pollutants, and provides a brief assessment on the feasibility of implementing these technologies at HMA facilities.

6.3.1. Sulphur Oxide (SO_x) Emissions

Sulphur is a natural component of all fossil fuels [30]. Upon the combustion of those fossil fuels, the sulphur is oxidized and emitted from the equipment. The majority of sulphurous emissions are in the form of SO_2, with small amounts of SO_3 and sulphate particulate [31, 32]. Sulphuric acid mist is also generated when SO_3 reacts with water vapour [30]. There are two main methods of controlling SO_x emissions: prevention of SO_x pollution (i.e. preventing the formation of SO_x) and flue gas treatment. Within each of these general streams, there are a number of different technologies. A number are highlighted below.

6.3.2. Fuel Switching

The emission of sulphur oxides during the combustion of fuel is proportional to the sulphur content within the fuel [32-34]. As such, the use of low-sulphur fuels can mitigate much of the SO_x emissions [32, 34]. Potential low-sulphur fuels include natural gas, ultra-low sulphur diesel, and No. 1 and No. 2 fuel oils [34]. The use of natural gas is optimal since it has the added benefit of producing negligible amounts of particulates and mercury, as well as reduced amounts of carbon dioxide and nitrogen oxides when compared to other fuel sources [33].

There are two concerns when considering changing fuels to mitigate SO_x emissions. First, it is important to ensure that existing combustion systems are capable of being converted to operate on these low-sulphur alternatives, while maintaining combustion efficiency [34]. This is not an issue for most HMA facilities in Ontario who are already using natural gas or No. 2 fuel oil as their primary fuel sources in dryers and hot oil heaters. Second, there are concerns regarding the availability and cost of low-sulphur fuel alternatives. While these concerns are valid for certain options, they do not apply to many fuels mentioned above. The cost of natural gas in Ontario, at the time of writing, ranged from \$2.61 to \$4.33 per MMBtu, depending on the provider [38, 39]. For comparison, the average price for diesel in Ontario in 2018 was roughly \$35.40 per MMBtu [40]. Along with the reasonable price, natural gas reserves in Canada are capable of meeting consumer needs for the next 300 years, and thus the availability of natural gas is not a concern [41, 42]. Likewise, the supply and distribution infrastructure for other low-sulphur fuels, such as light fuel oils, is well established in Ontario and does not represent a major concern in terms of product availability [43].

6.3.3. Combustion Modifications

There are currently two combustion methods that have been developed to prevent the production and release of SO_x during combustion: fluidized bed combustion (FBC) and integrated gasification combined cycle (IGCC).

Fluidized bed combustion (FBC) is used primarily in the combustion of solid fuels, such as wood, charcoal, and biomass [43]. FBC uses a hot, pressurized fluid (usually air) to suspend the solid fuel in a bed of ash and other particulate materials [43]. The airflow through the bed causes turbulent mixing of the bed materials and the solid fuel, and leads to the rapid combustion of the fuel [44]. The heat evolved from the combustion can be transferred to water to produce steam, or a similar working fluid [41]. Adding a sorbent, such as limestone or dolomite, to the bed initiates the capture and conversion of sulphur oxide emissions into solid by-products which can be safely removed. In addition, the fluidized nature of the bed promotes heat transfer between particles and allows for the bed to operate at lower temperatures than similar combustion equipment, thus reducing NO_x emissions as well. However, the requirement to maintain fresh sorbent in the reactor bed leads to elevated operating costs for FBC [43-44].

The use of an integrated gasification combined cycle is an alternative combustion method to reduce emissions of sulphur oxides. IGCC uses a high pressure gasifier to turn solid, coal-based fuels into synthesis gas (syngas). The heat produced during gasification can be used to produce steam for heating storage tanks. The syngas is then purified to produce a cleaner fuel which can be combusted in an engine or turbine. Since the syngas is cleaned before combustion, much of the sulphur is removed, and thus the combustion process releases considerably less SO_x [44-48].

While these technologies do present valid options to reduce the emissions of sulphur oxides during combustion, they require the implementation of entirely new technology not being used at HMA facilities. For one, the vast majority of HMA facilities in Ontario utilize either gaseous or liquid fuel sources (i.e. natural gas or No. 2 fuel oil), while FBC and IGCC are based upon the use of solid fuels. This would require the development of entirely new fuel supply chains, storage technology, and fuel loading technology, in addition to the cost of implementing the new combustors. In addition, the design of the burner used in HMA dryers has been highly specialized, and thus implementing new combustion technology may require redesigning the dryers, leading to increased capital cost requirements. These issues make the implementation of FBC and IGCC technology unfeasible at HMA facilities.

6.3.4. **Flue Gas Desulphurization**

Flue gas desulphurization (FGD) represents a set of technologies that are designed to remove SO_x emissions from the exhaust flue gas of the combustion equipment using a wet or semi-dry sorbent [32, 35]. These technologies do not focus on reducing the emissions within the combustion equipment, but instead attempt to remove SO_x in the emissions from the equipment. Generally, these technologies use alkaline reagents to absorb acidic sulphur oxide compounds in the flue gas and produce sulfate compounds that are removed by other equipment [31, 46].

One example of this is the Limestone Forced Oxidation (LSFO) Scrubber. In LSFO scrubbing, the polluted gas stream is contacted with an aqueous slurry of alkaline sorbent (often limestone) by either forcing it through a pool of the sorbent or spraying the gas with the sorbent. The acidic SO_x emissions are absorbed into the liquid and falls into an absorber tank. The cleaned flue gas passes through a mist eliminator before being exhausted through the stack [48]. The absorbed sulphur oxide in sorbent is then oxidized by forcing air into the tank to produce gypsum. The gypsum can be removed and discarded or sold. The efficiency of this technology can be as high as 98%, depending on the design of equipment and the sorbent used. However, capital and ongoing operational costs of this technology are relatively high due to the necessary handling of liquid reagent [35,32, 50].

Another example of this is the Lime Spray Dryer (LSD) Scrubber. LSD scrubbing is a semi-dry form of scrubbing whereby the flue gas is introduced into a spray dry absorber (SDA) where it comes into contact with a liquid sorbent slurry (often slaked lime) that has been atomized. During the process, water in the sorbent slurry is evaporated, while the sulphur oxides in the flue gas react with the lime droplets to produce a solid calcium sulfate/sulfite powder that can be collected by a filter. The efficiency of this technology is lower than that of its wet scrubbing counterpart, ranging from 85 to 92%, but the technology is also less expensive since there is no wet waste to be managed [50].

Both wet and semi-dry FGD technologies require units to be larger than a certain size (typically 25 MW) to be useful. However, as was described earlier, many facilities in Ontario operate dryers that meet these requirements. For most other facilities, it is likely optimal to utilize a different method to reduce emissions.

To understand the cost of implementing a wet or semi-dry FGD system, it is necessary to consider many individual costs: the capital cost of installing the necessary scrubber equipment, including sorbent handling and waste storage equipment; operating and maintenance costs, including any additional power requirements required to operate the technology; and pollutant removal costs. Generally, the capital cost and pollutant removal costs for wet systems are higher than those of semi-dry, but the operating costs of semi-dry systems are higher. It has been reported that performing a retrofit of an existing scrubber can increase the capital cost of the project by as much as 30%. An example of a typical cost breakdown for wet and semi-dry systems is given below. The removal of pollutant is reported to be roughly $100 less per ton for semi-dry systems than wet systems. An additional consideration must be given towards the selection of the sorbent used as some can provide higher efficiencies, but also incur considerable increases in operating costs. In addition, selection of an appropriate sorbent can allow for sale of the waste product and actually provide a benefit [50, 51].

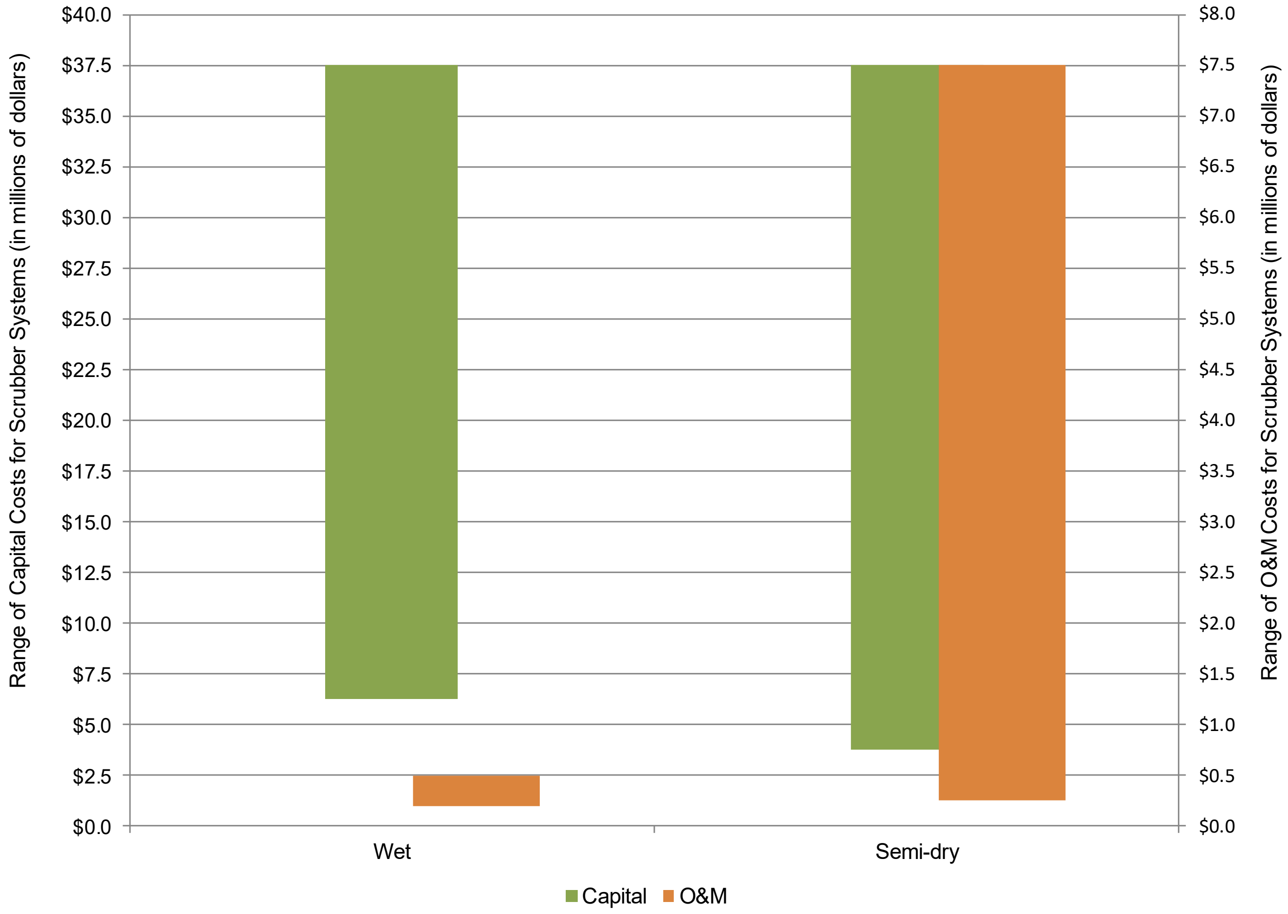

Figure 4 Typical Cost Range for Flue Gas Desulphurization Systems. [48]

6.3.5. Dry Injection

In dry sorbent injection, a dry, powdered sorbent—often Trona (sodium sesquicarbonate), sodium bicarbonate, or hydrated lime—is injected directly into the flue gas exhaust where it reacts with the SO_x in the flue gas forming calcium or sodium sulphates and sulphites, depending on the sorbent used. These compounds are then removed from the flue gas by a downstream baghouse or ESP.

The efficiency of this method is typically much lower than that of LSFO and LSD technologies, ranging between 50 and 60%, but some newer technologies are demonstrating considerably higher efficiencies, especially when accompanied by certain proprietary sorbents. Dry injection technology typically has lower capital and annual costs than wet and semi-dry scrubbers because they are simpler and require less maintenance. However, operating costs depend heavily upon the sorbent used and the amount of sorbent required to remove pollutants from the gas.

These systems are commonly used in retrofit applications due to their relatively simple installation and low space requirements [52-56].

6.4. Nitrogen Oxide (NO_x) Emissions

Nitrogen oxides are generated via two pathways during combustion: fixation of atmospheric nitrogen in the combustion air (“thermal NO_x”) and oxidation of nitrogen bound in the fuel (“fuel NO_x”). NO_x emissions are primarily in the form of NO, but do contain NO_2 as well. The main methods used to reduce NO_x emissions are outlined in the following sections: fuel alteration, combustion modification, and post-combustion controls [54-59].

6.4.1. Fuel Alteration

Similar to with SO_x emissions, fuel NO_x emissions can be reduced by switching to low nitrogen content fuels, such as natural gas or No. 2 fuel oil. As with switching fuels for SO_x control, the major issue is ensuring that existing equipment is capable of operating on, or being altered to operate on, the new fuels. But, as described before, the majority of facilities operating in Ontario are already designed to operate on the low-nitrogen fuels, and thus this is not a major issue for HMA facilities.

Alternatively, a heavy oil/water emulsion fuel can be used to reduce NO_x emissions. By emulsifying water within the fuel, there is a considerable loss of heat during combustion to water evaporation. This reduces the peak flame temperature within the engine, which helps to prevent the formation of NO_x at elevated temperatures. This technology is generally tailored towards use in diesel engines, with most diesel engines capable of being retrofitted with the required equipment. The emulsion technology has the added benefit of improving combustion efficiency due, primarily, to the improved atomization of the fuel. There are a number of difficulties incurred when using this technology, including phase separation of oil and water, a lack of emulsifying agents on the market, and dealing with the corrosivity of the mixture. Since most facilities are already using low-nitrogen fuels already, this is likely not a necessary change [60-69].

6.4.2. Combustion Modification

Combustion modification technologies deal with physical changes to the furnace and operational changes in the process designed to reduce NO_x emissions. There are a large number of potential modifications. A few are described below.

Low excess air firing involves reducing the amount of combustion air mixed with the fuel to the lowest possible level, while maintaining efficiency and environmental compliance [31, 46]. By reducing the amount of air, and hence oxygen, complete combustion is hindered and a lower temperature is maintained. It has been found that reducing excess air by only six percent can reduce NO_x emissions by as much as 19 percent. Despite the reduction in NO_x emissions, the incomplete combustion means an elevated production of carbon monoxide, which may require additional control technologies to maintain compliance. This modification requires no additional equipment, and thus is a very low-cost, simple modification that can offer considerable NO_x reductions. As such, it is recommended that all facilities perform an analysis of their burners to determine the minimum amount of excess air at which they can reasonably operate.

Using a similar theory, flue gas recirculation (FGR) involves extracting a portion of cooled flue gas and recirculating it back into the burner. There are two primary recirculation methods used in FGR: forced, in which an additional fan is used to recirculate the flue gas back into the furnace; and induced, where extra capacity in an existing forced draft fan moves the air back into the furnace. Both of these technologies have the same net effect: first, the cooled flue gas acts to reduce the combustion temperature by bringing in cooler air; and second, the concentration of oxygen in the combustion zone is reduced since the flue gas primarily contains CO_2 and other combustion products. FGR technology has been found to reduce NO_x emissions by as much as 50%. The major problem associated with FGR is the high cost associated with retrofitting burners, and the additional energy requirements used to power the recirculation fan, specifically when employing forced recirculation. However, the cost of an induced flue gas recirculation unit per ton of NO_x reduced is reported to be approximately 35 percent of low-NO_x burners and 15 percent of selective catalytic reduction technologies for burners of 30 MW heat outputs.

Staged combustion involves altering the injection ratio of either fuel or air to produce zones that are either fuel-rich or air-rich. There are a number of different technologies and modifications that use this technique, such as low NO_x burners, overfire air, and others. In air staged combustion, the air flow to the primary combustion zone is reduced in order to produce a fuel-rich zone, where the oxygen present is insufficient to combust all the fuel available. The remainder of the air is directed to a secondary zone where combustion of the fuel is completed. This maintains the peak temperature below that of NO_x formation, while ensuring complete combustion. Fuel staging works in a similar method except the fuel is diverted between multiple combustion zones instead of the air. The primary combustion zone is operated in a fuel-lean manner to reduce peak flame temperature. The remainder of the fuel is added downstream in a lower oxygen environment where reduction of NO_x occurs [70-73].

Low NO_x burners are designed to mix fuel and air in a way that reduces temperature, similar to the methods discussed in staged combustion. They can be designed to utilize fuel-staging, air-staging, or even flue-gas recirculation. The NO_x reductions from low NO_x burners are reported to be anywhere from 20 to 80 percent, with most estimates suggesting reductions of approximately 50 percent. These burners can be implemented on new equipment, or can be used to retrofit existing equipment to reduce NO_x emissions, with capital costs having been reported to be in the range of $1-2 per kW. It is common practice to use low NO_x burners with overfire air to achieve further reductions in emissions. The major concern with low NO_x burners is that the creation of reducing zones leads to incomplete combustion and the production of CO. This could require the use of additional control technology to maintain CO compliance. However, newer burners are being designed to manage the emissions of both NO_x and CO.

Overfire air uses the air-staging concept. A portion of the combustion air is diverted from the burners and is injected through ports above the top burner. Thus the burners operate in a fuel-rich environment where temperature is supressed, and the injected air is used to complete combustion at lower temperatures. As mentioned before, this modification is commonly used with low NO_x burners to further reduce NO_x emissions, as well as in reburning technology (another form of combustion staging). However, one of the major issues with the implementation of overfire air is the high capital cost requirements to redesign the furnace to allow for the injection of secondary air.

Reducing the air preheat has been used to reduce the peak flame temperature in the primary combustion zone by having some inlet air bypass the preheater. Using a cooler fuel leads to lower combustion temperatures. However, this results in lower process efficiencies, as well as increased emissions of the products of incomplete combustio.

The use of water or steam injection works in much the same manner as that described in the water/oil fuel emulsification modification. The water acts as a heat sink to reduce the peak flame temperature, which subsequently limits NO_x formation. This modification has been found to reduce NO_x emissions by as much as 35 percent, but incurs a significant efficiency penalty in the process. However, this technology is not typically applied to furnaces, and instead is found more in gas turbines [63-74].

6.4.3. **Post-Combustion Control**

Post-combustion controls, also known as flue gas treatment (FGT), include the set of technologies that are capable of reducing NO_x emissions once it has already formed. There are two main methods used in post-combustion NO_x control: selective catalytic reduction (SCR) and selective non-catalytic reduction (SNCR).

Selective catalytic reduction involves injection of ammonia into the flue gas in the presence of a catalyst in order to reduce NO_x into nitrogen and water. The majority of the catalysts used today are mixes of vanadium pentoxide, titanium dioxide, and tungsten trioxide, but some newer catalysts are being designed using base metals and zeolites. One of the major benefits of using SCR over SNCR is that the catalyst allows conversion to occur at much lower temperature—as low as 180°C, depending on the catalyst used. Thus, the catalyst bed can be located either before or after particulate control devices. Performance of SCR is influenced heavily by the flue gas temperature, space velocities, catalyst condition, and inlet NO_x concentration. One of the biggest issues with SCR is the high capital cost for installation, due to the extensive equipment requirements, as well as the cost of catalyst maintenance. Costs between $40-80 per kilowatt have been reported, with some estimates going as high as $200 per kilowatt. However, SCR has been found to be one of the most effective NO_x control technologies with reductions of up to 90%.

In selective non-catalytic reduction, the reducing agent—often ammonia or urea—is injected directly into the flue gas at zones of specific temperatures (900-1100°C). The injected fluid reduces the NO_x into water and nitrogen. It is very important that the injection occurs in the specified temperature range, otherwise ammonia may exit un-reacted or NO_x may be generated faster than it is being reduced. In addition to the importance of temperature, the residence time of the reagent in the flue gas must be sufficient for the required reactions to occur—typically just below one second. As such, the location of the injection, temperature of the flue gas, and mixing of the reagents are all very important parameters in implementing SNCR. When designing the injection system for the reducing agent, it is critical to ensure the flue gas is adequately covered with reagent, so multiple injection sites with variable injection rates are recommended [63]. These systems are not as effective as SCR, with maximum reductions of 70%, but the capital cost investments are likewise reduced. In fact, the cost of SNCR systems is generally found to be between $10-20 per kilowatt versus $20-200 per kilowatt for SCR systems.

In both SCR and SNCR post-combustion controls, one of the preeminent concerns is in relation to the use of ammonia and an occurrence known as ammonia slip. Ammonia slip refers to the emissions of unreacted ammonia from SCR and SNCR technologies as a result of incomplete reaction between the NO_x and reagent. Ammonia slip has four main consequences: 1) formation of ammonium sulfates which can damage downstream equipment; 2) formation of ammonium chloride in the stack plume; 3) ammonia odour in the fly ash; and 4) the emission of gaseous ammonia. This issue presents a significant hazard to human health; however, with modern control technologies and a better understanding of the equipment limitations, the frequency of ammonia slip is being reduced. As such, any controls that operate with the use of ammonia should be routinely checked to ensure operation is meeting equipment specifications. This can be done by periodically checking ammonia concentrations in collected fly ash [69-73].

7.0 Public Consultation

7.1. Summary of Public Consultation Efforts

The HMA sector is comprised of plants that are spread across Ontario. Therefore Ministry is taking a more generalized approach to engagement and consultation on this proposal.

Similar to other technical standards, the Ministry used a technical committee with members from the OHMPA and Ministry staff to engage the sector on various technical questions regarding contaminants, processes and environmental methods to better control or manage emissions. The technical committee included representatives from hot mix asphalt production plants, AC suppliers, and consultants. Meetings were held between 2013 and 2017. It is our understanding that OHMPA conducted outreach with its Ontario membership regarding our work with them on the HMA Industry Standard.

The Ministry also participates on the Air Standards/Local Air Quality External Working Group (EWG) which has members from various industry sectors, public health agencies, environmental non-governmental organizations and some members of First Nations. The EWG who provides general feedback and recommendations to the Ministry on issues related to the Local Air Quality Regulation (O.Reg.419/05). Status updates have been given to the EWG regarding the development of the HMA – Industry Standard, and more discussion will be offered during the public comment period. Input from the EWG is at a general program level (as opposed to sector-specific technical issues).

7.2. Consideration of Feedback from Public Consultation

The Ministry posted this Rationale Report and the proposed draft HMA – Industry Standard on the Environmental Bill of Rights Environmental Registry (EBR) for comment. All comments received during the public consultation period will be reviewed and considered by the Ministry before a final decision is made.

In addition, every application for registration to a technical standard is posted to the EBR for public comment. In some cases enhanced public outreach may be requested such as letters to neighbours, advertisements in a local newspaper to a public meeting. In some cases, no enhanced public outreach beyond the EBR posting may be requested. This is considered on a case by case basis.

7.3. Changes to the Proposed Industry Standard as Result of the EBR Comments

All comments received during the comment period were considered as part of the decision-making process by the ministry. The following are highlights of key comments received and how we considered them.

Comment: Changing the way the asphalt industry works will make a difference to the environment and to the health of the workers.

Why can't the asphalt industry make a permeable pavement that would help to prevent flooding highways and roads? The Provence would save millions! The environment would benefit too.

Response: The proposed TS was developed under O.Reg 419/05 and addresses emissions to air (except noise). It is up to the industry to decide how to make asphalt mix.

The Asphalt Mix Industry standard does allow for cooler materials to be produced such as warm and cold mix materials.

Comment: what is the primary concern of the ministry?

Response: The primary concern of the ministry was to develop a technical standard for the industry and reduce emissions of, as originally requested, benzo(a)pyrene. This request was later expanded to include all potential substances as asphalt cement fumes which contain benzo(a)pyrene also contain VOCs, metals. Any rules applied to reduce emissions of asphalt cement fumes would reduce emissions of other contaminants.

Comment: Consideration should be taken for emissions of suspended particulate matter and crystalline silica from aggregates.

Response: This comment was discussed and considered. The Asphalt Mix Industry standard does allow for certain operations (permanent asphalt mix plant) to register for suspended particulate matter associated with the aggregate handling and storage operations.

The aggregate materials used for production of asphalt mix are required to be clean and with limited silt content. The emissions of crystalline silica were deemed to be insignificant for this industry.

Comment: How do the mitigation methods proposed in this industry standard ensure that no adverse effects will occur in the communities surrounding asphalt plants?

Response: The technical standard imposes technical solutions that may not have been otherwise used at a site but are practiced in other jurisdictions.

Comment: Some definitions are not clearly describe the objectives and because of this, the requirements are not clear.

Response: We have worked with the industry to simplify the definitions to provide clarity.

Comment: Concern was brought up over the change of how asphalt mix is formulated and use of modified asphalt cement which results in higher production temperatures. Industry requested to increase the performance limit to be increased to allow for this change.

Response: The performance limit was increased to annual average temperature of 168 degrees Celsius plus the error of the instrument used to take the reading. We recognize that in addition to the process control that is necessary to minimize the temperature this technical standard also requires installation of a scavenging system.

The scavenging system draws fumes from the areas where asphalt mix is being transported and stored in the plant and then diverts the fumes to dryer or air pollution control equipment.

Comment: Reporting, notification record, record keeping are too onerous.

Response: Public reporting, notification and record keeping requirements are part of the industry standard to ensure the accuracy and public transparency of the operations.

Comment: The requirements spelled out under the registration for sulphur dioxide and nitrogen oxides substances were deemed to be best technology. A request was put forward to allow portable asphalt plants, crushers and screeners and asphalt plants located at a multi-use site (ie. in a quarry, or next to concrete plants) to allow burners associated with the dryer, boiler, generator to register for this TS.

Response: We have considered, discussed and incorporated this suggestion into the industry standard.

Comment: Note that there is no information in the Ministry background documents in support of the proposal as to how many asphalt mix facilities are unable to meet the air standards, the extent to which this is a sector-wide problem and whether an industry standard is even warranted for all contaminants.

Response: Section 2.0 Overview of the Hot Mix Asphalt Industry summarizes the industry in Ontario. In 2015 there was 130 plants in Ontario. In 2013 Ontario Road Builders Association (ORBA) formerly known as Ontario Hot Mix Producers Association, wrote to the Minister requesting for industry standard to be developed for benzo(a)pyrene. In their request, ORBA stated that two of its members were not be able to meet the updated benzo(a)standard.

This industry standard was expanded to include all contaminants for a number of reasons. Fumes of asphalt cement contain benzo(a)pyrene and many other contaminants (metals, VOCs). Any reduction in fumes will result in direct reduction of all contaminants that make up the fumes.

Furthermore, expanding the list to all contaminants will allow facilities to have another approach to comply with local air quality regulation and reduce regulatory burden. Facilities that register for a technical standard must adhere to the technical and operational requirements for managing emissions of the contaminants they are registered for.

8.0 Outline of the Asphalt Mix – Industry Standard

The Asphalt Mix IS applies to NAICS code 324121 primarily engaged in manufacturing asphalt paving mixtures. The Asphalt Mix IS does not include a facility that is part of the NAICS code and is engage in manufacturing of blocks from purchased asphalt, bituminous materials or coal tar. It does not include any part of a facility that is engaged in activities described by NAICS code 2123: non-metallic mining and quarrying.

For the purpose of this IS the asphalt mix means a mix of asphalt cement, aggregates and additives used for road surfacing, and includes hot mix asphalt, warm mix asphalt and cold mix asphalt.

The Asphalt Mix IS applies to activities defined above and emissions of various contaminants as listed in appendix B. Appendix B contains a list of what is reasonably anticipated from asphalt mix operations.

8.1. Structure

The structure of the Asphalt Mix IS is outlined below:

Part I: General

1. Definitions
2. Application
3. Tables and initial preparation

Part II: Performance Limits

4. Performance limit, annual weighted average temperature at Asphalt Mix loadout – applicable to benzo(a)pyrene, VOCs and metals.

Part III: Technology Specifications

5. Requirement to have a scavenging system – applicable to benzo(a)pyrene, VOCs and Metals
6. Scavenging system, air pollution control – applicable to benzo(a)pyrene, VOCs and metals

7. Asphalt Mix Conveyors, requirement to enclose – applicable to benzo(a)pyrene, VOCs and metals

8. Mixing structure and dryer air pollution control, drum-mix and batch-mix process – applicable to benzo(a)pyrene and suspended particulate matter

Part IV: Operation and Monitoring

9. Asphalt Mix loadout monitoring, temperature measurements – applicable to benzo(a)pyrene, VOCs and metals

10. Asphalt Mix monitoring, mass measurements – applicable to benzo(a)pyrene, VOCs and metals

11. Mix design, certified laboratory and records – applicable to benzo(a)pyrene, VOCs and metals

12. Asphalt Mix loadout monitoring, operational adjustments – applicable to benzo(a)pyrene, VOCs and metals

13. Asphalt Mix loadout monitoring, weighted average temperature – applicable to benzo(a)pyrene, VOCs and metals

14. Requirement to keep closed asphalt cement storage tank hatch- applicable to benzo(a)pyrene, VOCs and metals

15. Asphalt cement storage tank monitoring – applicable to benzo(a)pyrene, VOCs and metals

16. Asphalt cement storage tanks monitoring, operational adjustments – applicable to to benzo(a)pyrene, VOCs and metals

17. Operating Parameter Summary Table – applicable to benzo(a)pyrene, VOCs and metals

18. Measurement of operating parameters – applicable to benzo(a)pyrene, VOCs and metals

19. Deviations from normal operating range, operating parameters – applicable to benzo(a)pyrene, VOCs and metals

Part V: Inspection and Maintenance

20. Backup thermocouples, requirement – applicable to benzo(a)pyrene, VOCs and metals

21. Inspection and maintenance summary table
22. Inspection and maintenance activities
23. Deviations – inspection and maintenance
24. Inspection, valves and connections
25. Visual Inspection Table
26. Visual Inspection activities
27. Deviations – visual inspections

Part VI: Fuel Requirements

28. Fuel type, requirements –applicable to sulphur dioxide
29. Low nitrogen oxide burner – applicable to nitrogen oxides

Part VII: Odour Management Best Practices

30. Odour management plan, requirement to prepare – applicable to VOCs

Part VIII: Particulate Matter Management Best Practices

31. Store material, signage – applicable to suspended particulate matter
32. Crushing and screening – applicable to suspended particulate matter
33. Best practices, minimum requirements – applicable to suspended particulate matter
34. Particulate Matter Management , Best Practices Procedure

Part IX: Requirement to Continue the Use of Management Methods to Manage Emissions

35. Requirement to continue the management of originating sources
36. Management methods for new originating sources

Part X: Complaints, Annual Summary Report and Records

37. Complaint procedure
38. Summary Reports
39. Public Reporting

40. Record Keeping – general
41. Record Retention

Appendix 9-A: All Contaminants

Appendix 9-B: Volatile Organic Compounds

Appendix 9-C: Benzo(a)Pyrene

Appendix 9-D: Metals

Appendix 9-E: Combustion Gases

Appendix 9-F: Sulphur Dioxide

Appendix 9-G: Nitrogen Oxides

Appendix 9-H: Suspended Particulate Matter

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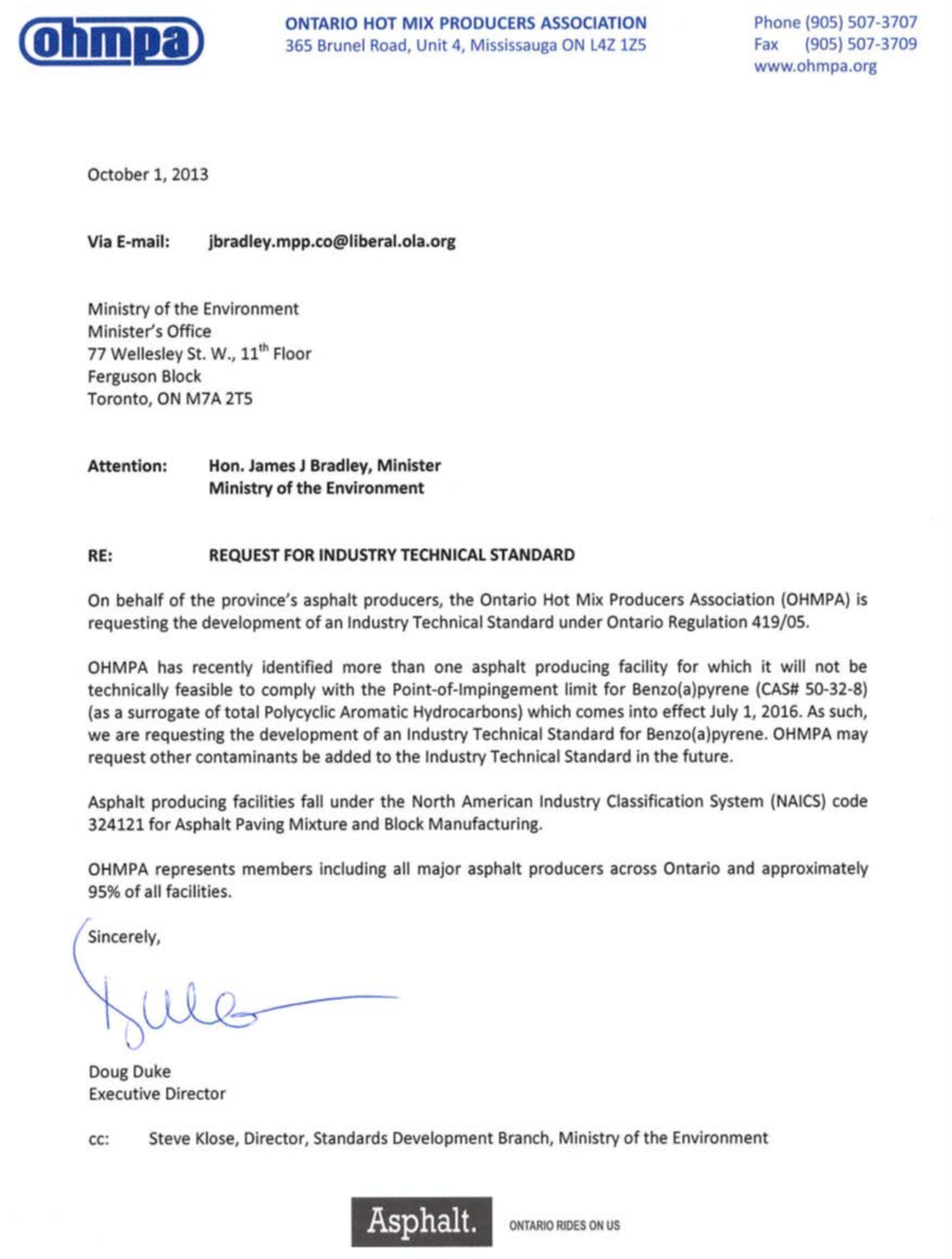
Appendix A: Request for Industry Technical Standard



ohmpa

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October 1, 2013

Via E-mail: **jbradley.mpp.co@liberal.ola.org**

Ministry of the Environment
Minister's Office
77 Wellesley St. W., 11th Floor
Ferguson Block
Toronto, ON M7A 2T5

Attention: **Hon. James J Bradley, Minister**
Ministry of the Environment

RE: **REQUEST FOR INDUSTRY TECHNICAL STANDARD**

On behalf of the province's asphalt producers, the Ontario Hot Mix Producers Association (OHMPA) is requesting the development of an Industry Technical Standard under Ontario Regulation 419/05.

OHMPA has recently identified more than one asphalt producing facility for which it will not be technically feasible to comply with the Point-of-Impingement limit for Benzo(a)pyrene (CAS# 50-32-8) (as a surrogate of total Polycyclic Aromatic Hydrocarbons) which comes into effect July 1, 2016. As such, we are requesting the development of an Industry Technical Standard for Benzo(a)pyrene. OHMPA may request other contaminants be added to the Industry Technical Standard in the future.

Asphalt producing facilities fall under the North American Industry Classification System (NAICS) code 324121 for Asphalt Paving Mixture and Block Manufacturing.

OHMPA represents members including all major asphalt producers across Ontario and approximately 95% of all facilities.

Sincerely,

Doug Duke
Executive Director

cc: Steve Klose, Director, Standards Development Branch, Ministry of the Environment

Asphalt. ONTARIO RIDES ON US

Appendix B: List of All Contaminants

Appendix 9-A: All Contaminants

Item	CAS No.	Contaminant
1	75-07-0	Acetaldehyde
2	67-64-1	Acetone
3	107-02-8	Acrolein
4	7440-36-0	Antimony
5	7440-38-2	Arsenic and compounds
6	7440-39-3	Barium - total water soluble
7	100-52-7	Benzaldehyde
8	71-43-2	Benzene
9	50-32-8	Benzo(a)pyrene
10	7440-41-7	Beryllium and Beryllium compounds
11	74-83-9	Bromomethane
12	106-97-8	Butane
13	78-84-2	Butyraldehyde
14	7440-43-9	Cadmium and Cadmium Compounds
15	124-38-9	Carbon Dioxide
16	75-15-0	Carbon Disulfide
17	630-08-0	Carbon Monoxide
18	75-00-3	Chloroethane

Item	CAS No.	Contaminant
19	74-87-3	Chloromethane
20	18540-29-9	Chromium Compounds (Hexavalent)
21	7440-47-3	Chromium and Chromium Compounds (Metallic, Divalent and Trivalent)
22	7440-48-4	Cobalt
23	7440-50-8	Copper
24	4170-30-3	Crotonaldehyde
25	92-82-8	Cumene
26	Not Applicable	Dioxins and Furans
27	100-41-4	Ethyl Benzene
28	74-85-1	Ethylene
29	50-00-0	Formaldehyde
30	142-82-5	Heptane
31	110-54-3	Hexane, n- (n-Hexane and Hexane isomers only)
32	66-25-1	Hexanal
33	540-84-1	Isooctane (2,2,4-trimethylpentane)
34	7439-92-1	Lead and Lead Compounds
35	7439-96-5	Manganese and Manganese Compounds
36	7439-97-6	Mercury (Hg)
37	7439-97-6	Mercury (as Hg) – alkyl compounds
38	74-82-8	Methane

Item	CAS No.	Contaminant
39	71-55-6	Methyl chloroform
40	75-09-2	Methylene Chloride
41	78-93-3	Methyl Ethyl Ketone
42	1634-04-4	Methyl tert-butyl ether
43	7440-02-0	Nickel and Nickel Compounds
44	10102-44-0	Nitrogen Oxides
45	109-66-0	n-Pentane
46	95-47-6	o-Xylene
47	127-18-4	Perchloroethylene
48	7723-14-0	Phosphorus
49	123-38-6	Propionaldehyde
50	106-51-4	Quinone
51	7782-49-2	Selenium
52	7440-22-4	Silver
53	100-42-5	Styrene
54	7446-09-5	Sulphur Dioxide
55	Not applicable	Suspended particulate matter (< 44 µm diameter)
56	7440-28-0	Thallium
57	108-88-3	Toluene
58	79-01-6	Trichloroethene (TCE)

Item	CAS No.	Contaminant
59	75-69-4	Trichlorofluoromethane
60	1330-20-7	Xylenes
61	7440-66-6	Zinc
62	109-67-1	1-Pentene
63	71-55-6	1,1,1-Trichloroethane
64	78-93-3	2-Butanone
65	763-29-1	2-Methyl-1-pentene
66	513-35-9	2-Methyl-2-butene
67	96-14-0	3-Methylpentane

Appendix 9-B: Volatile Organic Compounds

Item	CAS No.	Contaminant
1	75-07-0	Acetaldehyde
2	67-64-1	Acetone
3	107-02-8	Acrolein
4	71-43-2	Benzene
5	100-52-7	Benzaldehyde
6	74-83-9	Bromomethane
7	106-97-8	Butane
8	78-84-2	Butyraldehyde
9	75-15-0	Carbon Disulfide
10	75-00-3	Chloroethane
11	74-87-3	Chloromethane
12	4170-30-3	Crotonaldehyde
13	92-82-8	Cumene
14	See Schedule 8 in O.Reg. 419/05	Dioxins, Furans and Dioxin-like PCBs
15	74-85-1	Ethylene
16	100-41-4	Ethyl Benzene
17	50-00-0	Formaldehyde
18	142-82-5	Heptane

Item	CAS No.	Contaminant
19	66-25-1	Hexanal
20	110-54-3	Hexane, n- (n-Hexane and Hexane isomers only)
21	540-84-1	Isooctane (2,2,4-trimethylpentane)
22	74-82-8	Methane
23	75-09-2	Methylene Chloride
24	71-55-6	Methyl Chloroform
25	78-93-3	Methyl Ethyl Ketone
26	1634-04-4	Methyl tert-butyl ether
27	109-66-0	n-Pentane
28	95-47-6	o-Xylene
29	123-38-6	Propionaldehyde
30	127-18-4	Perchloroethylene
31	106-51-4	Quinone
32	100-42-5	Styrene
33	108-88-3	Toluene
34	79-01-6	Trichloroethene (TCE)
35	75-69-4	Trichlorofluoromethane
36	1330-20-7	Xylenes
37	109-67-1	1-Pentene
38	71-55-6	1,1,1-Trichloroethane
39	78-93-3	2-Butanone

Item	CAS No.	Contaminant
40	763-29-1	2-Methyl-1-pentene
41	513-35-9	2-Methyl-2-butene
42	96-14-0	3-Methylpentane

Appendix 9-C: Benzo(a)pyrene

Item	CAS No.	Contaminant
1	50-32-8	Benzo(a)pyrene

Appendix 9-D: Metals

Item	CAS No.	Contaminant
1	7440-36-0	Antimony
2	7440-38-2	Arsenic and compounds
3	7440-39-3	Barium - total water soluble
4	7440-41-7	Beryllium and Beryllium compounds
5	7440-43-9	Cadmium and Cadmium Compounds
6	18540-29-9	Chromium Compounds (Hexavalent)
7	7440-47-3	Chromium and Chromium Compounds (Metallic, Divalent and Trivalent)
8	7440-48-4	Cobalt
9	7440-50-8	Copper
10	7439-92-1	Lead and Lead Compounds
11	7439-96-5	Manganese and Manganese Compounds
12	7439-97-6	Mercury (Hg)
13	7439-97-6	Mercury (as Hg) – alkyl compounds
14	7440-02-0	Nickel and Nickel Compounds
15	7723-14-0	Phosphorus
16	7782-49-2	Selenium
17	7440-22-4	Silver
18	7440-28-0	Thallium
19	7440-66-6	Zinc

Appendix 9-E: Combustion gases

Item	CAS No.	Contaminant
1	124-38-9	Carbon Dioxide
2	630-08-0	Carbon Monoxide

Appendix 9-F: Sulphur Dioxide

Item	CAS No.	Contaminant
1	7446-09-5	Sulphur Dioxide

Appendix 9-G: Nitrogen Oxides

Item	CAS No.	Contaminant
1	10102-44-0	Nitrogen Oxides

Appendix 9-H: Suspended Particulate Matter

Item	CAS No.	Contaminant
1	Not applicable	Suspended particulate matter (< 44 µm diameter)

Appendix C: Description of the Various Asphalt Mix Manufacturing Processes

Following is a detailed description of the various hot mix asphalt manufacturing processes.

C.1 Batch Mix Plants

Figure C.1 shows the batch mix HMA production process. Processing begins as the aggregate is transferred from the storage piles into the appropriate hoppers of the cold feed bins. The material is metered from the hoppers onto a conveyer belt and is transported into a rotary dryer (typically fired by natural gas or fuel oil). Dryers are equipped with flights designed to shower the aggregate inside the drum to promote drying efficiency.

As the hot virgin aggregate leaves the dryer, it drops into a bucket elevator and is transferred to a set of vibrating screens, where it is classified into as many as four different grades (sizes) and is dropped into individual "hot" bins according to size. To control aggregate size distribution in the final batch mix, the operator opens various hot bins over a weigh hopper until the desired mix and weight are obtained. Simultaneous with the aggregate being weighed, liquid asphalt cement is pumped from a heated storage tank to an asphalt bucket, where it is weighed to achieve the desired aggregate-to-asphalt cement ratio in the final mix.

The aggregate from the weigh hopper is fed into the mixer (pug mill) and dry-mixed for 6 to 10 seconds. The liquid asphalt is then added into the pug mill where it is mixed for an additional period of time. At older plants, RAP typically is conveyed to the pug mill from storage hoppers and combined with the hot aggregate. Total mixing time usually is less than 60 seconds. Then the hot mix is either conveyed to a HMA storage silo or is loaded directly into a truck and hauled to the job site.

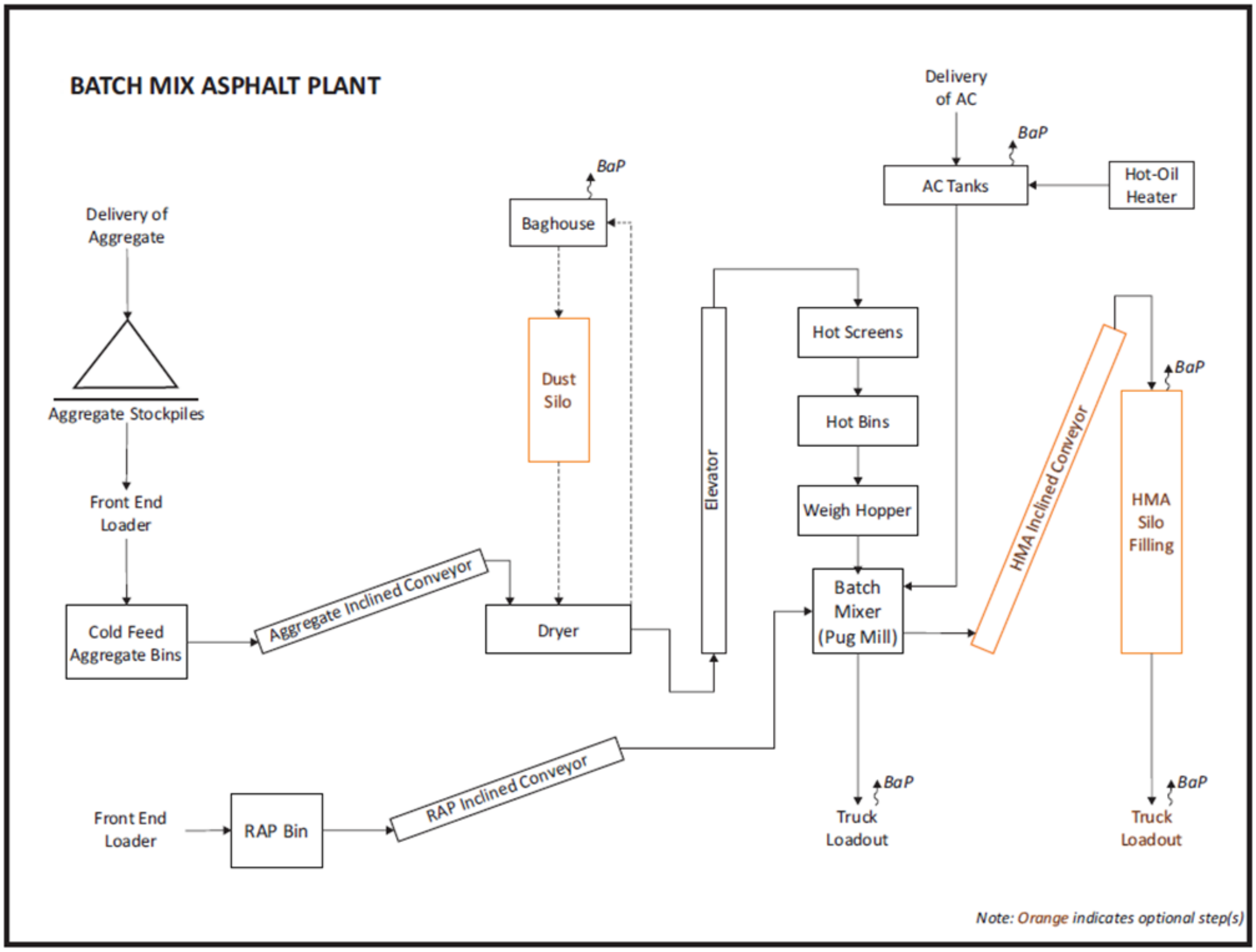

Figure C.1 Batch Mix Asphalt Plant, Generic Materials Flow.

C.2 Parallel Flow Drum Mix Plants

Figure C.2 shows the parallel flow drum mix process. This process is a continuous mixing type process. The major difference between this process and the batch process is that the dryer is used not only to dry the material but also to mix the heated and dried aggregates with the liquid asphalt cement. Classified aggregate is introduced to the drum at the burner end. As the drum rotates, the aggregates, as well as the combustion products, move toward the other end of the drum (i.e. parallel flow).

Liquid asphalt cement flow is controlled by a variable flow pump electronically linked to the virgin aggregate and RAP weigh scales. The asphalt cement is introduced in the mixing zone midway down the drum in a lower temperature zone, along with any RAP and fine aggregate.

The mixture is discharged at the end of the drum and is conveyed to either a surge bin or HMA storage silo, where it is loaded into transport trucks. The exhaust gases exit the end of the drum and are ducted to the asphalt plant's particulate matter collection system (usually a baghouse or baghouse in combination with a cyclone). Note, there are a few Ontario asphalt plants which still use a wet scrubber system.

Parallel flow drum mixers reduce the loading on the downstream particulate matter collection system because a substantial portion of the aggregate fines is retained in the asphalt product. However, because the mixing of aggregate and liquid asphalt cement occurs at the hot end of the drum, organic emissions (gaseous and liquid aerosol) may be greater than in other asphalt mixing processes.

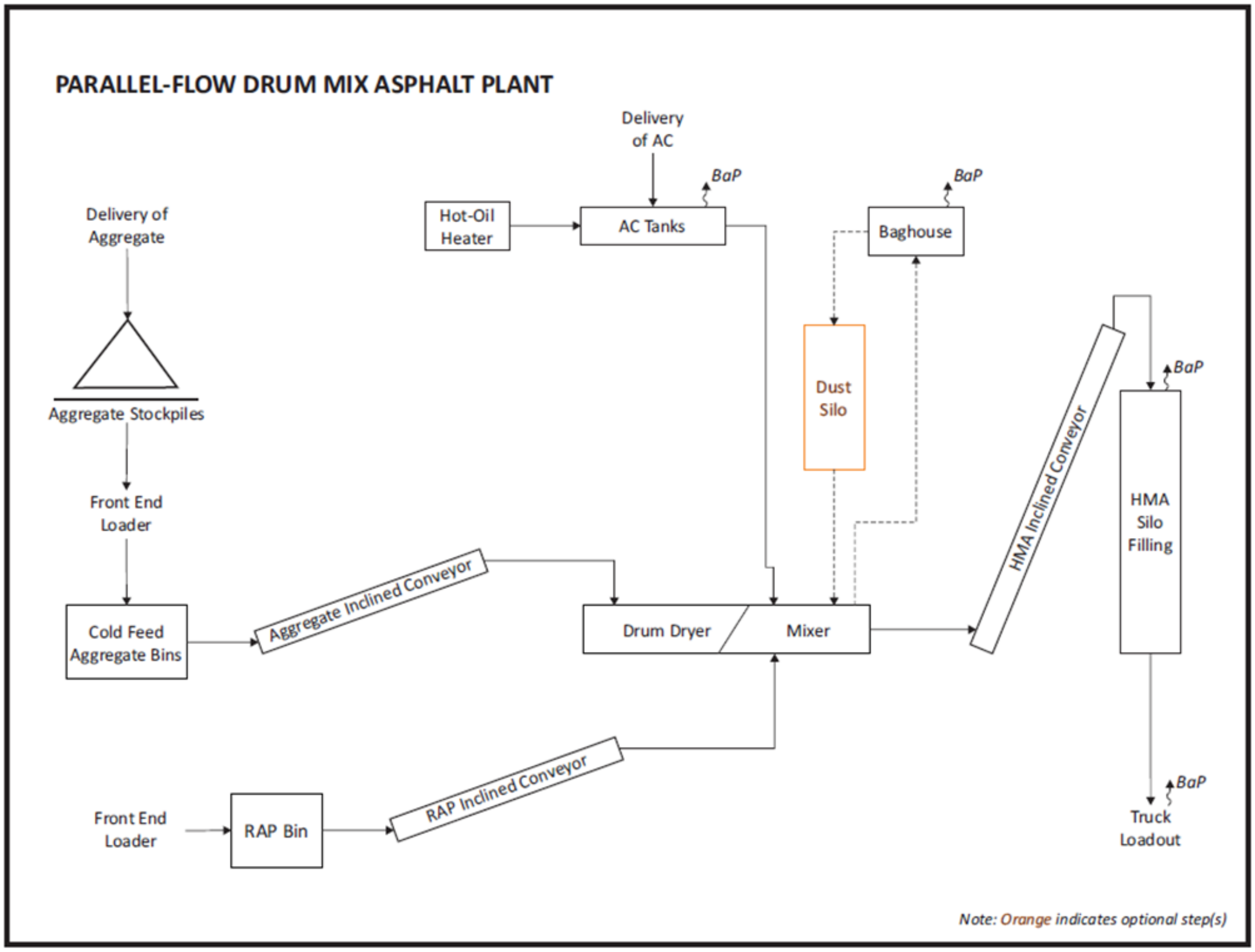

Figure C. 2 Parallel-Flow Drum Mix Asphalt Plant, Generic Materials Flow.

C.3 Counterflow Drum Mix Plants

Figure C.3 shows a counterflow drum mix plant. In this type of plant, the material flow in the drum is opposite or counter to the flow direction of exhaust gases. In addition, the mixing zone where the liquid asphalt cement is added is located beyond the burner flame zone (i.e. the end of the drum) so as to prevent the liquid asphalt cement and RAP from coming into direct contact with hot exhaust gases. Because of this counterflow drum mix plants may have organic emissions (gaseous and liquid aerosol) that are lower than parallel flow drum mix plants.

A counterflow drum mix plant can normally process higher ratios of RAP (up to 50 percent) than other types of asphalt plants. This is possible because RAP has a longer residence time with the heated virgin aggregates, and it is heated conductively in the vicinity of the hottest part of the dryer shell. Literature indicates that higher ratios of RAP have little or no observed effect on emissions.

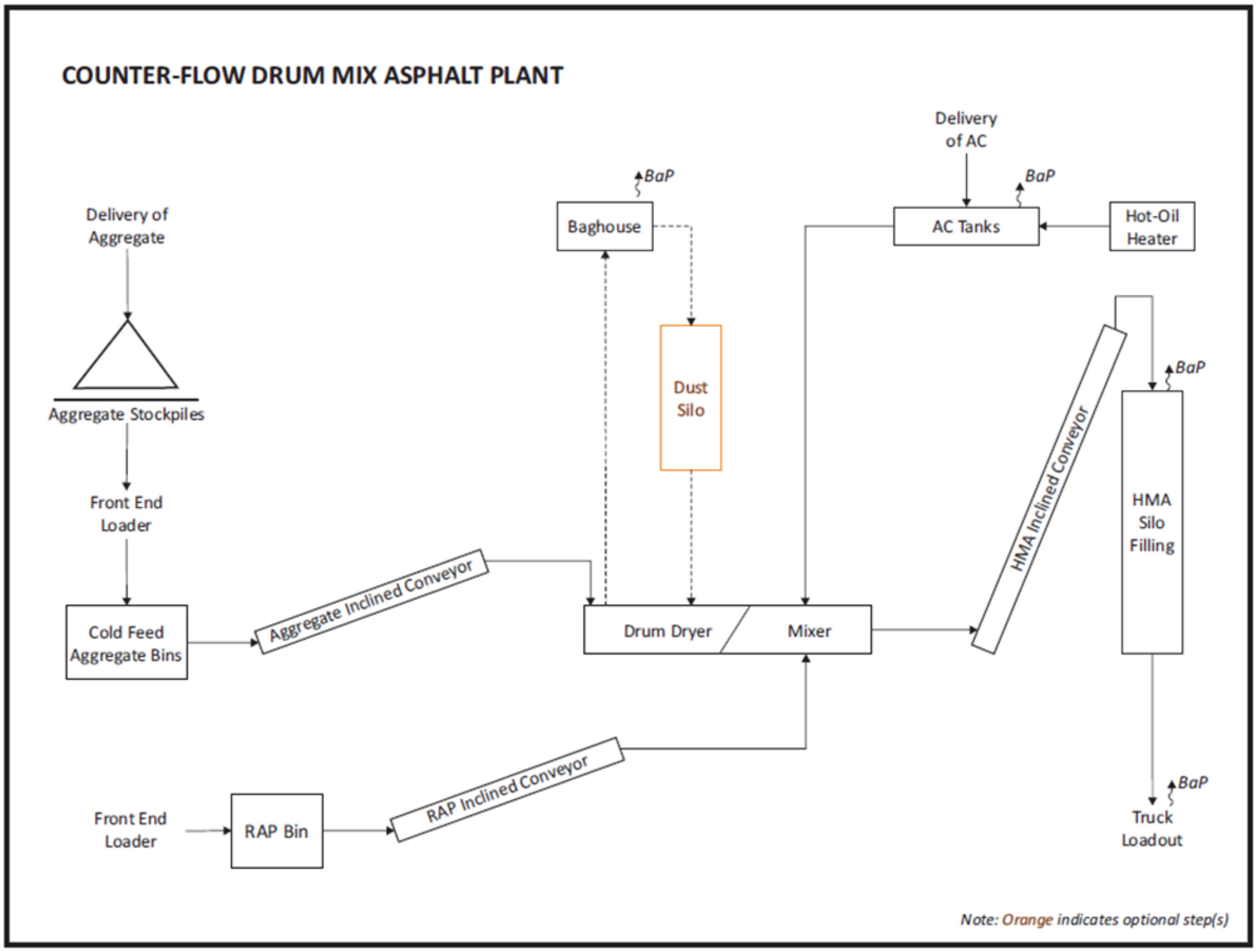

Figure C.3 Counter-Flow Drum Mix Asphalt Plant, Generic Materials Flow.

Appendix D: General Description of Two Types of Warm Mix

The warm mix asphalt is a relatively new and evolving approach of making asphalt and has not been fully utilized in the province of Ontario. There are two basic types of making warm mix: technology based or with aid of additives. It is worth nothing that within the warm mix achieved with the aid of additives there are numerous options that are not covered in this document.

D.1 Technology

There are two approaches to technology of warm mix asphalt.

First one is through purchase of warm mix equipment which is designed to manufacture the asphalt mix at cooler temperatures.

Second approach is to modify a hot mix asphalt plant (i.e. mainly the dryer). This does required for a plant to be shut down during the changeover. Many plants find this challenging to implement due to long shutdown to modify the equipment during which production cannot occur.

The technology and research around Warm Mix continue to develop, the implementation of Warm Mix should be considered for greater implementation.

D.2 Additives

Using organic additives is the process of adding waxes to the binder. When the additives are in the mix and the temperature rises above the melting point of the wax, the viscosity typically decreases. As the mixture cools the wax solidifies and increases the stiffness/deformation resistance of the binder. Waxes typically used in this process are high molecular weight hydrocarbon chains with a melting point that ranges from 80-120˚C. Within organic additives, there are three technologies used to reduce viscosity; Fischer-Tropsch wax, fatty acid amide and Montan Wax. Chemical Additives are a combination of surfactants, emulsifiers and polymers. Instead of reducing the viscosity, they work to improve coating, mixture workability and compaction. The additives are mixed in with the binder before mixing with aggregates.Foaming processes is the addition of water injected into a heated binder or a mixing chamber [3]. Adding water to high temperature asphalt causes it to evaporate; however, the steam remains trapped within the mix. This creates a large volume of foam and temporarily reduces the viscosity and increases the volume of the binder. This improves the coating and workability of the mix.

There are two methods of adding the water to the binder used in foaming processes: direct foaming (water-based), where water is injected directly into the asphalt, and indirect (water-containing), where hydrophilic materials containing water are added. Water-containing technologies use hydrophilic materials from synthetic zeolites. They contain about 20% of crystalline water which is released when the temperature rises. This creates a micro foaming effect in the binder that lasts for 6-7hrs. Water-based technologies use specialized nozzles to inject water into the heated binder. Similarly, it produces a large volume of foam that will eventually collapse. There are a number of products used in the process of water-based technologies, including WAM foam, Double Barrel Green, Ultra foam GX, and LT Asphalt, as well as others.

In 2014, the University of Puerto Rico did an analysis on four different additives used in WMA processes: Rediset, Sasobit, Kaoamin 14, and Evotherm M1. This study showed that the additives worked by reducing the viscosity of the mixture. This helps to maintain fluidity at lower temperatures. The study concluded that the asphalt was not negatively impacted by mixing and compaction at lower temperatures [1-9, 75].

Appendix E: Analysis of the Air Emissions from Asphalt Mix Plants Under Various Reporting Programs

E.1 Federal Emissions Reporting

The National Pollutant Release Inventory (NPRI) acts as the primary source of contaminant release data across Canada. Each year, all facilities that meet the reporting requirements outlined by Environment and Climate Change Canada must submit a report of the emissions from their facility, broken down by contaminant. The data from these reports is made available for public access [76-77]. The report is due on June 1 for activities from the previous year.

This allows for analysis of reported emissions to air from facilities in the Asphalt Mix industry. It is important to note, however, that the NPRI specifies a minimum number of employee work hours that must be exceeded for the facility to be required to report (20,000 hours), and this value is often not met by Asphalt Plants, due to the seasonal nature of their work. In addition, all substances have minimum release thresholds which must be met before reporting is a requirement. A large portion of the Asphalt Mix industry is exempted from reporting their emissions to the NPRI—of the estimated 155 active plants within Ontario, only 6 were required to report emissions in 2016. Thus, it is important to remember that the results shown below are based solely on the emissions of the facilities that meet the reporting requirements outlined by NPRI.

For the purposes of this analysis, the most recent 5-year period from the time of writing will be considered [79]. Over this period, from 2012 to 2016, 92 asphalt mix facilities across Canada reported emissions, with all provinces, except Prince Edward Island, Nova Scotia, and Newfoundland and Labrador, being represented (no territories reported emissions). On average, there were 62 facilities that reported emissions in any given year.

In order to determine their emissions in a given year, facilities utilize a variety of methods. The NPRI then sorts these different methods into seven (7) distinct classes: continuous emission monitoring systems, predictive emission monitoring, source testing, mass balances, site-specific emission factors, published emission factors, and engineering estimates. Over the course of the 5-year period (2012 to 2016), there were 1620 unique emissions estimated at facilities across Canada (155 of which were from Ontario). Of those 1620, 1349 (83%) are based on published emissions factors and 161 (10%) are based on engineering estimates. The remaining 7%, in order, comes from site-specific emissions factors, source testing, mass balances, predictive emissions monitoring, and continuous emissions monitoring. Of the 155 from Ontario, 63 (41%) are from engineering estimates and 60 (39%) are from published emissions factors. The remaining 20% come from mass balances and site-specific emissions factors.

Of the facilities that reported emissions, the main fraction were located in Alberta—roughly 45%. Outside of Alberta, the other major contributors were Quebec (23%), British Columbia (17%), and Ontario (11%). Meanwhile, Manitoba, New Brunswick, and Saskatchewan combined constituted only 4% of the reporting facilities across Canada. These fractions remained relatively stable over the course of the 5-year period in question, with only Quebec and Ontario showing any significant changes in the number of facilities. A breakdown of facility location by province is given in Figure E.1 below.

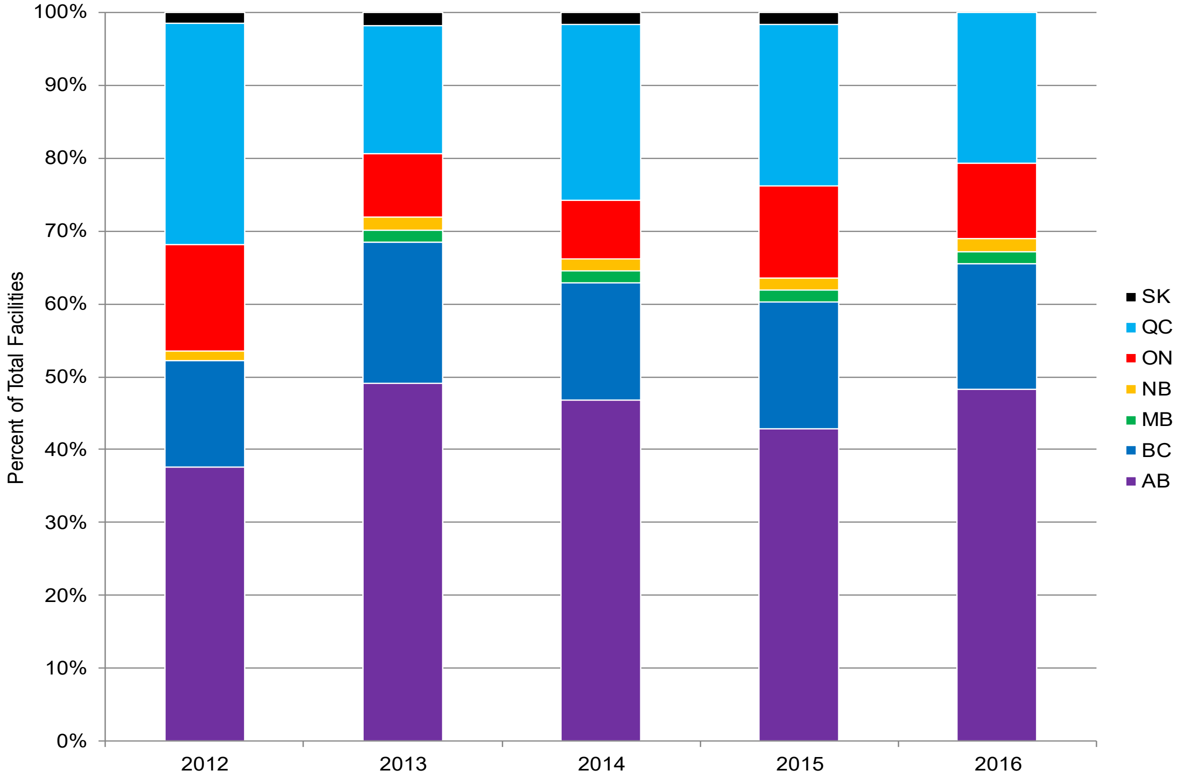

Figure E.1 Distribution of Reporting Facilities across Provinces by Year

While the minimum employee hours threshold allows a large number of asphalt plants not to report, there is a specification that a facility must report their emissions for a select class of contaminants if they operate stationary combustion equipment on their property. As a result, over 99% of the reported emissions across Canada in the asphalt industry are products of combustion, including: carbon monoxide (43.5% of total emissions), particulate matter (42% of total emissions), sulphur dioxide (12.5%), and nitrogen oxides (2%). The remainder of the pollutants reported—acenaphthene, acenaphthylene, fluorene, hydrochloric acid, PAHs, and VOCs—make up negligible portions of the total emissions.

The figures below show how the average emissions of the four major pollutants (carbon monoxide, particulate matter, sulphur dioxide, and nitrogen oxides) have changed over the course of the 5-year period.

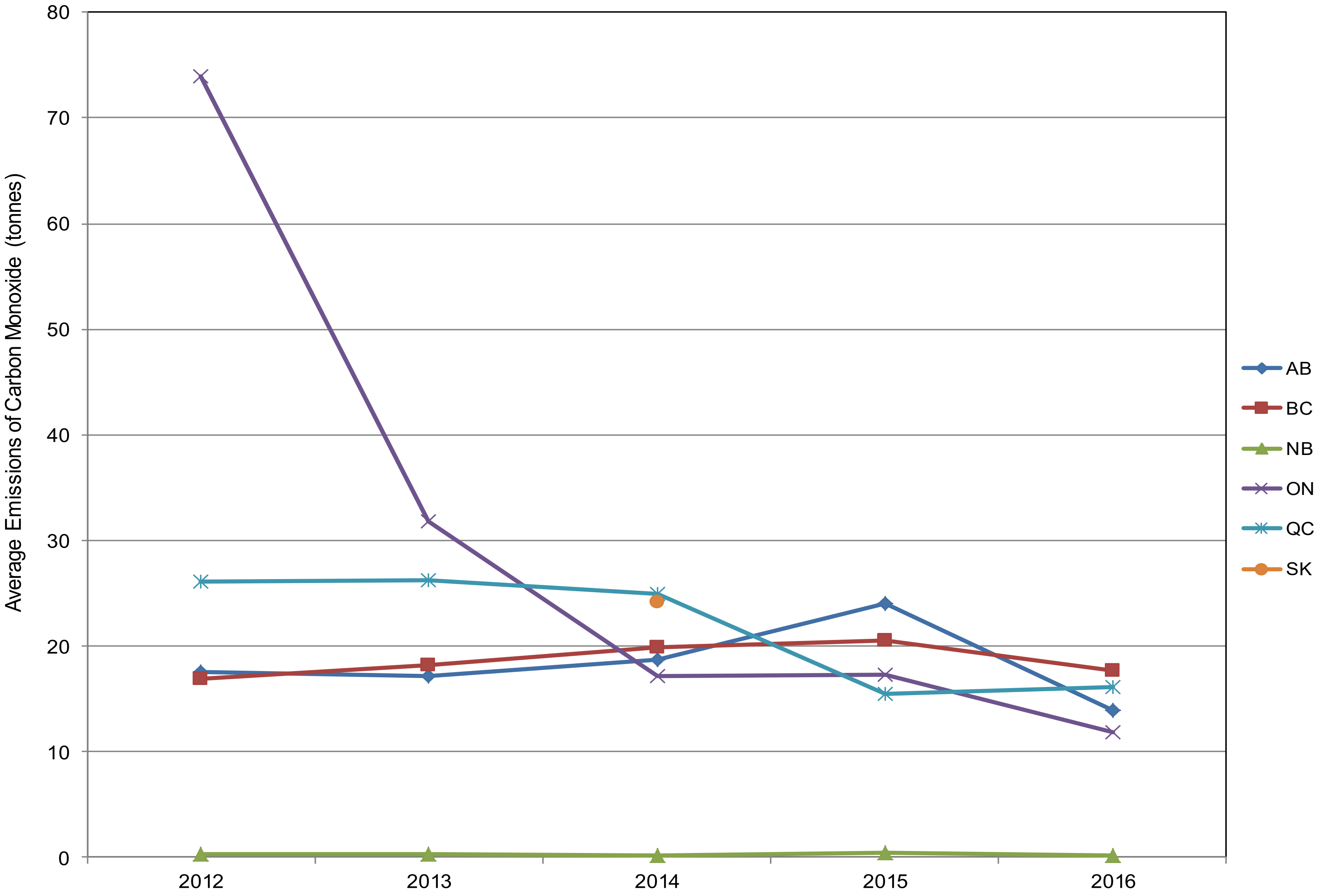

Figure E.2 Carbon Monoxide Emissions by Year

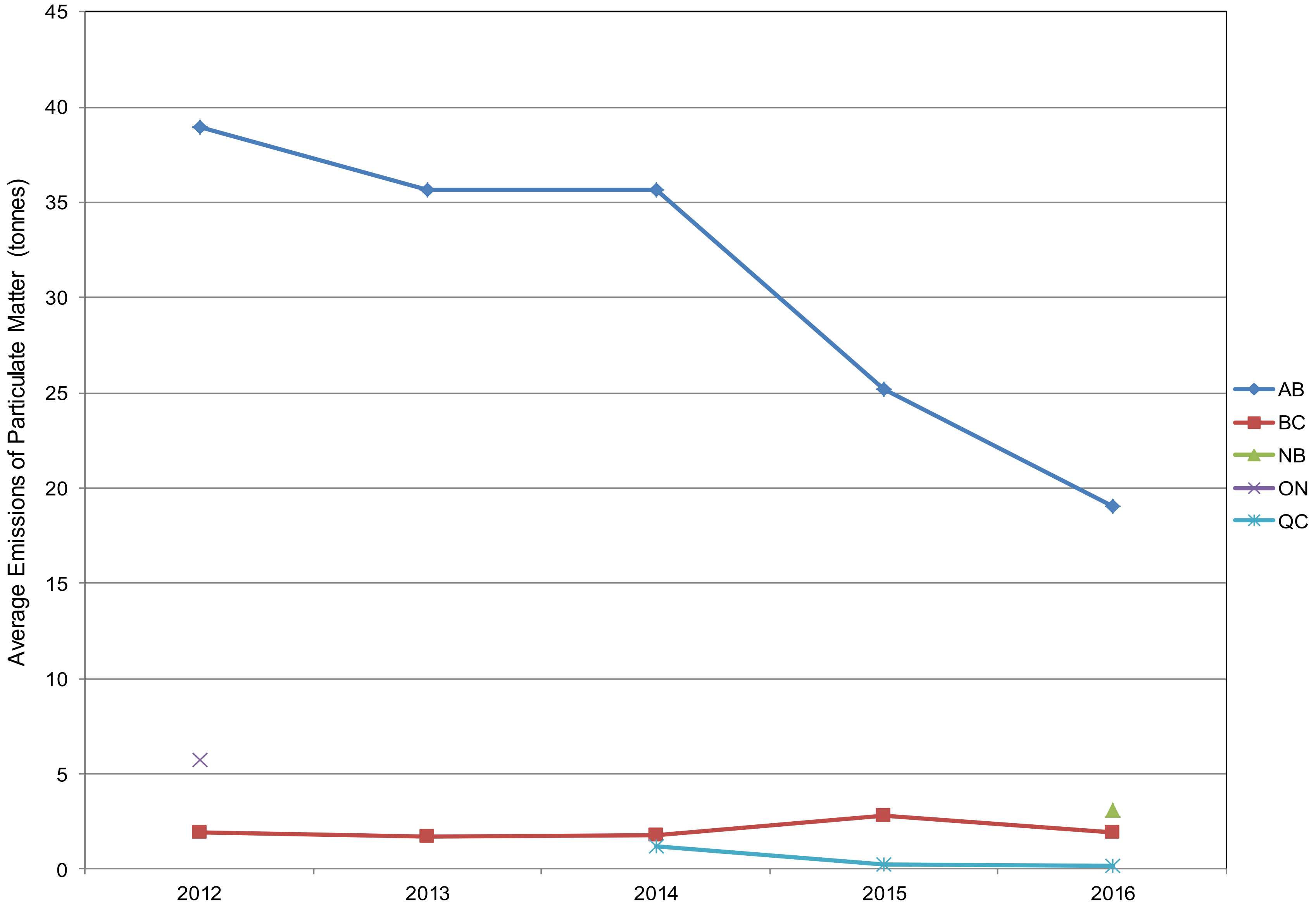

Figure E.3 Particulate Matter Emissions by Year

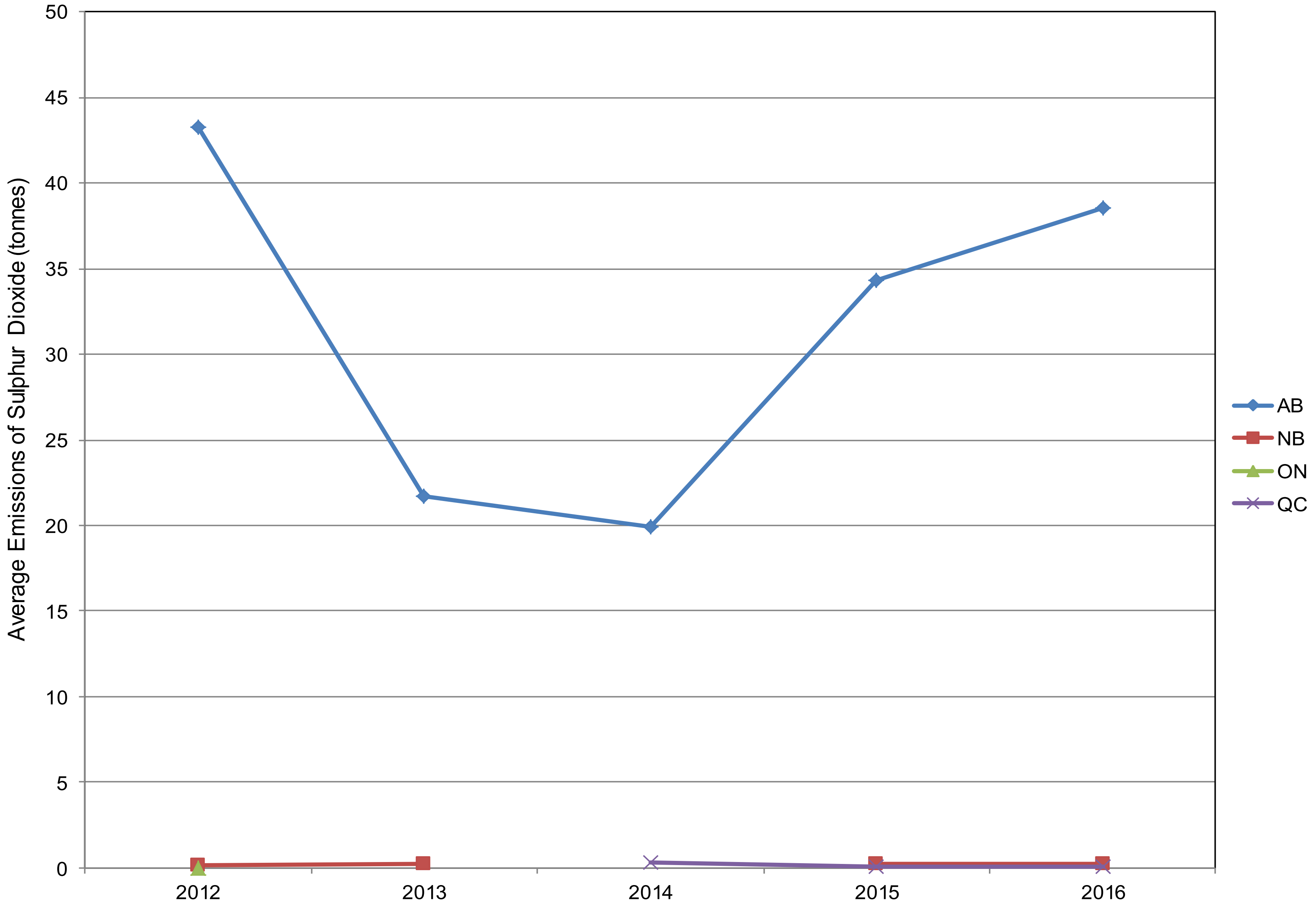

Figure E.4 Sulphur Dioxide Emissions by Year

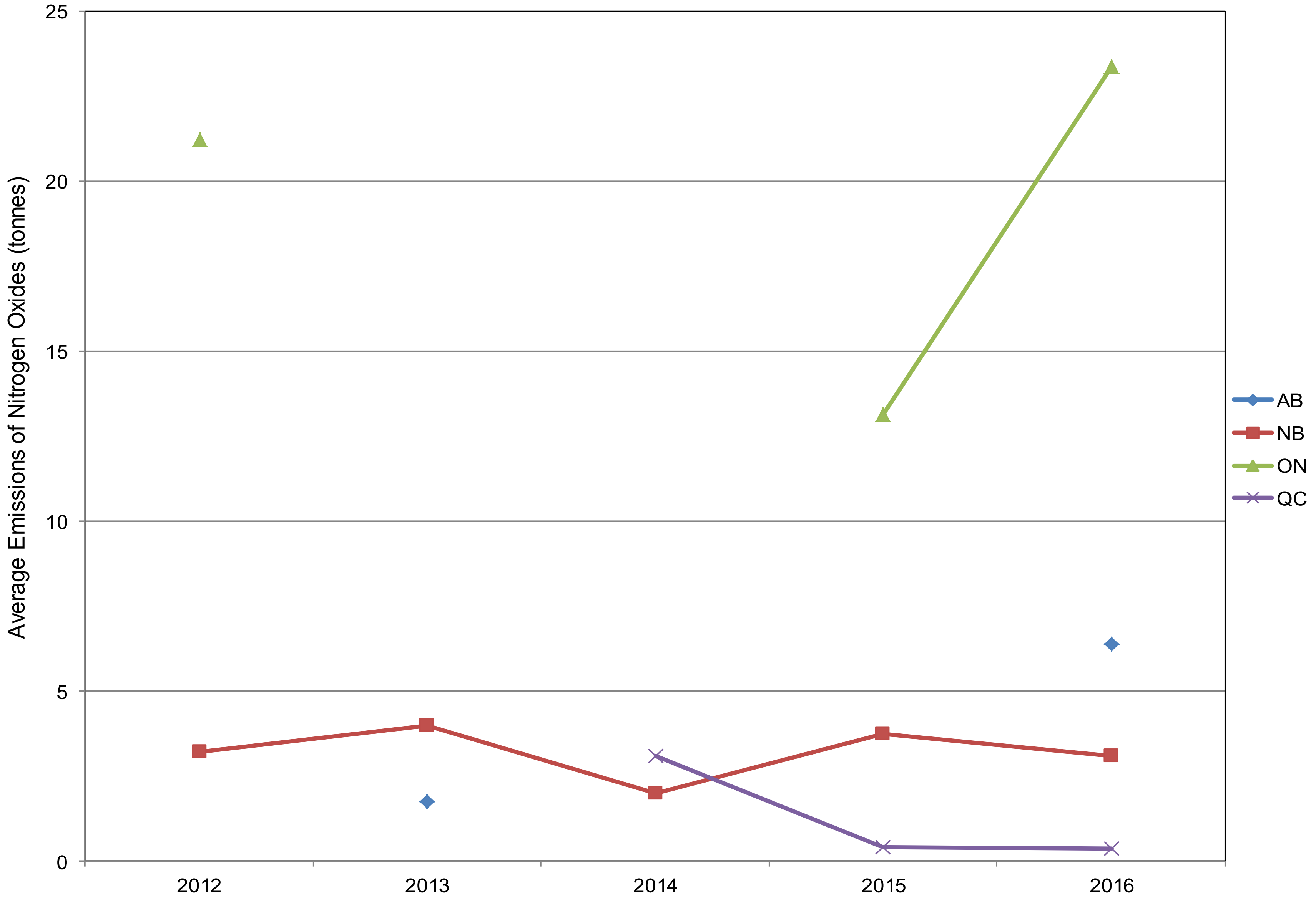

Figure E.5 Nitrogen Oxide Emissions by Year

For the most part, provinces showed similar pollutant emissions, and Ontario seems to fit with most provincial trends. The two major exceptions to this are carbon monoxide, where Ontario reported exceptionally high emissions in 2012 (but has since brought down those emissions to be amongst the lowest in the country), and nitrogen oxides, where Ontario reported an almost 100% increase in its average emissions per facility between 2015 and 2016. The spike in carbon monoxide emissions in 2012 is the result of displaying the data as average emissions in each province. It can be easily confirmed that the elevated emissions in 2012 are the result of single facility reporting high emissions with no other facilities to lower the average. When the total emissions are compared on an annual basis, it is clear that Ontario's emissions remained very stable between 2012 and 2016, and are amongst the lowest in the country. This is shown in the figure below.

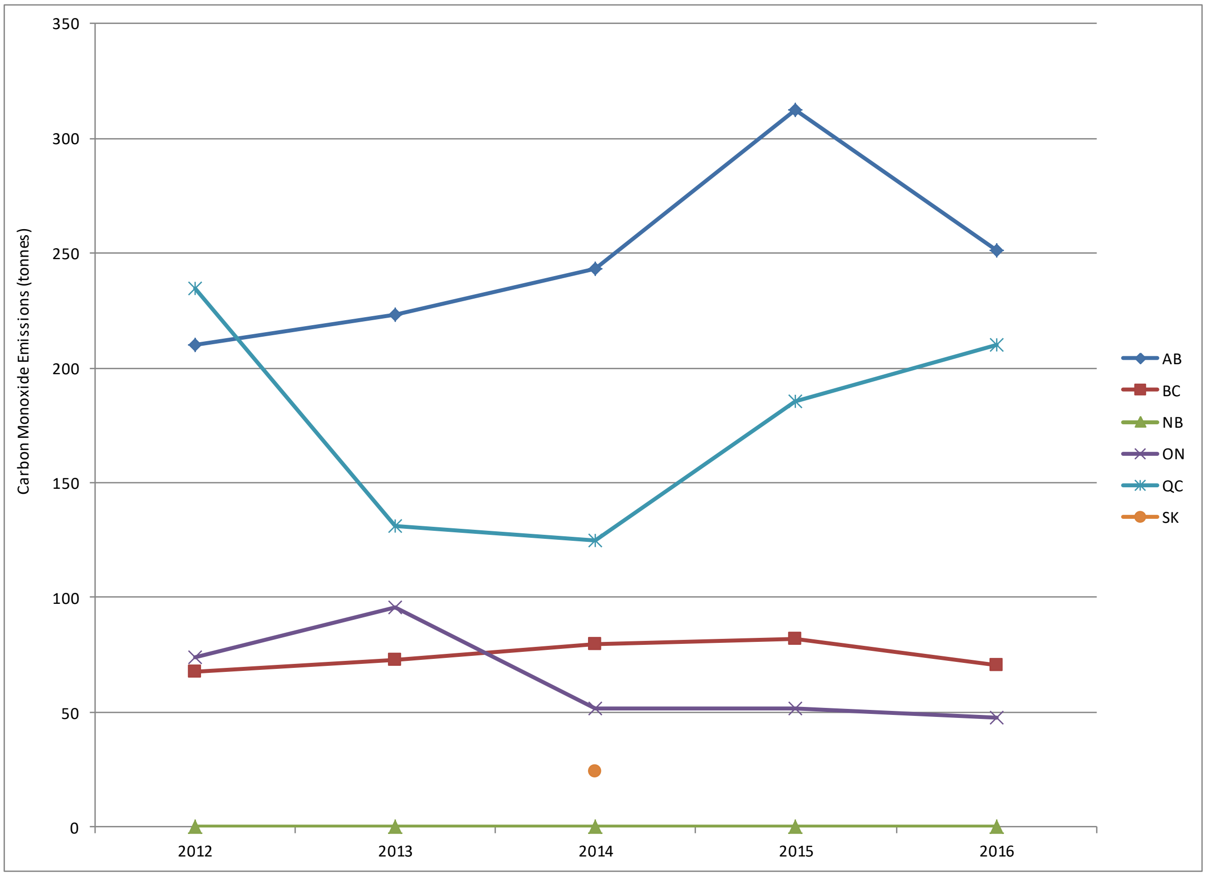

Figure E.6 Total Carbon Monoxide Emissions by Year

However, it is difficult to draw any definite conclusions based on this data due to the exceptionally high reporting requirements for NPRI, which excludes most asphalt facilities.

E.2 Provincial Emissions Reporting

To assist in the implementation of Ontario's cap and trade program, a *Quantification, Reporting, and Verification of Greenhouse Gas Emissions Regulation; O. Reg. 143/16* was filed under the *Climate Change Mitigation and Low-carbon Economy Act, 2016.* As part of *O. Reg. 143/16*, all facilities operating in Ontario who emit at least 10,000 tonnes of greenhouse gas emissions from a select group of activities must report their emissions. As a result of this minimum emission threshold for select activities, the Asphalt Mix industry does not meet the requirements to report their emissions, and thus are not included within the annual reports published under *O. Reg. 143/16*. As of July 3, 2018, Ontario revoked the cap and trade program. It is unclear at the time of writing whether or not reporting under *O.Reg. 143/16* will continue.

Prior to the establishment of *O.Reg. 143/16*, Ontario had implemented the *Airborne Contaminant Discharge, Monitoring, and Reporting Regulation; O. Reg. 127/01* in 2002. This regulation targeted a select group of facilities operating under specified NAICS codes, of which the Asphalt industry was included. Under this regulation, facilities that meet the specified screening criteria for two classes of pollutants, or who are required to report emissions under the NPRI requirements for a third set of pollutants, must monitor, quantify, and report their annual emissions. In order to avoid any duplication, all pollutants that are reported to the NPRI were placed in the third set of pollutants. As a result of this, many asphalt plants in Ontario are not subject to report under *O. Reg. 127/01* since they are not required to report under the NPRI requirements [80, 81].

E.3 Municipal Emissions Reporting

City of Toronto

In 2008, the City of Toronto created *Chapter 423, Environmental Reporting and Disclosure* bylaw with the Toronto Municipal Code. Under this bylaw, all facilities operating within Toronto who emit any of the priority substances outlined within the bylaw at an emission rate exceeding the mass reporting threshold must submit a report detailing the quantity of the substance that they released [82].

The results of these emission reports are aggregated and made available to the public via the City of Toronto's *ChemTRAC Chemical Tracking in Industry* site. With this resource, the emissions reports of asphalt facilities operating within Toronto can be studied. As a result of the considerably lower mass reporting threshold of the City of Toronto's system, asphalt plants are far less likely to be excluded from reporting.

For the purpose of this analysis, facilities that reported emissions between 2012 and 2016 will be studied, of which there were eight [82]. There were four main pollutants reported by Asphalt plants in Toronto: formaldehyde, nitrogen oxides (NOx), particulate matter (< 2.5 µm) (PM2.5), and volatile organic compounds (VOCs). Of these four classes of pollutants, NOx and VOCs comprise almost 90% of the total emissions on a mass basis.

The total emissions of each of these pollutants are shown on the next page, broken down by year.

Over the course of the 5-year period, formaldehyde emissions increased by an average of 50%. This increase was driven primarily by two facilities; however, four of the five facilities that reported formaldehyde emissions did show an increase. There were three facilities that did not report formaldehyde emissions in any year. NOx emissions increased by only 13% over the 5-year period, with half the facilities actually reporting decreases in their emissions. $PM_{2.5}$ showed a 9% decrease in average annual emissions from 2012 to 2016, with all but one facility reducing their annual emissions. VOCs, on the other hand, showed a 56% increase in annual emissions, despite only half the facilities actually reporting an increase in emissions. On the whole, there was a 30% increase in total annual emissions from all facilities over the course of the 5 years.

Town of Oakville

In 2012, the Town of Oakville established *Health Protection Air Quality By-Law Number 2010-035* with the goal of assessing and controlling the health effects of major emissions of particulate matter. Under this bylaw, any facility operating within Oakville that emits an air pollutant that poses a health risk at an emission rate above a defined minimum threshold must report the source of that emission, and the average and worst-case daily and annual emission rates, in kilograms [83].

Despite the low reporting threshold laid out in *Bylaw 2010-035*, facilities are only required to report once. After this, the facility must only report emissions if they undergo some change at the facility that causes a change in their emissions, otherwise they do not need to report. As a result of this, most asphalt plants are not subject to report their emissions on an annual basis, and thus the emissions reports from Oakville will not be analyzed within this document [84].

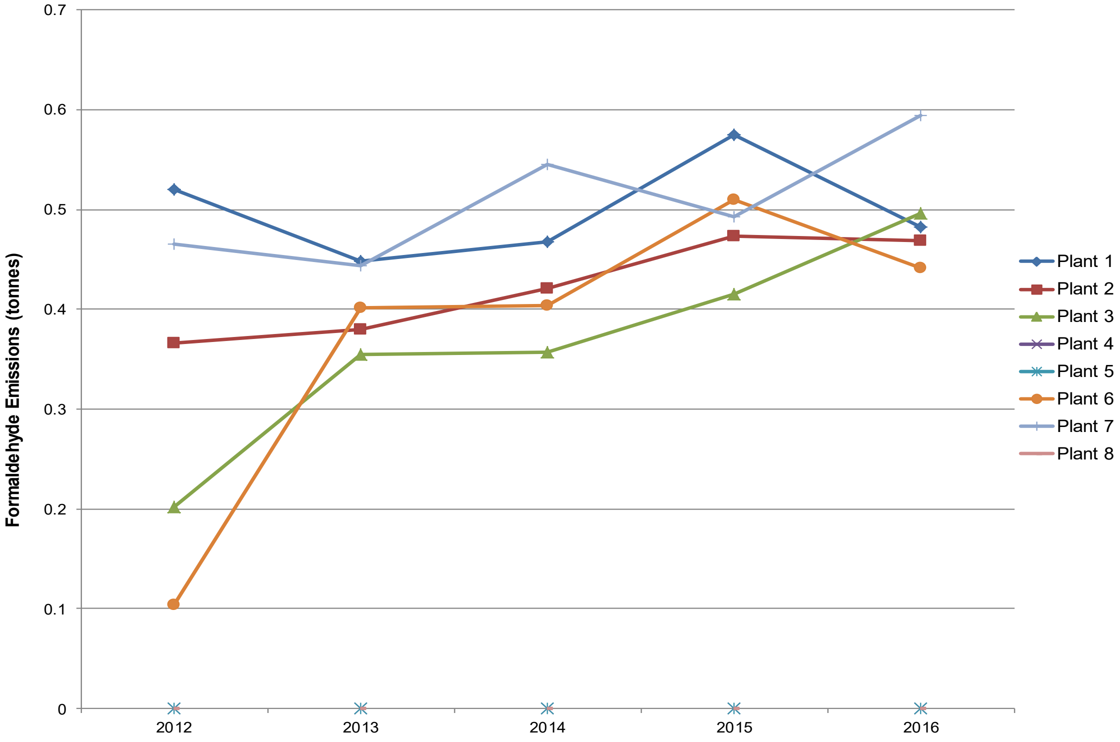

Figure E.7 Formaldehyde Emissions from ChemTRAC Facilities

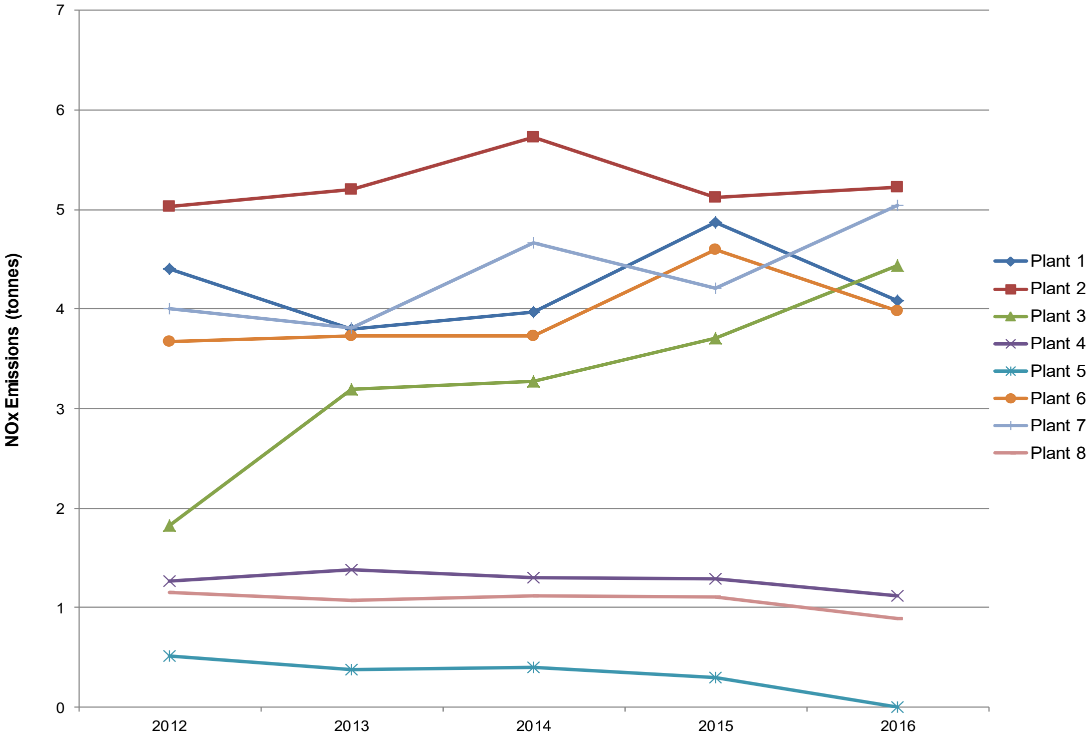

Figure E.8 NOx Emissions from ChemTRAC Facilities

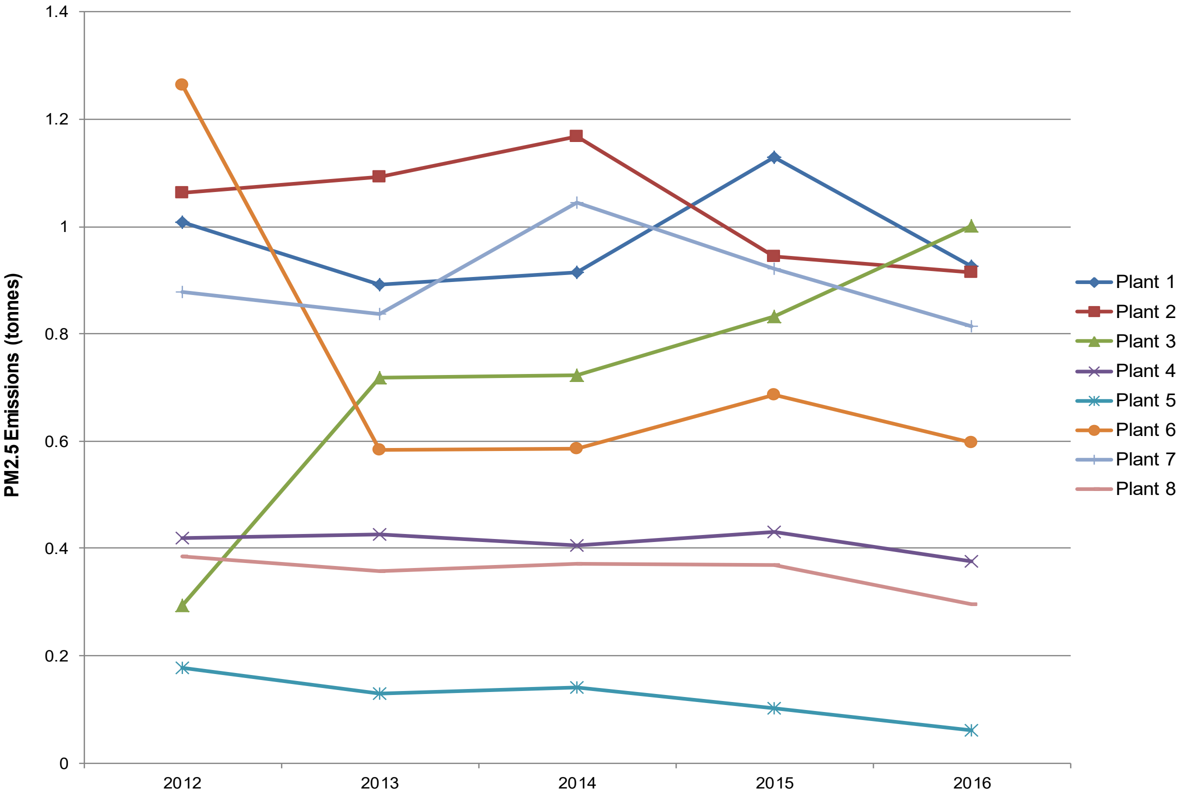

Figure E.9 PM2.5 Emissions from ChemTRAC Facilities

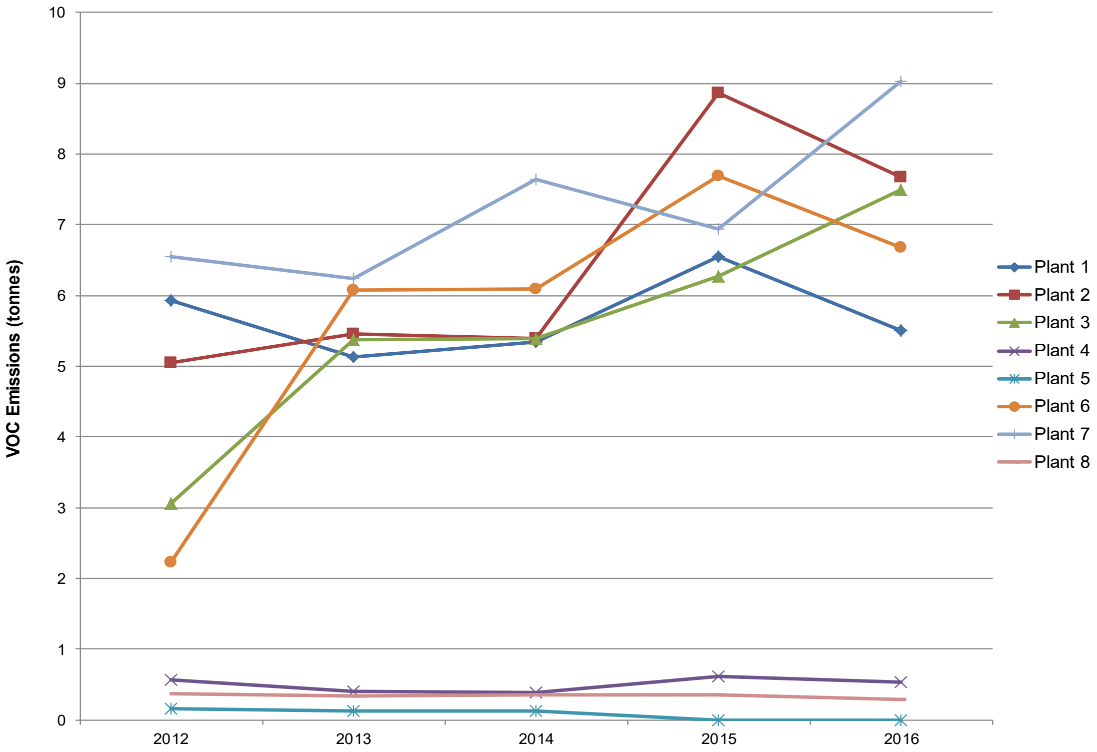

Figure E.10 VOC Emissions from ChemTRAC Facilities

Appendix F: Quantification of Emissions from Asphalt Cement Tank Temperature Effect on Emissions

To ensure proper compaction and the longevity of asphalt, it is imperative that the temperature of the mix remains within a narrow range [86]. If the asphalt becomes too cold, it will thicken, making it considerably harder to compact. Proper compaction of the asphalt is necessary to prevent rutting, improve durability, minimize fatigue, and ensure proper waterproofing.

In order to prevent the asphalt from cooling below the required compaction temperature during storage and travel to the job site, it is common practice to increase the temperature during production. This increase in temperature is designed to compensate for the heat lost during travel. While this is effective for maintaining the viscosity of the asphalt, there are two major issues: increasing the temperature can damage the liquid asphalt binder, thus reducing the performance of the asphalt; and elevated temperatures are known to increase emissions [86].

While it is inevitable that asphalt facilities will have emissions, there have been a number of recent studies showing the effect of temperature increases on emissions. Three separate studies are known to have investigated the relationship between temperature and emissions. Benzene soluble emissions where found to double with an increase in temperature between 11 and 12.5°C [85, 86]. The second showed a doubling of the emissions for a 30°C increase in the temperature. The third study showed a 30% increase in emissions for a temperature increase of 50°C. One additional study conducted by Eurobitume concluded that an increase in temperature leads to a positive correlation between the emissions and the relative amount of high molecular weight pollutants. According to this study, the increase in emissions is directly related to an increase in the substance’s vapour pressure.

An additional study conducted specifically on the emission of PAHs found that the emissions of these compounds are relatively stable until 190°C, after which they begin to increase dramatically. Additionally, the study noted the presence of larger PAHs (4-, 5-, and 6-ringed), which are more toxic than smaller PAHs, at elevated temperatures. Since most hot mix facilities in Ontario tend to operate below 190°C, this study provides more of a warning against further increases. However, the study notes that the emission rates of aromatics and PAHs are also strongly influenced by the performance grade of the asphalt binder used.

A similar study conducted on emissions of PACs found a correlation between emissions and crude source, refining process, application temperatures, and work practices. It was found that the typical operating temperature for hot mix processes led to low emissions, but increasing the temperature beyond 200°C significantly increased the emissions of PACs, especially those with 4 or more rings.

Evidently, in all cases, an increase in temperature is directly linked to an increase in emissions.

F.1 Estimating Emissions from Storage Tanks

There are a number of storage tanks at Asphalt Mix facilities. These tanks are used to store different materials, including fuel, asphalt cement, and the hot mix asphalt after it has been mixed. It is important that some of these tanks, specifically those with AC or HMA, store their contents at elevated temperatures to prevent hardening inside the tanks. According to the OAPC, the temperatures in these tanks are generally kept above 130°C [87].

There are two major emissions pathways from storage tanks: breathing losses and working losses. Breathing losses are the evaporative losses that occur during regular storage periods, when there is no change occurring to the liquid level within the tank. Working losses, on the other hand, occur during filling and emptying operations. In either case, the emissions from tanks are generally very difficult to quantify and are assigned a marginal data quality rating—the lowest possible rating, according to the United States Environmental Protection Agency and MECP. Despite this, the, U.S. EPA, together with the American Petroleum Institute, has developed a series of calculation techniques in *Chapter 7.1 Organic Liquid Storage Tanks* of their *Compilation of Air Pollutant Emissions Factors (AP-42)* to estimate the emissions from storage tanks.

Based on the equations outlined in the AP-42 document, there are two methods commonly used to estimate emissions from asphalt storage tanks: U.S. EPA's TANKS software and the Owens Corning method. The major differences between these are in the molecular weight and vapour pressure of the asphalt cement. The bases of these differences, as well as other considerations, are discussed in the sections below.

F.2 Development of Physical Properties in TANKS and Owens Corning

As described above, there have been two primary methods developed for estimating emissions from asphalt storage tanks. These methods differ primarily in the physical and chemical parameters they use to estimate asphalt cement—molecular weight and vapour pressure, specifically. The reasons for these differences are described in the following sections.

It is important to note that either choice of molecular weight can be used in the TANKS emissions estimation software, but only the U.S. EPA vapour pressure relationship in Section 4.4.1.2 can be used since TANKS does not support the relationship used by Owens Corning.

F.3 Molecular Weight of Asphalt Cement

To use the equations outlined in AP-42 Chapter 7.1, the user must provide an estimate of the vapour molecular weight of the material being held in the tanks. Since asphalt cement comes from petroleum crude oil, every source will have a slightly different product, and thus it is impossible to determine the exact properties of every batch of asphalt cement. Based on this, the U.S. EPA and Owens Corning developed estimates of the asphalt cement vapour molecular weight—105 and 84, respectively. Both methods, however, agreed on a value of 1000 for the asphalt liquid molecular weight.

The discrepancy in the values arises as a result of differing methods to determine the molecular weight. To develop their estimate, the U.S. EPA studied the emissions of vapour from a single storage tank in use at a facility in the United States. With this data, they modified the parameters used in their TANKS software to minimize the difference between the predicted value from the software and the actual value from the tank. By refining their estimate and minimizing the error, they found a value that closely predicted the emissions from the tank to a sufficient degree of accuracy. This value was then reported as the vapour molecular weight to be used in all calculations. Alternatively, Owens Corning separated and analyzed the organic species in the vapour phase of 12 different tanks. They then took a weighted average of the molecular weights of the species found in a particular tank to determine an overall molecular weight of the vapour phase in that specific tank. The molecular weights of the 12 tanks were then averaged together to get the vapour molecular weight of asphalt.

F.4 Vapour Pressure of Asphalt Cement

In addition to the molecular weight, one must also have data on the vapour pressure of the material in order to use the equations in Chapter 7 of AP-42. Since vapour pressure is a function of temperature, it cannot be provided as a single value. Instead, the U.S. EPA and Owens Corning developed equations that modelled the relationship between temperature and vapour pressure. The equations and theory behind their development are described below.

In the TANKS software, there are four methods provided for specifying the vapour pressure of the material in the tank: 1) provide the actual vapour pressure (in psi) at 7 listed temperatures; 2) Antoine's equation (using °C), where the user enters values for the constants A, B, and C; 3) Antoine's equation (using K), where the user enters the constants A and B; and 4) Reid Vapour Pressure and ASTM slope. In developing the vapour pressure relationship for asphalt facilities, the U.S. EPA created a relationship of the form of the Antoine equation (using K): $\log_{10}(P, mmHg) = \frac{-0.05223A}{T} + B$. They subsequently found values for the constants A and B by taking the average of those constants for two other known compounds that were believed to closely match the composition of asphalt cement (docosane and tricosane). This resulted in predicted emissions from the TANKS software that closely matched the actual emissions from an operational tank. The values of the constants, A and B, were found to be 75,350.06 and 9.00346, respectively.

The equation used to relate vapour pressure to temperature used by Owens Corning is based on the following equation derived from the Clausius Clapeyron relationship (using R): $\ln(P, mmHg) = a - \frac{b}{T}$. To determine the values of the constants A and B, Owens Corning determined the vapour pressures of 8 different samples of asphalt cement across the United States at a number of different temperatures. They then averaged the vapour pressures at each of the temperatures measured to determine the average vapour pressure at each temperature. Finally, they fit the data with a curve of the form given above to determine the values of the constants. Using this approach, they found the values for A and B to be 20.7962 and 15032.54, respectively.

The figure below provides a representation of the difference between these vapour pressure relationships. Thus, the Owens Corning relationship has been shown to predict vapour pressures as much as 6 times higher than that of the U.S. EPA relationship within the temperature ranges commonly found at Asphalt Mix facilities.

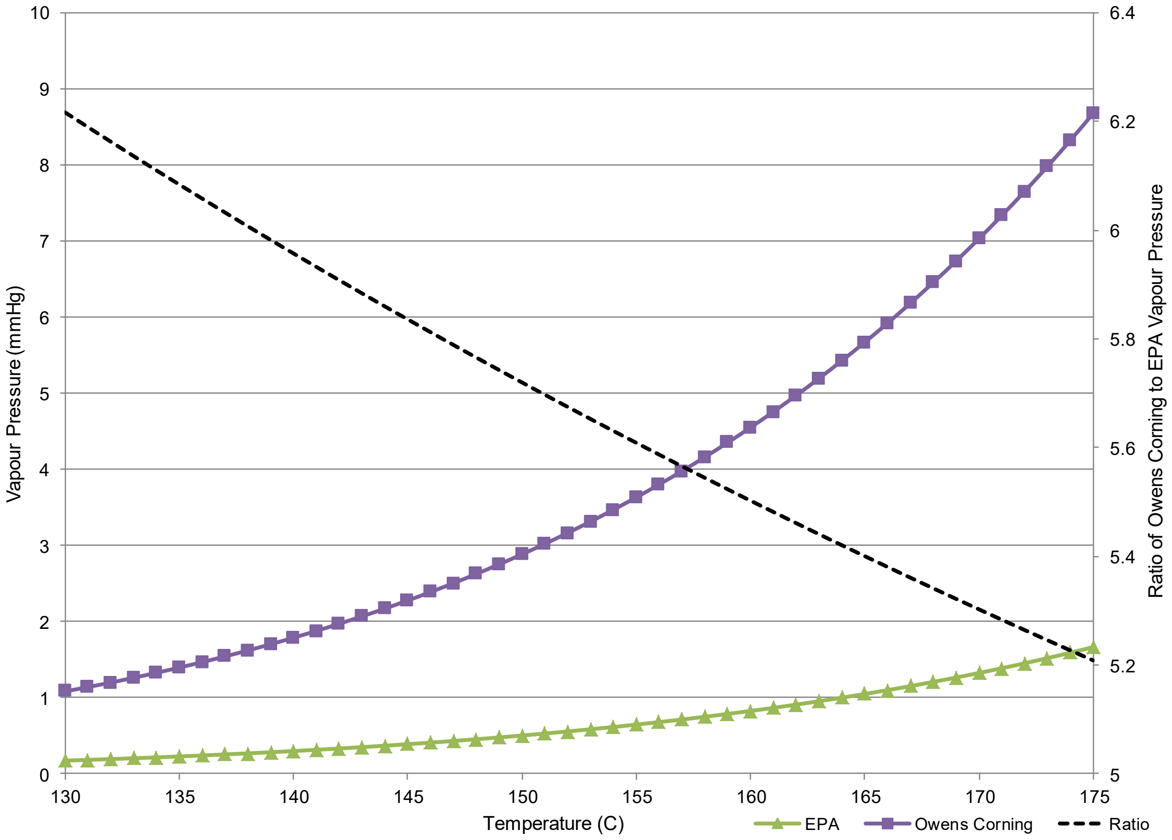

Figure F.1 Vapour Pressures Predicted by U.S. EPA and Owens Corning Relationships

F.5 Use Considerations

F.5.1 TANKS Emissions Estimation Software

As described above, the TANKS emissions estimation software was developed by the U.S. EPA to allow for the direct calculation and speciation of emissions from storage tanks based on the equations outlined in AP-42 Chapter 7.1. The user provides data on the physical characteristics of the tank, the location of the tank, the contents of the tank (as selected from a pre-loaded database), and the throughput in order to obtain an estimate of the emissions from the tank in a given timeframe (i.e. annual or monthly basis).

In addition, users have the option to edit the chemical database and add new chemicals with a specified molecular weight, density, and vapour pressure relationship. There is also the option to identify the fittings, seams, and seals used on a particular tank in order to further refine the breathing loss estimates.

While this system seems like an ideal choice for emissions estimates from storage tanks, there are a number of issues that have been identified in the software and the U.S. EPA has stated they are no longer providing support for the software [88].

A few of the issues with TANKS have been identified by the U.S. EPA and are outlined below. For one, the TANKS software uses only the annual average liquid temperature when performing monthly calculations, and thus is unable to account for monthly variations in temperature. Additionally, the software does a poor job in determining the emissions from heated tanks (requires assuming the tank is fully insulated on all sides), and produces vapour pressure estimates that vary drastically from actual values at temperatures above 100°F (38°C). On top of these programmatical errors, TANKS has a number of issues related to default settings, lack of guidance, and outdated factors and equations that make it a poor option for estimating storage tank emissions.

While TANKS is no longer considered the best option, the U.S. EPA still maintains that the equations presented in Chapter 7.1 of the AP-42 document are valid and present the best means of calculating emissions from storage tanks.

F.5.2 Owens Corning Emissions Estimation Method

The Owens Corning methods described above were produced as the result of Owens Corning’s Title V permit applications. In addition to the development of a vapour molecular weight and a relationship to describe the vapour pressure, Owens Corning has developed other techniques for performing specific estimations in areas the AP-42 document does not address sufficiently.

For instance, in the case where tanks use fume control technology and air sweeps (the bleeding of air into the tank to promote movement of the vapour out), the underlying assumption behind the AP-42 emissions estimates (that of only having working and breathing losses) is no longer valid. Based on this, Owens Corning used a series of techniques designed to measure the concentration of combustible gases in the vapour space of their tanks to determine the VOC and PM present. In the cited paper, Owens Corning outlines the calculation procedure for converting combustion meter measurements into VOC and PM emission rates from the tank, and then further into the emissions from the control devices. Using this methodology, Owens Corning confirmed their estimation technique by measuring the emissions from their fume-controlled tanks, and compared these results to AP-42 estimated emissions which were as much as 5 times higher than reality https://www.cbc.ca/news/technology/hemimastigotes-supra-kingdom-1.4715823.

In addition, Owens Corning used the same technology to develop estimates of the emissions of CO and H_2S from asphalt storage tanks. In most cases, the emissions of CO and H_2S from storage tanks are ignored; however, based on data from the combustion meters, Owens Corning determined that they were present, and thus were being emitted. After studying the data from their measurements, Owens Corning found a relationship between the combustion meter measurements and CO/H_2S emissions, and was able to quantify an emission rate from their tanks.

Despite these modifications, Owens Corning's relationships are ultimately still designed to be used within the framework of equations provided by the U.S. EPA in Chapter 7 of the AP-42 document, with only minor alterations being used to extend its application to a wider range of conditions.

Appendix G: Use of Warm Mix Asphalt

G.1 Warm Mix in Ontario, Canada

Warm mix asphalt has been used in Ontario. A major project involved the use of WMA for the Queen Elizabeth's Way (QEW) Pavement Rehabilitation Project. This project was considered the largest WMA project in Canada at the time of project completion (2011). 67,000 tonnes of WMA was placed on a 15.6 km stretch of highway between Grimsby and Lincoln. Previous Ministry of Transportation (MTO) contracts involved WMA in surface course paving but this time it was used as both binder and surface course layers. The QEW project was able to achieve:

- Reduced fuel consumption (by 1.5 to 2.0 litre of fuel/tonne of asphalt) and GHG emissions (by 4.1 to 5.5 kg CO_2 equivalent /tonne of asphalt) at the production facility
- Reduced asphalt fumes behind the paver, including 30% reduction in dust, 63% reduction in benzene soluble fraction, and 64% reduction in opacity
- Potential to include up to 50% RAP in the WMA mix
- Potential to reduce user delay, fuel consumption, and GHG emissions in construction zones due to reductions in cooling time
- Potential for improved pavement performance resulting in less maintenance/rehabilitation and lower overall life-cycle cost of pavement structure
- Overall construction cost neutrality relative to conventional HMA with the potential for WMA costs to decrease as its use in Ontario expands

This project report concluded that the MTO will continue to encourage the use of WMA through the development of construction and paving contracts [89].

G.2 Warm Mix in United States of America

In addition, the United States has conducted a number of projects using WMA. The National Cooperative Highway Research Program (NCHRP) wrote a report on the field performance of WMA technologies. Locations such as Missouri, Michigan, Colorado, Tennessee, Texas, and Washington all conducted research. Each field trial compares the quality of WMA to HMA over number years. It was concluded that [90]:

- By producing asphalt mixtures at decreasing temperatures by an average of 27˚C, there is an average burner fuel savings of 22%.

- The amount of CO_2 emitted is proportional to the amount of fuel usage.

- Exposure to respirable fumes decreased significantly. When compared to HMA mixtures, the total organic matter (TOM) of the warm mix asphalt was 33% lower. This is because the emissions released to air are dependent on the paving temperatures and binder.

The U.S. Department of Transportation Federal Highway Administration has stated that warm mix asphalt is “an important technology for the 21st century” that “is increasing the quality of our roads and our environment.” The 2017 Asphalt Pavement Industry Survey on Recycled Materials and Warm-Mix Asphalt Usage reported that 147.4 million tons of asphalt pavement was produced using warm mix technologies in the United States in 2017 alone—a 26% increase from 2016. This represents almost 40% of the total asphalt pavement produced in the United States.

https://www.fhwa.dot.gov/innovation/everydaycounts/edc-1/wma.cfm

https://www.asphaltpavement.org/PDFs/IS138/IS138-2017_RAP-RAS-WMA_Survey_Executive_Summary.pdf